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Features of phase-refined materials

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Abstract

The concepts of phase-refined materials are introduced and interpreted in this paper. Phase-refined materials are refined structures from the phase view in single or multiple phases. β-zinc oxalate refines zinc oxalate into villous structures. The specific β-phase zinc oxalate grows from multiphase α and β zinc oxalate. Compared with conventional methods, the phase always produces regular-shaped α-zinc oxalate instead of multiphase α and β phases. β-phase zinc oxalate is activated and refined into a villous shape. This villous material can be used for H_2 sensing, bio sensing, and other applications. Moreover, villous material can be a template for super paramagnetic iron oxide, which is used in magnetic target nanomedicine.

Keywords: zinc oxalate; villous; H_2 sensing; bio-sensing

Introduction

Zinc is an integral part of more than 200 enzymes in the human body. Most of crucial zinc-containing enzymes in the human body include carbonic anhydrase, pancreatic carboxypeptidase, DNA polymerase, aldehyde dehydrogenase, glutamate dehydrogenase, malic acid dehydrogenation enzymes, lactate dehydrogenase, alkaline phosphatase, and pyruvate oxidase. Zinc-containing enzymes include zinc ions and a boiligand mixed structure. The zinc in the enzymes activates catalytic and regulating effects. Therefore, the design of active centers and synthesized complexes has become a research topic.

Oxalate is an important organic ligand. It can be coordinated with transition and nontransition elements to form complexes with various molecular structures. Oxalate can coordinate with metallic ions to form one-, two-, and three-dimensional complex polymers such as zinc oxalate.

Purpose of this work

The purpose of this paper is briefly to review the structures and preparation methods of zinc oxalates and to interpret the concepts of phase-refined materials. Conventional materials feature single or multiple phases and exist in their original status following manufacture. Therefore, the properties of these materials are determined. Advanced methods are required to refine materials further to achieve superior properties. Phase-recurring materials are a new type of materials from the phase perspective. These materials can be used to synthesize novel magnetic target nanomedicine.

Structure of zinc oxalate

Zinc oxalate (ZnC_2O_4) normally exhibits an elongated tetrahedral geometry with two basic structures, namely α-ZnC_2O_4 and β-ZnC_2O_4[1]. The crystal form of α-ZnC_2O_4 is triclinic. The adjacent metal ions are linked in a one-dimensional chain structure, but the interchain is linked in a three-dimensional network structure through hydrogen bonding. By contrast, the structure of β-ZnC_2O_4 is determined by its cation and anion chains (i.e., –C_2O_4–Zn–C_2O_4–Zn and Zn–O). The octahedral structure formed through zinc cobonding is the optimal place for the insertion of impurities.

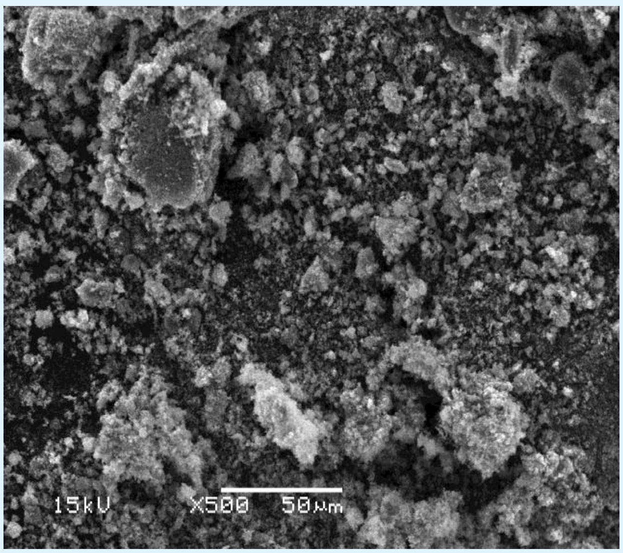

Figure 1: Field emission scanning electron microscopy image of zinc oxalate prepared using the sol-gel method.

Preparations from convention methods

$Zn_2C_2O_4$ can be prepared using various methods such as solid-phase, liquid-phase, or so-gel methods [2-5]. Zinc acetate ($C_4H_6O_4Zn$)and oxalic acid are used to prepare ZnC_2O_4. For the liquid-phase method, $C_4H_6O_4Zn$ and oxalic acid are combined, ground, and then heated. After the reaction, the precipitate is washed and dried. ZnC_2O_4 can also be prepared using the sol-gel method from zinc oxide and graphene.

Templates play a pivotal role in the shape control of $H_2C_2O_4$[6]. Sodium dodecylbenzenesulfonate (DBS) is used as a template to prepare rod-like nanoscale $ZnC_2O_4 \cdot 2H_2O$ whiskers. Zinc acetate hydrate ($ZnAc2 \cdot 2H_2O$) dispersed in DBS in the presence of DBS xylene to form a homogeneous cloudy mixture. Finally, the resulting white precipitate is centrifuged with deionized water to purify the product.

$H_2C_2O_4$ can be prepared using various acids [7]. For example, zinc sulfate heptahydrate, zinc nitrate heptahydrate, zinc chloride heptahydrate, and oxalic acid synthesis zinc oxalate dihydrate compounds have been used to synthesize zinc oxide with various structures and morphologies.

An example of phase-refined materials - novel villous zinc oxalate

A villous structure was prepared and published in a previous paper [5] and is illustrated in Figure 2 The zinc oxalate surface was melted and resolidified as protrusions that resemble a villous structure. The octa site can be occupied by other elements and exits specific properties owing to open structures. The villous structure possesses excellent H_2 sensing capability and will publish later.

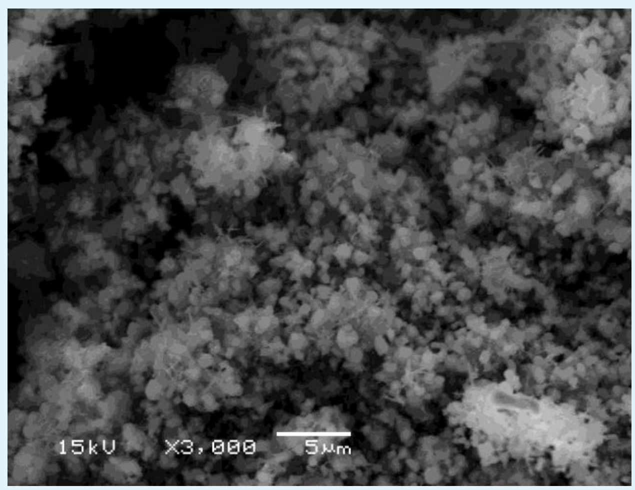

Figure 2: Field emission scanning electron microscopy image of the sample prepared using the sol-gel and laser methods.

Possible applications for nanomedicine

The villous structure exhibited an adhere capacity. Figure 3 shows the field emission scanning electron microscopy image of super paramagnetic Fe_3O_4. Iron oxide is commonly used in magnetic targeted nanomedicine. Villous zinc oxalate can be used as a template to nucleate and grow super paramagnetic nanoparticles of iron oxide. It can also be used as a template for surface-coated materials. For example, the villous structure can be coated as a film form for recombination tissue plasaminogen activator (rtPA).

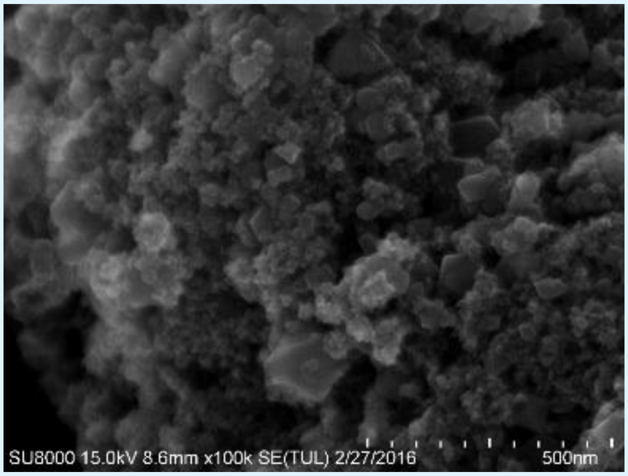

Figure 3: Field emission scanning electron microscopy image of superparamagnetic Fe_3O_4.

Conclusions

Phase-refined materials refine material structures are introduced in terms of phases. Herein, the example of zinc oxalate is used to explain these materials. When produced through conventional methods, zinc oxalate is normally dominated by elongated tetrahedralα structures. To include the β-phase, the sol-gel method is adopted to produce α- and β-zinc oxalate. To further refine the β-phase structure into a villous structure, the β-zinc oxalate is remelted in α-matrix by a microbeam laser. The phase-refined villous zinc oxalate provides excellent properties including hydrogen sensing.

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