

Clay reduces permeability of biomedical polymer

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A compound used in cosmetics and food supplements may help make artificial heart device polymer parts less permeable to air and water, according to a team of Penn State researchers.

"The polymers used for various parts of artificial heart devices are somewhat permeable to air and water," says Dr. James Runt, professor of polymer science. "We decided to look at two methods for decreasing permeability – a chemical method and a nanocomposites approach." The methods tried used a poly (urethane urea) polymer similar to that already used for the pumping chamber, cannula and compliance chamber in the Arrow LionHeart™, a left ventricular device developed by Arrow International and Penn State, and earlier heart devices developed at Penn State. In the current devices, air inside the compliance chamber helps in the pumping, but over time, the air seeps through the polymer wall of the chamber into the body and dissipates. The air has to be periodically replaced. The polymer used is also permeable to water, and care must be taken so that the electronics in artificial heart devices remain dry.

The chemical method took the standard polymer and attached polyisobutylene chains to it to form a comb like structure. The hope was that these combs would create a barrier for air and water. The researchers incorporated up to 35 percent by volume polyisobutylene into the poly (urethane urea). The resulting polymer had good mechanical properties, but has not been tested for fatigue resistance.

"Creating these copolymers was relatively difficult and only achieved a factor of two improvement in permeability over the original polymer," Runt told attendees at the 222nd American Chemical Society annual meeting in Chicago today (Aug. 26). "It involved quite a bit of work with only a modest return."

Turning to an alternative solution to the problem, the researchers looked at a commercially available silicate clay, cloisite 15A, produced by Southern Clay Products. This clay, which is approved for use in cosmetics and food supplements, is an alkyl ammonium modified montmorillonite. When the tiny constituent silica layers are mixed with the polymer in a common solvent, they disperse throughout the solvent and when the solvent is removed, the layers remain distributed to some extent.

"With an addition of 20 percent by weight of this modified silicate, we achieve a decrease in permeability of a factor of five," says Runt. "This method is much more convenient than the chemical method and produces a far greater decrease in permeability."

The layers distribute through the polymer either as tiny stacks or as minute random placements of layers. The layers effectively block many of the paths through which air and water can migrate through the polymer.

The addition of the modified silicate does produce some stiffening and enhances strength. But, unlike conventional composites, the nanoparticles do not decrease ductility. This nanocomposite polymer has also not been tested for fatigue resistance.

The research team included Runt; David M. Weisberg, graduate student in materials science; Ruijian Xu, post doctoral fellow; James T. Garrett, recent Ph.D. in materials science; Evangelos Manias, assistant professor of materials science; Alan Benesi, department of chemistry, all at Penn State's University Park campus; Alan J. Snyder, associate professor of surgery and bioengineering; Gerson Rosenberg, professor of surgery and bioengineering; and Christopher Siedlecki, assistant professor of bioengineering and surgery, all at Penn State Hershey Medical Center; and Bernard Gordon, currently at Polymer Chemistry Innovations, Tucson, Ariz..

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