Synthesis of carbon nanofibers based on humic acid and polyacrylonitrile by electrospinning method

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The article describes a method for producing carbon nanofibers from humic acid from oxidized coal and polyacrylonitrile (PAN) by electrospinning in laboratory conditions, the value of the interelectrode voltage was 20-25 kV. The elemental composition was determined and the surface morphology of the studied sample was studied, the type of modification of the carbon fiber was revealed. As a result of energy dispersive X-ray spectroscopy and SEM microscopy, the chemical composition of the initial CNF was revealed (C - 89.16%, O - 8.22%, Na - 0.11%, Mg - 0.02%, Al - 0.20%, Si - 0.18%, Cl - 0.11%, K - 1.11%, Ca - 0.09%, Fe - 0.55%, Cu - 0.24%), the diameter of carbon fibers was from 123.5 nm to 781.9 nm. Using the workover method, the degree of graphitization was calculated, which was - 23.97% and the ratio $I(D) / I(G) = 0.7$, $I(G) / I(D) = 1.4$

Humic acid and polyacrylonitrile are dissolved in N,N-dimethylformamide in an oven at 60 °C until homogeneous. Composition: humic acid-5%, polyacrylonitrile (PAN)-3%, N,N-dimethylformamide - 92%.

At the subsequent stages of high-temperature treatment - carbonization at 800 °C, accompanied by the removal of hydrogen and heteroatoms in the form of volatile compounds, the final formation of carbon fibers occurs (Fig. 1).

Figure 1. Electron microscopic images of carbonized carbon nanofiber based on humic acid and PAN: a) x5000, b) x10000, c) x50000.

Thus, the proposed method for producing CNFs is based on the electrospinning method, which is the most promising method of industrial production and provides a product with a relatively high fraction homogeneity, which determines the achievement of strength characteristics for structural materials. These characteristics make it possible to use CNF obtained from HA and PAN as an electrode material for batteries and supercapacitors. Batteries with high energy density and long service life are widely used in our daily life, such as electric vehicles, mobile phones, laptops, etc.

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