Synthetic Sorbent Materials Based on Metal Sulphides and Oxides

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Introduction

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Introduction

This book has been focused on the application of common nanomaterials for the removal of metallic species that are found in aqueous environment. The "most common" metallic species are As, Cd, Cr, Cu, Pb, Hg, and Ni. Sb, Pd, Pt, U, and Th are the other miscellaneous metallic species where nanoparticles are applied for their removal from aqueous solutions and water (Dubey et al. 2017). It is important to develop robust, eco-friendly, and economically viable treatment methods for the removal of heavy metals from the aquatic system (Vardhan et al. 2019).

Zinc sulfide finds its applications in optics, electronics, laser technologies, solar energy solutions, etc. Zinc sulfide, with addition of small amounts of suitable activator, is used as phosphor in many areas (Bower et al. 2002). For example, when silver is added, the emitted color is bright blue, whereas manganese yields in orange-red color and copper provides greenish color. Electroluminescent materials based on ZnS perform high brightness and are used as flat vacuum-free light sources in panels, scoreboards, or screens for fluoroscopy (Mateleshko et al. 2004). Zinc sulfide is also used as an infrared optical material, planar or shaped into a lens (Gupta and Gupta 2016). Zinc sulfide–based scintillators have the largest light output per event in the family of imaging scintillators used so far in fast neutron radiography (Wu et al. 2013). Apart from widely known optical properties, ZnS nanocrystals were reported to serve as a sorbent for Cu(II) removal from water (Xu et al. 2016),

Despite a broad interest, general synthetic methods to prepare such materials are lacking, due to at least two reasons. First, it is a significant challenge to ensure homogenous and atomic-scale dispersion of the dopant within the matrix. Second, it is difficult to prepare powders, films, or nanoscale wires made out of zinc oxides and sulfides. Moreover, most synthetic methods require stringent processing conditions or very high temperatures (Acton 2013).

Additional issue is concerning green technologies. Intense development of the industry, power engineering, and agriculture continuously increases pollution of the air (Guttinkunda et al. 2019), water (Xie et al. 2020), and soil (Baltas et al. 2020), which have negative impact on human health. Despite the numerous proposed methods of contamination removal, such as filtration, sedimentation, reverse osmosis, chemical deposition, biological treatment, and so on, sorption methods remain one of the most economical effective ones (Jaspal and Malviya 2020). That is why, sorption is often applied in the final stages of wastewater treatment. A variety of the sorption materials are used, both natural, such as clays, minerals, plant materials, or biomaterials, and synthetic ones. The main advantage of the natural sorption materials is relatively low cost, whereas synthetic ones perform much higher sorption capacity. The aforementioned challenges pose some limitations on the

production of the sorption materials, which must be greener itself through minimizing the energy consumption and other environment unfriendly factors. Thus, one of the trends in sorbent synthesis leads toward production of the same materials using different methods, with modification of the sorbent characteristics through different synthesis conditions. In this book, to achieve greener technology, the researches were focused on the water solutions without employment of any organic solvents.

This book proposes some solutions that address aforementioned challenges. Theoretical background of the sorption is described in detail in many works (Dąbrowski and Tertykh 1996; Ronco and Winchester 2001; Dragan 2014), but only experimental research makes it possible to evaluate practical advantages of the synthesized sorbent.

In this book, experimental data on the synthesis of micro- and nanoparticles of zinc, copper, and cadmium sulfides; iron oxides; and manganese oxyhydroxide are systematized and discussed. Much attention is paid to the processes of sulfide particles formation out of thiourea solutions, as well as to the thermal decomposition of precursors. The effect of decomposition processes on the morphological and structural properties of the obtained micro- and nanoparticles is emphasized. Especially emphasized are the sorption characteristics of the particles and their dependence on the synthesis conditions.

Who Should Read This Book?

The book is devoted to the researchers, students, and specialists who are interested in the inorganic synthesis and properties of the sorption materials. The presented material can be helpful as a review of methods and as a handbook of experimental research. It requires at least basic knowledge on chemistry and physics.

How This Book Is Organized?

In this book, we investigate the problems of the controlled synthesis of inorganic compounds and effect of their morphological characteristics on their sorption capacity. As the research objects, sulfides of divalent metals (zinc, cadmium, and copper), iron oxides, and manganese oxyhydroxide were chosen.

This book consists of introduction, two chapters, final remarks, and references.

In the first chapter, controlled synthesis of zinc, cadmium, and copper sulfide particles and their sorption properties are discussed. First, main methods of metal sulfides synthesis are described, emphasizing the impact of synthesis conditions on the structural and morphological characteristics of the obtained particles. After the discussion, investigations were focused on the method of particle precipitation from thiourea solutions. In this respect, detailed results for particle formation of zinc, copper, and cadmium sulfides in various synthesis conditions, such as pH, anionic composition, temperature, and microwave activation, are presented and discussed. And finally,

the sorption characteristics of the synthesized particles are described in connection with particles size and morphology and synthesis conditions.

The second chapter is dedicated to the production of iron oxides (hematite and magnetite) and manganese oxyhydroxide particles. Experimental data concerning the effects of iron oxides α-Fe_2O_3, γ-Fe_2O_3, and Fe_3O_4 particles synthesis conditions on their structural and morphological characteristics. Next, the issues of the particles formation of manganese oxyhydroxide are discussed. Then, the experimental sorption characteristics of the synthesized particles are presented.

At the end of monography, final remarks and references are added.

How to Use This Book?

The main objective of this book is to provide possibly full review of the results related to the topic. This book will be interesting to anyone who works in the field of inorganic synthesis or is interested in particles of various inorganic compounds synthesis methods.

In this book, the experimental research results are presented in full. They may be helpful in any work aimed to control structural and morphological characteristics of sulfides of zinc, copper, and cadmium; iron oxides; and manganese oxyhydroxide, especially ones focused on obtaining certain sorption capacities. Moreover, the proposed approach may be applied to other compounds as well.

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