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LESS EXPENSIVE DISPLAYS: NEW TECHNIQUE ALLOWS POLYMER PROCESSING OF A KEY SOLID-STATE FLUORESCENT MATERIAL

By chemically attaching a difficult-to-process solid-state fluorescent material to a universal polymer backbone, researchers at the Georgia Institute of Technology have built what may be a foundation for a new generation of optoelectronic display devices based on inexpensive organic light-emitting diodes (OLEDs).

Until now, the aluminum tris (8-hydroxyquinoline) (Alq3) material – which is used as the emission and electron transport layer in organic light-emitting diodes – had to be deposited under high vacuum conditions, which requires costly equipment. Attaching it to a polymer backbone allows the material to be applied using solution processes – simple spin-coating methods already widely used for applying thin films of materials.

Beyond the implications for less costly and more flexible flat panel displays and similar devices, the new technique demonstrates that small molecules with interesting properties can be self-assembled onto standard polymer backbones. Using this "Lego-like" approach could have applications to other materials that are easier to process in polymeric form.

"This could have a significant impact for industry because it would make the manufacture



Researchers Marcus Weck and Amy Meyers examine vials containing dilute solutions of polymers with functionalized Alq3. By allowing the fluorescent material to be applied as a polymer, the researchers could help lower the cost of manufacturing organic light-emitting diodes.

of organic light-emitting diodes much easier," said Marcus Weck, an assistant professor in Georgia Tech's School of Chemistry and Biochemistry. "You can do this on a lab bench without million-dollar equipment. Being able to spin coat these organic systems could allow production of large surfaces suitable for displays."

Details of the work were presented March 27th at the 225th American Chemical Society National Meeting in New Orleans, LA. Sponsored by the National Science Foundation and the Office of Naval Research, the research has also been published in the journal *Macromolecules*.

Because they are based on polymers,

organic light-emitting diodes produced with the new technique could offer another significant advantage – physical flexibility. That would allow production of displays that are less prone to damage and that can operate in shapes and forms not possible with current technology.

Using the polymer poly(norbornene) as a backbone, Weck and graduate student Amy Meyers designed a functional monomer containing Alq3, also known as aluminum tris (8-hydroxyquinoline). The Alq3 was covalently bonded to the poly(norbornene) backbone, which was selected because it can be polymerized by ring-opening metathesis, a method that tolerates many functional groups.

Though the prototype material shows great potential, Weck cautions that much work remains to be done before the new material finds its way into laptop computers and other display systems.

"From a scientific standpoint, this is a milestone, but there is a lot of optimization and evaluation that must be done," he said. "We've shown that we can change the polymer backbone and that we can change the connection of our Alq3 to the polymer."

Though the pure polymer has limited solubility, the researchers hope to improve that as part of an on-going optimization process. The optical properties of the new material appear equivalent to the conventionally-produced material, but the details are still under study. Weck believes the trade-offs between easier processing and optical performance will ultimately be positive.

As part of optimizing the chemistry, Weck and Meyers are adjusting the chemistry to provide emissions of different colors that would be necessary if the material is to be used in flat-panel displays. The material's yellow-green luminescence can be shifted with chemical additions or introduction of optically inactive spacer molecules.

"We want to produce a polymer system that would provide whatever color was needed," Weck said. "The goal would be to create a 'Lego-like' system in which you put different components together to get the output you need. We would provide a polymer backbone with an aluminum center, and then add more units to shift the wavelength."

The Georgia Tech researchers are working with scientists at the University of Arizona to assess how well the new material would work in OLEDs. If long-term testing shows the new polymer has the desired stability and other properties, it could help

open up new applications for OLEDs.

"One of the issues that has held back the market is this vacuum deposition requirement," said Weck. "Most polymeric LEDs are difficult to make and optimize. Our system would be straightforward and could be very interesting to industry."

Earlier efforts to improve the processing properties of Alq3 have involved mixing it with or doping it into a polymer. Neither of those strategies has worked well.

The Alq3 system is the first demonstration of a technique Weck hopes will allow his research group to build many new types of polymers using modular scaffolds programmed to attract building blocks of small molecules. Weak and easily reversed chemical interactions would self-assemble those molecules to form complex structures with predictable physical and chemical properties.

In the natural world, self-assembly techniques produce thousands of varied life forms -- bacteria to human beings -- based on a relatively small set of amino acids and nucleosides combined in different ways. By emulating this natural system, he hopes to simplify the synthesis of new materials for light-emitting diodes, optical storage materials, biosensors, drug-delivery materials and other applications.

"The goal is to simplify the synthesis of designer polymers via self-assembly using combinatorial chemistry," Weck explained. "Our group is taking design lessons from Nature by incorporating into one system several of these weak interactions to get a degree of complexity that is difficult to achieve otherwise. We believe we now have the basic proof of principle to show that we will be able to address this problem."

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