Enhanced biocompatibility and mechanical properties in carbon nanotube-reinforced natural rubber nanocomposites: a review for biomedical applications

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Nimota Adenike-Yakubu Alade ✉, Oladiran Kamardeen Abubakre, Rasaq Olawale Medupin, Ambali Saka Abdulkareem, Idris Babatunde Akintunde, Saheed Mustapha, Jimoh Oladejo Tijani, Rasheed Aremu Muriana & John Adeniran James

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Abstract

Carbon nanotube (CNT)-reinforced natural rubber (NR) nanocomposites represent a promising material platform for biomedical applications, particularly prosthetic systems requiring flexibility, durability, and mechanical resilience. These composites exhibit enhanced tensile strength, elasticity, and fatigue resistance, while offering improved biocompatibility when appropriately functionalised. This review examines recent advances in CNT synthesis, including chemical vapour deposition (CVD) and arc discharge methods, together with covalent and non-covalent functionalisation approaches aimed at improving dispersion and reducing cytotoxicity. Despite encouraging progress, challenges persist, including CNT agglomeration, long-term biocompatibility uncertainties, regulatory constraints, and production costs. Key research gaps are identified, including sustainable synthesis routes, standardised chronic biocompatibility evaluation, and patient-specific customisation. Addressing dispersion control, long-term safety validation, and scalability will be essential for establishing CNT-NR composites as next-generation materials for durable, multifunctional prosthetic devices.

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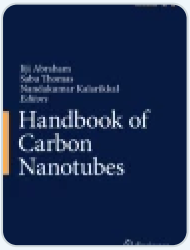
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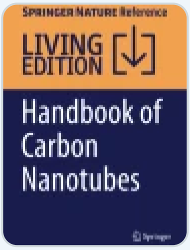
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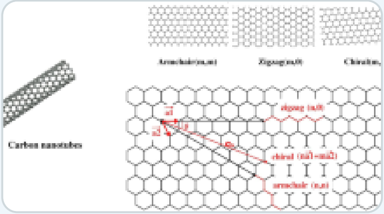

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Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author information

Authors and Affiliations

Department of Mechanical Engineering, Federal University of Technology, P.M.B. 65, Minna, Nigeria
Nimota Adenike-Yakubu Alade

Department of Materials and Metallurgical Engineering, Federal University of Technology, P.M.B. 65, Minna, Nigeria
Oladiran Kamardeen Abubakre, Idris Babatunde Akintunde & Rasheed Aremu Muriana

Department of Materials Development and Metallurgy, Federal Institute of Industrial Research, Oshodi (FIIRO), P.M.B 21023, Ikeja, Lagos, Nigeria
Nimota Adenike-Yakubu Alade

Department of Mechanical Engineering, Federal University Lokoja, P.M.B. 1154, Lokoja, Nigeria
Rasaq Olawale Medupin

Department of Chemical Engineering, Federal University of Technology, P.M.B. 65, Minna, Nigeria
Ambali Saka Abdulkareem

Department of Chemistry, Federal University of Technology, P.M.B. 65, Minna, Nigeria
Saheed Mustapha & Jimoh Oladejo Tijani

Department of Surgery, Federal Medical Centre, P.M.B. 14, Bida, Nigeria
John Adeniran James

Contributions

The authors’ contributions to this work are as follows: Nimota Adenike-Yakubu Alade: Conceptualisation, methodology, writing-original draft, writing-review & editing, data analysis. Oladiran Kamardeen Abubakre: Supervision, methodology, writing-review & editing, project administration. Ambali Saka Abdulkareem: Supervision, methodology, writing-review & editing, and reviewing the final manuscript. Rasaq Olawale Medupin: Supervision, writing-review & editing, critical revision of the manuscript. Idris Babatunde Akintunde: Data curation, writing-review & editing, supervision, resources. Rasheed Aremu Muriana: writing-review & editing, resources, and overall manuscript revisions. Saheed Mustapha: Methodology, writing-review & editing, data analysis, and visualisation. Jimoh Oladejo Tijani: writing-review & editing, resources, data interpretation. John Adeniran James: writing-review & editing, manuscript formatting, and language correction.

Corresponding author

Correspondence to Nimota Adenike-Yakubu Alade.

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