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PtRu/C DMFC-electrocatalysts prepared using gamma and electron beam irradiation

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Direct Alcohol Fuel Cell (DAFC) uses liquid alcohols as a fuel and is very attractive as power sources for mobile, stationary and portable applications. However, alcohols are very difficult to electro-oxidize completely and up to now methanol has been considered the most promising organic fuel. Carbon-supported PtRu nanoparticles (PtRu/C) are the best electrocatalysts for Direct Methanol Fuel Cell (DMFC), however, the synthesis of highly dispersed carbon supported PtRu nanoparticles with high loading remains a challenge.

The conventional methods of preparation, like wet impregnation and reduction, do not provide satisfactory control of the particle size and distribution. The colloidal methods have the advantage to produce very small and homogeneously distributed nanoparticles, however the methodologies are very complex. Thus, the search for alternative routes to produce carbon-supported metal nanoparticles by a simple methodology is a goal in this area. In this work PtRu/C electrocatalysts (20wt%, Pt:Ru atomic ratio of 50:50) were prepared in a single step using gamma (^{60}Co source of 800 Ci) and electron beam irradiation (Electron Accelerator's Dynamitron Job 188). The electrocatalysts were characterized by energy dispersive X-ray analysis (EDX), X-ray diffraction (XRD), and cyclic voltammetry (CV) and tested for methanol electro-oxidation using the thin porous coating technique, aiming fuel cell application. The electrocatalysts were prepared submitting water/2-propanol mixtures containing Pt(IV) and Ru(III) ions and carbon support to gamma or electro beam irradiation, which leads to the formation of radiolytic species of strongly reducing potential able to reduce the metal ions. In this manner, the atoms produced by the reduction of metals ions progressively coalesce, leading to the formation of carbon supported PtRu nanoparticles. A total dose of 3.0 kGy (0.5 kGy h^{-1}, 6 h) was necessary to reduce all of Pt(IV) and Ru(III) ions using ^{60}Co source. Using electron beam irradiation a total dose of 432 kGy (dose rate 1.6 kGy s^{-1}) was applied in 4.5 min. The Pt:Ru atomic ratio of the produced electrocatalysts determined by EDX were similar to the nominal ones. The X-ray diffratograms showed a broad peak at about 25°, which was associated to the Vulcan XC72R support material, and five diffraction peaks at about 2θ = 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 clear seen, however, they could not be discarded. The electrocatalysts also showed similar crystallite sizes of ca. 3.5 nm.

The material prepared using electron beam irradiation showed a slight superior performance for methanol oxidation compared to the catalyst obtained using gamma irradiation. Active PtRu/C

electrocatalysts for methanol oxidation could be prepared using gamma and electron beam irradiation; with the advantage that using electron beam irradiation (high dose rate) the catalysts can be prepared within few minutes.

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