Circular Economy of Composites enabled by TUFF Technology

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Carbon Fiber Composites (CFCs) recycling is in its infancy as an industry in the US with the key challenges being 1) the ability to recover both the fiber and polymer content, and 2) conversion of the recycled material into high-value CFC without significant property loss, reducing original embodied energy and cost. The University of Delaware - Center for Composite Materials (UD-CCM) will team up with members of the BOTTLE consortium including the National Renewable Energy Laboratory (NREL) and Colorado State University (CSU) to address these challenges, and develop and demonstrate a novel CFC recycling process. NREL and CSU will develop the fiber/polymer separation and depolymerization process and UD-CCM will demonstrate CFC processing of the recycled discontinuous fiber content using the *T*ailorable *u*niversal *F*eedstock for *F*orming (*TuFF)* process allowing full property translation. We will engage our industry members (Arkema, Axiom, Composites Automation (CA)) to provide the waste CFC, support material production, evaluate our recycling process and transition opportunities to commercial material forms and applications. The transformational benefits of our novel material and process solution are the ability to

1) ***Separate the CFC polymer and fiber content with catalyst and fiber recovery (NREL lead)***
2) ***Demonstrate a new class of recyclable by-design polymers (CSU lead)***
3) ***Process the recycled carbon fiber content into high-performance CFCs (UD-CCM lead)***

The EERE funding will support the development of new recycling concepts and demonstration of ***multiple*** recycling iterations with the *TuFF* process while maintaining near full property translation (we target 95% strength and modulus retention after each cycle). Our approach will meet/exceed the FOA stretch targets of 70% energy saving after 3 recycling iterations with 85% carbon utilization. The approach presents a compelling pathway to save energy and cost allowing recycling and not down-cycling of composites for the first time. Techno-economic analysis and life-cycle assessment will support the evaluation and show that the Green Economy for composites is feasible with the proposed approach.

The opportunity is to reduce material cost and lifetime-embodied energy through reclamation of CFCs at the end of product life with improved properties and cost compared to competing technologies. We intend to capture both the environmental and economic value of the CFRP recycling value chain in our approach. A successful implementation would result in reduced waste and smaller burden to landfills, lower material cost for CFC leading to new lighter weight automotive (and other industrial) applications reducing fuel consumption and greenhouse gas emissions, and provide new manufacturing jobs in the US where most of the CFC scrap material is available. Each of these aspects has an economic and environmental value. Our recycled CFC solutions will result in near full property translation after recycling/waste recovery and allow direct replacement of virgin material. This would create market acceptance beyond the environmental benefit and would allow long-term sustainability and growth of the technology and industry.