Producing of Electro-Conductive Smart-Textile

Z.A. MANSUROV, G.T. SMAGULOVA, S. KIM, A.A. ZAKHIDOV
Department of chemistry and chemical technology
Al-Farabi Kazakh National University
Almaty, al - Farabi Avenue, 71
KAZAKHSTAN
zmansurov@kaznu.kz

Abstract: - In this paper, a number of studies have been carried out to synthesize of carbon nanotubes on glass-cloth. Composition and structure of catalyst are the key components for synthesis of carbon nanomaterials. For coating metals oxides nanoparticles on surface of glass-cloth, efficient method solution combustion was used, which can produce of various metal oxide nanoparticles. In this paper presents results of the synthesis of carbon nanotubes on Fe_2O_3 and Co_3O_4 nanoparticles. For synthesis of carbon nanotubes on glass-cloth with metal oxides nanoparticles method chemical vapor deposition was used. For the glass-cloth with Co_3O_4 carbon nanotubes with diameters from 25 nm up to 35 nm are formed. For glass-cloth with Fe_2O_3 carbon nanotubes with diameters in the range of 9 - 25 nm are formed. Significant number of carbon nanotubes has a spiral structure with diameters 14 - 15 nm. The current-voltage characteristics of CNT on glass-cloth were investigated.

Key-Words: - solution combustion, nanosized metal oxides, carbon nanotubes, electrically conductive textiles

1 Introduction

«Nanosized materials» having 1-100 nm sizes demonstrate unique physical, chemical and mechanical properties. On account of these properties, they are useful as catalysts for synthesis of different carbon nanomaterials [1]. There are many methods of coating catalysts to various surfaces (including on cloths): vacuum deposition, lithography, sol-gel method, solution combustion, etc. Solution combustion method has several advantages: simplicity of the process, the possibility of obtaining of metal oxide nanoparticles predetermined size, the low cost.

Carbon nanotubes have unique physical and chemical properties and have been named «material of the future» [2]. Due to their properties, carbon nanotubes (CNT) are used in various fields such as energy, biotechnology, microelectronics, et. al. [3].

The structure and properties of carbon nanotubes depend on many factors: the initial components, the composition and morphology of the catalyst, synthesis conditions, etc. [4]. Not infrequently for the synthesis carbon nanotubes, the catalyst is a system consisting from the active phase and the matrix. In [5], the authors report the synthesis of carbon nanotubes on glass-cloth with palladium catalyst (1 and 2 wt. %). In [5] the samples need 3 hour treatment in N_2/H_2 at 400 °C, and growth time of carbon nanomaterials is about 2 hours. The use of glass-cloth is justified by their high levels of chemical stability and mechanical properties: resistance to high temperatures, chemical resistance, flexibility and the ability to create various geometric forms.

Lately quite sizable data on the use of catalysts based on glass fiber in many other chemical processes have appeared [6].

2 Experimental parts

2.1 Synthesis of nanosized metal oxides catalysts

For the synthesis of carbon nanotubes compounds of transition metals: Fe, Co has been used. When selecting the catalysts it is necessary to consider the nature of the transition metal. In a number of transition metals of Ti to Ni, when filling of *d* – level by electrons decrease strength in the bond of M-C of these metals. The formation of strong chemical bonds between metals Ti, V, Cr and carbon causes their low catalytic efficiency. In this work cobalt and iron oxides were used as the catalysts.

Co and Fe oxides were coated onto the surface of a glass-cloth by the method of "solution combustion", which is one of the versions of a self-propagating high temperature synthesis [7].

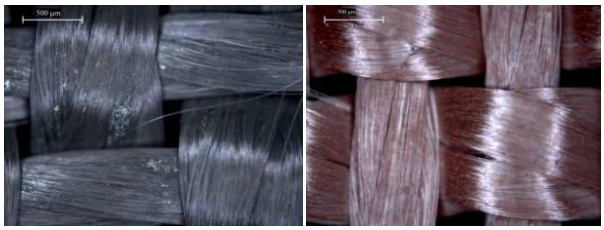
Glass-cloth of a definite size were impregnated with a solution of cobalt and iron salts, after that they were dried for 30 minutes in air at 100°C and then heated in air atmosphere at 500 °C. At this temperature the self-propagating high temperature synthesis resulted in the formation of nanoparticles with the size from 30 to 100 nm [8, 9].

2.2 Synthesis of carbon nanotubes by chemical vapor deposition

Synthesis of carbon nanotubes carried on the installation for chemical vapor deposition, consisting of an oven with three heating zones, a quartz tubular reactor. Gas flow: He - 650 cm^3/min, H_2 - 150 cm^3/min, C_2H_2 – 19.5 cm^3/min. Temperature - 710 °C, time of synthesis - 20 min.

3 Results and Discussion

Figure 1 shows optical microscope photographs of glass fiber fabrics with Co_3O_4 and Fe_2O_3.



Co_3O_4 Fe_2O_3

Fig. 1 Optical microscope photographs of glass-cloth with Co_3O_4 and Fe_2O_3

Figure 2 shows SEM and TEM images of carbon nanotubes grown on glass-cloth with Co_3O_4 (5 wt. %).

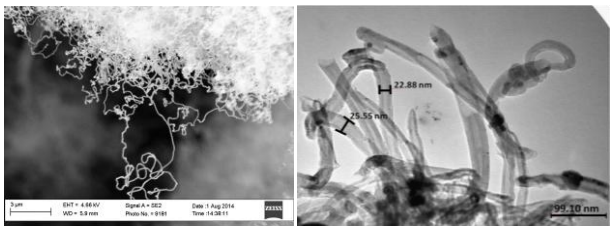


Fig. 2 SEM and TEM images of carbon nanotubes grown on glass-cloth with Co_3O_4 (5 wt. %)

Figure 3 shows SEM and TEM images of carbon nanotubes grown on glass-cloth with Fe_2O_3 (2 wt. %).

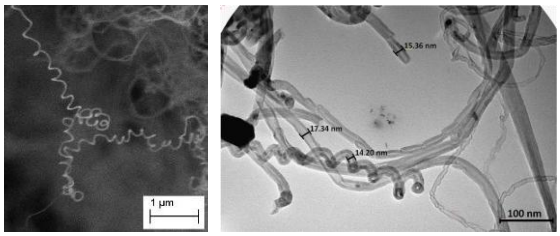


Fig. 3 SEM and TEM images of carbon nanotubes grown on glass-cloth with Fe_2O_3 (2 wt. %)

3.1 Investigation of the current-voltage characteristics of carbon nanotubes on the glass-cloth

Current-voltage characteristics of fiberglass with CNTs obtained by CVD were measured. Pure fiberglass is dielectric. The area of the sample was 4.95 cm^2. This sample has a resistance R = 1.7 Ω (R=0.3636 Ω/cm^2).

Figure 4 shows the current-voltage characteristics for fiberglass with CNTs.

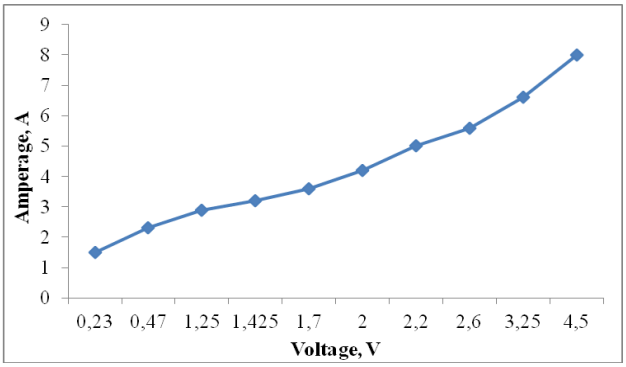


Fig. 4 Current-voltage characteristics of the sample of CNT@glass-cloth

As can be seen from the above data CNT on glass-cloth are good conductors of electrical current, which gives an effective Joule heating. The use of CNT@glass-cloth has a number of advantages. Studies the current-voltage characteristics of glass-cloth with carbon nanotubes showed that this material has semiconductor properties. Therefore, glass-cloth with carbon nanotubes is electrically conductive smart-textiles and may be used for manufacturing the heating element.

There was made a prototype of heated clothing. For this end, for electrically conductive fabric electrodes from metal wire are made and connected to the battery. On the basis of conductive smart-textile, model of soldier with a heated jacket was made (Fig. 5).

Fig. 5 Before and after heating the jacket of soldier based on glass-cloth with CNT

Before connecting to a power source, the temperature of the heated jacket was 28 °C, after connecting the jacket to a power source, the temperature increase to 36 °C, while increasing the capacity of the temperature rose to 45 °C. In the case of applying a protective polymer coating on the obtained smart textiles, can be produce products heated to a temperature of 700-800 ° C, since it eliminates the possibility of interaction between the carbon nanotubes with atmospheric oxygen.

4 Conclusion

Co and Fe nano-catalysts prepared by combustion on glass-cloth allow growing various types of carbon nanotubes. The CNT on glass-cloth have quite interesting electrical properties, as proved by I-V curves strongly depending on the temperature. This type of conductive CNT@glass-cloth can be used for various functional applications. Such CNT@ fiberglass coatings have advantages of Joule heating. Received results of researches confirm the efficiency of electrically conductive textiles as a basis for the creation of heated clothing. Development of smart-textiles is a new trend of the textile industry, including the newest developments in the field of chemistry, nanotechnology and electronics. In our work, we have focused on the practical use of smart-textiles in the home and technology. Our results show the effectiveness of the product obtained, as a heating element.

References:

[1] T. Mimani and K.C. Patil, Solution Combustion Synthesis of Nanoscale Oxides and their Composites, *Mater. Phys. Mech*., No. 4, 2001, pp.134-137.

[2] Forró L., Schönenberger Ch., Carbon Nanotubes, Materials for the Future, *Europhys. News*, Vol. 32, No. 3, 2001, pp. 86 – 90.

[3] Baughman R.H., Zakhidov A.A., A. de Heer W., Carbon Nanotubes – the Route Toward Applications, *Science*, Vol. 297, 2002, pp. 787-792.

[4] Chi P. Huynh, Stephen C. Hawkins, Understanding the Synthesis of Directly Spinnable Carbon Nanotube Forests, *Carbon*, Vol. 48, 2010, pp. 1105 –1115.

[5] Marwan Al-Haik, Jiguang Dai, Daniel Garcia, Jeremy Chavez, Mahmoud RedaTaha, Claudia Luhrs, and Jonathan Phillips, Novel Growth of Multiscale Carbon Nanofilaments on Carbon and Glass Fibers, *Nanosci. Nanotechnol. Lett*., Vol. 1, No. 2, 2009, pp. 1-6.

[6] Höller V., Yuranov I., Kiwi-Minsker L., Structured Multiphase Reactors Based on Fibrous Catalysts: Nitrite Hydrogenation as a Case Study, *Catal. Today*, Vol. 69, 2001, pp. 175-181.

[7] Kashinath C. Patil, Aruna S.T., Tanu M. Combustion Synthesis: an Update, *Curr. Opin.Solid state and Mat.Sci.* Vol. 6, 2002, pp. 507-512.

[8] G.B. Aldashukurova, A.V. Mironenko, Z.A. Mansurov, N.V. Shikina, S.A. Yashnik, Z.R. Ismagilov, Carbon Dioxide Reforming of Methane over Co-Ni Catalysts, *Chemical Engineering Transactions*, Vol. 25, 2011, pp. 63-68.

[9] Aldashukurova G.B., Mironenko A.V., Mansurov Z.A., Rudina N.A., Itshenko A.V., Ushakov V.A., Ismagilov Z.R., Carbon Dioxide Conversion of Methane into Synthesis-Gas on Glass Cloth Catalysts, *Eurasian Chemico-Technological Journal*, Vol. 12, No. 2, pp. 97-103.