Nanotechnology: Fueling the Chemical Industry's Future

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***Abstract*— Nanotechnology is an upcoming branch of Science and Engineering. It is defined as the controlled manipulation of nanomaterials with at least one dimension less than 100nm. Nanotechnology is emerging as one of the principal areas of investigation, integrating chemistry and material science to create new, undiscovered properties that can be exploited to gain fresh market opportunities. Commercial applications of nanotechnology, in the chemical companies which work on lubricants, improved catalysts, coatings, filtration technologies and other end products are increasing. Currently the research is more focused towards the nanostructured catalyst with enhanced physiochemical properties. Carbon nanomaterials like CNTs, Graphene, and Fullerene have been demonstrated to be an enabling technology for creating high-performance energy-conversion and storage devices. The field of nanotechnology presents the chemical industry with various tools for research, new materials, updated processes for fabrication, nanoelectronics including nanoparticle technology and revolutionary unknowns such as nano-CDs and quantum computers. In this paper, we review the vast applications of nanotechnology which can revolutionize the future of the Chemical industry.**

Index Terms: **Nanotechnology, applications, carbon nanomaterials, chemical industry.**

I. INTRODUCTION

Nanotechnology is considered one of the crucial technologies of the 21st century.. Nanomaterials are man-made, possessing special properties and functions with, at least one external dimension that measures 100 nanometers (1nm = 10-9 m). These nanomaterials include nano-objects like nanoparticles, nanoplates, nanorods, and nanotubes which can comprise different materials. Nanomaterials have a large range of applications established by their size, chemical, and physical properties. Because of the high surface-to-volume ratio, the nanoparticle may be used as an efficient adsorbent. In the chemical industry nanomaterials are used as a catalyst. Nanoparticles are utilized in filters, coatings, lubricants, fertilizers, and also in the food industry and oil & gas industry. There are many devices for water and gas purification. Energy sectors cause environmental pollution in numerous ways. So, renewable and green energy resources are greatly desirable in recent times. Nanomaterials are used to produce and store renewable resources like hydrogen. Iron, gold, and silver nanoparticles have many applications in several areas like catalysis, medical device, pollution abatement, etc. Nanotechnology offers the potential to design, synthesize, and control at a nanometer length scale.Although Nanotechnology appears to be the upcoming technology; its existence was found to be evident right from ancient times. One of the most fascinating ones is the piece of Roman glasswork. The stained glass windows during the medieval time are visible in numerous churches are constructed from a composite of the glass of nano-sized metal particles. The concept of nanotechnology was discussed for the first time in 1959 by renowned physicist Richard Feynman in his popular talk “There's Plenty of Room at the Bottom”[12].

II. THE DIFFERENT ROLES IN NANOTECHNOLOGY ARE:

1)Nanocatalysis:

Nanocatalysis is a rapidly growing field that involves the implementation of nanomaterials as catalysts for various homogeneous and heterogeneous catalysis applications [3]. Because of their complex physicochemical properties at the nanometer scale, even characterization of the varied active sites of most commercial catalysts proves to be elusive. A key objective of nanocatalysis research is to produce catalysts with 100% selectivity, extremely high activity, low energy consumption, and long lifetime. This will be achieved only by precisely controlling

the shape, size, spatial distribution, surface composition and electronic structure, and chemical and thermal stability of the individual nanocomponents. Nanoparticles have a large surface-to-volume ratio compared to bulk materials [8]. Hence, they're attractive candidates to be used as catalysts.

2)Nanocoatings:
Coating is a coherent layer formed from single or multiple applications of coating material to a substrate. "Smart coatings" or "Nanocoatings" are coatings with additional functions like thermal insulation, self-cleaning properties, controlled release of active ingredients, or self-healing functions. Novel nano-based coatings are widely used today, for example, to functionalize surfaces, for protection against corrosion and dirt, to forestall biological soiling and graffiti, or to form attractive designs by special color effects. Nanotechnology-based functional coatings typically contain the subsequent nanomaterials: Carbon black, titanium dioxide, silicon dioxide, iron oxide, zinc oxide, and silver.

3)Nanolubricants:
Even a little concentration of nanoparticles may be sufficient to boost the tribological properties of the system. When there is a small load between the sliding parts friction reduction is principally ascribable to the bearing-like behavior of nanoparticles that roll between the contact surfaces keeping their shape intact. For very high load conditions a coating induced by the presence of nanoparticles is deposited on the crests of surface roughness and it can reduce direct contact between the asperities. Thus, minimize wear.

4)Nanofiltration:
Membrane processes are considered prime components of advanced water purification, desalination, and remedial technologies. Nanomaterials like carbon nanotubes, nanoparticles, and dendrimers are contributing to the development of more efficient and cost-effective water filtration processes. There are two sorts of Nano technologically developed membranes: nanostructured filters, where either carbon nanotubes or nanocapillary arrays provide the premise for nanofiltration, and nonreactive membranes, where functionalized nanoparticles aid the filtration process.

5)Oil and Gas Industry:
Nanotechnology may be a key to introducing revolutionary changes in materials utilized in the oil and gas industries. Applications of nanomaterials like solid composites and functional nanoparticle fluid have brought many technological advances to the oil and gas industries. The development in nanotechnology has generated a brand new type of fluid called "nanofluid". Nanofluid is defined as a category of fluid that is a base fluid with NPs suspended with it. Its applications include engine cooling, solar water heating, biomedical applications, etc.[5] Several years ago nanofluids were introduced to the oil and gas industry. Because of progress in this area, nanofluids are now widely used in drilling, completion, enhance-oil-recovery (EOR), and lots of other applications.

6)Nanofertilizers:
A nanofertilizer refers to a product that delivers nutrients to crops in one of the 3 ways. The nutrient can be encapsulated inside nanomaterials like nanotubes or nanoporous materials, coated with a thin protective polymer film, or delivered as particles or emulsions of nanoscale dimensions. Attributable to a high surface area to volume ratio, the effectiveness of nano fertilizers may surpass the foremost innovative polymer-coated conventional fertilizers. Slow-release fertilizers are excellent alternatives to soluble fertilizers as nutrients are released at a slower rate throughout the crop growth; plants are ready to take up most of the nutrients without waste by leaching. Fertilizer particles are coated with nano-membranes which relinquish the nutrients slowly and steadily[9].

7)Chemical Sensors:
A chemical sensor is a self-contained analytical device that may provide information about the precise chemical composition of its environment. The information is available in the form of a measurable physical signal that's correlated with the concentration of a specific chemical species. Nanotechnology can allow sensors to detect very minute amounts of chemical vapours. Due to the tiny size of nanoparticles, some gas molecules are

sufficient to alter the electrical properties of the sensing elements.

8) Pharmaceuticals:
Nanotechnology is utilized in the pharmaceutical fields. The reason is to boost drug solubility. It also helps to develop new therapeutic devices. The utilization of various pharmaceutical nanocarriers has become a significant area in nanomedicine. Nanotechnology promises precisely targeted drug delivery of therapeutic molecules to the diseased areas of the body [12]. Pharmaceutical nanotechnology consists of two main objects: nanomaterials and nanodevices, which play a vital role in pharmaceutical and other areas. It achieved the dream of delivering a pharmaceutically active molecule to a selected site within the body.

III. ADVANTAGES

- Considerable improvements in technology.
- Revolutionized many industrial sectors.
- Rapid growth in energy, food safety, and environmental sectors.
- Able to manipulate objects at the atomic level and self-replicate using materials available.
- Can detect identify and neutralize harmful chemicals from air, soil, and water.

IV. DISADVANTAGES

- Potential joblessness in industrial sectors.
- Unknown environmental, health and safety risks.
- Unknown properties of nanomaterials.
- It could make conventional energy resources obsolete.

V. ISSUES AND CHALLENGES

The public is wary of the potential of nanotechnology for harm moreover is excited by its potential for the betterment. There's a legitimate concern that nanomaterials may carry unknown environmental, health, and safety risks. The issue related to the choices concerning the pursuit of nanotechnology research programmes, and how they should do so, becomes important. Synthesis of nanomaterials like quantum dots is difficult and expensive to reproduce. Nanomaterials are currently expensive for several practical applications because of their high cost and low production volumes. Manufacturing challenges embody operations ranging from particle formation, Coating, Dispersion, Characterization, Modelling, etc.

VI. CONCLUSION

Nanotechnology has a great impact on every area of science, technology, and industrial sector. This will only increase new ways for development in the future.
Thus, nanotechnology will be the chemical industry's future.

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