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| **Course Code and Title** | MS7130: Organic Materials |
| **Details of Course** | **Summary of course content**<br><br>This course will cover the subject of organic materials. Organic materials cover both bulk commodities such as polyolefins, natural biological materials and bio-inspired materials with medical and other applications, new cutting edge materials such as graphene and carbon nanotubes, and organic colourants and semiconductors with optical and electronic properties that can be tuned for use in applications such as organic electronic devices, including biosensors, LED displays, and organic solar cells, and medical applications such as biomarkers for imaging. A materials approach will be adopted. The processing-structure-property-performance paradigm will be employed. The structural, optical and electronic properties of organic materials will be discussed as will the interrelationship between synthesis, characterization and applications. The design and use of organic materials in current and future applications will be discussed. |
| | **Rationale for introducing this course**<br><br>The rationale of introducing this course is to cover functional organic materials and their applications employing a processing-structure-property-performance framework. |
| | **Aims and objectives**<br><br>At the end of this course the students will<br>• Obtain an understanding of organic materials and their role in modern technological applications.<br>• Understand the functional requirements of organic materials for various applications.<br>• Critically analyze and predict future directions in organic materials |
| | **Course Syllabus**<br><br>**(Refer to below)** |
| **Assessment** | 3 x Tutorials – 30%<br>CA1: MCQs – 25%<br>CA2: MCQs – 25%<br>Research paper critique: peer review – 20%<br><br>All components are assessed Individually. |
| **Hours of Contact/Academic Units** | *39 hours / 3 AU* |
| **Proposed Date of Offer** | Semester 1, AY2021-22 |
| **Instructor and Co-instructor (if any)** | Assoc Prof Andrew Grimsdale |
| **Class size** | 30 |
| **Any duplication of course** | No |

**Course Syllabus**

The following topics will be covered:

**MODULE 1: Fundamental Properties and Principles of Organic Materials**

1. Introduction to organic materials
   -Allotropes of carbon.
   -Types of organic materials --Polymers versus molecules.

2. Bonding in organic molecules
   -Hybridisation of carbon ($sp^3$, $sp^2$, sp).
   -Covalent bond types – properties and chemistry of □ vs □-bonds.

**MODULE 2: Structural Organic Materials**

1. Polyolefins
   -Synthesis of polyethylene and polypropylene (Ziegler-Natta)
   -Structure-property relationships in PP (tacticity)
   -Applications.

2. Substituted polyolefins
   -Polystyrene- synthesis and applications.
   -Radical and anionic polymerisations.

3. Carbon nanotubes and carbon fibres
   -Synthesis and structure-property relationships.
   -Use of CNTs and carbon fibres (composites).

4. Condensation polymers
   -Synthetic methods. Nylon. Kevlar.

5. Introduction to Bio-materials
   -Proteins and other types of biopolymers.

6. Biomaterials as structural materials
   -Examples of structural biomaterials, including cellulose, lignins, chitin and spider silk.

**MODULE 3: Electronic Properties of Organic Materials**

1. Introduction to conjugated materials
   -Introduction to conjugation and bandgaps.
   -Types of conjugated materials

2. Graphene and Nanotubes
   -Preparation and applications of graphene.
   -Structure and electrical properties of carbon nanotubes.

3. Polyacetylene
   -Synthesis and doping of polyacetylene.
   -Origin of conductivity.

4. Other conducting polymers
   -Synthesis, properties and applications of other conducting polymers including -PEDOT and polyaniline.

5. Semiconducting organic materials
   -Introduction to semiconductors.
   -Classes of organic semiconductors.

6. Molecular materials for transistors.
   -Acenes and oligomers.
   -Synthesis and processing.
   -Structure-property relationships.

7. Regioregular polythiophene
   -Regiorandom versus regioregular polythiophene.
   -Synthesis,
   -Structure property relationships.

8. High mobility copolymers
   -Donor-acceptor polymers for high mobility.
   -Synthesis and processing.
   -Structure-property relationships.

**MODULE 4: Optical Properties of Organic Materials**

1. Introduction to colour.
   -Origins of colour – absorption, emission, photonics.

2. Dyes and pigments
   -Difference between dyes and pigments.
   -Synthesis and applications, e.g. bioimaging, of coloured materials.

3. Dye-sensitised solar cells
   -Mechanism of dye-sensitised solar cells.
   -Dyes for solar cells.
   -Perovskite solar cells,

4. Electron donors for solar cells
   -Bulk-heterojunction solar cells
   -Polymer donors for high efficiency – design and synthesis.

5. Electron acceptors for solar cells
   -Fullerenes as acceptors
   -Non-fullerene acceptors

6. Organic luminescence
   -Origins of emission in organic materials – fluorescence versus phosphorescence.
   -Types of organic emitters – small molecules versus polymers

7. Materials for LEDs
   -Structure-property relationships
   -Super Yellow

8. Frontiers in OLEDs
   -Search for stable blue emitters
   -Phosphorescent materials
   -White emission

**MODULE 5: Analysis of Organic Materials**

1. Introduction to analysis of organic materials
   -Overview of methods used in analysis of organic materials: SEC
   -Thermal methods, spectroscopy
   -Microscopy
   -X-ray diffraction

2. Size Exclusion Chromatography
   -Uses and limitations of SEC.
   -Alternative methods for determining molar mass of polymers.
3. TGA and DSC
   -Principles and use of TGA and DSC for analysis of organic materials.

4. IR and Raman spectroscopy
   -Vibrational spectroscopy by IR and Raman – principles, uses and limitations.

5. UV-Vis and PL spectroscopy
   -Principles,
   -Uses and limitations of UV and PL spectroscopy.
6. NMR spectroscopy
   -Principles,
   -Uses and limitations of 1H and 13C NMR spectroscopy,
   -Including 2D NMR and solid-state NMR.

7. Microscopy
   -Introduction to optical,
   -Electron and scanning microscopies and their use in analysing organic materials.

8. Electrical characterization of organic materials.
   -Introduction to techniques such as CV,
   -Mobility measurements used in electronic characterization of organic materials.