Graphite-SiOx electrodes with a biopolymeric binder for Li-ion batteries

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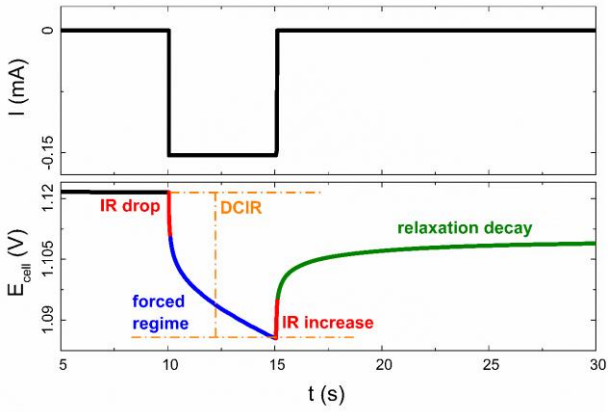
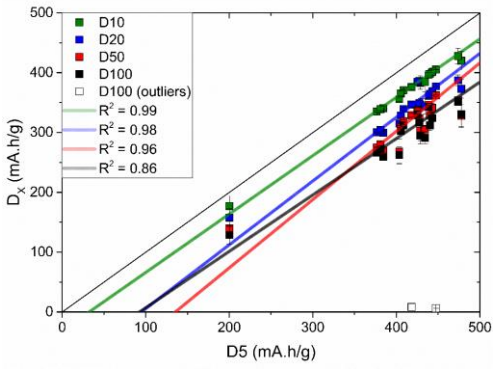
The rechargeable Li-ion battery is a fundamental necessity in modern society, being used in devices including cell phones, laptop computers, and digital cameras. Decades of incremental improvements have made today's rechargeable batteries longer-life with higher densities and are now being used in the emerging sector of electric vehicles. With this broad applicability of Li-ion batteries, it is important to take into account the environmental impact that they have and design the manufacturing, materials, processing and recycling with this in mind.



The most common anode material for Li-ion batteries is graphite, despite its relatively low energy storage density (372 mA.h/g), because of its cycle life stability attributed to its low volume expansion during lithiation and delithiation. In order to improve the specific capacity, but not compromise the volume expansion, silicon suboxide – SiO_x (1965 mA.h/g) can be mixed with graphite at low amounts to boost the specific capacity which is attractive for high-energy requirements. SiO_x is less conductive than graphite 6.7×10^{-4} S/cm compared to ~10^4 S/cm and a conductive 3D network with carbon black, or alternative conductive additives, is used to increase the electrically conductive pathways and enable the electron transfer from the surface of the electrode to the current collector. The binder also increases the resistivity of the coatings and thus its presence is preferred at a minimum, however it is very important to the mechanical stability of the electrode since it binds the active materials and conductive additive to the current collector and affects the electrode-current collector adhesion properties. In order to reduce cost, and improve the environmental impact of Li-ion battery electrodes, water-soluble binders can be utilized, most commonly carboxyl methylcellulose (CMC) and styrene-butadiene rubber (SBR). Other polymeric natural binders like carrageenan have been introduced and electrochemically investigated in the literature the past decade.



In this work, carrageenan gum has been investigated as a potential green binder system for graphite-SiO_x anodes. A relationship between the physical properties and the electrochemical properties has been explored, with an end goal the cycle life performance. A simple current interrupt test elucidated and the contributing ohmic and charge transfer resistances showing increases for both, related to the mass loading, porosity and state of charge. This method may enable faster screening of electrode formulations, and prediction of cycle life of this and other electrode types.