Ionic Liquids in Electrochemical Applications

Ionic liquids (ILs) are salts with melting points below 100°C and can be tuned to the desired properties by modifying the anion-cation pair. Beyond the desirable traits many ILs are touted for in general applications, such as a minimal vapor pressures, high (and tunable) solubilities, etc., there are additional properties that make them desirable for electrochemical use. These include wide electrochemical potential windows (EWs) and moderate conductivities. Traditional electrochemical systems are commonly limited by either the EW or conductivity. In aqueous solutions the conductivities can be high by dissolving appreciable quantities of electrolyte, but the EW is small due to water splitting. This small EW prevents many electrochemical redox potentials from being accessed. In organic solutions, the EW can be increased but solubility of electrolyte salts is limited, reducing conductivity significantly. With the use of ILs, the EW can be substantially widened compared to aqueous systems while having higher conductivities than what is possible in many organic systems, potentially creating a more favorable electrochemical environment. Two applications where ILs hold promise for use will be presented – electrodeposition of palladium in ILs for nanoparticle synthesis and use of IL-like materials as switchable electrolytes.

The electrochemistry and electrodeposition phenomena of palladium and its impact on the resulting morphology of the deposited nanoparticles will be reported. Through the IL used and the electrochemical parameters, the size and shape of the Pd nanoparticles can be dramatically changed.

As the energy density of electrochemical devices increases, so does the risk for runaway reactions which can lead to fires and explosions of the devices. By use of an in situ safety switch that when triggered by heat will significantly lower the conductivity, the device can shutoff prior to incident. It is also important that when the device cools again that it can return back to an operating state. Silylamine reversible ionic liquids can serve as a switchable electrode through the use of heat and CO₂ as the switching stimuli between a conductive RevIL state and a non-conductive molecular liquid state. The fundamentals associated with the switchable electrochemical properties will be presented.
Elizabeth J. Biddinger, Ph.D.

Elizabeth J. Biddinger joined the Department of Chemical Engineering at the City College of New York (CCNY) in the City University of New York (CUNY) system as an Assistant Professor in the Fall of 2012. Her research interests encompass green chemistry and energy applications utilizing electrochemistry, catalysis, alternative solvents and sustainable engineering methods. Prior to joining City College, Professor Biddinger was a Post-doctoral Fellow at the Georgia Institute of Technology. She received her PhD in 2010 in Chemical Engineering from The Ohio State University and her BS in 2005 in Chemical Engineering from Ohio University. While at Ohio University, Professor Biddinger did research in Professor Gerardine Botte’s research group, was very active in the engineering student societies, and was a Charles and Marilyn Stuckey Manasseh Cutler Scholar. Professor Biddinger recently received the 2016-2017 Electrochemical Society – Toyota Young Investigator Fellowship Award to work on reversible ionic liquid systems as electrochemical safety switches. She was awarded the 2014 CUNY Junior Faculty Award for Science and Engineering from the Sloan Foundation to investigate CO₂ electroreduction. Dr. Biddinger has held multiple leadership posts including serving as the student awards chair for the Industrial Electrochemistry and Electrochemical Engineering Division of the Electrochemical Society (ECS) (2014-Present), a Teller of Elections for ECS (2016-Present) and, chair (2009-2010) and vice-chair (2008-2009) of the Central Ohio Professional Section of American Institute of Chemical Engineers.