In situ X-ray and neutron studies to investigate proton conduction in proton exchange membranes for direct alcohol fuel cells

Krystina Lamb[a], Roland De Marco[a], John Bartlett[a], Vanessa Peterson[b], Dominique Appadoo[c], and San Ping Jiang[d]

[a] *University of the Sunshine Coast, Locked Bag 4 Maroochydore DC, Queensland, 4558, Australia*
[b] *Australian Nuclear Science and Technology Organisation, Locked Bag 2001, Kirrawee DC, New South Wales, 2232*
[c] *Australian Synchrotron, 800 Blackburn Road, Clayton, Victoria, 3168, Australia*
[d] *Fuel and Energy Technology Institute, 1 Turner Ave, Technology Park, Bentley, Perth Western Australia, 6102, Australia*

Medium temperature proton exchange membrane fuel cells (MT-PEMFCs) are solid-state energy conversion devices that electrochemically convert chemical energy (e.g., from alcohols) into electricity. MT-PEMFCs have advantages such as elimination of carbon monoxide poisoning of the electrocatalyst, enhanced oxidation kinetics of alcohol fuels such as methanol, and the use of liquid fuels. Heteropoly acids (HPA) such as phosphotungstic acid (HPW) can be used to functionalize ordered mesoporous silica (MSN) to make nanocomposite proton exchange membranes (PEMs).

While these HPW MSN composites have been studied extensively as catalysts, HPW functionalized MSNs have only recently be studied for use in MT-PEMFCs using methanol as a fuel. Previous studies have investigated the relationship between physical stability, temperature and fuel cell performance. However, the exact mechanism of proton conduction in these materials, and how this is altered by changes in the physical and chemical environment of the materials has not been investigated *in situ*.

In this project, MT-PEMFCs with HPW MSN will be operated under a variety of physical and chemical conditions, and the mechanism of proton conduction will be studied *in situ* using small angle neutron scattering (SANS), far- and mid-infrared spectroscopy (far-and mid_IR) and quasi-elastic neutron scattering (QENS). These techniques will be compared to molecular dynamics models, both from literature and developed by the research team. To conduct these studies, a specialized fuel cell testing station will be designed and constructed. Work at the Australian Synchrotron's (AS's) High Resolution Infrared beamline will be conducted in July 2013 using a custom-designed fuel cell tailored for the beamline at the AS.