Just add dendrimers, cellulose and graphene: New eco-friendly, long-lasting light-emitting electrochemical cell

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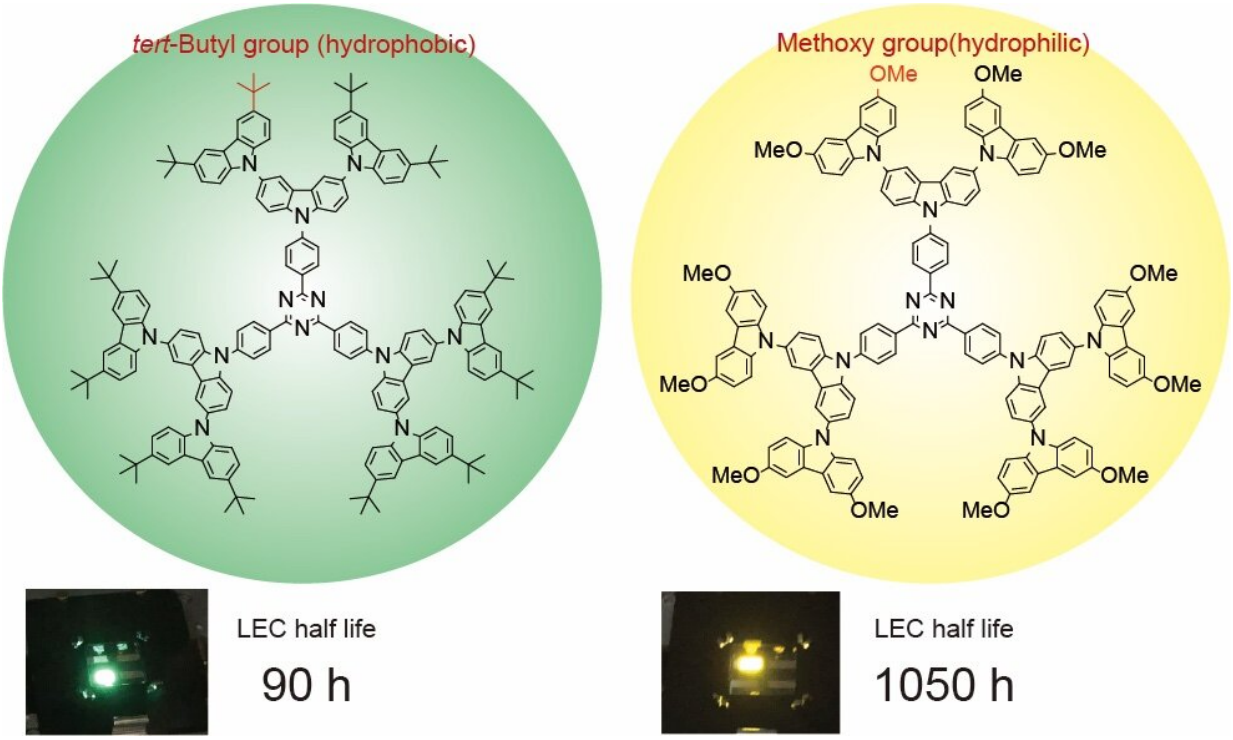

Second-generation dendrimers with tert-butyl (left) and methoxy groups (right) applied to light-emitting electrochemical cells (LEC). The lifetime of LEC devices using dendrimers with hydrophilic methoxy groups (right) is more than 10 times longer than that of hydrophobic dendrimers. Credit: Kyushu University/Albrecht Lab

In research that could lead to a new age in illumination, researchers from Japan and Germany have developed an eco-friendly light-emitting electrochemical cells using new molecules called dendrimers combined with biomass derived electrolytes and graphene-based electrodes. Their findings were published in the journal *Advanced Functional Materials*.

Electroluminescence is the phenomenon where a material emits light in response to a passing electric current. Everything from the screen you're using to read this sentence to the lasers used in cutting edge scientific research are results of the electroluminescence of different materials. Due to its ubiquity and necessity in the modern age, it is only natural that extensive resources go into research and development to make this technology better.

"One such example of an emerging technology is 'light-emitting electrochemical cells' or LECs," explains Associate Professor Ken Albrecht from Kyushu University's Institute for Materials Chemistry and Engineering and one of the leads of the study. "They have been attracting attention because of their cost advantage over organic light emitting diodes, or OLEDs. Another reason for LECs popularity is their simplified structure."

OLED devices generally require the carful layering of multiple organic films, making it tricky and costly to manufacture. LECs on the other hand can be made with a single layer of organic film mixed with light-emitting materials and an electrolyte. The electrode that connects it all together can even be made from inexpensive materials unlike the rare or heavy metals used in OLEDs. Moreover, LECs have lower driving voltage, meaning they consume less energy.

"Our research teams have been exploring new organic materials that can be used in LECs. One such candidate are dendrimers," explains Prof. Rubén D. Costa of the Technical University of Munich, who led the

research team in Germany. "These are branched symmetric polymeric molecules whose unique structure has led to their utility in everything from medicine to sensors, and now in optics."

Building upon their past work on developing dendrimers, the research team began modifying their materials for LECs.

"The dendrimer we developed initially had hydrophobic, or water repelling, molecular groups. By replacing this with hydrophilic, or water liking, groups we found that the lifetime of the LEC device could be extended to over 1000 hours, more than 10-fold from the original," explains Albrecht. "What makes it even better is that thanks to our collaboration with Dr. Costa's team the device is very eco-friendly."

For years, Costa's team in Germany had been working on developing cheaper and more environmentally friendly materials in light-emitting devices. One material they have been experimenting with is cellulose acetate, a common organic compound used in everything from clothing fibers and eyeglass frames.

"We used biomass derived cellulose acetate as the electrolyte in our new LEC device, and confirmed that it has the same long-life span," continues Costa. "Moreover, we also found that graphene can be used as an electrode as well. This is a vital step toward making flexible light-emitting devices using environmentally friendly materials."

The team explains that while their work is promising more research is necessary before the devices can be made to market.

"The device we made here only illuminates in yellow, so we need to develop it to illuminate in the three primary light colors: blue, green, and red. Luminescence efficiency, how bright the light is, also needs work," concludes Albrecht. "Though thanks to our international collaboration,

the future looks bright."

More information: Luca M. Cavinato et al, Dendri-LEC Family: Establishing the Bright Future for Dendrimer Emitters in Traditional and Graphene-Based Light-Emitting Electrochemical Cells, *Advanced Functional Materials* (2023). DOI: 10.1002/adfm.202302483

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