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Organic luminescent radicals enable bright circularly polarized light in the near-infrared region

New molecular design unlocks high photoluminescence efficiency and improved stability, with potential applications in lasers, bioimaging, and quantum technologies

Fukuoka, Japan— Circularly polarized light, a form of light in which the electromagnetic wave rotates in a circle as it travels, has properties that make it useful in a growing range of technologies, from next-generation 3D displays to bioimaging tools that can detect signals deep within living tissues. One way to produce this kind of light is with the help of chiral molecules—compounds that have a mirror-image form to which they cannot be perfectly superimposed. Among these, small organic molecules (SOMs) offer tunable emission wavelengths.

Luminescent radicals represent a promising type of SOM for red and near-infrared circularly polarized luminescence (CPL) emission. One particular family of radicals, tris(2,4,6‐trichlorophenyl)methyl (TTM)‐based radicals, is inherently chiral and a natural candidate for CPL. In practice, however, these molecules fall short on multiple fronts, with tradeoffs between stable chirality, high emission efficiency, and durability under operating conditions.

In this vein, researchers at Kyushu University, Japan, have developed a new type of organic material that emits CPL in the deep-red to near-infrared region of the spectrum. Published in *Angewandte Chemie International Edition* on April 24, 2026, the study describes a series of molecules classified as chiral luminescent radicals that combine high emission efficiency, durability, and stability.

In the present study, a research team led by Associate Professor Ken Albrecht of the Institute for Materials Chemistry and Engineering, Kyushu University, and including doctoral student Kazuhiro Nakamura of the Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, along with Prime Senior Researcher Takuya Hosokai of the National Institute of Advanced Industrial Science and Technology (AIST), Assistant Professor Soh Kushida of the University of Tsukuba, and other members from Tokyo Metropolitan University and Kyoto University, synthesized a new series of TTM radicals to address these issues. Starting with a bromine-containing derivative of TTM called TTBrM, the team incorporated a nitrogen-containing organic compound known as carbazole (Cz). This approach produced three carbazole-substituted TTM radicals: CzTTBrM, 2CzTTBrM, and 3CzTTBrM.

The introduction of the Cz units fundamentally changed how these molecules emit light. Rather than a simple localized electronic transition, emission now occurred through a charge-transfer process between the Cz donor and TTBrM acceptor, shifting the output into the red to near-infrared range of 650–800 nanometers (nm). Measurements of photoluminescence quantum yield, a metric describing how efficiently absorbed energy is converted into light, revealed values approximately 30 times greater in the best-performing compound than those reported for conventional chiral luminescent radicals.

In addition, photostability improved by approximately 100-fold, with the new radicals surviving over 1,300 seconds of continuous laser irradiation versus 19 seconds for TTBrM. The chirality of all three compounds was also stable, exhibiting high barriers to racemization (conversion of an optically active compound into its optically inactive form). Simply put, the radicals did not rapidly switch between their respective mirror-image forms at room temperature. Thanks to this, enantiopure (single mirror-image) forms could be successfully isolated, which exhibited remarkably bright CPL.

To further explore the optical behavior of these compounds, the researchers embedded the radicals in microscopic polystyrene spheres. When illuminated by a laser, these microspheres exhibited whispering gallery mode resonance, an optical effect in which light circulates within a spherical cavity, amplifying at specific wavelengths. "This phenomenon, representing a pre-lasing stage, had never before been reported in luminescent radical systems," remarks in Albrecht.

Beyond applications in displays, bioimaging, and lasers, the team also highlighted the broader potential of luminescent radicals as functional materials in emerging quantum technologies. "These compounds can potentially be used as magnetic field- and microwave-manipulated quantum materials, which are expected to be useful for next-generation quantum information science," says Nakamura.

Overall, this study demonstrates a powerful design strategy for combining a favorable electronic structure, chirality, and light emission in a single molecular system. By overcoming long-standing trade-offs, these luminescent radicals could help advance a new generation of optical and quantum technologies.

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For more information about this research, see "Luminescent Donor-Acceptor Radical with Propeller Chirality: Bright and Photostable Red Circularly Polarized Luminescence and Whispering Gallery Mode Resonance," Kazuhiro Nakamura, Kenshiro Matsuda, Kosuke Anraku, Keiko Yamaoka, Taisuke Matsumoto, Fumitaka Ishiwari, Takeaki Zaima, Wataru Ota, Emiko Fujiwara, Tohru Sato, Yoshitaka Inoue, Soh Kushida, Yohei Yamamoto, Takuya Hosokai, and Ken Albrecht, *Angewandte Chemie International Edition*, https://doi.org/10.1002/anie.1914320

About Kyushu University

Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutions of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World Rankings. Located in Fukuoka, on the island of Kyushu—the most southwestern of Japan's four main islands—Kyushu U sits in a coastal metropolis frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Its multiple campuses are home to around 19,000 students and 8,000 faculty and staff. Through its VISION 2030, Kyushu U will "drive social change with integrative knowledge." By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society's most pressing issues.

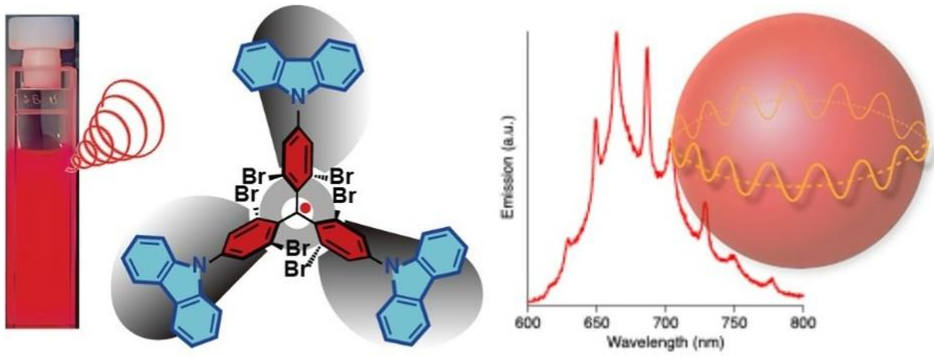

Fig.1 Structure and emission properties of the proposed luminescent radical
This innovative structure exhibits highly efficient circularly polarized light emission in the red to near-infrared range, as well as the peculiar whispering gallery mode resonance depicted on the right. This property could be leveraged in advanced optics applications and lasers.

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