Highly Dispersed Metal Catalyst for Fuel Cell Electrodes

America's astronauts have used fuel cells to generate electricity since the 1960s, but a major breakthrough is needed to make them durable and cost-effective for use in cars, trucks, homes, or businesses. Continuous improvements have been made during the past decades, however, commercial application is still challenging. Despite some demonstrations of stationary fuel cells, science has so far not been able to achieve close to DOE's target of $30/KW for proton exchange membrane (PEM) fuel cell stacks. The main cost is the expensive noble metal material used for electrodes. In addition, the electrical current density is also limited with current technology.

This nanomanufacturing concept definition study will bring industrial catalyst experience to fuel cell research. Specifically, industrial catalysts, such as those used in platforming, utilize precious metal platinum as an active component in a finely dispersed form. The platinum metal is practically dispersed as single atoms or mono layer on a porous catalyst support, so that each platinum atom has a chance to interact with reactant molecules. When a metal is deposited as particles, only atoms on the surface are active for catalytic reaction. The ratio of the surface atoms to the total atoms of all particles on average is commonly used to indicate how well the metal is dispersed, i.e., metal dispersion. A metal dispersion of 1.00 is defined as 100% of the metal atoms are available for catalysis. Values less than 100% may indicate crystallite growth or a surface interference. The metal dispersion of industrial catalysts is normally characterized by interacting with selective probe molecules to indicate the number of reachable metal atoms, which correlates with the catalyst activity very well.

Disassociate adsorption of oxygen or fuel is the rate-limiting step in fuel cell chemistry. Electrocatalytic activity could be enhanced remarkably simply by dispersing the noble metals to the catalyst support. Mathematical modeling indicates that the metal dispersion can increase by a factor of 10 to 100 times if nano particles (10-100 nm) are all dispersed into single atoms or mono layer. On the other hand, the usage of noble metal could be reduced by the same factor still maintaining the same catalytic activity. This research will prepare highly dispersed platinum in electrical conductive porous supports to be used as fuel cell electrode catalyst material. The finely dispersed metal will be in sub-nanometer scale and ultimately be single atom or mono layer.

This new approach has the potential to reduce the cost of fuel cells significantly by reducing the usage of precious metals. Another application would be in direct fuel cell (DFC) electrodes. The issue of the current methanol DFC is limited power although they can generate a small amount of power over a long period of time. If the electrical current density were increased by 2 to 3 magnitudes, it would be able to power transportation vehicles or vessels. This would also solve the hydrogen storage issue since each methanol molecule has 4 hydrogen atoms. Once the concept is proven, the scale up of this electrode fabrication at high volume is not difficult since metal loading and shaped catalyst are commercially achieved in the catalyst industry. The authors hope the research can break barriers between know-how of the commercial catalyst industry and fuel cell research.

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