The Application of Fullerene Materials in Dentistry

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Abstract

 Fullerene materials are composed of carbon atoms and are biocompatible in humans. Since fullerene’s discovery, nanocarbon fullerene materials have been researched and applied in various medical applications, including dentistry. Nanocarbon fullerene materials are used in dental diagnostics, prevention, and treatment. They are incorporated within biosensors, prosthodontics, mouthwash solutions, and toothpaste. Fullerene nanoparticles reduce oral bacteria, inhibit fungal infections, and prevent periodontal disease and dental caries.

Keywords: Biocompatibility; Dental Caries; Fullerene; Nanoparticles; Periodontal Disease

Abbreviations

C60: Carbon 60; CNO: Carbon Nano-Onion; NOLF: Nanocarbon Onion-Like Fullerene; OLC: Onion-Like Carbon; MWCNO: Multi-Walled Carbon Nano-Onion

Introduction

 Fullerene materials are used in various medical applications due to their biocompatibility. They can express different physical structures while retaining similar chemical properties. Fullerenes’ various shapes have advanced their practical applications in medicine. As a carbon allotrope, carbon 60 (C60)—also known as buckminsterfullerene [1,2]—adopts an onion-like shape with single or multiple shells in its structure. The structure has come to be known as carbon nano-onion (CNO), multi-walled carbon nano-onion (MWCNO), nanocarbon onion-like fullerene (NOLF), and onion-like carbon (OLC) [3–5].

Due to the various shapes and properties of fullerene materials, the substances are introduced into human bodies to enhance biological processes. Since fullerene’s discovery, nanocarbon fullerene materials have been researched and applied in various medical applications [6–9], including dentistry. Nanocarbon fullerene materials are used in dental diagnostics, prevention, and pharmaceuticals.

Discussion

In dental diagnostics, the use of fullerene materials centers around nano-biosensing, introduced to the medical field in 1962 by Clark and Lyons [10,11]. Biosensing, using fullerene materials, is applied in the biorecognition process, wherein dentists can diagnose patients’ conditions. Nano biosensors are used to identify dental conditions in patients, including cancerous cells [12]. These biosensors contain...
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gold nanoparticles that help detect malignant cells at low concentrations in dental tissues without adversely affecting normal biological processes [10–12]. The biosensors and carbon nanotubes detect circulating cancer cells [13,14]. These nano biosensors are implanted around the suspect tissues to diagnose dental sensitivity as the fullerene materials can be linked with antibodies. Due to the small size of the nanoparticles, fullerene materials can be introduced effectively into body cells and tissues [15]. Most nanocarbon fullerenes promote the proper placement of nano-biosensors in the body. These materials detect changes in the chemical bonds in dental cells or tissues at the molecular level, enhancing the early diagnosis of gum conditions [11,12].

Fullerene materials have been applied in the development of the nano-toothbrush, which helps maintain external dental health in humans. Nano-toothbrushes consist of nanosilver or nanogold materials placed between the bristles where bacteria can become implanted. Through the nano-toothbrush, individuals can remove mechanical plaque on teeth and reduce the prevalence of periodontal disease [16]. As a preventive measure against dental infections, fullerene materials have been integrated into toothpaste and mouthwash to promote oral hygiene. Nano-calcium fluoride included in specific mouthwash solutions inhibits dental carries and dentine permeability [17]. Nanoparticles with calcium carbonate in toothpaste promote the remineralization of teeth and microhardness of the enamel layer. Nanoparticles of fullerenes help prevent various dental conditions in humans, contributing to improved health outcomes in given populations [18]. Compared to conventional toothpaste, mouthwash solutions with nanoparticles augment microhardness and the resistance of the enamel surface against erosive forces. Nano-hydroxyapatite crystals have been used in toothpaste manufacturing to enhance dental health outcomes since they act as preventive materials against enamel wear [17,18].

Most antibacterial substances can be reinforced with these nanomaterials to promote antimicrobial efficacy in toothpaste and mouthwash solutions. The addition of nano-zirconium oxide nanoparticles in dental substances improves the toughness of the enamel and flexural strength [19]. The nanoparticle materials used in specific mouthwash solutions and toothpastes promote the transverse strength of teeth in humans. Due to the dispersion properties and biocompatibility of specific nanomaterials [20,21], they are widely incorporated in dental products to improve the hardness and toughness of the teeth [22]. Other nanoparticles, such as zirconium oxide, can potentially eliminate prosthodontics, affecting the strength of tooth enamel.

Nanoparticles in toothpastes and mouthwash solutions inhibit fungal infections in the mouth and oral cavity. By incorporating such fullerene compounds in dental materials, the physical dental properties are improved over time [23]. The addition of nanoparticle substances in dental silicones aids in controlling fungal infestations associated with gums and teeth. Nanoparticles do not adversely affect biological processes, such as water uptake and hydrophilicity. Thus, the application of fullerene materials contributes to the maintenance of dental health [24]. Nanoparticles inhibit metabolic activity in the gums and tissues where bacteria may adversely affect dental health. Various nanoparticles ensure longevity in oral health, given that the materials are efficiently integrated in toothpastes and mouthwash solutions [25]. Significant tensile strength and compressive abilities can be attained through the use of fullerene materials, wherein chemicals bind with the enamel [26].

Conclusion

Nanocarbon fullerene materials have demonstrated biocompatibility in humans and animals with low to no toxicity. The substances are widely used in medical research and treatment. In dentistry, fullerene materials are applied in diagnostics, prevention, and treatment. Through the integration of fullerenes and nanoparticles in dental products, various dental infections, such as periodontal disease and dental caries, can be inhibited or prevented. Nanoparticles in toothbrushes, toothpastes, and mouthwash solutions suppress oral bacterial and fungal growth and promote dental health.

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 dental science. Other articles have been or will be published on the application of NOLFs in the human cardiovascular system, digestive system, neurological system, orthopaedics, 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.

References


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