Researchers develop recycling method to address carbon and glass fiber composites waste

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Recycled product. Credit: Stefanie Zingsheim, University of Sydney.

Researchers at the University of Sydney have developed new methods to solve a major source of future waste from the automotive, aerospace and renewable industries.

It's estimated that by 2030 carbon and glass fiber composites (CFRP), materials commonly used in wind turbine blades, hydrogen tanks, airplanes, yachts, construction, and car manufacturing, will be a key waste stream worldwide.

The annual accumulation of CFRP waste from aircraft and wind turbine industries alone is projected to reach 840,300 metric tons by 2050—the equivalent of 34 full stadiums—if suitable recycling methods are not adopted.

While recycling methods do exist, most of this waste currently goes to landfill or is incinerated. The production of "virgin" composites has further implications for the environment too, including resource depletion and high energy input during production.

This is despite the existence of numerous methods to recycle carbon fiber composites which a research team at the University of Sydney says, if fully implemented, have the potential to significantly reduce energy use by 70 percent and prevent key streams of materials from going to waste.

"Carbon fiber composites are considered a 'wonder' material—they are durable, resistant to weathering and highly versatile—so much so that their use is projected to increase by at least 60% in the next decade alone," said Dr. Hadigheh from the School of Civil Engineering. "But this huge growth also brings a huge increase in waste. For instance, it's been estimated that around 500,000 tons of carbon and glass fiber composite waste from the renewable energy sector will exist by 2030."

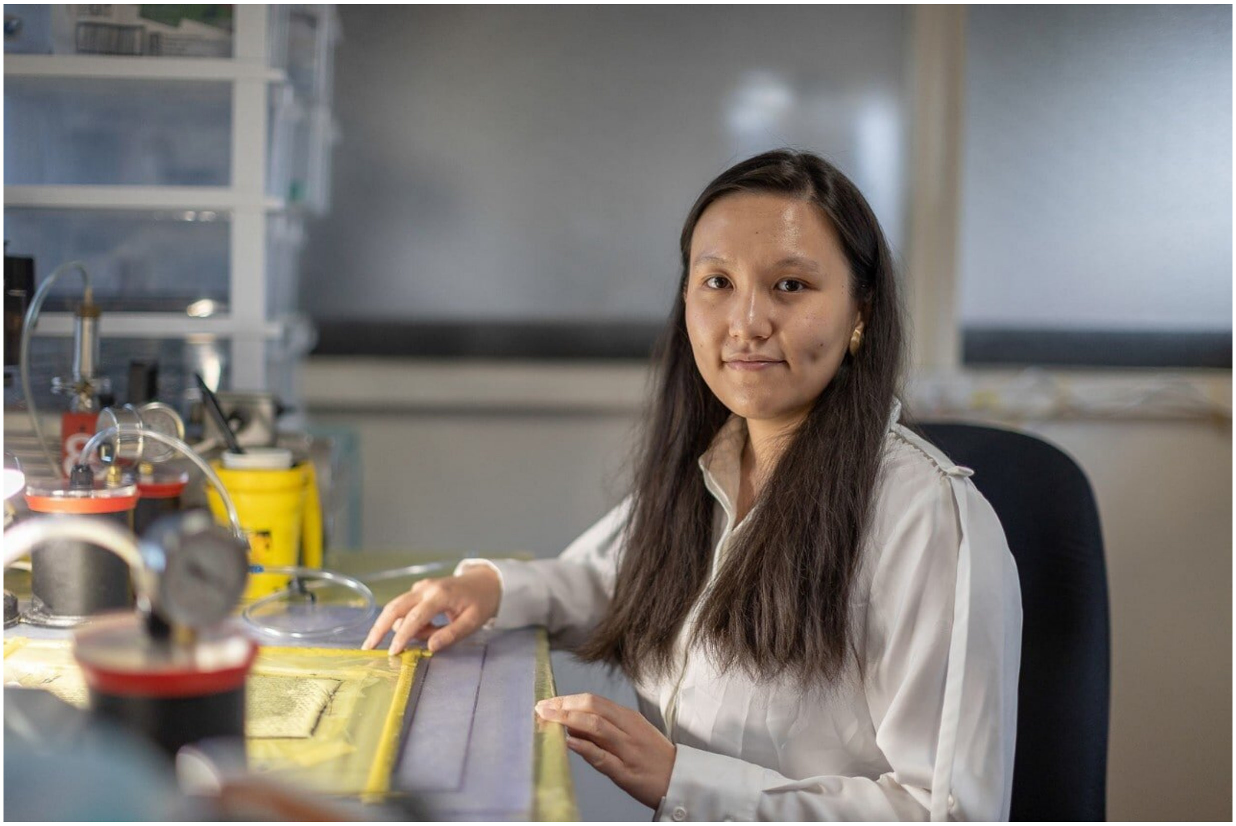
A new recycling method

To tackle this issue, Dr. Hadigheh and his recent Ph.D. graduate Dr. Yaning Wei have developed a new recycling method for carbon and glass fiber composites in a bid to prevent from end-of-generation materials going to landfill. Published in *Composites Part B: Engineering* their approach ensures increased material recovery and improved energy efficiency compared to previous methods.

"Our kinetic analysis revealed that pre-treated CFRP undergoes an additional reaction stage, enabling enhanced breakdown at lower temperatures compared to untreated CFRP," said Dr. Hadigheh. "The solvolysis pre-treatment not only facilitates greater breakdown but also preserves the mechanical properties of fibers by reducing heat consumption during recycling."

Recycled fibers obtained from pre-treated CFRP retained up to 90 percent of their original strength, surpassing the strength of fibers recovered through thermal degradation alone by 10 percent.

"To demonstrate the real-world applicability of our method, we successfully recycled part of a bicycle frame and airplane scraps made of CFRP composites using our hybrid approach. These results not only validate the effectiveness of chemical pre-treatment but also demonstrate the improved mechanical characteristics of the recycled carbon fibers," said Dr. Hadigheh.



Dr. Yaning Wei, who completed her Ph.D. on the topic. Credit: Stefanie Zingsheim, University of Sydney.

Reclaiming carbon fiber

In a previous paper, the team also presented a detailed evaluation of 10 different carbon and glass fiber composite waste treatment systems based on economic efficiency and environmental effects, taking into consideration the type of waste material and its geographical location.

Dr. Hadigheh's team found that solvolysis—a method whereby materials can be broken down with an application of solvent under a specific pressure and temperature—could reclaim carbon fiber while delivering a high net profit. Thermal recycling methods such as catalytic pyrolysis and pyrolysis coupled with oxidation also provided a high economic return.

Solvolysis and electrochemical methods were also shown to lead to substantially lower CO_2 emissions into the atmosphere than landfilling and incineration.

A huge opportunity

The researchers said that manufacturers should look beyond continuously creating virgin material and, in parallel, develop recycled products from end-of-life streams.

"This is a huge opportunity," said Dr. Wei. "And not only because various modes of recycling are cost-effective and minimally impactful on the environment."

"In an era of mounting supply chain disruptions, local recycled products can provide a more immediate product when compared to imports and create a burgeoning advanced manufacturing industry.

"While awareness of everyday consumer recycling is increasing and plastic waste is in the spotlight, Australia must urgently consider wide-scale recycling of new generation construction materials before they mount up as another waste problem and are put into the 'too hard basket.'"

Dr. Hadigheh's team is also developing methods for the recycling of composite materials and recently patented a machine to precisely align recycled carbon fibers, so that they can be repurposed.

The researchers conducted life cycle analysis (LCA), cost benefit analysis (CBA) and technology readiness level (TRL) assessments of the different waste treatment methods: landfill, incineration, mechanical recycling, catalytic pyrolysis, oxidation, pyrolysis combined with oxidation, fluidized bed, solvolysis using alkali and acid solvents, and electrochemical methods.

More information: Y. Wei et al, Development of an innovative hybrid thermo-chemical recycling method for CFRP waste recovery, *Composites Part B: Engineering* (2023). DOI: 10.1016/j.compositesb.2023.110786

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