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## XANES Study of Supported Bifunctional Electrocatalysts for Unitized Regenerative Fuel Cells

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Beamline(s): X18B, X19A

**Introduction:** Unitized regenerative fuel cells (URFCs) are promising energy storage systems for uninterrupted power supplies, solar powered aircraft, etc., by combining an electrolyzer (in which water is converted into hydrogen and oxygen by the primary energy source) and a fuel cell (in which the recombination of the stored hydrogen and oxygen generates water and electrical energy in the same dual mode system). Although URFCs are an appealing technology for meeting these energy needs, their development is still at an early stage. One essential issue is the development of corrosion-resistant and highly active electrocatalysts for both oxygen reduction and water oxidation at the oxygen electrode. We recently reported a combinatorial study of mixed metal and alloy catalysts for these reactions, and an unsupported ternary  $\text{Pt}_{4.5}\text{Ru}_4\text{Ir}_{0.5}$  catalyst was identified as an efficient and stable catalyst for the oxygen electrode in URFCs<sup>1</sup>. The second step involved studying a supported version of this catalyst as the effect of adding a support in catalytic reactions is well recognized. Further work showed Ebonex (consisting of several suboxides of Ti) as an excellent support. Optimized compositions were prepared in bulk, tested in a gas diffusion half-cell, and characterized.

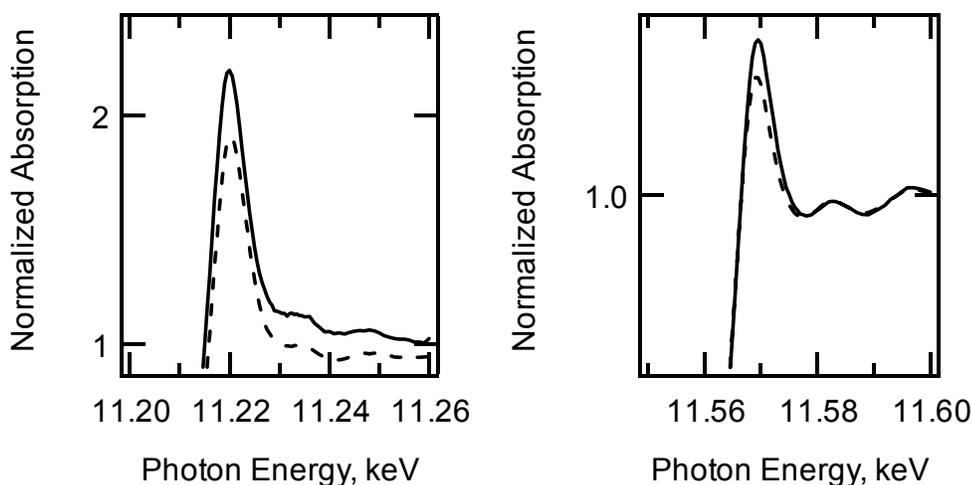
**Methods and Materials:** The catalysts were prepared from chloride precursors, and reduced using sodium borohydride. XANES data were collected at the Ti K-edge, to characterize the Ebonex support, and at the Pt and Ir  $L_3$ -edges and Ru K-edge to characterize the catalytic component. Data on the supported catalysts were obtained in transmission mode, and those on the unsupported catalysts in total electron yield mode

**Results:** Figure 1 shows a comparison of the Pt  $L_3$  and Ir  $L_3$ -edge XANES of the unsupported  $\text{Pt}_4\text{Ru}_4\text{Ir}$  and the respective Ebonex supported catalysts. At both the Pt and Ir  $L_3$ -edges the relative intensity of the white line resonance is greater for the supported than the unsupported catalysts. These data are consistent with the presence of an electronic metal-support interaction. Indeed, it is not unreasonable to conclude from the fact that the metal is highly dispersed on such a low surface area support that there is some type of chemical interaction between the metal particles and the Ebonex support. The Ru K-edge data (not shown) show that there is a mixture of both metallic and oxidized Ru present, with the oxidic component being larger on the supported catalyst.

**Conclusions:** XANES indicates a significant electronic interaction between the catalyst and the support, and a substantial increase in catalyst utilization is observed, even though the support surface areas are relatively low.

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**References:** <sup>1</sup>G. Chen, D.A. Delafuente, S. Sarangapani, and T.E. Mallouk, *Catalysis Today*, **67**, 341, 2001



Ir  $L_3$ -edge XANES (left) and Pt  $L_3$ -edge XANES (right) for unsupported (dash) and supported (solid) catalysts.