Versatility of wet-chemical synthesis for lithium ion battery electrode materials

SolStHore - Activity 2 - Development of an Electrochemical Storage Solution, from Materials to Battery

Introduction

As the fraction of the energy on the grid, originating from renewable sources such as PV and windmills increases, domestic stationary electrochemical energy storage systems (batteries) can improve the way we are able to utilise this energy. It allows us to alleviate the intermittent character of these energy sources, as energy can be buffered during peak generation times and consumed at a later time when demand is high and generation is low. Furthermore, it also lowers peak demands on the grid, as locally harvested and stored energy can be used. Innovative synthesis and engineering of electrode materials will help power these goals. They allow tailoring the materials to specific applications and enable the use of novel battery architectures.

Wet-Chemical Synthesis

Within the Inorganic and Physical Chemistry group at Hasselt University, we have an expertise in wet-chemical synthesis, which enables us to synthesize Li-ion battery electrode materials using a variety of synthesis routes, depending on desired properties (e.g. particle size, particle morphology, surface functionalization and boundary conditions (e.g. synthesis/processing temperature constraints). We hereby present a brief overview of some selected results.

Aqueous Solution-Gel

An aqueous solution containing metal ions of the desired composition is prepared. For phosphate compounds, such as the shales (LiMPO_4, LiMPO_4) or LiPO_4, an aqueous solution is prepared. The metal ions are stabilized in this solution by the addition of complexing agents (e.g. citric acid), while controlling pH (e.g. via addition of ammonia). After water evaporation, the gel is formed, in which the transition from the amorphous precursor to the desired crystalline material occurs. We use this route to form LTO structures, as shown in Equation 1.

\[ \text{Ti}^{3+} + \text{H}_2\text{O} \rightarrow \text{Ti}^{4+} + 2\text{H}^+ \]

Thermal Decomposition

In this synthesis, organic salts of the metal ions (e.g. ammonium or acetate) are decomposed at a low temperature through an exothermic reaction, which facilitates the synthesis of LiFePO_4 nanoparticles. The metal ions are mixed with organic solvent, which commonly contains a combination of the desired compound are dissolved in a suitable organic solvent, which commonly contains a combination of oleic acid and oleyl amine as surfactants. The mixture is heated to a temperature at which the desired compounds decompose. This results in the formation of nuclei, which then grow to form the desired material.

Precipitation

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References

1. T. Vranken, W. van Gompel, J. D’Haen, M.K. van Bael, A. Hardy, Aqueous-solution-gel precursors for LiFePO_4-based thermal decomposition synthesis at the low temperature route to LiFePO_4-based powders for lithium ion battery anodes, RSC Adv. 7 (2017) 18745–18754. doi:10.1039/C7RA02503C.
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