Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally Mandal, Ranga Reddy Dist., Hyderabad – 500 046

Seminar

Layer-by-Layer Synthesis of MOF Thin Films: Enhancing Optical Properties and Electrical Conductivity Through Self-Driving Robotic Laboratories

Christof Wöll

IFG-KIT, Germany

Metal–organic frameworks (MOFs) have traditionally been explored in powder form, but the transition to surface-grown, crystalline thin films—particularly via layer-by-layer (lbl) deposition—has opened transformative pathways in Surface Science. These films, often referred to as SURMOFs, enable unprecedented structural control, orientation, and integration with functional substrates, providing direct access to interfacial phenomena not observable in bulk materials. As such, SURMOFs offer a powerful platform for investigating physical processes at well-defined surfaces, including charge transport, optical processes, and dynamic host–guest interactions.

This contribution highlights how the deliberate assembly of "designer solids" from modular linker units—porphyrins, phthalocyanines, naphthalene diimides, and triphenylene—enables the bottom-up construction of crystalline thin films with tailored photophysical and electronic properties. We will discuss recent breakthroughs in device-oriented applications such as (photo)electrochemistry, sensing, and optoelectronics, with a particular focus on interface-specific effects and the emergence of novel transport mechanisms. Using the SURMOF platform, we demonstrate how band structure effects arise in ordered porphyrin arrays and how photon upconversion and diode functionalities can be realised through heterostructure design.

A major emphasis is placed on the integration of MOF films into functional devices, which requires reproducible electrical contacting and precise film engineering. SURMOFs excel in this regard, enabling straightforward fabrication of homo- and hetero-multilayers. We conclude with our recent discovery of the first metallic MOF thin film, exhibiting Dirac-cone transport characteristics. This advance—long considered a "holy grail" in MOF research—was realised through autonomous experimentation, with robotic systems guided by machine learning optimising key parameters such as crystallinity and conductivity. These developments firmly position SURMOFs at the frontier of surface science, bridging molecular design with macroscopic function.

Friday, Jan 16th 2026

16:00 Hrs (Tea / Coffee 15:45 Hrs)

Auditorium, TIFRH