Lab-Created Aurora Highlights New Polymer Physics

The discovery of a mini aurora above a light-emitting polymer material reveals an electron-ejection process that might be useful in field-emission displays and material fabrication.

By **Elizabeth Fernandez**

Auroras occur in the night sky when charged solar-wind particles, such as protons and electrons, are deflected by Earth's magnetic field and interact with molecules in the atmosphere. Researchers have now found an aurora-like emission coming from a light-emitting polymer [**1**]. The surprising display consisted of flashes of green light above the polymer surface. The researchers explained the emission as the result of electrons being ejected from the polymer and interacting with a vapor of organic molecules. The discovery suggests that these polymers might be useful as electron emitters for applications such as spectroscopy, medical technology, and lithography.

Jun Gao from Queen's University in Canada is amazed by auroras, and he's even gone out on cold nights to look for them. But he was not prepared for the aurora that showed up in his lab two years ago. He and his student at the time, Dongze Wang, were testing failure modes for polymer light-emitting electrochemical cells, or PLECs, used in light sources and display devices. These cells are organic semiconductors that are electrochemically doped on one side to have excess electrons (making an *n*-type semiconductor) and on the other side to have electron deficiencies, or holes (making a *p*-type semiconductor). Electrons crossing the *p*–*n* boundary can fill holes and produce red light.

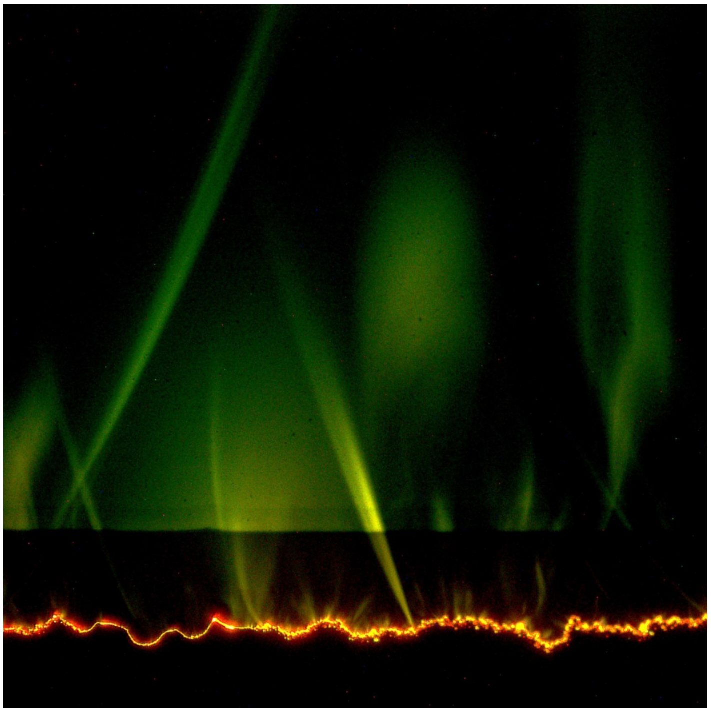
In their PLEC study, Gao and Wang were investigating a damaging phenomenon, called electrical treeing, in which the polymer develops voids that look like tree branches. In order to speed up and amplify the treeing behavior, the researchers cooled a PLEC to 200 K and applied an extreme voltage that was both high (up to 1000 V) and reversed (with the negative electrode on the *p*-type side and the positive electrode on the *n*-type side).

Images of the material during breakdown revealed the aurora-like emission. Rather than red light coming out of the PLEC, green flashes were spotted outside of the material, just above the *n*-type semiconductor's electrode. The flashes increased in both duration and number as the reverse voltage increased. “At the time, I couldn't fully explain what we had observed,” recalls Gao.

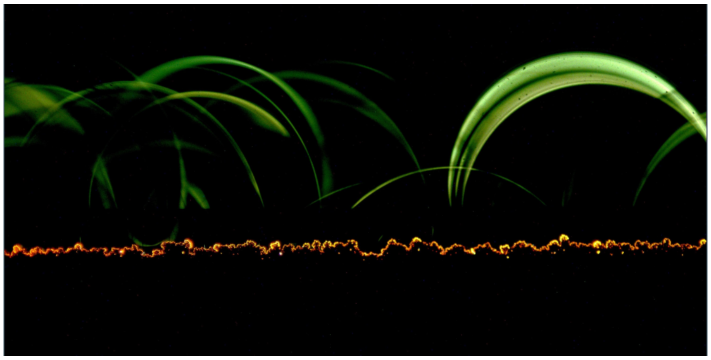
Now Gao and Wang have worked out an explanation. The first clue was a slight curvature to some of the flashes. Since photons would not normally take a curved path, they hypothesized that the flashes were caused by charged particle beams being deflected by Earth's magnetic field or by a stray magnetic field created by current flowing within the experimental setup.

To test this charged-particle hypothesis, the researchers applied a strong magnetic field to their system. This field caused the flashes to drastically curve, with a direction that depended on the orientation of the magnetic field. By measuring how much the curvature increased with the field strength, the researchers inferred that the particles in the beam had a charge-to-mass ratio consistent with electrons.

As for the source of the green light, Gao and Wang speculated that—like Earth's aurora—the electrons were colliding with some sort of gas, or “atmosphere,” around the PLEC. The spectra of the flashes had broad peaks, indicating that the gas was not some residual gas from the surrounding vacuum



Polymer Lights. Green aurora-like streaks appear above the surface of a light-emitting polymer. These short-duration light emissions are believed to be caused by electrons interacting with gas produced from the deteriorating polymer surface. The orange light at the bottom is electroluminescence coming from the junction between the *p* and *n* type semiconductors.
Credit: D. Wang and J. Gao [1]



Magnetic influence. The green flashes exhibit curvature when the researchers apply a strong magnetic field—evidence that emitted electrons are causing the light display.
Credit: D. Wang and J. Gao [1]

chamber. Instead, the gas most likely came from the PLEC itself, as the heating of the material during the electrical treeing process should cause polymer molecules to be released as vapor. Gao and Wang suspect that these molecules would be small polymer strands called oligomers. When electrically excited, PLEC oligomers are known to emit visible light at a wavelength that is proportional to the length of the oligomer. Thus, a vapor of short oligomers—excited by ejected electrons—could explain the green flashes that Gao and Wang observed.

One implication of these results is that polymers typically used for lighting applications might find a role as electron emitters. “Polymer-based electron emitters are potentially cheaper, have lower threshold voltages, and are more flexible in design than conventional metal- or silicon-based emitters,” Gao says. He also says that the aurora-producing process could be used to better understand polymer material failure by analyzing the light produced by polymer fragments, a technique he calls electrical breakdown spectroscopy.

“This study’s observation of free-electron emission is quite intriguing. The aurora-like green flashes, which are deflected by magnetic fields, clearly stand out from the expected behavior,” says Mohammad Javad Jafari, a research engineer at Linköping University in Sweden. He says that additional work is needed to understand the role of other potentially important factors, such as device geometry, impurities, and thermal effects.

Elizabeth Fernandez is a freelance science writer based in Raleigh, North Carolina.

REFERENCES

1. D. Wang and J. Gao, “Auroralike light from a polymer *p-n* junction emitting free electrons,” **Phys. Rev. Lett. 134, 096203 (2025).**