NANOSTRUCTURED CATALYTIC COMPOSITIONS FOR FUEL CELL ELECTRODE BASED ON MANGANESE DIOXIDE AND LEAD

M. O. Danilov[1], G. Ya. Kolbasov[1], A. V. Melezhyk[2]

[1]Institute of General and Inorganic Chemistry of the Ukrainian National Academy of Sciences, prospekt Palladina 32/34, Kyiv 142, Ukraine
[2]TM Spetsmash Ltd., vul. Viskoznaya 5, build. 23, 02660 Kyiv, Ukraine

Corresponding author: M. O. Danilov (dankoek@mail.ru)

Introduction

The advent of carbon nanomaterials, such as carbon nanotubes (CNT), made possible the production of novel catalytic materials by the application of catalysts to the surface or introduction of them into carbon nanotubes. In this case, occurrence of synergism effect is possible through the interaction of catalyst particles with nanocarbon structures, which results in the attainment of better electrical electrode characteristics than in the case of using carboniferous nanomaterials and metal-containing catalysts separately. It is known that activated carbon can interact with ions of some metals with their reduction on carbon. When CNTs are oxidized by various reagents in an aqueous solution, slightly ordered carbon oxidizes in the first place. Thus, metal compounds can be deposited on carbon nanotubes in an oxidizing medium with simultaneous removal of slightly ordered carbon impurities from them.

Experimental

Multiwalled carbon nanotubes have been obtained by catalytic ethylene pyrolysis using an Al : Fe : Mo (1: 1 : 0.7) catalyst [1]. Under these conditions, CNTs with a mean number of walls of 3-5, an outside diameter of 8-15 nm and a specific surface of 500 m^2/g have been obtained. An electron micrograph of these tubes, obtained an a JEM – 100 CX 11 microscope, is shown in Fig 1(a).

Taking into account the prerequisites for the deposition of metal compounds by the oxidation of CNTs, we have developed a method for the controlled production of nanostructured compositions containing MnO_2 [2]. Nanocompositions with different percentage of manganese dioxide applied to carbon nanotubes have been obtained. Manganese dioxide was obtained by the reduction of potassium permanganate with formic acid or carbon that is contained in carbon nanotubes.

Figure 1 (b) shows a photograph of a composition of carbon nanotubes and MnO_2, which were obtained by the reduction of potassium permanganate by means of CNTs; the mean MnO_2 particle size is 5-7 nm. Figure 1 (c) shows photographs of manganese dioxide obtained by the reduction of potassium permanganate with formic acid. It is seen from the figure that when the same 50% amount of manganese dioxide is applied to CNTs by different reduction methods, different sizes of MnO_2 clusters result. Nanocompositions containing 20% lead applied to CNTs have also been obtained.

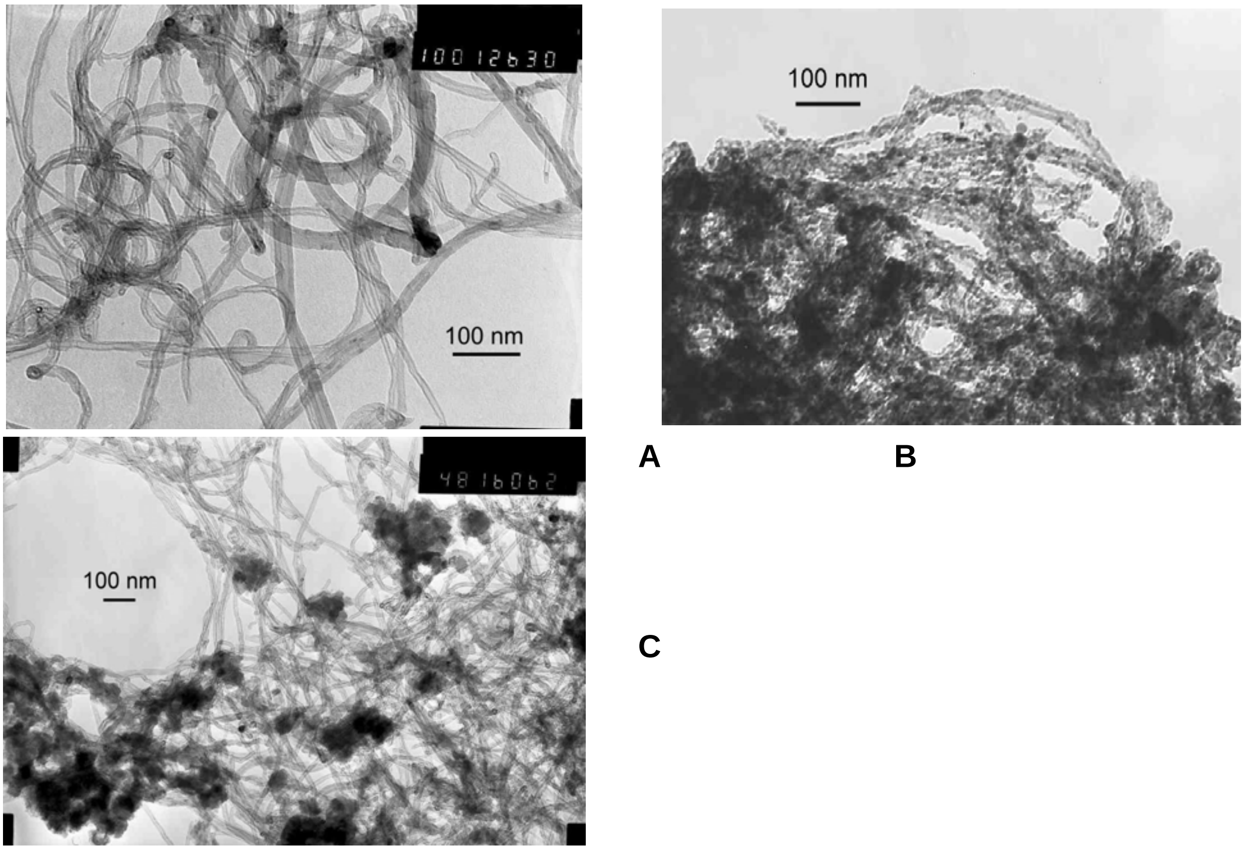

Fig. 1 *Electron micrographs: (a) initial carbon nanotubes; (b) carbon nanotubes modified with 50% manganese dioxide, obtained by the reduction of permanganate with nanotube carbon without addition of formic acid; (c) carbon nanotubes modified with 50% manganese dioxide, obtained by the reduction of permanganate with formic acid.*

Results and Discussion

Voltammetric curves for fuel cell oxygen electrodes for 20% manganese dioxide and lead content are shown in Fig 2. As follows from Fig 2, the electrodes containing a 20% nanocomposition of lead and CNTs operate at current densities of over 150 mA cm^{-2} better than the composition based on manganese dioxide with CNTs. Our experiments showed that the nanocomposition of MnO_2 and CNTs gives better characteristics than electrolytic manganese dioxide which is used for the manufacture of power sources. It is known from literature that manganese dioxide obtained by the reduction of potassium permanganate with formic acid is more active than electrolytic manganese dioxide. From Fig 2 it follows that the nanocomposition based on lead with CNTs is also a good oxygen reduction electrocatalyst.

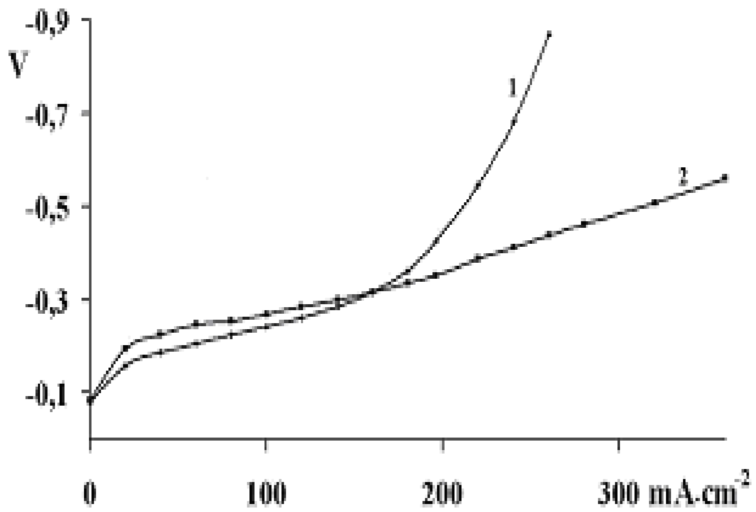

Fig. 2 *Voltammetric curves for fuel cell oxygen electrodes with various nanocompositions: (1) CNTs containing 20% manganese dioxide; (2) CNTs containing 20% lead.*

Conclusions

The method, developed by us, for the production of nanocompositions enables production of efficient materials for fuel cell electrodes. We have obtained a nanocomposition of lead with CNTs, which has a higher catalytic activity in the oxygen reduction reaction than manganese dioxide.

References

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