

Mesoporous Platinum And Platinum-Ruthenium As Electrocatalysts For Fuel Cell Relevant Reactions

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Liquid crystal templating [1] has been shown to be an effective method for producing highly nanostructured metallic systems [2,3]. In this work, nanostructured platinum and platinum-ruthenium have been prepared by the chemical reduction of hexachloroplatinic acid dissolved in aqueous domains of the liquid crystalline phases of oligoethylene oxide surfactants. The material is composed of porous particles of about 25-1000 nm diameter, Fig. 1(a). These particles have a significantly developed internal surface structure with parallel pores running through all of the particles, Fig. 1(b). The internal pores are approximately 4 nm in size, and the internal surface area is 30-40 times larger than the external surface area as determined from CO stripping voltammograms of the materials, Fig 2.

Owing to its high specific surface area and periodic mesoporous nanostructure we have examined both platinum and platinum-ruthenium materials as electrocatalysts for the electrooxidation of carbon monoxide, formic acid, formaldehyde and methanol. Oxygen reduction has been examined on the platinum catalyst. Electrodes were fabricated using the abrasive deposition approach described by Cha [4,5]. Cyclic voltammetry and chronoamperometry has been used to probe the electrocatalysts properties.

The methanol oxidation process on both Platinum (fig. 3) and platinum-ruthenium catalysts (Table 1) appear to proceed mainly through a direct pathway with CO₂ as the final product. The currents attain a steady-state value even at low potentials, a remarkable situation for platinum. These results are very important since the nanostructured catalysts do not appear to be poisoned at potentials relevant to fuel cell operation. The enhancement of electrocatalytic durability is likely to be attributed to the nanostructure of the material rather than its high specific surface area. It is interesting to note that the surface of these catalyst materials will display a negative surface curvature compared to the positive curvature expected for the usual spherical electrocatalyst particles. It is such fundamental differences that may be responsible for the differences in catalytic activity.

References

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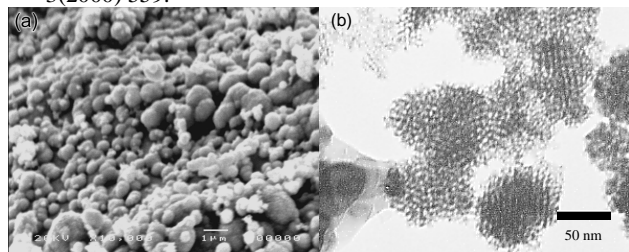


Fig. 1 SEM image, (a) and TEM image, (b), of H₁-Pt particles.

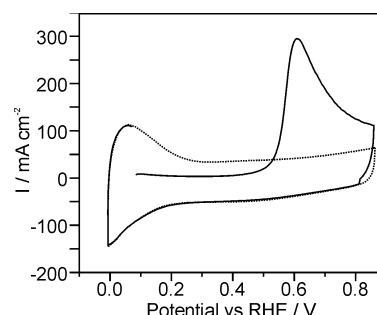


Fig. 2 Base (.....) and CO stripping (—) voltammograms for a mesoporous Pt-Ru electrode in 0.5 mol dm⁻³ H₂SO₄ at 20 °C (dE/dt = 50 mV s⁻¹).

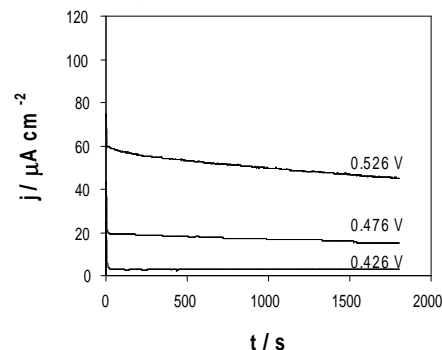


Fig. 3 Specific current density measured on a mesoporous Pt electrode in 0.5 mol dm⁻³ H₂SO₄ solution containing 0.5 mol dm⁻³ methanol as a function of electrode potential (E vs RHE).

E vs RHE / V	Mass activity / A g ⁻¹	Specific activity / μA cm ⁻²
0.326	3.7	5.2
0.376	11.0	15.0
0.426	20.7	27.5
0.476	35.0	48.1
0.526	49.0	67.3

Table 1 Mass and specific surface area activity of a mesoporous Pt-Ru electrode towards the methanol oxidation measured in 0.5 mol dm⁻³ H₂SO₄ + 0.5 mol dm⁻³ methanol at 60 °C.