PtRu/C Electrocatalysts Prepared by Co-reduction or by Successive Reduction of Metal Ions using Electron-Beam Irradiation for Methanol Oxidation

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Fuel cells employing alcohols directly as combustible (Direct Alcohol Fuel Cell – DAFC) are attractive as power sources for mobile and portable applications. Methanol has been considered the most promising alcohol and carbon-supported PtRu nanoparticles (PtRu/C electrocatalyst) the best electrocatalyst. The catalytic activity of PtRu/C electrocatalysts is strongly dependent on the method of preparation and it is one of the major topics studied in Direct Methanol Fuel Cell (DMFC). In this work PtRu/C electrocatalysts (20wt%, Pt:Ru atomic ratio of 50:50) were prepared by co-reduction (the metals were reduced together in a single step) or by successive reduction (the metals were reduced separately in two successive steps) of Pt(IV) and Ru(III) ions in the presence of the carbon support using water/2-propanol as reaction medium. The resulting mixtures were submitted to electron-beam irradiation, which leads to the formation of radiolytic species of strongly reducing potential able to reduce the metal ions. The PtRu/C electrocatalysts were characterized by EDX, XRD and cyclic voltammetry. The electro-oxidation of methanol was studied by cyclic voltammetry and chronoamperometry. The X-ray diffratograms of PtRu/C, Pt(1)Ru(2)/C, where Pt was deposited on first step and Ru on the second step of preparation, and Ru(1)Pt(2)/C electrocatalysts showed a broad peak at about 25°, which was associated to the Vulcan XC72R support material, and five diffraction peaks at about $2\theta = 40°$, 47°, 67°, 82° e 87° that are associated to the (111), (200), (220), (311) e (222) planes, respectively, of the fcc structure of platinum and platinum alloys. No diffraction peaks that could be attributed to metallic ruthenium or ruthenium oxides phases were observed, however, they could not be discarded. The cyclic voltammogram (CV) in 0.5 mol L^{-1} H_2SO_4 of the PtRu/C catalyst prepared by co-reduction of metal ions do not have a well-defined hydrogen oxidation region and the currents in the double layer are larger, which are characteristic of PtRu alloy with a molar ratio of 50:50. The CV of Ru(1)Pt(2)/C electrocatalyst showed a more defined hydrogen oxidation region (0 – 0.4V) than the catalyst prepared by co-reduction. The CV of Pt(1)Ru(2)/C catalyst was similar to Ru/C electrocatalyst. The electrocatalyst prepared by co-reduction was more active for methanol oxidation than the electrocatalysts prepared by successive reduction of metal ions. The results indicates that the electrocatalyst prepared by co-reduction of metal ions have a more uniform distribution of Pt and Ru on the nanoparticle surface than electrocatalysts prepared by successive reduction, where the metal used in the second step of preparation deposits preferentially on the pre-supported nanoparticles; and the chemical properties of these catalysts are mainly to metal deposited on the surface of the nanoparticles.