

Editorial

# Advances in Functional Inorganic Materials Prepared by Wet Chemical Methods

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Functional inorganic materials are an indispensable part of innovative technologies, which are essential to the development of many fields of industry. The use of new materials, nanostructures, or multicomponent composites with specific chemical or physical properties promotes technological progress in electronics, optoelectronics, catalysis, biomedicine, and many other areas that are concerned with plenty of aspects of human life. Due to the broad and diverse range of the potential applications of functional inorganic materials, the development of superior synthesis pathways, reliable characterization, and a deep understanding of the structure–property relationships in materials, are rightfully considered to be fundamentally important scientific issues. Only synergetic efforts of scientists dealing with the synthesis, functionalization, and characterization of materials will lead to the development of future technologies. The Special Issue on “Advances in Functional Inorganic Materials Prepared by Wet Chemical Methods” covers a broad range of preparation routes, characterization, and the application of functional inorganic materials, as well as hybrid materials that are important in the fields of electronics, optics, biomedicine, and others.

The sol-gel method is a simple, time- and cost-effective synthetic approach providing high homogeneity and stoichiometry control of the products. These reasons make it highly suitable for the preparation of mixed-metal oxide materials and different solid solutions. For instance, Grazenaite et al. [1] employed an aqueous sol-gel method for the preparation of Ga-substituted cobalt–chromium spinels as ceramic pigments. The ion substitution resulted in significant color tuning. This demonstrated that the full substitution of Cr<sup>3+</sup> by Ga<sup>3+</sup> ions led to the formation of light blue powders, which yielded a violet blue color for the corresponding ceramic glaze. Karoblis et al. [2] utilized the sol-gel method for the synthesis of (1–x)SrTiO<sub>3</sub>-xBiMnO<sub>3</sub> solid solutions in order to obtain new multiferroic material. The results indicated that single-phase perovskites with a cubic structure can only be synthesized up to x = 0.3. A higher BiMnO<sub>3</sub> content led to the formation of a negligible amount of the neighboring Mn<sub>3</sub>O<sub>4</sub> phase. Nevertheless, some compositional trends were observed in this range. The grain size increased drastically with an increase of BiMnO<sub>3</sub>, moreover, the gradual increase of the BiMnO<sub>3</sub> content resulted in noticeably higher magnetization values. Finally, using the sol-gel method, Inkrataite et al. [3] prepared cerium and chromium co-doped gadolinium–aluminum–gallium garnet (GAGG, Gd<sub>3</sub>Al<sub>2</sub>Ga<sub>3</sub>O<sub>12</sub>). The remarkable feature of this study is that an exceptionally intense emission in the near-infrared region (NIR) was achieved with an extremely low doping level. The chromium content in the obtained materials reached only 15 ppm. Another example of optical materials was provided by Buyer et al. [4]. The authors were able to synthesize Eu<sup>3+</sup>-substituted NaY[SO<sub>4</sub>]<sub>2</sub>·H<sub>2</sub>O under hydrothermal conditions. The anhydrated version of this material (NaY[SO<sub>4</sub>]<sub>2</sub>) was obtained by the post-annealing of as-prepared species. The structural and thermal properties of the synthesized compound were investigated in detail. Both compounds exhibited a strong emission in red region.



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Wet chemical methods allow not only crystalline to synthesize, but also amorphous materials, which can be very attractive for medical applications. A hydrothermal approach was employed by Anh Tuan et al. [5] for the preparation of bioactive glass  $58\text{SiO}_2\text{-}33\text{CaO-}9\text{P}_2\text{O}_5$ . The proposed synthetic approach avoided the use of harmful acid catalysts and was confirmed as one of the ideal methods for the preparation of ternary bioactive glass. For specific medical applications more complex hybrid organic–inorganic structures can be used. For example, the successful preparation of the biocompatible nanohybrid of ciprofloxacin-Ag/TiO<sub>2</sub>/chitosan was demonstrated by Zafar et al. [6]. The obtained nano-heterostructures were shown to be effective against mastitis causing *E. coli*.

Titanium dioxide, besides being used in heterostructures for biomedical applications, is a very technologically important material, which can be utilized for a broad range of applications. In this light, simple and cost-effective methods for the synthesis of TiO<sub>2</sub> are highly desirable. Serga et al. [7] demonstrated for the first time the possibilities of the extraction–pyrolytic method (EPM) for the production of nanocrystalline TiO<sub>2</sub> powders. It was observed that the EPM permitted the production of both monophase (anatase or rutile polymorph) and biphasic (mixed anatase–rutile polymorphs) nanocrystalline TiO<sub>2</sub>. The influence of poly(titanium oxide) obtained using the sol-gel method on the viscoelastic and thermophysical properties of interpenetrating polymer networks (IPNs) based on cross-linked polyurethane (PU) and poly(hydroxyethyl methacrylate) (HEMA), was studied by Tsebriienko and Popov [8]. It was found that an increase in poly(titanium oxide) content led to a decrease in the intensity of the relaxation maximum for HEMA phase and an increase in the effective crosslinking density due to the partial grafting of the inorganic component to acrylate.

Carbon-supported MnO<sub>2</sub> nanocomposites for the application of supercapacitors were fabricated by Jablonskiene et al. [9] using the microwave-assisted heating method. For comparison, the nanocomposites were synthesized by one-step and two-step approaches. The high specific capacitance of  $980.7\text{ F g}^{-1}$  was achieved from cyclic voltammetry measurements, whereas the specific capacitance of  $949.3\text{ F g}^{-1}$  at  $1\text{ A g}^{-1}$  was obtained from a galvanostatic charge/discharge test. The specific capacitance retention was 93% after 100 cycles at  $20\text{ A g}^{-1}$ , indicating good electrochemical stability.

Zeng et al. [10] utilized hydrothermally synthesized ZnO nanowires for the fabrication of 2D Bi<sub>2</sub>Se<sub>3</sub>/ZnO heterojunction, which was employed for the broadband photodetection. The fabricated heterojunction device demonstrated not only an enhanced photoresponsivity of  $0.15\text{ A/W}$  at 377 nm, which was three times higher than that of bare ZnO nanowire ( $0.046\text{ A/W}$ ), but also achieved a broadband photoresponse from UV to near-infrared region was achieved.

The present Special Issue on “Advances in Functional Inorganic Materials Prepared by Wet Chemical Methods” demonstrates the versatility of wet chemical methods for the preparation of functional materials for a broad range of applications. It can be considered as a status report reviewing the progress that has been achieved in the processing of inorganic materials.

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