MSE-Colloquium@NTU

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Flexibility and Phase Transitions in Metal-Organic Frameworks

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About the Talk

Much of our current research on metal-organic frameworks (MOFs) focuses on their physical properties, including their mechanical, optical, magnetic, ferroelectric and electronic behaviour. One of the characteristic features of MOF systems is that they undergo a wide range of phase transitions. These include classical transitions associated with the onset of magnetic ordering, ferroelectric ordering, high-spin low-spin transitions, and so on. Many transitions, however, are facilitated by the fact that MOF frameworks can show a remarkable degree of flexibility, much greater than that exhibited by inorganic framework materials such as zeolites. I shall discuss several cases of phase transitions that depend heavily on framework flexibility. These include the pressure-induced, ring-opening transition in the zeolitic imidazolate framework, ZIF-8, which increases the pore volume by about 4%, and the transition from a porous to a dense framework at 160K in ZIF-4, which is accompanied by a decrease in volume of ~23%. A third example involves a reversible, pressure-induced phase transition in a dense rare-earth formate, which shows the breaking and making of bonds during a transition that is accompanied by a 10% change in volume. We shall also discuss a dense oxalate that exhibits a transition from an insulating to a proton conducting phase in response to a change in humidity. Finally we shall explore chemical transformations that depend on flexibility, such as the topotactic dehydration of a dense MOF, lithium L-malate, to form lithium fumarate, and the topochemical dehalogenation of a copper trithiocyanurate framework that is accompanied by a change from an insulating crystalline phase to an amorphous semiconductor.

About the Speaker

Professor Tony Cheetham obtained his D.Phil. at Oxford in 1971 and did post-doctoral work in the Materials Physics Division at Harwell. He joined the chemistry faculty at Oxford in 1974, and then moved to the University of California at Santa Barbara in 1991 to become Professor in the Materials Department. In 1992 he took up the Directorship of the new Materials Research Laboratory, which he led for 12 years. He became the Director of the newly-created International Center for Materials Research at UCSB in 2004, and then moved to Cambridge in 2007 to become the Goldsmiths' Professor of Materials Science and a Fellow of Trinity College. Professor Cheetham is a Fellow of the Royal Society, the German Academy of Sciences, the American Academy of Arts and Sciences, and several other academies. He has received numerous major awards for his work in the field of materials chemistry; these include the Somiya Award of the IUMRS (with C.N.R. Rao, 2004), the Leverhulme Medal of the Royal Society (2008), and a Chemical Pioneer Award from the American Institute of Chemists (2014). He holds honorary doctorates from Versailles (2006), St. Andrews (2011), and Tumkur (2011). Professor Cheetham became the Treasurer and Vice President of the Royal Society in November 2012.