

Quaternary ammonium polyethyleneimine nanoparticles: A promising antibacterial filler for dental composites

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Abstract

Statement of the Problem:

An important issue concerning resin-based dental fillings is the occurrence of secondary caries, necessitating repetitive treatments. The quaternary ammonium polyethyleneimine nanoparticles (QNPs) have emerged as a promising antibacterial solution against various cariogenic strains. However, there is limited understanding regarding the characteristics of dental dimethacrylate polymer-based composites enriched with it. This study focused on experimental composites composed of a dimethacrylate matrix, reinforced with up to 3 (wt.%) QNPs and glass fillers. The cured composites underwent testing for *Streptococcus Mutans* bacteria adherence, cytotoxicity (MTT assay), degree of conversion (DC), water sorption (WSO), solubility (WSL), water contact angle (CA), flexural modulus (E) and strength (FS), compressive strength (CS), and Vickers microhardness (HV). The evaluated materials exhibited complete reduction in bacteria adherence and satisfactory biocompatibility. Addition of QNPs did not affect DC, VH, and E values, while it increased CA, WSO, and WSL, and decreased flexural and compressive strength. Unfavorable alterations were deemed insignificant and acceptable for most composites, also for material with the highest antibacterial filler content and were at clinically acceptable level.

Conclusion & Significance: The results showed that the compounding of QNPs allows to obtain antimicrobial effectiveness and satisfactory biocompatibility. The changes of mechanical and physicochemical properties were acceptable for most experimental composites. In the future, the developed materials may contribute to reducing the risk of secondary caries. The development of this type of materials is an opportunity to reduce the frequency of replacing dental fillings, which will contribute to prolonging the functioning of patients' own teeth and delaying the need to implement more advanced prosthetic treatment methods introduced after tooth extraction.

Image

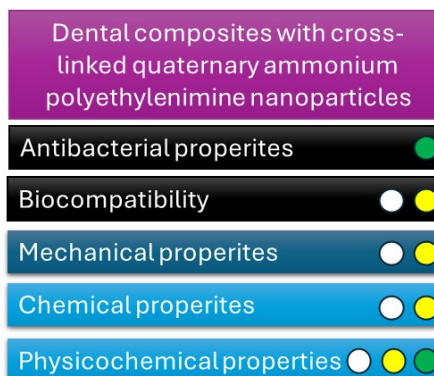


Figure 1. Graphical representation of property changes after the introduction of quaternary ammonium polyethyleneimine nanoparticles to dental composites: white dots represent no influence, yellow indicates acceptable changes, and green indicates positive changes.

Recent Publications

1. Chladek G et al. (2023) The effect of quaternary ammonium polyethyleneimine nanoparticles on bacterial adherence, cytotoxicity, and physical and mechanical properties of experimental dental composites. *Scientific Reports* 15;13(1):17497.
2. Stencel, R. et al. (2018) Properties of Experimental Dental Composites Containing Antibacterial Silver-Releasing Filler. *Materials* 11:1031/
3. Chrószcz, M. & Barszczewska-Rybarek, I. (2020) Nanoparticles of Quaternary Ammonium Polyethyleneimine Derivatives for Application in Dental Materials. *Polymers* 12: 2551.
4. Yudovin-Farber, I. et al. (2010) Antibacterial effect of composite resins containing quaternary ammonium polyethyleneimine nanoparticles. *J Nanopart Res* 12: 591–603
5. Barszczewska-Rybarek, I. M. A Guide through the Dental Dimethacrylate Polymer Network Structural Characterization and Interpretation of Physico-Mechanical Properties. *Materials* 12, 4057 (2019).

Photograph



Biography

Faculty of Engineering of Materials of the Silesian University of Technology in Gliwice in 2002. He completed his PhD thesis in the field of materials science in 2008. Since 2002, he works at Silesian University of Technology in Gliwice, first at the Faculty of Engineering of Materials (until 2012), then permanently at the Faculty of Mechanical Engineering. His scientific interests include materials engineering, within the specialization: biomaterials and dental materials. Since 2011 a member of the board of the Polish Society of Medical Engineering. His scientific output includes more than 180 scientific publications, in international journals and in scientific conference proceedings of worldwide range.

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