Thermoset Composite Having Thermoplastic Characteristics

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Technology Summary

ORNL researchers have developed a thermoset composite that incorporates tiny cellulose fibers or crystals into a resin matrix to allow easier handling and processing of thermoset materials. The reinforcing cellulose fibers give body to the liquid polymer so it can be processed by methods similar to those used for thermoplastics. The new material allows a wider range of applications for thermoset materials, which are more durable and resistant to corrosion than thermoplastics. By making thermoset resins dimensionally stable, it will enable 3D printing of thermoset plastics.

A thermoset resin contains polymers that cross-link via chemical reaction when heated. The polymers then set, or cure, rapidly to form a solid that cannot be reshaped or remelted. Thus any shaping must be done before the thermoset solidifies. A thermoplastic resin is a solid polymer that softens when heated and hardens again when cooled. The process is reversible, and thermoplastics can be remelted and remolded repeatedly. The advantage of thermoset materials is that they do not deform in high-heat environments such as electronics and appliances. Thermoplastics are easier to process because of their flexibility, but they lose their shape when heated.

The ORNL innovation is a preparation and drying procedure that yields an appropriate nano- and microstructure and bulk density of cellulose fibers and crystals. Cellulose nanofibers are freeze-dried and chopped with a blade mill, producing fibrils about 100 nm in diameter and 1 micron long. From 3 to 20% fibrils and crystals are then formed into a compound with a liquid epoxy in a roller blade shear mixer. The fibrils' entangled structure and strong hydrogen bonding make them like tiny sponges that absorb the resin and hold it. The fibers give dimensional integrity and stability to the liquid, forming from a paste to a dough-like substance (depending on the concentration) that can be processed (i.e., molded or extruded) in a similar manner to thermoplastics to form an uncured, dimensionally stable component. The component can then be heated to cure it. The invention may make it possible to use thermoset resins for 3D printing at room temperature. (Also, larger-size cellulose fibers were included.)

Advantages

- High mechanical strength
- Excellent chemical resistance
- Scalability to large-area processes
- Adaptability to different thermoset resins
- Strong layer-to-layer adhesion
- High-quality surface finish

Potential Applications

- Injection molding
- 3D printing
- Compression molding

Patent

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Inventor Point of Contact

Soydan Ozcan
Materials Science and Technology Division
Oak Ridge National Laboratory

Licensing Contact

Eugene R. Cochran
Senior Commercialization Manager
Technology Commercialization
UT-Battelle, LLC
Oak Ridge National Laboratory
Office Phone: 865.576.2830
E-mail: cochraner@ornl.gov

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