Electro-oxidation of Ammonia on Carbon Fibers

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Carbon fibers produced from polyacrylonitrile (PAN) have been used in many applications, such as spaceships, aircrafts, sporting goods, and industrial products where weight saving and performance are of primary consideration. Lately, a lot of work has been published using modified-electrodes of carbon fibers for different electrochemical applications including electronics medicine, bioelectrochemical, and others.

During recent years, electrocatalysis has been studied intensively. Many of these studies have been carried out especially on platinum,[1-2] which is the most common electrocatalyst for H_2 evolution, and O_2 reduction at low temperatures. Particularly, the PAN-based fibers have been utilized as a substrate for the catalyst (noble metals) because they have an important surface area, a good conductivity, and low cost as well.

A large amount of information is available from the literature regarding the electrodeposition of metals such as Ni,[3] Ag,[4] and noble metals (Pt, Ir,[5] Rh[2]) on carbon fibers. Deposition on carbon fibers is usually considered a challenging task as the surface preparation and its activation is critical to enhance the adherence of the deposit. Also the conductivity of carbon fibers is not as high as for metals.

In previous research, the electro-oxidation of ammonia in alkaline media for hydrogen production was investigated. Noble metals (Pt, Ir, and Ru) were successfully co-deposited on platinum and titanium substrates, showing a synergetic effect of bimetallic catalysts for ammonia electro-oxidation.[6]

In this paper, the electro-oxidation of ammonia in alkaline media for hydrogen production was studied by using carbon fibers as a substrate, plated with noble metals (Pt-Ir, Rh). PAN-based carbon fibers (Celion G30-500, diameter 7 μm, 12.000 filaments by bundle) were used to prepare the electrodes. Before being plated, the fibers were activated in H_2NO_3 for 30 min in order to enhance the adhesion; then they were rinsed in acetone. Different tests were performed: 1. Ni deposition on carbon fibers from Watt Bath followed by Pt electro-deposition from a solution of H_2PtCl_6 in alkaline media (solution 1 M NaOH); 2. direct electro-deposition of Pt from a solution of H_2PtCl_6 in 1M HCl; and 3. deposition of Rh from $RhCl_3$ in 1 M HCl. After plated the morphology of the fibers was observed on SEM and analyzed by EDS. The electrochemical performance of the electrocatalyst was evaluated by using cyclic voltammetry and galvanostatic techniques.

The SEM photograph of carbon fibers no coated is shown in Fig. 1. On the other hand, the morphology of the carbon fibers after electro-deposition of Ni, and Pt-Ir is shown in Fig. 2. An increased in the thickness of the fibers after metal deposition is observed. The diameter of the fibers increases around 3 μm after metal deposition. According to the EDS analysis, the nickel coating appeared to cover the entire surface of the fiber, and the Pt-Ir formed a rod-like microstructures (white spots in Fig. 2). Others observations in SEM made on carbon fibers coated with Rh shown that it is possible to produce a continuous coating of rhodium over carbon fiber. Pre-deposition of Rh forward by Pt on carbon fibers shown that the deposit formed is homogenous and adherent coating (picture not shown).

Preliminary results on electrodeposition of Pt on carbon fibers with a pre-deposit of Ni and Rh show an important catalytic effect on the electro-oxidation of ammonia. Figure 3 shows that the carbon fibers/Pt-Ir electrode is active for the oxidation of ammonia dissolved in a KOH electrolyte. Further results and analysis will be presented.

References:

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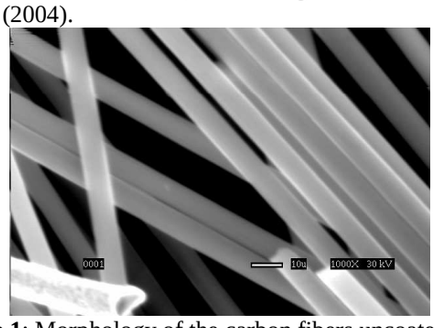

Figure 1: Morphology of the carbon fibers uncoated.

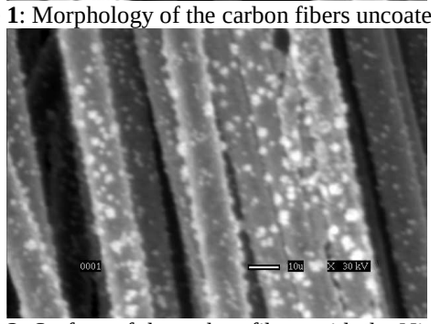

Figure 2: Surface of the carbon fibers with the Ni coating showing the Pt-Ir deposits (white spots)

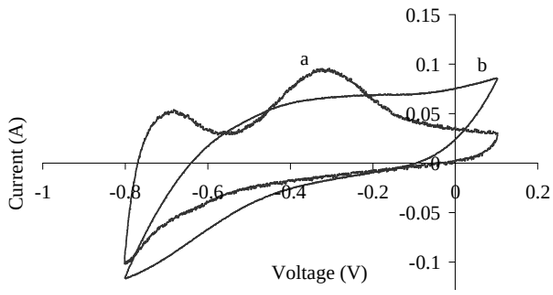

Figure 3: Cyclic voltammetry of different carbon fiber electrodes: (a) Pt-Ir on Ni/carbon fibers; and (b) Rh on carbon fibers in 1M NH_3, 5 M KOH. Sweep rate: 10 mV/s. The voltage is reported vs. an Hg/HgO reference electrode. A large surface area electrode was used as counter electrode. The counter electrode consisted of Pt on carbon fibers pre-coated with Ni.