Exploring New Proton Conducting Materials For PEM Fuel Cells: Inorganic-organcic Hybrid Compounds Containing Heteropoly Acids

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Heteropoly acids (HPAs) are an important class of inorganic solid acid compounds. The heteropolyanions are usually composed of early transition metal MO_6 (M = W^{6+}, Mo^{6+}, etc.) octahedra, a cluster of which enclose main group XO_4 (X = P, Si, etc.) tetrahedra in the center. Because of their diverse compositional range and significant structural versatility, HPAs have found numerous applications in catalysis, medicine, pigment industry, and sensor technology etc., by utilizing specific molecular composition, size, shape, charge density, redox potentials, acidity, and solubility characteristics.[1,2] More recently, HPAs have received particular attention in fuel cell electrolyte materials owing to their exceptionally high proton conductivities.[3]

Our group has been exploring the feasibility of using HPAs as PEM fuel cell electrolytes from both the fundamental and application points of view. While HPAs have shown many interesting properties and improved fuel cell performance, their high water solubility oftentimes poses an obstacle to the application in PEM fuel cells: HPAs tend to leach out of the membrane over time. In order to solve this problem, our approach is to immobilize HPAs in organic-based matrices via covalent bonding, hoping to combine the unique properties of the metal-oxo fragment with those of the attached organic groups.

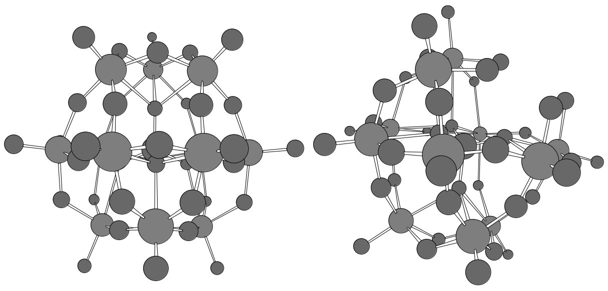

Figure 1. Structures of the Keggin anion ($XM_{12}O_{40}$, left) and its monovacant derivative ($XM_{11}O_{39}$, right).

As shown in Figure 1, compared to the original Keggin anion, the mono-lacunary species has a vacant site where one tungsten atom is missing. Generation of such vacant sites makes the anions possible tetra-dentate ligands towards other transition metal cations – a large number of transition metal complexes of this type are known. In addition, complexation with organic molecules through C-Si-O, C-Sn-O or C-Ge-O covalent bonds at the lacunary site has also been reported.[4-6] Guided by this chemistry, our work with these hybrid systems has focused on making solid state hybrid materials that can be used in fuel cell membranes,[7] and our findings in material syntheses and properties will be presented.

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