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ARC INSTALLATION FOR SPECTROSCOPIC STUDY AND PRODUCTION OF LOW-DIMENSIONAL CARBON STRUCTURES

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Abstract. The experimental installation CAF-2000, intended for spectroscopic study of carbon arc at lowered pressure as well as for production of low-dimensional carbon structures (fullerenes, nanotubes etc.) is described.

1. INTRODUCTION

At the present time the interest to low-dimensional carbon structures in many respects is determined by a possibility of existence of the closed structure of carbon atoms obtained by Kroto et al. (1985) at study of supersonic carbon cluster flows.

The great amount of scientific groups over the world is engaged now in study of applications and properties of fullerenes. However, the fullerene materials may find wide practical applications only in the long term. Substantially this is concerned with poor knowledge of fullerene properties and mechanisms of their formation due to limited opportunities of the experimenters to apply modern research techniques to the carbon arc at lowered pressure.

The most productive way of fullerene production is grounded on a thermal destruction of graphite in an electric arc at lowered pressure of buffer gas proposed by Kratschmer et al. (1990). The products of anode destruction are condensed on water-cooled walls of plasma reactor as fullerene-containing soot as well as dense deposit on a cathode surface. Further fullerene extraction is performed by dilution of the soot in a non-polar solvent, for example in toluene, and does not represent difficulties for usual chemical laboratory.

The most complicate step in fullerene production is the fullerene-containing soot synthesis. Only a few corporations in the world have available high-performance electrodischarge installations. These corporations deal with only commercial problems, and in conditions of relatively poor modern fullerene consumer market are not interested in study of physical processes in the arc reactor.

The further advance in study of mechanisms of low-dimensional carbon structure formation in electric arcs may be reached when handy compact installation providing noncontact optical and spectroscopic methods to study the processes in plasma as well as yielding carbon materials in quantity sufficient for study of their physicochemical properties will be available for the experimenters. An arc discharge module is basis of existing installations for fullerene production. The module comprises a vacuum chamber, fixed cathode, translated anode and water-cooled soot condenser. The installation on the basis of such module providing a possibility of observing of processes in the reactor with minimum service time is most suitable for carrying out of the investigation.

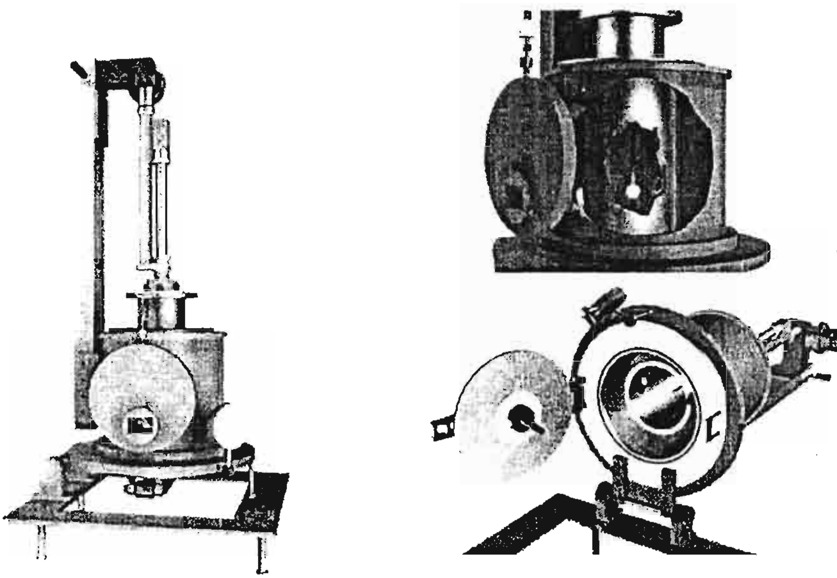
2. ARC INSTALLATION CAF-2000

Summarizing the experience of operation of arc devices for fullerene synthesis described early in the literature, the experimental installation CAF-2000 was designed and made in IMAPh of NASB. The installation is arranged with a vacuum gate permitting to depressurize the work chamber during two seconds that more than twice reduces time of preparatory operations and soot collection in comparison with the installations used by Afanasiev et al. (1994) and Shimanovich et al. (1998). A cathode is mounted in a fixed water-cooled holder placed on the vacuum gate door. An isolated anode unit is placed on a water-cooled movable manipulator with a vacuum seal and has a possibility of back-and-forth motion with adjustable speed. The anode holder, discharge chamber and cathode holder are isolated from each other. The working chamber is evacuated by a forevacuum pump with liquid nitrogen trap and provides a steady discharge at buffer gas pressures of 1-500 torr. There is a possibility of the chamber operation both in vertical and horizontal positions.

The current supply of installation can be yielded from different power supplies, including standard welding supplies of direct/alternating current (current range is 20-300 A, idle voltage is 40-500 V). The electrical insulation of cathode and anode from the working chamber permits to utilize power supplies with a voltage up to 2 kV. The installation construction allows application of discharge initiation both by a contact of graphite electrodes and by a high-voltage impulse.

The working chamber is fitted with a pair of opposite located quartz windows 38 mm in diameter for optical and spectroscopic observation of physicochemical processes in the arc plasma.

The installation CAF-2000 may be applied for carrying out of investigations on plasma physics, solid state physics, material technologies etc. both in research laboratories and in universities.



b

a c

The arc installation CAF-2000 (general view *a*, discharge chamber under operation *b* and discharge chamber with opened vacuum gate door *c*).

When using the installation CAF-2000 only for fullerene soot synthesis one can reach productivity up to 20 grams of fullerenes per an eight-hour shift.

The features of CAF-2000.

dimensions, *cm*	60x70x135
weight without a power supply, *kg*	75
volume of work chamber, *l*	15
working pressure, *torr*	1-500
working voltage, *V*	20-2000
discharge current, *A*	20-300
length of anode consumption, *mm*	150
feed rate of the anode, *mm/min*	3-50
soot mass for a duty cycle, *g*	
6 mm electrode	3
12 mm electrode	12
duty cycle in standard a mode, *min*	25
time of preparation of installation to operation, *min*	30
soot production for an eight-hour shift, *g*	> 20
content of fullerene in the soot, %	> 10

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