Carbonyl-based π-conjugated materials: The future of lithium-ion batteries

Hamid Oubaha, Jean-François Gohy, Sorin Melinte

Video Abstract

Keywords: carbonyl, π-conjugated materials, lithium-ion batteries, energy storage, global energy, electrode, LIBs, flexible, electron, imides, quinones, anhydrides, carboxylates, solid-state battery, all-organic battery, sustainable energy, radical mono-anion, ChemPlusChem

Posted Date: January 16th, 2020

DOI: https://doi.org/10.21203/rs.2.21323/v1

Abstract

For decades they've taken a backseat to their mineral counterparts. But today, organic materials are booming—not least of all for their applications in lithium-ion batteries. A new review article published in the journal ChemPlusChem discusses how one class of organics in particular is poised to yield high performance from a tiny but versatile package: carbonyl-based π-conjugated compounds. Like other organic materials, carbonyl-based π-conjugated materials present a unique and much-needed solution to the global energy crisis. Flexible, light, and naturally abundant, these compounds offer the prospect of nimble energy-storage systems with energy and power densities comparable to inorganic systems. What sets carbonyl-based π-conjugated materials apart from other organics is highly tunable electrochemical performance stemming from a versatile starting structure. The redox mechanism of carbonyls proceeds by a reversible one-electron reduction to form a radical mono-anion and the reverse reaction. That mechanism can be broadened to involve more electrons by virtue of extended conjugation and modulated by the form of the basic carbonyl unit, of which there are four main types: imides, quinones, anhydrides, and carboxylates. Each one represents a template for designing electrodes with properties suitable for solid-state battery applications. These include but aren't limited to high capacity, optimized output potential, and improved stability. Though many obstacles to full integration in lithium-ion technology remain, pathways for overcoming them are gradually coming into focus. Theoretical research, for example, could weigh in on issues such as what chemical units could boost the electrical conductivity of carbonyl-based electrode materials. Other research could point toward more efficient polymer electrolytes that suppress the solubility issue faced by redox-active compounds, leading to safer all-organic batteries. And still other studies could prime carbonyl-based electrodes for widespread use—by adapting them to grid-scale energy-storage systems and by finding techniques to nurture their inherent softness, bendability, and stretchability. As the push toward sustainable energy resources and away from fossil fuels gathers momentum, carbonyl-based π-conjugated materials represent an important opportunity to make significant gains. Indeed, their sheer versatility, extending from structure to performance, holds tremendous potential for future lithium-ion technology. For more information, read the full review online at http://dx.doi.org/10.1002/cplu.201800652.