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SHORT COMMUNICATION

CARBON NANOTUBES: EXPERIMENTAL EVIDENCE FOR A NULL RISK OF SKIN IRRITATION AND ALLERGY

A. Huczko* and H. Lange

Department of Chemistry, Warsaw University, 1 Pasteur, 02-093 Warsaw, Poland

ABSTRACT

Fullerene soot with a high content of single-wall carbon nanotubes was tested to assess its potential biochemical activity. The results of dermatological trials did not show any signs of health hazard related to skin irritation and allergic risks.

One of the challenging and exciting research areas is currently related to the bioactivity of nanocarbons and their derivatives[1]. Since the π-electron carbonaceous nanostructures can be very active in interacting with other materials[2], the assessment of the potential health hazard of these novel materials for humans is obviously relevant. Our previous physiological study[3] showed that the fullerene matter does not pose any risk regarding humans skin irritation and allergy potential.

Since the pathbreaking paper describing the discovery of carbon nanotubes[4] (CNTs) this topic seems to be presently one of the most active subfields in the materials science[5]. From high-strength composite materials to molecular electronics, CNTs continue to excite the scientific world, and new findings ap-

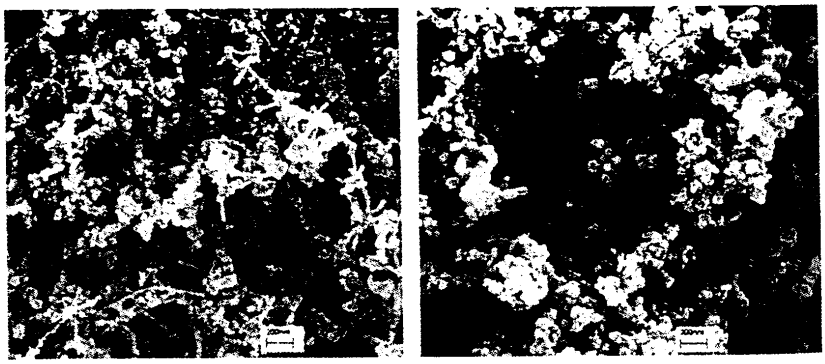
* Corresponding author. E-mail: ahuczko@chem.uw.edu.pl

pear at record pace. Large scale production of carbon nanotubes has already occurred[6] and the exploratory applications in electronics have emerged[7,8]. Extended carbon tubules, because of their curvature, have an excess of energy compared with the energy of the flat infinite graphite sheet hence the possibility of their chemical functionalization[9]. Holzinger et al.[10] studied the chemical activity of CNTs and described their derivatization. *Ab initio* quantum chemistry calculation were also carried out to determine the chemical behavior of CNTs[11]. Enzyme immobilization in carbon nanotubes[12,13] is an example of the biochemical activity of carbon nanotubes.

Thus, with the continually rising scope of research on carbon nanotubes the matter related to their biological relevance and toxicity has been raised[6]. In fact, Hyperion Catalysis Int. (USA), producing about 300 kilograms of multiple-walled carbon nanotubes every day, treats them as 'highly toxic materials'[6].

To evaluate whether CNTs can induce any significant skin hazards, we chosen two methods that are routinely applied in dermatological testing of skin sensitivity. Forty volunteers reporting various irritation and allergy susceptibilities were subjected to a patch test (filter paper Whatman 3 saturated with water suspension of soot) and controlled during 96 hours. In the second method, the modified Draize rabbit eye test was carried out. Four albino rabbits were tested. One eye of each rabbit was instilled with 0.2 ml of water suspension of soot while the other eye was a reference. The rabbits were controlled after 24, 48, and 72 hrs.

Soot with a high content of carbon nanotubes (Fig. 1A) was produced in our fully automated experimental system, described in detail earlier[14], under the preselected[15] operational parameters. Co/Ni-doped homogeneous graphite was



A B

Figure 1. SEM images of (A) soot with a high content of CNTs and (B) soot with a null content of CNTs.

used as the anode. The reference soot with a null content of CNTs (Fig. 1B) was obtained in a DC are sublimation of pure graphite anode in helium at low pressure (1 mb).

Considering the dermatological testing any activity of the tested soot with a high content of CNTs was detected. The patch test showed negative results after 96 hrs. Rabbit's eye abnormality was not observed after 72 hrs. The same results were obtained both for the soot containing carbon nanotubes and for a reference material. Thus, given the consistent results from these two methods, it is unlikely that working with a soot containing CNTs is associated with any risk of skin irritation and allergy. Thus, no special precautions have to be taken while handling these carbon nanostructures.

Research is in progress regarding the biological relevance and toxicity of pure carbon nanotube material. The new project has also been launched regarding the other aspect of CNTs bioactivity since, due to their physical characteristics, carbon nanotubes can, at least theoretically, reproduce the behavior of asbestos by reacting with cellular components to produce byproducts dangerous for humans[16].

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