Researchers Get TURI Funding to Develop 'Greener' Materials

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Will Lead to Safer Products for Workers, Consumers

UMass Lowell researchers are trying to come up with more eco-friendly alternatives to toxic materials used in industry, such as formaldehyde, above, which is a known irritant and cancer hazard.

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By Edwin L. Aguirre

Three faculty researchers — Assoc. Prof. Zhiyong Gu in Chemical Engineering, Asst. Prof. Christopher Hansen in Mechanical Engineering and Assoc. Prof. Ramaswamy Nagarajan in Plastics Engineering — were recently awarded academic research grants by the Toxics Use Reduction Institute (TURI) totaling nearly $64,000 to develop environmentally friendly alternatives to hazardous materials currently used in industry.

Gu is trying to create a new type of lead- and halogen-free "nanosolder paste" for use in next-generation electronics assembly and manufacturing of computers, cell phones, automobiles, satellites and medical devices such as heart pacemakers.

Hansen's project aims to reduce or eliminate styrene, which is classified as a carcinogen, in polyester resins used in composite-manufacturing applications, ranging from massive wind turbine blades to boat hulls, pools, tubs and showers.

Nagarajan's research involves using naturally occurring sugars to replace formaldehyde, a known irritant and potential cancer hazard, in phenolic resins used in wood adhesives, laminates and coatings and bonded and coated abrasives.

Established in 1989, UMass Lowell-based TURI provides resources and tools to help make Massachusetts a safer and more sustainable place to live and work by collaborating with businesses, community organizations and government agencies to reduce the use of toxic chemicals, protect public health and the environment and increase competitiveness of Massachusetts businesses.

Getting the Lead Out

Solder paste, a key material used in electronics assembly and packaging processes, may contain lead and halogens, which can be released at the factory and at home before finally ending up in landfills.

Gu and chemical engineering postdoctoral researcher Fan Gao are using the TURI grant to create a nanosolder paste based on lead-free nanosolder particles and halogen-free solvents.

"The use of nanoparticles can make the assembly processes more energy-efficient," notes Gu. "We want to scale up our experiments so we can identify the nanosolder paste's potential industrial applications."

Gu says the majority of the TURI funds will be used to support graduate student Evan Wernicki, who will conduct most of the experiments. The rest of the money will be used for lab supplies and materials characterization costs.

Last year, the National Science Foundation (NSF) awarded a $460,000 grant to Gu and his collaborators at UMass Lowell and the State University of New York, Binghamton, to study single nanowires and dispersed nanosolder particles (not in paste form) and to develop nanosoldering techniques for joining and bonding electronic components measuring only billionths of a meter in size.

Working Toward a Styrene-Free Environment

"Our research will use alternate, low-toxicity chemicals to reformulate the polyester resins so we can reduce or eliminate styrene's toxic vapors while maintaining the resins' mechanical performance critical to composites applications," explains Hansen.

According to the U.S. Department of Energy, global production of styrene in 2010 was 25 million metric tons, with a market value of $32.5 billion.

Hansen says New England companies use polyester resins for low-cost composites solutions in a broad range of applications, but must use excessive and energy-intensive ventilation on a daily basis to manage the styrene vapors.

"Our study aims to eliminate styrene and the resulting vapors in order to reduce the companies' energy demand and greenhouse gas emission while protecting the workers' health and safety," he says. New England industries that could directly benefit from this technology include the marine, wind energy and consumer construction sectors.

"Through the TURI funding, graduate student Richard Poillucci in the UMass Lowell composites lab will test alternative formulations with minimal vapors and toxicity and then measure their mechanical performance and compare them with industry-standard formulations," says Hansen. "We will also collaborate with an industrial resin formulator in Texas and with the Minnesota Technical Assistance Program, or MN-TAP, which has a similar mission to TURI in Minnesota."

You Can't Hide Formaldehyde

As the first commercial synthetic resin, phenolic resins have been used extensively in numerous applications due to their exceptional chemical, heat and water resistance, high mechanical strength, electrical insulation and dimensional stability, says Nagarajan, who

co-edits the Journal of Renewable Materials.

"Unfortunately, formaldehyde poses a problem both to workers during resin manufacturing and to consumers during use if there is untreated material left behind in the products," he explains. "This was the case in the temporary trailers provided by FEMA for thousands of people who lost their homes to Hurricane Katrina in 2005 — the trailers had laminates and people were getting sick from residual formaldehyde leaching out of the laminates."

The goal of Nagarajan and plastics engineering graduate student Kenneth Samuel Ogueri and Ph.D. candidate Zarif Farhana Mohd Aris is to develop formaldehyde-free phenolic novolac resin materials and establish whether the final properties of the newly formulated phenolic resins are at least comparable, if not better than, those of commercial phenol-formaldehyde resins.

"TURI has connected us to a few users of formaldehyde in Massachusetts," he says. "By learning more about their specific needs, we will be able to fine-tune the chemical reactions to explore if indeed this approach is going to be commercially feasible. The TURI grant provides funding and resources to move from the idea stage to a working product solution."

Nagarajan adds: "Replacing formaldehyde will have a profound and direct impact not only on the safety of workers, but also on end users like you and me."

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