Express Polymer Letters Vol.19, No.7 (2025) 651–652
Available online at www.expresspolymlett.com
https://doi.org/10.3144/expresspolymlett.2025.49

Editorial corner – a personal view

From scrap to structure: The challenges of carbon fibre recycling

Péter Sántha[1,2*], *Péter Tamás-Bényei*[1,2,3], *Andrea Toldy*[1,2]

[1]Department of Polymer Engineering, Faculty of Mechanical Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3., H-1111 Budapest, Hungary
[2]MTA-BME Lendület Sustainable Polymers Research Group, Műegyetem rkp. 3., H-1111 Budapest, Hungary
[3]HUN-REN-BME Research Group for Composite Science and Technology, Műegyetem rkp. 3., H-1111 Budapest, Hungary

The growing use of high-performance carbon fibre-reinforced polymers (CFRPs) in aerospace, automotive, wind energy, and sports industries – driven by their superior mechanical properties and design flexibility – has raised concerns about their end-of-life waste management, especially as global CFRP demand reached 181 kt/year in 2021 with a 12.5% annual growth rate over the past two decades (https://doi.org/10.1016/j.compositesb.2022.110463). Recycling CFRPs presents technical and economic challenges due to thermoset matrices like epoxy, which cannot be remelted, and their recycling requires chemical or thermal degradation, in contrast to thermoplastics. Despite technological advances, industrial-scale recycling remains limited primarily by the lack of scalable recycling technologies and the slow industrial uptake of resin systems designed for recycling, in addition to issues such as inconsistent material quality, logistical hurdles, and the lack of standardised processes, leaving a gap between laboratory-scale feasibility and market-ready implementation.

Current CFRP reclamation technologies – mechanical, thermal, chemical, and other – recover fibres using pyrolysis, solvolysis and thermolysis methods, retaining up to 90–95% of original fibre strength (https://doi.org/10.1016/j.compositesb.2020.108053). However, the quality and reusability of reclaimed carbon fibre (rCF) are primarily compromised by the loss of the original oriented textile structure, while recycling conditions may additionally cause surface damage, fibre shortening, and alterations in sizing. Moreover, the variability in post-consumer CFRP waste, though often sourced from known industries like aerospace or wind energy, still poses challenges for standardisation due to differences in resin systems, fibre formats, and service histories.

Recycled fibres are usually short and randomly oriented, severely limiting their suitability for high-performance applications. Efforts to remanufacture rCF into usable forms face varying levels of complexity – while non-woven mats are relatively straightforward to produce, creating aligned textiles or chopped tapes at scale involves higher production costs and lower throughput, confining rCF use to non-critical products like automotive interiors, consumer electronics and sports equipment. Achieving true upcycling, rather than downcycling, requires addressing fibre orientation and matrix compatibility. Promising developments include aligning rCF into highly oriented tapes or hybrid yarns (https://doi.org/10.3390/recycling9010011) and integrating tailored resin systems (https://doi.org/10.1016/j.compositesb.2023.110666) to produce prepregs, unidirectional tapes, and woven fabrics incorporating recycled content.

*Corresponding authors, e-mail: santhap@pt.bme.hu (Péter Sántha)
atoldy@edu.bme.hu (Andrea Toldy)

Although key technical challenges are still being addressed, their resolution alone is not sufficient; large-scale adoption also requires robust supply chains, viable economic models, comprehensive life cycle assessments, and supportive regulatory frameworks. The lack of standardised certification pathways remains a major barrier to using reclaimed CFRP in safety-critical sectors. Integrating recycling considerations into the initial design of CFRP components could further facilitate efficient recovery and reuse.

Recycling carbon fibres is not merely a waste management challenge, but also a technological opportunity. Unlocking its potential requires a systemic approach that integrates material innovation, process optimisation, and market development to make CFRPs sustainable.