MATERIALS SCIENCE AND TECHNOLOGY

AMMIN - Engineering MOF-Based Nanomaterials: From Controlled Synthesis to (Photo)catalytic Applications

Funded By	Politecnico di TORINO [P.iva/CF:00518460019]
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Context of the research activity	This PhD focuses on developing strategies for the preparation of engineered metal–organic architectures for advanced (photo)catalytic applications. The project includes controlled synthesis of MOF nanocrystals and metal–organic gels, comprehensive physico-chemical characterization, and integration into lab-scale reactors to evaluate catalytic and photocatalytic performance.
Objectives	The research activity focuses on the design of novel MOF-based nanomaterials and their dual application as heterogeneous (photo)catalysts for sustainable chemical transformations. Target reactions span both thermally driven processes, such as CO2 hydrogenation, and light-driven processes including solar fuel production (i.e. H2 evolution) and the photodegradation of organic contaminants. The activity will begin with the selection and optimization of synthesis routes for the preparation of MOF materials based on earth-abundant metal nodes (e.g., Fe, Cu, Zr, Ce). Particular attention will be devoted to the effect of synthesis parameters (solvent composition, temperature, modulator concentration) on the resulting physicochemical properties of the metal organic architectures. Subsequently, post-synthetic modifications (e.g., metalation, linker exchange, surface functionalization) or one-pot incorporation of a secondary metal will be explored to generate single-atom sites and tune specific structural and catalytic features. In parallel, metal–organic gels (MOGs) will be explored as versatile platforms to access hierarchically porous networks and as precursors for the synthesis of metal oxides with tuneable composition, morphology, and defect structures via controlled treatments. Comprehensive physico-chemical characterization (XRD, N2 adsorption, electron microscopy, UV–Vis diffuse reflectance spectroscopy, XPS) will be performed to elucidate the structural, textural, and electronic properties of the materials, with particular emphasis on the nature and role of defect sites. Subsequently, (photo)catalytic performance will be systematically evaluated under both thermal and light-driven conditions in the target reactions, with rigorous assessment of activity, selectivity, and long-term stability. The integration of catalytic data with physico-chemical descriptors will enable the establishment of robust structure–property–activity relationships, ultimately guiding the rational modification of the metal organic framework

	architectures.

Skills and competencies for the development of the activity	Candidates are required to have defended a MSc Thesis in: Material Engineering; Chemical Engineering; Industrial Chemistry; Chemistry; Materials Science. Previous experience in the field of porous materials synthesis, heterogeneous (photo)catalysis, or advanced materials characterisation constitutes a preferential skill for the selection process. Capacity to work in a multidisciplinary team and to prioritize the own work for accomplishing deadlines.