Surface Layer Removal of End-of-Life Carbon Fiber Composites

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BACKGROUND

Composites such as carbon fiber reinforced plastics (CFRP) are increasingly replacing metals as structural components of airplanes due to their strength and durability. In the Boeing 787, composites account for approximately 50% of the aircraft's weight, minimizing fuel consumption [1]. However, 6,000+ commercial aircraft are projected to be retired by 2030 [2].

Pyrolysis is a recycling method where CFRPs are heated to >450°C to burn off the epoxy that holds the carbon fibers together. Pyrolysis is used on factory scrap, but it is unknown how coatings might impact this process. Coatings on end-of-life parts include a polyurethane paint/primer and copper (lightning strike protection), and there is a fiberglass layer in the CFRP that needs to be removed.

Proposed Solution

Run samples with differing levels of coating removal through pyrolysis to understand how coatings might affect the breakdown of the epoxy resin and carbon fibers.

Objectives

- Determine if presence of coatings influences pyrolysis outcomes of end-of-life parts
- Investigate methods for removing post-pyrolysis coating residue

METHODS

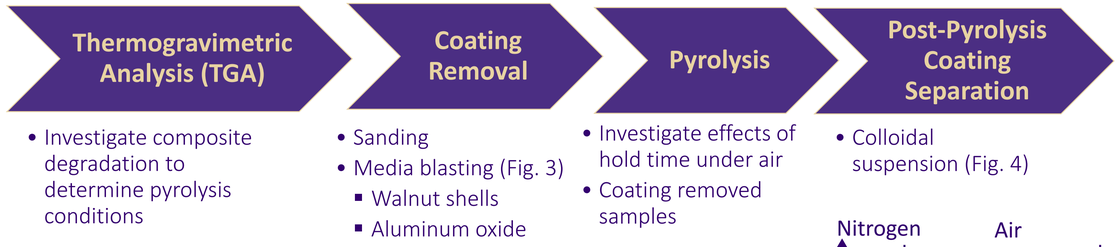

Figure 1. Overall project flow and methods used throughout winter and spring quarters.

> The flow of our project is depicted in Figure 1.

> Pyrolysis was first run on unaltered samples to select an optimal hold time of 120 minutes under air for all future samples (Fig. 2).

> Samples run under TGA and pyrolysis were analyzed via Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS).

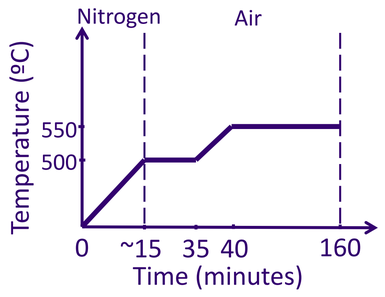

Figure 2. Pyrolysis run conditions

> Post-pyrolysis samples had paint residue removed via colloidal suspension (Fig. 4).

RESULTS

> SEM images showed approximately equal amounts of spotting/degradation in carbon fibers across all treatments.

> From SEM/EDS results, removal of coatings via media blasting introduced trace foreign elements and damages the fiberglass layer (Fig. 5).

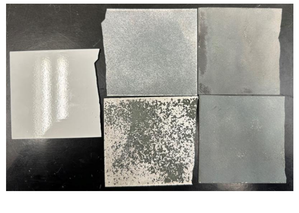

Figure 3. Media Blasted Samples. From left to right in columns: 0%, 42%, and 100% removal.

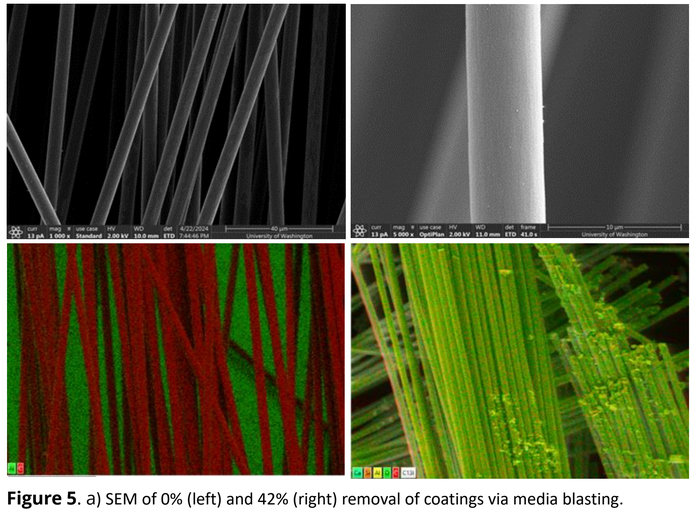

Figure 5. a) SEM of 0% (left) and 42% (right) removal of coatings via media blasting. b) EDS of carbon fibers of 0% (left) and fiberglass weave of 42% (right) via removal media blasting.

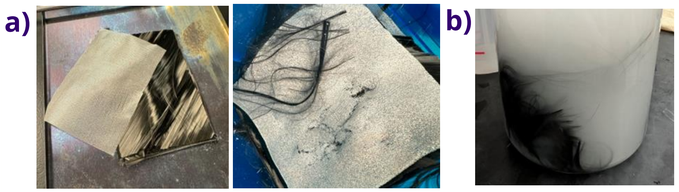

Figure 4. a) Images of the pyrolyzed coupons of 0% and 100% (left to right) removal via media blasting. b) Colloidal suspension to remove paint residue on post-pyrolysis sample.

CONCLUSION

Our experiments suggest that **the presence of paint surface layers on the composites during pyrolysis does not result in noticeable damage to the carbon fibers.** Coating removal methods before pyrolysis cost more and generally results in additional contaminants or damage that would be undesirable in recycling. Paint residue remaining post-pyrolysis can be removed through colloidal suspension methods.

Future Recommended Work Includes:

- Testing **pyrolysis and paint residue removal at larger scales**
- Performing **tensile strength testing** on fibers to quantitatively validate conclusions
- Testing surface effects on **solvolysis**
- Investigating **carbon fiber realignment** strategies for composite reconstruction

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[1] Slayton R,et. al. Technovation. 2016.
[2] J. Zhang, et. al Composites Part B: Engineering, 2020.