FULLERENE SYNTHESIS IN HELIUM FLOW AT ATMOSPHERIC PRESSURE

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Introduction

Unflagging interest of scientists from different fields to the fullerenes and their derivatives are determined by variety of their physicochemical, optical, mechanical and electrical properties.

Large-scale fullerene production is checked by imperfection of production methods. All well-known methods such as laser evaporation, electron-beam evaporation, arc discharge and other methods require the improvements because of their low effectiveness for industrial fullerene production [1-2]. The main drawback is either low fullerene yield or low yield of fullerene-contained soot. Therefore at the present improvement of the fullerene synthesis remains the actual direction of investigations.

Earlier we presented the method of fullerene synthesis at atmospheric pressure [3]. Described installation produced soot, which contained ~ 10% of fullerenes. Unfortunately, this and other arc discharge methods produced a large amount of condensate on electrode (~70% from the weight of evaporated graphite), which was not contained fullerenes.

In this paper we present method of fullerene synthesis which combine an arc feeding by the both high frequency alternative current (AC) and direct current (DC) together. At that almost whole graphite is transferred to the soot.

Results and discussion

By this method, the fullerene synthesis is carried out in the arc discharge at atmospheric pressure in the helium flow. Evaporated carbon is condensed on the water-cooled walls of chamber and formed the soot containing fullerenes. Using of three electrodes fed by AC (f = 44 kHz) and DC currents (fig. 1) is the main feature of this method. Combined arc feeding allows to incorporate the advantages of DC and AC currents: high rate of electrode evaporation and large fullerenes content in the soot.

It were investigated dependences of graphite electrode erosion rate, fullerene, fullerene soot and electrode condensate yield on the magnitude of DC

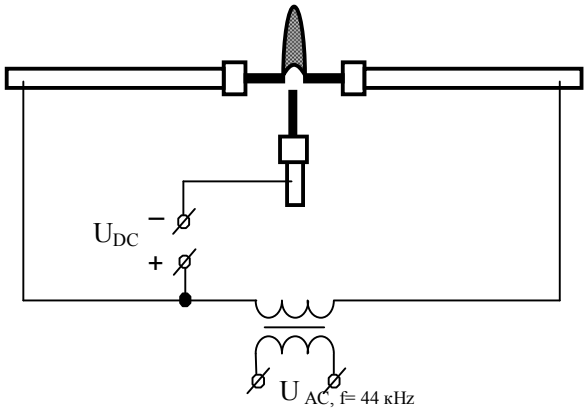

Fig. 1. Scheme of the power supplies connecting

(fig. 2). The AC magnitude was invariable and equal to 190 A. At this AC value the maximal fullerene yield was observed earlier for the case of arc feeding by AC only [4]. The DC power supply was connected to the electrodes so that the erosion of horizontal electrodes was maximal (fig. 1).

It was determined that DC below 80 A is not changed the fullerene yield (fig. 2). But in this case the speed of the fullerene production is increased significantly and reached the maximal value of 104 mg/min.. In the case of arc feeding by AC only the correspondent maximal value was reached of 16 mg/min only. For the conditions of the maximal fullerene yield (10 %) it were defined the temperature and electron concentration by the method of spectral line relative intensities. At emission spectra detecting the plasma radiation was projected on a spectrograph aperture with help of three-element lens system and was registered by a film. The plasma temperature and electron concentration during the fullerene synthesis were determined by the Mg spectral lines, for that MgO powder was injected into the plasma. Few MgO content (~0.2%) did not affect on the fullerene yield. The calculated plasma temperature value was 7250 K and value of electron concentration was $3*10^{17}$ sm^{-3}.

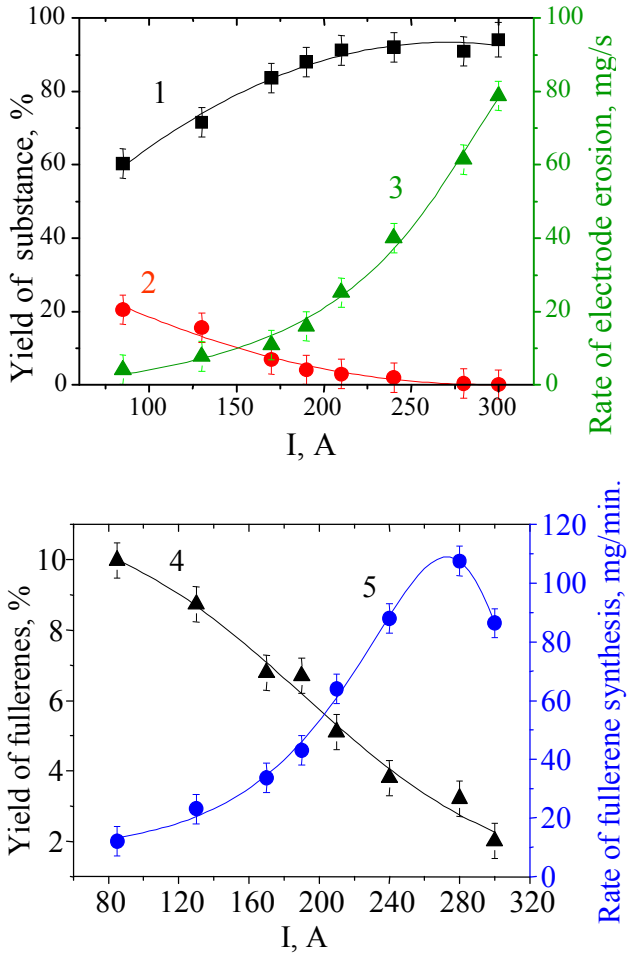

Fig. 2. Dependences of the fullerene synthesis parameters on the DC current value: 1 – the soot yield; 2 – the yield of carbon condensate on electrode; 3 – the rate of electrode erosion; 4 – content of fullerenes in the soot; 5 – the rate of fullerene synthesis.

Conclusions

It was shown that combination of DC and AC currents can be effective for the fullerene production in helium flow at atmospheric pressure. The test installation realized these conditions allowed to synthesize 104 mg of fullerenes per minute. Amount of the fullerene-contained soot was more than 90 % of the initial graphite mass. The maximal content of fullerenes in the soot was ~10%. The plasma temperature and electron concentration at the maximal fullerene yield were 7250 K и $3 \cdot 10^{17}$ sm^{-3} respectively.

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