

Платформа 2

Сучасні аспекти матеріалознавства та технологій в
текстильній та фешн-індустріях

UDC

678.674:

66.095.26:

544.478

NATALIIA HUDZENKO, BERND WETZEL

Leibniz Institute for Composite Materials, Kaiserslautern,
Germany

**ACID-BASED RECYCLING OF
FIBRE-REINFORCED COMPOSITES VIA
MICROWAVE AND GLASS REACTOR**

Purpose. Explore pathways for acid-based chemical recycling of fibre-reinforced composites using glass reactor and microwave reactor technology, and to assess matrix dissolution, fiber preservation, and feasibility of solvent recovery.

Keywords: Acid solvolysis; formic acid; acetic acid; microwave reactor; glass reactor; thermoset composites; fibre integrity; SEM; FTIR; solvent recovery.

Introduction. Acid-based chemical recycling offers a practical, low-energy route to separate polymer matrices from reinforcement fibres under controlled conditions. Using organic acids enables the dissolution of matrices and the recovery of fibres with minimal damage, while adjustable parameters (temperature, acid ratio, time) allow the adaption of the processes to different composite systems. Solvent regeneration and reuse reduce chemical waste and improve environmental performance. Compared to thermal or purely mechanical routes, acid recycling better preserves fibre quality and can be broadly applied to various polymer-fibre architectures.

Objectives. Evaluate the extent of matrix dissolution, verify the condition of recovered fibres, and assess the practicality of solvent recovery and material re-use using two laboratory routes (glass reactor and microwave reactor).

Methodology. Two variants of acid recycling were used: (i) processing in a glass reactor equipped with a condenser; and (ii) microwave-assisted processing for rapid, uniform heating. Mixtures of formic and acetic acids with specific formulation served as solvent media. As performance indicators the gravimetric mass change (apparent matrix removal), and the qualitative fibre surfaces/interfaces (via SEM), and the recovered fractions (via FTIR) were investigated. Solvent handling

employed precipitation and rotary evaporation to support regeneration and minimize waste.

Research results. Both routes provided effective matrix dissolution and fibre recovery under controlled laboratory conditions. Microwave processing consistently achieved faster separation than the glass reactor due to uniform volumetric heating. SEM observations showed clean, exposed fibres without visible damage for representative cases.

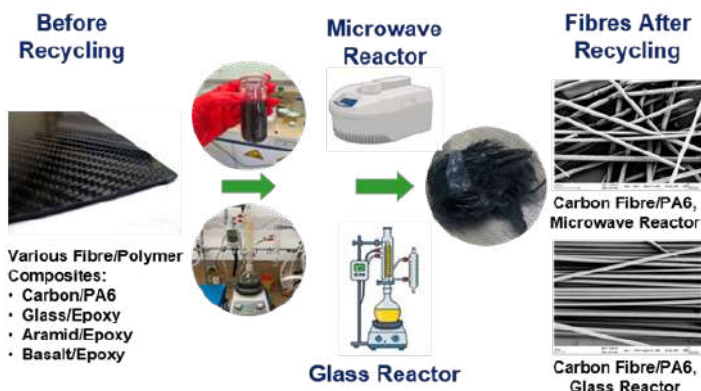


Fig. 1. Experimental setups - glass reactor and microwave reactor (placeholder)

The recovered polyamide polymer fractions exhibited FTIR features characteristic of the native material, with no indications of chemical decomposition within the method's sensitivity. However, the overall efficiency depended on both the composites' architecture and matrix chemistry. Thus, further research and optimization activities are planned in the future.

Conclusions. Acid-based recycling using formic/acetic media is suitable for dissolving composite matrices while preserving fibre integrity. Microwave assistance shortens processing time relative to a glass reactor, and both routes are compatible with solvent regeneration. Further refinement for specific material families and quantitative thermal analysis of recovered constituents are planned to support re-use.

References

1. Oliveux G., Dandy L.O., Leeke G.A. Current status of recycling of fibre reinforced poly-mers. Prog. Mater. Sci. 2015;72:61–99.
2. Yang Y., Boom R., Irion B., et al. Recycling of composite materials. Chem. Eng. Process. 2011;51:53–68.