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NEW PROCESSING TECHNIQUE IMPROVES MANUFACTURE & OPENS NEW APPLICATIONS FOR HIGH-PERFORMANCE POLYIMIDES

A new chemical technique for producing high-performance polyimide materials may make the widely-used polymers easier to process, expanding their use as coatings and opening up new potential applications.

Polyimides are used extensively in electronics manufacture and high-performance aerospace composites. Their high strength, ability to withstand high temperatures and immunity to moisture make the materials valuable -- and difficult to process, especially in coating applications.

"The factors that make the polyimides desirable as materials also make them very difficult to process," explained Dr. Laren M. Tolbert,



Dr. Laren Tolbert shows model of a polyimide molecule being manufactured through a new process which offers more flexibility. (Color/B&W Avail.)

professor of chemistry at the Georgia Institute of Technology. "They are very good vapor barriers and they are very tough polymers. These factors also mean they are insoluble and don't flow or process well."

Polyimides obtain their desirable properties from rings of atoms linked in a series. Existing production techniques begin with polyamic acid, a pre-polymer which already

contains the rings. The polyamic acid is applied where desired and then cured by heating to approximately 170 degrees Centigrade (about 340 degrees Fahrenheit).

The curing releases water vapor, however, which can leave pinholes that compromise the protection of the coating. Release of the

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water vapor also limits some potential uses for the material.

Tolbert and colleague Zhanqi He set out to develop precursor materials that could be combined chemically to produce polyimides through an alternative process. Their alternative technique chemically links shorter components in the precursors to produce the strong polyimide chains.

"We wanted to take these oligomers, these short chains, and link them together by a reaction that itself creates a link that is identical to the one in the innate polymer," Tolbert explained. "When you are done with the reaction, in principle you can't tell where the polyimide was linked because the link has disappeared into the chain."

Tolbert and He used a technique known as Diels-Alder polymerization to combine precursor materials they developed. Curing the combined precursors produces small amounts of sulfur dioxide, but no water vapor, Tolbert said.

In use, the precursor materials would be mixed together, then spread as a coating on an electronic component or laid up as part of a composite structure. The coating would then be heated to induce curing, or subjected to the normal consolidation process used for composite components.

"The main advantage is that this technique provides a way of curing polyimides without having to use the pre-polymer," Tolbert explained. "You could cure a resin that would contain all of the components you needed. You could also cure a layered structure by putting it into the press and heating it to cause the reaction to occur without worrying about the evolution of water."

Preliminary testing shows the polyimide produced through the precursor technique possesses thermal stability comparable to conventionally-produced materials. Tolbert hopes to obtain additional funding to study other important characteristics of the material.

"We don't know at the present time whether the other properties are as desirable," he said. "In principle, it should process well, but we still don't know that yet."

Because the process involves creating two separate precursor chemicals, it is more

complex than traditional polyimide production techniques. For that reason, polyimide produced through Tolbert's process would be more expensive.

"For a high-volume application where material expense is a major component, this could be a problem," he noted.

Tolbert believes the technique may also be applicable to other high-performance materials that share the same processing difficulties as polyimides. He hopes to study additional applications for the precursor and chemical combination techniques in the future.

Chemists have tried other approaches for making the polymer chains from shorter components. Most of those efforts, Tolbert noted, created chains with weak links whose performance could not match that of the conventionally-produced material.

The work grew out of a long-term interest Tolbert had in the Diels-Alder process, which he believes may find more uses in the future: "Because I have been interested in the reaction and had been doing some work over the years, I had been thinking about applications in polymers."

Information about the work was presented to the Spring meeting of the American Chemical Society in San Francisco in April. A paper is being prepared for submission to the journal Macromolecules. Sponsorship for the research came from Georgia Tech's Polymer Education and Research Center.

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