

A Novel Natural Fiber Filler Reinforced Bio-Medical Polymer Composite

Dear Editor

Bio-medical implants and prostheses are made of metals and their alloys and are prone to corrosion and wear. Therefore, it seems necessary to develop lightweight reinforced polymer composites with enhanced properties. Polyetheretherketone (PEEK) is known as a preferred medical and dental polymer composite biomaterial with enhanced properties. It is an aromatic and thermoplastic polymer with a high melting point.¹ PEEK is prone to deformation under high stress and temperature, which could result in material instability and severe wear. To avoid such failures, PEEK composites are strengthened with more thermally stable fiber fillers.

A composite is a combination of matrix and filler particles that enhances the characterization of a biomaterial. With due consideration of environmental safety, there is growing interest in natural filler materials. A green platform can be built through the synthesis of natural fiber filler-reinforced biopolymer composites. They have the advantage of being more biodegradable, biocompatible, and cost-effective because they can be extracted from predominantly available natural renewable sources. However, it is challenging to characterize them due to variations in shape, morphology, and size. A scanning electron microscope (SEM) analytical investigation is required to determine their properties.²

The microstructure of prepared samples was examined using SEM to determine the optimal volume fraction of fiber and matrix in the composites. The SEM images were obtained by analyzing the secondary and backscattered electron signals. Thus, SEM could be one of the most adaptable research tools for studying and analyzing biopolymer surface characterizations.³ It primarily determines the distribution and dispersion of the fillers in the polymer matrix. Besides, it indicates the presence of any additives as well as filler agglomeration within the polymer matrix.⁴ The performance and applicability of these materials are determined by their physical, morphological, and structural properties. With the advent of new biopolymer systems, it is necessary to obtain insights into the fundamental structures of these systems. Although there are numerous studies on PEEK with synthetic fibers, no studies have been found investigating the efficacy of PEEK with natural fillers such as basalt fiber. However, a thorough exploration of this area is of paramount importance.²

The present study focused on developing and analyzing PEEK composites reinforced with three different weight percentages of natural basalt fiber fillers using hot compression molding processes. The PEEK/basalt fiber composites were fabricated by the compression molding process because this technique achieved greater homogeneity in casting specimens than other molding processes.⁵ The prepared specimens were named PBC 1 (10% basalt+90% PEEK), PBC 2 (20% basalt+80% PEEK), and PBC 3 (30% basalt+70% PEEK). The study was approved by the Ethics Committee of Madha Dental College, Annamalai University, India (IEC/2020/MDC/135).

Among the three different proportions of basalt filler reinforced PEEK samples, PEEK with 20 weight percentages of basalt filler samples indicated a better outcome in SEM analysis.

Figure 1 indicates the clear orientation and distribution of fibers across the composites, indicating improved bonding between the PEEK matrix and the basalt fiber. Since the weight percentage of basalt was sufficient, the transformed load was equal and consistent throughout the composites. The PEEK melts were also found to adhere strongly to each fiber, which was a novel observation. This type of micro-image was not found in the samples of PBC 1 and PBC 3 composites, which indicated that PBC 2 was a superior microstructural polymer composite.

SEM images revealed the dispersion and exfoliation of fiber and matrix, as well as a perfect bonding between the PEEK and basalt. The PBC composites demonstrated proper scattering of basalt and depicted excellent microstructure with even fiber distribution in the case of the PBC 2 composite having 20% basalt fiber.

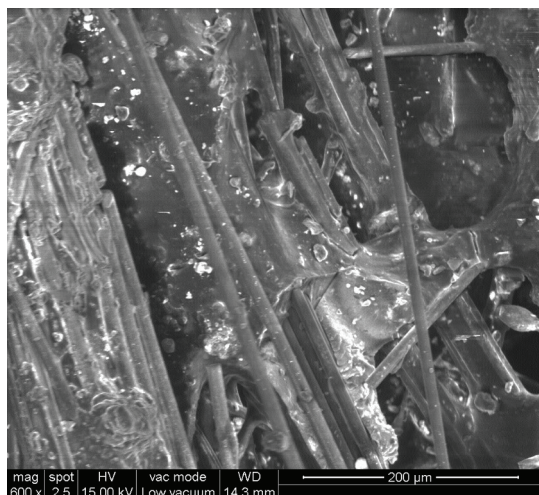


Figure 1: SEM image depicts the PEEK with 20 weight percentages of basalt filler. mag: Magnification of the sample is set in the order of 600 times; spot: The focus length of the beam of the spot is 2.5 mm; HV: High voltage SEMs (HVSEM) with large specimens are set as 15kV; Vac mode: Vacuum mode, which is set as Low Vacuum for our samples that are nonconductive or poorly conductive; Wd: Working distance is the distance between the specimen and the lower pole piece; The Working distance (wd) is fixed at 14.3 mm.

The rapid depletion of fuel supplies and the rise in public awareness of global warming and environmental concerns resulted in the emergence of these biomaterials as a potential alternative to conventional polymers.⁶ With continuing research and development in the field of new polymer materials with natural fiber filler components, there will be significant advancements in novel formulations with superior properties in the future.

Acknowledgment

The authors gratefully acknowledge the assistance offered by Dynamic Molding, Guindy Industrial Estate, Guindy, Chennai, Tamil Nadu, India, for providing facilities to conduct the experiments and also thank the Central Institute of Plastic Engineering Technology Guindy, Chennai, Tamil Nadu, India, for providing the testing facilities.

Authors' Contribution

Q.A.A and K.K.N have equally contributed to every aspect of conducting this research, pilot study, sample fabrication, testing, data entry, statistical analysis, and writing and reviewing the manuscript. Both authors have read and approved the final manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest: None declared.

Keywords • Biocompatible materials • Prostheses and implants • Polyetheretherketone

Queen Alice Arul¹, MDS, FICOI; Kurunji Kumaran Navaneetha Krishnan², MDS, PhD, M.Orth RCPSG

¹Department of Dentistry, AIIMS- All India Institute of Medical Sciences NH-34 Connector, Nadia, Saguna, Kalyani, Kolkata, West Bengal, India;

²Department of Orthodontics, Cuddalore Government Dental College and Hospital (Formerly Raja Muthiah Dental College and Hospital), Annamalai University, Chidambaram, Tamil Nadu, India

Correspondence:

Queen Alice Arul, MDS, FICOI;

4th Floor, OPD Building, AIIMS- All India Institute of Medical Sciences, Department of Dentistry, NH-34 Connector, Nadia, Saguna, Kalyani, Kolkata, Postal code: 741245, West Bengal, India

Email: alice.dental@aiimskalyani.edu.in, drqueenalice@gmail.com

Received: 15 July 2023

Revised: 27 October 2023

Accepted: 19 November 2023

Please cite this article as: Arul QA, Navaneetha Krishnan KK. A Novel Natural Fiber Filler Reinforced Bio-Medical Polymer Composite. *Iran J Med Sci*. doi: 10.30476/ijms.2024.99429.3148.

References

- 1 Najeeb S, Zafar MS, Khurshid Z, Siddiqui F. Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. *J Prosthodont Res*. 2016;60:12-9. doi: 10.1016/j.jpor.2015.10.001. PubMed PMID: 26520679.
- 2 Ma H, Suonan A, Zhou J, Yuan Q, Liu L, Zhao X, et al. PEEK (Polyether-ether-ketone) and its composite materials in orthopedic implantation. *Arabian Journal of Chemistry*. 2021;14:102977. doi: 10.1016/j.arabjc.2020.102977.
- 3 Fazeli M, Florez JP, Simão RA. Improvement in adhesion of cellulose fibers to the thermoplastic starch matrix by plasma treatment modification. *Composites Part B: Engineering*. 2019;163:207-16. doi: 10.1016/j.compositesb.2018.11.048.
- 4 Mafirad S, Mehrnia MR, Zahedi P, Hosseini SN. Chitosan-based nanocomposite membranes with improved properties: Effect of cellulose acetate blending and TiO₂ nanoparticles incorporation. *Polymer Composites*. 2018;39:4452-66. doi: 10.1002/pc.24539.
- 5 Lai YH, Kuo M, Huang J, Chen M. On the PEEK composites reinforced by surface-modified nano-silica. *Materials Science and Engineering: A*. 2007;458:158-69. doi: 10.1016/j.msea.2007.01.085.
- 6 Cacciotti I, Mori S, Cherubini V, Nanni F. Eco-sustainable systems based on poly(lactic acid), diatomite and coffee grounds extract for food packaging. *Int J Biol Macromol*. 2018;112:567-75. doi: 10.1016/j.ijbiomac.2018.02.018. PubMed PMID: 29408420.