(July 14, 2011) To the human eye, carbon nanotubes usually appear as a black powder. They can hardly be forced to emit light, as they are excellent electrical conductors and capture the energy from other luminescent chemical species placed nearby. The researchers from the Institute of Physical Chemistry of the Polish Academy of Sciences in Warsaw contributed recently to the development of a relatively simple method allowing the nanotubes exposed to UV to emit red light.

The researchers involved in the international FINELUMEN project, coordinated by Dr. Nicola Armaroli from Italy's Istituto per la Sintesi Organica e la Fotoreattivita, Consiglio Nazionale delle Ricerche (CNR-ISOF) in Bolonia, have developed an efficient method to fabricate a new photonic material: carbon nanotubes coated with chemicals that are capable of displaying red light. "We take part at the project as a research group specializing in studies on lanthanide compounds. We decided to combine their high luminescent properties with excellent mechanical and electrical characteristics of nanotubes," says Prof. Marek Pietraszkiewicz from Warsaw's Institute of Physical Chemistry of the Polish Academy of Sciences (IPC PAS).

Carbon nanotubes can be envisaged as a graphite sheet rolled-up into a seamless cylinder. The surface area of each nanotube is relatively high and allows to attach many other molecules, including those capable to emit light. "Attachment of light-emitting complexes directly to the nanotube is, however, not favourable, because the latter, as a black absorber, would highly quench the luminescence," explains Valentina Utochnikova, a PhD student at the IPC PAS. To reduce undesired effect of light absorption, the nanotubes are first subject to a thermal reaction at temperature 140-160 oC in a solution of ionic liquid modified with a terminal azido function. The reaction yields nanotubes coated with molecules acting as anchors-links. On one side the anchors are attached to the surface of the nanotube, and on the other they can attach molecules capable of displaying visible light. The free terminal of each link bears a positive charge.

So prepared nanotubes are subsequently transferred into another solution containing a negatively charged lanthanide complex -- tetrakis-(4,4,4-trifluoro-1-(2-naphtyl-1,3-butanedionato)europium. "Lanthanide compounds contain elements from the VI group of the periodic table and are very attractive for photonics, as they are characterised by a high luminescence quantum yield and a high colour purity of the emitted light," stresses Utochnikova.

After dissolving in solution, negatively charged europium complexes are spontaneously caught

by positively charged free terminals of anchors attached to nanotubes due to electrostatic interaction. As a result, each nanotube is durably coated with molecules capable to emit visible light. Upon completion of the reaction, the modified nanotubes are washed and dried. The final product is a sooty powder. If the powder is, however, exposed to UV irradiation, the lanthanide complexes anchored to nanotubes start immediately to emit red light.

The concept of how to modify the nanotubes and the reagents -- ionic liquid and lanthanide complex for carbon nanotube coating -- has been developed in Prof. Pietraszkiewicz's research group at the IPC PAS, whereas the modification of nanotubes and spectral studies have been performed by research groups from the University of Namur, Belgium, and CNR-ISOF from Bolonia, Italy. It is essential that chemical reactions leading to fabrication of new light-emitting nanotubes turned out to be significantly simpler than those used so far.

The photonic material received can be used, among others, to detect molecules including those of biological importance. The identification would then take place by analysing of how the luminescence of nanotubes changes upon deposition of molecules under study thereon. Good charge conductivity combined with high luminescence properties make new nanotubes an attractive material also for OLED-based technologies.

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