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Proton trapping: a key to design proton-conducting electrolyte for solid oxide fuel cells

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Proton conducting oxide, especially yttrium-doped barium zirconate, has gathered much attention as an intermediate-temperature solid oxide fuel cell electrolyte. It offers high proton conductivity as well as high chemical stability in the targeted intermediate temperature regime of 450~600 °C. Proton transport mechanism in the oxide is one of the most fundamental information to design solid oxide fuel cells. It has been proposed that protons are trapped on the oxygen site nearby dopant of doped oxides. Although proton trapping itself dictates the downward curved Arrhenius plot of proton diffusivity, there was no evidence for that. We applied electrochemical spectroscopy and thermogravimetry to the 20 at% yttrium-doped barium zicronate and provided such evidence [1]. Analysis of the curved Arrhenius plot based on association reaction, the equilibrium between trapped and trap-free protons, provides the association energy of 29 kJ/mol in case of yttrium-dopant, which is much larger than diffusion barrier for trap-free proton, 16 kJ/mol. High-temperature nuclear magnetic resonance also captured two proton environments. This fundamental understanding, in turn, provides how to design proton-conducting electrolyte for solid oxide fuel cells; the choice of dopant that has lower association energy leads to further enhance proton transport in the oxide.

[1] Yamazaki* et al., *Nature Materials*, 12(2013) 647.

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