ENABLING MORE RECYCLED RUBBER IN TIRES

Fundamental work to characterize micronized rubber powder yields a path toward increased recycled content in new tires.

Many new rubber tires on the market contain recycled rubber, but the amount is vanishingly small—less than 1 percent. Research conducted at tire manufacturer Michelin can change this and significantly increase the use of rubber recycled from scrap tires to manufacture new tires.

At Michelin, rubber recovered from used tires is cryogenically ground, a cost-effective process that yields powders with particle sizes in the hundreds of micrometers—not much thicker than a sheet of paper. This micronized rubber powder (MRP) is combined with virgin rubber to create a composite polymer material (CPM) that is used for new tires.

Higher levels of MRP can lead to a CPM with lower stiffness and higher hysteresis—energy loss from the tire rolling on the road—than a compound made exclusively of virgin rubber. These qualities increase heat buildup and lead to a decrease in the CPM's limit and fatigue properties. All these factors have a detrimental effect on tire reliability, durability, and rolling resistance.

Because of these issues, the use of MRP is limited today to between about 0.1% of the total amount of rubber for light duty tires and 0.4% for commercial vehicle tires. A project at Michelin aims to drastically increase this level, raising MRP reincorporation into new tires to about 12% for light duty vehicles and 15% for commercial vehicles without degrading tire performance or increasing manufacturing cost.

With research partner Northwestern University, Michelin has begun developing MRP specifications and tire designs that can incorporate more MRP into new tires. They did so by starting with a fundamental understanding of CPM micro-material properties and resulting physical properties.

PROJECT DESCRIPTION

This project had three objectives. The first was to characterize CPM samples at nanometer and micrometer scales. Specifically, the material analysis sought to characterize the local concentrations of chemical species, local stiffness distribution, and crosslink densities within the CPM and especially at the interface with the MRP. The CPM samples studied had MRP incorporation rates of 10, 20, and 30% by weight. They were formulated for tread, sidewall, and internal compounds—filler rubbers that do not come in direct contact with the environment—for both light duty and commercial vehicle tires. This characterization step was the key to the project's success and the main differentiating factor versus past work in the field.

The second objective was to develop sorting and grinding (i.e., particle size) specifications for MRP feedstock. The specifications indicate the feedstock composition that can allow the highest MRP incorporation without degradation in the CPM mechanical and physical properties.

Third, the team developed new CPM formulations and tire constructions that allow an incorporation of MRP ranging between 12% for light duty tires and 15% for commercial vehicle tires of the total amount of rubber that makes up the respective tires.

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To validate the product performance, the team used the new CPMs to fabricate 12 passenger and 12 truck tires in full-scale production equipment. The tires will be evaluated to determine tire endurance including mechanical, thermal, fatigue resistance, and rolling resistance relative to baseline new tires.

The project resulted in new CPM blends and tire construction concepts that could deliver comparable performance to tires made entirely of virgin material, but with higher percentages of recycled rubber.

PROJECT IMPACT

On an annual basis, this project could reduce the need for virgin rubber for new tires by 241,000 metric tons, save 21 PetaJoules of energy needed to obtain raw materials, and eliminate 407,000 metric tons of carbon dioxide emissions.

This work also provides the fundamental knowledge needed to manufacture composite materials with recycled rubber that can provide performance parity with products made out exclusively of virgin feedstock and may be extendable to applications other than tire rubber that presently develop composite rubber materials from virgin rubber.

NEXT STEPS

The project has resulted in promising chemistries and manufacturing specifications for CPMs that incorporate more MRP for tire manufacturing. Prototype tires incorporating the new CPM blends at various concentrations have been built. The prototype tires are undergoing endurance and rolling resistance testing. Future work will involve further projects to test increased MRP blends at pilot scale.

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