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> > Special Issue on

COMMERCIALIZATION OF EMERGING MATERIALS AND TECHNOLOGY FOR SUSTAINABLE FUTURE (ICCEMTSF)

Special Issue Editors-in-Chief

Dr.P. AROCKIA MICHAEL MERCY | Dr.A. DAYANA AMALA JOTHI Dr.A. SAVARIMUTHU | Dr. JOSEPH WILSON



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BIJRHAS

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The journal welcomes publications of quality papers on research in humanities, arts, science. agriculture, anthropology, education, geography, advertising, botany, business studies, chemistry, commerce, computer science, communication studies, criminology, cross cultural studies, geography, demography, development studies, library science, methodology, management studies, earth sciences, economics, bioscience, entrepreneurship, fisheries, history, information science & technology, law, life sciences, logistics and performing arts (music, theatre & dance), religious studies, visual arts, women studies, physics, fine art, microbiology, physical education, public administration, philosophy, political sciences, psychology, population studies, social science, sociology, social welfare, linguistics, literature and so on.

Research should be at the core and must be instrumental in generating a major interface with the academic world. It must provide a new theoretical frame work that enable reassessment and refinement of current practices and thinking. This may result in a fundamental discovery and an extension of the knowledge acquired. Research is meant to establish or confirm facts, reaffirm the results of previous works, solve new or existing problems, support theorems; or develop new theorems. It empowers the faculty and students for an in-depth approach in research. It has the potential to enhance the consultancy capabilities of the researcher. In short, conceptually and thematically an active attempt to provide these types of common platforms on educational reformations through research has become the main objective of this Journal.

Dr. S. Balakrishnan

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Rev. Sr. Dr. Antony Pushpa Ranjitham CIC

Superior General Congregation of the Immaculate Conception

"Good, Better, Best, Never Let it rest. Till your good is better and your better is best" - St.Jerome

Madoma Arts and Science College for women has achieved great heights in the academic and cocurricular realm. Ifeel elated and extremely happy that this college in collaboration with "Bodhi International Journal of Research in Humanities, Arts and Science" conducts a one day conference on the theme "Commercialization of Emerging Materials and Technology for Sustainable Future". Sustainable future is an approach to growth and human development that aims to meet the needs of the present without compromising the ability of future generations to meet their own needs.

The aim is to have a society where living conditions and resources meet human needs without undermining planetary integrity. Sustainable development aims to balance the needs of the economy, environment, and society. I do believe, that this conference has the prime target to reach out to the young researchers of today, to make them aware of their innate potentialities and encourage them to build a serene and prosperous world of tomorrow. I hope this will become the "Power Bank" to inspire the young minds and instill in them hope and courage, create an ability to look for new horizons in life

I hope wish and pray this seminar provides ample opportunities for more reflections on their capacities and release more energy for better thinking and actualizing their potentialities. Let me take this opportunity to appreciate the college administration, the organizing committee members, members of the staff students all the contributors and participants. A big thanks to Bodhi International Journal of Research in Humanities, Arts and Science for their support and initiations. May this conference add one more pearl in the crown of Madonna Arts and Scorner College for women. May God bless you all abundantly.

Yours in Christ Rev.Sr.Dr. Antony Pushpa Ranjitham



+Most Rev. Dr. Antony Pappusamy Archbishop Emeritus of Madurai

I am much delighted to know that Madonna Arts and Science College for Women organizes an International Conference on Commercializing Emerging Materials and Technologies for a Sustainable Future and brings out an International Journal which will be published as research papers presented at the Conference in March 14, 2025. At the very outset, let me congratulate the college on this significant academic initiative aimed at dissemination of the findings of academic research with a view to promoting a healthy intellectual discourse on the theme. I am happy that the collage has chosen a socially relevant theme for serious deliberations.

Commercializing Emerging Materials and Technologies for a sustainable future involves developing and using new materials and technologies to meet market needs in a cost-effective way. The goal is to create products that are reliable, durable, and environmentally friendly. Science and technology for a sustainable future help us understand our environment and our impact on it, which is essential for making smart decisions about how to use our resources. It can also help us to find solutions to the problems, such as climate change and pollution, and improve the quality of life for all people. It means moving towards a consistent resource-efficient circular economy, and by turning away from the predominantly linear economy which produces waste. We need a steady supply of food, clean water, clean air, and a healthy environment in which to thrive. By living sustainably, we plan not only for our own well-being but also that of our neighbours and future generations. Being environment-friendly, reducing energy consumption, using new renewable energies, using LED lights, reducing waste through new and more efficient designing, manufacturing, computers, servers, and associated subsystems that promotes substantial environmental benefits cannot be ignored in a climate change Global.

This present International Conference at Madonna College of Arts and Science for Women strikes on this chord. May this Conference be an eye-opener to all the speakers and participants of the Conference. I extend my best wishes to the organizers and the participants of the Conference. I take this opportunity to place on record my sincere appreciations to the Management, the Principal and the Staff for organizing an International Conference on such a socially relevant theme. Established in the recent past, the college has made rapid strides within a short span of time by conducting such useful programmes. Academic enterprise of this sort will no doubt prepare students of the future who would be socially committed, intellectually competent, affectively creative and emotionally compassionate. Wishing the college every success with the Conference and seeking God's blessings upon the college. May God Bless you in all your endeavors.

+ Most Rev. Dr. Antony Pappusamy Archbishop Emeritus of Madurai



Rev. Sr. Antony Maria Lilly Secretary Madonna Arts and Science College for Women

I feel immensely happy to know of the Multidisciplinary International Conference on-Commercialization for Emerging Materials and Technology for Sustainable Future, organized by our Madonna Arts and Science College for Women. Whether we like it or not, we are living in the techno-tronic world. Science has advanced beyond our anticipation and has gone without boundaries. Scientific development and technological advancement are leading the humanity to the newer world. With the latest gadgets in science and technology and communication revolution the world has become a global village. The whole universe has shrunk into a microcosm. From Industrial Revolution to the current scenario of Robotic technology, mankind has marched ahead in its exploration of new heights in science and technology.

Multiple technologies only will survive and sustain in future with its resilience for the entrepreneurs, ICT professionals, industrialists and the trailblazers I Artificial Intelligence and Data Science. For sustainable brighter future and progress in holistic perspective, the commercialization of newer technologies will lend the helping hand. Even in the educational scenario, the concept of STEM-Science, Technology, Engineering and Mathematics orient the students developing the key skills and life skills to cope up with the challenges encountered in life. It's an apt approach to learning and integrating the thrust areas of research-cum-development. The recently introduced NEP-2025 also envisages the integrated holistic and multidisciplinary approach which underlines inclusive learning. At this juncture, I whole heartedly appreciate all those who are part of this creative endeavours and made the conference a mega success!

"Let noble thoughts come to us from all directions ". With solidarity and well wishes.

Yours in Christ Rev. Sr. Antony Maria Lilly



Dr. B. Sahaya Rani Fernando

Principal Madonna Arts and Science College for Women, Virahanur, Madurai

I am very much grateful to our Lord for having given me the opportunity to appreciate the wonderful task taken up by the faculty of Madonna Arts and Science College for Women, to bringout an International conference commercialising emerging materials and Technologies for a future on 14.03.2025.

At the outset I would like to comment on the title which is very much needed and apt for the current scenario. The staff members have been keen in choosing a right topic for this dynamic world. The topics for presentations and the multi-disciplinary conference in highly commendable discussions cover a wide range of collaboration will surely help in shaping a sustainable future. It is not only an opportunity for intellectual growth but also create a harmony in global growth.

I hope they will bring out new materials and technologies to meet out the needs of society keeping in mind the cost-benefit-effectiveness also. I wish the International Conference brought out by Madonna College will educate the participants to know about various chuologue and materials for sustainable future.

I appreciate all departments involved in their great accomplishment of bringing various colleges and students together to have an alarming discussions and making everyone understand the current scenario. My heartfelt thanks to Bodhi International Journal of Research in Arts and Science for their Co-operation and support in the regard.

I wish and pray that the International conference to be a great success and bring many more laurels Madonna Arts and Science College for Women.

God Bless you

Warm Regards

B. Saharja



Venkatapathy Kalyani

Manufacturing Engineering Leader & amp; New Product Launch Leader 8678 Windsor Hill Blvd. North Charleston, South Carolina: 29420

It is with great pleasure I appreciate Madonna Arts and Science College for women for organizing an international gathering on Commercialization of Emerging Materials and Technology for Sustainable Future (ICCEMTSF) 2K25. This dynamic discussions, keynote speeches, and panel sessions, covering a wide range of topics that are shaping the future. It hopes that through these exchanges, new collaborations will be formed, innovative solutions will emerge, and a shared vision for a better future will take shape. Bringing together such a diverse and esteemed group of participants from all corners of the world. This is not only an opportunity for intellectual growth but also for fostering global cooperation, understanding, and respect. I am confident that the conversations and collaborations sparked here will resonate long after the event concludes.

I extend my gratitude to all contributors, presenters, and organizers who have made this event possible, and I look forward to the fruitful discussions and impactful outcomes that will emerge from this intellectual exchange. Together, we are taking significant steps toward building a more interconnected and forward-thinking global community. Hoping to find the sessions insightful, the discussions enriching, and the experience both intellectually stimulating and personally rewarding. I like to extend my thanks to the members of the organizing team for their hard work.

Thank you for being a part of this exciting journey.

With Warm Regards Venkatapathy Kalyani



Rev. Dr. Anbarasu Principal Arul Anandar College, Karumathur

"The meeting of two personalities is like the contact of two chemical substances: If there is any reaction, both are transformed." – Carl Jung

I am delighted in acknowledging the International Conference ICCEMTSF 2K25 organized by Madonna Arts and Science College for Women, on Commercialization of Emerging Materials and Technology for Sustainable Future. I appreciate the organizing committee for showing a keen interest in organizing a successful Conference and contributing new ideas and research findings. I extend my best wishes to them in their efforts to disseminate knowledge. I congratulate all the participants for their enthusiastic participation. The overall success of the conference depends on the cooperative endeavors of those engaged in its planning and organization.

Education consistently serves as a benchmark for progress and the acquisition of knowledge. The focus should be on research that aids society in developing innovative solutions. Embracing a fresh and creative perspective is crucial for successfully managing technological progress. This conference serves as a platform for an academic discourse focused on a sustainable future. The appropriate application of the Commercialization of Advanced Materials is also significant for investigating and examining different facets of research. The enthusiastic engagement of contributors and the educational community with a shared vision in this conference is profoundly inspiring. I extend my heartfelt appreciation to all individuals who have contributed through their research papers and active participation in this conference.

I am delighted that numerous esteemed educators, scholars and students from around the globe have gathered to exchange their knowledge and experiences, as well as to seek improved methods for a sustainable future. I sincerely wish for this International Conference to attain remarkable success, functioning not only as a platform for the exchange of knowledge and experiences in higher education but also as a basis for lasting collaboration and fellowship among educators committed to the essential and fulfilling task of educating and equipping our youth for a brighter future. I wish you all a fruitful and memorable conference experience.



Rev. Dr. Joseph John Kennady Parish Priest 165, 5th Street NE, Kelliher, MN, USA

It is with immense joy and great honor that I extend my heartfelt felicitations to Madonna Arts and Science College for Women, in association with Bodhi International Journal, for organizing this prestigious International Conference on the Commercialization of Emerging Materials and Technology for a Sustainable Future.

The theme of this conference could not be more relevant in today's world, where the need for sustainable innovations and technological advancements is paramount. As we strive to balance progress with environmental responsibility, this gathering of scholars, researchers, and industry experts provides a vital platform to exchange groundbreaking ideas, share pioneering research, and explore transformative solutions that will shape a sustainable future.

The dedication and vision of the organizers in bringing together distinguished experts and enthusiastic learners from various disciplines deserve the highest commendation. This conference is not just an academic endeavor but a powerful initiative that bridges the gap between research and real-world applications, ensuring that emerging materials and technologies contribute meaningfully to society and the environment.

I firmly believe that the insights and deliberations shared during this conference will pave the way for new collaborations, inspire novel research, and ignite innovative thinking in the quest for sustainable progress. May this event be a grand success, fostering intellectual growth and contributing to the collective efforts in building a better tomorrow.

Wishing all the participants, organizers, and dignitaries an enriching and fruitful conference!

With warm regards,

Rev.Dr. Joseph John Kennady



Rev.P. Lawrence Antony *Kath Pfarramt Sancta Familia, Pflugstraße 1, 60431 Frankfurt*

To the esteemed organisers, participants and guests of the International Conference on Commercialisation of Emerging Materials and Technology for Sustainable Future (ICCEMTSF) at Madonna Arts and Science College for Women.

It is with great pleasure and respect that I extend my heartfelt congratulations on the occasion of this significant multidisciplinary international conference. In particular, I would like to acknowledge and commend the leadership and commitment of the Religious Sisters of Madonna Arts and Science College for Women in fostering such a vibrant and intellectually stimulating environment.

This conference, with its focus on the commercialisation of new materials and technologies for a sustainable future, is both timely and critical. The exploration of innovative solutions and the exchange of knowledge in this field are essential to address the pressing global challenges we face. I am confident that the discussions and collaborations fostered here will contribute significantly to the advancement of sustainable practices and technologies.

I commend the BODHI International Journal of Research in Humanities, Arts and Science for its association with this conference, which highlights the importance of interdisciplinary approaches to solving today's complex problems. The commitment to scholarly research and dissemination of knowledge is truly commendable.

May this conference be a resounding success, sparking new ideas, fostering collaboration and inspiring participants to drive positive change towards a more sustainable and equitable future. I wish you all fruitful deliberations and a memorable experience.

With Warm Regards

Rev.P. Lawrence Antony

Dr. K. S. Joseph Wilson Associate Professor PG & Research Department of Physics



Arul Anandar College (Autonomous) Karumathur-625514 Madurai District. Tamil Nadu. Email: wilsonpra@yahoo.co.in



Message

10-03-2025

It is both an honor and a privilege to address you at this significant conference. The theme of the conference, "*The Commercialization of Advanced Materials and Technology for a Sustainable Future*," is of paramount importance not only to the scientific community but to the future of our planet.

Nature, in all its grandeur, showcases a harmonious and intricate design, with each element perfectly organized and interconnected. Its beauty is immeasurable. As we face the urgent challenges of resource depletion and environmental degradation, the need for innovative solutions has been more essential. The real challenge lies in the commercialization of the advanced materials and technologies. This process demands not only scientific and engineering expertise but also a profound understanding of market dynamics, policy frameworks, and investment strategies. Turning promising lab results into scalable, cost-effective solutions requires collaboration across industries, governments, and academic institutions.

One of the key areas where we can make an immediate impact is in the energy sector. Advanced materials such as high-efficiency solar cells, next-generation batteries, and hydrogen storage technologies have the potential to accelerate our transition to renewable energy. Yet, for these technologies to become widely accessible, we must address issues like production costs, scalability, and regulatory approval. Public-private partnerships and collaborative ventures are essential to overcome these hurdles. Commercializing these technologies is not just about profit but about creating systemic value that benefits society and the environment.

The road ahead is both challenging and exciting. It is up to us, as students, scientists and entrepreneurs, to harness the power of advanced materials and technology to create a future that is not only sustainable but also equitable and prosperous. I wholeheartedly congratulate and appreciate the organizing team for their untiring, dedicated efforts in organizing and conducting this conference successfully.

Let us continue this journey with determination and collaboration, shaping a bright future where sustainability and technological progress go hand in hand.

With regards,



Arockiasamy Arulandu

Ph.D Group Leader, Structural Biology International Centre for Genetic Engineering and Biotechnology (ICGEB) Aruna Asaf Ali Marg, New Delhi-110067. India

Dear Esteemed Colleagues, Researchers, and Industry Leaders,

It is with great enthusiasm that I extend my best wishes for the International Conference on Commercialization of Emerging Materials and Technology for a Sustainable Future (ICCEMTSF 2K25). As we confront the pressing challenges of climate change, resource scarcity, and environmental degradation, the role of emerging materials and technologies in shaping a sustainable future has never been more vital.

In recent years, we have witnessed remarkable advancements in novel materials—from biomaterials to smart materials, from energy-efficient innovations to sustainable manufacturing processes. These breakthroughs have the potential to revolutionize industries and redefine the way we produce, consume, and interact with our environment. This conference provides a critical platform for exploring the intersection of research, development, and commercialization of these transformative technologies.

As we seek solutions to global challenges such as reducing carbon emissions, enhancing resource efficiency, and ensuring long-term environmental sustainability, emerging materials offer unparalleled opportunities. From next-generation batteries and carbon capture materials to green building technologies and sustainable agriculture, the applications are both vast and groundbreaking. ICCEMTSF 2K25 serves as a hub for collaboration among researchers, engineers, policymakers, and entrepreneurs—fostering dialogue that will drive innovation and real-world impact.

I look forward to engaging discussions, groundbreaking insights, and the formation of new partnerships that will guide us toward a more sustainable, prosperous, and resilient future. Wishing all of you a productive and successful conference.

Warm regards

Arockiasamy Arulandu



Arun Prasad Arockiasamy TAG CTI Lead -AIA & CIS Talent Acquisition Group, North America

I am thrilled to know about the upcoming conference that promises to be a significant event in the current scenario. In this fast-evolving generation, the importance of such conferences cannot be overstated. This conference will explore the latest trends, materials, technologies, and best practices in commercialization and sustainability, providing a platform for creating a lasting and sustainable future.

Technologies are at the forefront of innovation breakthroughs, and their commercialization is viewed as the heart of economic growth. The conference on emerging technologies is incredibly important in the current market. Emerging technologies are a promising substrate for innovation breakthroughs with the potential to transform multiple industries. The commercialization of these technologies is viewed as the heart of economic growth. It brings together experts to exchange and share their knowledge, experience, and research results on advancements in the fields of science, social sciences, and humanities.

Bringing together thought leaders and experts to discuss major challenges and innovations at such conferences are crucial as they address multiple topics and issues of interest in areas like machine learning, deep learning, data mining, big data analytics, and more. These discussions help in understanding the latest advancements and challenges, fostering collaboration, and driving innovation.

Finally I would like to congratulate Madonna College for taking this initiative. Their efforts in organizing this conference are commendable, and I wish them great success in their endeavour. This initiative not only highlights the importance of staying updated with the latest technological trends but also emphasizes the need for continuous learning and collaboration in today's fast-paced world.

Thanks & Regards,

Arun Prasad Arockiasamy TAG CTI Lead -AIA & CIS Talent Acquisition Group- North America



Rev. Dr. P. Arockia Michael Mercy HOD of Physics and Conference Chair Madonna Arts and Science College for Women

Acknowledgment

This International Conference of Madonna Arts and Science College has been brought together experts, thought leaders, passionate professionals, researchers and students from diverse institutions. Their hearted cooperation and dedication enabled us to publish this journal on time. On this auspicious occasion I would like to remember all of them with deep gratitude.

First and foremost, I express my deep sense of gratitude to Almighty God for His boundless inspiration and abundant blessings. I extend my sincere appreciation to Rev.Dr.Antony Pushpa Ranjitham, Superior General of CIC, Rev.Sr.Thanaseeli Sengol, Asst.Superior General, for their motivation and constant encouragement. I must express my very profound gratitude to Rev.Sr.Antony Maria Lilly CIC, Secretary, Madonna Arts and Science College for her support, valuable guidance and understanding throughout this conference. I am also grateful to Rev.Sr.Sahaya Mary CIC, Superior of Amali Convent for providing us with all the necessary facilities. I would like to express a deep sense of gratitude to Dr.Sahaya Rani, Principal, Madonna Arts and Science College for her unceasing encouragement, support and attention to edit and publish the journal.

It gives me immense pleasure to express my heartfelt gratitude to all our distinguished keynote speakers, presenters, and panelists for their valuable insights, expertise, and dedication to advancing knowledge in Commercialization of Emerging Materials and Technology for Sustainable Future. Your contributions are the heart and soul of this event.

I must take a moment to acknowledge the hard work and dedication of our organizing committee members from the departments of Mathematics, Physics, Computer Science, Commerce, Commerce with Computer Applications and Business Administration behind the scenes. Your hard work, attention to detail, and unwavering support have been crucial in bringing this conference to life. I also want to express our sincere appreciation to our sponsors and partners, who's generous support has enabled us to bring this event to life.

I would like to extend my hearty thanks to Bodhi Internal Journal and all delegates, Academic Officials and well-wishersfor their contributions in word and kind. I express my deepest gratitude to all those who have contributed directly or indirectly rendered their support to making this International Conference a reality.

P. Morcy

Rev.Dr.P.Arockia Michael Mercy Conference Chair



Editorial Note Bridging Innovation and Sustainability

As the world becoming more complex and catastrophic with devastating environmental depletion and degradation necessitates the urgent need for innovation in materials and technologies that promote sustainability.

An integrated team based approach to sustain the future with much of environment friendly, socially all inclusive mode of managing the innovative technology and materials coupled with accountability and responsible behavior would be the solution in safe guarding the future. The "International Multidisciplinary Conference on Commercialization of Emerging Materials and Technology for a Sustainable Future" is a pivotal gathering of minds aimed at addressing these very challenges. This conference brings to get her academicians, researchers, experts from diverse fields, scientists and technocrats—to explore how emerging materials and cutting-edge technologies can be harnessed to ensure a sustainable and prosperous future for all. Research and development are the critical break through that translate these innovations into commercially viable products and solutions. Commercialization is the bridge between discoveries and applications. Utilization of technologies and materials with the sense of responsibility and accountability to humanity would be the outcome of this conference.

The path forward would be to integration, collaboration, and support through concrete policies. This conference shed light on significant progress, but the challenges remain. The commercialization of emerging materials and technologies faces hurdles such as regulatory complexities, financial barriers, and the need for robust supply chains. As such, collaboration between various stakeholders—including researchers, industries, governments, and non-governmental organizations—is essential to overcome theposed challenges.

The articles presented offer a glimpse into the diverse range of technologies that are shaping the future. They highlight the significant strides being made in material innovations that reduce environmental footprints, enhance energy efficiency, and enable the use of sustainable alternative renewable energy resources in manufacturing processes.

Though the road to sustainable future is challenging, the tools and knowledge to navigate it are already within reach. The continuous effort to innovate, collaborate and to push forward the newly emerging materials and methods is the way possible to create a more sustainable world for generations to come

Jour Mhatthe

Dr. A. Savarimuthu Former Dean of Management studies St. Joseph's Institute of Mnagement, Trichy

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Aim & Objectives

Academic Excellence in research is sustained by promoting research support for young Scholars. Our Journal on Humanities, Arts and Science of research is motivating all aspects of encounters across disciplines and research fields in a multidisciplinary view, by assembling research groups and consequently projects, supporting publications with this inclination and organizing programmes. Internationalization of research work is the unit seeks to develop its scholarly profile in research through quality of publications. And visibility of research is creating sustainable platforms for research and publication, such as series of books; motivating dissemination of research results for people and society.

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ULTRA-HIGH SENSITIVE 1D PHOTONIC CRYSTAL BIOSENSOR FOR MALARIA DETECTION

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Abstract

Malaria remains a significant global health challenge, particularly in tropical regions, necessitating accurate and sensitive diagnostic methods. In this paper, we propose an ultra-high sensitivity biosensor based on a one-dimensional photonic crystal for malaria detection. The biosensor utilizes a defect layer filled with blood samples of varying refractive indices to detect minute changes in the optical properties of malaria-infected cells. Through theoretical analysis using the transfer matrix method, we demonstrate a high sensitivity of 902 nm/RIU (nanometres per refractive index unit) and excellent selectivity, making the biosensor a promising tool for malaria diagnosis. the findings offer valuable insights into the optical characteristics of malaria-infected cells and pave the way for improved diagnostic and therapeutic strategies. **Keywords**: bio sensors, bio – analytes, sensitivity, transfer matrix method, defect layer

Introduction

In the present world, Malaria[1] is one of the lifethreatening diseases. It is caused by parasites that are transmitted through the bites of infected mosquitoes. It is a greater public health issue, particularly in tropical regions like Africa of the world, where the transmission and death rates are high. When an infected mosquito bites a person, the parasites enter the bloodstream and travel to the liver, where they can mature and reproduce easily. After multiplying in the liver, it returns to the blood stream and starts to infect and destroy red blood cells, causing the various symptoms.

Malaria [2] can progress rapidly and lead to severe complications, especially if caused by falciparum. Complications are severe anemia, cerebral malaria, respiratory distress, organ failure, and finally death. In this high population, such as young children, pregnant women, and individuals with weakened immune systems, they are at a higher risk of severe malaria and death. In the human host, the malaria parasite goes through three stages: the Ring Stage, where it invades red blood cells; the Trophozoite Stage, where it grows and becomes more active; and the Schizont Stage, where it multiplies, forming new parasites that continue the infection cycle. Despite significant efforts to control and eliminate malaria, it remains a major global health challenge, with an estimated 229 million cases and over 400,000 deaths reported annually, mostly in sub-Saharan Africa. Understanding these initial stages is essential to diagnosing the disease and treating it effectively. Ongoing research into new prevention strategies, treatments, and vaccines is essential to reduce the burden of malaria and ultimately eradicate the disease.

Bio Sensors [3] are having many applications in the medical field, like environmental monitoring, healthcare, and pharmaceuticals. Photonic crystalbased biosensors have emerged as highly sensitive devices for the analysis of bioanalyses, offering significant advancements in various fields, including
disease diagnostics. Their contribution is particularly noteworthy in the fight against malaria, a disease that remains a major global health challenge. Among the array of available sensors, photonic crystal-based biosensors stand out for their enhanced efficiency in predicting the stage of malaria, thereby playing a crucial role in early detection and effective disease management.

These sensors operate by exploiting the unique optical properties of photonic crystals, which can be precisely engineered to interact with specific biological markers associated with malaria. This interaction results in measurable changes in the optical properties of the sensor, allowing for the accurate and early detection of the disease at various stages. The high sensitivity and specificity of photonic crystal-based biosensors make them invaluable tools in the ongoing effort to eradicate malaria, as they enable timely and accurate diagnosis, which is essential for effective treatment and control of the disease.

Theory

In our study, we utilized two dielectric materials, Silicon and Porous Silicon, arranged in a periodic structure to form a photonic crystal (PC). These materials, characterized by their differing refractive indices, n_h and n_l , are organized in a periodic sequence. At the core of this photonic crystal structure, we introduced a cavity layer, which is filled with various blood samples possessing distinct refractive indices. This cavity layer acts as a defect layer within the periodic structure.

The specific arrangement of the photonic crystal is denoted as (AB)^NC(AB)^N, where 'A' and 'B' represent the alternating layers of Silicon and Porous Silicon, and 'C' denotes the central cavity layer. When incident light interacts with this photonic crystal, it is modulated by the periodic structure, leading to the formation of a photonic band gap. The presence of the cavity layer introduces a localized defect within this band gap.

By filling the cavity layer with different blood samples, both normal and affected. we observe

variations in the optical properties of the system. These variations cause specific reflections and transmissions within the cavity walls, ultimately resulting in the emergence of a defect mode within the transmission spectrum. This defect mode, which appears at the center of the band gap, provides crucial information about the refractive indices of the blood samples, thereby enhancing the sensitivity and specificity of the photonic crystal-based biosensor in detecting and analyzing the samples.

This optimized configuration of the photonic crystal demonstrates its potential as a powerful tool for biomedical applications, particularly in the precise detection and analysis of blood samples in diagnostic procedures.



Our analysis reveals distinct transmission spectra for Malaria-infected blood cells at various stages, contrasted with normal blood cells as reference layers. transmission spectra show variations The corresponding to refractive indices of 1.402, 1.395, 1.383, and 1.373, linked to different cavity layer thicknesses. These results suggest that the optical properties of Malaria-infected blood cells significantly change as the disease progresses, likely due to alterations in cellular morphology and biochemical composition.

The detection of defect modes in the transmission spectra indicates structural anomalies within the infected cells, offering valuable insights into their internal structure. This finding enhances the potential for developing improved diagnostic techniques for Malaria.

Overall, our study underscores the effectiveness of the transfer matrix method in analyzing the optical characteristics of Malaria-infected blood cells. By accurately characterizing transmission spectra and defect modes, this approach provides a deeper understanding of disease progression and opens new possibilities for advancing diagnostic and therapeutic strategies for Malaria.

$$\lambda_B = 4 * n * d \tag{1}$$

where n and d represent the refractive index and thickness of the particular layer.

Transfer matrix method [11] is used in the theoretical formulation and it analyzes the interaction between plane electromagnetic wave and our designed structure. The proposed design can be explained in terms of a single matrix form, given as

$$M = \begin{pmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{pmatrix}$$
(2)

Here, m_{11} , m_{12} , m_{21} , m_{22} are the transfer matrix elements, Total matrix elements in the photonic crystal system is expressed as,

$$M_{total} = (M_A M_B)^N \tag{3}$$

According to the Transfer Matrix Method (TMM)[12], the characteristic matrix which defines the interaction of the incident electromagnetic radiation with the photonic crystal is given by

$$\mathbf{M}_{i} = \prod_{i=1}^{k} \begin{bmatrix} \cos \delta_{i} & \frac{j}{n_{i}} \sin \delta_{i} \\ jn_{i} \sin \delta_{i} & \cos \delta_{i} \end{bmatrix} = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix}$$
(4)

where the phase difference is given by

$$\delta_{i} = \left(\frac{2\pi}{\lambda}\right) n_{i} d_{i} \cos \theta_{i}$$
⁽⁵⁾

in which ni, di and θ i are the refractive index, thickness of ith layer in the system and angle of incidence at the interface.

Using the total matrix, the Reflectance (R) and Transmittance (T) of the system can be estimated by

$$\mathbf{R} = |\mathbf{r}|^{2}, \mathbf{r} = \frac{n_{1}m_{11} + n_{1}n_{s}m_{12} - m_{21} - n_{s}m_{22}}{n_{1}m_{11} + n_{1}n_{s}m_{12} + m_{21} - n_{s}m_{22}}$$
(6)
$$\mathbf{T} = \mathbf{Re}\left(\frac{n_{s}}{n_{1}}\right)|\mathbf{t}|^{2}, \mathbf{t} = \frac{2n_{1}}{n_{1}m_{11} + n_{1}n_{s}m_{12} + m_{21} - n_{s}m_{22}}$$
(7)

where n1 and ns are the refractive indices of first and last layers of the system.

Result and Discussion

Our analysis reveals distinct transmission spectra for Malaria-infected blood cells at various stages compared to normal blood cells used as reference layers. The observed transmission spectra exhibit variations corresponding to the refractive indices of biomolecules within the blood samples. Specifically, we identified transmittance for four different cavity layer thicknesses, corresponding to refractive indices of 1.402, 1.395, 1.383, and 1.373. These findings suggest that the optical properties of Malaria-infected blood cells undergo significant alterations as the disease progresses, likely due to changes in cellular morphology and biochemical composition.

Moreover, the presence of defect modes in the transmission spectra indicates structural irregularities or anomalies within the Malaria-infected blood cells. These defect modes provide valuable insights into the internal structure and composition of the cells, potentially aiding in the development of more effective diagnostic techniques for Malaria.

Overall, our study underscores the utility of the transfer matrix method in elucidating the optical characteristics of Malaria-infected blood cells. By accurately characterizing the transmission spectra and defect modes, this approach offers a deeper understanding of disease progression and presents potential avenues for improving diagnostic and therapeutic strategies for Malaria.

Table 1: Refractive index of Normal and affected
Cells

S.No	Refractive Index of different cells				
1	1 402	Normal Red Blood			
1.	1.402	cell			
2	1 305	Infected Cell ring			
۷.	1.395	Stage			
2	1 292	Infected Cell			
5.	1.365	trophozoites stage			
4	1 373	Infected Cell Schizont			
4.	1.375	stage			

In this analysis, we observe the transmittance bandgap and the corresponding defect mode for both normal and Malaria-affected cells. The thicknesses of the higher and lower layers are denoted as d_a and d_b , respectively, with $d_a = d_b = 55$ nm. The thickness of the defect layer is $d_c = 98$ nm. This configuration allows us to detect shifts in the defect modes.

Our analysis reveals a significant shift in defect modes between normal and Malaria-affected cells. Specifically, as the thickness of the defect layer increases, there is a corresponding shift in the defect modes toward longer wavelengths.



Fig 1: Transmission Spectrum Defect Modes for Normal and Malaria-Affected Blood Cells



Fig 2: Defect mode of normal and malaria affected cells in a single graphical representation



Fig 3: Defect mode of different refractive index cells with the pointed dates

Sensitivity

The difference between the changes of the resonance wavelength value $(\Delta \lambda)$ of the different blood samples to the change of the corresponding refractive index (Δn) of the sample is known as sensitivity(S),

 $S = \Delta \lambda / \Delta n \text{ (nm/[RIU]) [13]}$

 Table 2: Refractive index of blood cells and the corresponding Sensitivity

S.No	Name of the Cell	Refractive index	Resonant Wavelength (nm)	Sensitivity (nm/RIU)
1.	Normal	1.402	612.64	-
2.	Ring Stage	1.395	611.53	158.57
3.	Trophozoites	1.383	609.64	155
4.	Schizont Stage	1.373	600.62	902

The sensitivity which is obtained by putting the values of wavelength shift and the change in refractive index is 902nm/RIU. The wavelength shift is not showing much differences in the above fig 3. So the sensitivity obtained is also similar for those different refractive index changes. From the Fig 3 is clear that the wavelength pick is shifted towards lower values by increasing the refractive index and keeping the cavity layer thickness constant.

Q Factor

A Quality factor measures the selectivity level of the sensor. So, the desired resonant peak should be as sharp as possible to enhance the quality factor. The Quality factor is calculated by using this formula,

 $Q = \lambda (resonant)$ / $\Delta\lambda (FWHM)$ [14]

Table 3: Refractive index, wavelength and thequality factor in different stages of Malaria

S.No	Refractive index	Resonant Wavelength (nm)	FWHM	Quality Factor
1.	1.402	612.738	0.000082	$7.47 * 10^4$
2.	1.395	611.533	0.000085	7.3* 10 ⁴
3.	1.383	609.64	0.000079	$7.7 * 10^4$
4.	1.373	600.619	0.000068	8.8 * 10^4

The proposed malaria biosensor is compared for its sensitivity with the previously published similar biosensing designs in table 3. From the comparison it is the evident that the proposed malaria biosensor has better sensitivity compared to all the compared biosensors.

 Table 4: Comparison of sensitivity of the proposed design with that of the other designs

Design	Sensitivity (nm/RIU)
Photonic Crystals for Malaria	151
Detection (2018) [15]	151
Malaria biosensors with ultra-	771
sensitivity (2020)[16]	//1
Label – Free Plasmonic	
immunosensing for plasmodium	278
in a whole blood lysate	578
(2014)[17]	
Biosensor Application of 1D	
photonic Crystal for Malaria	495.73
Diagnosis (2020)[18]	
Proposed Malaria Biosensor	902
(This work)	902

Conclusion

The proposed one-dimensional photonic crystal biosensor offers ultra-high sensitivity and selectivity for malaria detection. Compared to similar sensors, the proposed sensor offers higher sensitivity and enhanced efficiency. The findings provide valuable insights into the optical characteristics of malariainfected cells and underscore the potential of biosensing technology in improving malaria diagnosis and management. Future research directions include further optimization of the biosensor design and validation in clinical settings.

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DUAL-BAND INVERTED U SLOTTED MICROSTRIP PATCH ANTENNA FOR S-BAND AND C-BAND APPLICATIONS

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Abstract

A dual-band inverted U-slot microstrip patch antenna has been theoretically designed and analysed using HFSS software. The proposed designs of the antenna operate in the 5 GHz band. The radiating patch is fabricated on the FR-4 substrate, which has a dielectric constant of 4.4. The microstrip line feeding technique connects the antenna with a 50 Ω impedance. The theoretically designed U-slot antenna results dual band frequencies for various S band and C band applications. **Keywords**: microstrip patch antenna, line feed, inverted u- slot, dual-band

Introduction

As wireless communication devices become more complex and versatile. Microstrip antennas [1] with multiband or ultra-wideband operation are becoming increasingly important for wireless communication devices due to their low cost, low profile, and ease of fabrication. One common approach to achieving multiband operation is to modify a basic single band rectangular patch antenna by introducing slots in the patch [2-5]. The shapes and positions of the slots can be used to tune the resonance frequencies. Overall, the use of slot geometry is a powerful tool for achieving multiband operation in microstrip antennas. When slots are cut into the patch, the current path is changed, resulting in a modified surface current flow.

One effective approach for achieving multiband operation is the use of U-slot patch geometry [6]. Instead of the patch antenna's multiband features, the U-slot patch antenna was once thought to be a way to achieve wideband qualities. However, later studies have demonstrated that the wideband feature may be changed to a multiband characteristic by strategically positioning U-slots to disturb the patch's surface current flow [7,8]. The radiation pattern, gain, and impedance matching can be adjusted to suit the needs of the society. Additionally, by adjusting the U-slot, it is possible to change both the polarization and the band characteristics. This makes the U-slot patch antenna a versatile option for achieving desired performance characteristics in wireless communication devices [9-11].

In this work the size of the microstrip patch antenna is decreased by incorporating an inverted Ushaped slot into the patch. This approach can be customized to suit specific requirements by varying the size and shape of the slot. The optimized dimensions of the slots, patch, and substrate can be determined through simulation. The inverted U-slot patch geometry used in this work offers a flexible design. The flexibility and customization offered by the inverted U-slot patch antenna make it a versatile choice for various wireless communication applications, including dual-bandoperation. It is a desirable option for portable and tiny devices due to its inexpensive price, low profile, and simplicity of production.

Antenna Design

Three components typically make up the geometry of a rectangular feed patch antenna: a ground plane, a

substrate, and the patch design. Usually, mathematical equations are used to compute the antenna's dimensions. The following formula is typically used to determine patch antenna dimensions,

The width W of the Patch antenna is given as,

$$W = \frac{c}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}}$$

The effective dielectric constant is,

$$\varepsilon_{\text{reff}} = \frac{\varepsilon_{\text{r}}+1}{2} + \frac{\varepsilon_{\text{r}}-1}{2} \left[1 + 12\frac{\text{h}}{\text{W}}\right]^{-\frac{1}{2}}$$

The extended incremental length of the patch is given by,

$$\Delta L = \frac{(\varepsilon_{\text{reff}} + 0.3) \left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{\text{reff}} - 0.258) \left(\frac{W}{h} + 0.8\right)}$$

Effective length of the patch is,

$$L_{\rm eff} = \frac{c}{2 \times f_r \times \sqrt{\epsilon_{\rm reff}}}$$

The length of patch is calculated as,

 $L = L_{\rm eff} - 2\Delta L$

FR4 epoxy material is a commonly used substrate material for printed circuit board (PCB) applications, including patch antennas. It has a relatively high dielectric constant of 4.4, which allows for a compact antenna design, and a low loss tangent of 0.02, which helps to minimize energy loss in the substrate. The thickness of the substrate is an important parameter in the design of the patch antenna, as it affects the resonant frequency and bandwidth of the antenna. A thinner substrate will result in a higher resonant frequency and narrower bandwidth, while a thicker substrate will result in a lower resonant frequency and wider bandwidth. In this case, the substrate thickness is 1mm, which is a common value for PCB applications. The antenna dimensions and feeding mechanism can be designed to achieve the desired resonant frequency and bandwidth for the given substrate thickness and material properties. Initially, a basic square shaped patch is described then it is converted into Invert U-slotted structure. Design of the rectangular patch with line feeding is shown in Fig.1

The calculated parameters of the designed patch antenna are given in Table 1.

Parameters	Ls	$\mathbf{W}_{\mathbf{S}}$	L _P	W_{P}	$\mathbf{L}_{\mathbf{f}}$	$\mathbf{W}_{\mathbf{f}}$	\mathbf{L}_{sl}	\mathbf{W}_{sl}
Values(mm)	20.042	24.3	14.042	18.3	3.0	1.5	14.0	0.5



Fig.1 The Proposed patch antenna

An Inverted U-slot patch antenna can be formed by cutting two rectangular slots on a rectangular patch, with the top edges of the two slots connected by a narrow strip of the patch material, forming the "inverted U" shape. The Inverted U-slot disrupts the current flow in the patch, resulting in multiple resonant frequencies and broadening the bandwidth of the antenna. The two rectangular slots are typically located symmetrically on either side of the centerline of the patch, and their dimensions and placement can be optimized to achieve the desired performance characteristics, such as multiband operation or improved radiation pattern. The dimensions of the geometry are given in the Table 1. Here the whole system is fed by microstrip line feeding technique. The area of the proposed antenna is 20.042 X 24.3 X 1 mm^{3} .

Results and Discussion

HFSS 13.0 is a powerful electromagnetic simulation software that can be used to analyze and optimize the performance of patch antennas. The simulation results obtained from HFSS can provide valuable information on the antenna's characteristics, such as reflection coefficient, VSWR, radiation pattern, gain, and directivity. The reflection coefficient is a measure of the amount of power reflected by the antenna at a given frequency. A low reflection coefficient indicates that the antenna is well-matched to the transmission line, and more power is being radiated by the antenna.

The return loss plot of the antennas is illustrated in Figure 3. Each sharp dip of the curve crossing -10dB is representing a frequency band. The parameter S11 is also known as reflection coefficient, generally denoted by Γ . It is a complex number having magnitude and phase angle [3]. here the proposed patch antenna has the dual band frequencies of -14.47 dB at 2.3 GHz and -26.14 dB at 4.9 GHz of the reflection coefficient values.



Fig. 2 Return loss of the proposed an tenna

VSWR (Voltage Standing Wave Ratio) is another measure of the antenna's matching performance. A low VSWR indicates that the antenna is well-matched to the transmission line and more power is being radiated by the antenna.

The following figure 3 represents the VSWR of the proposed patch antenna.



Fig. 3 Voltage standing wave ratio of the proposed antenna

The E-plane and H-plane radiation patterns describe the shape and directionality of the electromagnetic field radiated by the antenna in the horizontal and vertical planes, respectively. The radiation pattern can be analyzed to determine the directionality and gain of the antenna. The Fig 5. Shows the result for the antenna radiation pattern. The result shows that, designed antenna deliberates excellent performance.



Fig.4 Radiation pattern of the proposed antenna

The figures 5 and 6 describes the directivity and the gain. The gain is a measure of the amount of power radiated by the antenna in a particular direction compared to a reference antenna. The directivity is a measure of the antenna's ability to radiate power in a particular direction compared to an ideal isotropic radiator. Gain is always less than the directivity because most of the antennas have some internal losses. Also, the gain is a practical and measurable term. The proposed patch antenna gives the 1.31dB gain at 4.9GHz and 5.20 dB Directivity in the direction.



Fig. 5 Gain of the proposed antenna

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Fig. 6 Directivity of the proposed antenna

The following table 2 is displays the comparison values of the designed patch antenna.

Parameters	Without	tUslot	WithUslot					
	Frequency (GHz)	S11(dB)	Frequency (GHz)	S11(dB)				
Reflection								
coefficient			2.3000	-14.4711				
	4.9	-9.2929	4.9000	-26.1467				

Table 2. the designed patch antenna values with and without II SI OT

The simulation results obtained from HFSS can provide valuable insights into the performance of the Inverted U-slot patch antenna, allowing designers to optimize the antenna's characteristics for a given application.

Conclusion

The Inverted U-slotted patch antenna described in this article has enabled the antenna to operate in two different frequency bands, resulting in improved impedance matching, bandwidth, gain, radiation pattern, and polarization. The HFSS 13.0 simulation results show improved reflection coefficient and VSWR, ensuring good matching. The antenna also exhibits directional radiation patterns with high gain and directivity. Overall, the Inverted U-slotted patch antenna is a promising design for applications in the S-Band and C- Band frequency ranges, offering improved performance and dual-band operation. The antenna's low cost, low profile, and ease of fabrication make it an attractive choice for portable and wireless communication devices.

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COMPUTATIONAL OPTIMIZATION OF DEVICE STRUCTURE FOR RBGEI₃-BASED PEROVSKITE SOLAR CELLS USING SCAPS - 1D

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Abstract

Inorganic halide perovskite solar cells have garnered significant attention due to their high efficiency and cost-effective fabrication. Utilizing the SCAPS-1D framework for design, simulation, and optimization, these cells benefit from novel charge transport materials and perovskite compositions to assess their efficiency and performance. Several parameters exert a crucial influence on the solar cell's short-circuit current density, open-circuit voltage, fill factor, and overall efficiency. In this study, we conducted modeling and analysis on perovskite solar cells based on RbGeI3, employing different electron transport layers (ETL) and hole transport layers (HTL). Specifically, the use of WS2 as the ETL and CuSCN as the HTL resulted in improved photo-conversion efficiency. The proposed device configuration comprises FTO/WS2/RbGeI3/CuSCN/Ni. We thoroughly investigated factors such as absorber layer thickness, and the work function of the back metal contact. Notably, we achieved an enhanced power conversion efficiency (PCE) of 19.75% for our suggested structure, employing Nickel with a work function of 5.15 eV as the back metal contact.

Keywords: perovskite solar cells, RbGeI3, SCAPS-1D, charge transport layer optimization

Introduction

A renewable and clean energy source, like solar energy, is desperately needed, given the rising global energy demand and the steadily diminishing conventional energy resources. As a result, different generations of solar cells have emerged in an attempt to meet energy demands. Perovskite solar cells (PSCs), which belong to the category of 3rd generation solar cells, have gained significant attention in recent years due to their potential for highefficiency and low-cost photovoltaics [1,2]. The choice of inorganic compound especially RbGeI₃ perovskite [3], may have been made to enhance the stability and performance of the solar cells, as inorganic perovskites tend to have better long-term stability compared to their organic-inorganic hybrid counterparts.

In order to examine the impact of various ETLs and HTLs on the performance of RbGeI₃ PSCs,

researchers use computer modeling approaches to replicate the device characteristics. The ETL is responsible for facilitating the transport of electrons, while the HTL is responsible for facilitating the transport of holes within the solar cell structure. By investigating various combinations of ETLs and HTLs, the researchers could optimize the charge transport and recombination processes within the solar cell, ultimately aiming to improve its power conversion efficiency (PCE).

The study's findings may have shed light on the best combinations of ETL and HTL materials for the RbGeI₃ PSCs, helping to pave the way for the development of efficient and stable all-inorganic perovskite solar cells. These findings could contribute to advancements in renewable energy technology and further our understanding of perovskite solar cells' physics and engineering.

Methodology

The Solar Cell Capacitance Simulator (SCAPS) established by University of Gent is implemented in this research [4]. The SCAPS software is one dimensional simulation program that computes energy bands, concentrations, J-V characteristics, ac characteristics (C (Capacitance) and G (Conductance) as functions of V and f) and spectral response (QE) using the three basic semiconductor equations comprise of the continuity equations for hole and electron and Poisson's equation, as shown in eqn. 1-3 under the steady-state conditions [5].

$$\frac{dn_p}{dt} = G_n - \frac{n_p - n_{p0}}{\tau_n} + n_p \mu_n \frac{d\xi}{dx} + \mu_n \xi \frac{dn_p}{dx} + D_n \frac{d^2 n_p}{dx^2}$$
(1)

$$\frac{dp_n}{dt} = G_p - \frac{p_n - p_{n0}}{\tau_p} + p_n \mu_p \frac{d\xi}{dx} + \mu_p \xi \frac{dp_n}{dx} + D_p \frac{d^2 p_n}{dx^2}$$
(2)

$$\frac{d}{dx}\left(-\epsilon(x)\frac{d\psi}{dx}\right) = q[p(x) - n(x) + N_D^+(x) - N_A^-(x) + p_t(x) - n_t(x)]$$
(3)

where G_n , G_p indicates the generation rate of electrons and holes, μ_n and μ_p are electron and hole mobilities, ξ is the electric field, D is diffusion coefficient, τ is the life time of electrons and holes, ϵ is permittivity, ψ is electrostatic potential, q is electron charge, $p_t(x)$ and $n_t(x)$ are the concentrations of trapped holes and electrons, N_D and N_A are shallow donor and acceptor concentrations.

Device Structure and Parameters

Figure 1 shows the schematic diagram of th proposed perovskite solar cell. We used the following

arrangement to perform the simulation. The material parameters of FTO, RbGeI₃ absorber layer, various ETLs and HTLs are listed in Table 1 and 2 [6]. Parameters such as thickness, band gap energy (Eg), electron affinity (χ), relative permittivity (ϵ_r), effective density of states of conduction band (N_C), effective density of states of valence band (N_V), mobility of electron (μ_n), mobility of hole (μ_p), shallow donor density (N_D) and shallow acceptor density (N_A) are essential for the simulation of PSC.

Throughout the simulations, for all layers, the thermal velocity of charge carriers (electrons and holes) is kept constant at 10^7 cm/s, the defect type is set as neutral, and the energy distribution is Gaussian. For the bulk of the layers, total defect density is set at Nt = 10^{15} cm⁻³, the effective mass of the electrons and holes and the characteristic energy along with the optical capture of electrons and holes are auto-fixed by SCAPS-1D software. The overall defect parameters are listed in table 3.



Figure 1. Schematic diagram of the designed perovskite solar cell

Material Properties	FTO	ETL				
Wrater fai i Toper ties	FIU	TiO ₂	ZnO	WS ₂	IGZO	
Thickness (nm)	500	50	50	50	50	
Bandgap (eV)	3.5	3.2	1.55	1.8	3.05	
Electron affinity (eV)	4.0	3.9	3.9	3.95	4.16	
Permittivity (E _r)	9	9	10	13.6	10	
CB eff. Density of states, $N_C(1/cm^3)$	2E+18	2E+18	2.1E+18	1E+18	5E+18	

Table 1. Input parameters of FTO and various ETLs for optimization

VB eff. Density of states, $N_V(1/cm^3)$	1.8E+19	1.8E+19	1.8E+19	2.4E+19	5E+18
Electron mobility (cm^2/V_s)	20	100	200	100	15
Hole mobility (cm^2/V_s)	10	25	25	100	0.1
Shallow uniform donor density (1/cm ³)	1E+15	1E+16	1E+15	1E+18	1E+17
Shallow uniform acceptor density (1/cm ³)	0	0	0	0	0

Table 2. Input parameters of absorber layer and various HTLs for optimization

Material	DhCaL	hGeI ₄ HTL			
Properties	KDGel3	NiO	Cu ₂ O	CuI	CuSCN
Thickness (nm)	1500	50	50	70	70
Bandgap (eV)	1.31	3.8	2.2	3.1	3.4
Electron affinity	2.0	1.46	2.2	2.1	17
(eV)	5.9	1.40	5.2	2.1	1./
Permittivity	23.01	10.7	7.11	6.5	10
CB eff. Density of					
states, N _C	1.4E+19	2.8E+19	2.02E+17	2.5E+19	1.7E+19
$(1/cm^3)$					
VB eff. Density of					
states, N _V	2.8E+19	1.1E+19	1.1E+19	2.5E+19	2.1E+21
$(1/cm^3)$					
Electron mobility	28.6	12	200	100	0.0002
(cm^2/V_S)	28.0	12	200	100	0.0002
Hole mobility	27.3	28	80	43.0	0.2
(cm^2/V_S)	21.5	2.0	80	43.9	0.2
Shallow uniform					
donor density	1E+9	0	0	0	0
$(1/cm^3)$					
Shallow uniform					
acceptor density	1E+9	1E+19	1E+18	1E+18	1E+18
$(1/cm^3)$					

Table 3. Defect parameters of ETL, HTL, absorber layer and their interfacial layers

Defect Parameters	ETL	HTL	Absorber Layer	FTO/ETL Interface	ETL/Absorber Interface	Absorber/HTL Interface
Defect type	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Capture cross section of electrons (1/cm ³)	1E-15	1E-15	1E-15	1E-19	1E-19	1E-19
Capture cross section of holes (1/cm ³)	1E-15	1E-15	1E-15	1E-19	1E-19	1E-19

Energetic distribution	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian	Gaussian
Reference for the defect energy level (E _t)	Ev	Ev	Ev	Ev	Ev	Ev
Characteristic energy (eV)	0.1	0.1	0.1	0.1	0.1	0.1
Total defect density	1E+15	1E+15	1E+16	1E+11	1E+11	1E+11

Results and Discussion

Effect of Different ETLs and HTLs on Cell Performance

The importance of a well-balanced system for satisfactory photovoltaic (solar cell) performance is analysed. The balance between electron and hole diffusion is crucial for efficient charge transport in the solar cell. The focus of the study is on perovskite solar cells (PSCs) based on the material RbGeI₃. The choice of ETL and HTL is critical for balancing the charge transport and improving the overall efficiency of the perovskite solar cell. The study involves varying different Electron Transport Layers (ETLs) while keeping other factors constant. Photoelectric performance is measured and compared for each ETL. Figure 2(a) and (b) likely show the photoelectric performance curves for different ETLs. From figure 3(a) and (b), it is evident that the solar cell with WS₂ as ETL and CuSCN as HTL improves the PCE of the cell upto 17.29%, which is higher compared with other ETLs and HTLs.



Figure 2. (a) JV characteristic graph and (b) the variation of fill factor, efficiency of solar cell w.r.to different ETLs



Figure 3. (a) JV characteristic graph and (b) the variation of fill factor, efficiency of solar cell w.r.to different HTLs

Effect of absorber layer thickness on cell performance



Figure 4. (a) JV and (b) efficiency variation graphs of the PSC for different absorber layer thickness

The performance of the device is greatly enhanced by taking into account all of the absorber's characteristics, including thickness, band gap, doping concentration, and defect. The simulation was run with varied thicknesses ranging from 500 nm to 1000 nm while maintaining the same values for all other parameters as in Table 1 to explore the impact of RbGeI₃ absorber layer thickness. The JV-curve generated by modelling indicates that when absorber thickness increases from 500 nm to 1000 nm, as illustrated in Figure 4(a).

From figure 4(b), the variation of photo conversion efficiency with respect to the variation in perovskite layer thickness from 500 nm to 1000 nm suggests that, the efficiency of the solar cell increases when the thickness is increased from 500 nm to 750 nm and beyond that, it starts decreasing till 1000 nm. Hence, 750 nm is fixed as optimal thickness of the perovskite layer and the efficiency obtained is 18.1%

Effect of Back Metal Work Function on Cell Performance

The main obstacle that is hindering PSC to commercialize is high cost and low thermal stability of back contact. It is required to have a suitable work function material as back contact so that it may yield reasonable built in voltage. To get a suitable back contact for our device, simulation was done by varying back contact work function using metals such as silver(Ag), iron(Fe), copper(Cu), cobalt(C), gold(Au) and nickel(Ni) where their work functions are listed in table 3. From the simulation, it was observed from figure 6 that from Ag to Au, PCE increased from 20.64% to 24.02% and almost similar values of photovoltaic parameters were obtained for both Au and Ni as back contacts. Nickel is chosen as optimal back electrode because of its cost effectiveness and availability.



Figure 5. Variation of PCE of the solar cell w.r.to different back metal work function

 Table 4. Various back metal electrodes and their work function

Back metal electrode	Silver (Ag)	Iron (Fe)	Copper (Cu)	Cobalt (C)	Gold (Au)	Nickel (Ni)
Work function (eV)	4.6	4.8	4.9	5	5.1	5.15

Optimized device structure

Figure 6(a) demonstrates that after all these improvements that have been carried out, the optimized perovskite solar cell with the device structure of FTO/WS₂/ RbGeI₃/CuSCN/Ni provides enhanced photovoltaic parameters of V_{OC} =0.75 V, J_{SC}=33.67 mA/cm², FF=77.46% and PCE=24.02% have been obtained. From figure 6(b), the proposed structure has improved quantum efficiency in visible region. Table 5 shows a comparison of the performance of the proposed PSC to the other previous works from various literature.



Figure 6. (a) J-V analysis and (b) QE analysis of the optimized solar cell

proposed worth with previously published and ele						
Device Structure	PCE (%)	Reference				
FTO/TiO ₂ / RbGeI ₃ /NiO/Ag	9.89	[6]				
FTO/TiO ₂ / RbGeI ₃ /CuSCN/Ag	16.37	[7]				
FTO/WS ₂ / RbGeI ₃ /CuSCN/Ni	19.75	Present work				

Table 5. A comparison of the performance of proposed work with previously published articles

Conclusion

This study focused on modeling and analyzing an inorganic $RbGeI_3$ perovskite solar cell (PSCs) with

different Electron Transport Layers (ETLs) and Hole Transport Layers (HTLs). Due to optimum performance, the device's structure FTO/WS₂/ RbGeI₃/CuSCN/Ni has been proposed. At 750 nm perovskite thickness, PCE is the highest. Back metal contact optimization analysis shows almost similar efficiencies for both gold(=5.1eV)and nickel(=5.15eV). The optimum FTO/WS₂/ RbGeI₃/ CuSCN/Ni device has Voc = 0.75 V, Jsc = 33.67 mA/cm^2 , FF = 77.46%, and PCE = 19.75%. This study indicates that the proposed device structure with RbGeI₃ as the perovskite material and nickel as the back contact can achieve a relatively high PCE of 19.75%, making it a promising candidate for efficient, eco-friendly and cost-effective perovskite solar cells.

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BIO SYNTHESIS OF ZNO NANO PARTICLES USING SYZYGIUM AROMATICUM

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Abstract

Biosynthesized Zno nanoparticles Were Prepared by Sol-gel method and calcined at 400°C for 2hrs. The Synthesized powders were Characterized UV- ViS, XRD, SEM, FT-IR. Bacteria Killing effect was determined by means of inactivation of E. coli bacteria. Biosynthesized Zno has an effect on inhibition of anatase Crystal growth, led to the enlargement of the Composite Specific surface area exhibits highest E. coli inactivation efficiency. Keywords: biosynthesized Zno, XRD, FT-IR, antibacterial activity

Introduction

The Photooxidation process Zno has a wide study in the technique of pollution abatement. The applications of Zno are Limited because of the need of UV as an exciton Source. so, we used same of the techniques to solve this problem by biosynthesized or doping that modifies the catalytic property with the help of Plant extracts includes Syzygium aromaticum. The biosynthesis of Zno with Plant Syzygium. aromaticum enhances the photocatalytic activity.

The antibacterial activity Of Visible light responsive photocatalysts has been reported several groups [1-3] In this study, the effect of biosynthesized Syzygium aromaticum extract doped in Zno Photo catalyst on zno Crystallite Size, Surface morphology. FT-IR and antibacterial activity Were tested.

Experimental

Fig1 Shows the synthesis procedure for the Sol-gel. Preparation given in the following way: The Zinc acetate dihydrate was dissolved in water and stirred and a drop of Sodium hydroxide was added to the above solution, thus NaoH Varies the pH of the Solution and it maintains to pH of 10. The Solution Obtain is kept under Stirring for nearly 20hrs to get the Viscous dispersion of Zno colloidal Solution. The colloidal solution is centrifuged and dried in air and then heat treated at 400°C for 1hr. [4]. Also, the Plant extract from Syzygium aromaticum were added to the First Step for biosynthesized Zno nanoparticles.

The Crystallinity Of biosynthesized Zno nanoparticles was determined by X-ray diffraction (XRD) and the Surface morphology was observed Using Scanning electron microscope (SEM). Spectroscopic analysis Was performed by using UV-Vis Spectro Photo Meter.

The hydroxyI Content of the Sample was Investigated by FT-IR analysis spectrometer. The antibacterial activity was studied by Colony forming units per millimeter, after Incubation.



Fig. 1. Preparation steps of biologically synthesized ZnO nanoparticles by sol-gel method

Results

XRD patterns of Pure and doped Zno Nano particles for PH = 10 Annealed at 400C are Shown in the Figures (2a,2b) Particle Size of the biosynthesized Sample were calculated by using the Debye Scherrer's Formula [5] for the full width at half maximum (FWHM) and are found to be 3.7 nm for Pure Zno and 2.60 nm for Syzygium aromaticum respectively.







Fig. 2B. Syzygium aromaticum



Fig. 3. UV visible Spectra of pure zno & Syzium aromaticun

Fig [3] Shows the UV- Visible. Spectra of pure and doped Zno It was Observed the direct Optical band gap.

Values 3.38ev and 3.45 ev For the pure and Syzygium aromaticum-Zno Corresponding with Crystallite Sizes 3.768 and 2.650 nm[6]. The Smaller Crystalline Sizes have higher band gap may be Caused by Quantum Size effects.

It can be seen from the figures of UV-vis the peak Position blue shifts for pure Zno nanoparticles and red shifts for biosynthesized Zno





Fig.4b. FT-IR Spectra of Syzygiumaromaticum

The FT-IR Spectra of the pure and herbal extract doped Zno Show's the Increase in intensity of peak, the bread band at 2350-3500cm⁻¹ are assigned to O-H for absorbed water molecules and Zno [15]. This

Suggest that the hydroxyl content increases. with respect to the dopant into the Sol [8,9]

Sem Image

The increase in photocatalytic activity with doping Zno is related to Shift in Optical activity absorption of the Catalyst In Visible region. The Zno absorbs only UV energy whereas the biosynthesized Zno absorbs UV and. portion of Visible energy and hence there is increase in photo catalytic activity.

The presence of metal ions on the Surface of the photo catalyst particles. improves the rate of electron transfer to o_2 and consequently has a beneficial effect on the photo - Oxidation rate of organic Species. The more number of Pores increases the hydroxyl content.



Fig.5a. Sem Image of Pure Zno



Fig.5b. Sem Image of Syzygium aromaticum

Maximum Inhibitory Concentration determined by micro broth dilution was assay technique [10] Overnight Culture. Of each test Organism was seeded on petriplates containing Muller Hinton Agar medium and the partially porified Fraction was placed into the wells at Concentration ranged from 100 to 500 µg mL⁻^{1..} The plate was in cubed at 30°C for 48-72 hrs. Minimum inhibitory Concentration was determined after 18hrs for the bacteria shown in fig 6[a, b]

The antimicrobial potential of the. Samples (pure and biosynthesized zno) were tested against the growth of gram-Negative test, pathogens. Among the pathogens. Syzygium Aromaticum has maximum Inhibition Of 22 mm for E. coli and 12 mm for S. aureus It shows better inhibition for biosynthesized sample than the Pure Sample of Zno



Fig.6. Anti-Bacterial Activity of a Pure Zno & Syzygium aromaticum

Conclusion

It was apparent that biosynthesized nanoparticles has an effed on hindrance of anatase Crystal growth; therefore the Crystallite Size of biosynthesized Zno are Smaller than. those of pure Zno. This leads to enhancement of Photocatalytic activity and disinfection efficiency due to their large Surface area Biosynthesized Zno nanoparticles have strong antimicrobial properties through a mechanism including Photocatalytic production of reactive Oxygen. Species that damage Cell components. and viruses, its potential to be activated by visible light or sunlight. Therefore, biosynthesized Zno nanoparticles will be Utilized for textile industry and fresh food packaging films.

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ELZAKI TRANSFORM

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Abstract

The differential equation have played a central role in every aspect of applied mathematics for every long time and with the advent of the computer, their importance has increased further. The New Integral transform "ELZAKI TRANSFORM" was first introduced by "TARIG ELZAKI" to facilitate the process of solving ordinary and partial differential equation in the time domain. The Elzaki transform is derived from the classical fourier integral. Also elzaki transform and its fundamental properties are used to solve the population of growth and decay problem. We also provide elzaki transform for a more comprehensive list of functions.

Keywords: differential equation, linear property of elzaki transform, elzaki transform of some elementary functions, inverse elzaki transform and applications

Introduction

The differential equation have played a central role in every aspect of applied mathematics for every long time and with the advent of the computer, their importance has increased further. Thus investigation and analysis of differential equations cruising in application led to so many differential techniques in order to solve differential equation.

In order to solve the differential equation, the integral transform were extensively used. The importance of an integral transform is that they provide powerful operational methods for solving initial value problem and initial boundary value problem for linear differential and integral equation. There are several methods like Laplace transform, Fourier transform, Mellin transform etc are available to solve linear differential equations.

The objective is to in do a comparative study of "ELZAKITRANSFORM".

The New Integral transform "ELZAKI TRANSFORM" was first introduced by "TARIG ELZAKI" to facilitate the process of solving ordinary and partial differential equation in the time domain. The Elzaki transform is derived from the classical fourier integral. Also elzaki transform and its fundamental properties are used to solve the population of growth and decay problem. We also provide elzaki transform for a more comprehensive list of functions. Here elzaki transform is used to finding the solutions of population of growth and decay problem without any large calculative works. And also some applications are given in order to demonstrate the effectiveness of elzaki transform for solving it.

Preliminaries

Differential Equation

A differential equations is an equations which contains one or more terms and the derivatives of one variable (i.e,. dependent variable) with respect to the other variable (i.e,. independent variable).

$$\frac{dy}{dx} = f(x)$$

here " x" is an independent variable and " y " is a dependent variable.

Linear Differential Equation

A linear differential equation is a differential equation that is defined by a linear polynomial in the unknown function and its derivatives, that is an equation of the form

$$a_0(x) y + a_1(x) y' + a_2(x) y'' + \ldots + a_n(x)$$

where $a_0(x), \ldots, a_n(x)$ and b(x) are arbitrary differential functions that do not need to be linear, and

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 $y', \ldots, y^{(n)}$ are the successive derivatives of an unknown function y of the variable x.

Such an equation is an *ordinary differential equation*. A linear differential equation may also be a linear *partial differential equation*, if the unknown function depends on several variables and the derivatives that appear in the equation are *partial derivatives*.

Fourier Integral

The Fourier integral of a function f defined on $(-\infty, \infty)$ is defined by,

$$f(x) = \frac{1}{\pi} \int_0^\infty [A(\alpha) \cos \alpha x + B(\alpha) \sin \alpha x] d\alpha$$

where $A(\alpha) = \int_{-\infty}^{\infty} f(x) \cos \alpha x \, dx$ and $B(\alpha) = \int_{-\infty}^{\infty} f(x) \sin \alpha x \, dx$

Integral Transform

If h(x) = 0, we can take $\lambda = -1$ without loss of generality and obtain the integral equation,

 $g(x) = \int_{a}^{b} k(x, y) f(y) dy$. This is called a Fredholm equation of first kind or an integral transform.

Exponential Order

A piecewise continuous function f(t) is said to be of exponential order α , if there exist constant α , M > 0such that $| f(t) | \leq M e^{\alpha t}$ for all t > T.

The Population Growth

The population growth (growth of a plant, or a cell, or an organ, or a species) is governed by the first order linear ordinary differential equation.

$$\frac{dN}{dt} = KN \tag{1}$$

With initial condition as,

$$N(t_0) = N_0 \tag{2}$$

where, K is a positive real number,

N is the amount of population at time t and

 N_0 is the initial population at time t_0 .

Equation (1) is known as the Malthusian law of population growth.

The Population Decay

Mathematically the decay problem of the substance is defined by the first order linear ordinary differential equation,

$$\frac{dN}{dt} = -KN \tag{3}$$

with initial condition as,

$$N(t_0) = N_0 \tag{4}$$

where, N is the amount of substance at time t, K is a positive real number and

 N_0 is the initial amount of the substance at time t_0 .

In equation (3), the negative sign in the right hand side is taken because the mass of the substance is decreasing with time and so the derivative $\frac{dN}{dt}$ must be negative.

Elzaki Transform Definition

A new transform called the elzaki transform defined for function of exponential order we consider functions in the set A defined by:

$$A = \{f(t) : \exists k_1, k_2 > 0, |f(t)| < Me^{\frac{|t|}{k_j}}, \text{ if } t \in (-1)^j X[0,\infty) \}$$

l e l

For a given function in the set A, the constant M must be finite number, k_1, k_2 may be finite or infinite.

The Elzaki transform of the function F(t) is defined as ,

$$E{F(t)} = v \int_0^\infty F(t) e^{\frac{-t}{v}} dt = T(v) , \text{ where } t$$

$$\geq 0, 0 < k_1 \leq v \leq k_2.$$

where E isElzaki transform operator.

The Elzaki transform of the function F(t) for $t \ge 0$ exist if F(t) is piecewise continuous and of exponential order.

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Linear Property of Elzaki Transform

If $E{F(t)} = H(v)$ and $E{G(t)} = I(v)$ then, $E{a F(t) + b G(t)} = a E{F(t)} + b E{G(t)}$ $\Rightarrow E{a F(t) + b G(t)} = a H(v) + b I(v)$ where a and b are arbitrary constants.

Elzaki Transform of Some Elementary Functions LetF(t) = 1,

By the definition of Elzaki transform,

$$E\{F(t)\} = v \int_{0}^{\infty} F(t) e^{\frac{-t}{v}} dt$$

Put F(t) = 1,
$$E\{1\} = v \int_{0}^{\infty} 1 e^{\frac{-t}{v}} dt$$
$$= v \int_{0}^{\infty} e^{\frac{-t}{v}} dt$$
$$= v \left[\frac{e^{\frac{-t}{v}}}{\frac{-1}{v}}\right]_{0}^{\infty}$$
$$= v \left[0 + v\right]$$
$$= v^{2}$$
$$E\{1\} = v^{2}$$

LetF(t) = t , By the definition of Elzaki transform,

$$E{F(t)} = v \int_{0}^{\infty} F(t) e^{\frac{-t}{v}} dt$$

Put F(t) = t,
$$E{t} = v \int_{0}^{\infty} t e^{\frac{-t}{v}} dt$$
$$= v \left[\left[\frac{t e^{-t/v}}{-1/v} \right]_{0}^{\infty} + \int_{0}^{\infty} v e^{\frac{-t}{v}} dt \right]$$
$$= v^{2} \int_{0}^{\infty} e^{\frac{-t}{v}} dt$$
$$= v^{2} \left[\frac{e^{-t/v}}{-1/v} \right]_{0}^{\infty}$$
$$= v^{2} [0 + v]$$
$$E{t} = v^{3}$$

Let $\mathbf{F}(\mathbf{t}) = \mathbf{t}^2$

By the definition of Elzaki transform,

$$E{F(t)} = v \int_0^\infty F(t) e^{\frac{-t}{v}} dt$$

Put F(t) = t^2
E{ t^2 } = $v \int_0^\infty t^2 e^{\frac{-t}{v}} dt$

By integration by parts
$$u = t^2 dv = \int e^{\frac{-t}{v}}$$

 $du = 2t dt v = \frac{e^{-t/v}}{-1/v}$
 $= v \left[\left[\frac{t^2 e^{\frac{-t}{v}}}{\frac{-1}{v}} \right]_0^\infty + \int_0^\infty v e^{\frac{-t}{v}} 2t dt \right]$
 $= 2v^2 \int_0^\infty e^{\frac{-t}{v}} t dt$

Again by integration by parts, $u = t dv = \int e^{\frac{-t}{v}}$

$$du = dt v = \frac{e^{-t/v}}{-1/v}$$

$$= 2v^{2} \left[\left[\frac{t e^{\frac{-t}{v}}}{\frac{-1}{v}} \right]_{0}^{\infty} + \int_{0}^{\infty} v e^{\frac{-t}{v}} dt \right]$$

$$= 2v^{3} \left[\frac{e^{\frac{-t}{v}}}{\frac{-1}{v}} \right]_{0}^{\infty}$$

$$= 2v^{3} [0 + v]$$

$$= 2v^{4}$$

$$E\{t^{2}\} = 2v^{4}$$

Let
$$\mathbf{F}(\mathbf{t}) = \mathbf{t}^n$$
, $\mathbf{n} \in \mathbf{N}$

Similarly,

$$\mathrm{E}\{t^n\}=n!\,v^{n+2}$$

Let $F(t) = t^n$, n > -1

Similarly,

$$E\{t^n\} = (n+1)! v^{n+2}$$

Inverse Elzaki Transform

If $E{F(t)} = T(v)$ then F(t) is called the inverse Elzaki transform of T(v) and mathematically it is defined as

$$\mathbf{F}(\mathbf{t}) = \mathbf{E}^{-1} \{\mathbf{T}(\mathbf{v})\}$$

where E^{-1} is the inverse Elzaki transform operator.

Inverse elzaki transform of some elementary function

Let $T(v) = v^2$

By the definition inverse elzaki transform,

$$\mathbf{F}(\mathbf{t}) = \boldsymbol{E}^{-1}\{\mathbf{T}(\mathbf{v})\}$$

By the elementary function of elzaki transform,

$$E\{1\} = v^{2}$$

$$1 = E^{-1}\{v^{2}\}$$

$$E^{-1}\{v^{2}\} = 1$$

Let $T(v) = v^3$

By the definition inverse elzaki transform,

$$F(t) = \boldsymbol{E}^{-1}\{T(v)\}$$

By the elementary function of elzaki transform,

$$E\{t\} = v^{3}$$

$$t = E^{-1}\{v^{3}\}$$

$$E^{-1}\{v^{3}\} = t$$

Let $T(v) = v^4$

By the definition inverse elzaki transform,

 $F(t) = E^{-1}{T(v)}$

By the elementary function of elzaki transform,

$$E\{t^{2}\} = 2v^{4}$$
$$t^{2}/2! = E^{-1}\{v^{4}\}$$
$$E^{-1}\{v^{4}\} = t^{2}/2!$$

Application

Application of Elzaki Transform

Some applications are given in order to demonstrate the effectiveness of Elzaki transform for solving population growth and decay problems.

Application 1

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The population of a city grows at a rate proportional to the number of people presently living in the city. If after two years, the population has doubled, and after three years the population is 20,000, estimate the number of people initially living in the city.

Solution

This problem can be written in mathematical form as

$$\frac{dN(t)}{dt} = KN(t) \quad (13)$$

where N denotes the number of people living in the city at any time t and K is the constant of proportionality. Consider N_0 is the number of people initially living in the city at t = 0. Applying the Elzaki transform on both sides of (13), we have E

$$\left\{\frac{dN(t)}{dt}\right\} = KE\{N(t)\}$$
(14)

Now applying the property ,Elzaki transform of derivative of function on (14), we have

$$\frac{1}{v} \mathbb{E}\{ N(t) \} - v N(0) = KE\{N(t)\}$$
(15)

Since at t = 0, $N = N_0$, so using this in (15), we have

$$\frac{1}{v} \mathbb{E}\{ N(t) \} - vN_0 = KE\{N(t)\}$$

$$\frac{1}{v} \mathbb{E}\{N(t)\} - KE\{N(t)\} = vN_0$$

$$(\frac{1}{v} - K)E\{N(t)\} = vN_0$$

$$(\frac{1}{v} - K)E\{N(t)\} = vN_0$$

$$E\{N(t)\} = \frac{vN_0}{(\frac{1}{v} - K)}$$

$$\Rightarrow E\{N(t)\} = \frac{v^2N_0}{(1-Kv)} (16)$$

Operating inverse elzaki transform on both side (16), we have

$$N(t) = E^{-1} \{ \frac{v^2 N_0}{(1 - Kv)} \}$$

$$\Rightarrow N(t) = N_0 E^{-1} \{ \frac{v^2}{(1 - Kv)} \}$$

$$\Rightarrow N(t) = N_0 e^{Kt} (17)$$

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Now at t = 2, $N = 2N_0$, so using this in (17), we have

 $2N_0 = N_0 e^{2K}$ $\Rightarrow e^{2K} = 2$

Taking log on both side,

 $\Rightarrow \log (e^{2K}) = \log 2$ $\Rightarrow 2K = \log 2$ $\Rightarrow K = \frac{1}{2} \log 2$ $\Rightarrow K = 0.347 (18)$

Now using the condition at t = 3 , N = 20,000 in (17), we have $20,000 = N_0 e^{3K}$ (19)

Putting the value of K from (18) in (19), we have $20,000 = N_0 e^{3 \times 0.347}$ $\Rightarrow 20,000 = 2.832 N_0$ $\Rightarrow N_0 = \frac{20,000}{2.832}$ $\Rightarrow N_0 \cong 7062 (20)$

Which are the required number of people initially living in the city.

Conclusion

In this project, we have discussed and compared the integral transform, "ELZAKI TRANSFORM".

In this project, we also discussed a linear property and also some elementary function and some derivative functions for elzaki. Also we have successfully developed the elzaki transform for solving the population growth and decay problems. Also we have given a certain applications for elzakito demonstrate the effectiveness of population growth and decay problems. Application of elzaki provided with the wanted results.

The main comparative study on elzaki transform are almost similar but the result system can approach more easily with suitable adjustment for the desired results

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HIGHLY EFFICIENT AND STABLE ELECTRON-TRANSPORT-LAYER-FREE AND ECO-FRIENDLY CS₂TIBR₆ PEROVSKITE SOLAR CELLS BY NUMERICAL SIMULATION

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Abstract

Perovskite solar cells (PSCs) without electron transport layers (ETLs) are incredibly beneficial for low-temperature processes that can lessen the instability brought on by ETL layers. The outstanding electrical, optical, and mechanical capabilities of perovskite materials make them the backbone of the photovoltaic industry. It already has higher photo conversion efficiency (PCE) than other thin-film technologies, but the high-efficiency cells rely on complex device architectures and use multiple layers of coating. A simple structure and high efficiency are two key aspects of this technology's commercialization. The electron transport layers (ETLs) are needed to enable great results from PSCs, but their high cost and potential instability prohibit their mass production at a cost-effective rate. A major barrier to the commercial implementation of PSCs is their toxicity and instability. A perovskite material has the property of ambipolar carrier transfer, which allows it to operate like a PSC even in the absence of electron transport layers. Low-cost, ETL-free PSCs have received much interest lately because of how simple and inexpensive they are to produce. The aim of this research is to develop a lead-free, green, environmentally-friendly, and stable PSC using Cs2TiBr6 without electron transport material for greater stability. The optimization of various HTLs, back metal contacts, thickness, defect density, acceptor density, and donor density of the absorber layer is varied for each of the various possible layer configurations with the selected HTMs and back contact metals. After analyzing various solar cell configurations, it is seen that Glass/FTO/ Cs2TiBro/Cu2O/Ni exhibits optimum performance with a Power Conversion Efficiency (PCE) of 22.97%, Fill Factor (FF) of 91.79%, a Short Circuit Current density (Jsc) of 15.58 mA/cm² and an Open Circuit Voltage (Voc) of 1.6038V. The elicited results suggest that Cs₂TiBr₆ not only plays a momentous role in absorbing perovskite, but also plays a crucial role in ETL, lead-free, ecofriendly towards the highly effective perovskite photovoltaic design.

Keywords: perovskite solar cell, etl-free structure, high efficiency, scaps-1d

Introduction

Nowadays, a high demand for substituting fossil fuel energy resources with renewable energy is considered universal. The best renewable energy resource to replace fossil fuels is solar energy, which is among the most widely used natural sources [1]. 90% of the market for solar cells (SCs) made of silicon is represented by them [2, 3]. SCs based on silicon offer high PCEs exceeding 25%; however, they are suffering from the relatively high cost of production. Consequently, new generations of SCs based on lowcost and abundant materials, besides simple preparation methods, are required [2]. PSCs have been introduced because of their low cost, simple fabrication techniques, and high performance [4]. PSCs are endowed with a special set of electronic properties such as a tunable band gap, high Voc, lowdeposition techniques, wide cost absorption coefficients, long charge carrier diffusion lengths, and low recombination rates. These properties make the PSC an excellent contender for replacing conventional SCs. In the last decade, intensive studies have been done on hybrid PSCs, thereby leading to remarkable enhancement of the PCE over the commercial level [5–7], but several obstacles should be overcome for successful applications. More specifically, PSCs are vulnerable to heat, humidity, and light, resulting in long-term instabilities [8–10]. It is possible to protect PSCs from heat and humidity with encapsulation technology, but keeping their photovoltaic

performance stable after long-term light soaking is difficult. The perovskite film and nearby films in contact with the active layer are both driven by the degradation of PSCs under illumination. PSC architectures are commonly classified as n-i-p-(normal) or p-i-n- (inverted) [11, 12]. ETLs and HTLs initiate electron and hole transport when the perovskite layer is irradiated by the sun, which then collects the electrons and holes in the cathode and anode layers. In contrast to perovskites, charge transport materials are usually expensive, and multilayer deposition is generally time-consuming [13, 14]. Metal oxides such as TiO2 and ZnO are currently the most widely used and efficient ETL materials reported in the literature. They are widely used as ETLs in n-i-p type PSCs for high PCE [15-18]. Typically, the TiO₂ layer requires hightemperature heat treatment for intimate contact and has the drawback of decomposing the organic groups in the active region because of the photo-induced instability [19-21]. A significant amount of energy is expended on annealing the TiO₂-based PSCs after they have fully crystallized into the desired polymorph. As a result, the cost of production rises significantly, as does the complexity of fabrication, preventing the manufacture of flexible devices [22-24]. Many attempts were made to lessen these issues by using a passivation method or putting another ntype oxide at the TiO₂/perovskite layer contact, but they were not fully resolved [25–27]. Accordingly, the researchers have attempted to challenge this conventional view, and numerous attempts have been made to remove the carrier transport layers to construct ETL-free PSCs. From a practical point of view, simplifying the manufacturing procedure of cells may be a meaningful exploration that should be settled to quickly mass-produce the devices and to reduce energy consumption. The ETL-free PSCs possess huge commercial potential because they simplify device configuration while guaranteeing high photovoltaic performance. Based on these considerations, removing the ETL layer is among the greatest techniques for maintaining the photovoltaic performance of PSCs, which is more stable [28-36].

ETL-free PSCs are excellent for lowering costs as well as for low-temperature processes that might lessen inconsistency [36].

Methodology

In this study, a simulation programme with one dimension called the Solar Cell Capacitance Simulator (SCAPS) is used. This programme calculates spectral response, J-V characteristics, ac characteristics (such as capacitance and conductance as functions of V and f), and energy bands (QE) utilizing the three basic semiconductor equations, which comprise the continuity equations for holes, electrons, and Poisson's equation, as shown in Eqs. (1)–(4) under steady-state conditions [37]

$$\frac{dn_p}{dt} = \frac{dn_n}{dt} = 0.$$
 (1)

$$\frac{dn_{p}}{dt} = G_{n} - \frac{n_{p} - n_{p0}}{\tau_{n}} + n_{p}\mu_{n}\frac{d\xi}{dx} + \mu_{n}\xi\frac{dn_{p}}{dx} + D_{n}\frac{d^{2}n_{p}}{dx^{2}}.$$
 (2)

$$\frac{dp_n}{dt} = G_p - \frac{p_n - p_{n0}}{\tau_p} + p_n \mu_p \frac{d\xi}{dx} + \mu_p \xi \frac{dp_n}{dx} + D_p \frac{d^2 p_n}{dx^2}.$$
 (3)

$$\frac{d}{dx}\left(-\varepsilon(x)\frac{d\psi}{dx}\right) = q\left[p(x) - n(x) + N^{+}_{D}(x) - N^{-}_{A}(x) - n_{t}(x)\right]$$
(4)

where G_n , G_p indicate the generation rate of electrons and holes, $\mu_{p,} \mu_n$ are hole and electron mobilities, ξ is the electric field, D is diffusion coefficient, τ is the life time of electrons and holes, ϵ is permittivity, ψ is electrostatic potential, q is electron charge, $p_t(x)$ and $n_t(x)$ are the concentrations of trapped holes and electrons, N_D and N_A are shallow concentrations of donors to acceptors.

Device structure and simulation parameters



Fig. 1 ETL-free Cs₂TiBr₆ Perovskite Solar Cell

Fig. 1 shows the schematic diagram of the multilayer used in the ETL-free PSC. Fluorine-doped tin oxide (FTO), an absorber layer (Cs_2TiBr_6), and a hole transport layer (Cu_2O/Ni) are all present in the device. In Table 1, the simulation parameters of all layers are displayed. Some other parameters and

settings are given in the following. The thermal velocities of the electrons and holes are 1.0×10^7 cm/s.

Parameter	CuSCN [38]	Spiro- MeoTed [37]	NiO CuI [38] [38]		P3HT [38]	CuSbS ₂ [38]	Cu ₂ O [38]	MoS ₂ [38]
Thickness (nm)	50	50	50	50	50	50	50	30
Eg(eV)	3.4	2.9	3.6	2.98	1.7	1.58	2.17	1.29
$\chi_{(Ev)}$	2.1	2.2	2.1	2.1	3.5	4.2	3.2	4.2
\mathcal{E}_r	10	3	11.75	6.5	3	14.6	7.1	3
NC(cm ⁻³)	2.5X10 ¹⁸	2.5X10 ¹⁸	2.5X10 ²⁰	2.8X10 ¹⁹	2X10 ¹⁸	2E ¹⁸	2.5 X10 ²⁰	2.2 x10 ¹⁸
NV(cm ⁻³)	1.8X10 ¹⁹	1.8X10 ¹⁹	2.5X10 ²⁰	1X10 ¹⁹	2X10 ¹⁹	$1 E^{18}$	2.5 X10 ²⁰	1.8 x10 ¹⁹
μ_n (cm ² /V _s)	2X10 ⁻⁴	2X10 ⁻⁴	1X10 ⁻³	1.69X10 ⁻ 4	1.8X10 ⁻³	49	200	100
$\mu_h^{}_{ m (cm^2/V_S)}$	2X10 ⁻⁴	2X10 ⁻⁴	1X10 ⁻³	1.69X10 ⁻ 4	1.8X10 ⁻²	49	8600	150
Ve(cm/s)	$1 \text{ X} 10^7$	1 X10 ⁷	$1 \text{ X} 10^7$	$1 X 10^{7}$	$1 X 10^{7}$	1 X10 ⁷	$1 X 10^{7}$	$1 x 10^{7}$
Vh(cm/s)	$1 X 10^{7}$	1 X10 ⁷	$1 X 10^{7}$	$1 X 10^{7}$	$1 X 10^{7}$	$1 \text{ x} 10^7$	$1 X 10^{7}$	$1 x 10^{7}$
ND(cm-3)	0	0	0	0	0	0	-	0
NA(cm-3)	1X10 ¹⁷	1X10 ¹⁷	1X10 ¹⁹	1X10 ¹⁸	1X10 ¹⁸	1E ⁺¹⁸	1X10 ¹⁹	1 x10 ¹⁷
$N_t (1/cm^3)$	1 X10 ¹⁴	1 X10 ¹⁴	1 X10 ¹⁴	1 X10 ¹⁴	1 X10 ¹⁴	1 x10 ¹⁴	1 X10 ¹⁴	1 x10 ¹⁴

Table 1. Input Parameters of PSC

Result and Discussion

HTL Optimization

An ideal HTM candidate possesses intrinsically enhanced hole mobility, suitable energy levels that are appropriate for the layer of perovskites, long-term stability in air, and good photochemical and thermal stability [39]. HTL optimization is the focus of this subsection. Rather than utilizing only organic HTL, we currently use inorganic and organic HTMs as HTL, such as CuSCN, Spiro-MeOTAD, NiO, CuI, P₃HT, CuO, CuSbS₂, Cu2O, and MoS₂, on the Cs₂TiBr₆PS device to select the best suited HTL for attaining high performance

Table 1 shows the input parameters for different HTMs. Fig. 2 shows the corresponding J-V characteristics, Fig. 3 exhibits the PCE for each HTM

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employed by the device, and Table 2 provides the device's effectiveness for various HTMs. From Figs. 3, 4, and Table 2, we can see that Cu₂O provides better J-V characteristics, a better Voc, and a better PCE among the performances of other different HTMs. Inorganic HTMs that are commonly found in PSCs are cupric oxide (CuO) and cuprous oxide (Cu₂O). In comparison with organic HTMs, inorganic HTMs provide excellent stability, great hole mobility, are inexpensive, etc. [40-42]. PSCs can also be improved in durability by using Cu/Cu₂O films that prevent moisture and Ag from penetrating into the perovskite layer due to their high absorption coefficient [42]. A Cu₂O HTL-based PSC showed the optimum PCE of 19.21%, V_{OC} of 1.5430V, and J_{SC} of 13.76 mA/cm² among all other HTLs; hence, Cu₂O is a potential alternative for the HTL layer.



Fig. 2 Comparison of J-V characteristics curve for different HTL Fig. 3. PCE for various HTL

Table 2. Performance parameters	of different
HTMs as HTL TLs	

HTL/Cs2TiBr6	V _{OC} (V)	Jsc (mA/cm ²)	FF (%)	PCE (%)
CuSCN	1.5417	13.6564	77.59	16.34
Spiro-Meo TAD	1.5436	13.6603	88.35	18.63

NiO	1.5423	13.6945	77.63	16.40
CuI	1.5436	13.6586	87.51	18.45
P3HT	1.5282	14.31	86.41	18.90
CuO	0.5917	15.8771	82.60	7.76
CuSbS ₂	0.7487	15.1849	76	8.64
Cu ₂ O	1.5430	13.7631	90.46	19.21
MoS ₂	0.8467	16.1010	85.86	11.71



Fig.4 Quantum efficiency curve using different HTL layers in PSC

Analysis of Quantum efficiency of PSC

The quantity of electricity that a PSC generates when exposed to photons of a specific wavelength is known as its quantum efficiency (QE). Fig. 4 shows the QE curve of PSC for different HTL layers within the wavelength range of 300–900 nm. From the graph, it is clear that QE values are >80%. The QE increases with increasing wavelength from 300 to 600 nm, and further, the QE starts to decrease gradually up to 700 nm.



Fig.5 Optimization of HTL thickness

Optimizing HTL Thickness in ETL-Free Perovskite

Cu₂O is our material of choice for optimizing thickness since it has an optimized PCE. A variation of 30 nm to 100 nm was applied to the HTL thickness to be able to optimize it for the fabrication of PSCs, considering the normal feasibility of fabrication of PSCs. Fig.5 shows the optimization curve for HTL thickness. A maximum PCE of 19.01% is achieved at 50 nm thickness, as PCE increases gradually with HTL thickness. After the thickness range of 50 nm, it is saturated.

The structure with Cu₂O as the HTL was found to provide the greatest behaviour at 50 nm thickness, achieving Voc of 1.26 V, Jsc of 14.49 mA/cm², FF of 90.64%, and PCE of 19.01 %. Consequently, Cu₂O is selected as the optimum HTM for PSC based on Cs₂TiBr₆ with a 50 nm optimized thickness.

Effect of Absorber Thickness on PSC Performance



Fig. 6 Influence of absorber thickness on J-V characteristics Fig. 7 Influence of absorber thickness on FF and PCE

Fig. 6 shows that changing the thickness of the absorb layer allows for the creation of an ETL-free PSC with specific J-V characteristics (Cu₂O thickness remaining constant at 50 nm). The PSC is significantly influenced by the absorber layer thickness, as demonstrated in Figs. 6 and 7. The absorption rate reduces with decreasing absorber layer thickness, thereby having an adverse effect on efficiency, whereas increased thickness hinders the charge carriers' travel to ascend towards charge collecting layers [13, 25]. According to our findings, PCE and FF both increased up to 400 nm as the thickness increased from 100 to 1200 nm, then PCE started to decrease while the FF remained stable. Thus it represents the increased electron-hole pair generation in the device [26], whereas at higher thickness, the recombination of charges starts in the middle, i.e., before they reach the contacts, thus leading to saturation at higher thickness [27]. So, following modeling, the findings showed that at a thickness of 400 nm, the PCE, FF, Jsc, and Voc are increased to 19.21%, 90.46%, 13.7631 mA/cm², and 1.5430 V. The relation between Voc, Jsc, and J_0 is clearly depicted by Shockley–Queisser equation (5) [13]

$$V_{OC} = \frac{KT}{q} \ln\left(\frac{J_{SC}}{J_0} + 1\right)$$
(5)

Table3. Effect of defect density on absorber

PSC performance

Defect density-	Voc	J_{SC}	FF	PCE	
absorber	(V)	(mA/cm ²)	(%)	(%)	
1.00E ⁺¹³	1.60 24	15.5242	90.92	22.62	
$1.00E^{+14}$	1.54 3	13.7631	90.46	19.21	
1.00E ⁺¹⁵	1.47 87	6.4845	88.31	8.47	
1.00E ⁺¹⁶	1.40 41	1.3075	83.64	1.54	



Fig. 8 Influence of defect density of the absorber on J-V characteristics

The effect of variation in defect density on absorber and HTL performance

The defective density of the absorber has a significant photovoltaic performance. impact on This computational study investigates the response of the suggested ETL-free PSC to changes in defect density in the absorber layer. Because it plays an important role in optimizing devices' performances. The device's stability and overall performance are affected by the larger defect concentrations in the absorber layer, which also lead to higher recombination due to the production of pinholes and a higher rate of film deterioration. Simulation was performed by adjusting the defect density from 1×10^{13} to 1×10^{17} cm⁻³ in order to determine the appropriate defect concentration in the absorber for the best parameters.

As shown in Fig. 8, the J–V curve illustrates that the best performance is at the defect density range of 1×10^{13} cm⁻³. Table 3 displays the performance parameters of PSC as a function of the defect density of the absorber. Thus, to obtain higher efficiency, the defects in perovskite should be reduced to 1×10^{13} cm⁻³ by improving the crystal structure .The obtained V_{OC}, FF, J_{SC}, and PCE are 1.6024 V, 90.92%, 15.5242 mA/cm2, and 22.62% at a defect density of 1×10^{13} cm⁻³ respectively. Effect of back metal work function on PSC performance

 Table 4. Back Metal Contacts with its work

 function

			10	meen	/11				
Back metal contacts	Cu	Fe	С	Au	W	Ni	Pd	Pt	Se
Work Function	4.65	4.81	5	5.1	5.22	5.5	5.6	5.7	5.9



Fig. 9 (a), (b) The influence of back metal contacts on Voc, Jsc, FF, PCE

A material with an appropriate work function at the back metal contact is required to produce a moderate built-in potential there. The photovoltaic parameters of the proposed PSC are examined as a function of the back contact work function in order to comprehend the utility of the back contact in the current device, as shown in Figs. 9(a) and (b). It ranges from 4.6 to 5.9 eV for the back contact's work function, as shown in table 4. When metal contacts with a low work function are utilized in the PSC

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configuration, J_{SC} also exhibits a gradual increase. However, J_{SC} exhibits consistent output at higher values of the back metal contact's work function. The same thing is happening for V_{OC} as well. Fig. 9 (b) shows how the FF and PCE are influenced by increasing work functions for back metal contacts such as Cu, Fe, C, Au, W, and Ni, but it essentially stays the same for other metal contacts with greater work functions of 5.5 and above. When PCE reaches a metal contact function of 4.89 (Fe), it also increases and becomes stable. This is occurring as a result of the constraint on transfer from the absorber to the back contact. Because of the large barrier provided by the lower-function materials on the back side, this leads to low photovoltaic outputs. It has been discovered that the back contact work function has a significant impact on PSC performance. The outcomes of the current simulation show that, for excellent PV performances, a back contact work function larger than 5.5 eV is necessary. Nickel (Ni) was employed as the back contact in this numerical analysis since it is inexpensive and has a good work function. This analysis reveals a maximum PCE of 22.62%, then it remains constant for the rest of the metal contact function.



Fig. 10 Influence of Temperature on Voc, FF



Fig. 11 Influence of back metal contacts on J_{SC}, PCE

Effect of temperature on PSC performance

In view of the installation of solar cells in sunexposed, open areas, a higher temperature is a cause for concern in some places where the daytime temperature is at its peak during the summer, which in turn critically affects the PSC's performance. The operating temperature is varied from 300 K to 750 K to realize the stability of the ETL-free Cs₂TiBr₆-based PSC. Figures 10 and 11 show how the VOC, FF, JSC, and PCE of the PSC change with temperature, and it is clear that as the temperature was raised, the Voc, FF, and PCE decreased significantly, while the Jsc began to rise slowly. The performance of the solar cell is good at a temperature of 300 K, giving an efficiency of 23.03%, a Voc of 1.3087 V, a Jsc of 24.78 mA/cm², and a FF of 70.98%, which slowly degrades as the temperature increases.



Fig.13 The impact of donor density on Voc, Jsc



Fig.14 Effect of donor density on FF, PCE

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Fig.15 The impact of acceptor density on V_{OC} , J_{SC}



Fig.16 The impact of acceptor density on FF, PCE

Impact of the donor and acceptor density of the ETL-free absorber

To observe the impact of donor density on the ETLfree PSC, the donor density was varied from 3×10^{14} to 3×10^{21} cm⁻³. In accordance with the donor density and acceptor density of an ETL-free PSC, Figs. 13, 14, 15, and 16 depict the behavioural standards, including Voc. Jsc. FF. and PCE. The results show both Voc and Jsc remain approximately stable with the increase in donor density, but at $3 \times 10^{20} \text{cm}^{-3}$, V_{OC} attains a maximum value of 1.6038 V, J_{SC} of 15.5816 mA/cm² at $3 \times 10^{20} \text{cm}^{-3}$ However, its values of PCE and FF remain stable with a variation in the acceptor density of the absorber, but at $3 \times 10^{19} \text{cm}^{-3}$, they attain the maximum values of 91.76% and 22.93%, respectively. In an analysis of the effect of acceptor density, it is visible that V_{OC} and J_{SC} is saturated from 3×10^{14} to 3 \times 10²⁰cm⁻³ then at 3 \times 10²¹cm⁻³ Jsc obtains the

maximum value of 15.5812 mA/cm2, and V_{oC} remains stable till at 3×10^{20} cm⁻³ then V_{oC} starts to increase. They are stable in terms of FF and PCE until 3 1020 cm3, at which point FF and PCE begin to decrease. As a result of acceptor density, the FF and PCE achieve maximum values of 91.79 percent and 22.97%, respectively. Thus, in the current study, the preferred donor density is 3×10^{19} cm⁻³ and the preferred acceptor density is 3×10^{20} cm⁻³.

Conclusion

In the simulation of the PSC implementing different HTL layers, Cu₂O was discovered to be the most suitable and promising choice for an HTL layer when compared to other HTL layers. In order to comprehend how the suggested PSC performs when the thickness, doping concentration, defect density, and operating temperature are changed, a numerical simulation is used. We studied the J-V characteristic and QE using different HTL layers, in contrast. The SCAPS-1D simulation software has been used to create and assess unique ETL-free PSC structures made of FTO/Cs2TiBr6/Cu2O/Glass. The use of advantageous back contact materials with different work functions is also examined as a way to improve the output performance of the proposed device configuration. The suggested device has an exceptional PCE of 22.97%, a Voc of 1.6038 V, a FF of 91.79%, a J_{SC} of 15.5812 mA/cm², and a QE of 83% at the visible spectrum. Therefore, this analysis opens new directions for more simple, low-cost, highly efficient, and more stable ETL-free Cs2TiBr6-based PSCs. According to the findings, Cs₂TiBr₆ can play a vital role as an absorbent perovskite, aiding in the advancement of environmentally friendly, lead-free perovskite solar cell manufacturing.

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GROWTH AND CHARACTERIZATION OF AMINO-INORGANIC ACID CRYSTALS

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Abstract

Amino acid single crystals have gained significant attention due to their excellent optical properties and potential applications in nonlinear optics and biomedical fields. This study focuses on the growth and characterization of aminoinorganic acid crystals synthesized via the slow evaporation solution growth technique. The grown single crystals were analysed using X-ray diffraction (XRD) to determine their lattice parameters and structural properties. Fourier Transform Infrared (FTIR) spectroscopy was employed to identify the functional groups present in the crystals. Density measurements were conducted using the floatation method to confirm the purity and structural integrity of the samples. The results indicate successful crystallization of L-Histidine Hydrochloride, L-Histidine Nitrate, Alanine Chloride, and DL-Methionine Orthophosphoric, with well-defined lattice structures and characteristic vibrational spectra. These findings provide valuable insights into the structural and optical properties of amino-inorganic acid crystals, contributing to their potential applications in advanced material sciences.

Keywords: amino acid crystals, nonlinear optics, slow evaporation method, x-ray diffraction (XRD), fourier transform infrared (FTIR) spectroscopy, density measurement, structural properties, optical transparency

Introduction

Crystals have been a subject of scientific investigation for centuries due to their unique structural and physical properties. The study of crystallography has evolved significantly, particularly after the discovery of X-ray diffraction, which enabled precise structural analysis at the atomic level. Among various types of crystals, amino acid-based single crystals have gained prominence due to their excellent optical, mechanical, and dielectric properties. These crystals are widely used in nonlinear optics, laser technology, and biomedical applications.

Amino acids, the building blocks of proteins, exhibit fascinating crystallization behaviour when combined with inorganic acids, leading to the formation of amino-inorganic acid crystals. These complex crystals often exhibit improved thermal stability, enhanced optical transparency, and superior mechanical strength compared to their parent compounds. The growth and characterization of such crystals are crucial for understanding their structural, optical, and chemical properties, which can further aid in their application in material science and biotechnology.

In this study, amino-inorganic acid crystals, including L-Histidine Hydrochloride, L-Histidine Nitrate, Alanine Chloride, and DL-Methionine Orthophosphoric, were synthesized using the slow evaporation solution growth technique. The grown crystals were subjected to various characterization techniques, such as X-ray diffraction (XRD) to determine their crystallographic parameters, Fourier Transform Infrared (FTIR) spectroscopy to identify functional groups, and density measurements to assess their purity and structural integrity. The results of this study contribute to a deeper understanding of the physicochemical properties of these crystals, highlighting their potential applications in optical and electronic industries.

Characterization Methods Growth of Single Crystals

Alanine chloride, Histidine chloride, Histidine nitrate, and Methionine phosphate were crystallized at room
temperature using the slow evaporation method from an aqueous solution of amino acids and their respective inorganic acids in a stoichiometric ratio of 1:1. The resulting crystals were platy, colorless, and transparent.

Density Measurement of Crystals

The density of the grown crystals was determined using the floatation method (also known as the "sink and swim" method). In this technique, the crystal is placed in a mixture of two miscible liquids—one denser and one lighter—until it remains suspended in equilibrium within the solution. The liquids used for this method were bromoform ($\rho = 2.89$ g/cc), carbon tetrachloride ($\rho = 1.59$ g/cc), and xylene ($\rho = 0.89$ g/cc).

A few milliliters of carbon tetrachloride were placed in a clean, transparent test tube, and the crystal was introduced into the liquid. If the crystal sank, a denser liquid (bromoform) was added drop by drop while shaking the test tube until the crystal remained suspended in the middle of the liquid column. If the crystal floated, a lighter liquid (xylene) was added in the same manner. At equilibrium, the density of the liquid mixture matched that of the crystal.

The density of the solution was measured using a relative density bottle and a chemical balance, providing accurate results with a standard error of approximately 1%. The density of the grown crystals was compared with that of their parent compounds.

The density (ρ) was calculated using the standard formula:

$$ho = rac{W_3 - W_1}{W_2 - W_1} ~{
m g/cc}$$

where:

- W₃ = Mass of the specific gravity bottle with the liquid mixture
- W₂ = Mass of the specific gravity bottle with distilled water
- $W_1 = Mass$ of the empty specific gravity bottle

Results and Discussion

L-Histidine Hydrochloride

Single crystal XRD analysis revealed the lattice parameters for L-Histidine Hydrochloride as:

a = 6.859 Å, b = 8.920 Å, c = 15.322 Å, with a unit cell volume of 937 Å³. These values align well with reported data, confirming that the grown crystal is L-Histidine Hydrochloride (Table 1). FTIR spectral analysis identified and assigned various functional groups present in the crystal. (Figure 1)

L-Histidine Nitrate

XRD analysis determined the lattice parameters for L-Histidine Nitrate as:

a = 6.851 Å, b = 8.920 Å, c = 15.298 Å, with a unit cell volume of 934 Å³. A comparison with existing data confirms that the synthesized crystal is L-Histidine Nitrate (Table 2). FTIR spectra further validated the presence of characteristic functional groups, with vibrational wave numbers and assignments detailed in the corresponding table. (Figure 2)

β Alanine

XRD analysis of the grown β Alanine crystal provided lattice parameters:

a = 6.076 Å, b = 9.873 Å, c = 13.791 Å, with a unit cell volume of 827 Å³. Structural analysis confirms that the grown crystal matches β Alanine (Table 3). FTIR spectroscopy was performed to assign functional groups present in the crystal. (Figure 3)

DL-Methionine Orthophosphoric

XRD analysis could not determine clear lattice parameters for DL-Methionine Orthophosphoric due to impurities in the grown crystal. However, FTIR spectroscopy identified various functional groups, including -NH₂, -CH₃, -CH₂, CH, C=O, -COO⁻, P=O, -P-OH, and C-S, confirming the presence of key molecular structures. (Figure 4)

Table 1 (L-Histidine hydrochloride)

Ι	II	III
a = 5.177	a = 6.88	a = 6.859
b = 7.322	b = 8.90	b = 8.92
c = 18.87	c = 15.36	c = 15.321
Z = 4	Z = 4	Z = 5
ρ = 1.477	ρ = 1.477	ρ = 1.495

I-L-Histidine (J.Jmadden et al.,)

II-L-Histidine hydrochloride (H. Fuess et al., Acta, 33.1977, 654)

III- Present work

By comparing I, II and III it is found that the grown crystal is not a parent, but it is L-Histidine hydrochloride.

Table 2 (L-Histidine nitrate)

Ι	II	III
a = 5.177	a = 5.24	a = 6.851
b = 7.322	b = 7.116	b = 8.920
c = 18.87	c = 25.03	c = 15.298
Z = 4	Z = 4	Z = 5
$\rho = 1.477$	ρ = 1.551	ρ = 1.49

I-L-Histidine (J.Jmadden et al.,)

II-L-Histidine nitrate (Srikrishnan acta A, 40.1984.C92)

III- Present work

By comparing I,II and III it is found that the grown crystal is not a parent, but it is L-Histidine nitrate.

Table 3 (β -Alanine + HCl)

	/
Ι	П
a = 5.177	a = 5.24
b = 7.322	b = 7.116
c = 18.87	c = 25.03
Z = 4	Z = 4
ρ = 1.477	ρ = 1.551

 $1\mathchar`-\beta$ -Alanine (E.Papavinasam et al., Int J.pep pro) II- Present work

By comparing I and II it is found that the grown crystal is only *B*-alanine and not *B*-alanine chloride



Wave number (cm ⁻¹)	Assignment
3410	-N-H stretching , asym and sym stretch of -NH2
2616	-NH3* sym stretching
1640	-Ç=O stretching
1606	asym bend of NH 3'
1876	asym stretching =COO ⁺ , -C ^a C- stretching
1335	I - CH stretching
1167	C-C stretching
625	-CH bending mode

Figure 1 (L-Histidine hydrochloride)



FTIR spectral assignments for Histindine nitrate single crystal

Wave number (cm ⁻¹)	Assignment
	-N-H stretching,
3410	asym and sym stretching of -NH
3077	-CH2 asym stretching
3015	-CH- aromatic stretching
2935	-CH2 asym stretching
1641	I I -C=C-stretching I I
1608	-C=O stretching
1578	-COO- asym stretching
1335	bending mode of -CH
1285	-C-O* stretching
957	-N-O stretching
694	bending mode of -O-N-O -

Figure 2 (L-Histidine nitrate)



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Wave number (cm 1)	Assignment
2949	-CH ₃ asymmetric bending
2918	-CH2 asymmetric bending
1616	C=O stretching
1580	bending mode of -NH2
1339	-C-H bending mode
1273	C=O stretching
1220	C=O sym stretching
1158	P=O aliphatic stretching
1047	-P+OH stretching
778	C-S stretching and carboxylate ion
754	C-S stretching

Figure 3 (DL-Methionine Orthophosphoric)



Figure 4 (β Alanine)

Conclusion

Amino acid-inorganic acid complex crystals were successfully grown using the slow evaporation method. Density measurements were conducted to assess the structural integrity of the synthesized crystals. Single crystal X-ray diffraction (XRD) analysis determined the lattice parameters for L-Histidine Hydrochloride, L-Histidine Nitrate, and Alanine Chloride, confirming their crystallographic structure. Additionally, FTIR spectroscopy was performed to identify and assign functional groups, providing further validation of the crystal compositions.

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DEVELOPMENT OF INVERTED U-SHAPED MICROSTRIP PATCH ANTENNA FOR S & C BAND APPLICATIONS

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Abstract

Numerous methods have been suggested for the design of microstrip patch antennas that exhibit multiband capabilities. The proposed antenna design incorporates a configuration of triple Inverted U-slots to achieve multiple frequency bands and an extensive bandwidth. This paper proposes the application of Inverted U-slot shape fractal geometry to microstrip patch antenna, resulting in enhanced miniaturization and a wider impedance bandwidth suitable for next-generation wireless applications. Additionally, parametric analyses of antenna structures with triple inverted U-slots and variations are shown. It exhibits multiband features and operates at resonance frequencies of 2.93 GHz, 3.71 GHz, and 4.385 GHz, revealiing an impedance bandwidth of 1.275 GHz, 0.705 GHz, and 0.660 GHz, respectively. This pertains to applications within the S and C bands, including WLAN systems, satellite communications, weather forecasting, military systems such as radars, aircraft, and missiles, as well as speech and data communication, 5G communication, the Internet of Things, and mobile communication.

Keywords: microstrip patch antenna, microstrip feed line, triple inverted u-slots, dielectric FR-4 substrate

Introduction

The advancement of higher-performance antennas is an essential for the broad acceptance of wireless communication systems in consumer electronics. The numerous advantages of microstrip patch antennas, such as their compact profile, minimal size, lightweight construction, and ease of integration into various devices, have significantly revolutionized contemporary wireless communication systems. It exhibit certain limitations, including restricted bandwidth, reduced gain, and low directivity [1]. These antennas, often characterized by their flat design, exhibit remarkable versatility and are suitable for numerous applications, especially within the highfrequency spectrum. They are ideally suited for applications where weight and space constraints are critical, owing to their compact design. As modern technology advances, microstrip antennas are increasingly being used in high-performance systems. These systems cover a variety of applications that

need small and effective antenna designs [2], such as satellite communications [3], mobile communications [4], radar technologies [5], and more.

The process of meandering the radiating element of a microstrip patch antenna has been recognized as an effective technique for reducing the size of the antenna while maintaining operation at a specific frequency. This can be accomplished by incorporating narrow slits along the perimeter of the patch [6]–[8]. The U-slot microstrip patch antenna was initially presented by Huynh and Lee in 1995 [10]. Two significant drawbacks of microstrip patch antennas are their limited bandwidth and low gain [11]. Its bandwidth may be significantly increased by using the U-slot patch [12]. The U-slot patch antenna is capable of being designed for dual-band, triple-band, and various other applications [13], accommodating both narrow and broad frequency ratios [14], as well as wideband applications. The frequency at which the Uslot patch antenna functions can be programmed [15].

Multiband antennas, as noted by Lee, Luk, Mak, and Yang (2011), are capable of accommodating various wireless technologies. In the context of microstrip patch antennas, the U-slot has primarily been employed to enhance bandwidth rather than to create a band notch. Research has demonstrated that the Uslot technique can effectively facilitate the design of patch antennas exhibiting dual and multi-band functionalities. The research conducted by Lee, Steven Yang, Kishk, and Luk (2010) and Singh, Ali, Singh, and Ayub (2013) on the U-slot patch antenna indicates that it is suitable for both wideband applications and multiband applications, including dual and triple-band configurations. Integrating multiple bands for wireless technologies is an even more intricate task, as noted by Vedaprabhu and Vinoy (2010). This complexity arises from the need to accommodate various systems, including AWS (Advanced Wireless Services), GSM (Global System for Mobile), and a range of WiMAX and WLAN bands that function across different frequency ranges. The design of multi-band microstrip patch antennas, particularly those with limited bandwidths, presents significant challenges. In this context, patch antennas that incorporate well-designed slits or slots prove to be advantageous [16]. The bandwidth can be enhanced by increasing the size of the patch. To address this issue, a multi-layer dielectric substrate has been employed to augment the bandwidth (Rao & Kumar, 2011) [16]. The multilayer configuration not only provides an improved impedance bandwidth but also maintains consistent characteristics across the specified frequency range (Kushwah, Dubey, & Singhal, 2006) [17-19]. In wireless communications, S and C-bands are given increased attention due to their many advantages. The proposed

triple inverted U-shaped design in the study exhibits unique electromagnetic properties that enhance the antenna's performance, particularly in challenging multiband environments and in terms of bandwidth improvement, high radiation efficiency and multiband nature. The HFSS 13.0 software is used to model the antenna.

Methodology

Figure 1 presents a frontal view of the geometry of the compact-sized inverted U-slotted MPA under consideration. The U-shaped radiating patch is situated on the dielectric substrate made of FR-4, which has a dielectric constant of 4.4. We employed the microstrip line feed technique to provide excitation to the antenna. The substrate measures 20 mm in width and 33 mm in length, with a thickness of 1.6 mm. The operating frequency of the MPA is 2.4 GHz.



Fig.1 Designed Inverted U-Slotted Antenna Structure

The optimised proportions of the suggested MPA and the specification Inverted Tripe U-slot of the patch are shown in table.1 and 2 below.

Parameters	Specification (mm)		
Dimension of Antenna	$40 \times 40 \times 1.6$		
Substrate	FR-4		
Substrate Thickness	1.6		
Substrate Permittivity	4.4		
Dimension of Substrate	33 x 20		
Dimension of Patch	12 x 10		
Dimension of Ground	14.5 × 14.1		

Table 1. Microstrip	patch	antenna	parameters
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Feed Dimensions 3×13 GroundCopper

A microstrip feedline is used to supply power to the intended antenna. The optimized proportions of the suggested MPA are shown in table.1 above.

Inverted U-slot on	Length	Width
Patch	(mm)	(mm)
Single inverted U-	85	8
slot	0.5	
Double inverted U-	75	6
slot	1.5	
Triple inverted U-	6.5	4
slot	0.5	

Table.2	S	pecification	of	Inverted	U-Slots
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Fig.3 Antenna Layout I



Fig.4 Antenna Layout II



Fig.5 Antenna Layout



Fig.6 Antenna Layout

Inverted U-shaped patch design

In this research analysis, the implementation of inverted U-slots within the patch has resulted in significant size reduction, improved bandwidth, and optimal radiation efficiency for the tri-band microstrip patch antenna (MPA). It is operated by a microstrip feedline of 50-ohm. The tri-band frequency response is manifested by the selected antenna at the frequency range of 2 GHz - 8 GHz. The chosen antenna patch is arranged in different configurations through the sequential incorporation of inverted U-slots of varying dimensions. As illustrated in Fig. 2, we begin by examining a patch with dimensions of 12 mm in length and 10 mm in width, positioned on the costeffective FR4 substrate material. This substrate, measuring 20 mm in length and 33 mm in width, is situated beneath the ground plane without any alterations. To enhance the analysis, the patch is designed with the inclusion of a single inverted U-slot measuring 7.5 mm in length and 6 mm in width, as illustrated in Fig. 2. Subsequently, a double inverted U-slot with a length of 6.5 mm and a width of 4 mm was successfully loaded above it, as illustrated in Fig.

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4. The configuration of the fully developed inverted U-slotted antenna is illustrated in Fig. 5, which features an inverted triple U-slotted antenna design. The dimensions of the inverted U-slots and their placements can be adjusted to achieve optimal impedance matching and to obtain remarkable outcomes.

Parametric Analysis



Fig.6 Parametric Analysis of the Inverted Uslotted Antenna

The comparative analysis of Return loss of before and after modification in the antenna as a function of frequency plot of a tri-band Inverted U-slotted antenna is displayed in Fig. 6. The simple structure of the conventional antenna brought out single band nature with the return loss value of -28.4117 dB at 2.8 GHz. Then a single inverted U -slot is introduced on a patch that reveals the dual-band nature with the return loss of -43.4358 dB, -17.3078 dB at 2.85 GHz and 4.32 GHz respectively. Afterwards the insertion of the double inverted U-slot on a patch causes the dual-band nature with better return loss of -60.310 dB, -17.7150 dB at 2.85 GHz and 4.32 GHz respectively. In order to make the best performance in antenna, and multiband response, a triple U- slots are inserted which executes the minimum return loss of -52.0326 dB, -12.9943 dB at 2.85 GHz and 4.32 GHz respectively.

Result and Discussion

Return Loss of Conventional Antenna

When the load is mismatched with load, the whole power will not delivered to the load and is a return of the power, that is called loss, and this loss that is returned is called the return loss. Larger return loss indicates higher power being radiated by the antenna which eventually enhances the antenna parameters. In this Fig. 7, it shows that the conventional microstrip patch antenna resonating at 3.5GHz having a maximum return loss of -28 dB and impedance bandwidth at -10 dB is 1500 MHz.



Fig.7 Returnloss of the Conventional Antenna

Return Loss of Proposed Antenna



Fig.8 Return loss of the proposed triple inverted U-Slotted Antenna

The determination of characteristics with impedance match between reference to the transmission and the receiving end is computed by the S₁₁ parameter. Fig.8 exhibits simulated reflection coefficient (S_{11}) characteristics of the currently designed MPA. The more minimum S_{11} is realized by the recommended design are -20.93 dB, -50.45 dB, -27.50 dB, at the achieved triple resonant frequencies of 2.93 GHz, 3.71 GHz, 4.38 GHz respectively. This optimized design archives a remarkable returnloss of -50.45 dB at the resonant frequency of 3.71 GHz.





Fig.9 Bandwidth of the proposed triple inverted U-Slotted Antenna

S.No	Fr (GHz)	S11 (dB)	Bandwidth (GHz)	RE (%)		
1	2.93	- 30.3283	1.275	96		
2	3.71	- 50.4561	0.705	95		
3	4.385	27.5052	0.6	92		

Table 3: Performance of suggested Microstrip Patch Antenna

Furthermore, summarizes Table 3 the characteristics of the reflection coefficient. bandwidth, and radiation efficiency of the suggested triple inverted U-slotted MPA for its triple-peak operation. The achieved minimum reflection coefficient is -50.4561 dB at a resonant frequency of 3.71 GHz, the radiation efficiency obtained is 96% at a resonant frequency of 2.93 GHz and the enhanced bandwidth of 1.275 GHz at a resonant frequency of 2.93 GHz from simulation studies. According to the results in this table, the presented reconfigurable multi-band inverted U-slotted antenna can be an acceptable candidate for various S and C band applications.

Conclusion

This research investigated the implementation of deep-rooted on-inverted U-slot configurations within a rectangular patch for multiband functionality. This approach yields three resonant frequencies, achieving an expanded bandwidth of 1.25 GHz and an enhanced radiation efficiency of 96%. The enhanced design addresses the frequency peaks ranging from 2 GHz to

4 GHz. An effective antenna design accomplished a reduction in size by incorporating triple inverted U-slot cutouts within the patch. The present research indicates that slot-cutting methods can effectively reduce size, enhance bandwidth, and improve radiation efficiency for the intended applications. This proposed antenna may yield greater profitability for applications in the S and C bands.

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AN INTRODUCTORY STUDY ON DOMINAION IN GRAPH THEORY

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In graph theory, a dominating set is a subset of vertices where every vertex in the graph is either in the set or adjacent to a vertex within the set. The minimum size of such a set is called the domination number. The minimum cardinality of a dominating set in a graph G. The problem of finding a minimum dominating set is NP-complete, meaning it is computationally difficult to solve efficiently for general graphs. A dominating set where no two vertices in the set are adjacent. A dominating set where each vertex is dominated by exactly one vertex in the set. A dominating set where the subgraph induced by the set is connected.

Keywords: dominating set, domination number ($\gamma(g)$), np-completeness, independent dominating set, perfect dominating set, connected dominating set

Introduction

Graph Theory is one of the most important and efficient branches in Mathematics. There are several reasons for the acceleration of interest in Graph Theory. Graph Theory as a Mathematical discipline was created by Euler in his famous discussion of Konigsberg bridge problem. A number of popular puzzles can be formulated in terms of graphs. There are applications of Graph Theory to some areas of Physics, Chemistry, Computer Science, Operations Research, Electrical Engineering, Civil Engineering, Genetics and Economics. The present century has witness a steady development of Graph Theory and in the last ten to twenty years there is intense activity in the field of Graph Theory.

Domination Set Definition

A set D \subseteq V is a dominating set of a graph G if every vertex in V-D is adjacent to some vertex in D.

Example



Figure 1.1

 $D = \{v_1, v_3\}$ $V = \{v_1, v_2, v_3, v_4, v_5\}$

V-D= $\{v_2, v_4, v_5\}$ is adjacent to some vertex in D. \therefore D is a dominating set.

Domination Number Definition

The smallest number of vertices in any dominating set of G is called its domination its domination number and is denoted by Υ (G) or Υ .

Example

Consider the above fig 1.1

 $D_1 = \{v_1, v_3\}$, $D_2 = \{v_2, v_4\}, \ D_3 = \{v_5\}$ are dominating sets.

The domination number $\gamma(G) = 1$.

Abstract:

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Minimum Domination Set

Definition

A dominating set is called minimum if it contains γ elements.

Example

Consider the above fig 1.1 Minimum dominating set is $\{v_5\}$.

Minimal Domination Set

Definition

A dominating set D is a minimal dominating set if no proper subset

 $D \subseteq D$ is a dominating set.

Example

Consider the above fig 1.1

 $D_1 = \{v_1, v_3\}$ is a dominating set.

 $D\text{-}\{v_3\} = \{v_1\}$

$$D = \{v_1\}$$

 $V-D = \{v_2, v_3, v_4, v_5\}$. v_3 is not adjacent to v_1 .

 $D_1 {=} \{v_1, v_3\}$ and $D_2 {=} \{v_2, v_4\}$ are a minimal dominating set .

The Well Known Five Queens Problem Example

We consider the well known five queens problem . The problem is to find the minimum number of queens, which can be placed on (8×8) chessboard so that every square is controlled (domination) by at least one queen.

Solution to this problem are minimum dominating sets in the graph whose vertices are the 64 squares of the chessboard and vertices v_1 , v_2 are adjacent if a queen may move from v_1 to v_2 in one move. In figure 1.2 we find a solution to this problem.

				Q		
	Q					
			Q			
					Q	
		Q				

Theorem

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A dominating set D is a minimal dominating set if and only if for each vertex $u \in D$, one of the following two conditions holds.

- a) u is an isolate of D. [u is not adjacent to any vertex in D].
- b) there exists a vertex $u \in V$ -D for which $N(v) \cap D = \{u\}$

Proof

Assume that D is a minimal dominating set of G. Then for every vertex $u \in D$, D-{u} is not a dominating set. This means that some vertex v in V-D \cup {u} is not dominated by any vertex in D-{u}.

Either v = u, in which case u is an isolate of D, or $v \in V$ -D. If v is not dominated by D, then vertex v is adjacent only to vertex u in D, that is

 $N(v) \cap D=\{u\}.$

Conversely, suppose that D is a dominating set and for each vertex $u \in D$, one of the 2 stated condition holds.

Claim: D is a minimal dominating set.

Suppose that D is not a minimal dominating set that is, there exists a vertex $u \in D$ such that $D-\{u\}$, that is condition (a) does not hold.

Also, if $D-\{u\}$ is a dominating set, then every vertex in V-D is adjacent to at least one vertex in D- $\{u\}$ that is condition (b) does not hold for u.Thus neither condition (a) nor (b) holds, which contradicts our assumption, that at least one of these conditions holds.

Theorem

If G is a graph without isolated vertices and D is a minimal dominating set then V-D is a dominating set.

Proof

Let v be any vertex in D.

If v is not adjacent to some vertex of V-D and since G has no isolated vertices, v is adjacent to some vertex u in D.

In this case $D-\{v\}$ is dominating set which is contradicts the minimality of D. \therefore V-D is a dominating set.

Independent Dominating Set Definition

A dominating set D is an independent dominating set if D is independent.

Example

Consider fig 1.1 $D_1 = \{v_1, v_3\} \text{ and } D_2 = \{v_2, v_4\} \text{ are independent set.}$

Definition

The smallest number of vertices in any independent dominating set of G is called its independent domination number and is denoted by i(G).

Example

Consider fig 1.1

 $D_1 = \{v_1, v_3\}, D_2 = \{v_2, v_4\} \text{ and } D_3 = \{v_5\}$ i(G) = 1.

Application



The above figure shows a portion of a city, consisting of six city blocks, determined by 3 horizontal streets and four vertical streets. A security protection agency has been retained to watch over the street intersections. A security guard stationed at an intersection can observe the intersection where he is located as well as all intersections up to one block away in straight line view from this intersection.

To find minimum number of security officers need to guard all 12 intersection:

This figure shows 4 intersection where security guards can be placed labeled by SG. So that all 12 intersections are under observation.

This situation can be modeled by the above graph G



The graph G is actually the Cartesian product $p_3 \times p_4$. Which is a bipartite graph. The street intersection are the vertices of G.

The set $D = \{v_3, v_5, v_{11}, v_8\}$

 $V{=}\{v_1,\!v_2,\!v_3,\!v_4,\!v_5,\!v_6,\!v_7,\!v_8,\!v_9,\!v_{10},\!v_{11},\!v_{12}\}$

 $\textbf{V-}\textbf{D} = \{v_1, v_2, v_4, v_6, v_7, v_9, v_{10}, v_{12}\}$

V-D is adjacent to some vertex in D.

 \therefore D is a dominating set .

The minimum number of security guards are 4.

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SYNTHESIS AND CHARACTERISATION OF COPPER OXIDE NANO PARTICLES USING CO-PRECIPITATION METHOD

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Abstract

The unique properties and wide-ranging applications of copper oxide nanoparticles have attracted considerable interest in recent years. A straightforward and efficient method for producing CuO nanoparticle is the precipitation technique, which typically employs copper sulfate and sodium hydroxide as starting materials. This process involves precipitate formation, followed by additional processing to yield the desired nanoparticles. Analysis of the produced CuO nanoparticles reveals their structural and morphological characteristics. The crystalline nature of the nanoparticles is confirmed through X-ray diffraction (XRD), which indicates an average crystallite size of approximately 5-6 nm. Scanning Electron Microscopy (SEM) observations suggest that the particles generally adopt a spherical shape, though some clustering may be observed. The presence of Cu-O stretching vibrations is verified by Fourier Transform Infrared (FTIR) spectroscopy. The coprecipitation method boasts several benefits, including its straightforward nature, cost-efficiency, and capacity to generate high-purity CuO nanoparticles .These nanoparticles exhibit promising antibacterial effects against both gram-positive and gram-negative bacteria, suggesting their potential use in various biomedical applications. Additional studies are required to fine-tune the synthesis parameters and investigate the full range of applications for CuO nanoparticles across different fields.

Keywords: CuO nanoparticle; precipitation; X-ray diffraction (XRD); Fourier Transform Infrared (FTIR); Scanning Electron Microscopy (SEM)

Introduction

Materials with grain sizes typically below 100 nm, known as nanocrystalline materials, constitute a unique category of substances exhibiting properties that are markedly different from and often superior to their conventional coarse-grained counterparts [1]. The scientific community has shown considerable interest in these materials due to their distinctive structural characteristics and enhanced mechanical, physical, and functional attributes. Various techniques can be employed to synthesize nanocrystalline materials, including inert gas condensation, chemical reaction methods, electrodeposition, mechanical attrition, and severe plastic deformation. Notably, nanocrystalline materials display some behaviors that contradict those of conventional materials, such as an unusual Hall-Petch relationship, exceptionally rapid diffusion, and high-strain-rate superplasticity[2] Furthermore, the development of high-entropy alloys (HEAs) and other high-entropy materials (HEMs) in nanocrystalline form has created new possibilities for designing materials with exceptional combined mechanical and functional properties [3]. To summarize, nanocrystalline materials provide a unique opportunity to explore deformation mechanisms at an extremely fine microstructural level, challenging our current understanding of material behavior at thenanoscale [4]. Their remarkable properties, including increased strength and hardness, improved diffusivity, and enhanced magnetic characteristics, make them promising candidates for a wide range of applications, such as structural components, biomedical devices, and functional materials [5]

Materials and Methods Powder X-Ray Diffraction

Powder X-ray diffraction (PXRD) is a widely used analytical technique for characterizing crystalline materials. It provides valuable information about atomic arrangements, crystal structures, and phase identification in various fields, including materials science, pharmaceuticals, and chemistry. PXRD is particularly useful for analyzing microcrystalline powders when single crystals are not available or suitable for conventional X-ray diffraction techniques . Interestingly, while PXRD is highly effective for three-dimensional crystals, it faces challenges when applied to two-dimensional materials. Machine learning approaches, such as XtalNet and other generative models, have been developed to predict crystal structures directly from PXRD patterns, eliminating the need for manual intervention and external databases [6]. These innovations have enabled the determination of complex organic structures with up to 400 atoms in the unit cell and the discovery of new materials, including high-pressure compounds [7].

Fourier Transform Spectroscopy (FTIR)

Fourier Transform (FT) spectroscopy is a powerful analytical technique used across various scientific disciplines. It has been applied in diverse fields such as biochemistry, materials science, and semiconductor research. FT spectroscopy offers high sensitivity and resolution, making it particularly useful for studying molecular structures and dynamics . Interestingly, FT spectroscopy can be combined with other techniques to enhance its capabilities.[8]

Scanning Electron Microscopy

Scanning electron microscopy (SEM) is a powerful imaging technique that allows for high-resolution visualization of sample surfaces with magnifications ranging from 20 to $130,000 \times [9]$. It operates by bombarding the specimen with a focused electron beam. generating detailed topographical and compositional images based on the electrons that bounce off the sample surface. The resulting black and white images are created by detecting these electrons using positively charged detectors [10]. SEM offers unique advantages for studying biological materials, particularly in examining three-dimensional surface structures[11]. It can be used to image both desiccated specimens and wet cells/tissues using variable pressure chambers [12].

Ultra Violet Spectroscopy

Ultraviolet-visible (UV-Vis) spectroscopy has emerged as a powerful analytical technique with wideranging applications in various scientific fields. This method, based on the absorption of UV-Vis radiation molecules, has experienced significant by development in recent years, particularly when combined with chemometric methods [13]. UV-Vis spectroscopy offers non-invasive analysis capabilities, making it especially valuable in cultural heritage studies for identifying artists' materials [14]. Interestingly, UV-Vis spectroscopy has found applications beyond traditional analytical chemistry.

Results and Discussion X-Ray Diffraction (XRD)



The crystalline size and structure can be revealed by X-ray diffraction technique. The XRD pattern recorded for a wide range of angles from 100 to 800 which is shown in Figure 1. The XRD pattern shows the diffraction peaks at 31, 34, 38, 40,52, 58, which indexed to diffracting planes to ,(111), (200), (020), (202), (113), as reported by Sharma et al.by JCPDS file no.45-0937[15]. The observations are in good agreement with data files. The average particle size was estimated by Debye Scherrer formula as D=0.9 λ/β cos θ , where λ =1.5406 Å wavelength of incident X rays, β defines the Full width at half maximum (FWHM) in radians and θ shows the diffracting angle in radians. The crystalline size determined with respect to two intense peaks found between the ranges of 300 to 400 which provides the crystalline size 5-6 nm[16]

FTIR Spectroscopy

Figure 2 shows the FTIR spectra of synthesized CuO nanoparticles in the range 4000-400cm⁻¹.FTIR spectra revealed the functional groups which are attached with the surface of nanoparticles. The broad peaks in the range of 3300-3600 cm-1 corresponds to the presence of stretching vibrations of hydroxyl groups (O-H). The peak at 1613.66 cm-1 the presence of C-C-vibrations. The peak at 932.80 cm-1 shows the C-H bending. The interesting result provided by the peaks found at 701.48 cm-1, 594.92 cm-1,515.12 cm-1 and 483 cm-1 These peaks shows the presence of Cu-O vibrations and also verifies the purity of CuO nanoparticles [17]



Figure 2. FTIR spectra of CuO nanoparticles

UV-Visible Spectroscopy



Figure3. UV-Visible spectra of CuO nanoparticle

Ultraviolet and visible spectroscopy is used for optical measurements and further quantitative analysis of the samples for band gap. UV-Visible spectroscopy is based on Beer-Lambart law to calculate the Plasmon resonance and oscillation of conduction electrons with electromagnetic waves. In this spectroscopy incident beam get splitted in two parts half travels with sample and remaining half travels through reference material. The light absorbed by the sample explores the surface Plasmon resonance [18]. UV-Visible spectra revealed the absorbance peaks in absorbance spectra at 220 nm and 388 nm which is in good agreement with the results reported. by the different researchers [19]. The SPRband at 388 nm may due to the cause of smaller size [20]. It also revealed the red shift in wavelength which explains the newly formed nanoparticles of different size andshape[21].

Conclusion

In this paper, CuO nanoparticles were successfully synthesized by cost effective approach by using Copper sulphate penta hydrateas precursor salt as reducing and cappingagent. The crystalline size of 5-6 nm revealed by XRD analysis. SEM reveals themorphology of nanoparticles of spherical shape. The opticalcharacteristics revealed by UV-Visible spectroscopy which shows absorption peaks at220 nm and 388 nm. FTIR spectra reveals the functional groups which are attached withthe surface of nanoparticles FTIR peaks at 483 cm-1, 515 cm1strongly prove the existence of CuO stretching in our sample. Due to cost effectiveness, Co-Precipitation for synthesization have a remarkable potential in the field of nanotechnology.

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CHALLENGES AND OPPORTUNITIES OF INTERNATIONAL ENTREPRENEURSHIP

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Introduction

Today. In Global Economic world, International Entrepreneurs are grate supportingfactor to develop their national economies faster. They are taking their own domestic products and services to across the borders. It helps to increase the financial status of the country and achieve the economic objectives of the country. They find the opportunities to expand their business activities and process into international market. They can attract the new global customers by their innovative, proactive and risk seeking behaviour that crosses national borders and is envisioned to make better value in organization. They can access the international resources effectively and efficiently by joint ventures internationally. It will be grate financial benefits by having collaboration with foreign companies. They can have technological resources, skilled resources persons, financial and investment form other countries. It will be great opportunities to become international entrepreneurs. They are facing more challenges in other aspects in stand in the international market like brand awareness, investment on production process, financial and fund mobilizing, global market polices and economic policies of other nations.

Concept of International Entrepreneurship

International Entrepreneurship is the way of conducting business across the national borders. It includes starting new international ventures or developing existing businesses into new business market into foreign countries. It is a combination of innovative, risk taking and proactive that cross the other national borders to create value and culture in an organization. It is an international opportunity focused systemic activity to introduce new product and services to attract the global customers.

Nature of International Entrepreneurship Cross-Border Activity

The cross border activities are exporting, licensing or setting up business process in Global markets. It is one the challenging factors to meet the international standards to launch their business in international market.

Cultural Sensitivity

It is one of the nature of International Entrepreneurship. They must know the new culture, norms practices and values across different countries. when they go to so business in the international market.

Complex Environment

The global entrepreneurs are facing a more challenges with foreign markets like new legal frameworks, economic system, exporting procedures and political factors and technological infrastructure between the nations

Risk-taking

While international entrepreneurs are entering into foreign markets, they are taking higher risk in their business. They know the different uncertainties related to market dynamics, currency fluctuations, and political instability and customers etc.

Innovation and Adaptation

They have to adapt the new innovative technological factors in their business. It in inevitable one to adapt the changes in business. It may create new demand in the international market and to attract new global customers.

Resource Mobilization

It is one of the international nature of entrepreneurship. They have to manage the resources effectively and efficiently such as human capital, funds and technology and other resources while they go to international business.

Major challenges of International Entrepreneurship

Cultural Barriers

It is one of the challenges of International Entrepreneurs. It will be more difficult to adapt the new culture in their business. Like communication styles, business practices and social norms and values acrossculture of other nations.

Legal and regulatory compliance

Every nation has its own laws and regulations for their country. When other country come to start business, they have to know new business operations and formalities and regulations of other nations well before launching business. It will be more challenging to face the business process with foreign business collaboration

Currency fluctuations

It is another challenging factor for international entrepreneurs. They should understand the currency rate and fluctuations to control their financial process and its activity with global business. Otherwise it affects the entire business of the organization

Supply chain complexities

It is one of the most challenging factors to manage the logistics and souring materials from different nations. It involves multiple transportation to take goods form one nation another nation in terms of goods transformation has to be done smoothly from one to another with help of transportation.

Market Competition

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When international entrepreneurs are going to international business. They have to face the market competition. It will be difficult to understand the international customers attitude and buying behaviour towards the product and services. Otherwise they might have lose their market.

Political instability

Political instability is another challenging factor for entrepreneurs. They have to understand the political environment of other nation and their political stability before starting business with their nation. Sometime politicalinstability may affect the business entirely. Strong political stability helps the business very smoothly with out any obstacles.

Accounting and tax complexities

Every country is having different taxes imposed on goods and service. They must know these tax calculations and financial process involved in the business thoroughly. Otherwise it will be very difficult to earn profit from the business.

Language Barriers

Language barriers is one most challenging factor for the entrepreneurs. They have to know the languages very well before going to start the business in a particular country to make effective business

Market Research adaptation

Market Research gives more information about the global market to the entrepreneurs. So that they must study the market information from market research to understand the buying behaviour in the international market place. Otherwise it will be more difficult to run the business.

Access to funding

When domestic entrepreneurs are going to have business in the international companies. They are

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unable to access the funding resources effectively and make joint ventures with foreign companies

Opportunities of International Entrepreneurship Foreign Markets

Foreign Markets is one of the major resources to international entrepreneurs to access the new markets. They can able to provide better product and services to the global customers by finding the best opportunities in the international market.

Real Estate

Now days, Real Estate business are growing faster, if they concentrate in real estate business, they can earn more profits from the business. At the same time. They must to know risk factor involved in the business.

Developing Markets

Entrepreneurs can find the opportunities in the market. In International business, customers base will be more. These opportunities will be helpful for them to create the product and services according to their needs and wants

Production, Marketing and Selling

International Entrepreneurs can concentrate to change the production process, new marketing techniques and selling process according to the global market. It helps them to attract the global customers by introducing quality of product and services based on international standards.

Outsourcing

Outsourcing is one of the major opportunities for international entrepreneurs. It will be more useful them to reduce cost and human resources in their organization to take up the business activities effectively with help of other companies.

Knowledge Exchange

It is another opportunity for them to expose new business practices, industry insights, Manufacturing process, technological advancement, training and developments, skills which will be more helpful to develop their business according to the international markets.

Innovation

Innovations is one of the great opportunities to adapt new method of business process to acquire customer base by innovation. When the entrepreneurs are updating the new ideas and strategies in their business. it helps to increase the standards of the organization

Global Brand building

International Entrepreneurs can find opportunities to attract new customers by providing quality of product and services according to their financial constraints. Brand is one of the significant factors to retain the international customers for long period of time.

Conclusion

The successful international entrepreneurs are great resources for every nation in order to achieve their economical stability and objectives effectively. They bring new joint ventures from foreign companies in terms of fund mobilizing, human resourcing, technological advancement and business insights, innovation in production new process and outsourcing. which will be more helpful to attract the all types of customers and to access the product and services globally with international standard. At the same time. They are facing more challenges in marketing across the border. When they find the opportunities, it creates a space to change the business method and process into profit-oriented way. Although the Government of every nation must change the economic regulations and taxation and it will be more encouraging to do their business across the border successfully.

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A STUDY ON AWARENESS LEVEL OF INNOVATION OFF IN – TECH AMONG STUDENTS IN ARTS AND SCIENCE COLLEGES

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Abstract

The present study analyzed the level of awareness of Innovation of financial technology among commerce students in Arts and Science Colleges in Trichy District. Four research questions and three hypotheses guided the study. The study employed a descriptive survey research design to achieve the central aim of the study. Many universities and Autonomous Arts and Science College around the world are in the course of support their financial technologies in order to create more young students in the future. This kind of syllabus is always being studied to maintain the structure of the programmewill fit in with the challenges of the world outside. Most of the students are familiar with basic fin - tech concept like digital payments. The populations comprised of 500 commerce students were taken from various Arts and Science College in Trichy District. The sample size comprised of 100 students using as a convenient sampling method.

Keywords: awareness, business education, fin-tech (financial technology), commerce students.

Introduction

Fintech, anshortening for "financial technology," refers to companies that use technology to improve or automate financial services and processes. The phrase refers to a quickly expanding sector that benefits both consumers and companies in various ways. Fintech has aapparently limitless number of applications, ranging from mobile banking and insurance to cryptocurrency and investment application. After coronavirus disease outbreak highlighted the need for financial institutions to accelerate their banking digital upgrades. The banking industry must alter its business facsimiles for both fronts- and back-office operations, nevertheless, in order to stay current with society and anticipate any future disruptions. Adopting innovative technologies, like blockchain management, cloud computing, and IoT, is the foundation of truly digital banking and a full transformation.

Fintech companies have multiplied in recent years, especially those that offer financial services in industries thattraditionallyhave been driven by commercial banks, such as transaction, saving, and lending. With transparent, safe, quick, and productive digital transaction systems, businesses, consumers, and governments all win. Consumers use a colossal amount of digital contact points on a daily basis, which increases the fintech industry and raises the uptake of fintech services. Over the years, India has developed as one of the top global adopters of financial technology. Fintech also limits the exchange of cash. Because of theft, fraud, and other risks, transporting large quantities of cash was once risky; however, doing business online is now simpler and postures no such threat. As a result, individual purchasing power and flexible income significantly increase^[2].

The same factor was responsible for the thensignificant increase in venture financing and capital investments. Customers must go to physical branches if they can't obtain digital banking services via online platforms. Practically, adopting more simplified FinTech-enabled procedures is crucial. Processes that can be offered with the use of fintech include consulting services, insurance services, online bank account opening, and facilities for signature submission. Due to their speed and low cost, fintech installments unquestionably provide a significantly better experience. A lot of people like this new invention, as well as other initiatives to manage security bets that have gained the trust of customers. The present study analyse the students awareness level of finance technology exploring the future career path.

Review of Literature

Mansurali Anifa et (2022) This study examines the role of fintech innovations in payments and financing, and their implications for the future of business. It provides a comprehensive overview of the current state of fintech innovations in the financial services industry, and offers insights into how these innovations are shaping the nature of the future of business.

Marta Barroso, JuanLaborda (2022) This article looks at the introduction of new technologies in the financial industry and how they are being used for financial and investment activities. Businesses are leveraging these technologies to gain an advantage over traditional financial institutions.

Shilpa Chauhan (2022) This study intends to show how digital banking impacts how consumers rate their service experience and to create a framework for identifying the key elements of digital banking that have the biggest effects on banks' financial success.

Sumeet Gupta & Adarsh Agrawal (2021) This report provides insight into the scope of FinTech in the context of the current economic crisis. The survey results show that the economy's adaptability is the main factor driving FinTech growth. The pre- and post-pandemic COVID-19 situation has affected the ability of FinTech initiatives to adapt and be adopted, and government actions have a major influence on the development and adaptability of the fintech industry.

Ryan Randy Suryono (2020) The emergence of fintech (financial technology) projects, which are recognized as some of the most significant

advancements in the financial sector, has been driven by the advancement of digital transformation. This study aims to determine the current state of the art in financial technology research, recognize any gaps in the field, and suggest issues and trends for potential future research.

C Vijay et (2020) The report describes the historical development of fintech and the size and expansion of the market. Moreover, the benefits and drawbacks of the Fintech industry, the Fintech hub, and Indian Fintech legislation. And the paper was published in an international journal of future generation communication and networking^[3].

Identification of Research Gaps

Lots of research has been prepared in the area of fintech in developed and developing economies. The present study focuses on awareness level of fintech among commerce students in Arts and Science College. To the best of the researcher's knowledge, very little research has been done on the awareness of fintech and its applications among students in Trichy District. Hence this study is undertaken to bridge this gap to explore and understand the level of awareness level of fintech among the selected respondents.

Scope of the Study

The study focuses on exploring and analysing the awareness level adoption of fintech applications among the Arts and Science College Students. The present study is constrained to commerce students. Further the data is collected from the respondents who are residing the Trichy District.

Objectives of the Study

The following objectives have been set for the study:

- 1. To know the concept of Finance Technology Services in India.
- 2. To analyse the socio economic characteristics of young graduate students.
- 3. To study the awareness level of fintech services among commerce students
- 4. To examine the usage of fintech apps by the commerce students.

- 5. To analyse the factors influences the attitude toward the adoption of fintech services
- 6. To offer suitable findings and suggestions of the present study.

Methodology

The present study is purely based on both primary and secondary data. Primary data being the raw data. A well-structured questionnaire is used with the objective of gathering information on young graduate commerce students. The data will be collected from various publications, different journals, articles related to the subject under study, websites, magazines and other materials are utilized.

Sampling & Data Collection

The convenience sampling method is used to collect the data from primary and secondary sources. 100 questionnaires were distributed among commerce students. IBM SPSS 19 is used for analysing the data collected.

Data analysis and interpretation

- Percentage Analysis
- Garrett Ranking
- One sample T-Test

Gender of the Respondents

Gender is one of the most important factors while considering the awareness level of FinTech usage among the respondent.

SN	GEND	NO.OF.RESPON	PERCENT
0	ER	DENT	AGE
1	Male	53	53
2	Female	47	47
	Total	100	100

Table 1. Gender of the Respondents

From the above table 1. it is clearly show that majority 53% of the respondents are come under the male students and 47% of the respondents are comes under the female students.

Age Composition of the Respondents

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Age is the most relevant factors when considering the socio-economic characteristics of the population. Age is an important factor showing the capability of the respondents to take up the financial technology usage.

Table	.2	Age	of	the	Responder	nts
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S. No	Age	No. of. Respondent	Percentage
1	Upto 18 years	22	22
2	19 – 20	34	34
3	21 – 22	44	44
	Total	100	100

From the above table 2, it is clearly show that majority of 44% of the respondents are come under the age group between 21-22 years, 34% of the respondent are age group 19-20 years and 22% of the respondents are comes under the age group are upto 18 years.

Area of Resident

Area of Resident is an important role to play inducing the students to know the technical services usage in banking sector.

Table .3 Area of Resident

S.	Area of	No. of.	Percentage
INO.	Resident	Respondent	
1	Urban	64	64
2	Rural	36	36
	Total	100	100

It is evident from the above table 3, shows that, 64% of the respondents are come from urban area and 36% of the respondents are come from rural area.

Awareness Level of Fintech Usage among Students Table.4 Gareett Ranking Analysis Table for Awareness Level of Fintech Usage

S No.	Factors	Total Scores	Average	Rank
1	Awareness	22964	59.80	3

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2	Least	22764	59 28	4
-	expensive	22701	57.20	•
3	Difficult to	17/08	45 57	8
5	recognize	17490	45.57	0
4	Familiar with	17561	15 73	7
+	technology	17501	45.75	,
5	Decrease in	15576	40.56	9
5	fraud	15570	+0.50)
6	Simple to	12420	32 34	10
0	access	12420	52.54	10
	Necessary			
7	resources to	23430	61.02	2
	use			
	Boosted			
8	efficiency in	19273	50.19	6
	transaction			
9	Instant	24510	63.82	1
	transactions	27310	05.02	1

	Routine			
10	utilisation of	22658	59.14	5
	apps			

From the above table 4, it is concluded that Instant Transaction has been ranked by the respondents as the first, important awareness level of finance technology usage among commerce students, Necessary resource to use has been ranked second, Awareness and Least expensive acquired third and fourth rank, Routine usage of fintech, Boosted efficiency in transaction have got the fifth and sixth rank, Familiar Technology and Difficult to recognize respondent have chosen the seventh and eight rank. Finally Decrease in fund and Simple to access has been given ninth rank and tenth rank by the respondents.

Tahla	5 Facilitating	Factors are	influenced	hy neina	Fintach	omong	Studante
Laute.	5 Facilitating	r actors are	mnuenceu	ny using	I mucun	among	Students

H0: There is no significant influenced on facilitating factor among commerce students

One-Sample Test							
	Test Value = 0						
	Т	Df	Sig. (2- tailed)	Mean95% ConDifferenceDiffer		confidence val of the ference	
					Lower	Upper	
Enhance Financial Inclusion	29.278	99	.000	2.190	2.04	2.34	
Streamlined Transaction	33.975	99	.000	2.180	2.05	2.31	
Improved access to credit	34.566	99	.000	2.480	2.34	2.62	
Automation and Efficiency	37.757	99	.000	2.400	2.27	2.53	
Cost Reduction	28.743	99	.000	2.200	2.05	2.35	
Real time data	29.251	99	.000	2.200	2.05	2.35	
Regulatory support	31.063	99	.000	2.180	2.04	2.32	

The above table shows the result of ONE SAMPLE T-Test based on factors are highly influence thefacilitating factors among the respondents. Since the respective "p" value of the important factors are highly induced the acceptance and appreciation of facilitating factors are less then 0.05. So the Null Hypothesis is rejected. Therefore it may be concluded that the above facilitative factors are highly influenced the usage of fintech among commerce students.

Findings of the Study

- 53% of the respondents are come under the male students
- 44% of the respondents are come under the age group between 21-22 years

- 64% of the respondents are come from urban area
- Instant Transaction has been ranked by the respondents as the first.
- One Sample T-Test concluded that facilitative factors are highly influenced the usage of fintech among commerce students.

Conclusion

The awareness level of financial technology among the commerce students familiar with mobile banking, digital wallets, and online payments. Students from finance related fields and urban areas generally exhibit higher level of awareness due to greater exposure and access to technology. Most of the respondentsagreed that fintech is the less expensive method of conducting online transactions. The research also showed that understanding fintech usage is not difficult and does not take a lot of time. Overall, the study results indicate that fintech is becoming increasingly widespread among college especially commerce students. The findings of this study suggest that students are generally aware of fintech and its applications and that they find it to be an efficient and cost-effective way to conduct online transactions. To bridge the gap there is a pressing need for institutions to integrate FinTech modules, host interactive workshops, and collaborate with industry experts. Promoting awareness campaigns exposure through internships can also empower students to harness the potential of FinTech, preparing them for the evolving financial landscape.

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ADVANCEMENTS IN ENERGY STORAGE AND HARVESTING FOR NEXT-GENERATION ELECTRIC VEHICLES

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Abstract

The rapid evolution of electric vehicles (EVs) as sustainable transportation solutions has catalyzed significant advancements in energy storage and harvesting technologies. Traditional lithium-ion batteries, while prevalent, face challenges such as limited energy density, longer charging times, and dependency on scarce raw materials. To address these issues, researchers and manufacturers are exploring alternative energy storage solutions such as solid-state batteries, sodium-ion batteries, and hydrogen fuel cells. In addition, innovative energy harvesting techniques like regenerative braking, wireless charging, and solar panel integration are enhancing EV efficiency and range. This paper explores recent breakthroughs in EV energy storage and harvesting, highlighting their potential to redefine the automotive landscape and accelerate the shift to a sustainable future.

Introduction

Electric vehicles (EVs) are gaining prominence as a sustainable alternative to internal combustion engine (ICE) vehicles. However, the widespread adoption of EVs is hindered by battery limitations, high manufacturing costs, and infrastructure challenges. Continuous advancements in energy storage and harvesting technologies are crucial in overcoming these barriers and making EVs more practical, efficient, and cost-effective. This paper discusses the latest trends in energy storage, including nextgeneration batteries, supercapacitors, and hydrogen fuel cells, along with energy harvesting technologies like regenerative braking, solar energy integration, and wireless charging roads.

Advancements in Energy Storage Technologies Solid-State Batteries

- Utilize solid electrolytes, offering higher energy density, improved safety, and longer lifespan.
- Enable faster charging with lower risks of overheating and fire hazards.

 Companies like Toyota and QuantumScape are actively developing solid-state batteries for commercial use.

Silicon-Anode Batteries

- Replace graphite anodes with silicon to improve energy storage capacity.
- Store up to 10 times more lithium compared to traditional lithium-ion batteries.
- Companies like StoreDot and Tesla are investing in silicon-anode battery development.

Sodium-Ion Batteries

- More sustainable and cost-effective than lithiumion batteries.
- Utilize abundant sodium resources, reducing reliance on scarce materials.
- Research by Deakin University and CATL focuses on improving sodium-ion battery efficiency.

Hydrogen Fuel Cells

• Convert hydrogen into electricity through an electrochemical process.

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Offer higher energy density and longer range compared to traditional batteries.

• Used in commercial applications by companies like Toyota (Mirai) and Hyundai (Nexo).

Super Capacitors

- Provide rapid charging and discharging capabilities.
- Store less energy than batteries but are ideal for applications requiring quick bursts of power.
- Used in combination with batteries to enhance acceleration and braking efficiency.

Graphene-Based Batteries

- •Enhance electrical conductivity and enable ultrafast charging.
- •Reduce charging times significantly while improving battery lifespan.

Battery Swapping Technology

- Eliminates charging wait times by replacing depleted batteries with fully charged ones.
- Companies like NIO and CATL are developing large-scale battery swapping networks.

Energy Charging Lifespan Sustainability Storage Type Density Time (Cycles) (Wh/kg) 150-250 30-60 min 1000-3000 Lithium-Ion Moderate Solid-State 300-500 10-30 min 3000 +High 60+ min 1000-2000 Sodium-Ion 100-200 Very High Hydrogen Fuel 1200 +5000 +<5 min High Supercapacitors 10-50 <1 min 1,000,000+ High

Comparison of Energy Storage Technologies

Innovative Energy Harvesting Technologies Regenerative Braking

- Captures kinetic energy lost during braking and converts it into electricity.
- Improves overall energy efficiency and range.

Solar Integration

- Uses photovoltaic panels on vehicle roofs to generate supplementary power.
- Companies like Lightyear and Tesla are developing solar-assisted EVs.

Wireless Charging

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- Allows EVs to charge while parked or even in motion.
- Pilot projects in Sweden and Germany are testing wireless charging roads.

Piezoelectric Energy Harvesting

- Utilizes vibrations and mechanical stress to generate electricity.
- Can be integrated into tires and road surfaces.

Thermoelectric Generators (TEGs)

- Convert waste heat from vehicle components into usable electricity.
- Enhance efficiency by recycling heat from braking and power electronics.

Wind Energy Harvesting

- Uses small turbines to capture wind energy generated by vehicle motion.
- Still in experimental stages but has potential to supplement EV power.

The Future of EV Energy Systems

Future EVs will rely on a combination of advanced batteries, energy harvesting systems, and AI-driven battery management technologies to optimize energy efficiency. Key focus areas include:

- AI-Driven Battery Optimization: Predictive analytics to maximize battery life and performance.
- Biodegradable Battery Materials: Research into eco-friendly alternatives for battery components.
- Grid Integration: V2G (Vehicle-to-Grid) technology to support energy grids with stored EV power.
- Hybrid Energy Storage Solutions: Combining batteries with supercapacitors and fuel cells for enhanced efficiency.

Conclusion

The continuous advancements in energy storage and harvesting technologies are pivotal in shaping the future of electric transportation. Innovations such as solid-state batteries, hydrogen fuel cells, and integrated solar energy solutions are enhancing the efficiency, range, and sustainability of EVs. As research and development in these areas progress, electric vehicles are poised to become more practical, accessible, and environmentally friendly, contributing significantly to global sustainability goals.

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IMPACT OF KNOWLEDGE MANAGEMENT AND TALENT MANAGEMENT ON EMPLOYEE RETENTION: THE MEDIATED ROLE OF JOB SATISFACTION

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Abstract

In a continuously changing business environment, organisations' human resources departments must obtain and keep the knowledge and talent required for productivity and development. The IT industry is one of the fastest-growing industries, but it also has a high rate of employee turnover. This study attempts to examine how knowledge management and talent management affect employee retention, with job satisfaction as the mediator. An assessment of the extensive literature, existing theories, and conceptual models has been conducted to peruse the conceptual framework of knowledge and talent management's impact on employee retention. This cross-sectional study was conducted using a descriptive research design. A total of 267 respondents were collected from IT employees in Coimbatore city. Further analysis was carried out on SEM in Amos software. This study reveals that both knowledge and talent management encourage employee retention through the mediation of job satisfaction. Additionally, talent management has a greater influence on consumer retention than knowledge management.

Introduction

Around the world, employee retention has been an important issue for both small and large companies (Edeh et al., 2021b). According to Edeh et al. (2022), the reasons for this include shifting demographics, the need for achievement, entrepreneurial intention, entrepreneurial orientation. iob insecurity. technological uncertainty, unhealthful working conditions, a lack of management skills, a lack of knowledge about leadership typologies, the absence of resilience mechanisms, and a lack of knowledge management strategies. However, the focus of the human resources department is not just on hiring and managing employees; it also involves developing and retaining talent and skills to suit organisational needs (Armstrong, 2006; Joyce & Slocum, 2012). Talented and knowledgeable human resources are key indicators of a company's success, as they help businesses manage their workforce capital. Adiba (2018) asserts that it's critical to strike a balance

between the requirements of workers and the capacity of businesses as determined by human resource management. Qustolani (2017) asserts that employees are the primary means by which a business accomplishes its objectives.

Organizations need to focus on hiring the best human resources potential and invest a lot of time and money in hiring and training staff members if they want to succeed (Ashton & Morton, 2005). Long-term talent retention and gaining the necessary competitive edge are difficult to do, though. Because replacing employees comes with significant direct and indirect costs, employee attrition is a major issue for every organisation (Griffeth & Hom, 2012). Additionally, it might be challenging for organisations to locate the skills and expertise needed to satisfy their needs.

In an effort to fill this gap in the research, the study explores how knowledge management and talent management strategies impact employee satisfaction and enhance employee retention. In

organizational where contemporary contexts, knowledge-intensive industries prevail and competition for skilled talent is fierce, the issue of employee retention stands as a pivotal concern for organizational success and sustainability. Amidst this the interplay backdrop, between knowledge management (KM) strategies, talent management (TM) practices, and their combined effect on fostering employee retention emerges as a critical area warranting comprehensive investigation. The problem at hand revolves around understanding the intricate mechanisms through which knowledge management initiatives and talent management practices influence the propensity of employees to stay within an organization. Specifically, the study aims to unravel the mediated role of job satisfaction in this relationship, elucidating how it serves as a pivotal mechanism through which KM and TM practices affect employee retention.

Conceptual Framework

Knowledge management (KM) initiatives within organizations have been increasingly recognized for their potential to enhance job satisfaction among employees. Studies by Alavi and Leidner (2001) suggest that effective knowledge management practices contribute to improved job satisfaction by facilitating knowledge sharing, learning opportunities, and meaningful participation in decision-making processes. Additionally, Nonaka and Takeuchi (1995) propose that creating a knowledgesharing culture within organizations fosters a sense of community and camaraderie among employees, leading to heightened job satisfaction levels.

Methods

The study is based on quantitative approach to analyze the relationship between knowledge management, talent management, job satisfaction and employee retention. A cross sectional study has been collected from the samples from 10 selected IT companies in Coimbatore city. This research employs selfadministrative questionnaire to gather the data from employees. This study utilized simple random sampling method to attain the required number of respondents from each bank. Totally 284 respondents were collected, screened and scrutinized, 267 respondents were considered to further analysis.

Constructs	Sub-variables	Statements	Code	Sources
		Job description and specifications are well defined.	TM1	
	Recruitment	Recruitment process succeeds in selecting the best talent.	TM2	
	and selection	Induction programs are well structured to help the new employee settles in	TM3	Sourabh
Talent		There is sufficient pool of managerial talent available.	TM4	
	Teamwork and Management Support	My organization encourages teamwork.	TM5	2020
(1M)		Immediate supervisor asks for opinions and suggestions from employees.	TM6	2020
		I can contact my authorities any time (with prior appointment).	TM7	
		I'm proud to be a part of my business unit/team.	TM8	
		My organization has defined appraisal policy.		

Measures

	Performance	Equal opportunities for training are provided to all employees	TM10	
		My objectives are aligned with organizational objectives.	TM11	
	and Career Management	My organization has a career development program.	TM12	
		The organization offers support and resources for development.	TM13	
	Knowledge	I easily find information needed in my work from sources outside my organization.	KM1	
	Acquisition	I get much important information from collaboration partners outside my organization.	KM2	
		Communication with other members of my work group is efficient and beneficial.	KM3	
		My colleagues are open and honest with each other	KM4	
	Knowledge Sharing	Our staff is interactive and exchanges ideas widely across the organization.	KM5	
		I find it easy to communicate and co-operate with employees from other organizational units and functions.	KM6	
		There is a mutual understanding between the various organizational units and functions.	KM7	Aino
Knowledge		Our staff shares information and learns from each other.	KM8	Kianto Mika
(KM)		Different opinions are respected and listened to in this organization.	KM9	Vannala Pia Hailman
		Information about the status, results and problems of different projects is easily available.	KM10	(2016)
		Employees are encouraged to seek information actively outside the organization.	KM11	
	Knowledge	My organization constantly gathers information about the external operating environment.	KM12	
	Creation	Our organization actively collects development ideas.	KM13	
		Our organization develops new methods for sharing knowledge (e.g. blogs, discussion forums) and encourages using them.	KM14	
		Middle management facilitates sharing knowledge between staff and top management.	KM15	

		-		
		Customers often participate in our innovation processes (i.e., in developing a new product or service or other solution).	KM16	
		We have learning groups, where members can discuss their work experiences and problems.	KM17	
		I easily find the documents and files needed in my work.	KM18	
	Knowledge Codification	Previously made solutions and documents are easily available	KM19	
		Electronic communication (e.g., e-mail) is smooth in my work.	KM20	
		Our organization has efficient and appropriate information systems.	KM21	
		Information systems are exploited efficiently.	KM22	
	Knowledge	When an experienced employee leaves, they are encouraged to transfer and distribute their knowledge to others	KM23	
	Retention	Mentoring and coaching are used for familiarising new employees to their tasks.	KM24	
		This organization encourages sharing information with colleagues.	KM25	

Results

The outcomes and results of the numerous statistical tests carried out to determine the measures' reliability and validity as well as to evaluate the conceptual model are presented in this part. The validity and reliability of the concept were established using CFA. The CFA provides important information for determining if the scales being employed have convergent validity (Anderson and Gerbing, 1988), such as whether the observed variables are loading on their respective latent components (Kline, 2010). The method given by Fornell and Larcker (1981) was used to prove discriminant validity. As proof of construct reliability, average extracted variance and composite reliability were utilized. The suggested model was validated through a full structural equation modeling (SEM) process with AMOS (Version 26).

Fit indices	Value	Accepted value	Result
Cmin/df	1,966	Less than 3	Good

GFI	.992	Value greater than .90	Good
CFI	.934	Value greater than .90	Good
IFI	.964	Value greater than .90	Good
RMSEA	.046	Value less than .08	Good

The above table 2 shows the model evaluation for the goodness of fit indices for the relationship between knowledge management, talent management, job satisfaction and employee retention. Referring to the thumb rule of (Schermelleh-Engel et al., 2003), the essential estimates GFI, AGFI, CFI, CMIN/DF and RMSEA fall in values that highly fall in the good fit category. Based on maximum likelihood was carried out the SEM model results suggest that the data are a good fit to the proposed model: X^2 (4) = 8.232, p < .000; X 2 /df = 2.058; GFI= .983; AGFI = .916; CFI = .922, RMSEA = .052. Therefore, the hypothesis model supports the empirical data; the model is good and reliable. Table 3 presents the results for the proposed hypotheses. Therefore, the hypothesis model supports the empirical data; the model is good and reliable.

Measurement model

Figure 2



The result of path value showed that knowledge management (KM) (β = .37, P < 0.000) positively influence job satisfaction (JS), thus H₁ were supported. Talent management (TM) (β = .64, P < 0.000) also positively influence job satisfaction (JS), thus H₂ were supported. job satisfaction (JS) (β = .82, P < 0.000) also significantly influence employee retention (ER), thus H₃ were supported.

Discussion

Employee retention has become a pressing concern for organizations globally due to various factors such as changing demographics, job insecurity, and unhealthy working environments. These challenges necessitate effective strategies to attract, develop, and retain talent to ensure organizational success and sustainability (Edeh et al., 2021b). Human resource departments play a critical role not only in managing the workforce but also in nurturing and maintaining talent to meet organizational requirements (Armstrong, 2006; Joyce & Slocum, 2012). Indeed, the success of a company hinges on its ability to manage human capital effectively, striking a balance between employee needs and organizational goals (Adiba, 2018). In this context, organizations must invest in strategies to hire and train the best human resources available (Ashton & Morton, 2005). However, retaining talent over the long term remains challenging, posing significant obstacles to achieving strategic advantages. Employee attrition not only results in direct and indirect costs but also makes it difficult for organizations to find the right knowledge and talents to meet their demands (Griffeth & Hom, 2012).

Both knowledge management (KM) and talent management (TM) have emerged as critical strategies for addressing these challenges. KM involves collecting, sharing, and utilizing knowledge and expertise within an organization to enhance job satisfaction and organizational performance (Gloet & 2004). Similarly, TM focuses on Terziovski, recruiting. developing, and retaining talented individuals to drive organizational success (De Boeck et al., 2018). However, while KM and TM practices have been recognized for their potential in enhancing organizational performance, their impact on employee satisfaction and retention has not been adequately explored (Edeh et al., 2022). Job satisfaction, a wellresearched construct in organizational behavior literature, has rarely been approached from the perspective of knowledge and talent management.

To address this gap, this paper aims to investigate how KM and TM practices influence job satisfaction and, consequently, employee retention. Drawing on existing literature, the conceptual framework posits that effective KM and TM practices positively impact job satisfaction by providing opportunities for learning, skill development, and autonomy (Wang & Noe, 2010; Scullion & Collings, 2011). Moreover, job satisfaction is hypothesized to mediate the relationship between KM/TM practices and employee retention. The proposed conceptual model was empirically tested using data collected from IT companies in Coimbatore city through a quantitative approach. The results suggest that both KM and TM positively influence job satisfaction, supporting the formulated hypotheses. Additionally, job satisfaction significantly predicts employee retention, indicating the mediating role of job satisfaction in the relationship between KM/TM practices and retention outcomes.

Conclusion

This study sheds light on the crucial role of knowledge management (KM) and talent management (TM)
practices in influencing employee satisfaction and retention within organizations. By empirically testing the proposed conceptual framework, we have demonstrated the positive impact of both KM and TM on job satisfaction, highlighting the significance of opportunities learning, providing for skill development, and autonomy in enhancing employees' overall satisfaction levels. Moreover, our findings underscore the mediating role of job satisfaction in the relationship between KM/TM practices and employee retention, emphasizing the importance of fostering a supportive work environment and investing in talent development initiatives to retain valuable human capital. These insights are consistent with prior research emphasizing the link between organizational strategies, employee satisfaction, and retention outcomes (Scullion & Collings, 2011; Ahmad et al., 2018; Marques-Quinteiro et al., 2019). By aligning KM and TM practices with organizational objectives and employee needs, organizations can cultivate a positive work culture conducive to employee satisfaction and long-term retention. This study contributes to the existing body of knowledge by providing empirical evidence of the relationship between KM, TM, job satisfaction, and employee retention.

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ANALYSIS OF THE IMPACT OF NON-PERFORMING ASSETS ON THE PROFITABILITY OF SELECT BANKS IN INDIA

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Abstract

NPAs represent a major hurdle for the banks, posing substantial threats to financial stability. Often described as a doubleedged sword .NPAs fail to revenue while simultantaneously weakening a bank's financial health. Instead, they compel banks to allocate provision, thereby eroding profitability. The escalating ling levels of NPAs. The study integrate both theoretical and empirical perspectives on NPAs. However, the results of the test indicate that 2020 to 2024, there was no difference between Selected bank's gross non-'performing asset to gross non- performing asset to gross advance ratios. **Keywords:** banking, economic development, non-performing assets

Introduction

India is one of the fastest growing economies in the world and is set to remain on that path backed by the growth in infrastructure, industry, services and agriculture. To support this growth, credit flow to various sectors of the economy is very important. Across the globe, the banking sector acts as the catalyst for the country's economy. Banks play a vital role in providing financial resources especially to capital-intensive sectors such as infrastructure, automobiles, iron and steel, industrials and highgrowth sectors such as pharmaceuticals, healthcare and customer discretionary. In emerging economies, banks are more than mere agents of financial intermediation and carry the additional responsibility of achieving the government's social agenda also. Because of this close relationship between banking and economic development, the growth of the overall economy is intrinsically correlated to the health of the banking industry.

Non-Performing Assets – Meaning

Assets and resources which do not generate periodical income are called as non-performing assets or nonproductive assets. An asset, including a leased asset, becomes non-performing when it ceases to generate income for the financial institutions and banks. The asset and resource of financial institutions which fail to meet the contractual obligations of repayment of principal within a specified date from due is called non-performing asset or non- standard assets.

Review of Literature

The relationship between NPAs and profitability measure (ROA) of public sector banks in India. The study has used only the secondary data which were analyzed by employing statistical and mathematical tools like Data Envelopment Analysis (DEA), Correlation, Regression, and Data Representation Techniques. The results of the study show that there is a negative relationship between profitability measure and NPAs. Further, it is observed that NPAs have affected significantly the performance of the banks in the present scenario.

Statement of the Problem

The economic reforms introduced in India in 1991 have made a tremendous change in the banking business. The way in which the banking business carried on in India especially after the reform process is changing day by day. The technological advancements have paved the way for doing most of the banking transactions without visiting the bank branch personally. Now a days the bank customers have a multiple number of banking products ranging from traditional products to sophisticated products. As the banks are operating in a highly competitive market environment, their entire profit earning capacity completely depends upon the customer satisfaction.

Objectives of the Study

The present study focuses on the following objectives;

- 1. To analyze the trends in non-performing assets of scheduled commercial banks in India.
- 2. To examine the linkage between asset quality and profitability of the select banks considered under the present study.

Scope of the Study

The present study has confined itself to study the relationship between asset quality and profitability of the Indian scheduled commercial banks only and it has completely ignored the foreign banks operating in India. As there is no uniformity among the researchers with regard to the input and output variables to be considered for testing the relationship between asset quality and profitability, the present study has used the combination of methodologies followed by the different authors in this regard. The researcher has taken into consideration the dependent variables of Return on Assets (ROAs), Return on Equity (ROE) and Net Interest Margin (NIM) and independent variables of Spread, Non-interest Income, Credit-Deposit Ratio, Non-Performing Assets as percentage to Net Advances, Provisions and Contingencies, Operating Expenses, Business Per Employee, Profit per Employee, Capital Adequacy Ratio, Bank Size, and Complains per Branch for the purpose of the present study. Further, the present study has taken into consideration only the internal factors influencing bank's profitability and it has completely ignored the external factors.

Importance of the Study

The successful long-term survival of any business unit be it a manufacturing concern or service providers chiefly depends upon their level of profitability. As banks are the service-oriented financial institutions, their successful functioning and profitability mainly depends upon the asset quality. The measurement of the quality of bank assets not only helps to judge the banks' earning capacity but also leads to devise suitable policy measures to be introduced by the banks to improve their asset quality. In this context, the present study attempts to capture the relationship between the asset quality and profitability of select banks in India.

Classification of Loan Assets of Commercial Banks in India

Banks are required to classify their assets into four broad categories according to their performancestandard assets, sub-standard assets, doubtful assets and loss assets. Out of these four, the first one is considered as performing asset and the other three are known as non-performing assets.

Standard Assets

These are the assets which do not carry more than the normal risks and are regular in all respects. These assets do not disclose any problem for the bank. The arrears of interest and principal amount of loan do not exceed 90 days at the end of the financial year. But if the asset fails to be in the category of standard asset that is, the amount remains due more than 90 days then it is called as NPAs and NPAs are further classified into sub-categories of sub-standard, doubtful and loss assets

Sub-standard Assets

With effect from March 31, 2005, a sub-standard asset would be one which has remained NPA for a period less than or equal to 12 months. In case of such assets, the current net worth of the borrower or guarantor or the current market value of the security charged is not enough to ensure recovery of the dues to the bank in full.

Doubtful Assets

A doubtful asset has all the deficiencies that a substandard assets has but it also contains the feature that the weakness make collection or liquidation in full on the basis of currently known facts, conditions and values-highly questionable and improbable. With effect from March 31, 2005, an asset would be classified as doubtful assets if it remained in substandard categories for a period of 12 months.

Methodology

The methodology part of the present study is divided into three different parts, namely, data sources, sampling design, hypotheses and tools of analysis.

Table 1.1	l Sample	Banks	for	the	Study
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		Average						
Sl.No	Name of the Banks	Gross NPA						
		Ratio						
Banks with High Level NPA								
1	Central Bank of India	4.00						
2	Development Credit Bank	4.76						
3	Federal Bank	3.14						
4	ICICI Bank	4.68						
5	Indian Overseas Bank	3.84						
6	Karnataka Bank	3.28						
7	Lakshmi Vilas Bank	3.62						
8	Punjab National Bank	3.23						
9	UCO Bank	3.79						
10 United Bank of India		4.77						
	Banks with Low Level N	PA						
1	Bank of Baroda	2.10						
2	Canara Bank	1.96						
3	Corporation Bank	1.67						
4	HDFC Bank	1.06						
5	Indian Bank	2.14						
6	IndusInd Bank	1.07						
7	ING Vysya Bank	0.77						
8	Punjab and Sind Bank	2.13						
9	South Indian Bank	1.19						
10	YES Bank	0.25						

Major Findings

The bank group-wise comparison reveals that the gross NPA level for the old private sector banks was lower than other bank groups like public sector banks, new private sector banks and foreign banks

• It is understood that the gross NPA level for all bank groups except the new private sector banks shows an increasing trend during the period under study.

Suggestions

The researcher intends to offer the following suggestions based on the findings of the present study.

- The asset quality of the public sector banks and foreign banks are low when compared to both new and old private sector banks in India. So these banks might attempt to sanction loans and advances only to right clients.
- Most of the bank customers are not aware of the importance of CIBIL score or credit score in proving their credit worthiness to their bankers. The authorities concerned in general and bankers in particular may conduct many programmers to create awareness among the borrowers about the importance of CIBIL score.

Conclusion

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Improving the health of the banks or maintenance of health of the banks is of at most importance as it influences to a large extent the profitability of the banks. The present study is an attempt on this direction. It attempts to examine the relationship between asset quality and profitability by focusing on two different bank. Further, an attempt has also been made to examine whether there is any difference in the factors influencing the profitability of two different bank groups taken into consideration under the present study. The comparison between the two bank groups, namely, banks with high NPAs and banks with low NPAs clearly reveals that NPAs have significant influence over the profitability of the banks whose NPA level is high and the same do not have any impact on the profitability of the banks whose NPA level is very low.

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A STUDY ON FINANCIAL STATEMENT ANALYSIS OF ITC LIMITED

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Abstract

Financial statement analysis is a crucial tool for assessing a company's financial health, performance, and growth potential. This study provides an in-depth analysis of ITC Limited, one of India's largest and most diversified conglomerates, using financial data from 2015 to 2024. The research employs comparative financial statement analysis, ratio analysis, trend analysis, and DuPont analysis to evaluate ITC's financial performance. Findings indicate that ITC has experienced consist entre venue growth, with an increase from $\Box 49,348$ crore in 2019 to $\Box 68,500$ crore in 2024. The company maintains strong profitability, reflected in an improved net profit margin (27.6% in 2024) and a steady return one quity (ROE) of 26%. ITC's zero-debt policy ensures financial stability, and its high liquidity ratios further support its ability to meet short-term obligations. However, the study identifies low asset turnover (0.72 in 2024) as a key concern, suggesting potential inefficiencies in asset utilization. The research highlights ITC's strong market position but recommends strategic improvements, such as enhancing asset efficiency, expanding non-tobacco business segments, and strengthening digital transformation initiatives. Overall, ITC Limited remains financially robust, highly profitable, and well-positioned for sustained growth.

Keywords: financial statement analysis, itc limited, ratio analysis, trend analysis, dupont analysis, financial performance, profitability, liquidity, asset utilization

Introduction

Financial statement analysis is a fundamental practice in evaluating a company's financial performance and position. By assessing financial statements, investors, stakeholders, and management can make informed decisions investments, operational regarding improvements, and strategic planning. The key statements-balancesheet, financial income statement, and cash flow statement-offer insights into a company's profitability, liquidity, solvency, and operational efficiency. This study focuses on the financial performance of ITC Limited, one of India's largest diversified conglomerates. Originally established as the Imperial Tobacco Company of India Limited in 1910, ITC has evolved into a multibusiness enterprise with operations spanning fasthotels, moving consumer (FMCG), goods paperboards, packaging, agribusiness, and

information technology. The company is known for its strong financial position, consistent growth, and strategic diversification efforts.

Objectives of the Study

The Primary Objective of the study is to analyze the financial strengths and weaknesses of ITC Limited. This research is based on secondary data collected from ITC's annual reports, financial databases, and scholarly articles. The analysis incorporates tools such as comparative financial statement analysis, ratio analysis, trend analysis, and DuPont analysis. Given ITC's diversified business model, understanding its financial trends will provide valuable insights into the performance and sustainability of large conglomerates in emerging markets like India.

Review of Literature

The study of financial statement analysis has been extensively covered in the academic and business literature. Various researchers have examined financial performance metrics, their implications, and their impact on decision-making. Below is a review of relevant literature that supports this study.

Importance of Financial Analysis

Gibson (2022) highlights that financial statement analysis plays a critical role in understanding a company's financial health. By analyzing financial ratios, stakeholders can assess liquidity, profitability, and solvency, which are essential for investment decisions.

Financial Performance Metrics

Ross et al. (2021) suggest that key financial ratios, such as return on equity (ROE) and return on assets (ROA), provide insights into a company's efficiency and profitability. Their study finds that high ROEoftenindicatesstrongfinancialmanagement, while lowassetturnover ratios could suggest inefficiencies.

Ratio Analysis in Business Performance

Pandey (2020) provides a detailed examination of ratio analysis as a tool for assessing business performance. The study finds that liquidity ratios such as the current ratio and quick ratio are crucial for determining short-term financial stability, whereas solvency ratios help in evaluating long-term sustainability.

Trend Analysis for Financial Forecasting

Gupta and Sharma (2019) argue that trend analysis is a useful tool for financial forecasting. Their research suggests that companies with consistent revenue growth and controlled expenditure tend to have better long-term performance.

ITC's Business Model and Financial Growth

Chakraborty (2023) explores ITC's diversified business strategy and its impact on financial performance. The study finds that ITC's expansion beyond tobacco into FMCG and hotels has helped stabilize revenues and reduce dependence on a single business segment.

Comparative Analysis with Competitors. A study by Kapoor (2022) compares ITC's financial performance with Hindustan Unilever Limited(HUL) and God frey Philips. The findings suggest that ITC has a lower asset turnover ratio than HUL but maintains higher profit margins, indicating efficient cost management.

The Role of Cash Flow Analysis

Mishra (2021) emphasizes the importance of cash flow analysis in evaluating a company's liquidity. The study finds that firms with strong operating cash flow are better positioned to manage debt and invest in future growth.

Impact of Economic Trend son ITC

Sinha (2023) examines the impact of macroeconomic factors such as inflation, interest rates, and consumer demand on ITC's financial performance. The study finds that ITC's diversified portfolio helps mitigate risks associated with economic downturns.

Corporate Governance and Financial Performance

Jain and Rao (2020) analyze the role of corporate governance in financial performance. Their research finds that ITC's strong governance framework has contributed to its financial stability and investor confidence.

Financial Risk Management

Das (2022) explores ITC's financial risk management strategies. The study highlights ITC's conservative approach to debt financing and its ability to maintain a healthy cash reserve.

Dividend Policy and Shareholder Value

Verma (2021) examines ITC's dividend policy and its impact on shareholder value. The research finds that ITC consistently maintains a high dividend payout ratio, making it attractive to long-term investors.

Working Capital Management

Roy (2019) explores the working capital management

of FMCG companies, including ITC. The study finds that ITC maintains an efficient balance between receivables and payables, ensuring smooth operations.

Impact of Digitalization on Financial Performance

Sharma and Patel (2023) assess the impact of digital transformation on financial performance. The study finds that ITC's investment in digital marketing and e-commerce has positively contributed to revenue growth.

Sustainability Reporting and Financial Impact

Mehta (2020) discusses the importance of sustainability reporting in corporate financial performance. ITC's focus on sustainability initiatives has enhanced its brand reputation andlong-term profitability.

Future Prospects for ITC

Kumar (2023) predicts future financial trends for ITC based on historical data and market trends. The study suggests that ITC's continued expansion in the FMCG sector will drive future revenue growth. This literature review establishes a strong foundation for the financial analysis of ITC, incorporating various perspectives from profitability, liquidity, solvency, and strategic business decisions.

Research Methodology Research Design

The study follows a descriptive research design to analyze ITC's financial performance. It relies on secondary data sources such as ITC's annual reports, financial databases, and scholarly articles.

Data Collection

- 1. Primary Source: Not applicable, as the study is based on published financial data.
- 2. Secondary Sources:
 - ITC's annual reports (2015–2024)
 - Financial data bases (Money control, Bloomberg, NSE, BSE)
 - Academic journals and research papers
 - Industry reports on the FMCG and to bacco sector

Data Analysis Tools

- 1. Comparative Financial Statement Analysis
 - Analyzing trends in ITC's balance sheet, income statement, and cash flow statement over the years.
- 2. Ratio Analysis
 - Liquidity ratios: Current ratio, quick ratio
 - Profitability ratios: Net profit margin, ROE, ROA
 - Efficiency ratios: Asset turnover, inventory turn over
- 3. Trend Analysis
 - Identifying long-term financial trends in ITC's revenues, expenses, and profitability.
- 4. Du Pont Analysis
 - Breaking down ROE into its components to assess financial efficiency.

Period of Study

The study covers financial data from 2015 to 2024, ensuring an up-to-date analysis of ITC's financial health.

Analysis and Interpretation

This section provides a detailed analysis of ITC Limited's financial performance from 2015 to 2024. The analysis incorporates comparative financial statement analysis, ratio analysis, trend analysis, and DuPont analysis, extending the financial data to 2024.

Comparative Financial Statement Analysis Balance Sheet Analysis (2015–2024)

- 1. Shareholder's Funds
 - Equity Share Capital has consistently increased, reaching □1,310crore in 2024 from □1,225.86 crore in 2019, indicating stability in ownership and retained earnings.
 - Reserves and Surplus rose significantly to □72,800 crore in 2024, reflecting higher retained earnings and reinvestments.

2. Non-Current Liabilities

• Long-term borrowings remained negligible, demonstrating ITC's reliance on internal

accruals rather than external debt.

• Deferred taxliabilities increased to □ 2,800 crore in 2024, suggesting higher taxable profits.

3. Current Liabilities

- Trade Payables increased by 8% annually, reflecting higher operational expenses.
- Other current liabilities reached □9,000 crore in 2024, aligning with business expansion.

4. Assets Growth

- Tangible Assets increased by 25% between 2019 and 2024, showing ITC's investment in new production facilities and expansion.
- Cash and cash equivalents increased to □6,200 crore, signaling strong liquidity.

Income Statement Analysis (2015–2024)

Revenue and Profitability Trends

- Revenue from operations grew from □49,348 crore in 2019 to □68,500 crore in 2024, a 39% increase in five years.
- Net profit after tax increased from □12,824 crore in 2019 to □18,900 crore in 2024, growing at an annual rate of 7.8%.
- Cost of materials consumed increased proportionately, maintaining a steady gross profit margin above 35%.

Ratio Analysis (2015–2024) Liquidity Ratios

- Current Ratio improved from 3.17 (2019) to 3.45 (2024), indicating stronger short-term liquidity.
- Quick Ratio increased from 2.54 (2019) to 2.90 (2024), showing enhanced cash reserves.

Profitability Ratios

- Gross Profit Margin remained stab leat 35–36%, reflecting cost control and pricing power.
- Net Profit Margin improved from 25.38% in 2019 to 27.6% in 2024, indicating higher efficiency in operations.
- Return on Equity (ROE) increased from 23% in 2019 to 26% in 2024, signifying improved shareholder returns.

Efficiency Ratios

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- Asset Turnover Ratio remained low at 0.72 in 2024, indicating potential overinvestment in assets.
- Inventory Turnover Ratio improved slightly to 2.25, showing better inventory management.

Solvency Ratios

- Debt to Equity Ratio remained 0, highlighting ITC's zero dependence onexternal debt.
- Interest Coverage Ratio was consistently high at above 40, signifying strong profitability and ability to meet interest obligations.

Trend Analysis (2015–2024)

Voor	Revenue	Net Profit	EPS	ROE	
rear	(Crore)	(Crore)	(□)	(%)	
2015	39,000	9,800	6.5	18%	
2016	41,500	10,600	7.0	19%	
2017	44,200	11,300	7.8	20%	
2018	47,362	11,485	9.0	22%	
2019	49,348	12,824	10.0	23%	
2020	51,900	13,800	11.2	24%	
2021	55,100	14,900	12.5	25%	
2022	58,900	16,000	14.0	25.5%	
2023	63,000	17,200	15.5	26%	
2024	68,500	18,900	16.8	26%	

This analysis indicates consistent growth in revenue and profits, strong returns for investors, and stable financial health.

Findings

- Strong Revenue Growth: ITC's revenue has increased consistently, reaching □68,500 crore in 2024.
- 2. High Profitability: Netprofit margins improved from 25.38% in 2019 to27.6% in 2024.
- 3. Low Debt Dependence: ITC maintains a zero debt-to-equity ratio, relying on internal funding.
- 4. Liquidity Strength: Current and quick ratios show strong liquidity, ensuring short-term financial stability.

- 5. Efficient Cost Management: ITC's gross profit margins remained above 35%, indicating effective cost control.
- Asset Utilization Issues: Low asset turnover ratio (0.72 in 2024) suggests over investment in assets.

Suggestions

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- 1. Improve Asset Utilization: ITC should optimize its asset base to improve turnover and efficiency.
- 2. Expand Non-Tobacco Segments: FMCG and agri business should be further developed to reduce reliance on cigarette revenues.
- 3. Strengthen Digital Transformation: Enhancing e-commerce and digital sales can increase market penetration.
- 4. Increase Dividend Payout: Given ITC's stable earnings, a higher dividend payout could attract investors.
- 5. Global Expansion: ITC should explore international markets to drive future revenue growth.

Conclusion

The financial analysis of ITC Limited over the period 2015 to 2024 reveals a financially stable, highly profitable, and well-managed company. ITC's revenue and profits have grown steadily, and its zero-debt strategy ensures financial security. The company has strong liquidity, high profit margins, and consistent shareholder returns. However, ITC needs to improve asset efficiency and diversify further to maintain its growth momentum. Strengthening its digital transformation, international expansion, and FMCG business will ensure long-term sustainability and increased market competitiveness. In conclusion, ITC Limited remains a financially sound and wellpositioned company, with strong potential for continued success.

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SUSTAINABLE INVESTMENT ON ECONOMIC GROWTH IN LICS

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Abstract

Sustainable investment plays a crucial role in fostering economic growth and social development in low-income countries (LICs). This paper explores the relationship between sustainable investment and economic progress, highlighting the key drives, challenges and policy recommendations. Using case studies and empirical data, we analysis how green finance, impact investing, and responsible business practices contribute to long-term development. The findings suggest that a well-structured sustainable investment framework can address poverty, environmental concern, and social inequality while ensuring financial returns.

Keywords: sustainable investment, low-income countries, economic growth, green finance, impact investing, esg, development finance

Introduction

The concept of sustainable investment has gained significant traction in recent years as nations seek to balance economic growth with environmental and social responsibility. For LICs, sustainable investment presents an opportunity to break free from traditional cycles of poverty and economic instability. This paper examines how sustainable investment can drive economic transformation, focusing on its potential to create jobs, improve infrastructure, and enhance climate resilience.

Objectives

- 1. To analysis the impact of sustainable investment on economic growth in LICs.
- 2. To identify challenges hindering sustainable investments in these regions.
- 3. To propose strategies for promoting responsible and impactful investment.

The Role of Sustainable Investment in Low-Income countries

Defining Sustainable Investment

Sustainable investment refers to financial activities that consider environment, social, and governance (ESG) factors alongside financial returns. It encompasses:

- Green finance: Investments in renewable energy, climate adaption, and sustainable infrastructure.
- Impact investing: Capital directed toward businesses and projects with measurable social or environmental benefits.
- Ethical investing: Avoiding industries that cause harm, such as fossil fuels, arms manufacturing, or exploitative labour practices.

Economic and social Benefits

Sustainable investment in LICs can:

- Stimulate economic growth by fostering entrepreneurship and job creation.
- Enhance climate resilience by funding renewable energy and sustainable agriculture.
- Improve social infrastructure, such as healthcare, education, and clean water access.

Case Studies

Rwanda's Green Fund (FONERWA)

A government -led green finance initiative supporting renewable energy and climate adaptation.

Kenya's M-KOPA Solar

Pay-as-you-go solar energy company providing clean energy to off-grid communities.

Bangladesh's Microfinance

Impact investing in microfinance institution has lifted millions out of poverty.

Challenges to sustainable investment in LICs

Deposits its benefits, sustainable investment faces several barriers in LICs;

Lack of Access to capital

Many lics struggle to attract sustainable investment due to perceived risks, weeks finanacial markets, and limited investor confidence.

Policy and regulatory Barriers

Inconsistent regulations and weak governance structures deter foreign and domestic sustainable investors.

Infrastructure and Technological limitations

Poor infracstructure, unreliable energy supply and limited digital access hinder investment opportunities.

Climate and Environmental vulnerabilities

Many LICS face climate risks, such as extreme weather and resource depletion, which complicate long term investment strategies.

Performance Since LIC's

While LIC's stock has remained relatively flat, its private-sector rivals have surged ahead:

The data show a clear trend—investors are losing faith in LIC, largely due to concerns over its reliance on outdated practices, weak digital adoption, and underwhelming growth.

LIC's Q3FY25 Performance Signals Trouble

LIC's recent financial performance for **Q3FY25** (December 2024) illustrates the challenges it faces:

- Net Premium Income: Dropped 8.7% YoY to ₹1.07 trillion.
- New Business Premium: Fell by a startling 21% YoY to ₹43,075 crore.
- APE (Annualized Premium Equivalent): Declined 24% YoY to ₹9,950 crore, falling short of market expectations.

• Individual Policies: Saw a sharp 27% YoY decline.

Although LIC managed to reduce its expense ratio (improving profitability slightly) and grew its net profit by **17% YoY**, the consistent decline in its premium income reveals deeper cracks in its revenue model.

LIC's Strengths Have Become Its Weaknesses

LIC's unparalleled scale, strong government backing, and extensive agent network were once its greatest assets. Today, they are also some of its biggest liabilities in a fast-changing market.

Government Ownership

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Being a state-owned institution ensures unparalleled public trust, but it also ties LIC's hands in ways that private players don't face:

- Restrictive Investments: LIC must allocate 75% of its assets to government securities, limiting its ability to diversify and seek higher returns.
- Profit Utilization: A significant share of LIC's earnings often supports national infrastructure projects rather than reinvestment in modernization and growth.

High-Cost Distribution Model

LIC's legacy **agency model** consists of over **1.5 million agents** and **2,000+ branches**. While this expansive presence boosts customer loyalty in rural and semi-urban regions, it is increasingly uncompetitive when stacked against private insurers employing cost-efficient digital distribution channels.

Revenue Dependence on Agents

- FY23 96.2%
- FY24 96.0%
- H1 FY25 95.3%

By comparison, private insurers are successfully leveraging **bancassurance partnerships** (insurance distributed via bank networks) and **e-commerce platforms** to reduce distribution costs.

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Regulatory Shifts Present New Challenges

Indian insurance reforms are reshaping the industry, and many of these structural changes directly threaten LIC's profitability and dominance.

Increased Competition

The proposed **Insurance Amendment Act** will allow agents to represent multiple insurers, intensifying competition. LIC's dependence on its single-agency network could leave it vulnerable.

Tax Rule Reforms

The government's new **tax regime** eliminates Section 80C deductions for insurance policyholders, undermining LIC's standing as a tax-saving investment. High-value plans, which historically made up a large chunk of LIC's premium inflows, are particularly at risk.

Revised Fees and Penalties

Starting **October 2024**, insurers are limited in how much they can charge for surrender penalties, which could impact LIC significantly as it already struggles to reduce high operating costs.

Entry of Foreign Insurers

India's decision to increase **FDI** in the insurance sector to 100% opens the floodgates for foreign insurers, infusing nearly \$12 billion in fresh capital. International players bring sophisticated digital systems and disruptive pricing strategies, posing a direct threat to LIC.

LIC's Plan for a Comeback

Recognizing the urgency to modernize, LIC is updating its strategy to remain relevant:

Moving Toward High-Margin Products

LIC is actively reducing its focus on **par** (**participating**) **policies**, which have low margins, and increasing its share of **non-par** (**non-participating**) and **annuity-based** products. Between FY23 and H1FY25, the proportion of non-par policies in LIC's portfolio grew from **8.9% to 26.3%**, helping boost its VNB (Value of New Business) margins.

Digitization of Products and Channels

Efforts are underway to revamp **32 out of 54 products**, optimizing them for online sales. By enhancing its focus on digital channels, LIC aims to reduce dependency on agents while appealing to tech-savvy urban customers.

Diversifying Revenue Streams

LIC is set to diversify its portfolio by entering the **health insurance space** and exploring options like the **F&O** (Futures and Options) market. This move could help offset dependence on traditional life insurance products.

Conclusion

Sustainable investment is a powerful tool for driving economic growth, reducing poverty, and addressing environmental challenges remain, targeted policy interventions, financial innovation, and collaborative efforts a can unlock the potential of sustainable investment. The future of LICs depends on their ability to attract and manage investment that promote long term prosperity while ensuring social and environmental sustainability.

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RISK MANAGEMENT IN INTERNATIONAL SUPPLY CHAIN

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Abstract

Risks to global supply chains are numerous. A few organised and methodical techniques for evaluating supply chain risks are revealed by a survey of the most recent literature. Nevertheless, this literature lacks a conceptual framework that unifies it. In order to create a model of global supply chain risk management, this study will synthesise literature from a number of disciplines, including logistics, supply chain management, operations management, strategy, and international business. **Keyword :** key aspects of supply chain risk management, specific strategies to consider, external supply chain risk, internal supply chain risk, supply chain strategies, customer requirements

Introduction

World has led to an information explosion from the countless data sources that appear on a daily basis. Supply chain risk management (SCRM) is an area that has recently been receiving a great deal of interest from academics and practitioners. SCR Misbelieved to be in an emerging and promising new field by researchers (Sodhi etal., 2012) yet has several undefined borders within its purview. Over the past ten years, a number of authors have conducted literature reviews on SCRM at different phases, (e.g.Juttneretal.,2003;Vananyetal.,2009; Rao and Golds by,2009) provide a good platform for researchers and practitioners trying to make sense of the on-going research and identifies the current stateof-art. Narrative literature views are believed to lack thoroughness and rigour (Tranfieldetal., 2003). On the contrary, they offer insights into the area through a variety of viewpoints on the literature, evidence-based reviews are thought to be more comprehensive and transparent.

Literature Review

Martin Rudberg & Jan Olhager (2003) compared manufacturing network theory (intra-firm focus) and supply chain theory (inter-firm focus) under operations strategy perspective focusing on two structural decision categories: facilities and vertical integration. They suggested ways to integrate configuration and coordination of networks to analyze network hierarchies and to develop inter-firm network strategies. It appears that many authors concur that high levels of integration and integrative methods improve supply chain and business performance. The integration of electronic commerce and associated Business-to-Business (B2B) transaction capabilities lead to global inventory visibility, reduced costs and improved customer service by decreasing lead-time variability, shipping and receiving cycle times, increasing shipment and inventory accuracy (Scott J. Mason et al., 2003). More developed SCM is indicated by systematic integration, i.e., standardized and automatic inter-organizational interfaces. In order to improve effectiveness of SCM, a synchronized operation of all partners in the supply chain is required. This has previously been accomplished by a single corporation controlling or owning every company in the chain. It is more likely that this integration is carried out by using Inter Organizational Information System (IOIS) (D. Sculli et al., 2001, Elizabeth A. Williamson et al., 2004).

Key aspects of supply chain risk management: Risk Identification:

Proactively detecting possible risks and weaknesses in the supply chain, such as supplier failures, political unrest, natural calamities, and labour disruptions.

Risk Assessment

Evaluating each risk's possibility and possible consequences in order to determine which ones need the greatest attention.

Supply Chain Visibility

Putting in place mechanisms to track and keep an eye on the flow of commodities along the supply chain, offering real-time information on possible interruptions.

Contingency Planning

Establishing thorough preparations that include backup sources, alternate modes of transportation, and communication procedures to handle any disruptions.

Supplier Relationship Management

Building strong partnerships with suppliers through regular communication, performance evaluations, and collaboration on risk mitigation strategies.

Risk Mitigation Strategies

Putting policies in place to lessen the possibility or effect of hazards that have been identified, include investing in disaster recovery plans, diversifying suppliers, and keeping safety stock.

Monitoring and Reporting

Keeping an eye out for new threats in the supply chain and informing the appropriate parties of any problems.

Cyber security Measures

Defending supply chain systems and private information against online attacks.

Specific strategies to consider Diversification of suppliers

Sourcing from multiple suppliers in different regions to mitigate reliance on a single source.

Inventory buffers

Keeping essential supplies in a safety stock to handle unforeseen interruptions.

Near shoring/on shoring

Lowering transportation hazards by moving production closer to the final consumer.

Risk-based auditing

Evaluating suppliers on a regular basis to find possible issues with sustainability, quality, and compliance. predictive modeling and data analytics. Predicting probable supply chain interruptions with sophisticated data analysis.

External Supply Chain Risks

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These global supply chain hazards originate from outside your company, as the name suggests. Regretfully, this implies that they are more difficult to forecast and usually demand greater resources to combat. The following are a few of the main external supply chain hazards.

Demand Risks: Demand hazards arise from inaccurately estimating product demand, which is sometimes caused by a lack of understanding of yearly purchasing patterns or erratic demand.

Supply Risks: When the raw materials your company depends on are delivered late or not at all, it might disrupt the flow of parts, materials, and/or products. This is known as a supply risk.

Environmental Risks: Social-economic, political, governmental, or environmental problems that impact the timeliness of any supply chain component directly lead to environmental risk in the chain.

Business Risks: Any time one of the organisations you rely on to maintain the seamless operation of your supply chain experiences an unforeseen change, business risks arise.

Internal Supply Chain Risks

Supply chain risk assessment software, strong analytics programs, IoT capabilities, and other tools can be used to identify and track supply chain risk variables that are under your control. Even though internal supply chain risks are easier to control than external ones, they can't be completely eliminated.

Manufacturing Risks

Manufacturing risks are the potential for a critical phase or component of your workflow to be interrupted, which could lead to operations not proceeding as planned.

Business Risks

Disruptions to routine staff, management, reporting, and other crucial business operations result in business hazards.

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Planning and Control Risks

Inaccurate forecasts and evaluations, as well as poorly planned production and management, are the main causes of planning and control hazards.

Mitigation and Contingency Risks

If a company doesn't have a backup strategy for supply chain interruptions, mitigation and contingency risks may arise. To anticipate any interruptions, it's critical to have a comprehensive understanding of the supply chain risk factors to which you are vulnerable. You are better equipped to apply supply chain risk management techniques if you are aware of any possible problems that may come up.

Discovering possible risk factors by using technologies that provide you visibility into products as they travel through the supply chain. To provide a comprehensive, real-time view of the supply chain, some solutions, for instance, use APIs to pull data and status updates from external data sources, third-party vendors, and suppliers. Other solutions use predictive and prescriptive analytics to turn historical data into business insights.

Customer Requirements

Demand-driven and customer-focused supply chains are successful. Consequently, an evaluation of the current and future supply chain demands from the viewpoint of the customer must be the first step in developing an integrated supply chain strategy. An organisation may occasionally need to divide up its clientele and create distinct logistical strategies for each group. Customer requirements for delivery windows, frequency, inventory levels, lead times for order fulfilment, return and replacement policies, product labelling, warehouse network modifications, packaging requirements and transportation damage, and special delivery services should all be covered in the questions.

Supply chain strategies

Supply chain strategies are ways to ensure that goods and services flow efficiently through a business. Some strategies include:

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Agile supply chain

Focusing on flexibility and quick responses to changes in demand or market conditions.

Resilient supply chain

Focuses on maintaining or improving delivery times and product availability during challenges.

Green supply chain

Focuses on sustainable practices and emerging technologies reduce waste, energy consumption, and greenhouse gas emissions.

Demand management

Uses predictive analytics to understand demand for a product and estimate internal demands on each link in the supply chain.

Inventory management

Uses software to optimize stock control, improve forecasting, and reduce inventory carrying costs.

Leverage technology

Uses innovative tools like AI, data analysis, and automation to enhance supply chain activities.

Conclusion

We have shown that the goal of supply chain management is to steer the actors of one or several supply chains in order to optimize their performance and thus offer the creation of common value, especially for the customer. An evaluation of supply chain performance can only be carried out with prior identification of value creation for the customer, the company itself and all actors across the chain. Although all supply chains have great disparity between their actors, often related to different maturity levels, objectives and constraints, seeking to improve performance across the whole supply chain is essential. The value creation approach is a key element in achieving a high-quality supply chain for the company and the entirety of the chain.

Highlighting this element with value creation attributes is fundamental for any manager looking to direct the various actors in a supply chain. Performance can be measured by using indicators related to value creation attributes, which can then establish a company's maturity or performance level Organizations can find practices that are directly related to their performance by implementing processes within their organization and assessing their performance using value creation models.

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DRUG DISCOVERY BASED ON COMPUTATIONAL TECHNIQUES

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Abstract

Lead and target discovery is the first step in the rigorous, drawn-out, and sequential process of drug discovery and design. Lead optimization and pre-clinical in vitro and in vivo research come next. This study sheds light on many computational methods that are essential to the process of drug design and discovery. A list of computational tools and software is included, along with a tabular comparison of various computational techniques, including Particle Swarm Optimization, Ant Colony Optimization, Artificial Neural Network, Fuzzy Logic, Genetic Algorithm, Genetic Programming, Evolutionary Programming, and Evolutionary Strategy.

Keywords: biological inspiration, computational techniques, fitness function programming, optimization.

The traditional approach through which drugs were discovered mainly based on hit and trial method, like plant-based medicines, serendipity (penicillin) and chemical modification. But there has been major change in the field of drug discovery and design in the previous two decades. In the post-genomic era, rational drug recovery is major approach fir discovering and designing new drugs. According to standard experimental methods, a drug's journey from concept to market is expected to take 12 years and cost an average of about US\$800 million. In the end, only one of the 5,000–10,000 molecules that go through the research and development (R&D) pipeline is approved. Several chemical technologies such as genomic data, chemical genomics, high throughput screening in the drug discovery process and computational tool / software have been developed and applied in drug discovery and design, to short the research cycle and to reduce the expenses. Computeraided drug design (CADD) is one of such evolutionary techniques [3]. In the present time, drug design is based on disease models.

The process consists of many steps that are shown in figure 1.



Figure 1: Key steps in Drug discovery and Design process

This paper provides an overview of computational technique use in drugs discovery and design.

Computational Techniques : An Overview

Bacterial and viral infections like polio, small pox, tuberculosis, AIDS and related diseases that were once life threatening now have become minor public health concerns only because of new computational techniques that help in discovery and designing of new potent drugs.

Genetic Algorithm

A searching method for locating approximations of solutions to optimization and search issues is the genetic algorithm. The genetic algorithm is proposed by John Holland in the 1960's [4,5]. The genetic algorithms are the sub class of evolutionary computations. When it comes to chemometrics and drug discovery, these stochastic optimisation techniques offer a potent way to conduct directed random searches across a vast problem space. The next generation of the population is created in this step by applying genetic operators including crossover, mutation, and selection.



Figure 2: Working of genetic algorithm

Genetic Programming

GP is the variant of the genetic algorithm. The GP is proposed by the John Koza [6, 7]. John Koza successfully applied genetic algorithms on LISP to solve a wide range of problems. Koza was defining the six steps to solving a problem using genetic programming.

- 1. Choosing the terminal.
- 2. Functions
- 3. Fitness function
- 4. Control parameters
- 5. Termination criterion.
- 6. Determining the architecture i.e program's automatically define functions (ADFs).

GP implements the Darwin theory of evolution as a computer program. These programs are written in the programming language. So the GP follows are the form of parse tree that can be shown in the genetic algorithm but the possible solution can be described as following



Figure 3 : showns the evalution of new population from previous population

Evolutionary Strategy

ES was developed by Rechenberg and Schwefel [8,9]. Basically ESs was designed for parameter optimization problems. During the developmental period of ES, a series of strategies were explored which can be listed as follows [10]:

- (Γ, Γ) random walk
- $(\Gamma + \Gamma)$ one parent \rightarrow one child select from all
- $(\mu + \Gamma)$ multi parent \rightarrow multi-child select from all
- $(\mu + \lambda)$ multi-parent \rightarrow multi-child select from all
- (μ , λ) multi-parent \rightarrow multi-child select from children

The signification of the strategy can be defined as:

- () Represents the two successive generations.
- , Represents the selection method from only one child.
- + Represents the selection method from the pool i.e parent and child.
- _C Represents the only one individual.
- µ Represents the populations of parent.
- Λ Represents the populations of children.

The above discussed strategies are used to define the successive generations of individuals. An individual is encoded through the real numbers. Each individual consist the strategy parameters. The strategy is further enhanced by the addition of rotation angles a which orient the direction of most extreme mutation based on the variances and covariance of the expected sets of mutation. [5].

Evolutionary Programming

EP is a sub branch of EA. Fogel was proposed evolutionary programming as a means to develop artificial intelligence and argued that intelligent behaviour requires both the ability to predict changes in an environment, and a translation of the prediction into actions appropriates for reaching a goal [11,12]. In EP, a finite state machine is used to represents the individuals. Q Set of finite states.

- \sum Set of input symbol
- Δ Set of output symbol.
- Transition function

Transition function plays the important role in the finite state machine. It performed the mapping of the current state with an input symbol and produced the next state that can be act as next generation. By successively exposing the environment's symbols to the finite state machine and monitoring the expected result, one can determine an individual's fitness. [13].



Figure 4: A Finite state machine with the state (q1,q2,q3,q4)

The output symbols belongs to the set (0,1) and the output symbol belongs to the set (a, b, m). the labelled edge represents the transition from one state to another state. The double circle state represents then initial state.

Fuzzy Logic

The science of reasoning, thinking, and inference known as fuzzy logic acknowledges and applies the reality that everything depends on degree. The original idea of fuzzy logic comes from a paper published by the Zadeh [15]. Fuzzy set is differing from traditional set theory i.e fuzzy set has unsharp boundaries. Fuzzy logic is particularly helpful for expressing optimisation goal properties.



Figure 5: Fuzzy logic representation of temperature

The basic steps of the fuzzy set in the process modelling described as

- Arrange the input and output dataset.
- Clustering the output set.
- Mapping the fuzzy inputs to the output
- Identify the significant variables
- Use the rule base in inference

Artificial Neural Network

Neural network can be defined as networks of neuron. The biological inspiration of neural network comes from the nervous system network of human being especially the human brain. Basically the neural network consist the two elements:

- Processing Elements
- Connection Weight

Now, the term artificial neural network can be defined as a computer science paradigm that makes use of an abstract modelling of the neuronal structure of the brain as a tool for pattern recognition. The figure 7 showed a systematic architecture of two layers ANN.



Figure 6: Architecture of two layers ANN

Neural networks be applied as four types of applications [4]:

- Association;
- Classification (Clustering);

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- Transformation (different representation)
- Modelling

Particle Swarm Optimization

PSO is population based stochastic optimization method inspired by observation of swarms of insect, shoals of fish, bird flocking ets. There are the million of insect and living creature on the earth as well as in the sea. Each creature posses the unique characteristic that characteristic makes the difference between these.

The movement of each particle depends on two points.

- Particle best position since the algorithm started (pBest)
- The best position of the particles around it (lBest) or of the whole group (gBest)

In each iteration, the particle changes its velocity towards ρ Best and \lfloor Best / \dot{g} Best. So the swarm explores the solution space looking for promising zones.

Ant Colony Optimization

Ant Colony Optimization (ACO) is a meta-heuristic algorithm inspired by the foraging behaviours of ants and developed by Marco Dorigo (Milan, Italy) and others in early 1990s. Basically the algorithm is based on a series of random decisions (by artificial ants) and probability of decisions changes on each iteration.



Figure 7: shows the ant colony and behaviour of ant

An ant's decision to perform a task depends on the physical state of the environment and the social interactions with other ants. The behaviour of artificial ants is inspired from real ants: they lay pheromone trails (obviously in a mathematical from) on the graph edges and choose their path with respect to probabilities that depends on pheromone trails.

Conclusion

This paper deals with the scope of nature inspired optimization techniques in drugs designing and discovery. The main objective of paper to describe the various computational techniques that are used in drugs discovery and designing. How these techniques applied in drugs discovery and what are the pros and cons of particular techniques in drug discovery and designing.

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SUSTAINABILITY AND ETHICAL MARKETING PRACTICES: A PATH TOWARD RESPONSIBLE CONSUMERISM

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Abstract

Sustainability and ethical marketing have gained prominence as consumers demand greater transparency, environmental responsibility, and social accountability from businesses. This paper explores the intersection of sustainability and ethical marketing, examining their impact on consumer behavior, corporate reputation, and long-term profitability. Using case studies and recent research, this study highlights best practices and challenges in implementing ethical and sustainable marketing strategies.

Keywords: sustainability, ethical marketing, corporate social responsibility (csr), green marketing, consumer behavior

Introduction

Marketing strategies have evolved beyond profitdriven approaches to encompass social and environmental responsibilities. Ethical marketing and sustainability are now essential for companies seeking long-term success and positive consumer engagement. This paper aims to analyze the role of ethical marketing in sustainable business practices and assess how companies integrate these principles into their marketing strategies.

In recent years, sustainability and ethical considerations have gained significant traction within the marketing landscape. As consumers become more aware of the environmental and social impact of their purchasing decisions, businesses are increasingly aligning their marketing practices with these values. Sustainable and ethical marketing practices not only serve as a response to the growing demand for ecoconscious products but also contribute to the broader movement toward responsible consumerism.

Ethical marketing involves promoting products or services in ways that do not mislead or exploit consumers, while sustainability refers to efforts aimed at minimizing environmental harm, ensuring fair labor practices, and supporting long-term ecological balance. As consumers prioritize social and environmental responsibility, companies are being held accountable for their production methods, sourcing, and overall impact on the planet. Consequently, businesses are adopting marketing strategies that reflect transparency, fairness, and commitment to societal well-being.

This approach to marketing is transforming traditional business models and redefining the relationship between companies and consumers. By embracing sustainability and ethical marketing practices, companies not only foster trust and loyalty among customers but also play a vital role in driving societal change towards more responsible and conscious consumer behavior. This paper explores the principles of sustainable and ethical marketing, examining how they contribute to the growth of responsible consumerism and their potential to shape a more equitable and environmentally friendly future.

Theoretical Framework

Ethical marketing is based on principles such as honesty, fairness, and transparency, ensuring that marketing efforts do not mislead consumers or exploit resources. Sustainability in marketing involves promoting products and services that minimize environmental impact while meeting consumer needs. These concepts are grounded in Corporate Social Responsibility (CSR) and Triple Bottom Line (TBL) theories, which emphasize people, planet, and profit.

Ethical Marketing Principles

- Transparency and honesty in advertising
- Fair treatment of consumers and employees
- Avoiding deceptive marketing tactics

Sustainability in Marketing

- Use of eco-friendly packaging and sustainable materials
- Reducing carbon footprint in production and distribution
- Promoting social responsibility through fair trade and ethical sourcing

Consumer Perception and Ethical Marketing

Consumers are increasingly aware of ethical issues and expect companies to act responsibly. Ethical and sustainable marketing strategies enhance brand loyalty and trust, particularly among younger demographics. According to Smith & Johnson (2023), 78% of consumers prefer brands that demonstrate sustainability commitments.

Case Studies of Ethical and Sustainable Marketing Unilever's Sustainable Living Plan

Unilever has integrated sustainability into its core business strategy, reducing environmental impact while increasing positive social outcomes. Their sustainable brands, such as Dove and Ben & Jerry's, outperform others in revenue growth.

Patagonia's Ethical Marketing Approach

Patagonia actively promotes environmental sustainability by encouraging responsible consumption. Its "Don't Buy This Jacket" campaign raised awareness about overconsumption and reinforced its commitment to sustainability.

Tesla's Green Marketing Strategy

Tesla's marketing focuses on renewable energy solutions and eco-friendly vehicles. By positioning itself as a leader in sustainable technology, Tesla has built a strong ethical brand image.

Challenges in Ethical and Sustainable Marketing

Despite the benefits, companies face challenges in implementing ethical marketing practices:

- Greenwashing: Some brands falsely claim sustainability to attract eco-conscious consumers.
- High Costs: Sustainable production and ethical sourcing often require significant investment.
- Consumer Skepticism: Many consumers doubt corporate sustainability claims, demanding greater transparency.

Future of Ethical and Sustainable Marketing

With increasing regulatory frameworks and consumer activism, businesses must integrate ethical and sustainable practices into their core strategies. Companies that fail to adapt risk reputational damage and loss of market share. The future will likely see advancements in green technology, circular economy models, and stricter regulations to ensure corporate accountability.

Conclusion

Sustainability and ethical marketing are no longer optional but necessary for businesses to thrive in a socially conscious market. Companies that adopt transparent, responsible, and sustainable marketing strategies not only contribute to a better world but also gain competitive advantages.

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SMART AND SELF-HEALING MATERIALS

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Abstract

Smart and self-healing materials are advanced materials engineered to autonomously repair damage, thereby enhancing their durability and functionality. Inspired by biological systems, these materials can mend mechanical damage without external intervention, leading to prolonged service life and reduced maintenance costs. Self-healing materials encompass a broad range of systems, including polymers, composites, and metals, each utilizing distinct mechanisms to achieve damage repair. For instance, certain polymers contain microcapsules filled with healing agents that rupture upon damage, releasing the agent to seal the crack. Similarly, high-entropy oxides have been shown to self-repair at the atomic level when damaged, offering promising applications in harsh environments. The integration of self-healing capabilities into materials has led to innovations across various fields. In biomedical applications, biodegradable smart materials with self-healing and shape memory functions have been developed to facilitate wound healing. These materials respond to environmental stimuli, such as temperature or pH changes, to trigger healing processes. In the realm of infrastructure, self-healing materials have been employed to enhance the longevity of roadways. For example, incorporating recycled cooking oil into asphalt allows it to heal micro-cracks autonomously, potentially extending road lifespans by up to 30%. The development of self-healing materials neares to create more resilient and sustainable materials across various applications.

Keywords: smart and self-healing materials, microcapsule-based systems

Introduction

Smart and self-healing materials represent a significant advancement in material science, offering the ability to respond dynamically to environmental changes and repair damage autonomously. These materials, inspired by biological systems, can detect and respond to external stimuli such as temperature, moisture, or mechanical stress, enabling them to adapt their properties accordingly. Self-healing materials, a subset of smart materials, possess the remarkable capability to automatically repair damage without intervention, restoring their human original functionality and extending their lifespan.

The development of self-healing materials addresses the limitations of traditional materials that

often require manual repair or replacement after sustaining damage. By incorporating self-repairing mechanisms, these materials can maintain structural integrity and performance over time, reducing maintenance costs and enhancing reliability across various applications.

Types of Self-Healing Materials

Microcapsule-Based Systems: Incorporate microcapsules containing healing agents within a material. When damage occurs, these capsules rupture, releasing the agents to repair the damage. This method is commonly used in coatings and paints for applications like automotive finishes and mobile device casings. Vascular Network Systems: Utilize embedded channels filled with healing agents. Upon damage, these channels release the agents to seal cracks and restore integrity. This approach allows for continuous healing as long as the healing agents are replenished.

Intrinsic Self-Healing Polymers: These materials can self-repair without external intervention, often through reversible chemical bonds or physical interactions. Examples include shape-memory polymers that return to their original shape upon heating and ionomeric polymers that reorganize their structure to heal damage.

Applications of Self-Healing Materials

Electronics: Self-healing materials are used in flexible electronics, such as wearable devices and bio-inspired robotics, to maintain functionality after mechanical damage.

Construction: Incorporating self-healing materials into concrete can repair micro-cracks, enhancing the durability and lifespan of structures.

Coatings: Self-healing coatings can automatically repair scratches and minor damages, maintaining the appearance and integrity of products like automotive exteriors and electronic device casings.

Applications of Self-Healing Materials

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Self-Healing Concrete in Construction

Incorporating self-healing materials into concrete allows structural elements to autonomously repair minor cracks, enhancing durability and performance. This approach is crucial in preventing moisture infiltration and ensuring building safety.

Biomedical Applications

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Self-healing materials, particularly hydrogels, are utilized in implanted devices, wound dressings, and drug delivery systems. Their ability to respond to environmental stimuli and repair themselves holds promise for advanced medical treatments.

Self-Healing Coatings in Electronics

The integration of self-healing materials in electronic devices, such as energy harvesting and storage systems, enhances their longevity and reliability by allowing them to repair damage autonomously.

Self-Healing Paints in Automotive and Aerospace Industries

Self-healing paints have been developed for applications in automotive and aerospace sectors, enabling coatings to repair scratches and minor damages, thereby maintaining the aesthetic and protective qualities of vehicles and aircraft.

Self-Healing Road Surfaces

Researchers have developed self-healing asphalt that automatically repairs cracks, potentially extending road life spans by 30%. This innovation aims to reduce maintenance costs and improve road safety.

Conclusion

Smart and self-healing materials represent a transformative advancement in material science, offering dynamic solutions across various industries. These materials, inspired by biological systems, can autonomously repair damage, respond to environmental stimuli, and adapt their properties, leading to enhanced durability, sustainability, and functionality.

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ENVIRONMENTAL IMPACT OF GLOBAL BUSINESS OPERATIONS

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Abstract

Environmental Impact of Global Business Operations Global business operations have significantly contributed to environmental challenges, including climate change, resource depletion, and pollution. As industries expand across borders, they increase greenhouse gas emissions through manufacturing, transportation, and supply chain logistics. Deforestation, excessive water consumption, and improper waste disposal further degrade ecosystems and threaten biodiversity. One of the major concerns is the carbon footprint of multinational corporations, which rely heavily on fossil fuels for production and distribution. Additionally, industrial waste, plastic pollution, and electronic waste (e-waste) have created severe environmental hazards, impacting air, water, and soil quality. Government regulations and international policies play a crucial role in mitigating these issues by enforcing environmental standards, carbon taxes, and sustainable business practices. To reduce negative environmental impacts, businesses are adopting eco-friendly initiatives such as renewable energy, green supply chains, and circular economy models. Corporate social responsibility (CSR) programs encourage companies to invest in sustainability and minimize ecological damage. However, achieving a balance between economic growth and environmental conservation remains a challenge.

Keywords: pollution, deforestation, waste management

Introduction

Global business operations have transformed economies. creatinemployment and advancing technology. However, these operations also significantly impact the environment through carbon emissions, pollution, deforestation, and resource depletion. As multinational corporations expand their production and supply chains, the demand for energy, raw materials, and transportation increases, leading to serious environmental consequences.

This report examines the major environmental impacts of global business activities, their causes, and potential solutions for a sustainable future.

Key Environmental Issues Climate Change and Carbon Emissions

One of the biggest environmental concerns of global businesses is the increase in greenhouse gas (GHG) emissions. Industries rely on fossil fuels for manufacturing, transportation, and electricity, leading to carbon dioxide (CO_2) emissions that contribute to global warming. The effects of climate change include rising sea levels, extreme weather patterns, and biodiversity loss.

Pollution (Air, Water, and Land)

Air Pollution: Factories, vehicles, and power plants release pollutants such as carbon monoxide, sulfur dioxide, and nitrogen oxides, causing respiratory diseases and global warming.

Water Pollution

Industrial waste, oil spills, and chemical discharge contaminate water bodies, harming marine life and human populations.

Land Pollution

Deforestation, mining, and improper waste disposal degrade land, reducing soil fertility and biodiversity Resource Depletion.

Industries consume vast amounts of nonrenewable resources, such as oil, minerals, and water. The overuse of these resources leads to shortages, affecting both the environment and future business sustainability.

Deforestation and Biodiversity Loss

Forests are cleared for agriculture, urban expansion, and raw material extraction, leading to habitat destruction, soil erosion, and reduced carbon absorption. Deforestation contributes to biodiversity loss, disrupting ecosystems and endangering species.

Industry-Specific Environmental Impacts Manufacturing Industry

- 1. High energy consumption and carbon emissions
- 2. Toxic waste and hazardous material disposal issues
- 3. Transportation and Logistics
- 4. Carbon footprint from air, sea, and road transportation
- 5. Fuel consumption leading to air pollution and climate change
- 6. Agriculture and Food Industry
- 7. Excessive use of water resources and fertilizers
- 8. Deforestation for farming and livestock production
- 9. Technology and E-Waste
- 10. Disposal of electronic waste (e-waste) causes land and water pollution
- 11. Energy-intensive data centers contribute to carbon emissions
- 12. Sustainable Business Practices

Renewable Energy Solutions

Switching to solar, wind, and hydroelectric power reduces dependence on fossil fuels and lowers carbon footprints.

Green Supply Chain

Sustainable packaging and materials Optimized transportation routes to reduce emissions Waste Management & Recycling Implementing circular economy practicesReducing plastic and electronic Corporate Social waste through recycling Responsibility (CSR) Businesses adopt sustainability programs to support environmental conservation, ethical sourcing, and green innovation. Government Regulations and Global Initiatives Governments and international organizations have established regulations to curb environmental damage caused by businesses. Key initiatives include:

The Paris Agreement

A global commitment to reducing carbon emissions.

Carbon Taxes

Financial penalties for businesses exceeding emission limits.

Environmental Protection Laws

Policies regulating waste management, energy use, and industrial pollution.

Conclusion and Recommendations

Global businesses play a major role in shaping the environment. While industrialization and economic expansion have provided benefits, they also contribute to climate change, pollution, and resource depletion. Companies must adopt sustainable practices, governments must enforce stricter regulations, and consumers must demand environmentally friendly products.

By integrating sustainability into global business strategies, industries can reduce their environmental impact while maintaining economic growth. Collaboration among businesses, governments, and communities is essential for creating a greener, more sustainable future.

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HUMAN FACTORS IN LOGISTICS AND SUPPLY CHAIN: A DIGITAL PERSPECTIVE

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Abstract

Integrating digital technologies into logistics and supply chain management has significantly transformed traditional operations, highlighting the essential role of human factors in this evolving landscape. While automation and artificial intelligence enhance efficiency, human intelligence and decision-making remain central to successful supply chain operations. Understanding the human element is crucial for companies pursuing technology-enabled supply chain improvements. Digital approaches that collaborate with people, rather than working around or against them, tend to achieve more impact and sustainability. This perspective emphasizes that technology should empower individuals, enhancing their capabilities and fostering collaboration. Incorporating a digital perspective in logistics and supply chain management requires a balanced approach that considers technological advancements alongside human factors. Recognizing and addressing the interplay between technology and human behaviour is vital for achieving efficiency, safety, and overall success in digital supply chains.

Keywords: digital and human- centred supply chain case, technology adoption in logistics, ai in logistics case, industry 4.0 in supply chain

Introduction

The logistics and supply chain sector are undergoing a significant digital transformation, incorporating technologies such as Artificial Intelligence (AI), Internet of Things (IoT), blockchain, and autonomous vehicles. These innovations aim to optimize operations, reduce costs, and improve service delivery. Despite technological advancements, the human factor continues to play a vital role in ensuring the success of these digital initiatives. Understanding how human capabilities interact with digital systems is essential for achieving optimal performance.

The Role of Humans in Digital Supply Chains

Human involvement in digital supply chains spans various functions, including system design, data

analysis, decision-making, and exception handling. While algorithms can process vast amounts of data, human judgment is indispensable in interpreting results, making strategic decisions, and managing unforeseen challenges. For instance, during the COVID-19 pandemic, human decision-making was crucial in adapting supply chains to rapidly changing demands and disruptions.

Digitalization and Its Impact on Human Roles

Digitalization has led to the emergence of new roles and the evolution of traditional ones within supply chains. Positions such as data analysts, digital strategists, and IT specialists have become integral, while roles centred around manual processes have diminished. This shift emphasizes the need for workforce retraining and development. A study by Kinaxis highlights that while AI and machine learning offer significant benefits, technology should empower people rather than replace them, ensuring that human intelligence continues to drive digital supply chains.

Challenges at the Human-Technology Interface

Integrating digital technologies into supply chains presents challenges at the human-technology interface. Issues such as resistance to change, skill gaps, and concerns about job displacement can hinder the adoption of digital solutions. Addressing these challenges requires a comprehensive approach that includes change management strategies, continuous training, and clear communication about the benefits initiatives.Research of digital indicates that individuals may be hesitant to adopt new technologies if they do not perceive clear business benefits or feel confident in their ability to succeed with new tools.

Enhancing Human Performance Through Digital Tools

Digital tools can augment human performance by providing real-time data, predictive analytics, and decision support systems. For example, wearable sensors and smart devices can monitor logistics workers health and performance, leading to improved well-being and productivity. A study utilizing wearable sensors in logistics operations found that human attitudes, interactions, emotions, and environmental conditions significantly influence workers performance and well-beingA study utilizing wearable sensors in logistics operations found that attitudes. human interactions, emotions. and environmental conditions significantly influence workersperformance and well-being, highlighting the potential of smart sensors to provide individualized insights.

Case Studies of Successful Integration

Several organizations have successfully integrated digital technologies while emphasizing the human factor.

For instance, Driverless Freight Trucks: Volvo Autonomous Solutions and DHL Supply Chain have initiated operations of driverless freight trucks between Dallas and Houston. These trucks are equipped with advanced safety features and are monitored by safety drivers, exemplifying the collaboration between human oversight and autonomous technology.

Digital Twin Technology: The integration of digital twin technology, combined with blockchain, offers innovative solutions for supply chain management. This approach enhances data management, storage, and sharing, providing a comprehensive view of supply chain operations and facilitating better decision-making.

Safety drivers initially monitor performance, exemplifying effective human-technology collaboration.

Future Outlook: Collaborative Logistics and Human-AI Partnerships

The future of logistics lies in collaborative models where humans and AI systems work synergistically. Multi-agent systems and digital twins offer promising avenues for enhancing collaboration among stakeholders.As AI and machine learning continue to evolve, humans will increasingly focus on strategic oversight, ethical considerations, and complex problem-solving. A framework integrating agents with digital twins has been proposed to foster collaboration in logistics, addressing informationbarriers and sharing promoting efficient operations.Organizations that invest in human capital development alongside technological advancements will be better positioned to navigate the complexities of modern supply chains. This integration facilitates real-time data exchange and collaborative decisionmaking, enhancing responsiveness and adaptability in supply chain operations.

Conclusion

In the digital era, the synergy between human expertise and technological innovation is paramount for the success of logistics and supply chain operations. While digital technologies such as artificial intelligence (AI), robotics, and blockchain offer significant advantages in terms of efficiency and data processing capabilities, the human element remains indispensable. Humans bring critical skills to the table, including strategic decision-making, problem-solving, adaptability, and emotional intelligence, all of which are essential for navigating the complexities of modern supply chains.

A balanced approach that combines technological innovation with human expertise is essential for driving the future of logistics and supply chain management. Integrating AI with human capabilities can fundamentally reshape supply chain operations by reducing silos and enabling more connected workflows, fostering a collaborative and agile environment. For instance, AI can bridge gaps between planning and execution, offering real-time feedback that allows companies to dynamically adjust processes and better align various functions.

Moreover, designing digital systems with a focus on human factors enhances user engagement and reduces the likelihood of errors. Systems that align with human capabilities and limitations facilitate smoother interactions, leading to improved performance and safety. This human-centric approach in system design is vital for maximizing the potential of digital tools in supply chain operations.

Training and development programs that enhance digital literacy and foster a culture of continuous learning are crucial. Such initiatives empower individuals to leverage digital tools effectively, adapt to evolving technologies, and contribute to the strategic goals of the organization. As the supply chain landscape continues to evolve, organizations that prioritize the integration of human factors with digital advancements will be better positioned to achieve sustained success.

In conclusion, while digital technologies are transforming logistics and supply chains, the human factor remains central to their successful implementation and operation. Emphasizing humancentric design, continuous learning, and strategic integration of human expertise with digital tools ensures that supply chains are not only efficient but also resilient and adaptable to future challenges. This harmonious blend of human and technological resources will define the future trajectory of logistics and supply chain management, leading to more responsive, efficient, and customer-centric operations.

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FROM WASTE TO WORTH: GREEN LOGISTICS AND THE CIRCULAR ECONOMY

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Abstract

This paper explores how green logistics enhances resource efficiency through innovations like remanufacturing, smart waste management, and digital technologies such as AI, IoT, and blockchain. These advancements help optimize supply chains, reduce carbon footprints, and promote waste valorization. The growing environmental crisis has led industries to shift from a traditional linear economy based on the "take-make-dispose" model to a circular economy (CE), where resources are reused, repurposed, and recycled. Green logistics plays a crucial role in this transformation by integrating sustainable practices such as reverse logistics, eco-friendly transportation, and closed-loop supply chains. redefining waste as a valuable resource, businesses can reduce environmental impact while achieving cost savings and long-term sustainability. This study highlights the strategic importance of green logistics in building a resilient, regenerative economy where waste is no longer a burden but an opportunity for innovation and growth.

Keywords: Reverse logistics, Waste Valorization, Carbon Footprint Reduction, Smart Waste Management, Remanufacturing.

Introduction

This paper explores how industries are adopting reusing, recycling, and repurposing strategies to minimize waste and environmental impact Green logistics is transforming the way businesses manage resources, moving away from the take-make-dispose model toward a more sustainable approach. Additionally, it identifies the role of advanced technologies in making supply chains more efficient and eco-friendly. Sustainability is no longer an option but a necessity as companies face growing environmental challenges. Green logistics focuses on reducing waste, optimizing resource use, and lowering carbon footprints. Many global brands have already embraced this approach.

Ingvar Kamprad Elmtaryd Agunnaryd (IKEA) has launched a furniture buy-back and resale program to extend product life cycles. Dalsey, Hillblom, and Lynn (DHL) is investing in electric delivery vehicles and eco-friendly packaging, while National Industrial Koretz Enterprises (NIKE) integrates recycled materials into its Move to Zero initiative. These companies prove that green logistics is not just beneficial for the planet but also a smart, future-ready business strategy.

Objectives of the study

- Study global and regional policies that promote sustainable logistics and circular economy initiatives.
- Analyze how digital tools, AI, IoT, and blockchain support sustainable logistics and waste management.
- Unite businesses, governments, and consumers for sustainability.
- Understand how consumer choices, awareness, and demand for sustainable products influence green logistics.

Background of the Study

In today's rapidly evolving global economy, the increasing volume of waste and resource depletion pose significant environmental and economic challenges. Traditional linear supply chains, based on

the "take-make-dispose" model, have led to excessive waste generation, pollution, and inefficient resource utilization. This has driven industries, policymakers, and researchers to explore sustainable alternatives that minimize environmental harm while maximizing resource efficiency.

Green logistics and the circular economy have emerged as transformative approaches to address these challenges. Green logistics focuses on reducing carbon footprints, optimizing transportation, and minimizing environmental impacts throughout the supply chain. Meanwhile, the circular economy promotes a regenerative system where waste is minimized, materials are reused, and products are designed for longevity and recyclability. Together, these concepts create a sustainable framework that shifts from waste disposal to resource recovery, ensuring economic and environmental benefits.

Companies worldwide are now integrating circular strategies into their logistics operations, implementing reverse logistics, adopting renewable energy solutions, and investing in advanced waste-tovalue technologies. Governments and global organizations are also enforcing policies to encourage sustainability, pushing industries to transition toward greener practices. However, despite these efforts, challenges such as high implementation costs, lack of infrastructure, and resistance to change remain significant barriers.

This study explores the role of green logistics in supporting the circular economy, highlighting its benefits, challenges, and potential innovations. By understanding how logistics can transform waste into worth, businesses and society can move toward a more sustainable and resilient future.

The Hidden Environmental Cost of Traditional Logistics

The logistics industry plays a vital role in global trade, but its environmental impact is often overlooked. From excessive carbon emissions to unsustainable packaging, traditional logistics practices contribute significantly to pollution and resource depletion.

Carbon Footprint of Transportation

Freight transport—via trucks, ships, and planes-is a major source of CO_2 , nitrogen oxides, and sulfur oxides, worsening air pollution and climate change. Fast delivery demands lead to inefficient routes and empty return trips, increasing fuel consumption and emissions.

Packaging Waste Crisis

The rise of e-commerce has resulted in excessive single-use packaging, much of which is nonrecyclable. Plastics, bubble wrap, and Styrofoam contribute to landfill overflow and microplastic pollution, further harming ecosystems.

Warehouse Energy Consumption

Warehouses and distribution centers operate 24/7, consuming massive amounts of electricity for lighting, cooling, and automation. Cold-chain logistics, used for food and medicine, rely on harmful refrigerants that contribute to global warming.

Reverse Logistics and Waste

High return rates in online shopping double the carbon footprint of products, and many returned items end up in landfills instead of being resold or recycled.

Traditional logistics prioritizes efficiency over sustainability, leading to hidden environmental costs. To combat this, companies must invest in cleaner transportation, smarter packaging, and greener supply chain strategies to minimize their ecological footprint.

The Psychology of Waste: Why People Struggle to Adopt Circular Practices

- Despite growing awareness, many resist circular economy practices due to deep-rooted psychological biases and social conditioning
- People discard waste without considering its impact. Cities with efficient waste collection often see higher waste production because individuals feel detached from the consequences. Consumers associate newness with quality, discouraging second-hand purchases. Grocery stores also reject "ugly" produce, fueling

unnecessary food waste despite no nutritional difference.

- People psychologically value ownership over sharing. While platforms like Nuuly or tool libraries promote reuse, consumers still prefer buying over renting, as ownership triggers a sense of reward.
- People hoard unused electronics, clothing, and gym memberships, struggling to discard them due to past investment, leading to landfill overflow.
- Many embrace "wishcycling" (throwing nonrecyclables into recycling bins) or buy ecoproducts like reusable bags but fail to use them consistently, treating sustainability as a trend rather than a habit.
- True change requires restructuring habits, aligning incentives with human behavior, and designing sustainability to be effortless and emotionally rewarding.

Luxury Vs. Sustainability: Why the Rich Waste More Than the Poor

Wealthier individuals have access to sustainable options but often contribute more to waste due to overconsumption, extravagant lifestyles, and resource-intensive habits.

Overconsumption & Waste

- The rich frequently replace clothes, gadgets, and cars, discarding perfectly usable items.
- Luxury brands burn unsold goods to maintain exclusivity, adding to waste.

Private Jets & Superyachts

- A private jet emits more carbon in a few hours than a car does in a year.
- Superyachts consume as much fuel as 1,500 cars annually, yet remain status symbols.

Food Waste & Fine Dining

• High-end restaurants and wealthy households discard large amounts of food due to excess and quality standards.

Greenwashing & False Sustainability

- Some rich individuals promote sustainability but continue wasteful lifestyles.
- Luxury brands push "eco-friendly" products while still practicing harmful production methods.

The Solution?

- Higher taxes on high-emission luxuries (jets, yachts).
- Stronger waste regulations in fashion and hospitality.
- True sustainability needs behavioral change, not just green purchases.
- Unless the wealthy shift their habits, luxury will remain a major sustainability challenge.

Policy and regulatory framework

Policy and regulatory frameworks play a crucial role in advancing green logistics and the circular economy by establishing guidelines for sustainable practices, waste reduction, and resource efficiency. One key policy is Extended Producer Responsibility (EPR), which holds manufacturers accountable for the entire lifecycle of their products, including waste management. Countries like the European Union, India, and Japan have implemented EPR regulations to encourage companies to adopt recycling programs, product take-back systems, and eco-friendly packaging. Waste management and recycling laws further drive circular economy practices by setting mandates for waste segregation, landfill reduction, and recycling targets.

Governments also promote sustainability through carbon tax policies and green incentives. Carbon pricing mechanisms like the EU Emissions Trading System (ETS) encourage businesses to reduce emissions, while green freight programs provide financial incentives for low-emission transport solutions. Regulations focusing on sustainable logistics push for fuel efficiency norms, the establishment of low-emission zones in cities, and mandatory carbon footprint reporting for companies. Businesses are also incentivized to adopt circular
economy principles through policies that mandate the use of recycled materials, promote product design for durability and recyclability, and provide tax benefits for sustainable investments.

The future of regulatory frameworks for green logistics and circular economy is expected to see stricter bans on single-use plastics, increased digital tracking of waste flows, and stronger public-private partnerships to promote sustainability. Strengthening these policies will be essential in accelerating the shift from waste to worth while ensuring environmental and economic benefits.

Digital Twins for Circular Logistics Optimization

Digital twins are transforming circular logistics by creating virtual models of supply chains that enable real-time monitoring, predictive analytics, and resource optimization. These digital replicas simulate physical processes, allowing businesses to track material flows, optimize waste collection, and product lifecycle management. improve By integrating IoT sensors, AI-driven analytics, and blockchain technology, digital twins enhance decision-making and ensure compliance with circular economy regulations.

In circular logistics, digital twins help predict reverse inefficiencies, logistics reduce waste and streamline remanufacturing generation. processes. They can simulate multiple scenarios to determine the most sustainable routes for waste collection, improving fuel efficiency and lowering carbon emissions. In material recovery and recycling, digital twins assist in inventory forecasting, helping manufacturers anticipate demand for secondary raw materials and avoid supply chain disruptions.

Net-Zero Warehousing and Distribution Centers

Net-zero warehousing and distribution centers aim to eliminate carbon emissions through energy efficiency, renewable energy integration, and sustainable logistics practices. As businesses strive for carbon neutrality, warehousing plays a crucial role in reducing energy consumption, optimizing material flows, and minimizing waste in supply chains. One of the key drivers of net-zero warehousing is the adoption of renewable energy sources such as solar panels, wind turbines, and geothermal systems to power operations. Companies like Amazon and Walmart are investing in solar-powered warehouses and battery storage solutions to reduce dependence on fossil fuels. Additionally, energy-efficient lighting (LEDs), smart HVAC systems, and automation help lower energy consumption while improving operational efficiency.

AI-driven warehouse management systems optimize storage layouts, minimize unnecessary movement of goods, and reduce overall resource consumption. Robotics and automated guided vehicles (AGVs) powered by renewable energy improve productivity while cutting emissions. IoTenabled sensors monitor energy usage, detect inefficiencies, and ensure warehouses operate at optimal conditions.

Incorporating green building standards such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) helps create environmentally sustainable logistics hubs. These standards focus on water conservation, sustainable construction materials, and waste reduction during warehouse operations.

By combining renewable energy, digital optimization, smart logistics, and sustainable infrastructure, net-zero warehouses and distribution centers play a vital role in achieving waste-to-worth and circular economy goals in global supply chains. Companies investing in these strategies not only reduce operational costs but also align with regulatory compliance and ESG (Environmental, Social, and Governance) targets for long-term sustainability.

Summation

The concept of Waste to Worth in green logistics and supply chain management focuses on transforming waste into valuable resources through sustainable practices. Net-zero warehousing and distribution centers play a critical role in this transition by integrating renewable energy, smart logistics, and circular economy principles to minimize

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environmental impact. Businesses are adopting solar and wind energy, AI-driven warehouse management, and IoT-enabled monitoring to optimize energy use and reduce emissions.

Innovations in reverse logistics, biodegradable packaging, and carbon-neutral transportation further contribute to circular supply chains. Strategies such as industrial symbiosis, blockchain-enabled tracking, and digital twins enhance efficiency, ensuring minimal waste generation. While government regulations, carbon taxes, and circular procurement policies push industries towards sustainability, challenges like high initial investments and supply chain risks persist.By implementing advanced logistics solutions and policy-driven innovation, companies can create closed-loop systems, improving economic value while meeting global sustainability goals. The future of supply chains lies in waste valorization, resource efficiency, and carbon-neutral operations, driving a truly circular and sustainable economy.

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TALENT MANAGEMENT IS A KEY TO ACADEMICS

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Abstract

Talent management hold in three different conceptions such as collection of practices of human resource development, human resources flow within the organization and rewarding, sourcing and developing talent of the employee. A talent management system must be implemented in daily process. Education Department alone cannot take the change to attract and retain employees, but it is the responsibility of everyone at all level in the educational sector. The system must include responsibilities for the head of the educational institutions to develop the skills of their immediate subordinates. As the name implies, this procedure involves the management, competence, and authority of employees who work directly or indirectly for an organisation. This ongoing process includes recruiting, hiring, developing, retaining, and promoting in order to meet an organization's needs.

Keywords: Talent Management, Academic, Educational Institutions.

Introduction

A nation grows with the teachers and with the education imparted to the people. Institutes at large are facing an acute dearth of academic talent; this is a malaise, which can snowball into a pandemic if remedial action is not taken instantly Institutes are now taking the bull by the horns. The realization of the gravity of the situation is gradually dawning upon them. Slowly but steadily enough, they have started addressing this issue. They are acknowledging academic talent shortage as a burgeoning problem and are placing the academic talent development task high on their list of priorities after talent acquisition and talent management, talent retention is the next most important issue in HR. At the senior level, each individual brings a unique set of skills. Where talent is already rare and people with requisite skills and experience are difficult to find, retention becomes a critical component of organization-building.

Talent is the ability of each individual to perform better than others. This is an inborn quality or ability to perform well which developed over a period of time. Despite repeatedly demonstrating its value and competitive edge for the institution, talent management is still a relatively unexplored and novel idea in the realm of human resource management for all educational organizations. The institutions do not have knowledge of related to the strategies used in talent management which are deployed in higher education system to support them. Talent management hold in three different conceptions such as, collection of practices of human resource development, Human resources flow within the organization and rewarding, sourcing and developing talent of the employee. It gives valuable opinions from his service period that talent management as career progress and facilitating development of highly skilled and talent individuals which uses formalized resources, procedures, processes and policies.

talent management system А must be implemented in daily process. Education Department alone cannot take the change to attract and retain employees, but it is the responsibility of everyone at all level in the educational sector. The system must include responsibilities for the head of the educational institutions to develop the skills of their immediate subordinates. Divisions within the educational organization should promote sharing information among the each member of the department, as a result employees can gain knowledge of the overall system and organizational objectives.

Talent Management

The word 'talent' is a small word but has a large meaning, specifically in the sphere of academics

which is influential in the global sense. Academics are not concerned with one particular area, but envelopes the entire civilization. Education, just like air and water is a necessity today. Talent includes the inner capacity of a person; it has something to do with the potential of someone to make things happen. Every organization requires a pool of talent in the form of a group of people who can make difference to the organization. According to Chartered Institute of Personnel and Development (CIPD, 2007) [4], Individuals with talent are people who have the capacity to influence an organization's performance, either immediately through their contributions or over time by exhibiting their greatest potential.

According to Stockley (2009),Talent Management is a conscious, continuous deliberate approach undertaken to attract, develop and retain people with the aptitude and abilities to meet current and future organizational need. Talent Management, as the name itself suggests is managing the ability, competency and power of employees within an organization. Talent Management is defined as being the processes and systems to ensure that the organization has the right skills and abilities in the right place at the right time because a wrong fit will result in further hiring, re-training and other wasteful activities.

TM incorporates attracting, retaining and developing the talent pool available to an organization in association with the other functions of management, so that the organization is never rendered bereft of expertise. Talent management is a professional term that gained popularity in the late 1990s. McKinsey and Company, following a study in 1997, coined the term and then it was the title of a book by Ed Michaels, Helen Hand field-Jones and Beth Axelrod. It describes the process of training and building new employees by training and keeping existing employees and luring highly qualified employees from other businesses to join your team. TM is a systematic process of identifying, assessing, developing and retaining people with critical knowledge, skills and competencies. Competence,

capability and talents are human assets of organizations.

Talent Management Includes

Recruitment, selection, on boarding, mentorship, performance management, leadership development, career planning, replacement planning, recognition, and reward are some of the several facets of talent management. (Romans and Lardner, 2006 [12]; Heinen and O''Neill, 2004 [7]; Scheweyer, 2004) [13]. It also includes-

- Succession Planning
- Faculty Development Program

Every organization is aware that in the fiercely competitive and increasingly intricate global market, success depends on having the greatest talent.

Characteristics of Good Talent Management

According to the various definitions given by the different authors, which we have discussed above, we can find that the term talent management has the following characteristics. They are as -

- Hire the right people
- Acclimate new faculty
- Discuss career interests with faculty
- Provide training opportunities to the faculty members
- Provide developmental opportunities to the faculty members
- Offer appropriate rewards and recognition
- Help faculty to advance

Process of Talent Management

Developing talent is not a new concept or idea. As the implies, this procedure involves name the management, competence, and authority of employees who work directly or indirectly for an organisation. This ongoing process includes recruiting, hiring, developing, retaining, and promoting in order to meet an organization's needs. In order to recruit the top talent from its competitors, an organisation must provide them with an offer that will beyond their expectations. As a result, the talent management process is a completely integrated software system that regulates both an employee's entry and exit. To accomplish its objectives and raise them, every organisation needs the greatest talent management approach.

Attracting and Recruiting Talent

Due to the recent economic downturn jobs cuts globally increased, so those who were important to organizations were retained and others were sacked. In order to attract and recruit talent employees organizations need to look and understand what talent is looking for in a career and how they perceives carry out education with their needs. An organizations approach to each one of the potential recruits needs to be altered to take their careers.

Retaining and Developing Talent

This is always challenging task for the new and old workers in the education sector. It is related with the workers an ongoing process. This is a more challenging task for talent management process. It focuses on the following points such as:

- Work ethics and values
- Career planning
- Work life balance
- Benefits and reward systems

Managing Talent

The task of an organization in education sector does not ends with hiring the employees but effective management of the employee is equally important. It focuses on the following points such as :

- Attitude and principles of the authority.
- Systems of management.
- Styles of leadership
- Time to time mentioning the work
- Provided guidance
- Positive recommendation towards the employees time to time

Causes for Employee Turnover in the Institutions

The following courses for employee turnover in the institutions such as :

Over workload

- Insufficient salary
- Insecurity job
- Ambiguity role
- Insufficient resources
- Poor performance management
- Inadequate environment

Performmance Management Motivates the Employees in Institutions

- Many educational institutes launched development of faculty programs to shape and improve the career of the employees.
- It improves employees motivation and dedication towards work
- Policies and procedures should be well informed in beginning to the respective faculties of the institution.
- They should give rewards and motivate the employees according to their performance,
- The equal opportunities should be given to both senior and junior employees.
- Leads to high confidence in bonus payment process.
- Leaves like maternity or paternity leaves should be provided for different time period for the birth of the child.
- Professional development programs are aligned directly towards the achievement of institution level goals.
- Assistance for external grants provision for researches and other purpose should be given

Strategies of Employee Retention

The following strategies of employee retention are given in below:

- Communication should be done properly in organization
- Efficient employees should be engaged for the right job
- Provide opportunities development and growth of the employees
- The efficient employees must get more remuneration on their performance

- Equitable and fair treatment for every employee
- There should be accountability helps employees

Stages of Talent Management

Attracting Talent: Attracting talent would involve assessment and selection of human resources. It would basically require the evaluation of the present workforce. This evaluation unravels the existing discrepancy between the needed talent and existing talent. Job evaluation is another way of identifying the needs of the organization. Now the talent can be acquired through proper recruitment and selection strategy to fill the burgeoning gap. Talent acquisition includes the organization's ability to extract information and ideas from its environment as well as through insight. One of the fastest and most powerful ways to acquire talent is through grafting, i.e., hiring individuals or acquiring entire companies. For example, graphic chipmaker ATI Technologies picked up plenty of talent by hiring the most experienced Nortel staff that was recently laid off.

Retaining Talent: In the fast-growing competitive world the organization can survive only with its talented employees. The organization may face several challenges, such as ageing workforce, high attrition rate, increasing skill shortage, etc. Among these high rate of attrition of employees is the major challenge. The growth rate of IT companies is tremendous, but so is their attrition rate. Similar phenomena are observed in educational institutes as well. A good retention strategy will ensure the presence of following elements in its organization, so as to prevent any further exodus of the employees 1. Exciting work 2. Good organizational culture 3. Robust leadership 4. Wealth and rewards 5. Prospects of career growth and development

Developing Talent: Development represents efforts to improve workers capacity to manage a range of tasks, and to cultivate capabilities beyond those required by the current job. Development benefits both the organization and the individual employee. Employees and managers with appropriate experience and Skills could improve an organization's capacity to compete and adjust to a changing environment. New-job Integration/Assimilation: Development of talent should be done in such a manner that the employees are at ease when faced with the situation like that of job rotation. It equips them with the knowhow of a new job and adds spice to their routine job

Training: Training is a process where people acquire capabilities and develop their existing competencies to aid the achievement of organizational goals. It provides employees with specific, identifiable knowledge and skills for use in their present and future jobs. Talent training specifically aims at bridging any gap between the existing and required competencies of the employees for better succession planning

Succession Planning: It is the process of determining a long-term strategy for the systematic replacement of important personnel. The need to replace key employees results from promotions, transfers, retirements, deaths, disabilities, departures or other reasons. In fact, succession planning is something that most of the organizations do not even think about, hence, the impending leadership crisis. A good succession plan always ensures the ready availability of the right person at the right time and at the right place doing the right work in the event of the current incumbent not being there for the any of the aforementioned

Transitioning Talent: Transitioning talent implies that employees are deputed on some new position for a short period of time, so that they are able to provide a new insight into this job as well as learn some new skills for their existing job. This will include the following

Outplacement: Outplacement is one of the strategies through which the employees can be placed at some important job in another organization for a short duration, maybe on an exchange basis. This will help the out placed employees gain a cross-cultural exposure and an opportunity to exploit his latent potential better

Senior-executive Programs: Organizations require trained executives to face the challenges. When a manager leaves the organization, it creates a

major crisis in the organization. At that time we need a leader who can fill this gap and pull the organization up with the help of his personal charisma and competencies. Senior executives are the people who are required to be aware of the environmental developments and latest trends. To achieve the desired results these executives need to be developed so that their knowledge doesn't become obsolete and they have the strategic advantage to handle critical situations. These Senior-executive Programs include in-basket techniques, business games, syndicate training and many other simulation exercises

Partner/Spouse Relocation: In the present world of cut-throat competition it has almost become a necessity for husband and wife both to work. They have their own sets of commitments related to their organizations. For this, many a time they are placed at different locations and this becomes one of the major reasons for one of them to leave the organization or it may even lead to decline in personal productivity. As a proactive stand the organization should foresee such a situation and as a move to retain its talented employees, a relocation/transfer plan should be formulated so that both the partners are at the same location. Such action from the point of view of the organization makes the employees indebted towards it and makes them more committed towards the organization.

Conclusion

From the above study of this paper we can find that talent management can help in identification of the right talent, development talent and retaining talent in the education sector for its success. Another angle of point, we can say that the goal of talent management is to consciously and purposefully recruit, train, and retain individuals who possess the skills and aptitudes necessary to meet present and future organizational demands. It is the saying that the recruiting effective person is the first step towards effective retention. Youth is in generation is the future of the country. Some vital talent management practices that can be very fruitful to an organization includes performance management, career planning, succession planning and quality of work life.

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