Contribution ID : **16** Type : **Oral Presentation**

An ex situ near edge X-ray absorption fine structure spectroscopy study of metal phthalocyanine catalysts for CO2 reduction

Thursday, 16 August 2018 15:45 (15)

The electrochemical reduction of CO2 is a process that has attracted considerable attention due to the combined benefits associated with the environmental remediation of CO2 and the production of valuable feedstock materials (e.g. CO) for the production of liquid fuels [1]. We have been studying the use of molecular catalysts such as metal phthalocyanines (MPc) as desirable candidates for CO2-to-CO electrochemical catalysis as they can be tuned to achieve high activity and selectivity over proton reduction. In particular, iron phthalocyanine (FePc) is particularly interesting because the Fe(0) centre can donate electrons in the activation of CO2 molecules and exhibits a relatively low onset potential for CO2 reduction when compared with other metal phthalocyanine systems.

Recently, we observed that the addition and self-assembly of metal-oxide nanoclusters (MOx, where M = Ni or Co) on FePc catalysts can result in improved catalytic performance compared to the neat material [2]. Ex situ near edge X-ray absorption fine structure (NEXAFS) measurements were performed on the catalyst materials as a function of applied potential during CO2 reduction. Remarkably, the NEXAFS investigation revealed that at certain potentials, electrochemical substitution occurs between the active iron centre in FePc with the Ni or Co from the MOx nanoclusters. In this presentation, details of the ex situ NEXAFS investigations will be presented, in addition to transmission electron microscopy, atomic force microscopy and electrochemical results that demonstrate improved electrocatalytic performance.

References:

[1] Wilhelm D., Simbeck A., Karp R., Dickenson R., Fuel Process Technol. 71, 139 (2001).
[2] Cheng Y., Veder J.-P., Thomsen L., Zhao S., Saunders M., Demichelis R., Liu C., De Marco R., Jiang S.P., J Mater. Chem. A 6, 1370 (2018).

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Session Classification : Speaker Sessions and Seminars

Track Classification : Catalytic Materials and Processes