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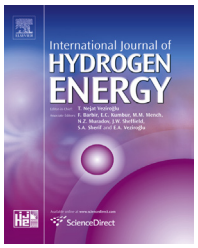

Graphene supported platinum–cobalt nanocomposites as electrocatalysts for borohydride oxidation

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ABSTRACT

In the study presented herein a rapid microwave heating method was used to prepare the graphene supported PtCo catalysts with Pt:Co molar ratio 1:7, 1:22 and 1:44. The transmission electron microscopy was employed to characterize the catalysts. Inductively coupled plasma optical emission spectrometry was used for estimation of Pt and Co metal loadings. The electrocatalytic activity of the synthesized catalysts towards the oxidation of borohydride was investigated by means of cyclic voltammetry and chronoamperometry. The kinetics of the catalytic hydrolysis of $NaBH_4$ in the presence of the synthesized catalysts was investigated.

It has been determined that the synthesized graphene supported PtCo catalysts show an enhanced electrocatalytic activity towards the oxidation of H_2 generated by catalytic hydrolysis of BH_4^- and direct oxidation of BH_4^- ions comparing with the graphene supported bare Pt catalyst and graphene supported bare Co catalyst. The graphene supported PtCo catalyst having the Pt:Co molar ratio 1:44 exhibits the highest electrocatalytic activity for the both oxidation reactions of H_2 and BH_4^- ions.

1. Introduction

The demand for clean and sustainable energy sources has become a strong driving force in continuing economic development, as well as in the improvement of human living conditions. Proton exchange membrane (PEM) fuel cells, as clean energy-converting devices, have drawn a great deal of attention in recent years due to their high efficiency, high energy density, and low or zero emissions. PEM fuel cells have several important application areas, including transportation, stationary and portable power, and micro-power [1–4]. In relation to other types of fuel cells direct borohydride fuel cells (DBFCs) are of particular value for their high theoretical capacity and specific energy density, i.e. 5.6 Ah/g and 9.3 Wh/g for $NaBH_4$, respectively. Moreover, the theoretical voltage of 1.64 V for DBFC is much higher than that for other fuel cells using hydrogen (1.24 V) or methanol (1.19 V) as a fuel [5–7]. One more significant feature is power performance at ambient temperature. Unfortunately, these promising characteristics

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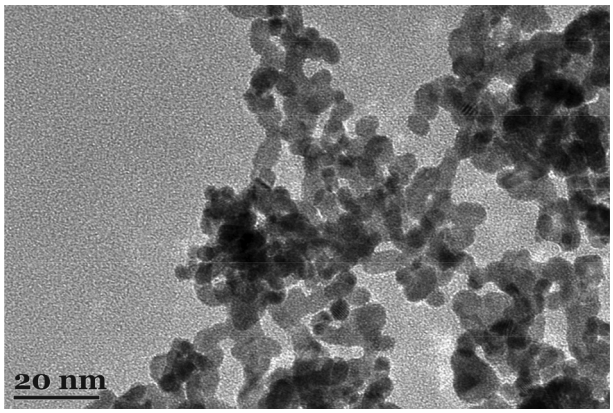

Fig. 1 – HRTEM image of Pt/GR.

have still to be not fully realized in practise. Their performance is still limited by kinetics of anodic reactions and poor catalytic stability. Platinum is a good catalyst for both the hydrolysis and oxidation reactions of borohydride [8]. From the fuel cell power output view, anode materials such as Ni, Pt and Pd demonstrate fast electrode kinetics and, thus, good power performances. Although platinum has been widely investigated as electrocatalysts for DBFCs, unfortunately, the use of it as an electrode material is limited by its high price. For reducing the amount of Pt, transition metals such as Ni, Co, Fe, Cu have been added as alloy metals to the Pt-based catalysts, and the resulting catalysts were found to exhibit a better catalytic stability and a higher activity for the oxidation of borohydride, methanol and reduction of oxygen than bare Pt catalyst [9–16]. The catalytic enhancement of Pt alloys with

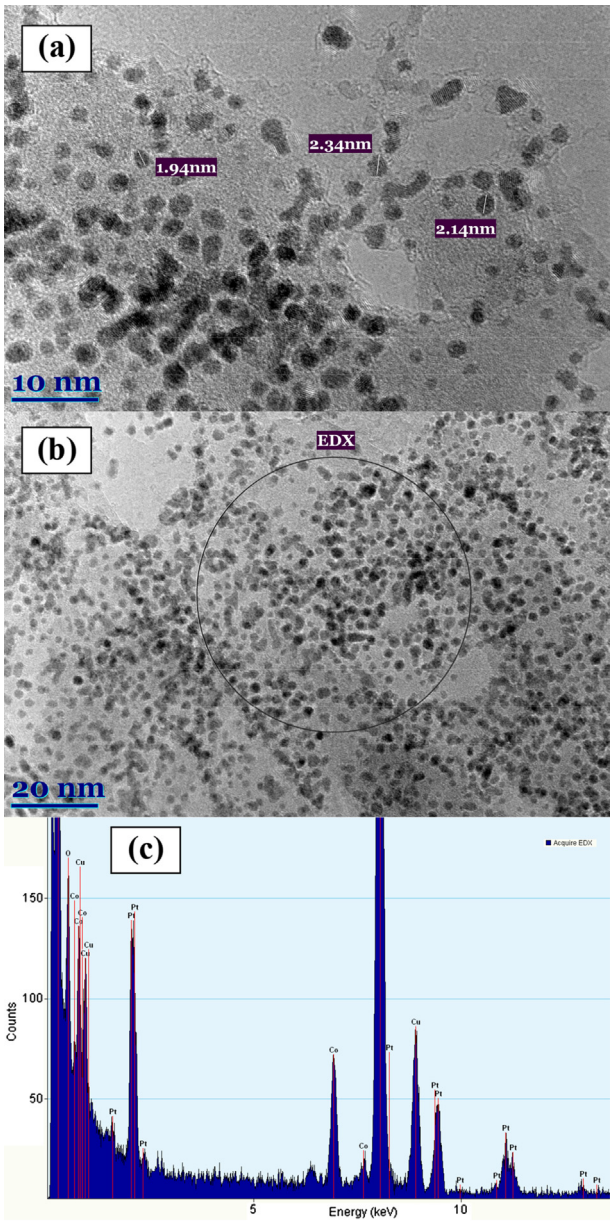

Fig. 2 – HRTEM images of PtCo/GR-1 (a,b) and corresponded EDX spectrum (c).

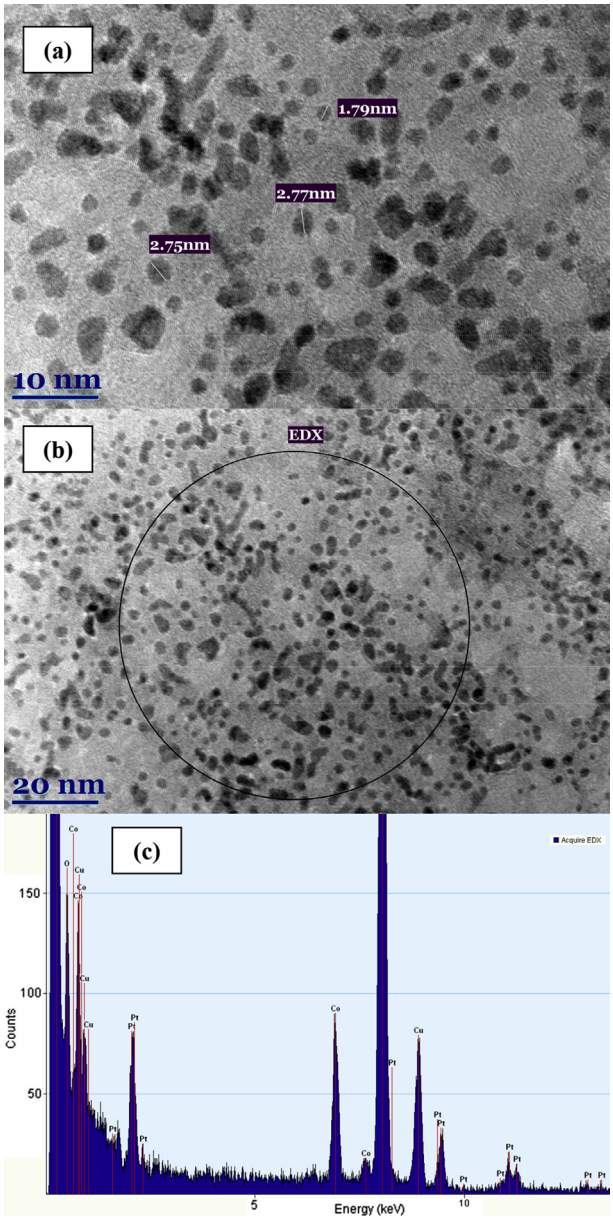

Fig. 3 – HRTEM images of PtCo/GR-3 (a,b) and corresponded EDX spectrum (c).