Solid-State Preparation of Metal and Metal Oxides Nanostructures and Their Application in Environmental Remediation

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Abstract

Nanomaterials have attracted much attention over the last decades due to their very different properties compared to those of bulk equivalents, such as a large surface-to-volume ratio, the size-dependent optical, physical, and magnetic properties. A number of solution fabrication methods have been developed for the synthesis of metal and metal oxides nanoparticles, but few solid-state methods have been reported. The application of nanostructured materials to electronic solid-state devices or to high-temperature technology requires, however, adequate solid-state methods for obtaining nanostructured materials. In this review, we discuss some of the main current methods of obtaining nanomaterials in solid state, and also we summarize the obtaining of nano-materials using a new general method in solid state. This new solid-state method to prepare metals and metallic oxides nanostructures start with the preparation of the macromolecular complexes chitosan·Xn and PS-co-4-PVP·MXn as precursors (X = anion accompanying the cationic metal, n = is the subscript, which indicates the number of anions in the formula of the metal salt and PS-co-4-PVP = poly(styrene-co-4-vinylpyridine)). Then, the solid-state pyrolysis under air and at 800° C affords nanoparticles of M°, M_x O_y depending on the nature of the metal. Metallic nanopar-ticles are obtained for noble metals such as Au, while the respective metal oxide is obtained for transition, representative, and lanthanide metals. Size and morphology depend on the nature of the polymer as well as on the spacing of the metals within the polymeric chain. Noticeably in the case of TiO_2, anatase or rutile phases can be tuned by the nature of the Ti salts coordinated in the macromolecular polymer. A mechanism for the formation of nanoparticles is outlined on the basis of TG/DSC data. Some applications such as photocatalytic degradation of methylene by different metal oxides obtained by the presented solid-state method are also described. A brief review of the main solid-state methods to prepare nanoparticles is also outlined in the introduction. Some challenges to further development of these materials and methods are finally discussed.

Author keywords

Ambient remediation; Metal oxides; Nanostructures; Photocatalyst; Solid state