Electrocatalytic Oxidation of Ethanol at Metallic Nanoporous Catalyst Structures

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An important effort is currently underway to make use of renewable, biomass-derived fuel stocks such as ethanol[1-3] in technologies such as fuel cells. For fuel cell technology to be a competitive source of energy, the fuel sources need to be readily available, renewable and inexpensive. Biomass-derived fuels meet all of the above criteria, and provide an added bonus of producing less atmospheric pollutants than their fossil fuel counterparts.[2]

The critical component in fuel cells is the catalyst, which needs to be efficient and durable. Platinum and palladium catalysts can be utilized in direct alcohol fuel cells but catalytic efficiency and loading density are typically significant issues. The USDOE has targeted a loading density of ≤ 0.15 mg Pt/cm^2 of surface area in order for fuel cells to be cost effective.[4] However, the current Pt catalyst loading density used in methanol fuel cell applications is on the order of 0.6 – 0.8 mg/cm^2. Lower loading densities needed for these applications can, in principle, be achieved by using high surface area catalysts. It is with this in mind that we have examined inverse opal nanoporous solid structures as catalysts.

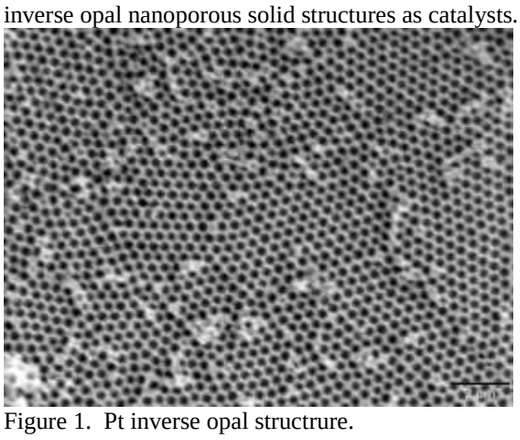

Figure 1. Pt inverse opal structrure.

We have investigated the relative efficiency of Pt and Pd catalysts present as inverse opals and planar metallic surfaces, for the electro-oxidation of ethanol in acidic and basic aqueous solutions. There are two issues of primary concern in this comparison. These are the surface area of the catalyst structures and the crystalline morphology of the metals. We find that the Pt and Pd inverse opals afford greater electro-oxidation efficiency and increased catalytic stability relative to the corresponding planar metallic surface for alcohols. The increase in current density seen for Pt inverse opals is greater for basic conditions than for acidic conditions. Both Pt and Pd provide enhanced catalytic activity and the reactivity of Pt is greater for methanol, while Pd exhibits greater reactivity for ethanol. We consider the fundamental reasons for the observed catalytic activity enhancements seen with inverse opals as well as opportunities for further enhancements.

References

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