

Review

Review on the Polymeric and Chelate Gel Precursor for Li-Ion Battery Cathode Material Synthesis

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Abstract: The rapid design of advanced materials depends on synthesis parameters and design. A wide range of materials can be synthesized using precursor reactions based on chelated gel and organic polymeric gel pathways. The desire to develop high-performance lithium-ion rechargeable batteries has motivated decades of research on the synthesis of battery active material particles with precise control of composition, phase-purity, and morphology. Among the most common methods reported in the literature to prepare precursors for lithium-ion battery active materials, sol-gel is characterized by simplicity, homogeneous mixing, and tuning of the particle shape. The chelate gel and organic polymeric gel precursor-based sol-gel method is efficient to promote desirable reaction conditions. Both precursor routes are commonly used to synthesize lithium-ion battery cathode active materials from raw materials such as inorganic salts in aqueous solutions or organic solvents. The purpose of this review is to discuss synthesis procedure and summarize the progress that has been made in producing crystalline particles of tunable and complex morphologies by sol-gel synthesis that can be used as active materials for lithium-ion batteries.

Keywords: gel precursor; sol-gel; chelating agent; metal-citrate gel; polymeric gel; lithium-ion battery; cathode material



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1. Introduction

The concept of optimizing the synthesis of advanced inorganic materials is a grand challenge that can speed up the process of discovery. Many design variables interact with one another in synthesis, leading to complexity. For each element in the target material (oxides, hydroxides, carbides, etc.), these design variables include a variety of possible precursor candidates [1–4]. There are several other factors that contribute to the complexity of synthesis. These factors include the conditions used in the experiment (temperature, atmosphere, etc.) and the order in which operations are performed, i.e., mixing, firing, reducing, etc. A successful synthesis requires the careful selection of a combination of these experimental variables [5]. When preparing inorganic materials, such as metal oxides or carbides, it is typically a matter of mixing powder reactants and heating them to form the desired compound. This approach is well known as the solid-state method [6]. However, this method does have some drawbacks, even though reaction conditions are relatively easy to attain. The limited mass transport of powders leads to inhomogeneity of starting materials, making it difficult to achieve complete conversion in a mixture of two or more powders. If reactant diffusion is restricted, areas of unreacted starting materials will remain. The initial reaction therefore occurs at the edges of adjacent particles. By using ball-milling to decrease the particle size and increase the sample surface area, some of these problems can be overcome [7,8]. However, repeated sample milling steps or extended heating may be necessary. The most important issue is that solid-state methods often present

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