

DOI: <http://doi.org/10.21698/simi.2025.ab06>

CHARACTERIZATION STUDIES OF A MULTIPHASE COMPOSITE MATERIAL BASED ON NOVOLAC, CaCO₃, AND FIBERS FOR BIOMECHANICAL APPLICATIONS

Maria Cristiana Enescu, Elena Valentina Stoian

Valahia University of Târgoviște, Faculty of Materials Engineering and Mechanics, Department of Materials, Equipment, Instalations and Robots, 13 Aleea Sinaia, 130004, Târgoviște, cristiana.enescu@valahia.ro, Romania

Keywords: *biomechanical requirements, calcium carbonate (CaCO₃), novolac resin.*

Introduction

The paper presents the results of an experimental study on the development and characterization of a multiphase composite material based on novolac resin, calcium carbonate (CaCO₃), and reinforcing fibers, intended for use in biomechanical applications such as prosthetic components or other orthopedic devices. The main objective is to evaluate the influence of each phase on the mechanical and structural behavior of the composite. The obtained material is subjected to complex analyses, including evaluations of interfacial adhesion between the constituent phases. The results indicate good compatibility between novolac and the filler phases, highlighting the potential of this type of composite for biomechanical applications due to its balance between stiffness, strength, and adaptability to the specific demands of the biological environment. The study contributes to the optimization of polymer composite formulations for applications with stringent biomechanical requirements.

Materials and methods

For the production of the multiphase composite, novolac phenolic resin (Figure 1), calcium carbonate (CaCO₃), reinforcing fibers, and hexamination (curing agent) were used as raw materials. Three compositional variants were prepared in the study, with different proportions of novolac and fiber, keeping the CaCO₃ fractions constant and hexamine, as follows (Figure 2):

Sample 1: 50% Novolac / 30% CaCO₃ / 10% Fibre / 10% Hexamina,

Sample 2: 40% Novolac / 30% CaCO₃ / 20% Fibre / 10% Hexamine,

Sample 3: 30% Novolac / 30% CaCO₃ / 30% Fiber / 10% Hexamine.

The components were mechanically homogenized until a uniform mixture was obtained, after which they were hot-pressed (temperature 150-180°C, pressure 20-50 MPa, time: 5-15 minutes, depending on thickness) to obtain the necessary specimens for mechanical and structural testing.

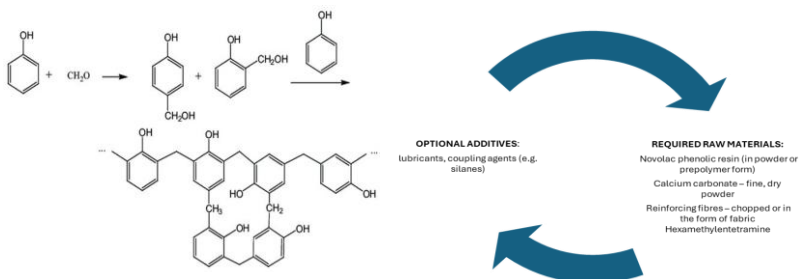


Figure 1. Synthesis of novolac

Figure 2. Obtaining a multiphase composite

Results and conclusions

The novolac–calcium carbonate–glass fiber composite exhibited outstanding mechanical and thermal properties, highlighting its potential for applications in lower-limb prosthetics. Key findings include:

1. Superior mechanical strength, with tensile and compressive values suitable for structural use.
2. High thermal stability ($T_g \approx 145^\circ\text{C}$), ensuring reliable performance under diverse temperature conditions.
3. Good environmental resistance, characterized by low water absorption and improved toughness under impact.
4. Homogeneous structural behavior, confirmed by SEM and FTIR analyses, demonstrating effective filler dispersion and fiber integration.

Further biocompatibility assessments are required, particularly for direct skin contact applications. Additionally, enhancing impact resistance could be achieved through optimized formulations or the incorporation of supplementary fibers.

Overall, this composite emerges as a promising candidate for durable and efficient prosthetic components, with significant potential to improve patient quality of life.

Acknowledgment

Authors from Valahia University of Targoviste, Romania (www.valahia.ro) would like to acknowledge the financial support of the project CNFIS-FDI-2025-F-0421 financed by the Romanian Ministry of Education and Research.