Buckyballs (fullerenes): free radical sponges or inflammatory agents?

C. Cadenas · R. Marchan · J. G. Hengstler

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In this issue, Andreja Trpkovic, Biljana Todorovic-Markovic and Vladimir Trajkovic from Belgrade contribute a comprehensive review on the in vitro and in vivo toxicity of fullerenes, also named “Buckyballs” (Trpkovic et al. 2012; this issue). “Buckyballs” are molecules composed entirely of carbon, named after Richard Buckminster Fuller. Particularly, well known is the C₆₀ fullerene, which resembles a nanoscale football. Fullerenes can also form cylindrical structures, aptly named buckytubes or nanotubes. The existence of C₆₀ was predicted already in the 1970s by scientists from both the USSR and Japan (Henson and Osawa) based on quantum-chemical considerations. However, this discovery was initially not acknowledged in Europe and America. Later, Kroto, Curl and Smalley, incidentally from the USA and the UK, were awarded the Nobel Prize in 1996 for the discovery of C₆₀ fullerenes.

Today, fullerenes are invaluable to the field of nanotechnology, because of their superconductivity and heat resistance. Moreover, they are studied for their potential medical use as drug delivery systems. However, air fullerenes are also environmental contaminants, most probably as a result of combustion processes, for example, in coal power plants. Buckyballs have also been detected in outer space and discussed as “seeds for life” on earth, although this is all speculative.

Because of their chemical and toxicological properties, it seems to be relevant that fullerenes are not completely

unreactive. To form a closed sphere, the sp²-hybridized carbon atoms must be bent, thus producing angle strain. The C₆₀ fullerene contains thirty double bonds and readily binds free radicals. On the other hand, in vitro tests have shown the following effects upon exposure to fullerenes:

- generation of reactive oxygen species
- activation of signaling factors
- mitochondrial depolarization
- induction of autophagy, reflected by an increase in acidified vacuoles or levels of the autophagosome marker LC3-II
- lipid peroxidation
- lysis of erythrocytes

Although fullerenes accumulate in the lung, liver, spleen and kidney, in vivo toxicity seems to be minimal. Inflammatory reactions in the lung and liver, as well as increased neutrophil counts, have been reported. However, high doses are required to induce toxicity in vivo. Currently, adverse effects of nanomaterials represent a cutting-edge topic in toxicology (Kim et al. 2011a, b, 2012; Zhang et al. 2011; Ronzani et al. 2012; Nakagawa et al. 2011; Marchan 2011a, b, 2012; Hengstler 2011). The current review of Trajkovic and colleagues gives a systematic and complete overview of the toxicity studies both in vitro and in vivo performed with fullerenes.

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C. Cadenas (✉) · R. Marchan · J. G. Hengstler
Leibniz Institut für Arbeitsforschung an der TU Dortmund,
Leibniz Research Centre for Working Environment
and Human Factors (IfADo), Ardeystrasse 67,
44139 Dortmund, Germany
e-mail: cadenas@ifado.de

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