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1. Main Research Topics

① Development of Redox-Active Ionic Liquids and Functional Deep-Eutectic Solvents

Ionic liquids are salts composed of cations and anions that remain liquid at room temperature. Because they are scarcely volatile even under high-temperature or low-pressure conditions, they can be used as electrolytes without concern for evaporation. Leveraging their excellent ionic conductivity, we are developing new functional ionic liquids.

Our first focus is the creation of redox-active ionic liquids capable of reversible electron transfer. Some of these compounds exhibit electrochromism, changing color in response to their redox state. The display device shown in Fig. 1(a) employs a redox-active ionic liquid and can be colored or bleached with the voltage of a single alkaline battery.

Our second focus is the development of deep-eutectic solvents that liquefy host materials. By liquefying host molecules at high concentrations, we aim to incorporate poorly soluble guest molecules in equally high concentrations. A deep-eutectic solvent is a liquid obtained by mixing two or more high-melting-point substances, resulting in a pronounced depression of the melting point. Taking advantage of this behavior, we liquefy the host material itself, as illustrated in Fig. 1(b), to create a universal solvent capable of dissolving otherwise insoluble compounds.

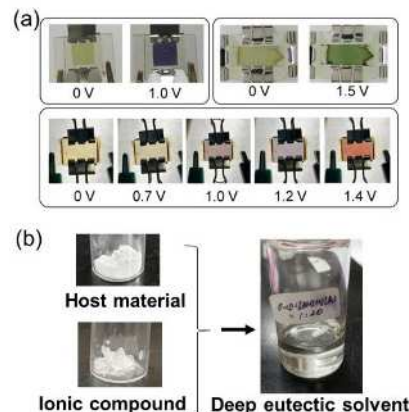


Fig. 1 (a) Coloration of electrochromic devices based on Redox-Active Ionic Liquids. (b) Deep eutectic solvent based on host material.

② Optical Responses of Metal and Semiconductor Nanoparticles

Metal and semiconductor nanoparticles ranging from a few to several hundred nanometers exhibit unique optical absorption and scattering phenomena known as Mie resonance and localized surface plasmon resonance (LSPR). Downsizing bulk metals, which ordinarily show only metallic luster, or semiconductors with low absorption coefficients, transforms them into materials with strong light absorption. Such nanoparticles can be applied in energy-conversion materials for photo-thermal, photo-electric, and thermo-electric technologies. We are pursuing the theoretical design of light-energy conversion and sensing materials based on nanoparticle technology.

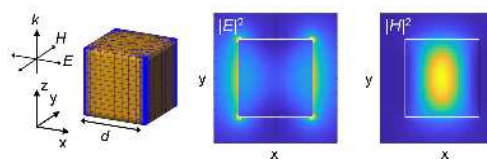


Fig. 2 Electric field distributions around a PbS nanocube.

2. Keywords

ionic liquid, electrochromism, deep eutectic solvent, surface plasmon resonance, Mie resonance, instrumental analysis

3. Remarks and Websites

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We possess expertise in designing ionic liquids, synthesizing them with high purity, and engineering materials that exploit the optical resonances of noble metals and semiconductors. These efforts are underpinned by advanced analytical instrumentation and data-analysis techniques. For external users interested in the university's spectroscopic equipment, we offer technical consultation on both measurement and data analysis. If our research or capabilities align with your needs, please feel free to contact us. Offprints of our journal articles are also available upon request.