TITLE: Extending the Lifetime of Low-cost PEM Fuel Cells With Highly Stable Intermetallic Pt-alloy Electrocatalysts

Summary: In humanity's goal to become a carbon-neutral society, mass adoption of H_2 as the energy carrier and proton exchange membrane fuel cells (PEMFCs) as the energy production technology are becoming recognized as one of the most important pieces of the puzzle in the fight against the negative impacts of climate change. In PEMFCs, H_2 as fuel and O_2 are converted into clean electricity with water as a by-product. This makes PEMFCs especially suitable for competing with and eventually replacing conventional internal combustion engines (ICEs) in transport-related applications. Specifically, while PEMFCs are expected to find their use also in passenger light-duty vehicles (LDVs), it is becoming increasingly more evident that they can be significantly more competitive for use in heavier transport-related applications that require longer travel times. Thus, one of the most promising development directions that is starting to receive significant attention is, for instance, the use of PEMFCs in heavy-duty vehicles (HDVs).

Today, PEMFCs require significant amounts of scarce platinum that act as an active catalyst. Currently, the state-of-the-art PEMFC electrocatalysts are comprised of nanoparticles made out of scarce platinum or platinum alloys that are supported on partly graphitised high surface area carbon blacks. Namely, platinum alloys made out of less expensive 3d transition metals (M = Ni, Cu, Co) play a critical role in unlocking the sustainable mass commercialisation of PEMFC technology by enabling significant decreases in the required platinum contents. While platinum alloys already show significant promise in reducing the platinum content in a PEMFC, the other grand challenge lies in extending their lifetime. In addition to the usual degradation mechanisms (dissolution of platinum and corrosion of the carbon), additional critical degradation phenomena of the platinum alloys are related to the dissolution of the less noble metal. In the project, we propose an in-depth study of a new class of 'ordered' intermetallic platinum alloys with increased resistance against the less noble metal dissolution. Intermetallic alloys of platinum provide a promising catalyst direction toward combining both performance and durability. Furthermore, different supports for the stabilization of Pt-alloys will be considered. The project will combine the most advanced intermetallic platinum-alloy electrocatalysts with unique and advanced electrochemical methods to enable the development of the next generation of highly durable and low-cost PEMFCs.

Research techniques used: synthesis & electrochemical equipment, XRD, Raman, TG-MS, potentiostats, transmission & scanning electron microscopy, X-ray photoelectron spectroscopy, ICP-MS, etc.

The reason why the topic is innovative: Nobody has so far been able to combine both the high performance and durability of intermetallic platinum-alloy structure. Thus, gaining new knowledge and insights into fundamental corrosion mechanisms in this class of materials will enable the faster mass commercialization of PEMFC technology and thus, a greener and emission-free transport.

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