Electroplating from High Internal Phase Emulsions (HIPEs)

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Porous electrode coatings have been produced by electrodeposition from the aqueous domains of a water-in-oil High Internal Phase Emulsion (HIPE) containing the components of the electroplating bath in the aqueous phase. HIPE's of 80% v/v aqueous phase were prepared by controlled mixing of the two phases, with the oil phase being a mixture of styrene, 2-ethyl-hexyl-acrylate, divinylbenzene and sorbitan monooeleate. The technique was used for the cathodic electrodeposition of Ni on Ni substrates and the anodic deposition of PbO_2 on graphite substrates. Electroplating from the low conductivity water-in-oil emulsion is attributed to partial phase separation and the creation of interconnected aqueous domains.

The adherent porous deposits resulting from Ni electroplating through HIPE have an irregular structure characterised by a variety of features (e.g. hollow spherical aggregates with a layered outer surface, see **Figure 1**) indicative of high local current densities and Ni ion depletion from the aqueous domains. The coatings had typical BET surface areas of 300 m^2gr^{-1}, porosities of 80% and specific electrode areas of 250,000 m^2m^{-3} (electroactive area, estimated by the charges associated with the formation and removal of a $Ni(OH)_2$ layer, per coating volume). They exhibited comparable or higher currents for hydrogen evolution than typical sintered Ni electrodes of similar thickness while also exhibiting higher surface area utilization. This is probably due to their more open structure, allowing for hydrogen gas disengagement from the pores.

Porous deposits of anodically grown PbO_2 (relevant to battery active material and industrial anodes) were also deposited through HIPE onto graphite substrates and were organized in pyramidal aggregates of 10-20µm, pitted with pores of 0.5-2 µm holes (See **Figure 2**).

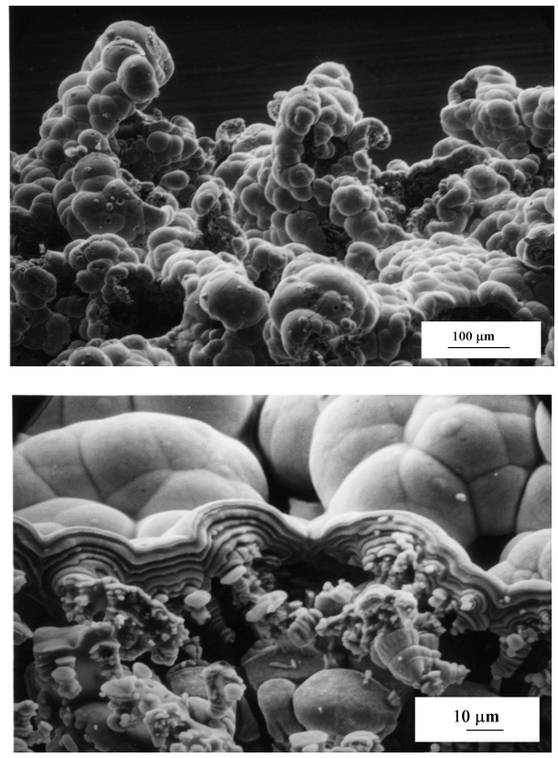

***Figure 1**: SEM micrographs of Ni deposit produced at 5 mA cm^{-2} through a HIPE emulsion on a Ni substrate.*

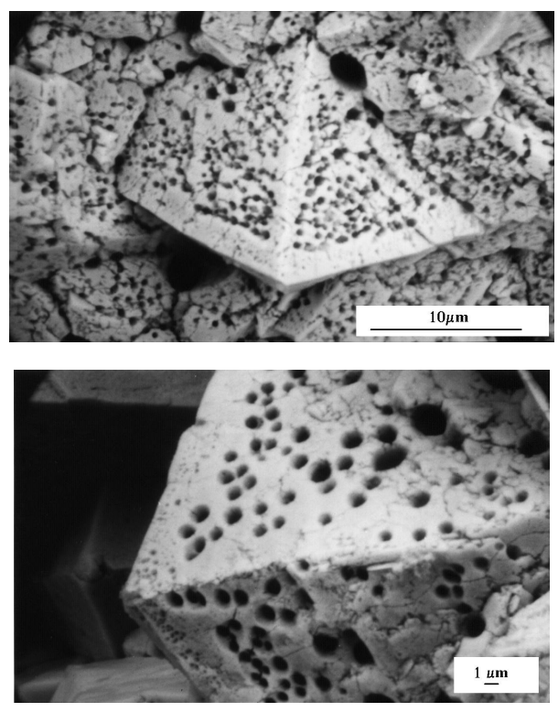

***Figure 2:** SEM micrographs of PbO_2 deposited at 3 mA cm^{-2} through a HIPE emulsion on a graphite substrate.*