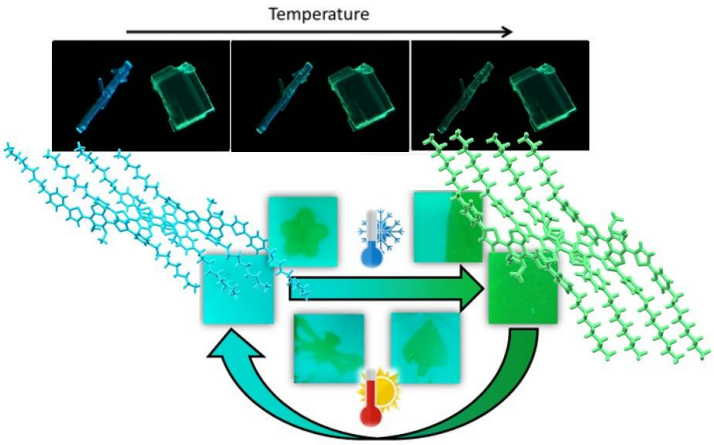
CONTRATO 3

Título: Stimuli-Responsive Molecular Crystals for Energy-Efficient Photonic and Actuating Composites

Descripción: This PhD project focuses on developing stimuli-responsive composite materials incorporating molecular crystals (MCs). The basis on these changes relay on large changes in the crystalline packing on relatively large organic molecules. Recently the Youtube Chanel Veritasum produced an excellent documental about materials with these properties. https://youtu.be/ksn5yrsC3Wg?si=ruzj6-2yT6p6u6uW.

The length and lack of point symmetry of the selected organic molecules allows many different ways of packings, corresponding to different crystalline polymorphs. As not all the crystalline configurations are equally efficient, phase transitions (PTs) between different molecular packing are associated to giant electronic and/or volume density variations, (around ~2%) introducing huge changes in optical and mechanical properties (these are known as “martensitic transformation”). These PTs occur at relatively low temperatures (~100 °C), making them easily triggered by light, mechanical stress, or chemical potentials. This project aims to overcome these by embedding MCs in polymeric or hybrid matrices, enhancing stability, scalability, and functionality. These composites can exhibit light-triggered actuation, pressure-sensitive fluorescence, and tunable optical properties. The project will explore: (1) MC-polymer metamaterials for actuators, (2) fluorescent composites for sensing/labeling, (3) MC-metal nanoparticle hybrids for plasmonic heating, and (4) photonic structures via nanofabrication.

This project offers the PhD student multidisciplinary training in molecular design, materials engineering, and device prototyping, preparing them for a career in advanced functional materials. The thesis work will include chemical synthesis, materials characterization as well as and advanced optical and mechanical measurements. Chemists, Physicists as well as Chemical Engineers, and some other master students could finish the work with the assistance of the Thesis supervisors.



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Grupos de investigación donde se desarrollarán las actividades

(Research Groups | ICMM):

- Supramolecular, Polymeric and Reticular Materials
- Photonic Crystals Group

Publicaciones relacionadas

(1) Martín, R.; Echeverri, M.; González, F.; De Andrés, A.; Ruiz Delgado, M. C.; Concellón, A.; Serrano, J. L.; Gómez-Lor, B. Disrupting J-Aggregation in Triazatruxene Dimers to Develop Responsive Luminescent Inks for Anti-Counterfeiting Applications. *Advanced Optical Materials* **2025**, *13* (8), 2400965. https://doi.org/10.1002/adom.202400965

(2) Uddin, M. A.; Gámez-Valenzuela, S.; Ruiz Delgado, M. C.; Gómez-Lor, B. Stimuli Responsive Behavior in a D–A–D Organic Fluorophore: The Role of Cold Crystallization. *J. Mater. Chem. C* **2025**, *13* (22), 11052–11059. https://doi.org/10.1039/D5TC00852B

(3) Uddin, M. A.; Martín, R.; Gámez-Valenzuela, S.; Echeverri, M.; Ruiz Delgado, M. C.; Gutiérrez Puebla, E.; Monge, A.; Gómez-Lor, B. Giant Thermosalient Effect in a Molecular Single Crystal: Dynamic Transformations and Mechanistic Insights. *J.*

Am. Chem. Soc. **2024**, *146* (40), 27690–27700. https://doi.org/10.1021/jacs.4c09222

(4) Echeverri, M.; Ruiz, C.; Gámez-Valenzuela, S.; Alonso-Navarro, M.; Gutierrez-Puebla, E.; Serrano, J. L.; Ruiz Delgado, M. C.; Gómez-Lor, B. Stimuli-Responsive Benzothiadiazole Derivative as a Dopant for Rewritable Polymer Blends. *ACS Appl. Mater. Interfaces* **2020**, *12* (9), 10929–10937. https://doi.org/10.1021/acsami.9b21209