Abstract

[Research Title]

Development of Porous Oxide Materials for Promoting Recycling of Lithium from Spent Batteries

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[Abstract]

The use of lithium-ion batteries (LIBs), which are high-capacity and high-potential storage batteries, is expected to increase further in the future due to increasing demand for renewable energy and global environmental regulations toward a decarbonized society. However, the lithium resources contained in the components of LIBs pose a geopolitical risk, and it is necessary to establish efficient lithium recovery and reuse technologies from used LIBs to maintain a stable balance between supply and demand. In the conventional method, lithium ions are precipitated from the treated solution as lithium carbonate (Li_2CO_3). This recovered Li_2CO_3 can then be reused as a raw material powder for electrode materials. Here, this study reports a new process to recover Li_2CO_3 by complexing it with porous transition metal oxides and reusing it as LIB cathode powder by heat treatment. Utilizing environment-friendly water vapor processes, we synthesized spherical manganese oxide (Mn_3O_4) powders with a maze-like pore structure (Kozawa et al., 2022) and manganese oxyhydroxide (MnOOH) pellets with a hierarchic pore structure constructed with needle-like and rod-like particles (Kozawa, 2022). The recovered amount of Li_2CO_3 nanoparticles by adding Mn_3O_4 porous spheres to an aqueous solution containing lithium ions resulted in a more than 20% increase compared to the precipitation test without Mn_3O_4. Furthermore, Li_2CO_3 nanoparticles could be easily recovered from their dispersed solution through a filtration method using the porous MnOOH pellet. Spinel-type LIB cathode particles were synthesized by heating Li_2CO_3/Mn_3O_4 composites and exhibited stable cycle performance during charge and discharge tests for 200 cycles. The fabrication of porous materials by the water vapor processes has the following academic novelties: (1) the spontaneous formation of maze-like pore structure by random particle growth, and (2) the formation of hierarchical pore structure by one-dimensionally grown particles. Therefore, it is expected to have a wide range of applications in resource recovery, resource recycling, water purification, and composite material synthesis (Kozawa et al., 2022). In addition, we have demonstrated the possibility of synthesizing porous Mn_3O_4 from various manganese compounds. This result will contribute to adding value to manganese compounds produced in the resource recovery process from waste LIBs.

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