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Editorial: Water as Solvent for Catalysis

One of the most important distinctions of Earth from the rest of the planets is the presence of vast quantities of liquid water on the surface of the Earth. Water is the solvent and transport media for biological processes and participates or catalyzes many chemical reactions in the environment. It has recently been suggested that water may even play an important role in the earliest processes during the evolution of the Solar System. Although water has been used extensively as a solvent by chemists in previous centuries, polar organic liquids have been the preferred solvents in modern organic and organometallic chemistry. Consequently, most homogeneous catalytic processes have been designed and developed to operate in polar organic solvents. This has been especially true for catalytic systems utilizing organometallic complexes. In fact, vigorous drying of organic solvents is a standard procedure for most organometallic chemists.

The application of water as solvent in organic syntheses and in homogeneous transition-metal catalyzed reactions has been steadily growing during the last twenty years. The most attractive feature of water as a solvent is its utility in the development of environmentally benign chemical processes. It is not toxic and available in most parts of the world in sufficient quality and quantity. Because water is odorless and colorless, impurities can be easily detected. In addition, the non-flammable nature of water is an important safety feature for large scale applications.

The successful application of water as solvent in homogeneous transition-metal catalyzed processes requires an understanding of the fundamental physical and chemical properties of water. Although the exact structure of liquid water is not known, it probably consists of either a mixture of monomeric water and hydrogen bonded polymers or clusters (mixture theory) or a network of water molecules with essentially complete hydrogen bonding (continuum theory). The physical properties of water, such as heat of vaporization, heat of fusion, heat capacity, melting and boiling points, are strongly influenced by the extensive intermolecular hydrogen bonding. For example, the viscosity of water decreases ten-fold as the temperature is raised from 0°C to 100°C due to the disruption of hydrogen bonds. Water is an excellent solvent for many substances, especially for those which can be solvated by or form hydrogen bonds with water molecules. In contrast, substances which cannot interact with water via ionization or hydrogen bonding have limited solubility in water. Thus, most aqueous catalysts are either ionic or made water soluble by attaching hydrophilic polar (ionic) groups to the ligands. Water can be used as a solvent in one-phase or two-phase catalysis. In one-phase catalysis all reactants, products and catalysts are water soluble, the separation of the product(s) from the catalyst can be a major challenge for industrial application. In contrast, aqueous two-phase catalyst systems offer an easy separation of the aqueous catalyst phase from the product phase provided the products have limited solubility in water. Thus, it should be emphasized

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that aqueous biphase systems are particularly attractive for reaction producing apolar products. Finally, the role of water as a solvent could go well beyond just simple physical dissolution of catalysts and substrates. The acidity/basicity of aqueous reaction mixtures as well as hydrophobic interactions between catalyst and substrates could have dramatic effects on reaction rates and product selectivities.

The papers of this special issue on *Catalysis in Water* provide an overview of current results and future trends and clearly demonstrates the tremendous potentials for the use of water as the solvent of choice for catalytic reactions.

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