Sustainable PFAS-free Binder for High-Energy Lithium-Ion Batteries

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Climate change and the energy transition require a sustainable energy supply. Besides the green generation of energy, its storage is crucial for economic and social development. Research and industry demonstrate that high-energy lithium-ion batteries (LIB) represent the key technology toward a sustainable future.
The LIB constitutes a very complex system due to the interaction of many materials working together to create a well-working device. Considering the cathode, it consists of a current collector made from aluminum foil coated with a mixture of the active lithium transition metal oxide (Ni, Mn, Co) and electrically conducting carbon black. This cathode is soaked in electrolyte and is connected to a polyethylene foil that serves as the separator (Figure 1a). This composite electrode is held together by a polymeric binder that ensures intensive contact between all components and maintains mechanical integrity. Currently, fluorinated polymers are used as binders in lithium-ion batteries, which require hazardous per- and polyfluorinated chemicals (PFAS) and toxic solvents as processing aids.
Herein, a sustainable approach to the energy storage sector is presented, encompassing a holistic view of the value chain, achieved with polymeric surfactants derived from 11-acrylamidoundecanoic acid [1]. The materials developed facilitate the production of PFAS-free batteries, with the primary raw material sourced from the renewable resource, castor oil (Figure 1b). Enhanced adhesion and flexibility result in a longer battery service life, and the salt character provides the polymer with ionic conductivity, along with the option to process the cathodes in water and utilize a water-based recycling process. Thus, elements with limited availability, such as Li, Ni, Mn, and Co, can be recovered in an energy-efficient and environmentally friendly manner. Due to the pH-dependent solubility of the polymers, it can be recovered as well. The binder was also shown to work with other battery systems based on sodium or potassium.

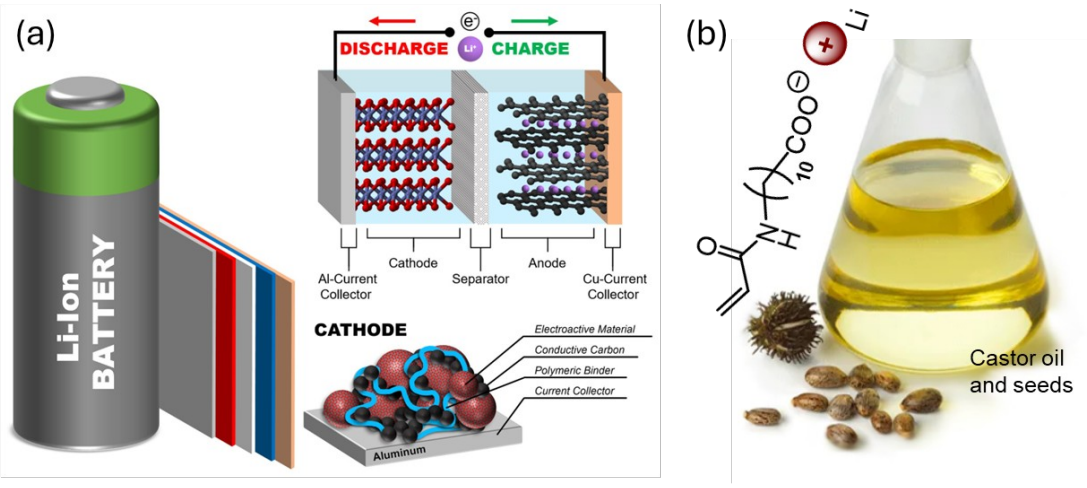

Figure 1. Schematic representation of the components and operating principle of a lithium-ion battery (a) and the castor oil-related monomer as the basis of the sustainable polymeric binder (b).

Keywords: PFAS-free, sustainable energy materials, polymeric surfactant, polyelectrolyte

References

[1] Leibetseder, F.; Xie, J.; Leeb, E.; Hesser, G.; Pettinger, K.-H.; Bretterbauer K. Recyclable Fluorine-Free Water-Borne Binders for High-Energy Lithium-Ion Battery Cathodes. *Advanced Energy Materials* **2024**, *14*(27), 2401074.