

Single Molecule Magnetism

Overview

Molecular magnetism is one of the most active areas of research in modern chemistry. Molecule-based magnets comprise a class of materials which differ from conventional magnets. Whereas most traditional magnetic materials are comprised purely of metals or metal oxides, in molecule-based magnets, the structural building blocks are molecular in nature. These building blocks can be a combination of both organic and inorganic moieties. The *f*-block metals play a significant part in the design and synthesis of molecular magnets. Chemical tailoring of the molecular building blocks to tune the magnetic properties poses a stiff challenge in this area. While all of the main group and transition metal (*d* block) is fairly well covered in most Indian institutions in their teaching curriculum, the component on lanthanides and actinides (*f*-block) is rather limited. This, and the broader topic of molecular magnetism will be covered at IIT Indore and GNDU, Amritsar by an internationally renowned expert, Professor Richard Layfield, Professor of Inorganic Chemistry in the School of Chemistry and Assistant Vice-Dean for Research in the Faculty of Engineering and Physical Sciences, in coordination with Professor Pradeep Mathur, Professor of Chemistry at IIT Indore (*f*-block chemistry) and by Professor Geeta Hundal, Professor of Chemistry at Guru Nanak Dev University, Amritsar (molecular magnetism)

Course participants will learn these topics through lectures and hands-on experiments. Also case studies and assignments will be shared to stimulate research motivation of participants.

Transition metal and lanthanide complexes in molecular magnetism

(to be taught at Guru Nanak Dev University Amritsar)

Modules

The course on molecular magnetism has following components:

Module 1 - Introduction to molecular magnetism (1 hour)

Historical aspects; playing with the periodic table; magnetic orbitals; units in molecular magnetism.

Module 2 - Electronic structures of free ions (1 hour)

‘Gas-phase’ ions; spin-orbit coupling.

Module 3 - Electronic structure of complex ions: transition metals (2 hours)

The crystal field; simple examples from coordination chemistry; the angular overlap model; magnetic anisotropy.

Module 4 - Electronic structure of complex ions: lanthanides (2 hours)

Structure, bonding and kinetics; simple examples from coordination chemistry; crystal field effects; term symbols; magnetic anisotropy.

Module 5 - Synthetic methods (2 hours)

Survey of common ligand types and synthetic methods; common characterization techniques.

Module 6 - Magnetism of ions (1 hour)

The Curie law; the van Vleck equation; anisotropy revisited.

Module 7 - Molecular orbital of isolated magnetic centres (1 hour)

Moving to MO; correlation effects; brief survey of theoretical methods.

Module 8 - Exchange-coupled molecular magnets (2 hours)

Magnetic interactions; spin hamiltonians; the giant-spin model and multicentre interactions exchange and super-exchange; *f* orbitals and orbital degeneracy; *d* orbitals; *f-d* interactions.

Module 9 - Dynamic properties and single molecule magnets (2 hours)

Mn₁₂; quantum tunnelling; the phthalocyanine family: the polyoxometalate family; SMMs with lanthanides; single chain magnets (SCM); the special case of dysprosium.

Module 10 - Applications of molecular magnetism (1 hour)

Molecular spintronics; NMR; magnetic resonance imaging; magnetocaloric effect; luminescence; electroluminescent materials for OLEDs; biological assays and medical imaging.

f-Block Chemistry**(to be taught at Indian Institute of Technology Indore)****Modules****This course is structured using the following topics:****Module 1 - 6 hours**

Atomic, ionic and electronic structure: 4*f* and 5*f* orbitals, lanthanide contraction, separation of lanthanides, Oxidation states: commonly occurring and 'exotic', Chemical bonding: ionic vs. covalent, Thermodynamic aspects of *f*-element chemistry.

	<p>Module 2 - 6 hours</p> <p>Coordination chemistry of Ln(III), Ln(II) and (IV) (hydrides, oxides and hydroxides, halides, chalcogenides, pnictides, carbides, borides), mixed ligand complexes, complexes with neutral ligands, Organometallic compounds.</p> <p>Module 3 - 3 hours</p> <p>Physicochemical properties of Lanthanides-</p> <p>Magnetism-</p> <p>Magnetic properties, role of lanthanides in molecular magnets, spin states, Models for the magnetic coupling of <i>f</i> and <i>s</i>, <i>p</i>, <i>d</i> electrons, nature of magnetic coupling involving Gd(III), Zero, one and two dimensional systems of lanthanides involving transition metal ions or organic radicals.</p> <p>Spectroscopy-</p> <p>Crystal field spectra of lanthanides, <i>4f-4f</i> transitions, <i>5d-4f</i>, LMCT transitions.</p> <p>Luminiscence</p> <p>Long lived excited states, Time resolved emission spectroscopy, Antenna effect, Applications in biology (medical imaging, cancer research, pH probes, virology, hydrogen peroxide sensors, bio-sensors), FRET phenomenon,</p> <p>Shift reagents in nuclear magnetic resonance, Role of Lanthanides in catalysis</p>
<p>You Should Attend If...</p>	<ul style="list-style-type: none"> * Masters and PhD students from Chemistry, Physics, Material Science and Engineering from different institutes across the country. * Researchers in R&D laboratories. * Faculty and academics interested in interdisciplinary research in design and synthesis of molecular magnets. * Researchers in education from reputed institutes as catalysis by metal complexes is a much sought after, but little taught in India, subject.
<p>Fees</p>	<p>The participation fees for taking the course is as follows: Academic Institutions: Rs 3,000/- per participant for each host institute Participants from industry: Rs 20,000/- per participant for each institute Free for participants from host institute</p> <p>The above fee includes all instructional material, tutorials, and refreshments. Participants can use institute accommodation on payment basis, subject to availability and on first come first serve basis.</p>

The Faculty



At The University of Manchester, **Richard Layfield** is Professor of Inorganic Chemistry in the School of Chemistry and Assistant Vice-Dean for Research in the Faculty of Engineering and Physical Sciences. He graduated with a Masters degree from the University of Leeds in 1999, and a PhD from the University of Cambridge in 2002. His research covers a range of topics centred on synthetic organometallic and coordination chemistry, with emphasis on lanthanides, molecular magnetism and carbene complexes. He has received numerous awards, including: the RSC's Meldola Medal (2006) and Frankland Fellowship (2013); an Experienced Researcher Fellowship from the Humboldt Foundation; and a Rising Star Lectureship from the ICCC. He currently holds an ERC Consolidator Grant and an EPSRC Grand Challenge Fellowship.



Dr. Geeta Hundal has obtained her Ph.D from Guru Nanak Dev University, Amritsar, in the field of small molecule crystallography. She did her post doctoral research from 1994-1996, at CSIC, Rocasolano, Madrid, Spain, working on protein and small molecule crystallography. She has worked in South Korea for two years (2008 and 2012) as Brain-pool scientist in the Korean Research Institute of Chemical Technology. She is presently Professor in the department of Chemistry, Guru Nanak Dev University, Amritsar, India. She has published

Course duration:

August 6 - 10, 2017
at GNDU, Amritsar

Course Coordinator at
GNDU Amritsar

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145 research papers in journals of international repute. Besides crystallography, her other interests are chemical sensing, supramolecular chemistry and coordination chemistry. She teaches course on Ligand Field Chemistry and spectroscopy to graduate and post graduate students.



Professor Pradeep Mathur is the Director of the Indian Institute of Technology Indore. He is also a Professor of Chemistry at the same institute as well as at Indian Institute of Technology Bombay. Prior to joining IIT Bombay in 1984, Dr. Mathur was at Yale University as a postdoctoral research associate and has been a Visiting Professor at Cambridge University, Freiburg University and Karlsruhe University.

He obtained his Ph. D. and DSc-hc from Keele University and a BSc (Hons) in Chemistry from the University of North London. Dr. Mathur is a recipient of the prestigious Shanti Swarup Bhatnagar Prize in Chemical Sciences. He is a J. C. Bose Fellow and a Fellow of the Indian Academy of Sciences, Bangalore. He is a member of various committees of the Government of India's largest funding agency, the Council of Scientific and Industrial Research and has authored over 200 research papers and has supervised 27 PhD theses. He has been or is on Editorial Boards of several journals, including Organometallics, Journal of Organometallic Chemistry and Journal of Cluster Science.

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*October 22 - 27,
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