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Editorial

Graphene: The Future in Prosthodontics and Oral Implantology

Arpit Sikri[1]* and Jyotsana Sikri[2]

[1]Associate Professor and Post Graduate Teacher, Department of Prosthodontics, Crown and Bridge and Oral Implantology, Bhojia Dental College and Hospital, Budh (Baddi), Teh. Baddi, Distt. Solan, Himachal Pradesh, India
[2]Associate Professor and Post Graduate Teacher, Department of Conservative Dentistry and Endodontics, Bhojia Dental College and Hospital, Budh (Baddi), Teh. Baddi, Distt. Solan, Himachal Pradesh, India

***Corresponding Author:** Arpit Sikri, Associate Professor and Post Graduate Teacher, Department of Prosthodontics, Crown and Bridge and Oral Implantology, Bhojia Dental College and Hospital, Budh (Baddi), Teh. Baddi, Distt. Solan, Himachal Pradesh, India.

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When prosthodontic materials are used in the mouth, they encounter saliva, gingival crevicular fluid, and water. They must withstand high temperature fluctuations, chewing forces, and abrasion, which can lead to mechanical failures and require costly replacements. Moreover, since these materials closely interact with oral tissues, it is crucial that they are non-toxic and biocompatible to ensure they function effectively without causing harm to the surrounding tissue.

Graphene was first discovered in 2004 by Andre Geim and Konstantin Novoselov at the University of Manchester, an achievement that earned them the Nobel Prize in 2010. Novoselov utilized Scotch tape to peel layers of graphene from a flake of graphite, repeating the process until only a few layers remained. According to the International Union for Pure and Applied Chemistry (IUPAC), "graphite" refers to the three-dimensional material, while "graphene" specifically denotes the properties of the single-layered sheet. Graphene consists of a single layer of atoms arranged in a honeycomb-like lattice structure.

Graphene consists of a single layer of carbon atoms arranged in a hexagonal lattice, each atom bonded to three others through sp^2 hybridization. Weak van der Waals forces govern the stacking of these layers, contributing to the material's flexibility.

Graphene exhibits remarkable properties: it is exceptionally strong, with a tensile strength of 42 N/m, despite being relatively brittle. It can stretch up to 25%, making it suitable for flexible electronics. Graphene is impermeable even to helium atoms, and its electrical resistivity at room temperature (1×10^-8 Ω•m) is significantly lower than copper's.

Additional noteworthy attributes include complete impermeability, high density, a large surface area (approximately 2600 m^2/g), exceptional thermal conductivity (5000 W/m•K), chemical stability, high intrinsic mobility (100 times greater than silicon), biocompatibility, and antibacterial properties.

Graphene-related materials can be categorized based on either their layer count (mono- or multi-layered) or chemical modifications, including graphene oxide (GO), reduced GO (rGO), and nitrogen-doped graphene (N-G). GO is derived from graphite oxidation, resulting in a highly oxidized form of graphene. rGO is produced by further reducing GO, eliminating oxygen-containing groups to restore a conjugated structure.

Different forms of graphene include nanoplates, nanoflakes, powder, thin sheets, and foam. Graphene offers numerous advantages: it is the thinnest and strongest material known, an excellent conductor of heat and electricity, flexible and transparent. It finds applications in high-speed electronics, stem cell differentiation enhancement, and biocompatible prosthetics manufacturing. Its high elastic modulus prevents permanent deformation from biting forces, and it resists cracking, fractures, abrasion, and chemical dissolution in oral fluids better than traditional acrylic resins.

However, graphene faces challenges: it is susceptible to oxidation in certain environments, potentially hazardous due to its sharp edges that can penetrate cell membranes, and expensive to produce.

Graphene-based biosensors are utilized for detecting biomolecules like dopamine, glucose, proteins, and DNA, leveraging pi-pi stack interactions. Graphene oxide (GO) and its derivatives are employed in drug delivery for transporting DNA, proteins, and antibodies. In cancer therapy, graphene shows promise against drug-resistant cancer stem cells (CSC) and tumor-stimulating cells, which can otherwise resist conventional treatments.

In dentistry, graphene's tensile strength comparable to bone, enamel, and dentin makes it suitable for dental restorations and implants. Its biocompatibility and unique properties enable effective bacterial detection, with potential applications in identifying specific organisms.

Graphene-derived nanomaterials have been integrated into glass ionomers to enhance their mechanical properties in restorative dentistry. When combined with poly(acrylic acid), graphene significantly improves the physio-mechanical performance of these materials.

In prosthodontics, graphene's single-atom thickness and honeycomb lattice structure, with sp^2 hybridization of carbon atoms, offer biocompatibility, biodegradability, high strength (Young's modulus of ~1.0 TPa), antimicrobial properties, flexibility, and transparency. Graphene sheets, GO, and reduced GO (rGO) hold potential for various prosthodontic applications.

Furthermore, graphene's osteogenic and antibacterial properties suggest it as a promising coating material for dental implants, promoting better osseointegration.

Conclusion

Graphene's unique 2D structure and exceptional properties hold great promise for advancing prosthodontics and implant dentistry. Despite being the strongest material known, its inherent brittleness limits its structural use, but it can effectively reinforce other materials. Graphene's applications in the medical field are diverse and include potential uses in prosthodontics and implant dentistry. Continued research is essential to fully explore and harness graphene's capabilities in these areas [1-9].

Bibliography

1. Lee JH., *et al*. "Reduced graphene oxide-coated hydroxyapatite composites stimulate spontaneous osteogenic differentiation of human mesenchymal stem cells". *Nanoscale* 7.27 (2015): 11642-11651.

2. Liu X., *et al*. "Two-dimensional black phosphorus and graphene oxide nanosheets synergistically enhance cell proliferation and osteogenesis on 3D printed scaffolds". *ACS Applied Materials and Interfaces* 11.26 (2019): 23558-23572.

3. Liao C., *et al*. "Graphene nanomaterials: synthesis, biocompatibility, and cytotoxicity". *International Journal of Molecular Sciences* 19.11 (2018): 3564.

4. Fallahzadeh F., *et al*. "Dentin bonding agent with improved bond strength to dentin through incorporation of sepiolite nanoparticles". *Journal of Clinical and Experimental Dentistry* 9.6 (2017): e738-e742.

5. Gu M., *et al*. "Is graphene a promising nano-material for promoting surface modification of implants or scaffold materials in bone tissue engineering?" *Tissue Engineering Part B: Reviews* 20.5 (2014): 477-491.

6. Moldovan M., *et al*. "Chemical and structural assessment of new dental composites with graphene exposed to staining agents". *Journal of Functional Biomaterials* 14.3 (2023): 163.

7. Bregnocchi A., *et al*. "Graphene-based dental adhesive with anti-biofilm activity". *Journal of Nanobiotechnology* 15.1 (2017): 89.

8. Bei H., *et al*. "Graphene-based nanocomposites for neural tissue engineering". *Molecules* 24.4 (2019): 658.

9. Farooq I., *et al*. "Synergistic effect of bioactive inorganic fillers in enhancing properties of dentin adhesives-A review". *Polymers* 13.13 (2021): 2169.

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