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The Future of Nanotechnology: A Deep Study

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Abstract

Experts are hopeful about the future of nanotechnology since it is still a new field of study. The impact on EU economic development and job creation over the coming several decades is anticipated to be substantial. Four different waves of advancement in nanotechnology have been identified by researchers. Another way of putting it is that the nanomaterials we utilise now are either first- or second-generation types. In a first, "passive nanostructures" are used to improve materials' performance. Polymers may be made stronger with the addition of various materials, such as coatings and carbon nanotubes. Active nanostructures are used in second-generation technologies to direct drug delivery to particular organs or tissues. In certain cases, this might be accomplished by attaching a protein coating to the problematic nanoparticle. Between the third and fourth generation, complexity increases dramatically. A molecular nanosystem for regulating the development of synthetic organs and an improved nanosystem for uses like nanorobotics make up the fourth generation of nanomaterials. New and fascinating applications in the food industry are on the horizon because to breakthroughs in nanoscience and nanotechnology. The food industry and the research of functional foods are only two of the many areas where nanotechnology has shown to be a valuable tool. As with the introduction of any new food processing method, packaging material, or ingredient, further study is required to demonstrate that the potential advantages of nanotechnologies and engineered nanomaterials for use in foods exceed the hazards to human health. Particularly useful in the food business, nanoemulsions have several advantages over regular emulsions, including high optical clarity, strong physical consistency against gravitational partition and droplet aggregation, and improved bioavailability of encapsulated components. Nano-encapsulation is a promising technology with the potential to capture bioactive compounds. The current applications of nanotechnology research in food technology and agriculture are emphasised, including nanoemulsion, nanocomposites, nanosensors, nano-encapsulation, and food packaging, and future prospects in the developing area of agrifood nanotechnology are presented. Also covered are the many applications of nanostructured materials in the growing subject of food science, both now and in the future.

Keywords: Nanotechnology, nanoemulsion, nanocomposites, nanosensors,Nanotubes ,Buckyballs

Introduction

The term "nano" originates from the Greek word "nanos," which means "dwarf." one quadrillionth of a metre. Therefore, when we think of nanoscience and nanotechnology, we immediately think of minuscule objects. Yes, materials having at least one spatial dimension in the range of 1–100 nm are the primary focus of this field of research. The major goal of this innovation is to improve product performance in a compact form. Mobile phones epitomise this idea because of the many features they pack into a very small form factor. Nanotechnology isn't exactly state-of-the-art when it comes to technological advancements.

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Polymers, which are large molecules made of nanoscale subunits, have been synthesised by chemists for decades, and nanotechnologies have been used to generate the minute features on computer chips over the past two decades. Technology advancements that allow for very precise study and probing of atoms and molecules have facilitated the widespread use and development of nanotechnologies across a wide range of sectors, including agriculture, medicine, the military, construction, etc. Every day brings additional excitement thanks to the emergence of new technology. As the world's population rises, so does the urgency with which we must advance the state of the art, perform extensive scientific research, and ensure the broad adoption of groundbreaking technologies. As nanotechnology emerged in the last years of the twentieth century, it became clear that the twenty-first century would be regarded as the "century of nanotechnology." Research institutions across the world are collaborating to find new ways to reduce particle size and condense matter. Nanotechnology's potential is enormous because of our growing understanding of how to manipulate molecular and atomic structures. Specifically, it refers to the research and development of structures on the nanometer (nm) and sub-nanometer (ff) scales. Think about how little that is: if you lined up particles that are just one nanometer wide, they would be the same width as a human hair. The primary objective of this research was to advocate for nanotechnology as a promising, long-term scientific and technological tool.

Nanotechnology

When used to resize and manipulate particles, nanotechnology can produce chemical bonds hundreds of times stronger than steel. Materials strengthened by these bonds are more durable, conductive, and flexible than their naturally scaled equivalents because more atoms may interact with it through the expanded surface area provided by these bonds. A nanotech product's density, size, visibility, transparency, reflectivity, and wave absorption are all determined by the particle manipulations used to create them. Nanomaterials are the items that are manipulated via particle manipulation. Natural nanomaterials (like haemoglobin in blood) and man-made nanomaterials (like titanium dioxide) are the two primary groups (such as quantum dots). Carbon-based nanoparticles, metal-based nanomaterials, dendrimer-based nanomaterials, and nanocomposites are the most frequent forms of artificially created nanomaterials. Nanocomposites mix numerous distinct nanomaterials with bulkier, high-volume materials, while dendrimers may extend either outward from a robust core or inward from a strong shell. A nanomaterial is one whose manufacturing process takes place at the nanoscale or smaller. It's not hard to find examples of nanotech's current pervasiveness in our daily lives. You've definitely come across it in a variety of contexts, including clothes, food packaging, and transportation. Recent developments in nanotechnology have allowed for lighter vehicles across all terrains, including land, sea, air, and space. Medical imaging and diagnostics have benefited from nanotechnology, and it is currently being utilised to selectively deliver antigens to injured cells without harming the healthy ones. How did you manage to achieve that? Though the answer seems out of this world, it is really taking place right now. Nanobots, or very small robots, may be programmed to do certain tasks. They work on both bioorganic and inorganic materials, making them vital to recent discoveries in domains including virology, renewable energy, water filtration, and 3D printing. Nanobots have several potential applications, including the delivery of medicine, the purification of water, the generation of energy from renewable sources, and the reproduction and use of 3D models.

Nanomaterials

Nanomaterials may be produced unintentionally by the burning and evaporation of substances.

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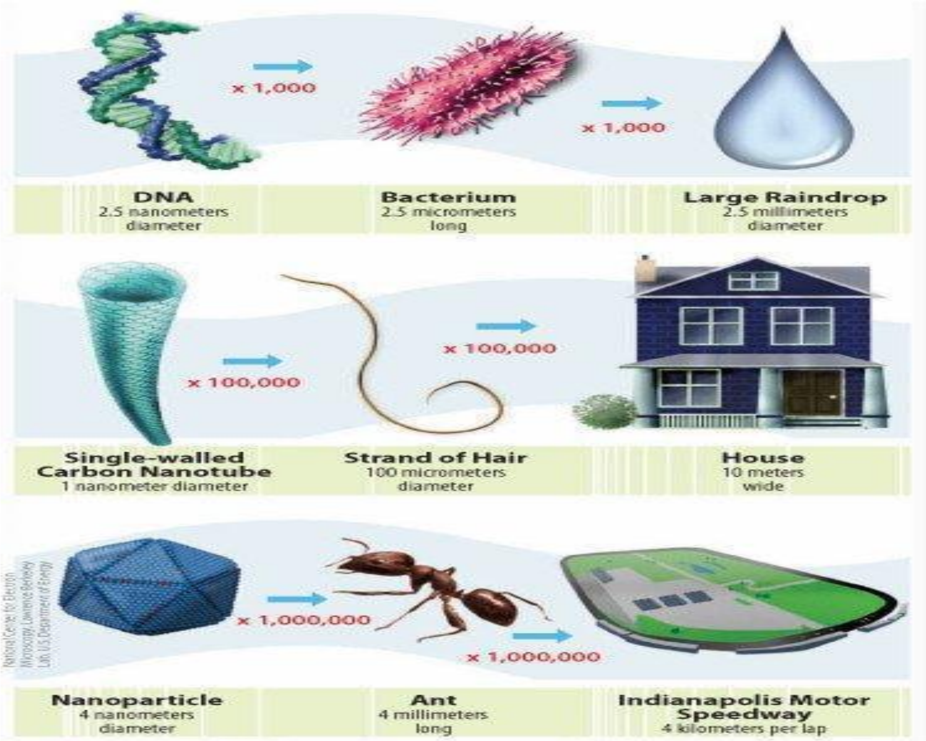
Accidental release of nanoparticles into the environment may occur via several processes, including vehicle exhaust, smelting, welding, and the domestic combustion of solid fuels for heating and cooking. A group of nanomaterials known as fullerenes is created, for instance, when gas, biomass, or a candle is burned.(Rawat, Srivastava, & Dixit, 2017)

Wear and corrosion byproducts might potentially play a role in causing this. Pollutants in the air may be ultrafine particles, such as atmospheric nanoparticles, that are unintentionally produced during an otherwise useful process. It is usual practise to examine the percentage of a nano-dimensions object's that fall inside the nano-scale when determining its classification. To qualify as a nanoparticle, an object's longest and shortest (external) axes must not deviate from one another by more than a factor of 100. Nanotubes are hollow nanofibers with two external dimensions, whereas nanorods are solid nanofibers. Nanoplates and nanosheets only have one nanometer-scale external dimension,[20] but nanoribbons have two significantly distinct macro-scale dimensions. Nanofibers and nanoplates may have additional dimensions that are not nanoscale, but they must still be rather large. The average difference between these groups is at least three times as large. A substance's nanostructure may be utilised to place it in a broad range of categories. Having at least one feature on the nanometer scale and at least one physically or chemically distinct region or set of features defines a nanocomposite. The foam itself is made up of a liquid or solid matrix filled with a gaseous phase, and the gaseous phase has dimensions on the nanoscale scale. A material is considered nanoporous if it has either open or closed pores smaller than one micron in size. **(Klaessig, Marrapese, & Abe, 2011)**

Future of Nanotechnology

The word "nanotechnology" is quite inclusive, including a wide range of disciplines in the STEM community. It may be summed up as the manipulation of little objects. Very small details that cannot be seen with common microscopes. What was always there but we failed to notice. The fundamental units of matter, atoms and molecules. Understanding matter on a "nano" size is essential to the field of nanotechnology.**(Haynes, 2012)**



Array of vertically aligned carbon nanotubes credit: NASA

Nanotubes and Buckyballs

Like many of the subjects I cover on this blog, nanotubes were first beyond my understanding. The bartender's bible is where I learned all the chemistry I know. It was crucial that I at least attempt to grasp the fundamentals of nanotechnology because of the crucial role that nanotubes play in the advantages and disadvantages of the field as a whole. What's the matter with you, though? As soon as I realised what an allotrope was, I had no trouble grasping the idea of a nanotube or buckyball.(Shujun & Gao, 2016)

Allotropes

Diamonds, the hardest natural substance, and flaky graphite, used to sharpen pencils, both consist of carbon. Justify this striking difference. Carbon may be found in pencil lead (graphite) and diamonds (the hardest naturally occurring material known to man). In what ways do their traits differ from one another? Allotropes are the names given to the several pure forms of carbon (structures which differ only in the way the atoms are arranged.) Allotropes may be distinguished from one another in a number of ways, including their colour and hardness. Both diamond and graphite are possible allotropes of carbon. Two others are nanotubes and buckyballs. Here you may see the atomic structure of each kind of allotrope. It was in 1985 when buckminsterfullerene (buckyball) was discovered, marking the beginning of a new age in carbon chemistry and the creation of innovative materials. In 1991, a Japanese scientist named SumiIjima made the first discovery of nanotubes. Nanotubes created in a lab impressed with their excellent tensile properties, thermal conductivity, and flame resistance. A nanotube is a long cylinder with a diameter of just a few nanometers, and it plays an important role in physics. In terms of frequency of occurrence, carbon nanotubes dominate the market. As the nanotube is essentially a flat sheet that has been rolled into a cylinder, it is easiest to visualise graphite (carbon atoms bonded in a chicken wire pattern) as the nanotube's building component. **(Evans & Davidge, 1969)**

The buckyball halves near the end of the cylinder's potential several hundred micron length. Carbon nanotubes have remarkable chemical, physical, electrical, and mechanical properties, making them useful in many different contexts. They are just one-sixth the weight of steel but can withstand 100 times as much force. As a comparison to copper and diamond, they are much more excellent. There are a wide variety of pure carbon allotropes (structures which differ only in the way the atoms are arranged.) Allotropes may be distinguished from one another in many ways; colour and hardness are only two. Diamond and graphite are the two most well-known allotropes of carbon. Buckyballs and nanotubes are two further examples. Here, the atomic structure of each possible allotrope may be seen. With the discovery of buckminsterfullerene (buckyball) in 1985, a new era in carbon chemistry and the creation of ground-breaking materials was ushered in. In 1991, a Japanese scientist named SumiIjima made the first discovery of nanotubes. Laboratory-made nanotubes exhibited remarkable mechanical properties, thermal conductivity, and flame resistance. A nanotube is an extremely long cylinder with a diameter of just a few nanometers. Usually, carbon is used to make nanotubes. Carbon nanotubes may be imagined as a thin, rolled-up sheet of graphite (atoms of carbon connected in a chicken wire pattern). The cylinder, maybe hundreds of microns in length, is sealed at both ends by a buckyball half. Carbon nanotubes have the potential to be used in several fields because to their remarkable chemical, physical, electrical, and mechanical properties. They're just one-sixth the weight of steel yet claim to be one hundred times stronger. They are more conductive than copper and more heat-resistant than diamond. **(Verma & Stellacci, 2010)**

Conclusion

The potential of nanotechnology is no longer limited to the realm of science fiction. The focus of nanotechnology today may be on material composition, but the technology has far broader possibilities. Nanotechnology's popularity and potential importance in the future have contributed to its rapid expansion. Its potential to revolutionise fields as diverse as medicine, agriculture, and energy production makes it fit for a futuristic novel. Since Richard Feynman gave the groundbreaking talk that laid the groundwork for this business and inspired others to study this technology, this has become a reality. Due of its singular properties, nanotechnology is predicted to see far-reaching advancements in the near future.

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