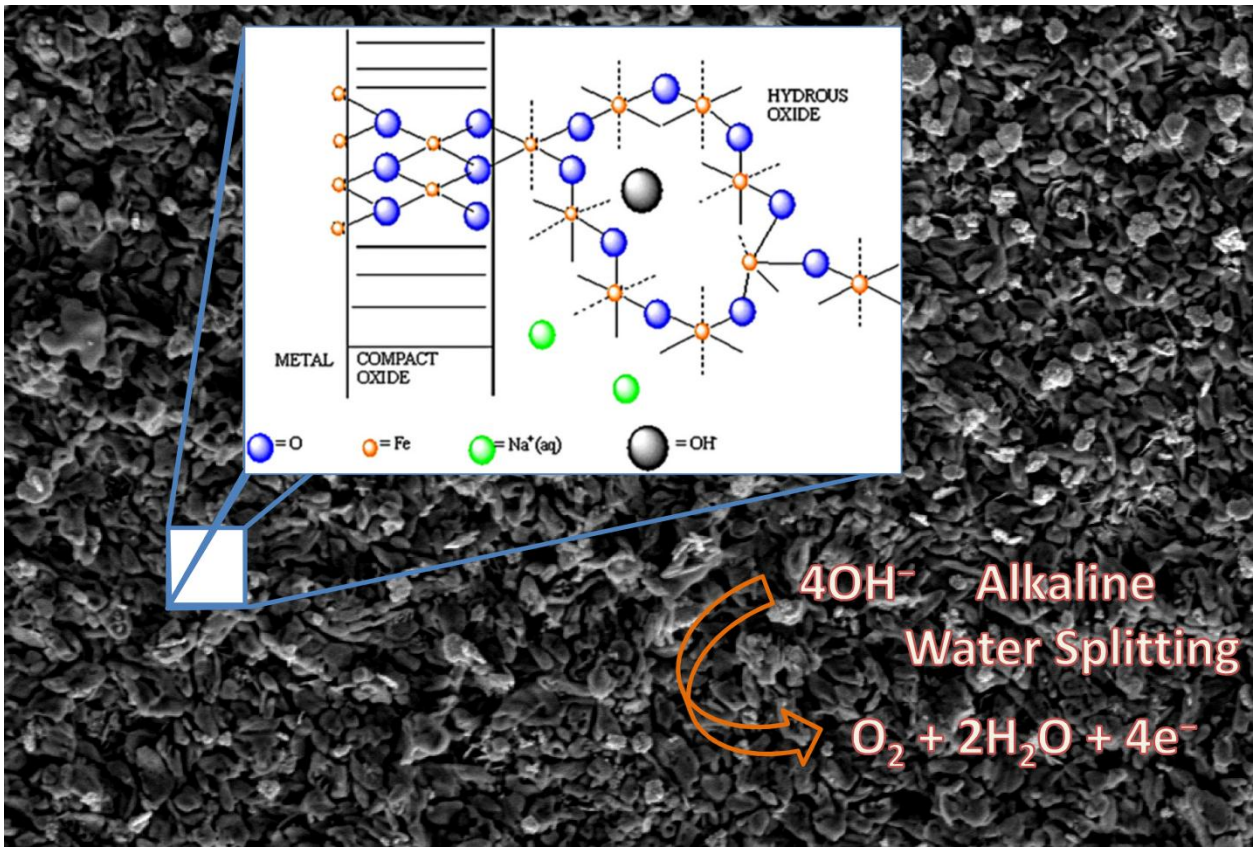
**Bringing the hydrogen economy that much closer: TCD Chemistry/CRANN researchers optimize electrochemical water-splitting using cheap oxide materials**




The electrolysis of water to its constituents hydrogen and oxygen may feature in school textbooks but the topic is still one of the existing grand challenges in materials science and engineering. The problem arises with developing suitable materials that are stable, efficient and cheap.

Recent work funded by SFI on electrochemical water splitting by the Trinity Electrochemical Energy Conversion & Electrocatalysis (TEECE) Group, which is headed by PI Prof. Mike Lyons and located within the School of Chemistry & CRANN, has been featured in a large Perspective article in the prestigious Journal **Physical Chemistry Chemical Physics** (PCCP) that has been granted **hot article** status by external peer review[1].

Over the past 50 years considerable research efforts have been devoted to the realization of efficient, economical and renewable energy sources. Metal-oxide materials have played a large part in this drive, with demonstrated applications at both the research and commercial level. Their use in areas such as batteries, fuel cells and water electrolysis has resulted in the development of materials with a diverse range of structural and chemical properties. In all cases, understanding the fundamental electrochemistry of the material can be invaluable for rational design and optimization. This review focuses on the redox, charge transport and electrocatalytic properties of transition-

metal-oxide electrodes as they pertain to the electrolytic splitting of water. Particular emphasis is placed on the nature of the active surface, which is interpreted in terms of hydrated interlinked oxymetal complexes termed surfaquo groups. In this way, the Perspective review seeks to bridge the gap between heterogeneous electro-catalysis and homogeneous molecular catalysis for water oxidation; two areas of considerable modern interest and world-wide activity.

The Perspective Article summarizes recent work published by the TEECE Group and discusses recent significant mechanistic insights, technical developments and detailed kinetic analysis of the behaviour of inexpensive transition-metal-oxide electrodes as substrates for the oxidation of water to form molecular oxygen gas. Optimizing the performance of the latter reaction presents a key challenge to developing efficient photo(electrochemical) cells for water-splitting and, hence. bringing the hope of a hydrogen economy closer to reality.

A significant **conceptual** advance has been that of associating the active material with respect to water oxidation at oxide surfaces with the **surfaquo group**, a catalytically active anionic chemical entity located within the hydrated surface of the metal oxide. The latter may, from the perspective of a molecule, behave very similarly to an inorganic water oxidation catalyst (WOC) that is used in homogeneous solution in photo-electrolytic systems . Hence the idea proposed by the TEECE group draws together two previously disparate fields: heterogeneous and homogeneous catalysis.

The group has also developed **very efficient inexpensive metal-oxide catalytic materials** that evolve oxygen at significant rates and at low overpotential , when directly compared to current state-of-the-art, thereby making the industrially important processes of water electrolysis/metal electrowinning much more economically viable. Furthermore, commercial spin-off in the area of glucose and pH sensing arising from the TEECE Group's oxide work is also in the pipeline as evidenced by the recent award of a TIDA award by SFI to Prof. Lyons on metal oxide materials for non-enzymatic glucose sensing.

The TEECE research programme is rapidly gaining significant international attention. Members of the Group (Dr Richard Doyle, Mr Ian Godwin and Ms Michelle Browne) recently presented their work at the 223$^{rd}$ ECS meeting in Toronto. The ongoing TEECE-Group activity will shortly be showcased in invited feature articles in the Journal of Physical Chemistry C and in ChemElectroChem to appear in late 2013. Professor Lyons will lecture on these developments over the months of August/September at invited plenary lectures in Brazil (USP), UK (Southampton & Cambridge), Pakistan (Peshawar) and Australia (Perth and Melbourne).

**[1] Redox and electrochemical water splitting catalytic properties of hydrated metal oxide modified electrodes** Richard L. Doyle, Ian J. Godwin, Michael P. Brandon, and Michael E. G. Lyons ***Phys. Chem. Chem. Phys.***, 2013, Advance Article **DOI:** 10.1039/C3CP51213D Received 20 Mar 2013, Accepted 23 Apr 2013
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