Journal of Nano- and Electronic Physics
Vol. **18** No 5, 05021(6pp) (2026)

Журнал нано- та електронної фізики
Том **18** № 5, 05021(6cc) (2026)

OPEN ACCESS

REGULAR ARTICLE

Performance Assessment of Recycled Polymer Composites with Multi-Walled Carbon Nanotubes

Firas Tayseer Ayasrah[1], P. William[2,3,*], Mohammed Almakki[4], Kalpana G. Joshi[5], Shanthi Kumaraguru[6], Shashikant Raghunathrao Deshmukh[7], Ritesh Ravindra Agwan[5]

[1] *College of Education, Humanities and Science, Al Ain University, Al Ain, United Arab Emirates*
[2] *School of Computer Science and Technology, Karunya Institute of Technology and Sciences (Deemed University), 641114 Coimbatore, India*
[3] *Centre for Research and Consultancy, UNITAR International University, 47301 Selangor, Malaysia*
[4] *School of Engineering, Architecture and Interior Design, Amity University Dubai, P.O. Box 345019, Dubai International Academic City, United Arab Emirates*
[5] *School of Engineering and Technology, Sanjivani University, Kopargaon, MH, India*
[6] *Department of Information Technology, D Y Patil College of Engineering, Akurdi, Pune, India*
[7] *Department of Computer Engineering, Sanjivani College of Engineering, Kopargaon, MH, India*

(Received 05 June 2026; revised manuscript received 20 October 2026; published online 28 October 2026)

The development of sustainable polymer composites from recycled materials is crucial for environmental and economic benefits. This research evaluates epoxy-based composites fabricated from carpet waste and reinforced with multi-walled carbon nanotubes (MWCNTs) at five distinct weight components (0.1-1.0 wt. %). Mechanical characterization revealed a significant increase in compressive strength, reaching 30.4 MPa at 1.5 wt. % MWCNT, while the compressive modulus also improved. Moisture resistance tests showed reduced water absorption and thickness swelling, with optimal performance at 0.25 wt. % MWCNT. Fire-retardant evaluation demonstrated decreased flame spread, char length, and mass loss as MWCNT content increased. Thermal analysis (TGA/DSC) indicated enhanced thermal stability, and SEM confirmed uniform nanotube dispersion, ensuring efficient load transfer and strong interfacial bonding. These results collectively demonstrate that MWCNT reinforcement effectively enhances the physico-mechanical, thermal, and fire-resistant properties of recycled PET/epoxy composites. The developed composites are therefore suitable for lightweight structural applications such as wall panels, roadside barriers, toys, decorative frames, and insulating materials, providing a sustainable approach for waste valorization and high-performance material development.

Keywords: Recycled polymer composites, Multi-walled carbon nanotubes, Epoxy, Recycled Polyethylene Terephthalate (PET), Compression strength, Water absorption, Scanning electron microscopy (SEM).

DOI: 10.21272/jnep.18(5).05021 PACS numbers: 61.48.De, 71.20.Rv

1. INTRODUCTION

The increasing volume of plastic waste is presently a major environmental issue in the world, which has led to the pollution of the land as well as the depletion of resources [1]. Polyethylene terephthalate (PET) is one of the most frequently used plastics in packaging and textiles, and its disposal presents significant challenges given its non-biodegradability [2, 3]. Repurposing PET waste into new and value-added products is thus a valuable approach to foster sustainability and the concept of a circular economy [4, 5]. Nevertheless, recycled polymers tend to have lower mechanical and thermal characteristics than virgin polymers, which constrains their structural use [6]. The traditional methods of enhancing recycled polymers are mixing with virgin plastics or employing chemical additives [7]. Although these techniques offer partial improvements, they frequently do not result in major strengths, waterproofing, or thermal augmentations and are expensive or hazardous to the environment [8, 9]. To overcome these restrictions, nanofillers like multi-walled carbon nanotubes (MWCNTs) have become a candidate reinforcement material because they possess superior strength, stiffness, and thermal stability. To improve thermal and physico-mechanical characteristics, reinforced composites made of epoxy with different concentrations of MWCNTs and recycled PET waste were produced in this research. To present a high-performance sustainable material that can be utilized in practical applications, the research assesses the performance of low MWCNT concentrations to enhance compression strength, water resistance, and fire retardancy.

2. RELATED WORK

With the aid of MWCNT, the research [10] aimed to enhance the mechanical properties of recycled Polypropylene (PP). Extrusions and injection molding were

* Correspondence e-mail: williamacads@gmail.com

© 2026 The Author(s). Journal of Nano- and Electronic Physics published by Sumy State University. This article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

Cite this article as: F.T. Ayasrah, et al., *J. Nano- Electron. Phys.* 18 No 5, 05021 (2026) https://doi.org/10.21272/jnep.18(5).05021

performed under twin screws, and tensile, Dynamic Mechanical Analysis (DMA), and creep tests were conducted afterwards. Findings indicated better modulus, lower creep, and homogeneous composites. These were shortcomings, such as a concentration on PP and fillers. Research [11] focused on the mechanical enhancement of multimaterial recycled polymers through the use of carbon nanotubes, with testing performed on Polypropylene (PP) and High/Low Density Polyethylene (HDPE/LDPE) blends. Results indicated improved Young's modulus and processability, but the research lacked evaluations of thermal, fire, and long-term mechanical properties. Enhancing the temperature and conductivity of recycled PET nanofibers using carbon nanotubes and carbon nanotube graphene hybrids was the goal of the investigation [12]. Electrospinning was utilized, and thermal conductivity, heat dissipation, and infrared thermography were measured. Findings indicated a high improvement in conductivity and heat dissipation. Restrictions were that there was no mechanical assessment of the property and possible processing difficulties. ZnO nanoparticles were employed in the research [13] to reinforce Polyvinyl Alcohol and Polyvinylidene Fluoride (PVA/PVDF) polymer blends to enhance their structural, optical, and dielectric qualities. Crystal structure, surface texture, bonding, and light absorption of the composites were analyzed with superior crystallinity and dielectric performance, but mechanical and thermal tests were omitted. By adding different weight percentages of MWCNTs to epoxy composites made from carpet waste, the research aimed to increase the composite's physico-mechanical and fire-resistance properties. Compression, swelling, and water absorption experimental tests indicated that the best results were obtained with 0.25 wt. % MWCNT. But long-term durability and high ratios of MWCNT were not determined. Improving recycled carbon fiber-based composite through a CNT-bonded nano fibrillated cellulose covering by electrophoretic deposition was the goal of the experiment. XPS and SEM ensured an enhanced adhesion on the surface, leading to 32 % and 27 % higher tensile and flexural strengths, respectively. The complicated processing approach has reduced scalability and cost-efficiency, although the outcomes were promising. An MWCNT-modified phenolic composite reinforced with a hybrid Cytostachy Renda/kenaf fiber was examined in the investigation to enhance its fire and heat resistance. Experimental results indicated that this hybrid exhibited the highest stability regarding thermal and flame resistance. The testing was mechanical, and varying levels of nanofillers were not assessed.

Recycled polymer composites usually lack adequate mechanical, thermal, and fire-resistance features, which restrict their application. Most of the research [11, 12] concentrated on individual polymers or does not thoroughly examine long-term performance, thermal stability, and multifunctionality. These limitations were overcome by this research through optimization of MWCNT content in epoxy/carpet waste composites, resulting in increased compression strength, decreased water absorption.

3. METHODOLOGY

The physico-mechanical characteristics of epoxy-based composite materials manufactured from recycled PET carpet waste reinforced with MWCNTs are examined in the research. Fig. 1 depicts the general flow of the work, where the process starts with the preparation of materials, proceeding to the fabrication of the composite, and finally to the mechanical, thermal, and moisture-related characterization.

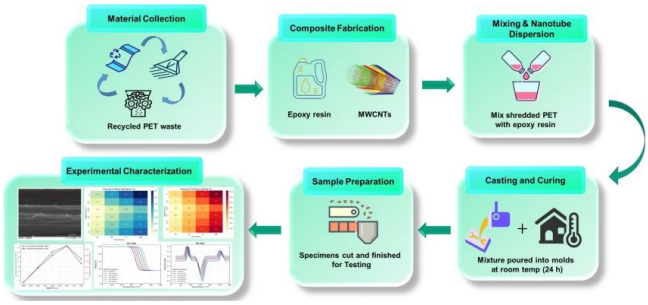


Fig. 1 – Fabrication process of MWCNT-reinforced PET/epoxy composites

3.1 Materials and Methods

The following supplies were utilized in the preparation of the composites:

- **Recycled PET granules** – Recycled carpet waste.
- **Epoxy resin** (Epoxy based on Bisphenol-A) – It is the polymer matrix.
- **Hardener** – Works with the epoxy resin.
- **MWCNTs** – Reinforcing nanofillers were 5-15 μm long and 10-20 nm in diameter.
- **Solvents** (acetone, ethanol) – To be cleaned and dispersed.
- **Distilled water** – Used to do moisture absorption and swelling tests.

Table 1 summarizes the composition of each batch.

Table 1 – Materials and quantities

Material	Specification / Grade	Amount / Proportion
Recycled PET granules	Carpet waste	100 g
Epoxy resin	Bisphenol-A based	50 g
Hardener	Compatible with epoxy	10 g
MWCNTs	Diameter 10-20 nm, Length 5-15 μm	0.1, 0.25, 0.5, 0.75, 1.0 wt.%
Solvents	Acetone, Ethanol	10-20 mL
Distilled water	Laboratory grade/ Deionized	Sufficient for immersion

3.2 Composite Fabrication and Sample Preparation

The production of MWCNT-reinforced recycled PET composites was done in controlled steps to produce a homogenous dispersion and optimum curing. To avoid variation in all of the specimens, this required careful processing to determine the difference between MWCNT content and composite performance. In the fabrication process, ultrasonication was employed to disperse

MWCNTs in epoxy resin to prevent agglomeration. The mixture was combined with PET granules and stirred for 15 minutes to achieve homogeneity. It was then poured into molds, cured at room temperature for 24 hours, and post-cured for four hours at 80 °C. After curing, the composites were demolded and sliced into samples for various tests, ensuring uniform MWCNT distribution, strong interfacial bonding, and reproducibility for characterization.

3.3 Experimental Characterization

The composite specimens were prepared and then categorically characterized to test mechanical, thermal, moisture, and fire-retardant behavior. Each test performed was under standardized procedures so as to maintain reliability and comparability of the results.

- **Compression Testing:** The ASTM D695 test was utilized to measure the stiffness and load-bearing capability utilizing a universal testing machine (UTM).
- **Analysis of Water Absorption and Swelling:** The specimens were placed in purified water, and their water uptake and dimensional swelling were measured according to ASTM D570.
- **Fire-Retardant Test:** A fire-resistant test was conducted under dry conditions and under water-dipped conditions by measuring ignition duration, flame spread, and degradation of material.
- **Thermal Analysis:** Differential scan calorimetry (DSC) and thermogravimetric analysis (TGA) were utilized to measure decomposition temperatures, weight loss, and the temperature at which glass transitions (Tg) occur, which shows stability of thermo.
- **Microstructural Analysis Scanning Electron Microscopy (SEM):** SEM determined surface morphology, dispersion of MWCNTs, and interfacial bonding to determine the structural integrity and the ability to transfer loads.

4. RESULT AND DISCUSSION

4.1 Compression Test

A UTM tested the compressive strength of composites following ASTM D695 standards, focusing on the influence of MWCNT reinforcement on the stiffness and load-bearing ability of recycled PET-epoxy materials. Cylindrical specimens (12 mm diameter, 25 mm height) were made for each composite formulation and preserved for 24 hr at ambient temperature before testing to ensure uniform height and moisture content. Tests were conducted on the samples until they failed and were subjected to the maximum load (Q_{max}), compressive strength (σ_d), and compressive modulus.

$$\sigma_d = \frac{Q_{max}}{B} \quad (1)$$

In which σ_d represents strength under compression (MPa), Q_{max} was the maximum load that fails (N), and B is the sample's cross-sectional region (mm^2). Every test was conducted three times, and Table 2 shows the average outcomes.

Table 2 – Compressive properties of recycled PET-MWCNT composites

Sample	MWCNT wt.%	Maximum Load (N)	Compressive	
			Strength (MPa)	Modulus (GPa)
C_0	0.0	3200	22.6	1.02
C_1	0.5	3650	25.8	1.14
C_2	1.0	4100	29.1	1.25
C_3	1.5	4350	30.4	1.33
C_4	2.0	3980	27.6	1.18

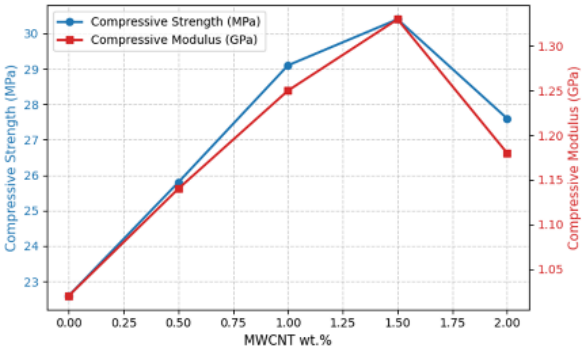


Fig. 2 – Compressive properties of recycled PET-MWCNT composites

Table 2 and Fig. 2 reveal that the compressive characteristics of recycled PET-epoxy composites are enhanced significantly with the addition of MWCNTs. The purest PET composite (C_0) was the weakest (22.6 MPa) and had the lowest modulus (1.02 GPa). Both strength and stiffness improved with additions of MWCNT, with the greatest values of 30.4 MPa and 1.33 GPa at 1.5 wt.% (C_3) as a result of enhanced transfer of loads and a solid bond between the nanotubes and the polymer. When nanotube clustering occurred at 2.0 wt. % (C_4), the properties went slightly down due to stress points and low effectiveness. In general, the best compressive performance is achieved at 1.5 wt. % MWCNT.

4.2 Water Absorption and Swelling Analysis

To evaluate the effect of the MWCNT content on the uptake of water and the stability of dimensions of recycled PET-MWCNT epoxy composites under the ASTM D570 guidelines, moisture resistance was tested. Rectangular specimens ($25 \times 25 \times 3$ mm^3) were dried at 50 °C for 24 h, and the sample's original mass and thickness were determined. After being left at room temperature in filtered water, samples were taken 24, 48, 72, and 168 hours later.

Water Absorption (%): $W(\%) = \frac{W_s - W_p}{W_p} \times 100$ (2)

Thickness Swelling (%): $T(\%) = \frac{T_s - T_p}{T_p} \times 100$ (3)

Where W_p indicates the initial dry mass (g), W_s is the weight following submersion (g), T_p is the initial thickness (mm), and T_s is the thickness after immersion (mm).

Table 3 – Absorption of water and composite thickness swelling

MWCNT wt.%	Water Absorption (%)				Swelling of Thickness (%)			
	24h	48h	72h	168h	24h	48h	72h	168h
0 (Neat PET)	2.5	3.6	4.2	5.0	1.2	1.8	2.3	2.8
0.1	2.1	3.0	3.5	4.2	1.0	1.5	2.0	2.5
0.25	1.6	2.2	2.6	3.0	0.8	1.2	1.6	2.0
0.5	1.8	2.5	3.0	3.5	0.9	1.4	1.8	2.3
0.75	2.0	2.8	3.3	3.8	1.0	1.5	2.0	2.4
1.0	2.2	3.1	3.7	4.1	1.1	1.6	2.2	2.6

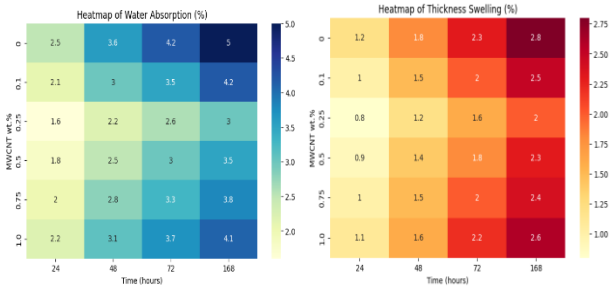


Fig. 3 – Moisture resistance of water absorption and PET-MWCNT composites' thickness swelling

The observations of thickness swelling and absorption (Table 3 and Fig. 3) reveal that the addition of MWCNTs offers a significant enhancement in the moisture resistance of the recycled PET epoxy composites. With 0.25 wt. % MWCNT, water absorption and swelling were reduced to 3.0 % and 2.0 %. Respectively, neat PET composites showed the highest level of water uptake (5.0 % at 168 h) and thickness swelling (2.8 % at 168 h). Higher loadings (0.5-1.0 wt. %) of MWCNT demonstrated slightly higher values (water absorption: 3.5-4.1, swelling 2.3-2.6 %), which is probably caused by slight agglomeration of nanotubes, showing 0.25 wt. % as a reinforcement with the highest effectiveness in moisture resistance.

4.3 Fire-Retardant Evaluation

Fire-resistance of MWCNT-reinforced PET epoxy was measured by applying the ASTM D3801 vertical burning test. Conditioning: Different material types were prepared at 23 ± 2 °C and 50 ± 5 % relative humidity, and 24 hours of preconditioning were carried out using five replicas of each formulation. The specimens were held upright, and a flame was applied to the lower edge for 10 seconds. These were time to ignition (TTI), flame spread time (FST), after-flame time (AFT), char length (CL), melt-drip behaviour, and mass loss (%). The quantitative measurements were computed as follows (4):
Mass Loss (%):

$$ML(\%) = \frac{m_{initial} - m_{final}}{m_{initial}} \times 100 \quad (4)$$

Where $m_{initial}$ and m_{final} are the sample masses before and after testing.

Table 4 – Fire-retardant performance of recycled PET-epoxy composites reinforced with MWCNTs

Sample (MWCT (wt.%))	TTI (s)	FST (s)	AFT (s)	Char length (mm)	Melt-drip	Mass loss (%)
PET-0 (Control)	2.5 ± 0.3	30.0 ± 2.1	32.0 ± 2.5	55 ± 4	Yes (Flaming)	18 ± 1
PET-0.1	3.0 ± 0.3	27.0 ± 1.8	28.5 ± 2.0	50 ± 3	Yes (Non-flaming)	16 ± 1
PET-0.25	4.2 ± 0.4	21.5 ± 1.5	22.0 ± 1.6	38 ± 3	Non-flaming	14 ± 1
PET-0.5	5.8 ± 0.5	15.0 ± 1.3	15.5 ± 1.2	25 ± 2	None	12 ± 0.8
PET-0.75	6.2 ± 0.5	10.5 ± 1.0	10.5 ± 0.9	18 ± 2	None	10 ± 0.7
PET-1.0	6.6 ± 0.5	7.5 ± 0.9	7.5 ± 0.8	14 ± 1	None	9 ± 0.5

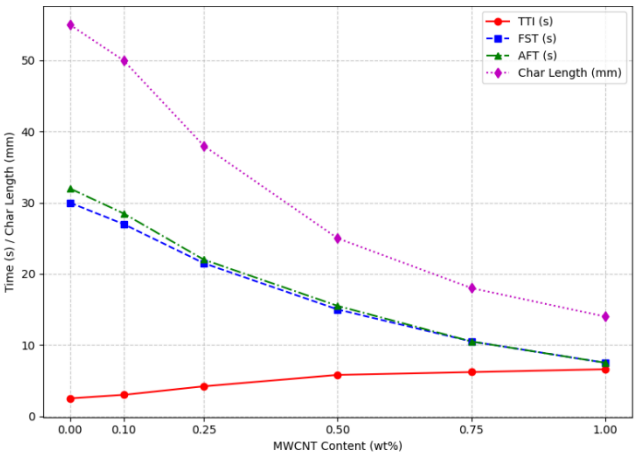


Fig. 4 – Performance of recycled PET-epoxy composites reinforced with MWCNTs in terms of fire resistance

The performance of the recycled PET-epoxy composites with a rise in the MWCNT concentration, and flame retardant increased (Fig. 4 and Table 4). The more the MWCNTs, the better the fire resistance of recycled PET epoxy composites. Ignition time rose to 2.5 s in the control and fell to 6.6 s at 1.0 wt % MWCNT; both flames spread time, and after-flame time dropped to 7.5 s each, respectively. Char length also decreased to 14 mm as compared to 55 mm, and melt-dripping ceased at ≥ 0.5 wt. % and above MWCNT. Mass loss was also reduced to 9 to 18 %, demonstrating that MWCNTs enhance flame resistance and thermal stability.

4.4 Thermal Analysis

TGA and DSC were used to examine the thermal properties of the reclaimed PET/epoxy composition enhanced with MWCNT. In TGA, at a rate of 10 °C per minute, samples were heated from room temperature to 600 °C in the presence of nitrogen to record weight loss and ascertain the decomposition temperatures. DSC consisted of heating at 10 °C/min, and subsequent heating to 300 °C, to determine the flow of heat and the behavior of glass transition (Tg), crystallization (Tc), and melting (Tm).

In TGA analysis, W_o is the initial weight of the sample, W_T is the weight at temperature T, In DSC, heat flow rate is denoted as (dQ), sample mass as m, heat capacity as (C_p), and the heating rate as $\frac{dT}{dt}$, all mentioned in equations (5 and 6).

$$weight\ loss\ (\%) = \frac{W_o - W_T}{W_o} \times 100 \quad (5)$$

$$\frac{dQ}{dt} = m\ C_p \frac{dT}{dt} \quad (6)$$

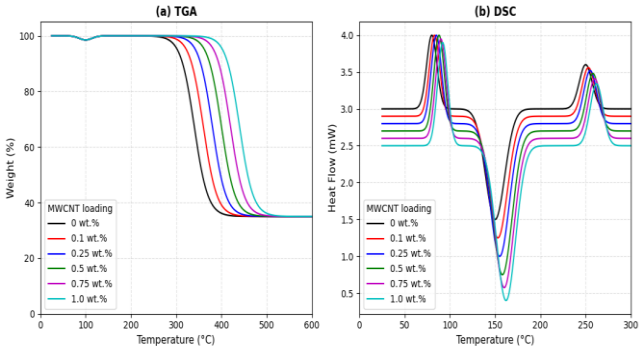
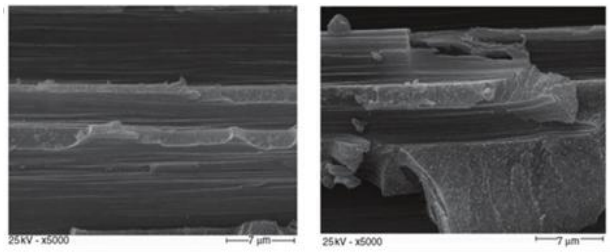


Fig. 5 – PET/epoxy Composites with MWCNTs of (a) TGA thermograms (b) DSC thermograms

According to the TGA results (Fig. 5 (a)), the onset temperature of decomposition increased as the weight percentage of the sample increased (320 °C to 400 °C, 1.0 wt. %), and the residual weight grew (10 percent to 18 %), which demonstrates enhanced thermal stability with MWCNTs. DSC analysis indicated in Fig. 5 (b) Tg (80-65 °C), Tc (150-135 °C), and Tm (250-235 °C), and lower heat-flow intensity indicated that MWCNTs inhibit polymer mobility and increase heat resistance.

4.5 SEM Analysis

To determine the microstructure and dispersion of MWCNTs in recycled PET/epoxy composites, SEM was used, as illustrated in Fig. 6.



(a) (b)

Fig. 6 – SEM images of recycled PET/epoxy composites showing MWCNT dispersion: (a) 0.5 wt. % and (b) 1.0 wt. %

In PET/epoxy, SEM examined the microstructure and the distribution of MWCNT in the recycled material (Fig. 6). Low loadings (0.1-0.5 wt. %) resulted in uniform distribution of MWCNTs, which ensures high bonding and enhanced mechanical strength. Greater loadings (0.5-1.0 wt. %) were slightly agglomerated. In general, the SEM analysis confirmed that optimized ultrasonic and controlled mixing led to well-dispersed MWCNTs, which was in favor of increasing the composites' thermal stability and physico-mechanical properties.

Nanofillers play a significant role in improving the recycled polymer composites. The research [12] enhanced the tensile and thermal characteristics of recycled PET nanofibers with CNT and CNT graphene, but only on non-structural mats. The investigation has indicated mechanical enhancements of MWCNT-enforced carpet waste composites but has not assessed thermal, moisture, and fire resistance behavior. The current research fills these gaps through designing a bulk recycled PET/epoxy composite with MWCNTs reinforcement, 22 % compression strength, improved thermal stability, and lower water uptake at 0.5 wt. % MWCNTs were proving their applicability to lightweight, multifunctional, and durable structures.

5. CONCLUSION

The physico-mechanical, thermal, and fire-resistant qualities of recycled PET/epoxy composites may be significantly improved by MWCNT reinforcement, as demonstrated in the research. Compressive strength was the highest at 30.4 MPa (1.5 wt. % MWCNT), and the maximum moisture resistance was at 0.25 wt. % MWCNT. SEM verified consistent nanotube dispersion, which is in favor of robust interfacial binding. Nevertheless, further improvement of performance by agglomeration was slight at high MWCNT loading, and the experiments involved only laboratory-sized specimens. Further studies might investigate the fabrication of large-scale, durable, hybrid nanofillers and the aging of nanofillers in the environment.

REFERENCES

1. B. Jiang, J. Yu, Y. Liu, *J. Environ. Earth Sci.* **2** No 2, 26 (2020) https://doi.org/10.30564/jees.v2i2.2340.
2. S.E. Shalaby, N.G. Al-Balakocy, M.H. Elshakankery, M.K. Beliakova, *J. Eng. Fiber. Fabr.* **19**, 1 (2024) https://doi.org/10.1177/15589250241276861.
3. J.B. Ali, A.B. Musa, A. Danladi, M.M. Bukhari, B.B. Nyakuma, *J. Nat. Fiber.* **19** No 9, 3195 (2022) https://doi.org/10.1080/15440478.2020.1841062.
4. F.S. Hassan, W.U. Eze, R. Umunakwe, T. Oyegoke, M.I. Uzochukwu, *Cleaner Waste Syst.* **12**, 100383 (2025) https://doi.org/10.1016/j.clwas.2025.100383.
5. A. Rahmouni, W. Chaouch, T. Hamdi, M. Jmali, S. Msahli, *J. Indust. Textil.* **55**, 1 (2025). https://doi.org/10.1177/15280837251381082
6. D. Ferrández, A. Zaragoza-Benzal, R. Pastor Lamberto, P. Santos, J. Michalak, *Appl. Sci.* **14** No 14, 6226 (2024)

https://doi.org/10.3390/app14146226.
7. D. Ferrández, A. Zaragoza-Benzal, E. Barrak, P. Santos, C. Rodrigues, *Res. Eng.* **24**, 103535 (2024) https://doi.org/10.1016/j.rineng.2024.103535.
8. J.M. Khare, S. Dahiya, B. Gangil, L. Ranakoti, *Mater. Today: Proc.* **38**, 345 (2021) https://doi.org/10.1016/j.matpr.2020.07.420.
9. N. Rajabifar, S. Ghanemi, A. Rostami, M. Bahrami, *Polym. Compos.* **46** No 2, 1416 (2025) https://doi.org/10.1002/pc.29047.
10. A. Bata, P. Gerse, K. Kun, E. Slezák, F. Ronkay, *Res. Eng.* **25**, 104150 (2025) https://doi.org/10.1016/j.rineng.2025.104150.
11. A. Dib, N. Fantuzzi, J. Agnelli, L. Paleari, M. Bragaglia, F. Nanni, A. Pierattini, *Polym. Compos.* **46** No 2, 1080 (2025) https://doi.org/10.1002/pc.27663.
12. O.I. Kalaoglu-Altan, B. Karagüzel Kayaoğlu, L. Trabzon, *Polym. Eng. Sci.* **65** No 3, 1070 (2025) https://doi.org/10.1002/pen.27057.
13. S. Saini, V. Dhayal, N.S. Leel, Ravina, A.M. Quraishi, S.Z. Hashmi, S. Dalela, B.L. Choudhary, P.A. Alvi, *Opt. Quant. Electron.* **56** No 12, 1943 (2024) https://doi.org/10.1007/s11082-024-07816-3.

Оцінка ефективності перероблених полімерних композитів з багатошарових вуглецевих нанотрубок

Firas Tayseer Ayasrah[1], P. William[2,3], Mohammed Almakki[4], Kalpana G. Joshi[5], Shanthi Kumaraguru[6], Shashikant Raghunathrao Deshmukh[7], Ritesh Ravindra Agwan[5]

[1] *College of Education, Humanities and Science, Al Ain University, Al Ain, United Arab Emirates*
[2] *School of Computer Science and Technology, Karunya Institute of Technology and Sciences (Deemed University), 641114 Coimbatore, India*
[3] *Centre for Research and Consultancy, UNITAR International University, 47301 Selangor, Malaysia*
[4] *School of Engineering, Architecture and Interior Design, Amity University Dubai, P.O. Box 345019, Dubai International Academic City, United Arab Emirates*
[5] *School of Engineering and Technology, Sanjivani University, Kopargaon, MH, India*
[6] *Department of Information Technology, D Y Patil College of Engineering, Akurdi, Pune, India*
[7] *Department of Computer Engineering, Sanjivani College of Engineering, Kopargaon, MH, India*

Розробка стійких полімерних композитів з перероблених матеріалів має вирішальне значення для екологічних та економічних переваг. У цьому дослідженні оцінюються композити на основі епоксидної смоли, виготовлені з килимових відходів та армовані багатостінними вуглецевими нанотрубками (MWCNT) при п'яти різних вагових компонентах (0,1-1,0 мас. %). Механічна характеристика виявила значне збільшення міцності на стиск, досягнувши 30,4 МПа при 1,5 мас.% MWCNT, водночас покращився модуль стиску. Випробування на вологостійкість показали зменшення водопоглинання та набухання по товщині, з оптимальними характеристиками при 0,25 мас. % MWCNT. Оцінка вогнезахисних властивостей продемонструвала зменшення поширення полум'я, довжини обвуглювання та втрати маси зі збільшенням вмісту MWCNT. Термічний аналіз (TGA/DSC) показав підвищену термічну стабільність, а СЕМ підтвердив рівномірну дисперсію нанотрубок, що забезпечує ефективне передавання навантаження та міцне міжфазне зчеплення. Ці результати разом демонструють, що армування MWCNT ефективно покращує фізико-механічні, теплові та вогнестійкі властивості перероблених ПЕТ/епоксидних композитів. Таким чином, розроблені композити підходять для легких конструкційних застосувань, таких як стінові панелі, придорожні бар'єри, іграшки, декоративні рамки та ізоляційні матеріали, забезпечуючи сталий підхід до утилізації відходів та розробки високоефективних матеріалів.

Ключові слова: Перероблені полімерні композити, Багатостінні вуглецеві Нанотрубки, Епоксидна смола, Перероблений поліетилентерефталат (PET), Міцність на стиск, Водопоглинання, Скануюча електронна мікроскопія (СЕМ).