UNDERSTANDING THE CHARACTERIZATION OF THERMAL DECONSOLIDATION FOR FLAX FIBER REINFORCEMENTS IN THERMOPLASTIC COMPOSITES

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Introduction

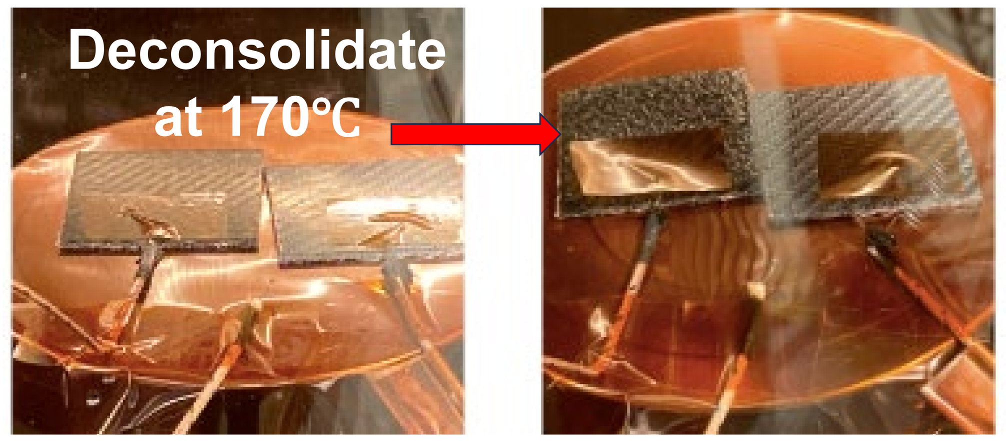
- Thermoplastic composites have reversible phases from solid to a molten state when heated, but the thermodynamic transitions cause porous voids to form. This process is known as deconsolidation (DE)
- Most studies have characterized deconsolidation on glass fiber thermoplastic composites, but there are very few done on flax fiber thermoplastic composites [1, 2]
- The goal is to understand the characterization of flax fiber reinforced thermoplastic composites before and after deconsolidation

Material Composition

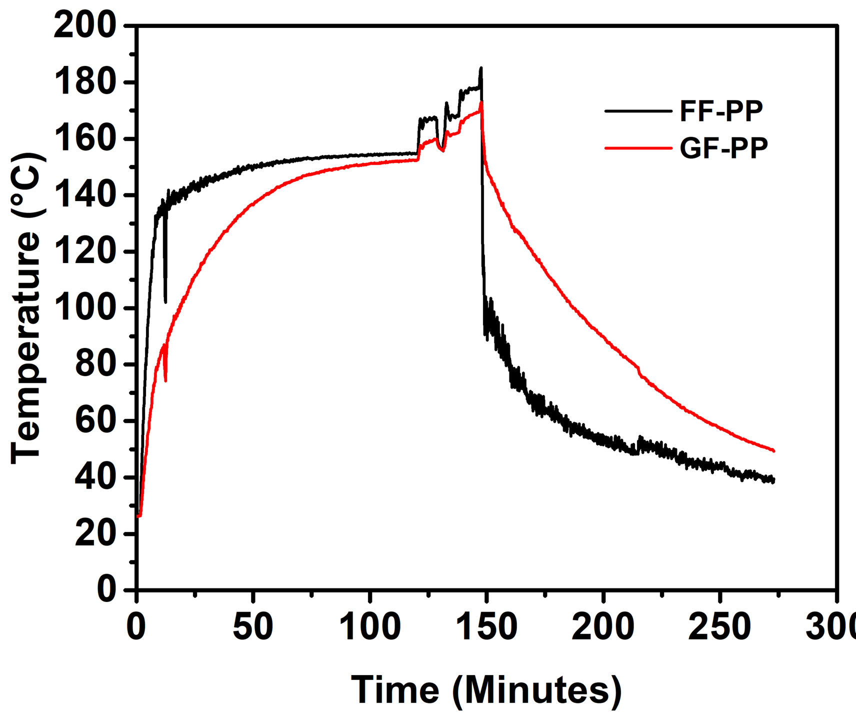
- 34% Flax Fiber, 66% Polypropylene (FF-PP), 4x4 twill weave
- 45% Glass Fiber, 55% Polypropylene (GF-PP), 2x2 twill weave

Deconsolidating

- Placed inside Instron oven, raised temperature to 205℃ and waited for sample to reach 170℃ using a thermocouple attached to the samples
- After reaching 170℃, the oven was shut down and samples were naturally cooled down to 50℃

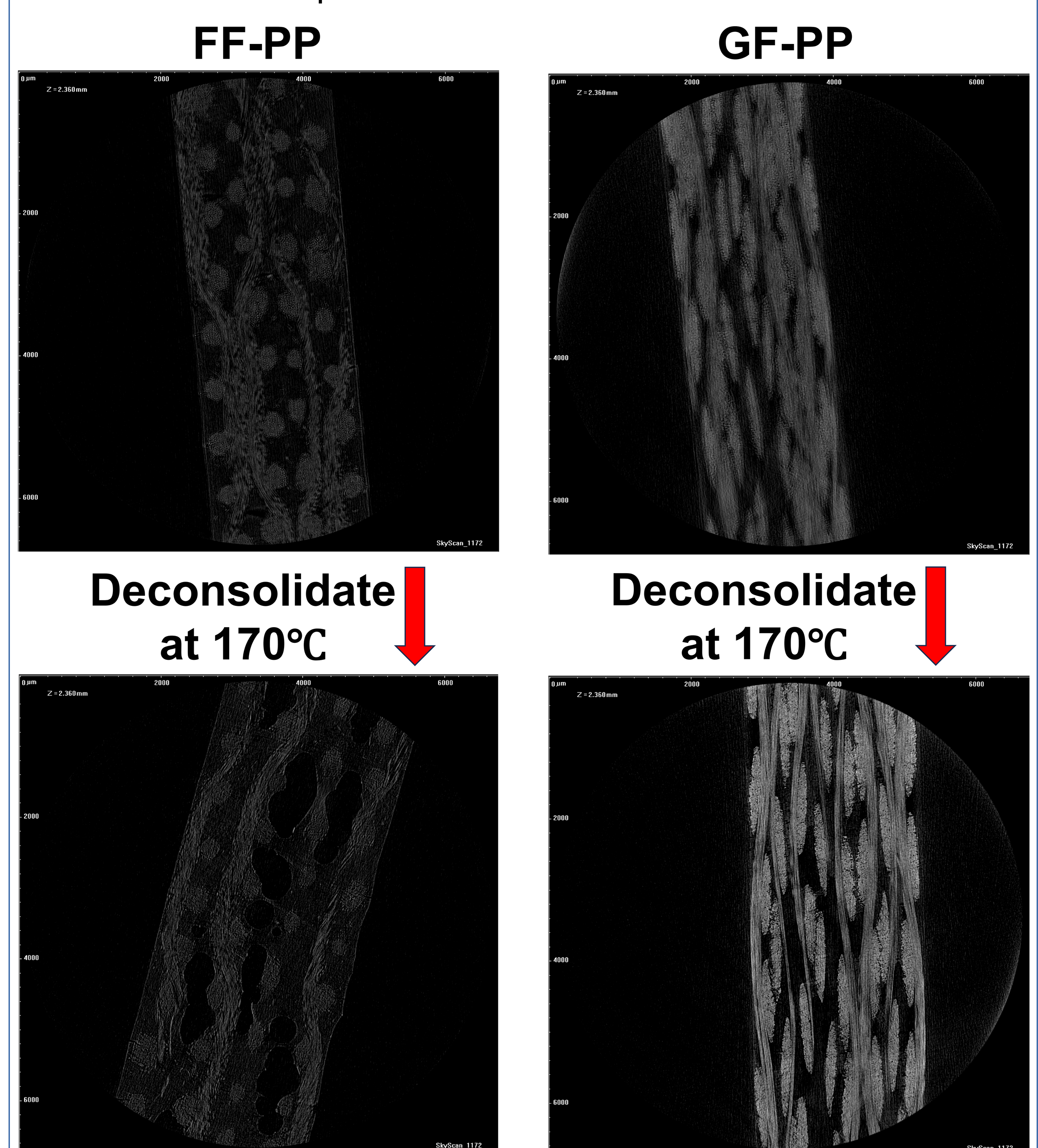


- Flax fiber took less time to heat up to 170℃ and less time to cool down to 50℃ compared to glass fiber



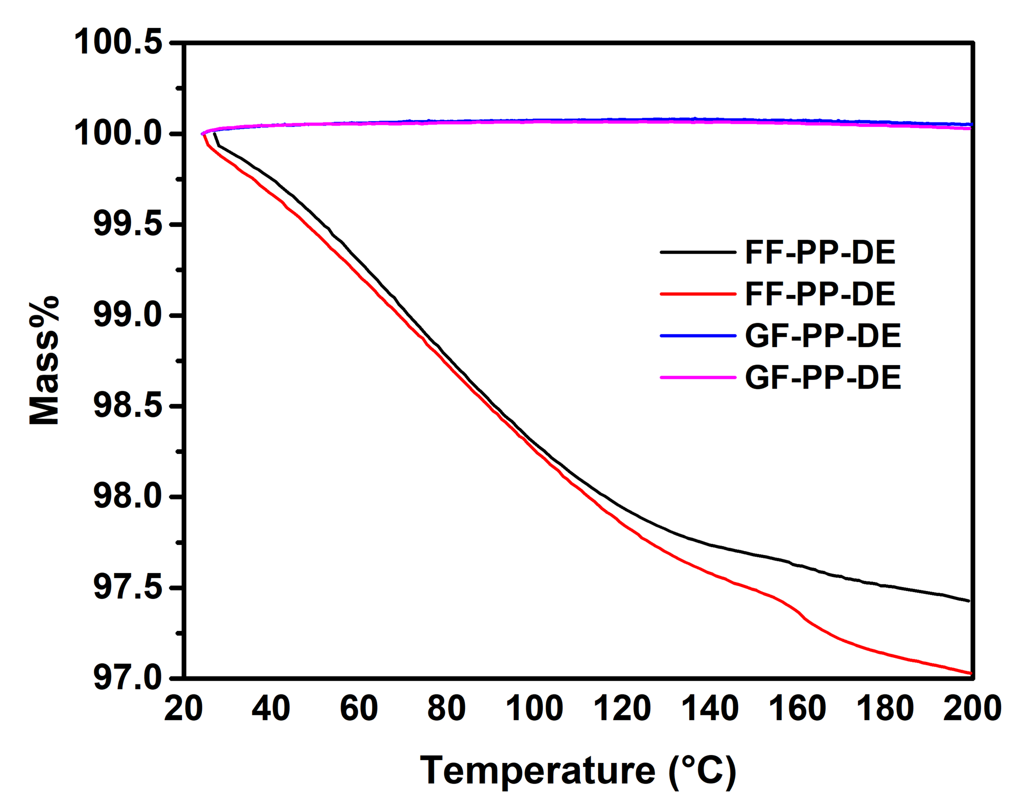
Micro-CT images

- FF–PP settings: 55 kV, 0.5 mm filter, pixel size 1.7 μm
- GF-PP settings: 100 kV, Al + Cu filter, pixel size 1.7 μm



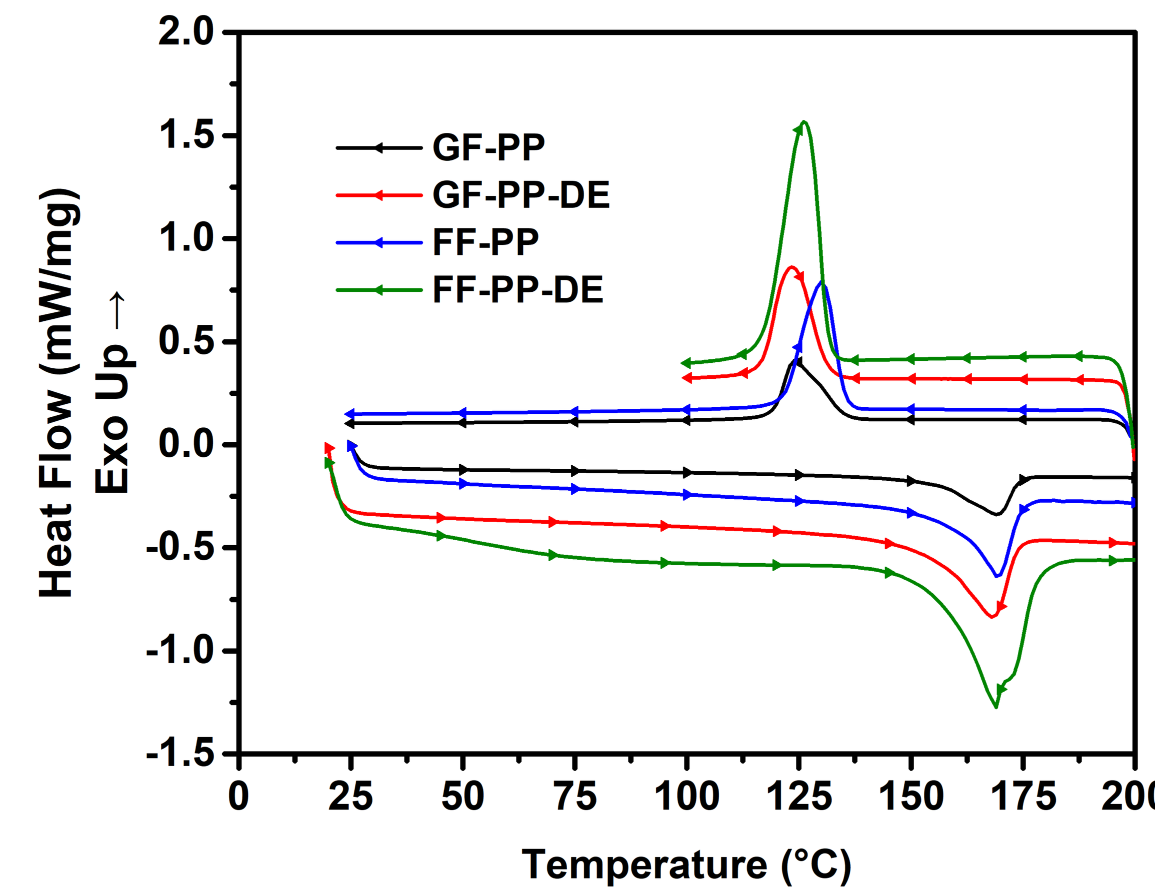
TGA

- Samples cut to fit inside TGA crucible
- A ceramic crucible was first weighed by itself, and then the TGA sample was weighed and inserted
- Started at 25℃, raised to 240℃ at 5 $\frac{K}{min}$
- Protective, purge air gas outputted at 20 $\frac{ml}{min}$



DSC

- Samples were cut to fit inside a 25 μl aluminum DSC crucible
- DSC crucible was first weighed by itself, a hole was poked in the middle of the lid, and then the DSC sample was weighed by itself
- Started at 20℃, raised to 200℃ at 10 $\frac{K}{min}$, and then cooled to 100℃ at 10 $\frac{K}{min}$
- Nitrogen purge, air purge, and nitrogen protective gasses outputted at 250 $\frac{ml}{min}$



- The average melting/crystallization temperature, and % crystallinity (X_c) were found for the 4 DSC trials each done for FF-PP, GF-PP, and their deconsolidated counterparts

$$X_c(\%) = \frac{\Delta h_m(PP) - \Delta h_{cc}(PP)}{\Delta h_l(PP)} \times \frac{100}{w_{PP}}$$

Sample	Average Crystallization Temperature	Average Melting Temperature	Average % Crystallinity
FF-PP	130.05 ± 0.10	169.63 ± 0.17	47.34 ± 1.78
FF-PP-DE	127.30 ± 0.78	168.93 ± 0.54	52.39 ± 2.48
GF-PP	123.83 ± 0.26	169.58 ± 0.37	43.71 ± 1.66
GF-PP-DE	123.10 ± 0.37	168.03 ± 0.39	44.76 ± 3.39

Conclusion

- TGA results showed FF-PP-DE samples had mass loss, which could be attributed to water loss, while GF-PP-DE samples showed no mass loss.
- Micro-CT images shows more visible voids in FF-PP-DE than GF-PP-DE
- Deconsolidation increased % crystallinity while decreasing the melting temperature

Path Forward

- Conducting same procedure on different fiber volumes to validate the relationship between flax and glass fibers
- Conduct the same procedure on different sample areas (i.e., edges, middle, corners, and anywhere in-between) to study deconsolidation at different boundary conditions
- Use an image processing software to quantify voids
- Ensure isothermal heating when doing deconsolidation
- TGA trials on consolidated GF-PP and FF-PP to see correlation of mass loss before and after deconsolidation

References

- [1] M. Längauer et al., Influence of thermal deconsolidation on the anisotropic thermal conductivity of glass fiber reinforced, pre-consolidated polypropylene sheets used for thermoforming applications, https://onlinelibrary.wiley.com/doi/epdf/10.1002/jcp.27833 (accessed Jul. 31, 2024).
- [2] M. Brzeski , Experimental and Analytical Investigation of Deconsolidation for Fiber Reinforced Thermoplastic Composites, https://kluedo.ub.rptu.de/frontdoor/deliver/index/docId/5498/file/_Diss+Brzeski+komplett+f%C3%BCr+Kluedo.pdf (accessed Jul. 31, 2024).

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