Preparation of Pt Rare Earth/C electrocatalysts using the alcohol-reduction process for ethanol electro-oxidation

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Fuel cell employing alcohols directly as combustible (Direct Alcohol Fuel Cell - DAFC) are attractive as power sources for mobile, stationary and portable applications. Compared to hydrogen-fed fuel cells which need a reforming system, or have hydrogen storage problems, DAFC uses a liquid fuel simplifying the fuel system. Methanol has been considered the most promising fuel, because it is more efficiently oxidized than others alcohols, however, slow anode kinetics are observed and it is a toxic product. Ethanol offers an attractive alternative in relation to methanol as a fuel in low temperature fuel cells because it can be produced in large quantities from agricultural products and it is the major renewable biofuel from the fermentation of biomass. However, its complete oxidation to CO_2 is more difficult than that of methanol due to the difficulty in C–C bond breaking and to the formation of CO-intermediates that poison the platinum anode catalysts. In this context, more active electrocatalysts are essential to enhance the ethanol electro-oxidation. In recent years, it is found that certain metal oxides, such as RuO_2, SnO_2 and CeO_2, can enhance the catalytic activity for ethanol or methanol electro-oxidation through synergetic interaction with Pt. Among those, rare earth oxides exhibit a number of characteristics that make them interesting for catalytic studies. In this work, Pt Rare Earth/C electrocatalysts (Rare Earth = La, Ce, Pr, Nd, Sm, Tb, Dy, Ho Er, Tm and Lu) were prepared in a single step by an alcohol reduction process using ethylene glycol as reduction agent and solvent and Vulcan XC 72 as support. The obtained materials were tested for ethanol oxidation in acid medium using cyclic voltammetry and chronoamperometry. The EDX analysis showed that the Pt:RE atomic ratios obtained for all electrocatalysts were approximately 60:40 and were similar to the ones used in the preparations. The X-ray diffractograms of Pt Rare Earth/C electrocatalysts showed the typical fcc structure of platinum and the presence of rare earth (III) hydroxides. The average particle size were calculated using Scherrer equation using the reflections of Pt(220) peak and the values are in the range of 6-15 nm. The final current values after holding the cell potential at 0.5V versus RHE for 30 min are following: PtLu/C> PtTb/C > PtEr/C ≈ PtNd/C ≈ PtCe/C > PtHo/C > PtLa/C >PtDy/C > PtTm/C > PtPr/C > PtSm/C > Pt/C. The superior activity of Pt Rare Earth/C electrocatalysts in relation Pt/C could be attributed probably to the bi-functional mechanism were Pt acts on ethanol adsorption and dissociation and Rare Earth provides oxygenated species at lower potentials for oxidative removal of adsorbed CO.