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Editorial

Luminescent Materials: Synthesis, Characterization and Application

Amalia Mesaros

Physics and Chemistry Department, Technical University of Cluj-Napoca, 28 Memorandumului Street, 400114 Cluj-Napoca, Romania; amalia.mesaros@chem.utcluj.ro

Luminescent materials, or phosphors, are organic, inorganic, or hybrid organic/inorganic systems that convert certain types of energy into electromagnetic radiation over thermal radiation [1]. The ability of these materials to produce luminescence does not depend on the aggregation state, which can be solid, liquid, or even gaseous. M. G. Brik shortly defined the phenomenon of luminescence as a method of conversion of excitation energy (which can be supplied to a luminescent object in various ways via external sources) into emitted light energy [2]. A wide range of energy sources (excitants) can stimulate luminescence phenomena, and, depending on their nature, a standard classification can be established [1–8]:

- Photoluminescence (PL)—The emission process occurs after the system has been excited via electromagnetic radiation (UV or visible light). Depending on the duration of persistence after the cessation of excitation, there are two types of photoluminescence: fluorescence, with a lifetime less than microseconds, and afterglow luminescence, with a lifetime from microseconds to hours, known as phosphorescence or persistent luminescence, PersL [2–5]. In this regard, J. Xu and S. Tanabe [5] give relevant insights into the terminology, history, and mechanisms of these two long-lived luminescence phenomena.
- Thermoluminescence (TL)—The luminescence arises due to the moderate heating of a luminescent substance and generally occurs below incandescence. It should be mentioned that there is a kind of opposite phenomenon—called cryoluminescence—whereby light is emitted upon the cooling of a luminescent material.
- Cathodoluminescence (CL)—the excitant is a beam of high-energy electrons (cathode rays).
- Electroluminescence (EL)—the ability of a material to emit light by applying an electric field to a substance.
- Chemiluminescence—the emission light appears as a result of chemical reactions and, according to their type, can be classified as bioluminescence, electrochemiluminescence, lyoluminescence or candoluminescence [2].
- Mechanoluminescence—A mechanical action or impact is responsible for the optical response. Depending on the type of mechanical impact, several kinds of mechanoluminescence can be distinguished: piezoluminescence, fractoluminescence, triboluminescence and sonoluminescence.
- Radioluminescence—the luminescent response is obtained after excitation via ionizing radiation.
- Crystalloluminescence—the emission of light is caused by a change from the amorphous to the crystalline state.

Despite this typical classification, special attention must be paid to studying and understanding the physical mechanism behind each type of luminescence in order to develop new luminescent systems. The enthusiasm for research in this field is stimulated both by the interest of humankind in discovering a new generation of luminescent materials and by their tremendous applicative potential, ranging from lighting technologies—fluorescent lamps,

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Citation: Mesaros, A. Luminescent Materials: Synthesis, Characterization and Application. *Appl. Sci.* **2023**, *13*, 11221. https://doi.org/10.3390/app132011221

Received: 5 October 2023
Accepted: 7 October 2023
Published: 12 October 2023

light-emitting diodes (LEDs), organic light-emitting diodes (OLEDs)—to new opportunities in the biomedical domain, namely bioimaging, biosensing, cell tracking, photodynamic therapy, optical thermometry, information storage, and water remediation [5,7–10]. The scientific challenges associated with the development of new luminescent systems can be illustrated by the following interconnections: *Chemical Composition ↔ Structure and Morphology ↔ Luminescent Properties*.

Regarding the chemical composition, the question is how to design the targeted stoichiometry: inorganic, organic, and hybrid systems are considered. The main strategies used to elaborate upon the luminescent systems are as follows: (i) the top-down approach, which covers physical and mechanical methods, and (ii) the bottom-up approach, which includes chemical methods, namely wet-chemical synthesis, co-precipitation, sol–gel, combustion, etc. Generally, though not universally, it is accepted that emission energy is dictated by intrinsic traps and/or the traps intentionally introduced into the host lattice by suitable emitters/dopants, such as rare earth ions that present intraconfigurational 4f-4f transitions or transitional metal ions that generate intraconfigurational 3d-3d transitions. The origin of the traps is still debatable, and herein, a deep understanding of the influence of synthesis parameters on the final stoichiometry is beneficial. Furthermore, another issue is the effect induced by the host lattice's defects or distortions and this marks the second challenge related to the system's crystallinity. Regarding the morphological characteristics, it is generally accepted that the synthetic method and parameters allow for the engineering of morphology, in terms of size (micro- or nano-scale) and shape, and offer good control over uniformity and agglomeration. All of these factors strongly influence the luminescence intensity by tuning the excitation irradiance and emission wavelength, as well as the lifetime and quantum efficiencies.

In conclusion, this Special Issue focuses on the recent progress made in the field of luminescent materials and considers new designs, synthetic routes, and investigation methods to evaluate the applicative potential in lighting, displays, sensing, optical information storage, biomedicine, and so on. This Issue aims to encourage more scientists to discover the field of luminescence and I hope that these studies will represent outstanding pieces in this amazing Lego-puzzle-like domain. Moreover, due to the wide range of application prospects, the scientists involved will develop new applications and accelerate the development of new luminescent systems. Finally, I would like to express my appreciation to all of the authors and reviewers for their contributions.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflict of interest.

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