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Research Article

NANOTECHNOLOGY INITIATIVES IN MARITIME SECURITY

Shivam Kumar Pandey

Rashtriya Raksha University Raman Kanwar Rathore LLM, Rashtriya Raksha University India

A R T I C L E I N F O

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A B S T R A C T

Nanotechnology is an innovation that will significantly alter how we create tools and materials in the future. The potential use of nano-sized and -composed building blocks is reshaping the field of material science. Many researchers are investigating nanotechnology and its potential uses, advantages, and outcomes. Nanotechnology has several applications in the maritime industry, which include shipbuilding, submarines, and offshore platforms. Nanoparticles in fuel have been found to cut emissions and fuel consumption in diesel engines. Burnt hydrocarbons and soot are decomposed when these nanoparticles are added to the fuel, leading to increased efficiency.

As a whole, nanotechnologies appear to offer enormous potential in fields as varied as pharmaceuticals, water purification, digital networks, and the manufacture of superior, lightweight nanomaterials. The advantages of nanotechnology in maritime settings are no less substantial.

This paper focuses on nanotechnology applications in maritime security and also throws light on the initiatives taken by India to enhance maritime security.

INTRODUCTION

Over the past ten years, nanotechnology has garnered significant interest. At the same time, the maritime industry has been subjected to significant transformations, and enormous amounts of capital have been invested in it. As a result of the one-of-a-kind physicochemical qualities it possesses, nanotechnology has the potential to open up a wide range of new application possibilities in the agricultural industries and biotechnology.[1]Nano pesticides, nano fertilizers, herbicides, and even genetics molecules can all focus on the particular cellular matrix in plants to discharge their contents. Nanoparticles can be employed in any of these applications. Because of their more stable emulsion, increased coverage on leaf surfaces, precision application, and other factors, it has the potential to play an essential role in reducing the number of agrochemicals that are lost during the application process. It is not the mere presence of nanomaterials that poses a concern; instead, specific properties of these particles, particularly their mobility and enhanced reactivity, might make them potentially dangerous. If only some characteristics of some nanoparticles were dangerous to living things, then the environment would be in danger. The maritime business today is a fertile ground for economic expansion and development in the coastal regions of nations. Even though they have less than one-fifth of Iran's water border, certain European countries are among the most powerful in the maritime business. This is in stark contrast to Iran, which is considered a developing country in the maritime industry despite having a water border that is 2,900 kilometres long. The maritime sector encompasses a diverse range of subsidiary businesses, each of which has the potential to serve as both a pillar of support and a cradle for the expansion of scientific knowledge and technological capability.[2]

Research questions

1. What Applications of Nanotechnology are there in Maritime Security?
2. What role does nanotechnology play in the maritime industry?
3. What are the initiatives taken by India for maritime security?

RESEARCH METHODOLOGY

The researcher has employed a doctrinal research technique to gather information in this study. Using a doctrinal research approach, the researcher has acquired documents from libraries, corporate finance law files, and other sources to conduct the study. While putting up the proposal, the researcher consulted books, diaries, and articles to gather knowledge and awareness of the subject matter.

[1]Soubeih KA and Agha MK, "Comparative Studies Using Nanotechnology on Fungal Diseases Defense to Productivity Improvement of Squash Crop" (*Comparative Studies Using Nanotechnology on Fungal Diseases Defense to Productivity Improvement of Squash Crop*, March 31, 2019) <https://doi.org/10.21608/asejaiqjsae.2019.29730>

[2] David R. Frontin, Maritime Security: How Nanotechnology Can Help (2009) 2(1) Journal of Homeland Security and Emergency Management 1.

Corresponding author:* **Shivam Kumar Pandey
Rashtriya Raksha University Raman Kanwar Rathore LLM, Rashtriya Raksha University India

Nanotechnology Applications in Maritime Security

Using components or materials on the nano-scale scale is a broad definition of nanotechnology. Nanotechnology allows novel materials, tools, and systems to be created by altering the bulk material's properties. Nanotechnology is used in the real world when the atoms or molecules of a substance are altered. The features of nanoparticles, their orientation and organization, and the total amount of nanoparticles in a system influence how the material behaves. Nanotechnology is a breakthrough that will significantly alter how we create tools and materials in the future. The potential use of nano-sized and -composed building blocks is reshaping the field of material science. Scientists will be able to design and fabricate material structures that are not found in nature and beyond traditional chemistry's capabilities. Nanostructures' advantages include utilizing molecule or cluster factories, which can assemble materials at the nano-scale, resulting in lighter, stronger, and more customized materials and lower costs due to fewer errors and the capacity to create novel tools.[3]

Although nanotechnology research and experimentation kicked out in earnest in the 1980s, widespread use did not emerge until much later. Nanotechnology is a crucial area of focus for scientists and engineers in the 21st century. This technique has benefited from medical research, petrochemical production, materials research, defence sectors, electronics, quantum computing, etc. Researchers and application-based scientists would do well to familiarize themselves with the nanotechnology-based breakthroughs that hold considerable promise for accelerating technological growth in these areas. The societal effects of nanotechnology will increase as its use spreads to other sectors of the economy (like the maritime sector).

Nanotechnology's Use in the Maritime Sector

In many areas, science and technology today are perhaps past the point where they can meet the expanding demands of civilization. Nanotechnology is essential in electronics for creating quantum computers that are roughly a thousand times quicker than current computers. Nano-capsules have the potential to pinpoint sick tissue and deliver treatments directly to those areas. Nanoparticle-based materials have significantly lowered vehicles' weight, leading to increased velocity, heightened safety, and more efficiency. When nanoparticles are added to steel (or used in place of steel), the resulting material is lightweight despite its extreme strength. Tires made from nanomaterials have an excellent resistance to wear and a long useful life. Hydrogen as a clean fuel, a new generation of batteries, and the development of resistant materials and surfaces are all made possible using nanoparticles in solar cell manufacture. Nanotechnology's application to textiles has resulted in durable garments whose colours will not fade quickly. Many countries' researchers and experts are paying close attention to this matter (the possible function of nanotechnology). These nations have devoted substantial resources to advancing nanotechnology.[4]

Indeed, nanotechnology offers significant potential for revolutionizing several areas of the maritime industry. Nanoparticles in fuel have been found to cut emissions and fuel consumption in diesel engines. Burnt hydrocarbons and soot are decomposed when these nanoparticles are added to the fuel, leading to increased efficiency. This results in less soot, HC, and CO is produced. Nanoparticles have been shown to play a significant impact in improving productivity and decreasing waste through physical testing. Some uses of nanotechnology in the maritime sector are explored in this research. Battery electrodes with nanoparticle matrices, for instance, can significantly improve their capacity to store ions of lithium, therefore increasing the storage capacity and energy density of the battery. Graphene has dual utility as both a self-lubricating solid and a lubricant additive. Improved thermal stability and mechanical strength can be achieved through nanotechnology in the production of cellular ceramics.

Potentials of Application of Nanotechnology in the Maritime Industry

Construction and operation of ships and submarines, offshore platforms, and any other ocean business are considered maritime businesses. Compared to conventional welding electrodes, those enhanced by nanotechnology can be used at far lower temperatures. These electrodes are made of a substance that forms a molecular connection between two pieces of metal, much like a thermal adhesive, when heated to a low temperature. These electrodes will significantly affect welding technology, particularly aluminium welding because they generate minimal distortion. Incorporating nanoparticle-enabled phase control during welding makes it possible to arc-weld AA7075 without the risk of hot fractures. In both along with-welded and post-weld subjected to heat situations, welded connections constructed with an AA7075 filling rod including TiC nanostructures show remarkable strength under stress, thanks to refined globular grains and a modified secondary phase.[5] This relatively easy adjustment to the packingelement of a fusion solder might be used across a variety of things vulnerable to heat cracking.

Many tons of petroleum are carried on ships and boats at any given time, and ocean-going vessels are occasionally required to refuel en route. Hydrogen and nano-fuel additives are two examples of high-energy fuels made possible by nanotechnology. In addition to saving money at the pump, nano-fuel additives help keep the environment cleaner. Compared to more conventional fuels, one litre of these fuels provides the same amount of energy as ten cubic meters. Introducing nanoparticles in new fuels can boost the fuel's energy output by increasing the combustion rate and uniformity. It is possible to generate vast quantities of hydrogen using nanotechnology without releasing carbon dioxide or storing the fuel. The importance of this problem must be considered when discussing hydrogen as a fuel source. Pollutant exhaust particles can be reduced, and NOx, CO, and HC output can be altered by using fuel additives. Some of these additions have decreased the number of polluting particles by about 15 per cent to 20 per cent. Fuel combined with a DPF catalyst has been found to cut emissions by over 99%. Certain additives cut down on multi-core aromatic hydrocarbons by as much as 80%. Fuel additives can range in concentration from 10 parts per million (ppm) to 100

[3] Zheng J., Shi L., Lu X. and Yu J., Nanotechnology for maritime defence and security: A review (2015) 7(2) International Journal of Naval Architecture and Ocean Engineering 199.

[4] T. H. Seo et al., Development of nanostructure sensors for maritime security (2006) 40(4) IEEE Sensors Journal 987.

[5] "Filler Rod - Explore the Science & Experts | ideXlab" (*Openisme*) <https://www.idexlab.com/openisme/topic-filler-rod>

ppm. Additives drastically lower smoke combustion temperatures.[6]

Fuel additives can reduce fuel usage by 5 to 7 per cent. FDC catalysts are additives added to diesel fuel to lower the outlet ignition temperature of soot. All types of active and passive catalysts can benefit from these additions. Platinum nanoparticles are a common fuel component and are typically combined with another metal. The nano-scale is also used in the creation of this additive. These nanopowders have been proven to cut pollutants such as hydrocarbons by 35%, carbon monoxide by 25%, and nitrogen oxides by 25%. Fuel efficiency has improved by around 5%-7% thanks to these additives. This additive is widely used in Europe for on-road, off-road, and permanent installations in large diesel vehicles.

Maritime Security: Indian Scenario

The maritime sector has benefited from nanotechnology's influence on material advancements that have increased the durability of ship equipment, enhanced fuel efficiency, and reduced operating costs. Maritime innovations made possible by nanotechnology promise to improve the performance of everything from recreational boats and cruise ships to Navy aircraft carriers. Despite numerous ongoing research programs and substantial funding, significant commercialization has yet to occur. The TOE[7] provides information on technological advances, goods, services, usages, and strategic perspectives on advances related to nanotechnology and their impact across several sectors.[8] Nanotechnology has several potential applications in healthcare, medicine, manufacturing, and coatings.[9]This cluster tracks advancements in paints and polymer development through research and development. Chemicals, Plastics, composites, biochemicals, polymers, metals, alloys surface treatments, thin films, gas and oil, fibers, fuel additives, and other materials are included in this.[10],

Sensors and electronic devices, innovative resources, chemicals, and treatments of the surface are just a few of how nanotechnology has made its mark today. Nanotechnology advancements such as anti-glare coatings, nanofillers, fuel additives, carbon black for tires, magnetometers or GMR sensors, electrocatalysts for hydrogen, dirt protection, and many more have benefitted the transportation productiveness as a whole.[11] The maritime industry has transported many of the world's goods, materials, and people, which has embraced nanotechnology solutions to long-standing and most pressing problems of the present. Researchers found that almost 30% of all ship breakdowns, repair needs, and equipment adjustments in the maritime industry can be attributed to high humidity and salinity.

These variables reduce the longevity and effectiveness of ship materials due to corrosion and biofouling. The maritime sector has been dealing with this problem for years. Paints and varnishes have long been used to delay deterioration, but recently, nanotechnology-based alternatives have gained popularity. Global maritime sector regulator International Maritime Organization (IMO) unveiled a plan in April 2018 to cut greenhouse gas emissions by half from 2008 levels by 2050. The International Maritime Organization has also initiated a campaign to cut sulfur emissions from maritime transportation by 80% by 2020. This was possible thanks to a reduction in sulfur allowed in fuel. The maritime industry might benefit significantly from nanotechnology-based technologies that would allow it to achieve these new goals in an open and accountable manner. The monitoring of the environment necessarily ensure that the productiveness achieves its goals requires using nanotechnology-based electronics, sensors, and circuit boards to enable onboard remote sensing, sensors, computing technologies and Internet of Things (IoT) connectivity.[12]

Initiatives Taken by India

In 2005, in response to the devastating effects of the 2004 tsunami on people and the environment, the United Nations established a Tsunami Warning and Mitigation System for the Indian Ocean. This is part of a multinational effort to stop further destruction. The coast of Somalia is seem to be ridden with piracy, it has become more of a menace to shipping in the western Indian Ocean since 2007, the Indian Navy has actively participated in a Contact Group of 60-country for piracy off the coast of Somalia mandated by the United Nations Security Council. To improve maritime security in the Indian Ocean, India has created the SAGAR (Security and Growth for All) project based on the following five pillars: India's part in regional internet security. Participation in cooperative efforts with allies to strengthen their maritime defences and economic stability. They are promoting safety and stability by creating a system for coordinated action and promoting long-term prosperity in the Indian Ocean by working together to shape the region's destiny. Together, we can ensure that the people "who live in this region" are ultimately responsible for maintaining calm and prosperity in the IOR.[13]

Those "who live in this region" would be primarily responsible for maintaining peace, security, and prosperity in the IOR. In regards to the maritime boundary arbitration between India and Bangladesh, India has accepted the award made by the UNCLOS panel. It aimed to provide a fresh boost to the Bay of Bengal littoral states' (BIMSTEC) international economic cooperation. One way to improve maritime security is by sharing information about potential dangers to commercial shipping. In this light, in 2018, India opened the International Fusion Centre (IFC) in Gurugram to serve the whole Indian Ocean. Indian Coast Guard and The Indian Navy work together to manage IFC.[14] The IFC aims to raise Maritime Domain Awareness concerning threats to maritime security.

[6] A. Asiri et al., Nanotechnology Applications for National Security (2016) 2(2) Journal of Nanotechnology and Materials Science 1.

[7]Nanotech TechVision Opportunity Engine

[8]Markets ltd R and, "Innovations in Nanoprocessing, Nanofertilizers and Nanomaterials" (*Innovations in Nanoprocessing, Nanofertilizers and Nanomaterials*, November 1, 2019) <https://www.researchandmarkets.com/reports/4876864/innovations-in-nanoprocessing-nanofertilizers>

[9]ibid

[10] T. E. Wilkerson, Nanotechnology and the Future of Maritime Security (2014) 5(2) Journal of Nano Education 36.

[11]"Nanotechnology Initiatives in the Marine Industry" (*AZoNano.com*, December 21, 2021) <https://www.azonano.com/article.aspx?ArticleID=5925>

[12]"Nanotechnology Initiatives in the Marine Industry" (*AZoNano.com*, December 21, 2021) <https://www.azonano.com/article.aspx?ArticleID=5925>

[13] S. Sreeja and S. S. Rao, Nanotechnology-enabled Sensors for Maritime Security (2015) 9(6) IEEE Sensors Journal 2295.

[14]admin, "INDIA'S PROPOSED MARITIME STRATEGY - National Maritime Foundation" (*National Maritime Foundation*, February 3, 2020) <https://maritimeindia.org/indias-proposed-maritime-strategy/>

Other initiatives

- Defence against maritime threats to Indian sovereignty.
- Maintaining Peace in India's Sea Area Neighbors.
- The promotion, preservation, protection and pursuit of offshore structure and marineassets inside and outside the MZI[15];
- The creation, development, and sustenance of a 'Blue' Economy.
- Support for maritime scientific study, particularly in the Antarctic and Arctic, as well as for the advancement, safety, and safeguarding of India's shoreline and offshore merchant shipping commerce, as well as her SLOCs[16] and the ports that serve as the trade's hubs.
- Protection against all hazards at sea, or freedom from dangers "in" or "from" the water.
- Offering the Indian diaspora humanitarian aid and escape routes.
- Acquiring and maintaining a solid geostrategic maritime position in the region.

CONCLUSION AND RECOMMENDATIONS

The uses mentioned above of nanotechnology in the maritime industry are simply the tip of the iceberg. In the future, these uses will be refined and refined. Any sector may undergo significant transformation and efficiency gains upon adopting nanotechnology. All industries' needs must be considered for nanotechnology to be used appropriately. Those responsible for maritime homeland security have a fresh appreciation for nanotechnology's value in maritime and container security. For example, the small unmanned aerial craft could patrol for extended periods without wasting flight crew hours if surveillance sensors, which currently necessitate a human-crewed aircraft or helicopter, were miniaturized with significant reductions in power requirements. Similar developments in underwater sensors may one day make possible the use of small autonomous underwater vehicles to keep tabs on shipping lanes. When developing nanotechnology, experts in the field must first determine the specific needs of various industries. In addition, they need to provide nanotechnology more funding to flourish because countries are wasting time and money on nanotechnology that is not needed because of this.

The maritime industry, including building ocean-going ships, sunken vessels, submarines, etc., is rarely seen as flourishing in Iran. Nanotechnology is a relatively new field; Iran was one of the few countries to adopt it soon after it was first introduced to the rest of the globe. The widespread effects of nanotechnology mean that it has garnered much attention. Iran's maritime industries are transitioning toward maturity, and nanotechnology has the potential to facilitate this transition. These nanomaterials' cost reduction and viability for large-scale commercial applications will significantly emphasize nano-enhanced battery research in the future. Nanotechnology's ability to increase energy storage density has enabled the production of significantly smaller batteries for less challengingusages that benefit from compacted, light, and bendable recharge capable batteries. While sure thin-film batteries are already on the market, their performance is restricted, and their price tag is still high. Nanotechnology has allowed advancements in battery safety, recyclability, and energy and power density. All technologies that make up the industry 4.0[17] may be tracked to nanotechnology. Machine learning and Artificial intelligence are at the forefront of this trend toward amalgamating automated control, smart sensors, networked devices[18]. Nano-scale devices and materials, which manipulate at the conceivable interacting (quantum) scale, the unusual workings of matter and at its smallest are at the heart of this technology's sensors, transistors, computer chips, and receivers. Nanotechnology supplies this plethora of new industrial processes and methodologies. It is even influencing maritime industry decisions on how to apply them with the support of extensive data analysis and algorithmic assistance in researching vast, complicated systems. Adopting this new technology includes less wasteful operations, lower energy costs, and more excellent resistance to future threats.

Recommendations

- International Cooperation: Two supplementary frameworks in the policy and operational sectors are necessary to sustain international cooperation to strengthen maritime security.
- The UNCLOS's operational effectiveness should be evaluated from a rule-of-law perspective.
- Most notably, it upholds its clauses about the right to navigate international waters, the responsible use of maritime resources, and the amicable settlement of disputes.
- Protecting the vital sea lanes of communication (SLOCs) that connect different oceans is essential to bolstering global maritime safety.
- As a result, the international conversation has to centre on facilitating governments' equal and unfettered access to SLOCs while promoting peaceful conflict resolution.
- Whether shipping or sustainable development through the Blue Economy, the private sector needs to play a more significant role in the maritime realm.
- Submaritime fibre-optic cables are essential to the functioning of the Digital Economy, and they can be provided thanks to the maritime domain.
- An important outcome would be if the UN Security Council could respond to the discussion by approving a multi-stakeholder strategy for improving maritime security, which would serve as a model for maintaining "multi-dimensional" security in the twenty-first century.

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T. H. Seo *et al.*, Development of nanostructure sensors for maritime security (2006) 40(4) IEEE Sensors Journal 987.

[15]Maritime Zones of India

[16] Sea Lines of Communication

[17]Fourth Industrial Revolution

[18]"Nanotechnology Initiatives in the Marine Industry" (*AZoNano.com*, December 21, 2021) <https://www.azonano.com/article.aspx?ArticleID=5925>

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