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OBTAINING FULLERENE-CONTAINING THIN FILMS FROM C_{70} NANOPARTICLES

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Abstract. The morphological features and exact dimensional characteristics of fullerene-containing nanoaggregates and thin films by electron and atomic force microscopy are established. In the process of cooling the C_{70} solution from \( \sim 30^\circ C \) to \( \sim 20^\circ C \), fractal spherical C_{70} nanoaggregates with diameters of \( \sim 150\div200 \, \text{nm} \) are formed on the surface of the cover glass in the solution. It was found that a fullerene-containing film obtained in the process of solvent evaporation from the volume of a drop of C_{70} solution on a horizontally located substrate (heated to \( \sim 33^\circ C \)) is completely crystalline and nanostructured.

Keywords: fullerene C_{70}, drops of solution, nanostructure, thin film.

Recently, there has been a growing interest in the development of effective methods for producing thin films based not only on metals and semiconductors, but also on fullerenes C_{n} (n = 60, 70) for the needs of modern electronics, solar energy, etc. [1-2]. The diameter of the C_{n} fullerene molecule (n = 60, 70) is less than 1 nm, they are semiconductors with a band gap of \( \sim 1.24 \div 1.95 \, \text{eV} \). Therefore, thin films saturated with fullerenes exhibit photoconductivity properties when illuminated by radiation with a wavelength of \( \sim 380\div800 \, \text{nm} \) [3]. The search and improvement of simple effective methods for the controlled synthesis of conductive materials in the form of thin films based on nanoparticles is an important step in many modern applications.

This work presents for the first time the results of a study of the controlled synthesis of porous mC_{70} nanoaggregates (where m- the number of fullerene molecules in one nanoaggregate) of various sizes in solution. Methods for obtaining thin fullerene-containing films from drops of C_{70} solutions on a flat substrate surface will be mastered.

Powders of fullerene C_{70} (SES Research, USA) and an organic solvent - xylene of the special grade grade were used in the work. (Sigma-Aldrich, USA). The initial fullerene solution was prepared by the nonequilibrium method described in [4].

In fig. 1 shows an atomic force microscope (AFM) image of mC_{70} nanoaggregates formed in a fullerene solution. To synthesize fractal aggregates mC_{70}, a solution of fullerene C_{70} in xylene was heated to \( \sim 30^\circ C \), then a standard plane-parallel cover glass of the brand “KS-8” 0.25 mm thick was introduced into the solution. It was found by high-resolution atomic force microscopy (AFM) that during the cooling of the C_{70} solution to a temperature of \( \sim 20^\circ C \), mC_{70} nanoaggregates are formed on the cover glass surface. It is seen that the synthesized nanoaggregates are fractal, and their size in diameter is \( d \sim 150\div200 \, \text{nm} \) (see Fig. 1). Further AFM studies have shown that an increase in the C_{70} concentration in the same solution leads to an increase in the average size of the C_{70} fullerene aggregates formed in the solution.

In fig. 2 shows an electron microscopic image of a thin film obtained by us in our experiments, consisting practically of macromolecules of fullerene C_{70}. The film was obtained in
the process of evaporation of xylene from the volume of droplets of a molecular solution of fullerene C$_{70}$ located on a smooth surface of a horizontally located glass substrate heated to T$\approx$33°C. The image was obtained using a S-4800 scanning electron microscope (SEM) (Hitachi, USA) with a resolution of $\leq$0.4 nm. It is seen that the C$_{70}$ film is crystalline with an area of $\sim$10x15 $\mu$m$^2$ and a surface roughness of less than $\sim$15 nm. Note that at a fixed concentration of C$_{70}$ in a droplet of the working solution, an increase in the substrate temperature and fullerene concentration led to the accelerated growth of a thin film.

Fig.1. AFM image of mC$_{70}$ nanoaggregates synthesized on the surface of a glass substrate. The initial concentration of fullerene C$_{70}$ in the solution was $\sim$0.5 g / L.

Fig.2. SEM image of a nano-structured thin film formed from C$_{70}$ fullerene. The C$_{70}$ fullerene concentration was $\sim$0.5 g / L.
In fig. 3 shows an SEM image of a nanostructured film of fullerene $C_{70}$ molecules. It can be seen that the three-dimensional dimensions of this fullerene-containing film are $2.6 \times 0.6 \times 2.0 \, \mu m^3$. The film obtained by evaporation of xylene from the volume of one isolated drop of a molecular solution of fullerene $C_{70}$ is nanocrystalline. It can be noted that our method of deposition of fullerene-containing thin films on the surface is a simple technology and allows working with almost any type of substrate.

![SEM image of a nanostructured fullerene-containing thin film](image)

**Fig-3.** SEM image of a nanostructured fullerene-containing thin film synthesized by self-assembly of $C_{70}$ molecules on a horizontally located glass substrate heated to $T \approx 33 \, ^{\circ}C$. The concentration of fullerene $C_{70}$ in the solution was $\approx 1.2 \, g/L$.

Thus, the experimental results obtained on the synthesis of nanoaggregates and thin films of fullerene $C_{70}$ can be very useful in the further development of methods for efficiently obtaining fullerene-containing nanostructured matrices (sensors, emitters, photoresistors, photodetectors, etc.) for the development of nanoscience and nanotechnology.

**References**


