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Editorial

Microscopic Techniques in Materials Science: Current Trends in the Area of Blends, Composites, and Hybrid Materials

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Microscopic techniques such as optical microscopy (conventional light microscopy (LM), fluorescence microscopy (FM), confocal/multiphoton microscopy, and stimulated emission depletion microscopy (STED)), scanning probe microscopy (scanning tunnelling microscopy (STM), atomic force microscopy (AFM), near-field scanning optical microscopy, and others) as well as electron microscopy (scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), and focus ion beam microscopy (FIB)) are often used in materials science. Those techniques make it possible to assess the morphology, composition, physical properties, and dynamic behaviour of materials, thus making a significant contribution to the development of materials science. They are necessary for both the quality control of products and the development of new materials. Design, synthesis, characterisation, and development of useful innovative, technologically advanced, adaptable, and multifunctional materials and devices with lower mass, smaller volume, higher efficiency, and lower cost, in particular novel materials and structures, are rapidly growing fields of materials science. Advanced blends, composites, and hybrid materials are the most-developing classes of new materials based on ceramic, glass, silica, and carbon that lead to numerous technological innovations. Metals and alloys, intermetallic composites, magnetic materials, ionic crystals, covalent crystals, coatings, films, foils, and pigments are used for advanced applications. Above all, functional materials are found applications in automotive and transportation industry, aeronautics and space industry, and energy, engineering, and environmental sectors. New solutions are also being developed in agriculture and horticulture sectors and packaging and food-service sectors. Knowledge on the relationships between structures, properties, functions, and performance is essential for prospective safe applications of such materials in the areas of human health (in medical, pharmaceutical, and dental industry) and the environment. The study of the physical and technical foundation of the latest developments in the areas described is based on microscopic techniques that are also used in a variety of industrial applications, including topographic and dynamical surface studies of many materials. Fundamental and applied research in emerging application areas in nanotechnology, interfacial science and engineering, advanced manufacturing, catalysis, bioengineering, bio-inspired synthesis, green production routes, sensing, and actuation is often also based on microscopic techniques.

The aim of the Special Issue was not only to present novel achievements and contribution of microscopic techniques to the development of materials science but also to present significant improvements to proven research techniques and recent technical and methodological changes, particularly in applications in the field of human health and the environment. The proposed scope concerned to research on the design, synthesis, characterisation, development, and manufacturing of useful innovative, technologically advanced materials and devices that have general applicability and that form the basis for the evolving knowledge about blends, composites, and hybrid materials. Special emphasis was placed on environmentally friendly blends, composites, and hybrid materials from renewable resources with no adverse effect on the environment, with a short global carbon life cycle, with green production routes, suitable to recycle materials based on natural, renewable, and synthetic polymers for the sustainable future.

The articles in the special issue focus mainly on the characterisation of new materials using microscopic techniques, especially SEM and AFM. The first paper in this Special Issue presents an overview of the recent advances of the three-dimensional (3D) characterisation of carbon-based materials conducted using focused ion beam-scanning electron microscope (FIB-SEM) tomography. Current studies and further potential applications of the FIB-SEM 3D tomography for carbon-based materials are discussed. The advances of FIB-SEM 3D reconstruction are highlighted to reveal the high and accurate resolution of internal structures of carbon-based materials, as well as suggestions for the adoption and improvement of the FIB-SEM tomography system for broad carbon-based research. The next article provides an overview of topographic and dynamical surface studies of (bio)degradable polymers, in particular aliphatic polyesters, the most promising ones. The (bio)degradation process promotes physical and chemical changes in material properties that can be characterised by microscopic techniques. These changes occurring both under controlled conditions as well as in the processing stage or during use indicate morphological and structural transformations resulting from the deterioration of the material and have a significant impact on the characteristic of materials used in many applications, for example, for use as packaging. The following article examines the structure, morphological control, and antibacterial activity of silver-titanium dioxide (Ag/TiO_2) micro-nanocomposite materials against *Staphylococcus aureus* using SEM, energy dispersive X-ray (EDX) spectroscopy, and AFM. The results revealed that the shape of micro- and nanocomposites materials could be arranged by adjusting the parameters. The proper nanorod structure, ideal for antibacterial applications, is obtained at 1000°C growth temperature during 8 hours of baking. Treating of *S. aureus* stock with Ag/TiO_2 nanocomposites is able to reduce bacterial growth with a significant result. In the next article, a SEM analysis is conducted to investigate the effect of fly ash and polypropylene fibres on the microstructure of soil-cement with different polypropylene fibre contents. Also to solve the problems of failure of pretensioned bolt supports under high ground pressure and temperature, a new kind of anchorage agent with excellent performance has been developed. The reasons for this excellent performance in physical and mechanical tests compared to a conventional full-length anchorage agent were examined, among others, by SEM imaging. Subsequently, Cu-SiCp/AZ91D composites were prepared with high-density pulse currents. The wettability between SiCp and matrix during solidification is improved by coating a 0.095 μm thick copper film on the surface of SiCp. In order to analyse the tissue changes of the samples, SEM analysis of solidification structures at high resolution for elemental scanning was performed. Another review concerns the current state of characterisation techniques for the interface in carbon nanotube-reinforced polymer nanocomposites. The different types of interfaces that exist within the nanocomposites are listed. The emerging trends in characterisation techniques and methodologies for the interface are presented, and their strengths and limitations are summarised. The intrinsic mechanism of the interactions at the interface between the carbon nanotubes and the polymer matrix is discussed. Special attention is given to the chemical functionalisation of carbon nanotubes. The last review presents critically existing studies on the microstructure of glass fibre reinforced polymers (GFRPs) reinforcing bars exposed to various conditioning regimes. In addition, the review identifies research gaps in the existing knowledge and highlights the directions for future research. Fibre reinforced polymer (FRP) composites are proposed as corrosion-resistant alternatives to traditional steel reinforcement in concrete structures. In this group of composites, GFRPs are the primary selection of FRP for construction applications. Despite the fact that they have many advantages, their widespread use by the industry is hindered due to the deterioration of their performance in severe environmental conditions. The last article examines the development of strength in different calcium aluminate cement (CAC) mixture mortars with granulated ground blast-furnace slag (GGBS). In addition, the pore structure analysis is accompanied to quantify the porosity. The surfaces of the fragment for cement paste of CAC-GGBS mixtures cured at 365 days were investigated using SEM analysis. The presence of stratlingite was detected. To compare atomic ratios (Ca/Al and Si/Al) at the C2ASH phase in the paste of the binary mixtures, EDS analysis was performed simultaneously.

The special issue presents a contemporary overview of latest developments in the field of advanced blends, composites, and hybrid materials, in particular the latest breakthroughs and approaches in the science of those materials leading to the development of the new generation of multifunctional materials with enhanced features and improved properties for the production of high-performance systems and devices using microscopic techniques.

Conflicts of Interest

The editors declare that there are no conflicts of interest.

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