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Full Paper

Investigation of the Storage Behavior of Shredded Lithium-Ion Batteries from Electric Vehicles for Recycling Purposes

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Abstract

Shredding of the cells is often the first step in lithium-ion battery (LIB) recycling. Thus, $\text{LiNi}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}\text{O}_2$ (NMC)/graphite lithium-ion cells from a field-tested electric vehicle were shredded and transferred to tinplate or plastic storage containers. The formation of hazardous compounds within, and being released from, these containers was monitored over 20 months. The tinplate cans underwent fast corrosion as a result of either residual charge in the active battery material, which could not fully be discharged because of contact loss to the current collector, or

redox reactions between the tinplate surface and metal parts of the shredded material. The headspace compositions of the containers were investigated at room temperature and 150 °C using headspace–gas chromatography–mass spectrometry (HS–GC–MS). Samples of the waste material were also collected using microwave-assisted extraction and the extracts were analyzed over a period of 20 months using ion chromatography–electrospray ionization–mass spectrometry (IC–ESI–MS). LiPF_6 was identified as a conducting salt, whereas dimethyl carbonate, ethyl methyl carbonate, and ethylene carbonate were the main solvent components. Cyclohexylbenzene was also detected, which is an additive for overcharge protection. Diethyl carbonate, fluoride, difluorophosphate and several ionic and non-ionic alkyl (fluoro)phosphates were also identified. Importantly, dimethyl fluorophosphate (DMFP) and diethyl fluorophosphate (DEFP) were quantified using HS–GC–MS through the use of an internal standard. DMFP, DEFP, and related compounds are known as chemical warfare agents, and the presence of these materials is of great interest. In the case of this study, these hazardous materials are present but in manageable low concentrations. Nonetheless, the presence of such compounds and their potential release during an accident that may occur during shredding or recycling of large amounts of LIB waste should be considered.

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