Synthesis of nanodiamonds from fuel oil processing products using an arc discharge

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This work presents the results of a two-stage experimental study on the synthesis of carbon nanostructures from liquid hydrocarbons. At the first stage, fullerene soot and carbon micro- and nanostructures are synthesized on the electrode upon initiation of a microarc discharge in liquid hydrocarbons. At the second stage, an electrode with carbon micro- and nanostructures is used as an anode of an arc discharge in argon at a pressure of 500 Torr. During arc initiation, at the second stage, active evaporation of atomic carbon from the anode and synthesis of nanostructures at the molybdenum cathode are observed. The results of electron microscopy studies showed the presence of nanotubes and nanodiamonds at the cathode.

Experimental Setup

a) b) c) d)

Fig. 1. Fisrt step of experiment: a) Installation diagram with rotating electrodes for the decomposition of hydrocarbons. 1 - ammeter, 2 - voltmeter, 3 - ballast resistance, 4 - power supply, 5 - electric motor, 6 - cover, 7 - axis, 8 - anode, 9 - scraper, 10 - belt drive, 11 - sliding contact, 12 - a container with raw materials, 13 — a cathode, 14 — a gas outlet pipe, 15 — a container for collecting gas, 16 — a bearing, 17 — a protrusion, 18 — a rod, 19 — a valve, 20 — a reducer, 21 — a compressor; b) photograph of the experimental setup; c) a photograph of the discharge in the bulk of hydrocarbons; d) arc discharge in vacuum chamber

In the experiments at the first stage, we used fuel oil as hydrocarbon feedstock, similar to our earlier works. Two electrodes, in the form of graphite rods, were placed in a ceramic container filled with hydrocarbon raw materials. Further, a microarc discharge was initiated in fuel oil, which burns in the vapor of gaseous hydrocarbons.

In accordance with the depth of immersion of the arc in fuel oil, a certain pressure is established in it. In the process of arc burning in fuel oil, the electric arc channel will be filled with gases and vapors of hydrocarbons of various fractions, most of which contain gasoline and other light fractions, to some extent soluble in fuel oil. Part of the fuel oil that directly contacts the arc will boil, sending various fractions of complex hydrocarbons to the discharge limits. Surface boiling and relatively low thermal conductivity of fuel oil stop the excessive heating of the fuel oil and its coking. Once in the discharge region, hydrocarbon molecules are bombarded by fast electrons and discharge ions, as well as excited atoms and molecules of hydrocarbon gases, which leads to the destruction of hydrocarbon molecules. The released atomic carbon deposits on the electrodes.

RESULTS

Fig. 2. Carbon growths formed at the cathode in a microarc in liquid hydrocarbons.

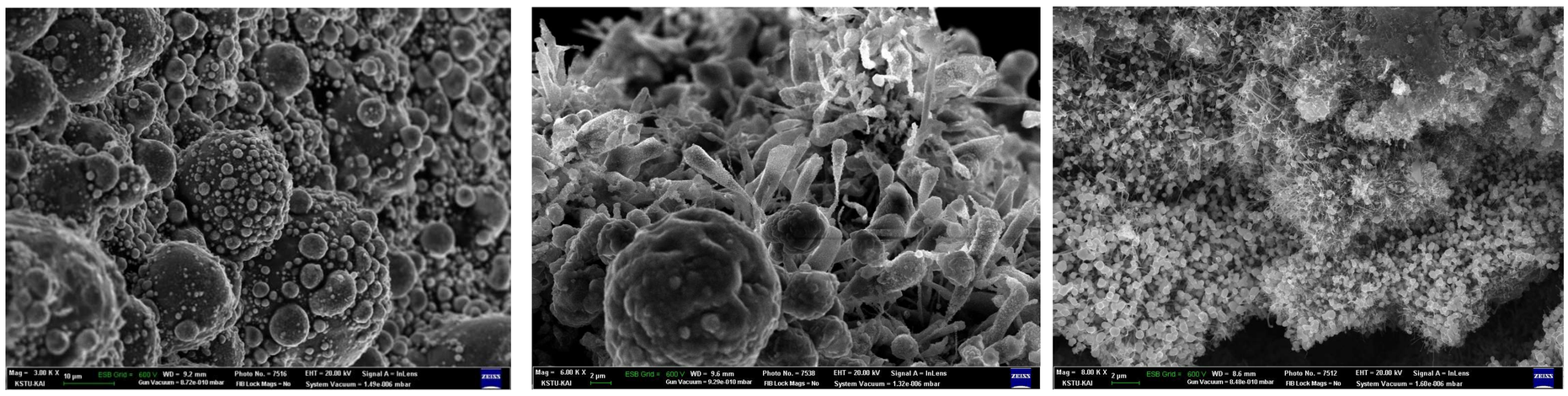

Fig. 3. Electron microscopic photograph of the surface of the cathode of a microarc discharge in a liquid dielectric with a magnification of a) 3000 times, b)6000 times c) 8000 times

As a result of the first stage, carbon growths are formed on the electrodes, which are fullerene soot, micro- and nanostructures. So, Figs. 2, 3 show images of the cathode with carbon deposits formed during an arc discharge in the thickness of fuel oil.

At the second stage, an electrode with carbon growths is used as an anode of a microarc discharge in argon at a pressure of 500 Torr. A molybdenum electrode was used as a cathode. The experimental setup is described in detail in [12,13]. As a result of the experiment, carbon nanotubes and nanodiamonds were discovered on the cathode surface.

The obtained nanostructures on the cathode surface were analyzed using an electron microscope. In fig. 3-4 show electron-microscopic photographs of nano-objects in magnifications of 6000 and 8000 times.

In fig. 3 a-b is a photograph of nanostructures at 3000 and 6000 times magnification. In the lower right corner we see processes on which nanodiamonds in the form of specks are located. Their approximate size is 10 nm

In fig. 3 c shows a photograph at a magnification of 8000 times. As can be seen, there are a large number of nanodiamonds with dimensions of about 500 nm, as well as a large content of carbon nanotubes with a length of 1-3 microns.

Almost all samples obtained by the electric arc discharge method are gray powders. We tested this powder for cutting abilities. Crystals of the resulting powder were placed between two glass plates. When the plates moved relative to each other, deep cracks remained on the glass, which confirms the presence of diamond structures, since only diamond, thanks to its strength, is able to leave such traces.

Conclusion

In this work, by double distillation of carbon atoms, nanodiamonds with sizes from 10 to 500 nm were synthesized. The appearance of almost all nanodiamonds is the same. They have clear edges. Some of them have a pyramidal shape.

Thus, this work presents the results of a two-stage experimental study of the synthesis of carbon nanostructures from liquid hydrocarbons. At the first stage, fullerene soot and carbon micro- and nanostructures are synthesized on the electrode upon initiation of a discharge in an arc in liquid hydrocarbons. At the second stage, an electrode with carbon micro- and nanostructures is used as an anode of an arc discharge in argon at a pressure of 500 Torr. During arc initiation, at the second stage, active evaporation of atomic carbon from the anode and synthesis of nanostructures at the molybdenum cathode are observed. The results of electron microscopic studies showed the presence of nanotubes and nanodiamonds at the cathode. Nanodiamonds with sizes from 10 to 500 nm. The appearance of almost all nanodiamonds is the same. They have clear edges and are more like faceted diamonds. Some of them have a pyramidal shape.

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