Tiny rubber balls give plastic bounce

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Automobile bumpers that deform and recover rather than crack and splinter, computer cases that withstand the occasional rough encounter, and resilient coatings that can withstand the ravages of the sun, may all be possible if tiny functionalized rubbery particles are imbedded in their plastic matrices, according to Penn State materials scientists.

"Plastics such as polypropylene, nylon, polycarbonate, epoxy resins and other compounds are brittle and fracture easily," says Dr. T.C. Chung, professor of materials science and engineering. "Usually, manufacturers take rubbery compounds and just mix them with the plastic, but there are many issues with this approach."

The problems include difficulty in controlling the mixing of the two components and adhesion between the plastic and rubber. Chung, and Dr. Usama F. Kandil, postdoctoral researcher in materials science and engineering, looked at another way to embed rubbery particles into a plastic matrix. They described their work today (Aug. 29) at the 230th American Chemical Society National Meeting in Washington, D.C.

The researchers used polyolefin ethylene-based elastomer, a very inexpensive stable rubber that withstands exposure to ultra violet radiation. This rubber is often used as the sidewall in many automotive tires. However, rather than simply produce micro particles of polyolefin, Chung and Kandil produce a core-shell particle structure with a tangle of polymerized polyolefin rubber forming a ball with functionalized groups hanging out like bristles.

"These functional groups can combine with the plastic and improve the adhesion of the rubber with the plastic," says Chung. The rubber particles embedded in other materials absorb some of the energy of impact. Rather than the brittle portion breaking on impact, the rubber parts deform and absorb the energy without breaking. Chung and Kandil believe if they can introduce the rubber particles into other materials, such as ceramics, the rubber would function in the same way, making resilient ceramics. Plastics and rubbers are both polymers, but have one significant difference. Plastics have relatively high glass transition temperatures – the temperature at which the materials cease being pliable and become brittle like glass. Rubbers, especially polyolefin, have very low glass transition temperatures.

"Tires never freeze above glass transition temperature," says Chung. "So the material is always in a pliable state at ambient temperatures. This can improve the toughness of any material."

The functionalized groups on the outside of the rubber balls can be tailored to join with any plastic or ceramic, solving the problems of adhesion found when using only untailored rubber particles. These core and shell particles range in size from 30 nanometers to 10 micrometers.

The researchers manufacture their tiny rubber balls in a one-pot procedure that causes the rubber components to cross-link into the shape of a tiny rubber ball with their functional groups intact. Addition of a surfactant – a soap-like compound – causes the polymers to entangle into a ball with some of the functional groups sticking out from the surface. By controlling the process, the researchers can control the size of the particles from micron-sized to nano particles.

The researchers have applied for a provisional patent on this work.

Source: Penn State

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