Special Issue on “Synthesis and Characterization of Nanomaterials”

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1. Introduction

Nanomaterial is defined a natural, incidental or manufactured material containing particles, in an unbound state, as an aggregate, or as an agglomerate, and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1–100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness, the number size distribution threshold of 50% may be replaced by a threshold between 1 and 50%. The classification of the nanomaterials can be based on the type of materials they consist of, such as metallic nanomaterials, carbon-based nanomaterials, polymeric nanomaterials, ceramic-based nanomaterials and biomolecule-derived nanomaterials. Nanomaterials not only differ from the corresponding bulk materials in morphological properties, but they can also demonstrate different physicochemical characteristics. Due to this fact, changes in chemical properties, (photo-) catalytic activities, reactivity and energetic properties of the nanomaterials can be induced, making them potential candidates for excellent performance in many applications [1].

The introduction of innovative functions in products and technologies can be made possible through nanomaterials. New products and devices that present improved efficiency over conventional bulk materials have been fabricated based on nanomaterials. Therefore, manufactured nanomaterials are regarded as key components of innovations in various fields with high potential impact, such as energy generation and storage, electronics, photonics, diagnostics, integrated sensors, semiconductors, foods, textiles, structural materials, sunscreens, cosmetics, coatings or drug delivery systems, and medical imaging equipment [2]. Widespread use of nanomaterials raises concerns about their safety for humans and the environment, possibly limiting the impact of the nanotechnology-based innovation. The development of safe nanomaterials has to result in a safe as well as functional material or product. Its safe use, and disposal at the end of its life cycle must be taken into account too. Responsibility for the safe handling of synthetic nanomaterials therefore rests with the manufacturer and importer.

In order to update the field of development, synthesis, structure–activity relationships and future applications of nanomaterials, a Special Issue entitled “Synthesis and Characterization of Nanomaterials” has been introduced. This editorial manuscript gathers and reviews the collection of five contributions (four articles and one review), with authors from Europe and America, accepted for publication in the aforementioned Special Issue of *Fibers*.

2. Production and Applications of 0D–2D Hybrid Nanomaterials

In recent years, taking into account the pandemic situation, it is of high importance for antimicrobial textiles to be produced that are able to be used either in a medical field, or for generalized use as face mask. Microorganisms can be easily grown onto fabrics, increasing the risk of infection due to the fact that fabrics can easily retain water, are porous, and, as they are close to human body, their normal temperature is approximately

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37 °C. Thus, the creation of a fabric with antimicrobial properties is essential in order to face this problem. It is known that silver-based nylon can act as an antimicrobial agent for wound therapy. Moreover, silver and chitosan can both demonstrate a synergistic effect for preventing the agglomeration of silver nanoparticles resulting in biocompatibility improvement. In the work of Botelho et al. [3] a dip-coating method using a mixture of chitosan and silver nanoparticles was conducted for the functionalization of nylon fabric that had been previously treated with double dielectric barrier plasma. The obtained results revealed that according to the aforementioned procedure, an antimicrobial textile appropriate to be used as a face mask is produced. It was proved that the synthesized coating presented improved effectiveness against Gram-negative (*P. aeruginosa*) and Gram-positive (*S. aureus*) bacteria, reducing their live count after 2 h of treatment by approximately 60% and 80%, respectively. Thus, the new coated fabric could be utilized for a single-use facemask with success.

Currently, recycling, reduction and reuse are high importance parameters in order for waste problems to be tackled, and subsequently to move from linear economic systems and processes towards a more circular economy. Thus, green production procedures, the reusability of raw materials as well as recycling strategies are being taken into deep consideration for the establishment of material development methods. Moreover, in the companies related to coating and composite manufacture, reclaimable materials are required, based on bonding between reinforcing material and the matrix. Debonding on demand is a mechanism for the two-phase separation of a coated surface or a composite material via the application of an external stimulus. In the study by Kainourgios et al. [4], silica nanoparticles were synthesized and surface functionalized with iron chloride in order for substrates/catalytic particles to be provided for the growth of carbon nanotubes. The obtained nanomaterials were subsequently microwave irradiated, and the resulting heat production was estimated. The added value of this work resides in the fact that the individual properties of each component, namely, microwave absorption for silica nanoparticles and MWCNTs, respectively, as well as surface functionalization, render the produced hybrid material a potential debonding-on-demand agent in the coating and composite industries. The resulting hybrid structures present both microsilica properties (surface functionalization/chemical affinity with polymer matrices, high surface area) and heat production via microwave absorption due to the MWCNT counterpart, and therefore can be considered a novel material that could benefit polymer technology as well as the coating and composite industries.

Recently, there has been a requirement for improved chemical procedure effectiveness and accuracy. Therefore, there has been an increase in new micro- and nano-structured core-shell copolymer production due to the fact that they are easy to be synthesized, and can be applied together with the potentiality to solve problems in many fields such as medicine, infrastructure and materials. Core-shell polymers have been used in several medical, biological, energy, electronic and engineering applications such as stem cells, wound healing, virus chromatography, antibacterial applications, controlled calcium and drug delivery, glaucoma treatment and cancer, hyperthermia therapy, energy storage, solar cells, fuel cells and sensors, photovoltaics, batteries and finally, as fillers, due to their high tensile and strength performance. In the work of Goulis et al. [5], an organic core-shell copolymer was synthesized in order to be used for selective debonding of coating applications. For this reason, the core had a different glass transition temperature (104 °C) from the shell (228 °C). The obtained results confirmed the production of the copolymer poly(methyl methacrylate)-*g*-poly(methacrylic acid-co-ethylene glycol dimethacrylate) with a homogeneous spherical shape, thin shell and uniform size distribution. The added value of their work relies on the fact that the produced copolymer was synthesized in a one-pot synthetic process, had combined lipophilic and hydrophilic parts and exhibited different glass transition temperatures between the shell and the core, rendering the compound appropriate for various applications.

A transparent oxide that is of great importance is ZnO due to the fact that it is a wide and direct bandgap ($E_g = 3.23\text{--}3.42$ eV), II–VI semiconductor, with relatively large exciton-binding energy (about 60 meV) at room temperature and high electron mobility. These properties render ZnO a potential candidate for a plethora of applications such as photocatalytic cells, solar cells, sensors and optoelectronics. Electrodeposition is an effective method for the production of ZnO layers with specific structural properties. In the work of Sakellis et al. [6] ZnO single-crystalline nanorods of controllable diameter, length and density were grown on seeded ITO glass substrates using a simple, novel electrodeposition method. Zinc salts were utilized as the source of the required zinc ions for the growth of ZnO nanostructures. The obtained ZnO nanorod arrays were vertically well-aligned and textured with the c-axis perpendicular to the substrate, and homogeneously distributed over the whole substrate area.

Additionally, in the fields of energy and composite reinforcement, many advanced applications can be gained from electrospun materials with superior dielectric and mechanical properties. More specifically, aligned electrospun fibers can be applied in energy storage devices as well as to the structural reinforcement of materials. However, taking into account these applications, it is important that the effects of electrospun fiber alignment on dielectric and mechanical properties be understood. In the review paper of Isaac et al. [7], the advances and challenges of aligned fibers' fabrication via electrospinning techniques are discussed. This paper presents the research status of electrospun fibers' alignment and their resulting dielectric and mechanical properties in detail, and introduces the basic principles, research difficulties and existing problems of methods such as the electrospinning method, as well as the effects of these techniques on the mechanical and dielectric properties of electrospun fibers. It was summarized that the most important factor for the improvement of mechanical properties is the molecular orientation of fibers along the fiber direction.

3. Future Strategies

Although this Special Issue has been closed, more in-depth research in the field of development, synthesis, and structure–activity relationships of nanomaterials is expected. It can be anticipated that more effective nanomaterials will be demanded in large numbers in the future in order to be used for recycling, reduction and reuse—parameters that are of high importance in order for waste problems to be tackled and subsequently to move from linear economic systems and processes towards a more circular economy. In this case, suitable strategies should be ready for consolidation and utilization.

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