Synthesis of ultrapure nanoparticles and its applications to electroocatalysis: Ethanol and Ethylene glycol oxidation on Pt.

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Numerous current and potential applications of nanoparticles cause an immense and still growing interest in new size- and shape-controlled nanostrucures. New functional materials are preferably obtained with properties tailored for given applications, such as more effective or selective catalysis and storage devices. Such applications usually require high purity and high surface area, as a prerequisite for its effectiveness. Nonetheless, obtaining pure nanoparticles colloids of controlled particle size is not a trivial task. Nanoparticles are virtually exclusively synthesized in the presence of surfactants and/or complexing agents, which are commonly used both as size- and shape-controlling agents and as effective colloid stabilizers. Major drawback of this methodology is the presence of adsorbed surfactants, which often entirely block the metal's active sites, hinder many of the valuable properties of nanoparticles and eventually impede the majority of potential applications. Numerous procedures of surface decontamination were therefore developed [1]. Here we report the methods of preparation of ultrapure nanoparticles. The procedure resulted in high purity nanoparticles characterized by relatively narrow size distribution. For the reason that the surfactant was eliminated, the usual oxidative cleaning of the nanoparticles was not necessary. This approach significantly simplifies the synthesis procedure and markedly decrease the amount of chemical wastes produced during synthesis. The samples were characterised by using classical transient methods and impedance spectroscopy. For the sake of comparison the control samples obtained with polyvinylpyrrolidone (PVP) were also synthesized in the same experimental conditions. Electrocatlytical activities of both types of samples were tested toward ethanol and ethylene glycol oxidation. Control samples were electrochemically cleaned before these experiments. Fig.1 shows an exemplary comparison of voltammograms registered in 0.5 M sulfuric acid solution + 1.5 M EG for both types of samples. It can be observed that ultrapure nanoPt sample is approximately two times more active towards EG oxidation in comparison to cleaned nanoPt(PVP). To overcome the variation in size of the nanoparticles between those samples, the data obtained were normalized to both: catalyst's mass and active surface area. Results indicate that ultrapure nanoparticles are significantly more catalytically active towards EG oxidation, as determined per mass and active surface of the catalyst, in comparison to decontaminated nanoparticles prepared in presence of PVP. The results obtained for the control sample were consistent with those reported in literature [2,3].

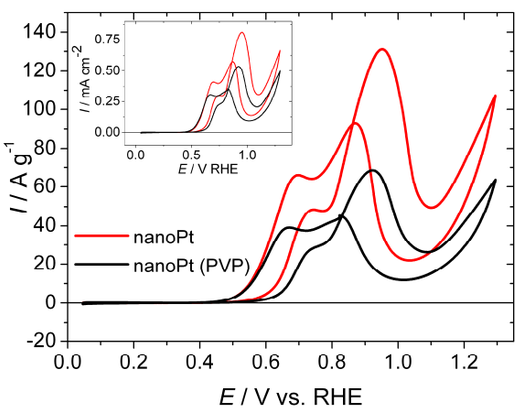

Fig.1 Electrooxidation of EG in voltammetric experiment: on ultra-pure Pt nanoparticles (red line) and reference sample (synthesized in PVP, further electrochemically oxidative cleaned) (black line) in 0.5 M sulfuric acid and 1.5 M EG. Inset – the same data recalculated per surface area

References:

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[3] A.M.A. Ouf, A.A. Ibrahim, A.A. El-Shafei, Electroanalysis, 23 (2011) 1998-2006.