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Novel Nanomaterials

Synthesis and Applications

*Edited by George Z. Kyzas
and Athanasios C. Mitropoulos*



NOVEL NANOMATERIALS - SYNTHESIS AND APPLICATIONS

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and **Athanasios C. Mitropoulos**

Novel Nanomaterials - Synthesis and Applications

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Introductory Chapter: Nanomaterials in the 2020s

George Z. Kyzas and Athanasios C. Mitropoulos

Additional information is available at the end of the chapter

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1. Introduction

This work is an introductory chapter of the book *Novel Nanomaterials - Synthesis and Applications*. Nanomaterials are a special topic of recent research and are a milestone of nanoscience and nanotechnology. Nanoscale materials are a series of substances/compounds, in which at least one dimension has smaller size than 100 nm. Nanomaterials have a broad area of development which day by day is rapidly growing. Their impact to commercial applications is huge as well as respective to academia and education. A high percentage of nanomaterials exist naturally, but the great interest is for the type of nanomaterials which can be synthesized. The latter is called as “engineered nanomaterials.” These nanomaterials are formed at the molecular (nanometer) level in order to present the positive of the small/tiny size and innovative properties. Those properties are not generally observed in their common/bulk counterparts/nanoparticles. The big bang was very crucial for the nanomaterials science given that many theories refer the existence of nanostructures after falls of early meteorites, and until now they are under examination with new nanoforms. All of the above clearly indicate that the “world” of nanomaterials is explosively growing in various sections. Therefore, the target of this book is wide. It includes many approaches of metal oxide nanostructures, nanocomposites, and polymer materials. Synthesis, characterizations, various processes, fabrications, and some promising applications are also developed and analyzed.

2. Nanomaterials science

Nanomaterials are a special topic of recent research and are a milestone of nanoscience and nanotechnology. These materials have a broad area of development which day by day is rapidly growing. Their impact to commercial applications is huge as well as the respective to academia and education.

At this point, it is mandatory to give a brief definition of nanomaterials. So, nanoscale materials are a series of substances/compounds, in which at least one dimension has smaller size than 100 nm. 1 nm is equal to 10^{-6} mm, meaning 10^5 times smaller than a possible size of a human hair (obviously measuring the diameter). Another question which must be replied is why nanomaterials have such big interest. The answer is not difficult. Since at this scale, interesting optical, attractive, electrical, and some other different properties rise. These innovative properties have the potential for extraordinary effects in various gadgets, especially in biomedicine, biochemistry, or other relatively similar fields.

Another crucial question is where nanomaterials can be found or how they are “born.” A high percentage of nanomaterials exist naturally, but the great interest is for the type of nanomaterials which can be synthesized (engineered nanomaterials (EN)). This type of materials is extensively used in many processes producing even commercial products. They can be found in such things as sunscreens, cosmetics, sporting goods, stain-resistant clothing, tires, and electronics. They also exist in everyday things and especially products of medicine and biomedicine (e.g., drug delivery, imaging, or even diagnosis purposes).

Engineered nanomaterials are formed at the molecular (nanometer) level in order to present the positive of the small/tiny size and innovative properties. Those properties are not generally observed in their common/bulk counterparts/nanoparticles. Two major explanations can be given to answer why these materials at nanoscale have different properties. These materials showed high (or better increasing) relative surface area and some new types of quantum effects. Also, it is noteworthy that their conventional forms present much lower surface area to volume ratio than the new forms (EN). The latter cause higher chemical reactivity, influencing also their strength. Going to nanoscale, the importance of quantum effects is great especially regarding the determination of materials properties and characteristics; this confirms some new optical, electrical, and magnetic behaviors. Nanomaterials are already used for commercial purposes in industry. The available commercial products of nowadays belong to a broad technologic area, including stain-resistant and wrinkle-free textiles, cosmetics, sunscreens, electronics, paints, and varnishes. Nanocoatings and nanocomposites are finding uses in diverse consumer products, such as windows, sports equipment, bicycles, and automobiles. There are novel UV-blocking coatings on glass bottles which protect beverages from damage by sunlight and longer-lasting tennis balls using butyl-rubber/nano-clay composites. Nanoscale titanium dioxide, for instance, is finding applications in cosmetics, sun block creams, and self-cleaning windows, and nanoscale silica is being used as filler in a range of products, including cosmetics and dental fillings [1].

3. Historical points for nanomaterials

The big bang caused very crucial for the nanomaterials science given that many theories refer the existence of nanostructures after falls of early meteorites. After that start, the nature physically created some other nanostructure-like formations as seashells, skeletons, etc. However, the scientific/technological story and official start of nanomaterials can be pinned much later.

Michael Faraday has synthesized colloidal gold particles synthesized in 1857. In the 1930s, nanostructured catalysts were also investigated. During the 1940s, the market of the USA and Germany was filled after manufacturing with precipitated and fumed silica nanoparticles as substitutes for ultrafine carbon black for rubber reinforcements. Then, from the 1960s to the 1970s, some metallic-like nanopowders used to produce magnetic recording tapes were also developed. In 1976, Granqvist and Buhrman published a work reporting a new term; the popular inert-gas evaporation technique according to which nanocrystals were synthesized for the first time.

Nowadays, the engineering of nanophase or generally nanotechnology is rapidly developing investigating more and more structural and functional materials (inorganic and organic). Therefore, there is a possibility to change/modify or even treat some important electric, magnetic, mechanical, catalytic, optical, and electronic functions. The synthesis of materials in nanophase or the so-called cluster-assembled materials is based on the separated small cluster formation. Then, these are fused into a material (majorly in bulk form).

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