Researchers review recent progress of organic room-temperature phosphorescent materials towards application

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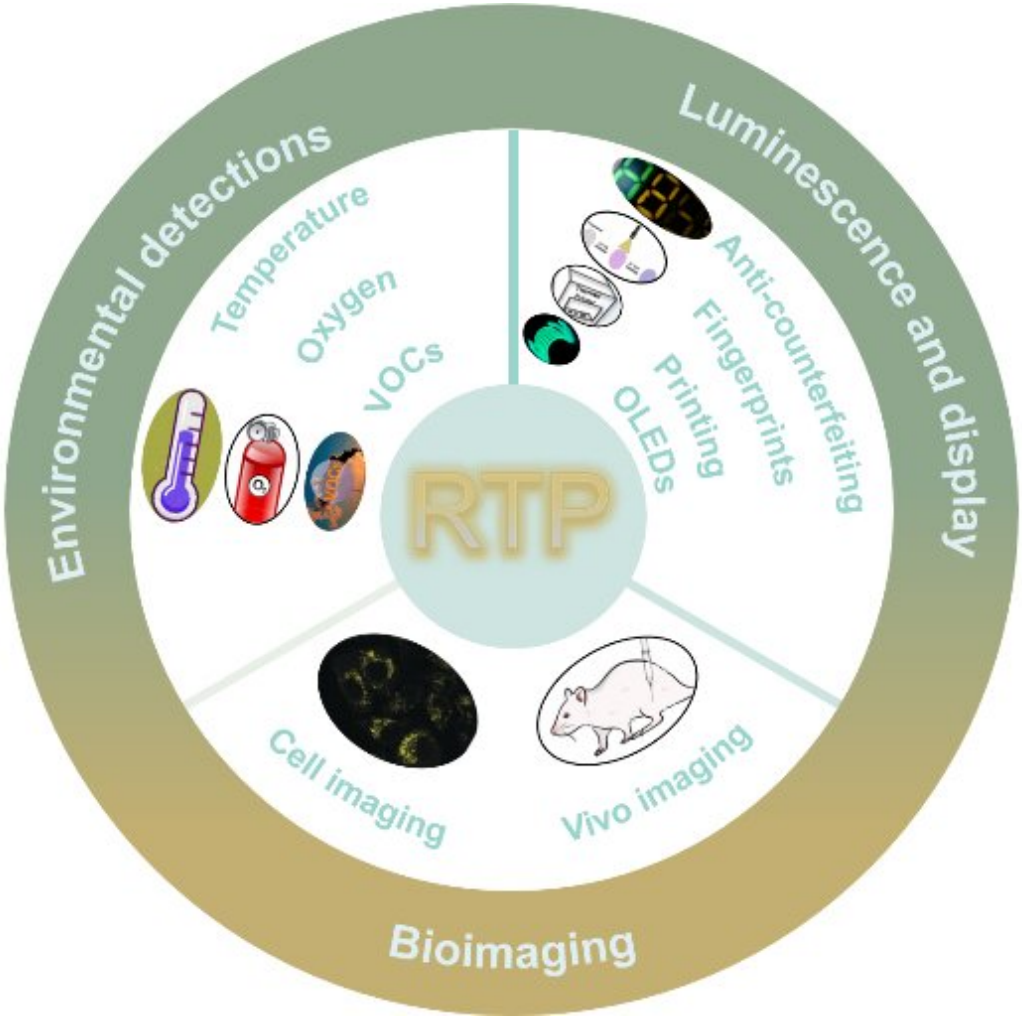

A summary of recent progress aims at application of room temperature phosphorescent materials in luminescence and display, environmental detections

and bioimaging. Credit: Xiang Ma, East China University of Science and Technology

Organic materials with room-temperature phosphorescence (RTP) emission have attracted extensive attention due to extraordinary properties including long lifetime, large Stokes shift, stimuli-responsiveness, and so on, and show bright prospects in broad fields. However, the energy of the excited state of organic phosphors is easily consumed through thermal radiation and collision deactivation.

Therefore, numerous design strategies such as creating a rigid environment through crystallization and supramolecular assembly are employed to improve the luminescent characteristics of RTP materials by restricting nonradiative transition, enhancing intersystem crossing, and so forth.

A team of scientists summarizes the recent progress of organic RTP materials from the perspective of practical applications including luminescence and display, environmental detection, and bioimaging. Based on their works, the requirements of organic RTP materials for different applications are summarized, which may bring enlightenment to the future application research of RTP materials. This review was published in the journal *Industrial Chemistry & Materials*.

Organic light-emitting diodes (OLEDs) have shown excellent performance on display screens recently, while only 25% of singlet excitons in fluorescent materials can be utilized to emit light. Therefore, the harvesting of singlet excitons and triplex excitons to achieve 100% theoretical internal quantum efficiency makes phosphorescent materials attractive.

"Relevant scientific researchers have designed many organic light-emitting diodes based on RTP with high external quantum efficiency by using different strategies, which far exceeds the 5% theoretical limit for typical fluorescent materials," said Ma, a professor at East China University of Science and Technology, China.

Due to UV irradiation and the different lifetime of RTP emission, anti-counterfeiting or data encryption based on RTP materials has become a common and popular application. In addition to simple anti-counterfeiting and data encryption based on the on-off of UV light, the different lifetimes of RTP materials provide a feasible way to realize multiple anti-counterfeiting or data encryption by using time resolution techniques.

Besides, the chemical-responsive RTP is also a potential means to realize multiple anti-counterfeiting. In addition to the applications above, RTP materials have also been studied for two rare but meaningful applications, printing, and visualization of latent fingerprints, due to their unique luminous properties.

"As we all know, many factors affect the luminescence properties of RTP materials, such as oxygen, temperature, and so on," Ma said. "So chemical sensors based on RTP are also an indispensable research direction, which can produce practical applications in environmental detection."

The spin triplet property of ground state oxygen makes it easy for O_2 to quench the triplet excitons of RTP materials, which makes RTP materials ideal candidates for O_2 detection. Generally, the decreasing phosphorescent intensity and lifetime can both be utilized to realize quantitative detection of oxygen.

Temperature is also a significant external environmental factor to affect

RTP emission because the high temperature will enhance nonradiative transition, and thus the corresponding RTP materials are developed for temperature sensing. In addition, the quenching effect of small organic molecules on RTP emission makes chemical sensors based on RTP materials possible.

Optical imaging plays an important role in biomedical and clinical research. Compared with fluorescence, RTP has a longer lifetime at a longer wavelength which is beneficial to eliminate fluorescence background interference and scattered light and gain a higher signal-to-noise ratio (SBR). Although RTP materials have many advantages in bioimaging, non-radiative decay and quenchers in aqueous solutions seriously hinder their practical application.

Researchers innovatively proposed a supramolecular self-assembly strategy and top-down nanoparticle formulation to achieve stable phosphorescence at room temperature in an aqueous solution. Therefore, the researchers not only successfully constructed near-infrared phosphorescent materials with high resolution and deep penetration, but also developed RTP materials with long-wavelength excitation and phosphorescent emission simultaneously, effectively avoiding the damage of ultraviolet light to organisms.

These works show huge potential application value in biological imaging.

Although organic room temperature phosphorescent materials constructed by different strategies are widely used in various fields due to different luminescence properties, there is still huge research space to fabricate more excellent applied RTP materials. Therefore, the team also discusses how to overcome the challenges and the prospect of phosphorescent materials.

To obtain efficient organic light-emitting diodes, phosphorescent

materials need to meet the characteristics of high quantum yield and short lifetime, while RTP materials for anti-counterfeiting and encryption often require rich luminous colors and perform differently with UV excitation. And the application in biological imaging demands RTP materials to have longer wavelengths and lifetime to eliminate fluorescence background interference and gain a higher signal-to-noise ratio.

Moreover, the application scope should be broadened due to the extraordinary optical properties of RTP materials. Further exploration of RTP materials will not only contribute to a deeper understanding of photoluminescence but promote the practical application of photoelectric functional materials in our life.

More information: Mengxing Ji et al, Recent progress with the application of organic room-temperature phosphorescent materials, *Industrial Chemistry & Materials* (2023). DOI: 10.1039/D3IM00004D

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