

OBTAIN OF SPECTROPHOTOMETRIC STUDY OF ORGANIC SOLUTIONS OF ENDO- AND EXOMETALLOFULLERENES OF C₆₀

Borts B.V., Tkachenko V.I., Moskvitin A.V., Kazarinov Yu.G.

National Science Center "Kharkov Institute of Physics and Technology"

1., Academiceskaya Str., Kharkov, 61108, Ukraine

Tel./Fax: 8-057-335-1703, E-mail: borts@kipt.kharkov.ua

Introduction

State of atomic particles, contained in fullerene cladding, is unique and cannot be reproduced by any other method. Thus, partially or completely, metal atoms transfer their valence electrons to external part of a fullerene cladding losing practically their chemical individuality. At present, possibility of direct implementation of endohedral structures in technology and technics of physical experiment is rather limited, first of all, due to extremely high cost of production [1].

Results and discussion

1. Obtain of metallfullerenes.

Method of ion implantation synthesis of endohedral fullerenes is based on bombing of hollow fullerenes by ions of the element that should contained in carbon frame of fullerene molecule or joint by electron coupling outside the frame. However, obtain of accelerated metal ions is related to creation of ion source that can obtain ions and desirably all ions of Mendeleev table, and this is quite a complicated task. The second problem, all ion sources, as a rule, require beam mass separator, and energy, which is obtained at the output of ion injector, is in the range of 20-30 keV. With such energy, incoming metal ion destroys electron couplings, knocks-out carbon atoms from the grid and does not communicate necessary fullerene junctions. Energy required to obtain endo- and exofullerenes is in the range of 10-100 keV. It is necessary to select such energy for metal atom implantation where metal atom would fit the window or install energy coupling with carbon atom or penetrated the carbon cladding, and electron coupling then would renovate.

We have developed the machine that allows to carry out fullerene implantation by any metal atoms.

Fig. 1. shows the scheme of experimental machine for synthesis of endo- and exometalfullerenes. This machine represents a source of gas ions of argon or xenon operating in the range of 10-100 μ A. Beam can be directed under angle from 0° to 85° to metal support atoms of which are diffused. Energy dependencies of the

knocked-out atoms from the type of the accelerated ion are shown in the work.

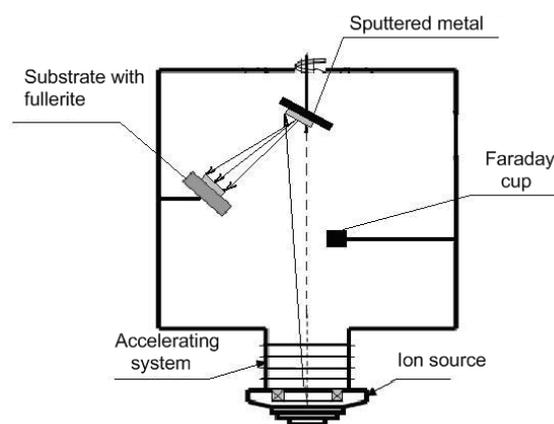


Fig. 1. Machine for obtaining of metallfullerenes.

Under influence on the surface of metal target by inert gases with energies of 10-30 keV the diffused atoms have a wide distribution on energy with maximum near low values of kinetic energy. Irradiating the metals under different angles, one can separate maximums of angle distribution of high energy reflected particles of inert gas and the diffused particles of the target with energies sufficient for implantation of metal ions inside the fullerene molecule.

Due to slump of probability of the diffused particles yield with energies sufficient to destroy fullerenes, this method can be used for effective obtain of couplings – endo- and exometalfullerenes. Preliminary, we have carried out a computer simulation of targets diffusion of platinum and iron. We have obtained energy and angle dependencies of the diffused particles. We have calculated the diffusion factors of target and reflection of Ar atoms for different energies.

2. Spectrophotometric study of organic solutions of endo- and exometalfullerenes C₆₀.

Previously, in the work [2], we have studied organic solutions of pure fullerenes synthesized in laboratory on vacuum-arc machine. These spectra were standards during spectrometric studies of organic solutions of endo- and exometalfullerenes of C₆₀ realized in this work. The idea to carry out such studies is that metal atom implemented inside fullerene molecule changes essentially its electronic and other characteristics. These changes

could be fixed by optical spectroscopy method of diluted organic solutions of metalfullerenes because it gives quite many information on interaction of modified fullerenes with molecules solvent [3,4].

In this work you see a series of modifications of absorption spectra of diluted fullerenes $C_{60}+Fe$, $C_{60}+Pt$, $C_{60}+Fe+Pt$ in toluol on SF-2000 spectrometer at room temperature. The obtained absorption spectra were compared to the standards. The comparison of the obtained spectra for different metals, despite distinction of charge of the captured atoms, proves validity of empirical rule: absorption spectra of toluol solutions of different $C_{60}+Me$ are identical [5].

Identity of spectra is in similarity of spectral curves. However, there are differences between these spectra. It is proved by behavior of curves obtained as a result of calculations of spectra rates: $S_1 = C_{60}+Fe / C_{60}$; $S_2 = C_{60}+Pt / C_{60}$; $S_3 = C_{60}+Fe+Pt / C_{60}$ and static processing of initial spectra. the curves, obtained after calculations of spectra rates, are similar to parabola, all points of which are located higher the line with ordinate 1 that proves broadening of S_1 absorption bands located near RF 335nm, with growth of atomic weight of metal and its mixtures. The value of absorption band broadening λ (S_1) satisfies inequality: $\lambda(S_1) < \lambda(S_3) < \lambda(S_2)$.

Besides broadening of absorption bands we observe their shift into short-wave part of spectrum. Value of shift increases with growth of mass of the captured metal.

Fig. 1. shows the normalized optical absorption spectra of absorption spectra of diluted fullerenes in toluol (upper curves) and fitting with Gaussians.

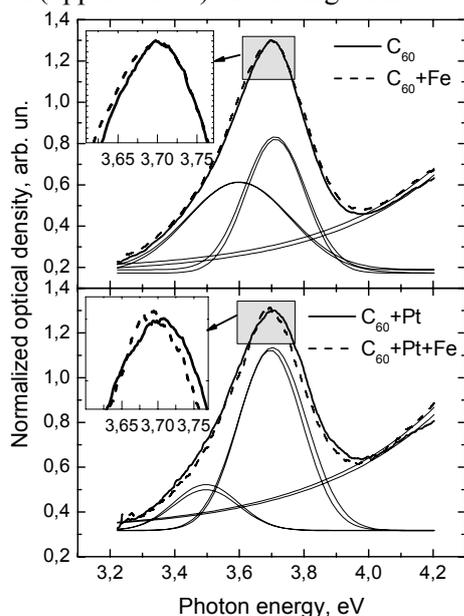


Fig. 2. Optical absorption spectra of fullerene in toluol.

Conclusions

We have developed method to obtain endo and exo-fullerenes by ion implantation method.

We have carried out spectrophotometric studies of diluted organic solutions of the obtained fullerenes.

We have proved that connection of metal atom to fullerene leads to increase of half-width of absorption spectrum and to displacement of absorption maximum into short-wave part of spectrum. At this, the half-width is increased in such a way that for Fe-Pt mixture it is higher than for the half-width with Fe and is less for the half-width with Pt.

References

1. Makarova T.L. "Magnetic characteristics of carbon structures. Physics and technology of semiconductors", 2004, volume 38, edition 6, p. 641-664.
2. Necklyudov I.M., Borts B.V., Moskvitin A.V., Kazarinov Yu.G., Pisarev G.V., Skortomnaya S.F. "Influence of magnetic field on optical characteristics of fullerene solutions (C_{60} , C_{70}) in organic solvents. Nanoparticles in the condensed fields". Collection of scientific articles, NAS of Belarus, Institute of heat and mass exchange, under edition of P.A. Vityaz (responsible editor) and others – Minsk: Publishing center of BSU, 2008, 286 p., p. 118-123.
3. Churilov GN., Bulina N.V., Fedorov A.S. "Fullerenes: synthesis and theory of formation". Novosibirsk: Publishing house SO RAS, 2007. – 229 p.
4. Shchur D.V., Matysina Z.A., Zaginaychenko S.Yu. "Carbon nanostructures and phase modifications". Science and education. Dnepropetrovsk, 2007. 678 p.
5. Shinohara H. Rep. Prog. Phys., 2000, V. 63, p. 843-898.