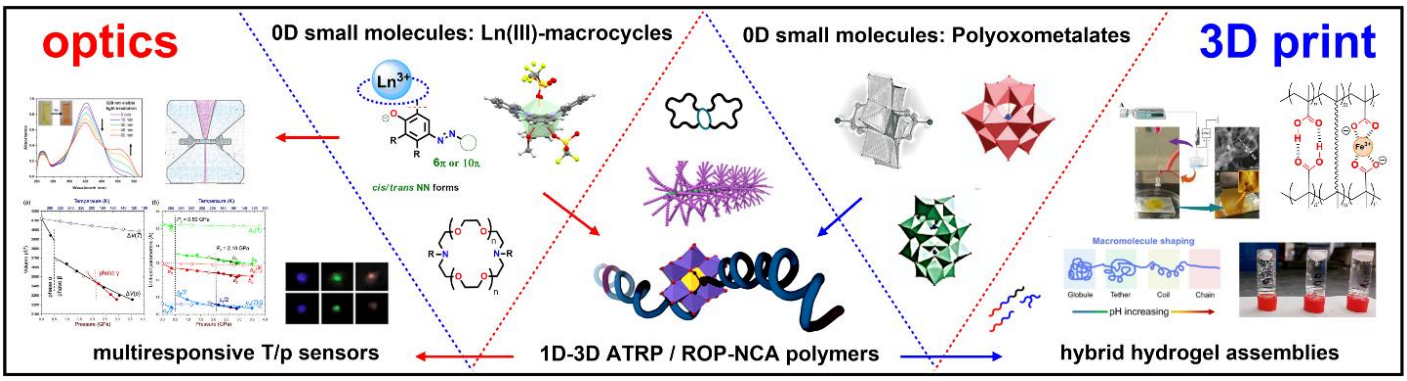
Dr. Adam Gorczyński SONATA BIS: ***Two sides of the same coin: leveraging order and disorder at the molecular level for the design and preparation of advanced functional materials***

Project goal

We aim to develop a new way of designing materials in which order and disorder are treated as tools, not flaws. We start from molecular building blocks: complexes of rare-earth metals (lanthanides) and inorganic metal-oxide clusters (polyoxometalates, POMs). From these elements we build larger polymer architectures using modern, precise ("living") polymerizations that let us control chain length and arrangement according to the design assumptions.



Research description

The properties of modern materials - such as strength, conductivity, color, recyclability and environmental stability - are determined by their structure. In classical, perfectly ordered crystals or in completely disordered glasses it is rare to achieve such a full set of properties. Moreover, "disorder" can be beneficial (e.g., it can enhance optical signals), but it usually appears by chance and its programmed control is hard to reproduce. Our approach programs both order and controlled disorder at the molecular level, producing materials that are reproducible and created under milder, more sustainable conditions, with multifunctional practical properties. We will examine how the new materials emit light and how they respond to temperature and pressure, which is the basis of optical sensors. The best systems will be transferred into thin layers and (hydro)gels, and we will then investigate the possibility of 3D printing. The systems will respond to light, pH changes or metal ions, so that they change color, volume, and/or shape - a step toward simple actuators (soft moving elements) and sensors.

Project outcomes

1) Design rules: clear, validated links between molecular-level structure and material performance.
2) New families of hybrid materials combining polyoxometalates with living vinyl polymers and polypeptide polymers.
3) Prototypes: thin coatings for temperature/pressure sensors and printable gels for simple sensing systems and soft robotics.
4) Broader benefits: procedures developed in the spirit of sustainable chemistry, reusable datasets, and training for young researchers at the interface of coordination chemistry, polymer chemistry, and materials science.