Process for Recovery and Recycling of Polymer Matrix Composites

Carbon fiber reinforced polymer matrix composite (PMC) materials are exhibiting such high strength-to-weight ratios that they are finding increasing applications in the aerospace industry. They are also being evaluated as possible construction materials in the automotive industry. The major barriers to their widespread use is their high cost and concerns about whether they are going to be recyclable when the vehicles reach the end of their useful lives. With funding provided by the Department of Energy's Office of Advanced Transportation Technologies, Argonne is developing an efficient and cost-effective process to recover the high-valued carbon fibers.

The technical approach to process development consisted of 4 major stages. They are:

(1) Investigate and bench-scale test the potential methods for liberating the carbon fibers from the polymeric substrate. Three processes were investigated: thermal treatment, chemical treatment, and thermal shock. We also evaluated hybrid methods (thermal followed by chemical, chemical followed by thermal, and thermal treatment followed by ultrasonic separation).
(2) Test the most advantageous method at a larger scale and analyze its economics.
(3) Test PMC panels made with recovered fibers and compare their properties with similar virgin-fiber panels in order to establish the quality of the recovered fibers.
(4) Recover carbon fibers for re-use in an automotive application.

Fibers were recovered, using the thermal treatment process, from PMC panels that were supplied by Hexcel Carbon Fibers, Inc., and were made with known fibers and known substrates. The recovered fibers were evaluated by Hexcel and by ORNL. The recovered fibers had high shear strength and high O_2 on the fiber surfaces which indicate that the recovered fibers should adhere well to matrix resins without the need for additional surface treatment. This will save about $0.40/lb. of fibers. Surprisingly, some of the recovered carbon fibers exhibited

higher levels of elemental oxygen at and just beneath the fibers surface than do the cooresponding virgin fibers.

Hexcel used the recovered fibers to produce new PMC panels of equivalent dimensions and then compared the properties of these panels to the original PMC panels from which the fibers were recovered. The data showed a 10% reduction in stiffness, a 12% reduction in the short beam strength and a 50% reduction in strength and elongation relative to long-fiber panel applications. The reduction in physical properties is consistent with the difference in physical properties of oriented long-fiber panels relative to random orientation short-fiber panels. The physical properties indicate that the recovered fibers are suitable for use in chopped fiber applications.

Work conducted so far has demonstrated that the recovery of carbon fibers from PMC scrap is technically feasible and potentially economical. The recovered fibers have properties that make them usable in chopped fiber applications for making value-added products such as automotive, fuel cell, and battery parts.