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Superionic polymer electrolytes for batteries and fuel cells energy materials: Battery materials

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Use of polymer electrolytes instead of traditional liquid electrolytes provides significant advantage for electrical energy storage applications. However, limited ionic conductivity of polymers remains a major obstacle for their broad use in batteries. We present an overview of ionic conductivity in various polymers. We demonstrate that in contrast to liquid electrolytes, there is a strong decoupling of ionic conductivity from structural dynamics in many polymers. This decoupling is caused by frustration in packing of relatively rigid polymer chains. As a result, ions retain high mobility even when structural dynamics is very slow or completely frozen. Based on this analysis we emphasize that the best way to polymer electrolytes with sufficiently high ionic conductivity is through the effective decoupling of ionic diffusion from structural relaxation. The second important parameter that controls ionic conductivity is the concentration of free ions. It depends on salt solubility and energy of the salt dissociation. We demonstrate that increase in the dielectric permittivity of polymers helps to increase significantly the concentration of free ions. To provide a systematic picture of ionic conductivity in polymers we employ the so-called Walden plot. Application of this analysis to different classes of polymer electrolytes, including polymerized ionic liquids, helps to identify 'superionic' behavior for many polymers. We present several examples of promising polymers with conductivity approaching 10-4 S/cm at room temperature. At the end we demonstrate that similar ideas can be applicable to proton conductivity and design of polymer membranes for fuel cells that might work in non-aqueous conditions.

Biography

Alexei P Sokolov received his PhD in Physics from Russian Academy of Sciences in 1986. He continued his work at the Russian Academy of Sciences till 1991. Then he worked in Germany as a Humboldt Fellow, and a Max-Planck Fellow and at the end of 1998 he became a Professor at the Department of Polymer Science, The University of Akron, USA. In 2009, he accepted the Governor's Chair position at the University of Tennessee, Knoxville, where he currently leads Soft Matter efforts at both UT and Oak Ridge National Laboratory. He has published more than 200 peer-reviewed papers.

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