Advanced Materials for Electrochemical Energy Conversion

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Summer undergraduate research projects in the Creager group will involve synthesis and characterization of advanced materials and devices for electrochemical energy conversion, especially, rechargeable lithium batteries and a variety of fuel cells including conventional fuel cells utilizing hydrogen as fuel, and microbial fuel cells utilizing biotic organic matter as fuel. In the lithium battery area, students will synthesize fluoropolymer electrolytes in acid form using methods which have been previously developed at Clemson for preparing proton-conducting membranes. Then, they will convert the electrolytes into lithiated form and incorporate them as binders into battery cathodes. We hypothesize that the use of lithiated fluoropolymer electrolytes as electrode binders will promote ion transport within the electrodes, which in turn will allow for battery operation at higher powers as is needed in large-format lithium ion batteries for electric, hybrid electric, and plug-in hybrid electric vehicles. In the hydrogen fuel cell area, students will synthesize similar fluoropolymer electrolytes in acid form, and study their protonic conductivity under conditions of variable temperature and humidity. Finally, in the microbial fuel cell area, a project is proposed whereby students will fabricate and test a benchtop microbial fuel cell utilizing simple plastic components (acrylic acid body, granular carbon electrodes (e.g. aquarium carbon), and electro-dialysis membrane separators) in an up-flow, packed-bed format. Inoculation with sediments from a variety of sources including local fresh-water lakes, marshland from the South Carolina coastal region, and from various extreme environments, e.g. sediments from the Great Salt Lake in Utah, and from various hot springs, will be attempted, to see which ones grow electricigenic biofilms that can catalyze electro-oxidation of fuels to produce electricity directly from organic matter. Fuel cells of this type are known, but there has been relatively little exploration of their generality. This project is in collaboration between Prof. Creager in the Clemson chemistry department, Prof. Drapcho in the Clemson biosystems engineering department, and Prof. May in the Department of Microbiology & Immunology at the Medical University of South Carolina.