Pacific Northwest NATIONAL LABORATORY

PNNL-36253

Wholly Sustainable, Cost-Effective Carbon Fiber-Nylon Compounds (CRADA 592) Final Report

June 2024

Khaled W Shahwan
Kevin L Simmons

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
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Richland, Washington 99354

Cooperative Research and Development Agreement (CRADA) Final Report

Report Date: June 2024

In accordance with Requirements set forth in the terms of the CRADA, this document is the CRADA Final Report, including a list of Subject Inventions, to be provided to PNNL Information Release who will forward to the DOE Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research. **PNNL acknowledges that the CRADA parties have been involved in the preparation of the report or reviewed the report.**

Parties to the Agreement:

Battelle as Operator of Pacific Northwest National Laboratory ("PNNL")

DowAksa USA LLC

CRADA number: **592**

CRADA Title: **Wholly Sustainable, Cost-Effective Carbon Fiber-Nylon Compounds**

Responsible Technical Contact at DOE Lab (PNNL): Khaled W Shahwan

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Sponsoring DOE Program Office(s): Assistant Secretary for Efficiency and Renewable Energy

Joint Work Statement Funding Table showing DOE funding commitment:

	Funding Amounts			
CRADA Parties	**DOE Funding**	**Funds-In**	***In-kind**	**Total**
Participant(s)			$500K	$500K

DOE Funding to PNNL	$500K	N/A	N/A	$500K
Total of all Contributions	$500K		$500K	$1M

Provide a list of publications, conference papers, or other public releases of results, developed under this CRADA:

Because of the project's early termination and engagement's short duration no products were developed, and no technology transfer will be needed. No publications or conference papers were generated as a result of this short engagement. No future publications or conference presentations will be developed. No intellectual property including subject inventions, patent applications, copyright applications, copyrights, trademark applications, and trademarks were conceived or developed. The short and limited engagement focused on discussing existing material systems and potential industrial applications within the automotive industry. No commercial products, internet sites, data or databases, physical collections, audio or video, software, models, educational aid or curricula, and instruments or equipment were conceived or developed.

Provide a detailed list of all subject inventions, to include patent applications, copyrights, and trademarks:

No subject inventions were generated under this CRADA.

Executive Summary of CRADA Work

Carbon fiber composites have attracted considerable attention due to the potential for substantial mass savings, with many examples now implemented in the low-volume luxury car market. However, migration to higher volume applications has been hindered by: (a) high material cost, (b) high processing times, and (c) perception of low Sustainability. This project will address all three of these barriers: (a) carbon fiber material to replace aluminum in structural components at a cost penalty of no more than $5/Kg-saved (aka weight buy), (b) fitting into high-rate processes for automotive production like injection molding, and (c) end-to-end Sustainable material – based on post industrial waste carbon fiber and nylon 66 and ability to recycle end-of-life auto parts. The opportunity lies in combining DowAksa capabilities in carbon fiber manufacturing, resin chemistry intermediate production with the unique testing capabilities inherent within PNNL.

The teams from PNNL and DowAksa held several meetings virtually and in-person in Michigan and at PNNL, including a lab tour at PNNL. Throughout, the teams discussed DowAksa material sources, commercially available recycled base materials, and preliminary material properties. The teams also engaged in multiple discussions and evaluations of potential automotive applications based on the ideas suggested by PNNL. The teams discussed several potential automotive applications in which recycled carbon fiber and recycled PA resin can be used. The PNNL team identified 38 cast aluminum components that can potentially be assessed for redesign using the DowAksa materials system. The PNNL team also identified 27 polyamide components. The teams discussed the lists and narrowed it down to a handful of applications that are exterior and interior to common vehicle architectures. The team also considered semi-structural and structural components and short-listed the highest potential candidates, such as cross-car-beam. The cross-car beam was considered to be highly suitable and potentially viable demonstration applications based on the properties of the materials as well as the weight savings potentials and the reduction in embodied energy by utilizing wholly sustainable materials, since both materials, carbon fiber and resin, were derived from recycled materials.

The next step was to reach out to potential OEMs and/or Tier1s who were interested in exploring such technology for future applications. However, the project was terminated, and no further discussions or exchange of information took place. No new data were generated, including no IP and no publications.

Summary of Research Results

The PNNL and DowAksa teams discussed several potential applications in which recycled carbon fiber and recycled PA resin can be used for automotive applications. DowAksa has proposed utilizing recycled carbon fiber and recycled polyamide (PA) resin as the base materials to develop fiber reinforced thermoplastic composites. The teams reviewed the materials properties specific to the particular recycled carbon fiber as well as those for a specific PA system (PA66). The materials data was generated by DowAksa based on their preliminary evaluations and characterizations.

Based on this information from DowAksa the PNNL team identified 38 cast aluminum components that can potentially be evaluated for redesign using the DowAksa materials system. The PNNL team also identified 27 polyamide (often called Nylon) components that are common in automotive applications. In general, albeit there are exceptions, most automotive applications that utilize PA tend to require higher thermal performance (e.g., close to heat source) than other common thermoplastics such as polyethylene (PE) or polypropylene (PP).

Based on PNNL's was aware that while an average 2021/2022 vehicle across the entire US fleet has about 50 lbs of PA66, it also has about 450 lbs of Aluminum. This implies that focusing on aluminum components will have a higher potential in achieving the project's goals and objectives especially since sustainability is a major driver.

The teams discussed the lists of all identified automotive applications and narrowed it down to a handful of applications that are exterior and interior to common vehicle architectures. The down selection process was driven by several criteria most of which are based on whether both lightweighting and sustainability would be impactful should a material change take place. The team also considered semi-structural and structural components and short-listed the highest potential candidates. Based on such discussions, the team identified cross-car-beam as the applications with the highest chance of having the most impact when switched from aluminum to recycled carbon fiber reinforced with recycled PA66. A cross-car bean is a structural component with often complex geometry that spans the width of the vehicle and attaches as bridge between the left and right sides of the vehicle at the lower side of the A-pillars and just behind the instrument panel (often called the dashboard). It is used as a primary structural support for two functions: vehicle overall lateral and torsional stiffnesses, and a support for many attachments and subcomponents.

The cross-car beam was considered to be highly suitable and potentially viable demonstration applications based on the properties of the materials as well as the weight savings potentials and the reduction in embodied energy by utilizing wholly sustainable materials, since both materials, carbon fiber and PA66 resin, were derived from recycled materials. It was also selected since manufacturing it could also consider a low-cost low-energy process (the team was to assess that as part of the project).

At this point the project was terminated, and no further activities took place. In addition, because of this termination the team was not able to proceed to the next step of evaluating the impact of the new material system towards the objective of the project.

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