EC VETERINARY SCIENCE
Mini Review

The Application of Nanocarbon Onion-Like Fullerene (NOLF) Materials in Animals and Veterinary Medicine

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Abstract

Since the 1980s, carbon fullerene materials have been investigated for applications in humans and animals [1]. Fullerene materials are composed of carbon atoms and are compatible with biological systems in vertebrates. They reduce free radicals in cells, provide anti-inflammatory effects, and inhibit tumor growth. However, the primary antioxidant benefit of fullerene materials might 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 systems for varying conditions, such as cancer therapy. However, NOLFs safety, manufacture, and dosage should be further evaluated and established for their therapeutic use in humans and animals [2].

Keywords: *Biocompatibility; Free Radical; Fullerene; Nanocarbon; Quantum Cell; Veterinary Medicine*

Abbreviations

C_{60}: 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 discovery of fullerenes and development of the quantum cell theory

Quantum cell mechanisms in medicine involve complex processes in humans and animals. The application of carbon fullerene materials in animals and veterinary medicine plays an essential role in the quantum cell and medicine [3]. Fullerene is a carbon allotrope that exists in a non-graphitized and non-crystalline form [4,5], and was discovered in shungite rock in Russia. The allotrope consists of 5% to 95% of the material comprising in the shungite rock [6].

Initial research on carbon fullerenes began in 1970 when Japanese scientists proposed the chemical functions of the material; however, only a limited number of the studies were published. A team of scientists, Robert Curl, Richard Smalley, and Harold Kroto, published the carbon 60 allotrope properties at Rice University [7]. Later, the symmetry of the physical structure of carbon fullerene was determined, and named buckminsterfullerene after Buckminster Fuller's geodesic dome [8]. Recently, due to its biocompatibility, the carbon allotrope has been introduced into animal studies to investigate its effect on metabolism and physiological processes as an advancement in veterinary medicine [9].

Historically, fullerene was known to have various shapes with a slight alteration in its physical structure, while its chemical features, such as energy levels, remained unaltered. Carbon-60 is the most stable fullerene allotrope, consisting of a complex physical structure of twelve pentagonal rings that form a truncated icosahedral shape [10]. In 1980, Sumio Ijima described an onion-like carbon structure after observations using an electronic microscope. Subsequently, the structure was modified by Daniel Urgate, who, by 1992, could manipulate the substance into nanocarbon onion-like fullerene (NOLF) materials [11]. Other multilayered fullerenes have been developed through research, including onion-like carbon (OLC), multiwalled carbon nano-onions (MWCNOs) and carbon nano-onions (CNOs) [12]. Due to the many carbon atoms present in NOLFs, covalent functionalization studies suggested several synthetic pathways applicable in medical examinations. In particular, fullerenes have biological targeting ability and water-solubility properties [13–15], which indicate biocompatibility in animal tissues [16,17].

Discussion

The biocompatibility of NOLFs in animal cells and tissues

NOLF materials complement animal cells and tissues with little or no toxic effects, which has advanced the use of the carbon allotrope in veterinary medicine. NOLF materials have high biocompatibility with animal tissues or cells, wherein biological processes remain normal over long periods of use [18]. When fullerene materials are introduced into the body, they interact with functional protein structures without significant alterations in metabolism. As a result, fullerene materials enhance the functions of enzyme receptors in animals and promote organelle physiological processes.

NOLFs in the immune response and their antitumor properties

Nanocarbon fullerene materials interact with the deoxyribonucleic acid (DNA) double helix structure as intercalators, which can inhibit various infections [12,16,17]. In animals, nanocarbon fullerene materials interact with catalytic activities and cell signaling processes without interfering with metabolic reactions. As a result, these fullerene materials are used in antitumor and anticancer procedures that aim for the minimum alteration of metabolism [19–21].

Research on fullerene materials in animals has enhanced interest regarding the biological significance of the onion-like carbon allotropes. Generally, the application of fullerene materials boosts the immune system in animals and eliminates tumors, even in organisms with high cancer rates [22–26]. An animal's immune system is improved over long periods of use due to fullerene's interaction with cellular pathways through free-scavenging radical action in tissues [27–33]. However, the primary antioxidant benefit of fullerene materials might be the activation of nuclear factor (erythroid-derived 2) factor 2 (Nrf2) [2,24]. Under light energy, fullerene materials have been observed to destroy malignant cells in animals, and the likelihood of tumor recurrence is often diminished or eliminated [22,27,28].

The favorable cellular and biological interaction observed in fullerene materials led to the Baati rat study, which investigated the toxicity of the substances. Fullerene molecules were introduced in olive oil to test the longevity properties of the carbon allotrope materials [27]. Oral administration of fullerene materials dissolved in the olive oil demonstrated longevity in experimental rats [34,35]. Also, the intoxication of CCl_4 in the rats was prevented by nanocarbon fullerene materials applied over extended periods [36]. Unlike other nanomaterials, the fullerenes displayed no toxicity in the animal cells, which prompted further investigations into medical applications of the substances. Over time, studies regarding fullerene materials characterized their benefits in veterinary medicine, including anticancer effects, increasing animal lifespans, and immune enhancement [34]. However, the application of fullerenes in veterinary medicine faces limitations, such as in its potential toxicity [37–41], lack of defined guidelines for dosage, timing, and duration, and batch consistency [2].

Conclusion

Nanocarbon fullerene materials were identified from the natural form of the shungite rock element in the late 20th century, and have since been used in medical research widely. Nanocarbon fullerene materials have biocompatibility properties in that they interact with cells or tissues in animals without significant metabolic alterations. Thus, numerous scientific investigations have been conducted, including the Baati rat study, wherein the nanocarbon fullerene materials demonstrated biocompatibility and longevity in animals. Moreover, nanocarbon fullerene materials interact with protein structures in the body, including DNA, enhancing specific cell functions. Fullerene materials can treat tumors in tissues, destroying malignant cells over time and inhibiting cancers in animals. Although most studies involving nanocarbon fullerenes lack inclusive models and definitive justifications, the benefits of such materials continue to spawn advanced research on their beneficial effects in humans and animals.

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 application in veterinary medicine. Other articles have been or will be published on the application of NOLFs in the human cardiovascular system, digestive system, neurological system, orthopaedics, dentistry, agriculture, pharmacology and toxicology, 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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