CLOSED LOOP RECYCLING OF CFRP INTO HIGHLY ALIGNED, HIGH PERFORMANCE SHORT FIBER COMPOSITES USING THE *TUFF* PROCESS: FIBER RECOVERY THROUGH PYROLYSIS

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Introduction

• Producing carbon fibers is expensive and energy intensive process but the use of carbon fibers is increasing every year. Despite this increase, the biggest problem is the production cost of virgin carbon fiber (vCF).

• Recovery solutions are available to recycle fibers from composite scrap. For this, pyrolysis involving decomposition at high temperatures was used.

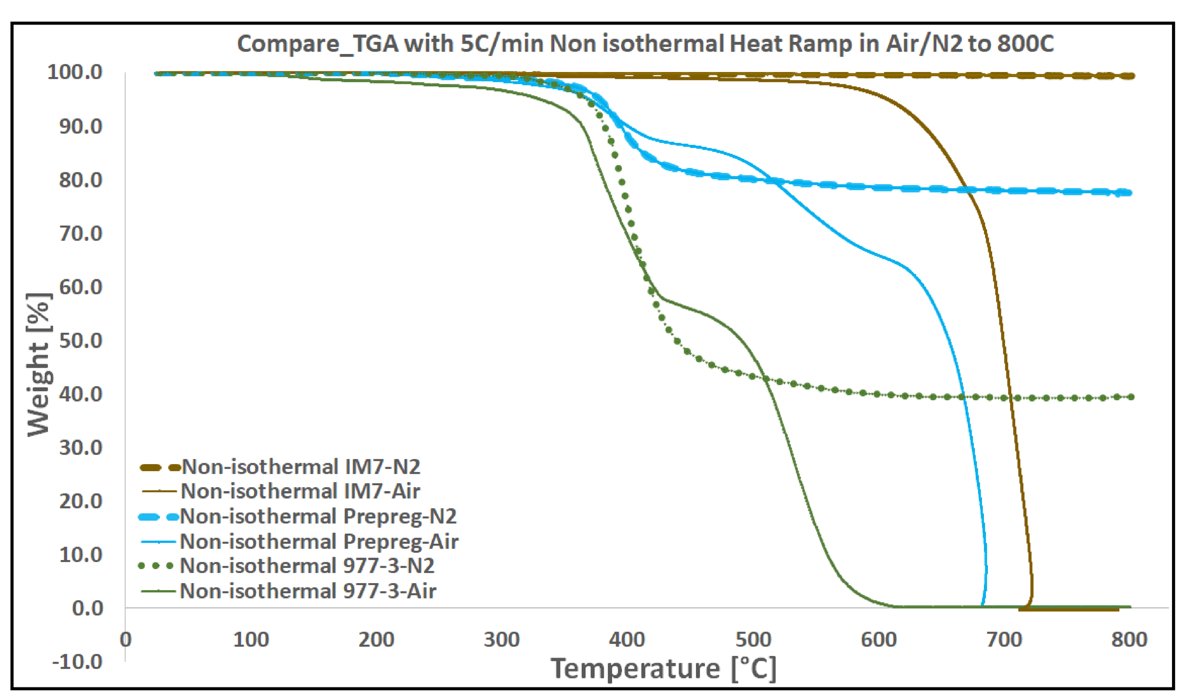
• Recovered fibers must exhibit high: Modulus and Strength Retention

• Goal is to retain high carbon fiber properties, and to use fibers in the Tailored Universal Feedstock for Forming (*TuFF*) panel.

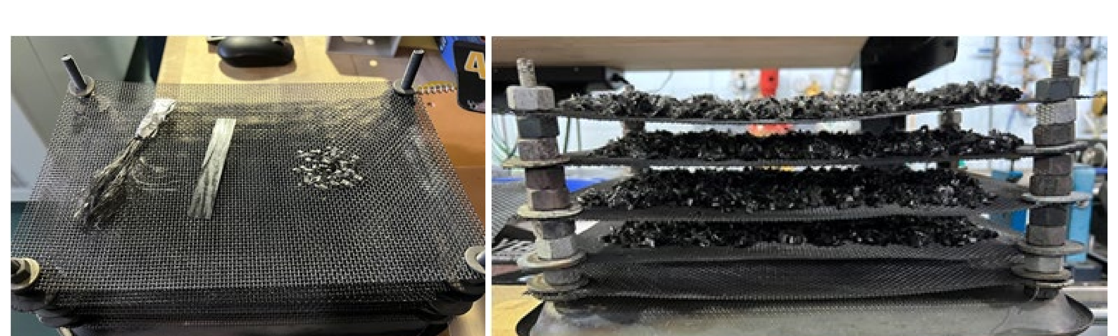
Materials and Methods

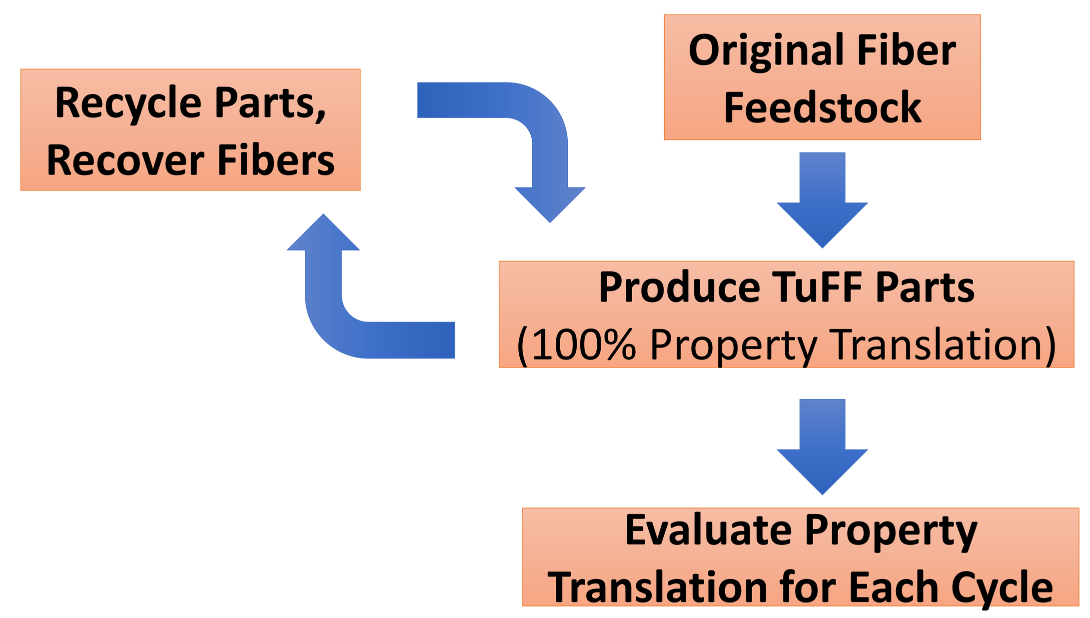
Materials used are:

- ❑ *IM7 carbon fiber*
- ❑ *977-3 toughened epoxy resin*
- ❑ *Cycom IM7/977-3 prepreg*



• GLO Furnace was programmed to heat to 500C at 5C per minute under a nitrogen environment, dwell for 4 hours before air was added to completely oxidize the resin material.

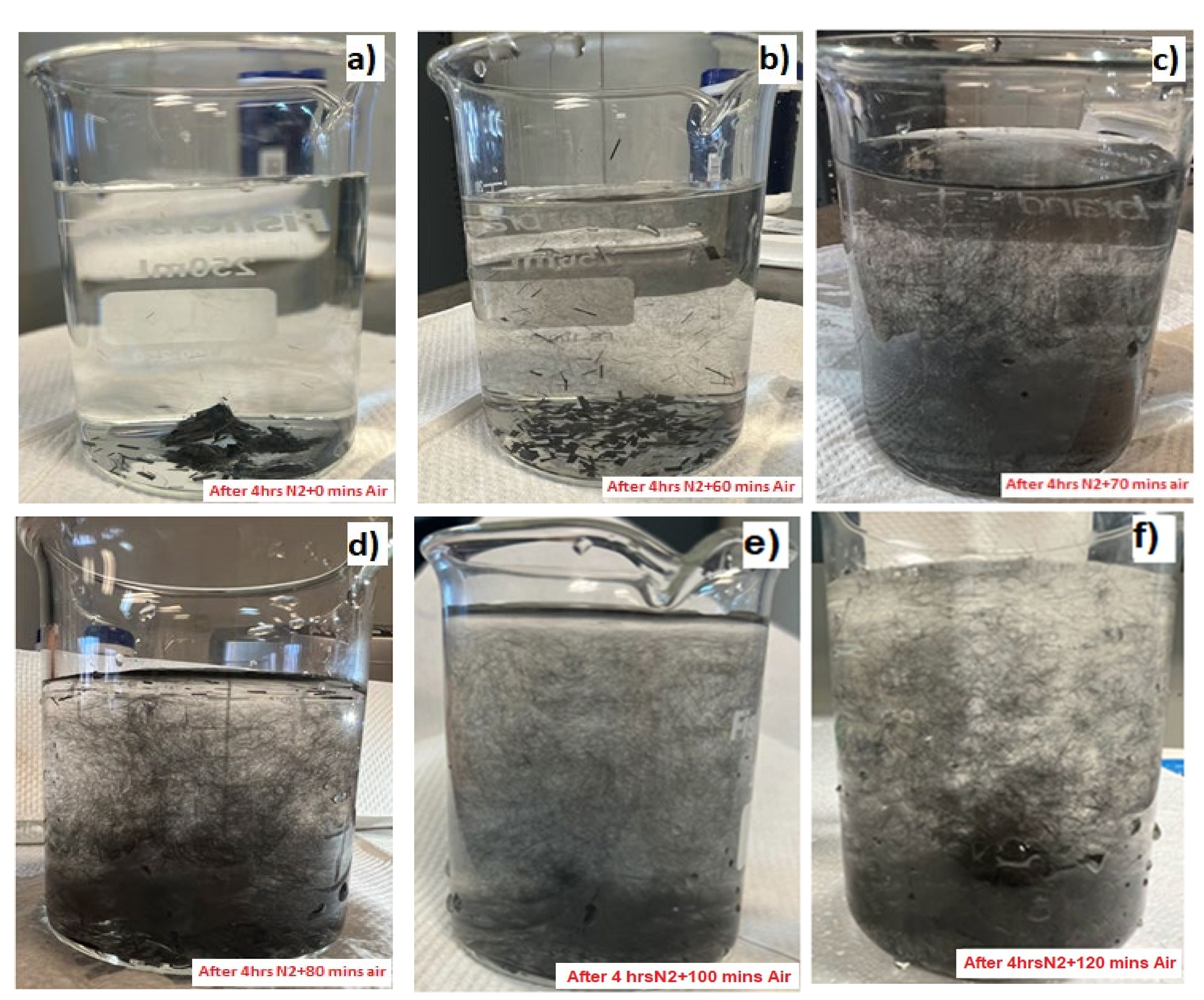




- Short carbon fiber is used in *TuFF* process
- *TuFF* material is pyrolyzed so fibers are recovered.
- Quality of the carbon fiber obtained may vary according to the applied parameters.
- Carbon fibers are again passed through the *TuFF* process so the process is repeated.

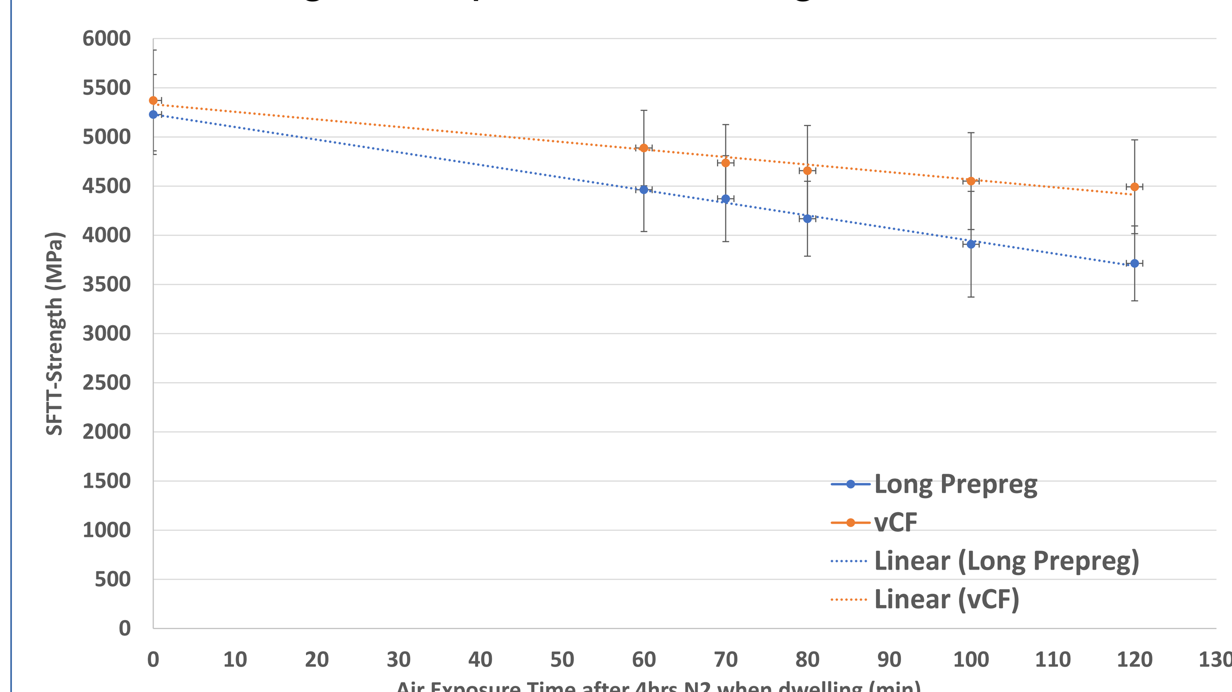
Results and Discussions

- TGA results have shown a polymer content of 35% in the prepreg. 18.76% weight loss for long prepreg and 21.02% weight loss for short prepreg are achieved after the 4hrs nitrogen dwell has finished.
- Good dispersion of the recycled fiber material can be seen in Figure c-f. Here, the material is broken up consistently into the filaments, which is a requirement for good alignment in the *TuFF* process.

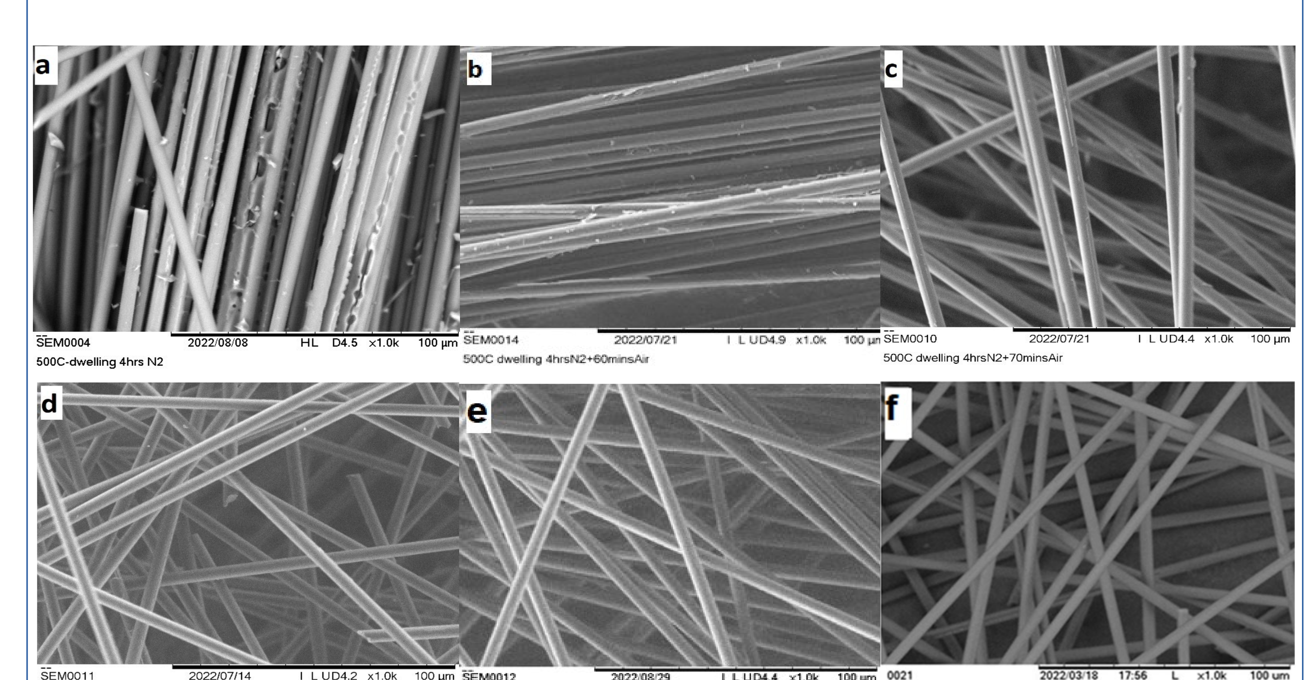


	Air Exp. Time	Mass Retention (%)		
		vCF	Long Prepreg	Short fiber
dwell 4hrs N2+	0	98.95	81.24	78.98
	60	97.91	68.67	67.29
	70	97.84	65.93	65.86
	80	97.92	65.31	65.37
	100	97.72	65.41	65.54
	120	97.59	65.33	65.49

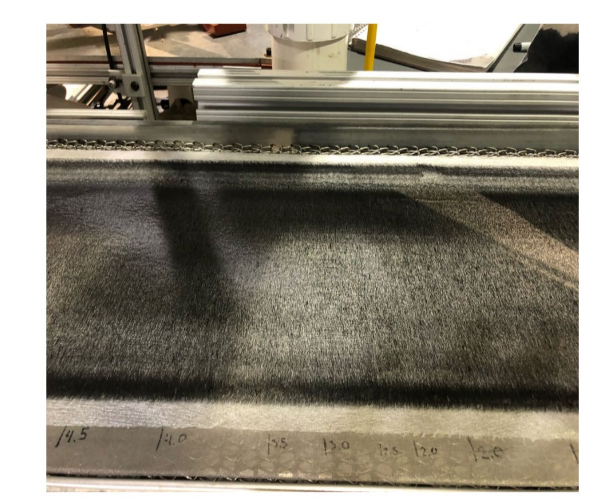
- The fibers didn't degrade after the nitrogen step but air exposure reduced strength significantly.
- At the air exposure of 70 min, which is required for good dispersion, fiber strength of the recovered virgin and prepreg fiber material has been reduced to 4735 MPa ± 782 MPa and 4372 MPa ± 874 MPa, respectively. This is a 15.4% and a 21.9% reduction in fiber strength compared to the virgin fiber material.

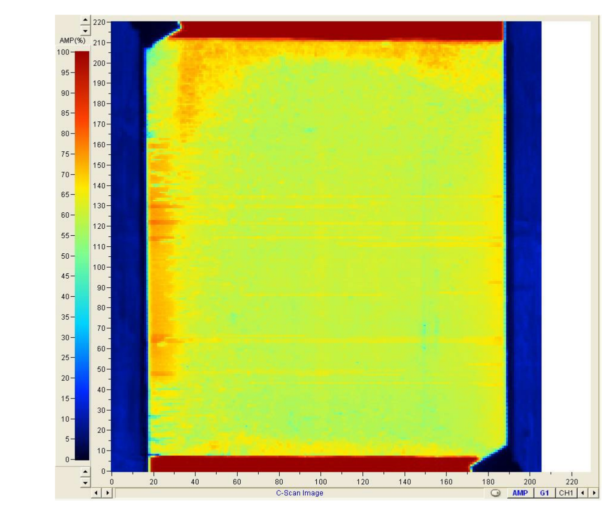


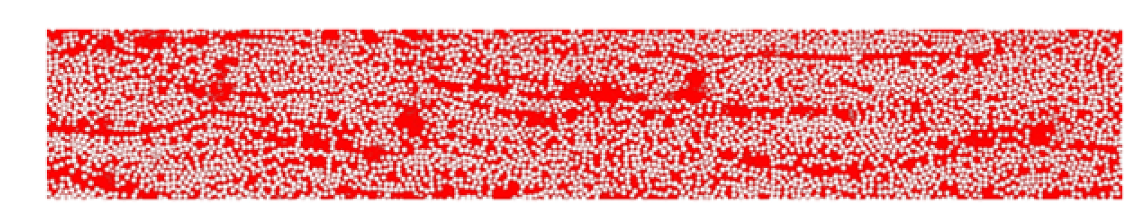
- SEM of the different minutes 0(a), 60(b), 70(c), 80(d), 100(e) and 120(f) exposure under air. Much of the polymer content is gone, but some smaller polymer volume remains which adheres individual fibers together. Finally, after an air exposure of 70, 80, 100 and 120 minutes all polymer content has been eliminated which allows good separation of the individual filaments during dispersion. However, after 60 minutes in air, prominent resin residues were still observed on the fiber surfaces.



- Fibers after 120 mins air exposure were aligned in the *TuFF* process, alignment quality of the produced sheets were good indicating good dispersion of the fibers in the mix tank.
- Ultrasonic C-scan evaluated overall quality uniformity and a microscopic sample evaluated microstructural properties. No significant porosity is observed in the sample and calculated approximately 48.5% fiber volume fraction in the sample. The high fiber volume fraction (FVF) is enabled by good alignment allowing superior packing efficiency compared to random mats typically used when recycled fiber material is processed.







Tensile strength 126 ksi±9.6 ksi and tensile modulus of 18.6 msi±0.702 msi was measured. This indicates full stiffness translation compared to virgin continuous fiber prepreg material from the Hexel datasheet is 129 GPa (normalized to 48% FVF).

Acknowledgements

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TuFF Tailored universal Feedstock for Forming