ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Mini Review

The Application of Fullerene Materials in Dentistry

Nicholas A Kerna[1] * and John V Flores[2,3]

[1]*SMC–Medical Research, Thailand*

[2]*Beverly Hills Wellness Surgical Institute, USA*

[3]*Orange Partners Surgicenter, USA*

***Corresponding Author:** Nicholas A Kerna, POB47 Phatphong, Suriwongse Road, Bangkok, Thailand 10500.

Contact: medpublab+drkerna@gmail.com

Received: August 07, 2020; **Published:** September 15, 2020

DOI: 10.31080/ecde.2020.19.01520

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 fugal infections, and prevent periodontal disease and dental caries.

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

Abbreviations

C_{60}: 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 (C_{60})—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

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

1. Hawryluk M. "Discovery of Buckyballs a Nobel effort by professors. Rice duo and British colleague opened the door to field of nanotechnology". *Chron* (2016). https://www.chron.com/local/history/medical-science/article/Discovery-of-Buckyballs-a-Nobel-effort-by-7939221.php

2. Kroto. "C60: Buckminsterfullerene". Gary Taubes, "The Disputed Birth of Buckyballs". *Science* 253 (1991): 1477. http://www.kroto.info/wp-content/uploads/2015/05/AT-2-Taubes-Disputed-Birth-of-Buckyballs_News-and-Comment_1991-Science.pdf

3. Bartelmess J and Giordani S. "Carbon nano-onions (multi-layered fullerenes): Chemistry and applications". *Beilstein Journal of Nanotechnology* 5.2 (2014): 18. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4222380/

4. Bhinge SD. "Carbon nano-onions-An Overview". *Journal of Pharmaceutical Chemistry and Chemical Science* 1.1 (2017): 2. https://www.alliedacademies.org/articles/carbon-nanoonions-an-overview-8569.html

5. Xu BS. "Prospects and research progress in nano onion-like fullerenes". *New Carbon Materials* 23.4 (2008): 12. https://www.sciencedirect.com/science/article/abs/pii/S1872580509600019

6. Salata OV. "Applications of nanoparticles in biology and medicine". *Journal of Nanobiotechnology* (2004): 2. https://jnanobiotechnology.biomedcentral.com/articles/10.1186/1477-3155-2-3

7. Bartelmess J and Giordani S. "Carbon nano-onions (multi-layered fullerenes): Chemistry and applications". *Beilstein Journal of Nanotechnology* 5.2 (2014): 18. https://www.researchgate.net/publication/268154868_ChemInform_Abstract_Carbon_Nano-Onions_Multi-Layer_Fullerenes_Chemistry_and_Applications

8. Giordani S., *et al.* "Carbon nano-onions: a valuable class of carbon nanomaterials in biomedicine". *Current Medicinal Chemistry* 26.38 (2019): 6915-6929. https://www.eurekaselect.com/167732/article

9. Mykhailiv O., *et al.* "Carbon nano-onions: Unique carbon nanostructures with fascinating properties and their potential applications". *Inorganica Chimica Acta* 468 (2017): 49-66. https://www.sciencedirect.com/science/article/abs/pii/S0020169317302426

10. Bahadır EB and Sezgintürk MK. "Applications of commercial biosensors in clinical, food, environmental, and biothreat/biowarfare analyses". *Analytical Biochemistry* 478 (2015): 107-120. https://www.sciencedirect.com/science/article/abs/pii/S0003269715001086

11. Lee TM. "Over-the-Counter Biosensors: Past, Present, and Future". *Sensors* 8.9 (2008): 5535-5559. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3705519/

12. Das A and Nasim I. "Nanotechnology in Dentistry-A Review". *Journal of Advanced Pharmacy Education and Research* 7.2 (2017): 43-45. https://www.speronline.com/japer/Articlefile/JAPER_37_2017.pdf

13. Amelinckx S., *et al.* "A formation mechanism for catalytically grown helix-shaped graphite nanotubes". *Science* 265 (1994): 635-639. https://science.sciencemag.org/content/265/5172/635

14. Iijima S. "Helical microtubules of graphitic carbon". *Nature* 354 (1991): 56-58. https://www.nature.com/articles/354056a0

15. Giordani S. "Biocompatibility and biodistribution of functionalized carbon nano-onions (f-CNOs) in a vertebrate model". *Scientific Reports* 6.1 (2016): 1-9. https://www.researchgate.net/publication/308698814_Biocompatibility_and_biodistribution_of_functionalized_carbon_nano-onions_f-CNOs_in_a_vertebrate_model

16. AlKahtani RN. "The implications and applications of nanotechnology in dentistry: A review". *The Saudi Dental Journal* 30.2 (2018): 107-116. https://www.sciencedirect.com/science/article/pii/S1013905218300038

17. Zafar MS., *et al.* "Therapeutic applications of nanotechnology in dentistry". *In Nanostructures for Oral Medicine* (2017): 833-862. https://www.sciencedirect.com/science/article/pii/B9780323477208000274

18. Chaughule RS. "Dental applications of nanotechnology". *Springer* (2018). https://www.springer.com/gp/book/9783319976334

19. Verma S., *et al.* "Nanotechnology in dentistry: Unleashing the hidden gems". *Journal of Indian Society of Periodontology* 22.3 (2018): 196. https://www.researchgate.net/publication/325648857_Nanotechnology_in_dentistry_Unleashing_the_hidden_gems

20. Bourassa DJ and Kerna NA. "Pristine Nanocarbon-based Fullerene-like Material Toxicity and Biocompatibility (Part 2 in the series: Will Nanocarbon Onion-Like Fullerenes Play a Decisive Role in the Future of Molecular Medicine?)". *Determinations in Nanomedicine and Nanotechnology* 1.1 (2019). https://www.researchgate.net/publication/333185454_Pristine_Nanocarbon-based_Fullerene-like_Material_Toxicity_and_Biocompatibility_Part_2_in_the_series_Will_Nanocarbon_Onion-Like_Fullerenes_Play_a_Decisive_Role_in_the_Future_of_Molecular_Medicine

21. D'Amora M., *et al.* "Biocompatibility and biodistribution of functionalized carbon nano onions (f-CNOs) in a vertebrate model". *Scientific Reports* 6.1 (2016): 1-9. https://www.nature.com/articles/srep33923

22. Chole D., *et al.* "Nanotechnology: conservative dentistry and endodontics". *IOSR Journal of Dental and Medical Sciences* 16 (2017): 102-107. https://www.researchgate.net/publication/316044600_Nanotechnology_Conservative_Dentistry_and_Endodontics

23. Shahana RY and Ganapathy D. "Applications of nanotechnology in dentistry". *Drug Invention Today* 14.5 (2020).

24. Akbarianrad N., *et al.* "Applications of nanotechnology in endodontic: A Review". *Nanomedicine Journal* 5.3 (2018): 121-126. https://en.civilica.com/Paper-JR_NAMJ-JR_NAMJ-5-3_001=Applications-of-nanotechnology-in-endodontic-A-Review.html

25. Panchbhai A. "Nanotechnology in dentistry". In Applications of Nanocomposite Materials in Dentistry (2019): 191-203. https://doi.org/10.1016/B978-0-12-813742-0.00012-2

26. Subramani K and Ahmed W. "Nanotechnology and its applications in dentistry-An introduction. In Emerging Nanotechnologies in Dentistry William Andrew Publishing (2018): 1-15. https://doi.org/10.1016/B978-0-12-812291-4.00001-7

Volume 19 Issue 10 October 2020