coatings

Editorial

Nanomaterials Applied in Coatings: Synthesis, Structures, Properties, and Applications

Shoyebmohamad F. Shaikh

Department of Chemistry, College of Science, King Saud University, Riyadh 11451, Saudi Arabia; sshaikh1@ksu.edu.sa; Tel.: +966-114675981

Nanomaterials are an innovative class of materials in high demand for a wide range of practical uses. Imagine five atoms of silicon or ten atoms of hydrogen lined up in a row; this represents the length of one nanometer. A material is called a nanomaterial if its size or dimensions are between 1 and 100 nanometers. While it is difficult to determine exactly how long people have been utilizing tiny objects, the use of nanomaterials dates back to ancient times, and people have used these materials for a wide range of applications for a very long time. Richard Adolf Zsigmondy was the first to use the term nanoscale in 1914. American scientist and Nobel Prize winner Richard Feynman proposed the concept of nanotechnology in 1959 during the annual meeting of the American Physical Society. "This is widely recognized as the first academic exposition of nanotechnology." He delivered a speech titled "There's Plenty of Room at the Bottom." His goal was to develop machines on a smaller scale, down to the molecular level [1].

During this talk, Feynman explained that the laws of nature do not constrain our ability to work at the atomic and molecular levels; rather, our capability to work at these levels is constrained by a lack of proper equipment and techniques. The idea of advanced technologies was spread as a consequence of this. As a result, he is frequently referred to as the "father" of modern nanotechnology [2]. In 1974, Norio Taniguchi was credited with perhaps being the first to use the term "nanotechnology." According to Norio Taniguchi, "nanotechnology primarily consists of the processing of, separation of, consolidation of, and deformation of materials by one atom or molecule." (Nanotechnology mostly consists of) Before the 1980s, nanotechnology was only a topic of conversation. Still, the idea of nanotechnology was planted in the minds of researchers during this period to be developed further in the future [3].

The synthesis of designed nanomaterials, which have a large potential for producing products with significantly improved performances, is made possible through nanotechnology, which is an excellent illustration of a technology that is currently developing. Currently, nanomaterials are being used in the industrial production of scratch-resistant paints, surface coatings, electronics, and cosmetics. In addition, nanomaterials are being used in the research and development of sensors, healthcare, energy storage, biomedicine, photodetectors, photonics, drug targeting, cancer delivery, pharmacokinetics, and protein delivery applications. Based on the Special Issue, this editorial article aims to present information about the fundamental ideas and developing trends in nanomaterial synthesis, structural characterization, chemical and physical properties, and a wide range of applications. For this purpose, pertinent information will be covered, and discussions will be held regarding synthesis methods, properties, and opportunities associated with the expansive and exciting topic of nanomaterials. It is difficult to cover all of the literature associated with nanomaterials; nonetheless, this article will highlight key publications published in past Special Issues and the current literature. This article provides researchers with essential insights by quickly highlighting the breakthroughs and features of a variety of nanomaterials in one area for the convenience of researchers.

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Nanomaterials are created in various methods, but there are two main approaches: a top-down and bottom-up synthesis. The former uses larger bulk materials and breaks them down into nanosized particles, whereas the latter uses individual atoms and builds them into more significant nanomaterials [4]. There are two types of nanomaterial synthesis methods: traditional and green. There are numerous appealing advantages to using traditional nanomaterial manufacturing processes. These technologies generate a wide range of nanoparticles with various applications. Some approaches have high control over nanoparticle morphology and considerable scalability with applications in new battery conduction, electrical applications, targeted disease therapy, and energy storage/conservation [5].

Compared to their bulk counterparts, the properties of matter at the nanoscale level exhibit strikingly different characteristics. At the nanoscale, size-dependent effects can be observed in a more pronounced manner [6]. For instance, gold solution seems orange in its bulk form, but it appears to be either purple or red when viewed on a nanoscale. It is possible to alter nanomaterials' properties by adjusting the nanomaterial's size. Compared to bulk materials, the electrical characteristics of substances undergo significant transformations at the nanoscale [7]. For instance, in its elemental state, boron is not regarded as a metal, but boron arranged in the shape of a two-dimensional network, known as borophene, looks to be an outstanding example of a 2D metal [8]. Because of advances in crystal perfection or reductions in crystallographic flaws, the mechanical characteristics of nanomaterials are significantly improved when compared to their bulk equivalents. This is because of the smaller size of the individual crystals. In the range of one to ten nanometers, the electronic characteristics of semiconductors are controlled by quantum mechanical concerns. As a result, nanospheres ranging in diameter from 1 to 10 nm are referred to as quantum dots. Nanomaterials' sizes and shapes have a significant impact on the optical qualities that they exhibit; quantum dots are one example of this. Excitons have diameters ranging from 1 to 10 nanometers, and photogenerated electron–hole pairs also have diameters in this range. Tuning the nanoparticle size in this range can influence the amount of light absorbed and emitted by semiconductors. However, the mean free path of electrons in metals is between 10 and 100 nm. As a result, electrical and optical effects are likely to be noticed in the range of 10 to 100 nm [9]. Altering the aspect ratio of metal nanoparticles suspended in aqueous solutions makes it possible to produce a range of hues. Different aspect ratios result in a spectrum of colors displayed by aqueous solutions of Ag NPs. When the aspect ratio is increased, a red shift in the absorption band can be seen. The following important features can be acquired by modifying the sizes and morphologies of nanomaterials, among various other unique properties. At this time, a significant number of theoretical and experimental research has been conducted in the literature on nanomaterials and nanotechnology. The effectiveness with which materials may be modified on the nanoscale for various applications will determine the direction of future technologies. However, synthesizing nanomaterials and their successful application simultaneously involves great difficulty.

This Special Issue's goals are to provide a forum for researchers to share their most recent research findings and to encourage further investigation into the nanomaterials applied in coatings: their synthesis, structures, properties, and applications. This Special Issue will ultimately collect two original research articles on the most recent works not limited to the relevant research area of nanomaterials applied in coatings.

According to Al-Enizi et al., the sol–gel process was successfully utilized in producing both pure and W-substituted zinc ferrite, with nominal compositions of W-substituted zinc ferrite. Several different analytical approaches were utilized to research the physical and chemical characteristics of the powders obtained. Mixed-shaped particles, including cube-shaped, spherical, and hexagonal ones, were seen in TEM images of all different compositions—the microstrain increases as the amount of W-substituted zinc ferrite in the material increases. In addition, the surface areas of pure zinc ferrite and W-substituted zinc ferrite were calculated, with a mesoporous pore structure being used for all ferrite samples. All of the W-substituted zinc ferrite samples exhibit H–M loops that have features of being paramagnetic. The increase in the applied field (H) causes a direct increase in the magnetization (M), which continues up to a value of 20 kA/m without reaching saturation. To give you an idea of how it compares, the magnetization at 20 kA/m progressively declines as the W-substituted level rises.

The current study aims to manufacture and improve Naringin hybrid nanoparticles using chitosan, D-tocopheryl polyethylene glycol succinate, and lipids. The formulations were improved using a Box–Behnken Design, and the best composition was chosen based on the point prediction method's high entrapment efficiency and low particle size requirements. The effectiveness of the optimized Naringin hybrid nanoparticles was further assessed to examine drug release, permeation, the effect of antioxidants and antimicrobials, and cell viability. The optimized Naringin hybrid nanoparticles showed improved permeability and drug release. The hybrid nanoparticles significantly increased the antibacterial activity against Escherichia coli compared to Staphylococcus aureus. Additionally, they displayed increased activity in the examined cell line. Based on the report's results, hybrid Naringin nanoparticles offer a different oral delivery system for treating cancer cells.

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