Superprotonic Solid Acid Membranes: Alternative Proton Conductors for Fuel Cells

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Sustained efforts in the engineering of fuel cells based on polymer electrolyte membranes have resulted in the development of practical systems for vehicular, portable, and stationary applications. However, the low operation temperature of PEMFCs requires stringent management of liquid water content and fuel purity, increasing ultimate system cost and raising barriers to widespread adoption.

The so-called superprotonic solid acids (SSAs)[1] have recently emerged as a possible alternative to polymer electrolytes. Essentially chemical intermediates of acids and salts, SSAs are distinguished by thermally-activated polymorphic phase transitions at intermediate temperatures (140 °C to 230 °C) to phases with proton conductivity approaching that of polymers (~0.03 S cm^{-1}).

By operating at elevated temperatures, solid acid fuel cells (SAFCs) are spared the difficulty of managing liquid water, and have an extreme tolerance to fuel impurities. The solid-state nature of SSA membranes also imparts excellent barrier properties. In practice, SAFCs face a categorically different set of obstacles than PEMFCs[2].

In this tutorial I will review the principles essential to understanding superprotonic solid electrolytes and the unique challenges facing the development of SAFCs. Focusing on CsH_2PO_4, I will discuss aspects of solid acid phase equilibria[3] that are essential to managing SSAs in fuel cell applications. Furthermore, I will elaborate on the difficulties of developing functional electrodes for these solid-state systems, and address advanced electrode synthesis routes[4].

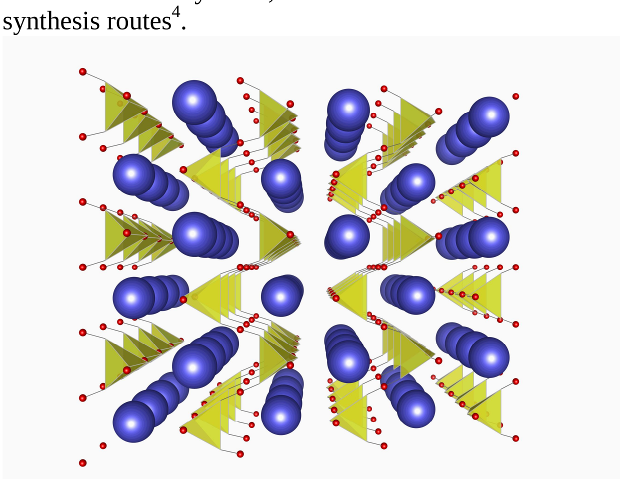

Figure 1. The room-temperature crystal structure of the superprotonic solid acid CsH_2PO_4 (CDP).

References

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