Investigation of Environmentally Friendly Binders for Battery Electrodes in Aqueous Systems

Silver Sepp
Institute of Chemistry, University of Tartu
Ravila 14a Tartu, 50411, Estonia
silver.sepp@ut.ee

When it comes to energy storage devices, it's crucial to consider affordability, durability, and environmental safety. Currently, PVDF (polyvinylidene fluoride) is widely used as a binder in battery electrodes. However, its processing involves the use of toxic solvents like N-methyl-pyrrolidone (NMP)[1, 2]. To address this, alternative water insoluble organic binders that are more environmentally friendly have been explored. Here are some noteworthy options: a) Ethyl cellulose: this biodegradable and water-insoluble polymer can replace PVDF as a binder. Slurries based on ethyl cellulose can be prepared using ethanol as a solvent, making the process more sustainable and cost-effective. b) Cross-linked gluten which is another potential binder choice. Using water-based slurry, electrodes can be prepared in simpler production setup [3]. This replacement offers benefits such as faster assembly due to rapid solvent evaporation, no strict humidity control requirements, and easier recycling (as there are no fluorinated compounds). Therefore, this change in binder composition would enable us to produce safer and cheaper energy storage devices.

In this study, positive electrodes with varying compositions using galvanostatic charging-discharging and cyclic voltammetry have been investigated. Additionally, different cell setups have been explored to better understand the behavior of these electrodes. The findings shed light on the electrochemical properties and performance of these materials. LiMn2O4 (LMO) has been utilized as the active material for the cathode, along with carbon black Super P as a conductive additive. PDVF has been compared with various organic biodegradable polymers. Remarkably, performances of cross-linked gluten and ethyl cellulose are comparable to the results obtained when PVDF is used as a binder. With ethyl cellulose, discharge capacity 100 $mAhg^{-1}$ was achieved at 0.2C rate for LMO cathode. After 500 cycles at a 1C rate, electrodes prepared using PVDF showed somewhat better capacity retention. The findings indicate that certain biodegradable and cost-effective binders hold promise as potential replacements for PVDF (polyvinylidene fluoride) as binders in aqueous systems. This is particularly significant in the context of aqueous redox flow batteries with solid boosters, where a substantial quantity of solid charge storage material is employed in tanks to enhance system capacity.[2]

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