PENNSTATE

ONLINE
RESEARCH | PENN STATE

HOME ARCHIVES ABOUT SEARCH

january 2003 volume 24 issue 1

encyclopedia

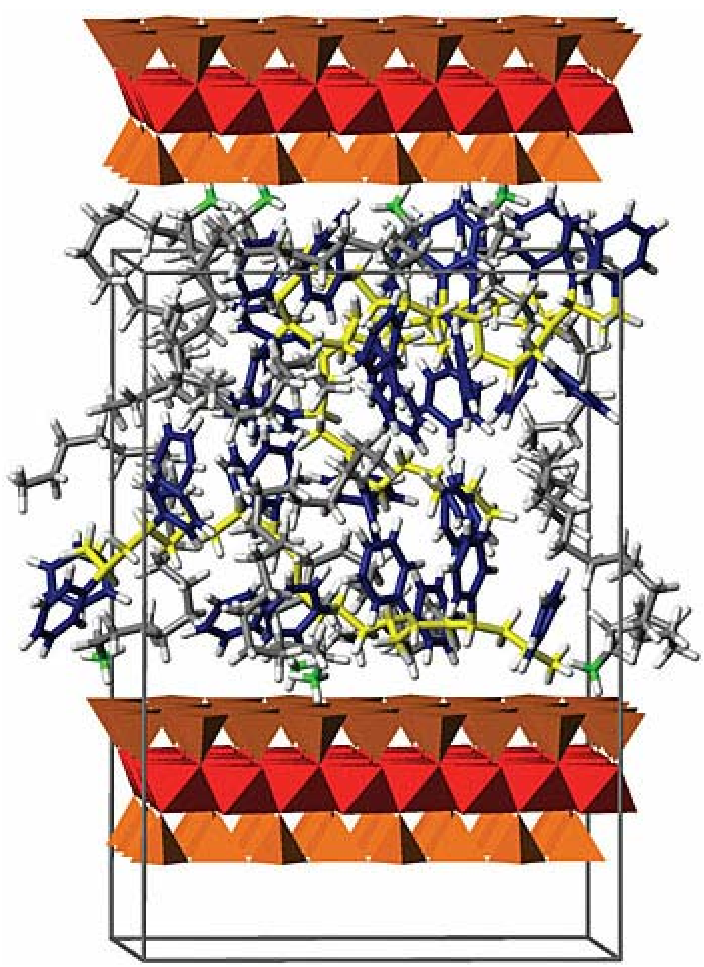
Clay into Plastic

Plastic is cheap. That's its niche. It's cheap and it's versatile, and so it is ubiquitous. But plastic, when it comes right down to it, is pretty mediocre stuff. Compared to metal, for example," says Evangelos Manias, "the material properties of polymers are poor."

For decades, researchers have worked at boosting these properties by adding "fillers" to plastic — small amounts of talc or glass or carbon to lend strength or resiliency. Now Manias, an assistant professor of materials science and engineering at Penn State, is working on a new type of additive: natural clays.

Clay particles, Manias explains, are exceedingly tiny, on the order of half a micron to a micron across and no more than three to five atoms thick. "When you disperse these particles in a polymer," Manias says, "they look like tiny sheets of paper." Taken together, thousands of these super-thin sheets add up to a whole lot of surface area. And all that interface makes a big impact on a polymer's properties.

The automotive industry was first to notice this effect. "About eight years ago, Toyota was looking to improve heat resistance in polymers so they could make cheaper car parts by replacing metal and ceramic casings with plastic ones," Manias says. "They started with nylon 6," a common industrial polymer that starts to soften at 60 degrees C. When they added 3 to 5 percent clay to the nylon, the composite material's heat resistance jumped to 140 degrees C — "good enough to make parts for under the hood."



Evangelos Manias

In addition to preserving strength at high temperatures, the addition of clay improves a plastic's barrier properties, i.e., its ability to hold gases and liquids in, or to keep them out. This effect has attracted the food-packaging industry. Adding clay, Manius says, could make cheap plastic bottles suitable for storing beer or wine.

Impermeable "packaging" is also needed inside your computer, he notes. ("Here, oxygen is not the big problem, water is. You don't want those chips to get wet.") And inside your body, as well. Manias is currently working with James Runt, professor of materials science and engineering, and researchers from the College of Medicine to improve the polymers used to construct the Penn State artificial heart.

The working principle for improved barrier behavior in these “nanocomposites,” he notes, is not chemical but physical. “When you add clay, you are adding thousands of tiny particles that these molecules have to go around” in order to pass through the polymer matrix. This molecular obstacle course, “elevates the barrier properties by at least ten times. And because the desired effects depend on particle size and surface area, rather than on chemical reactions, clays can be used universally. “They are not polymer-specific.

“The thing that nobody predicted,” he adds, “was the effect of clay dispersal on flame retardancy.” When burned, polymers shrink, and the clay particles inside them draw together to form a char, a tight seal which chokes a fire by keeping out oxygen. Clay could thus be a safer alternative to currently used bromine-based flame retardants, which release toxic gases as they burn.

“What excites people in the plastics industry the most is that with clays you can enhance a range of properties concurrently,” Manias says.

Right now, he and others are working hard to find the best and cheapest recipes for making the new composites. Clays and polymers don’t ordinarily mix, he explains.“They’re like oil and water.”

One approach is to add surfactants directly to the clay, a process already used for mixing clays into paints and cosmetics. Another would first modify the polymer.

Either method could be incorporated fairly easily into standard industrial plastic-making, Manias says. “But it’s a new field. We’re still working out the fundamental chemistry and physics.”

—David Pacchioli

Evangelos Manias, Ph.D., is Philip Walker assistant professor of materials science and engineering in the College of Earth and Mineral Sciences, 325-D Steidle Bldg., University Park, PA 16802; 814-863-2980; manias@psu.edu. His work is supported by the National Institute of Standards and Technology, the National Science Foundation, the National Institutes of Health, and the Federal Aviation Administration.