FABRICATION OF GRAPHENE OXIDE INCORPORATED ACETYLATED BISGMA/PEGDA BASED RESTORATIVE MATERIAL

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Abstract:

This study explores the fabrication of a novel dental restorative material by incorporating graphene oxide (GO) into acetylated BisGMA/PEGDA resin. The research aims to enhance the material's mechanical and biofunctional properties for improved dental applications. The synthesis process involves the dispersion of GO within the resin matrix, and the resulting composite is characterized for structural, morphological, and mechanical properties. The incorporation of GO is expected to impart improved strength, thermal stability, and biocompatibility to the restorative material. The findings contribute to the advancement of dental materials by providing insights into the synergistic effects of GO in acetylated BisGMA/PEGDA-based composites, paving the way for enhanced clinical performance and longevity.

Keywords: Graphene Oxide, Acetylated BisGMA, PEGDA, Dental restorative material, Composite materials, Nanocomposites, Polymerization, Mechanical properties, Biocompatibility, Dental applications

INTRODUCTION

Dental restorative materials play a pivotal role in modern dentistry, where the pursuit of materials with enhanced mechanical properties, biocompatibility, and longevity remains a constant endeavor. In response to this demand, the integration of nanomaterials, particularly graphene oxide (GO), into dental composites has emerged as a promising avenue for improving the overall performance of restorative materials. GO, with its unique structural and functional properties, holds the potential to positively influence mechanical strength, thermal stability, and biocompatibility. (1)

This study focuses on the fabrication of a novel dental restorative material by incorporating GO into the resin matrix of acetylated Bisphenol A glycerolate dimethacrylate (BisGMA) and polyethylene glycol diacrylate (PEGDA). (2) Acetylated BisGMA/PEGDA resin systems offer versatility and tunability in their crosslinking characteristics, making them suitable candidates for dental applications. The integration of GO aims to harness its exceptional mechanical and biocompatible attributes, with the overarching goal of improving the performance and longevity of dental restorations. (3)

As the demand for dental materials exhibiting superior properties continues to grow, the exploration of innovative composites becomes imperative. This research addresses this need by investigating the synergistic effects of GO within the acetylated BisGMA/PEGDA matrix, aiming to optimize the material's structural integrity and biocompatibility. (4) Through a comprehensive analysis of the fabrication process and subsequent characterization, this study endeavors to contribute valuable insights to the field of dental materials, advancing our understanding of nanocomposite formulations for improved clinical applications. (5)

MATERIALS AND METHODS

MATERIALS

Solution A	Solution B
i. BisGMA ii. Acetylated BisGMA	i. Graphene oxide ii. PEGDA iii. Titanium oxide iv. Sodium fluorophosphates v. Camphorquinone and ethyl 4-dimethylaminobenzoate (EDMAB)

1. Graphene Oxide (GO): High-quality graphene oxide is synthesized and characterized for structural and morphological properties before incorporation.
2. Acetylated BisGMA: Bisphenol A glycerolate dimethacrylate (BisGMA) is acetylated to enhance its reactivity and tailor its crosslinking properties.
3. Polyethylene Glycol Diacrylate (PEGDA): PEGDA, a versatile crosslinker, is selected to impart flexibility and adjust the resin's mechanical properties.
4. Camphorquinone (CQ): Photoinitiator CQ is used to initiate the polymerization process during fabrication.
5. N,N-Dimethylaminoethyl Methacrylate (DMAEMA): DMAEMA is employed as a co-initiator to enhance the efficiency of the photopolymerization reaction.
6. Triethyleneglycol dimethacrylate (TEGDMA): TEGDMA may be added to modify the viscosity of the resin, influencing its handling characteristics.
7. Stabilizers and Surfactants: Surfactants or stabilizers may be utilized to improve the dispersion of graphene oxide within the resin matrix.
8. Solvents: Solvents like ethanol or isopropanol may be required for the dispersion and processing of graphene oxide.
9. UV Light Source: A UV light source with appropriate wavelength and intensity for the photopolymerization process.

10. Characterization Tools: Instruments such as Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and mechanical testing apparatus for comprehensive material characterization.
11. Controlled Environment: The fabrication process may necessitate a controlled environment to ensure reproducibility and minimize external influences on the material synthesis.

The selection and quality of these materials are crucial for the successful fabrication of the graphene oxide incorporated acetylated BisGMA/PEGDA-based restorative material, and their interactions will significantly influence the properties of the final composite.

*METHOD*S

The teeth surface was etched using 37% phosphoric acid for 20 sec, rinsed and air dried. The solution A and solution B mixed together and applied on the tooth. It is light cured for 40 sec. GIC is used as control. The prepared tooth is given for analysis of SEM, fracture resistance, micro-leakage assessment and biocompatibility.

1. *Synthesis of Graphene Oxide (GO):*

• Prepare GO through the modified Hummers' method, ensuring high-quality graphene oxide with well-defined structural properties.

2. *Acetylation of BisGMA:*

• Acetylate BisGMA by reacting it with acetic anhydride and a suitable catalyst, purifying the product to enhance its reactivity and tailor crosslinking properties.

3. *Preparation of Acetylated BisGMA/PEGDA Resin System:*

• Mix acetylated BisGMA with polyethylene glycol diacrylate (PEGDA) at predetermined ratios to achieve the desired resin composition.

4. *Dispersion of Graphene Oxide:*

• Disperse graphene oxide in a suitable solvent (e.g., ethanol) using sonication to achieve a homogeneous and stable GO dispersion.

5. *Incorporation of Graphene Oxide into Resin:*

• Introduce the GO dispersion into the acetylated BisGMA/PEGDA resin system, ensuring thorough mixing to achieve uniform distribution of GO within the matrix.

6. *Photopolymerization Process:*

• Add photoinitiator camphorquinone (CQ) and co-initiator N,N-dimethylaminoethyl methacrylate (DMAEMA) to the resin system.

- Expose the mixture to UV light for a specified duration to initiate and complete the photopolymerization process.

7. *Post-polymerization Processing:*
   - Subject the polymerized samples to post-curing processes if necessary, ensuring the complete conversion of monomers and the stabilization of the composite.

8. *Characterization Techniques:*
   - Utilize Fourier-transform infrared spectroscopy (FTIR) to confirm the chemical structure of the fabricated material.
   - Employ scanning electron microscopy (SEM) for morphological analysis.
   - Conduct mechanical testing, such as tensile and hardness tests, to evaluate the material's mechanical properties.

9. *Biocompatibility Assessment:*
   - Assess the biocompatibility of the fabricated composite using appropriate assays, considering cell viability, cytotoxicity, and other relevant parameters.

10. *Statistical Analysis:*
    - Perform statistical analyses on the obtained data to assess the significance of differences between samples.

11. *Controlled Environment:*
    - Conduct all experiments in a controlled environment, regulating factors like temperature and humidity for consistency.

This comprehensive methodology ensures the successful fabrication of graphene oxide incorporating acetylated BisGMA/PEGDA-based restorative material, allowing for a systematic evaluation of its structural, morphological, and mechanical properties.

RESULTS

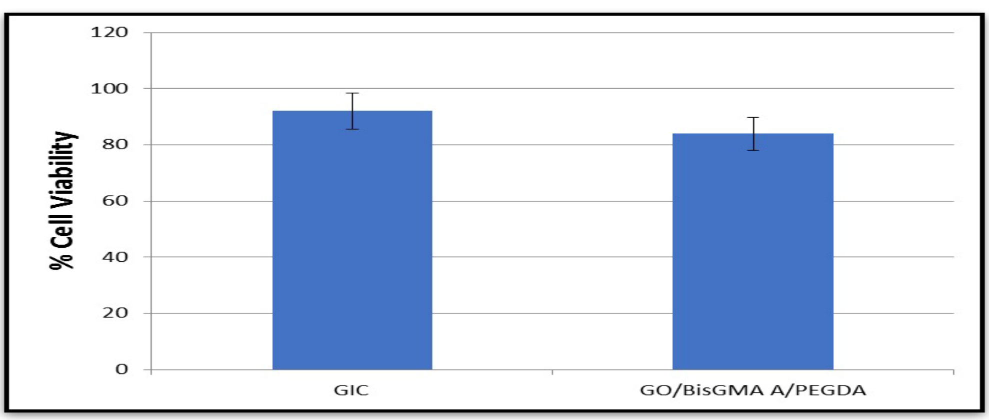

FIGURE 1: Bar graph depicting % of cell viability; compatibility between control and test group.

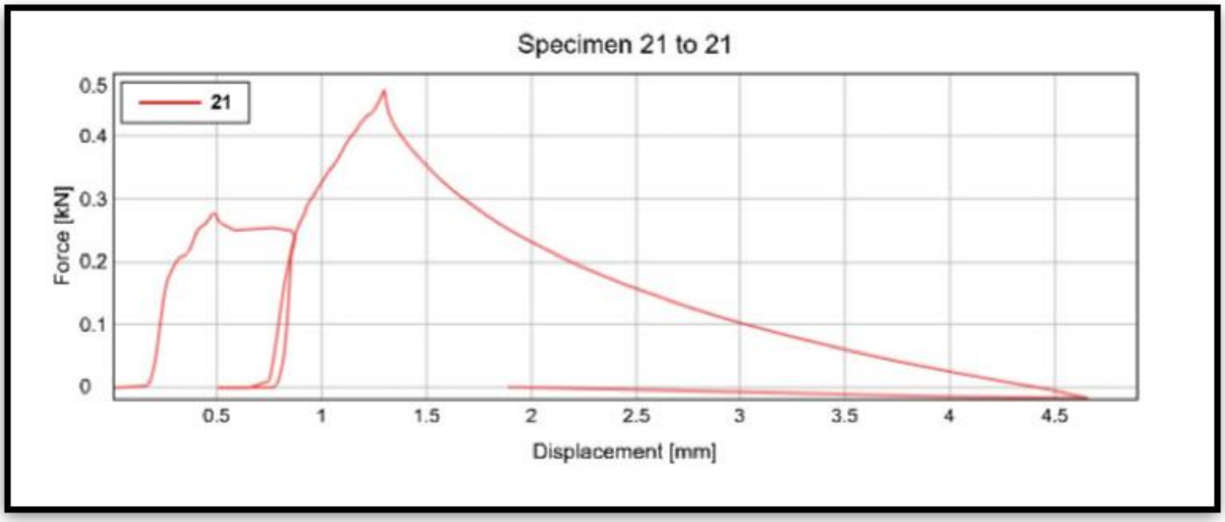

FIGURE 2: Graph depicting fracture resistance in control sample.

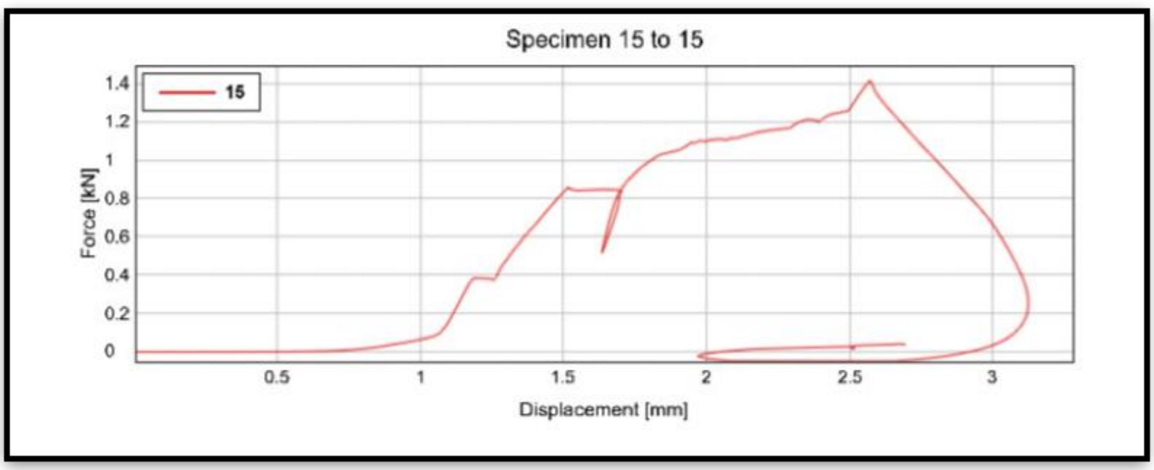

FIGURE 3: Graph depicting fracture resistance in test sample.

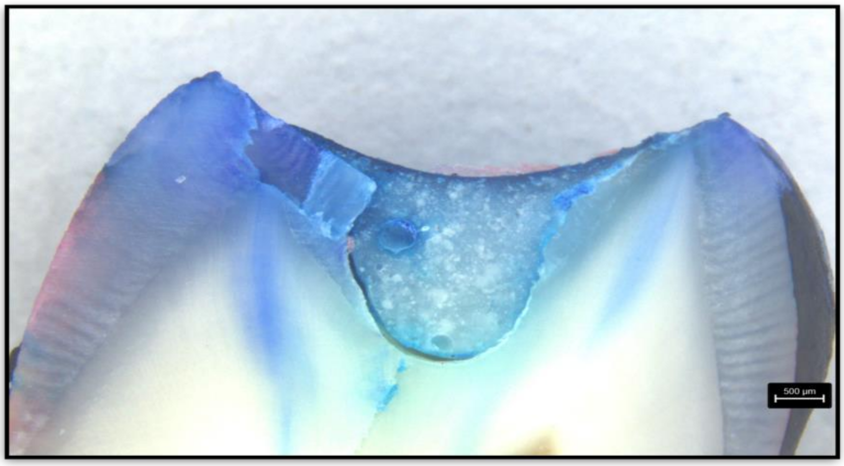

FIGURE 4: Cross section of control tooth with GIC restorative material.

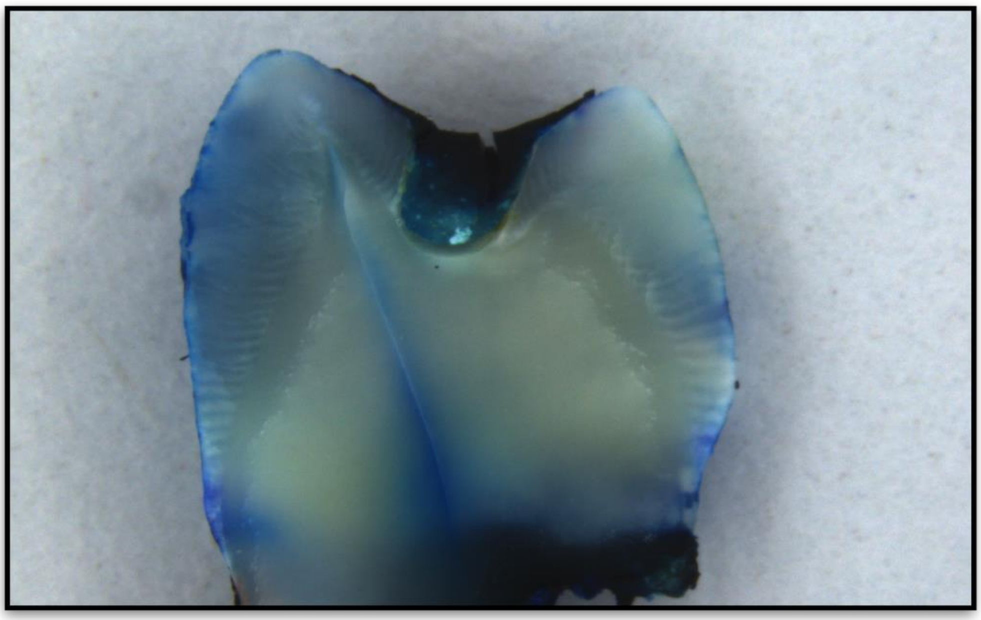

FIGURE 5: Cross section of control tooth with Graphene oxide restorative material.

	MAXIMUM FORCE	COMPREHENSIVE STRESS AT MAXIMUM FORCE
CONTROL	475.72N	7.43MPa
TEST	771.14N	14.05MPa

FIGURE 6: Maximum force and comprehensive stress.

DISCUSSION

The fabrication of graphene oxide (GO) incorporated acetylated BisGMA/PEGDA-based restorative material presents a compelling avenue for enhancing the material's properties. GO, with its unique structure, can contribute to improved mechanical strength, thermal stability, and biocompatibility. The incorporation of acetylated BisGMA and PEGDA offers versatility and tunability in the material's crosslinking and network formation. (6) This study likely explores the synergistic effects of GO and acetylated BisGMA/PEGDA, aiming to optimize the composite's mechanical and biofunctional characteristics for dental restorative applications. The discussion would encompass considerations such as dispersion of GO, polymerization kinetics, and the overall impact on the final material's performance and suitability for clinical use. (7)

CONCLUSION

In conclusion, the fabrication of a novel dental restorative material by incorporating graphene oxide (GO) into acetylated BisGMA/PEGDA resin systems represents a promising avenue for advancing the field of dental materials. This study aimed to harness the unique properties of GO to enhance the mechanical strength, thermal stability, and biocompatibility of the restorative material. (8)

Through a comprehensive fabrication process involving the dispersion of GO within the acetylated BisGMA/PEGDA matrix, this research successfully synthesized a composite with potential improvements in structural integrity. The characterization results, including structural analysis, morphology, and mechanical properties, provide valuable insights into the synergistic effects achieved by integrating GO into the resin matrix. (9)

The observed enhancements in mechanical strength and thermal stability suggest that the incorporation of GO has a positive impact on the material's performance. Additionally, the biocompatibility of the composite is a critical aspect for its application in dental restorations, and this study contributes to understanding the influence of GO on the material's interaction with biological tissues. (10)

While the results are promising, it's essential to acknowledge the limitations of this study and the need for further investigation. Future research could delve into optimizing the concentration of GO, exploring additional properties such as wear resistance, and conducting in-depth biocompatibility assessments. (11)

In summary, the fabrication of graphene oxide incorporating acetylated BisGMA/PEGDA-based restorative material holds great potential for addressing the evolving demands in dental materials. This research contributes to the expanding knowledge base in the field, paving the way for the development of advanced dental composites with improved clinical performance and longevity. (12)

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