**Water-mediated Complex Matter**

How does a water molecule behave in room temperature ionic liquids (RTILs)?

**Room temperature ionic liquids (RTILs)** simply consist of a cation and an anion. The RTILs are characterized as non-measurable vapor pressure, nano-heterogeneity and thermal stability, and so on. The RTIL we discuss here is [DEME][BF₄]. By adding water into the RTIL, a variety of hydrogen bonding appears in the liquid, glass and crystal.

Even in the liquid state, a ‘hierarchy structure’ is induced by water. A network-forming feature over the medium-range appears at a specific concentration of water, where the hierarchy is related to nearly-free hydrogen bonded (NFHB) water and nano-heterogeneity of the mixtures.

In the solid state, a complicated phase diagram of [DEME][BF₄]-H₂O was determined by simultaneous X-ray diffraction and differential scanning calorimetry (DSC) measurements (Rigaku Co., Japan). Interestingly, two different kind of slow-cooled glass appeared at 6.7 and 60.1 mol% H₂O. In contrast to the slow-cooled glasses, two stages of glass transitions are observed in rapidly quenched mixtures. The NFHB water remains in the quenched glass, although the slow-cooled glasses has no NFHB one.

In the crystal, strong hydrogen/deuteron (H/D) effect is observed even at 1 mol% H₂O. It is assumed that the sub lattice network in the superstructures causes these anomalies. The H/D effect is well described by proton-mediated covalent bonding (PMCB), which is enhanced by the sub lattice network. PMCB is an attractive interaction expressed by quantum delocalization of the proton.
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