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Process control of fullerene synthesis by the influence of a magnetic field on the plasma of a high-frequency carbon arc

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Theoretical estimates, and then quantum chemical calculations, confirmed that fullerene formation rate in plasma depends on the values of temperature and electron density [1, 2]. The helium pressure increase in the chamber was also shown to lead to an increase in the temperature gradient and the electron density in the arc - discharge plasma, with the higher fullerene content in the resulting fullerene mixture increasing significantly [3]. As above, it can be assumed that the arc plasma, being in a magnetic field, and therefore under its pressure, will form a fullerene composition upon cooling, depending on the pressure.

Studies of the effect on the fullerene composition and yield in an HF arc discharge plasma in case when the discharge current vector and magnetic field direction vector were collinear have been carried out. In a fullerene mixture formed without a magnetic field, the amount of higher fullerenes (C_n, where $n > 70$) was 8.7 wt.%. In case of a phase shift between the discharge current and the magnetic field strength of $\pi/2$, the number of higher fullerenes is up to 9.8 wt.%. The field synthesis cophased with the discharge current results in the higher fullerene formation in amounts of 12 wt.%. For both cases, the field influence leads to a decrease in the fullerene content by 2–3 wt.%.

Thus, the study results of the influence of the magnetic field on the composition and number of the formed fullerenes correspond to the pressure effect of the buffer gas, helium, in the chamber. Not only will collinear magnetic fields, but also perpendicular ones to the discharge current be presented in current work in the research results.

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Fullerene formation in plasma at different rates of temperature and electron concentration change

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There are various models of the formation of fullerenes, based both on the idea of assembling fullerenes from small clusters [1] and on annealing large clusters with the emission of carbon dimers [2]. These models reveal important aspects of the phenomenon of spontaneous transformation of carbon vapor into stable fullerene molecules. From a practical point of view, a model that takes into account the rate of change of temperature and electron concentration in plasma along the arc discharge radius may be of great interest.

Earlier, we proposed a model [3, 4] of the formation of fullerenes accounting the charges of carbon clusters in a plasma. Then it was improved [5]. The model takes into account the cluster heating and cooling. In addition, the heating and cooling of the carbon clusters by buffer gas is considered. The calculations give the qualitatively correct correlation between fullerene yields in helium and argon.

In this work, in the model the data obtained on the temperature distribution and electron concentration in a carbon-helium plasma [6] were taken into account. The results of calculations carried out for different pressures of the buffer gas correlate with the results of experiments [6] and will be used in the future to improve the technique of controlled fullerene synthesis.

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