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Mini Review

The Biocompatibility and Toxicity of Nanocarbon Onion-Like Fullerene (NOLF) Materials in Humans and Living Systems

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Abstract

Carbon fullerene materials have been investigated for applications in humans for nearly fifty years. Fullerene materials are composed of carbon atoms and are compatible with specific biological systems. They reduce the number of free radicals in cells, provide anti-inflammatory effects, and inhibit tumor growth. However, the primary antioxidant benefit of fullerene materials seems to be the activation of nuclear factor (erythroid-derived 2) factor 2 (Nrf2). Nanocarbon onion-like fullerene (NOLF) materials have a high surface area to volume ratio, making them viable for transportation within humans and animals. They aid in targeted drug delivery for varying conditions, such as cancer therapy. However, NOLFs safety, manufacture, and dosage should be further evaluated for consistency and toxicity and established for the safe therapeutic use in humans, animals, and plants.

Keywords: *Biocompatibility; Diamagnetic; Free Radical; Fullerene; Nanocarbon; Quantum Cell; Toxicity*

Abbreviations

ATP: Adenosine Triphosphate; C60: Carbon-60; CNO: Carbon Nano-Onion; DNA: Deoxyribonucleic Acid; NOLF: Nanocarbon Onion-Like Fullerene; Nrf2: Nuclear Factor (Erythroid-Derived 2) Factor 2; OLC: Onion-Like Carbon; MWCNO: Multi-Walled Carbon Nano-Onion

Introduction

The carbon 60 allotrope, also known as C60, was investigated from 1985–1990 by scientists Kroto (University of Sussex), and Smalley and Curl (Rice University) who described the material's chemical and physical properties [1–3]. The C_{60} molecule was found to be hydrophobic and electrically non-conductive due to the numerous atoms in its structure, contributing to the allotrope's stability. Subsequently, further studies on the allotrope were conducted, leading to the descriptions: multi-layered carbon nano-onions (CNOs), nanocarbon onion-like fullerenes (NOLFs) and onion-like carbon (OLCs) [1–3]. Although nanocarbon fullerenes have various carbon arrangements, they possess similar amounts of inherent energy. Generally, carbon fullerene is biologically compatible with cells and tissues when applied in medical, veterinary, and agricultural research, exhibiting low levels of toxicity in humans, animals and plants.

Discussion

The biocompatibility of fullerene materials in humans, animals, and plants

Nanocarbon fullerene materials demonstrate biocompatibility properties wherein they induce or augment beneficial reactions. Due to the high degree of complementary reactions associated with nanocarbon fullerenes, they are widely used in various areas of human medicine, veterinary medicine, and agriculture. Nanocarbon fullerenes have shown positive results in metabolic reactions as the carbon double bonds are exposed as successive shells during the breakdown process. The fullerene materials correlate with mitochondrial perturbation, promoting and supporting biological processes in humans, animals, and plants [4].

The introduction of nanocarbon fullerenes *in vivo* helps regulate cell functions through their free radical scavenging abilities and in mitigating oxidative stress [5–8]. Also, fullerene substances demonstrate electrodynamic properties, attributable to their dense delocalized pi cloud and unique physical structure wherein carbon atoms form pentagonal rings [9]. Moreover, the primary antioxidant benefit of fullerene materials seems to be the activation of nuclear factor (erythroid-derived 2) factor 2 (Nrf2) [10,11]. Fullerene materials are compatible with the quantum conductivity present in human, animal, and plant biomolecules due to their electrodynamic properties [12–14]. Thus, the fullerene materials introduced into cells regulate the bio-energies in perturbation states. Further, fullerene materials can absorb and release energy involved in cellular processes, helping to normalize mitochondrion function [14,15].

The diamagnetic properties of nanocarbon fullerene materials enhance the regulation of structured water in mitochondria. In doing so, fullerene materials support cellular and mitochondrial structures in maintaining and restoring water within specific structures [16]. Fullerene materials are assimilated into the body's protein structures, whereby they assist in the production of energy. As these materials adapt to cell functions, biological processes at specific sites are enhanced as more favorable conditions are established [17]. In particular, the fullerene materials assist native aggregation of adenosine triphosphate (ATP), wherein energy is produced for metabolic processes [18,19].

Fullerene materials complement various cellular processes, including the unfolding of proteins in the mitochondrion and exposure of dipolar charge sites, enhancing the formation of structured cell water. Additionally, an electron cloud present in fullerene chemical compounds and their endogenous electric field help regulate the adverse effects caused by prolonged mitochondrial perturbation and oxidative stress [14,15,20,21].

Fullerene materials introduced into cells and protein structures enhance various metabolic reactions due to their biocompatibility with tissues and organs [22]. However, research of fullerene's action on mitochondria is limited, resulting in inconclusive and inadequate empirical findings on the biocompatibility of these materials. Further scientific research is needed to assess the action of fullerene molecules in mitochondrial protein synthesis.

The toxicity of fullerene materials in humans, animals, and plants

Thus far in research, fullerene materials have demonstrated limited toxicity in cell and tissue environments in humans, animals, and plants. The apparent absence of significant toxicity has resulted in mounting research on the application of fullerene materials in medical, veterinary, and agriculture and husbandry research. NOLF materials advantageously impact cell-signaling pathways and catalytic activities with seemingly no toxic reactions [23–25].

In various experimental applications of NOLFs, the fullerene materials present in organs and cells contribute to longevity and anticancer properties rather than inducing harmful reactions [26]. The Baati rat study revealed the absence of toxicity of fullerene materials [23]. In this study, the subject rats did not develop malignant tissues, which affirmed the anticancer properties of specific nanocarbon fullerenes. After administering the fullerene materials to the rodents (the fullerene material had been dissolved in olive oil), no signs of toxicity or tumor recurrence were observed, even after the fullerenes were reinforced with photodynamic energy. The rats showed improved immune responses and general long-term beneficial effects as tumors were eradicated [23,27].

Fullerene materials promote favorable biological and cellular interactions, supporting metabolic reactions over time. Unlike some nanomaterials, fullerene demonstrate no consequential toxic effects on the plant or body cells; instead, the substances complement various biological processes and metabolic reactions [19,28–32]. Research continues on the effects of fullerene materials, including vitality, immune response, antitumor properties, and longevity in humans, animals, and plants. However, research on quantum cell phenomena in the presence of fullerene materials has been limited.

Conclusion

Nanocarbon onion-like fullerene materials have shown biocompatibility with limited or absent toxicity. As fullerene fully adapts to cellular environments, most metabolic reactions in specific human, animal, and plant cells are improved or enhanced over time. The diamagnetic properties, free radical scavenging actions, and mitigation of oxidative stress associated with fullerene materials *in vivo* augment various beneficial metabolic reactions. Experiments conducted with fullerene materials have resulted in low toxicity of tissues and cells. The low toxicity property of these materials allows for their application in boosting vitality, longevity, and the immune system in humans, animals, and plants. However, the outcomes in the manufacturing process of experimental-grade nanocarbon onion-like fullerene materials can be inconsistent (even within the same batch), making it challenging to perform reliable assessments and reproducible studies of their biological benefits, biocompatibility, and potential toxicity. Also, their dosage, timing, and duration should be further evaluated and established for therapeutic use in specific conditions [11].

Conflict of Interest Statement

The authors declare that this paper was written in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

Supplementary Note

This paper, as a mini-review, is designed as a brief introduction to nanocarbon onion-like fullerenes (NOLFs), regarding their biocompatibility and toxicity in humans and living systems. Other articles have been or will be published on the application of NOLFs in the human cardiovascular system, digestive system, neurological system, orthopaedics, dentistry, veterinary medicine, agriculture, and other topics. These distinct mini-review articles could have been combined into a much lengthier review or research article. However, to have done so, the subject matter would have resulted in only one publication in one journal, to the exclusion of other medical specialties. The purpose of these papers is to disseminate the purported biocompatibility and beneficial effects of NOLFs to the broadest audience of students, researchers, and medical practitioners as possible. The authors hope that the introduction to NOLFs' application in various and diverse disciplines spawns curiosity and further research regarding NOLFs and fullerene materials. Fullerene materials seem poised to become a vital part of the future of medicine, veterinary medicine, and agriculture. However, more research is needed to determine any adverse effects of their long-term use. Also, the NOLF manufacturing process requires standardization to provide consistent quality and batch samples. Dosage and duration of treatment with fullerene materials for specific conditions need to be established by evidence-based research.

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