# Subject Description Form

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| **Subject Code** | ABCT5037 |
| **Subject Title** | Green Chemistry for Sustainable Products Development |
| **Credit Value** | 3 |
| **Level** | 5 |
| **Pre-requisite/ Co-requisite/ Exclusion** | Nil |
| **Objectives** | This subject aims to introduce the principles and the application of green chemistry for developing eco-friendly and safe chemical products. Students will learn to identify major environmental challenges associated with chemical industries. Students will be equipped with tools available to scientists and engineers to practice green, energy-efficient and safe chemistry. This subject will also provide students with updated development of selected emerging technologies for sustainable chemical synthesis. |
| **Intended Learning Outcomes** | Upon the successful completion of this subject, students will be able to:<br>a) identify common environmental sustainability issues associated with chemical processes;<br>b) apply the concepts and principles of green chemistry to develop sustainable chemical processes and products;<br>c) analyze the efficiencies and limitations of different green chemistry tools for designing sustainable processes and products;<br>d) recognize some latest developments in new chemical processes and technologies to develop greener products. |
| **Subject Synopsis/ Indicative Syllabus** | **1. Green chemistry and processes in the context of sustainability**:<br>• Environmental, health and safety issues<br>• Principles of green chemistry for sustainable development<br><br>**2. Strategies and principles for developing sustainable processes**:<br>• Waste minimization and atom economy<br>• Reduction of materials use (catalytic reactions; reduction of non-renewable feedstocks or starting materials)<br>• Reduction of energy requirement (energy efficiency improvement; alternative energy sources) |

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| | • Reduction of risk and hazard (safe product design; alternative solvents)<br><br>**3. Measuring and controlling environmental performances**<br>• Evaluating the effects of chemicals on human, wildlife and local environment<br>• Introduction of Life Cycle Assessment (LCA) methodology and framework<br>• Product- and process-oriented LCA<br>• Evaluating methods to design safer chemicals<br><br>**4. Catalysis and green chemistry**<br>• Introduction to catalysis<br>• Heterogeneous and homogeneous catalysts for bulk and fine chemical industries<br>• Catalytic oxidation using hydrogen peroxide<br>• Biocatalysis<br><br>**5. Organic solvents**<br>• Organic solvents and volatile organic compounds<br>• Solvent-free systems<br>• Supercritical $CO_2$ as the solvent<br>• Ionic liquids and fluorous biphasic solvents<br>• Comparing of green-ness of solvents<br><br>**6. Renewable feedstocks and starting materials**<br>• Chemicals from fatty acids<br>• Polymers from renewable feedstocks<br>• Conversion of biomass to some other chemicals<br>• Catalysts from chemical wastes<br><br>**7. Emerging green technologies for green chemical processes**<br>• Design processes for energy and atom-efficiency<br>• Photochemical reactions<br>• Chemistry with microwaves<br>• Sonochemistry<br>• Electrochemical synthesis |
| **Teaching/Learning Methodology** | **Lecture**: basic concepts and working principles will be introduced and discussed with particular emphasis on the latest applications. Examples will be used to illustrate the applications of various methods and techniques. Tutorial sessions will be used to consolidate the contents of lectures and guide the students in problem solving and discussion. |

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<tr><td></td><td>Presentation and written essay: The class will be divided into groups with 2~3 students per group, and various topics of the subject will be assigned to each group. Students will conduct literature research on the topic, present it in the class, and submit an individual written essay.</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="6">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td></td><td></td></tr>
<tr><td>1. Presentation</td><td>30%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>2. Written essay</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>3. Examination</td><td>50 %</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Total</td><td>100%</td><td colspan="6"></td></tr>
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Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:<br><br>
Presentation: Students are required to prepare an oral presentation on assigned topics related to the emerging technologies for sustainable chemical synthesis. They will work in a small group for literature searching, discussion, and preparation of slides and a written report. Understanding of the topic, communication skill, and critical/creative thinking will be assessed.<br><br>
Written essay: Students need to analyse at least one case relating to green chemistry and processes. The assigned case question will be sent to students one week in advance. Students need to submit an analysis report before the in-class group presentation. The objective of the written essay is to assess students' understanding of the principle and application of green chemistry and technologies for developing greener products.<br><br>
Examination is a major assessment component of the subject, which will be conducted as a closed-book examination. This will be used to test the students' overall understanding of all intended learning outcomes and problem-solving skills.
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| **Student Study Effort Expected** | Class contact: | |
| | ▪ Lecture | 33 Hrs. |
| | ▪ Presentation | 6 Hrs. |

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| | Other student study effort: | |
| | ▪ Self-study and group work | 81 Hrs. |
| | Total student study effort | 120 Hrs. |
| **Reading List and References** | Anne E. Marteel-Parrish, Martin A. Abraham, Green Chemistry and Engineering: A pathway to sustainability, Wiley, 2014.<br>Paul T. Anastas, John Charles Warner, Green Chemistry: Theory and Practice, Oxford University Press, 1998.<br>Davor Margetic, Vjekoslav Štrukil, Mechanochemical Organic Synthesis, Elsevier, 2016<br>J. L. Luche, Synthetic Organic Sonochemistry, Plenum Press, 2001<br>Jean-Marc Lévêque, Giancarlo Cravotto, François Delattre, Pedro Cintas, Organic Sonochemistry: Challenges and Perspectives for the 21st Century, Springer, 2018<br>Georgios Stefanidis, Andrzej Stankiewicz, Alternative Energy Sources for Green Chemistry, RSC publication, 2016<br>Cheanyeh Cheng, Enzyme-Based Organic Synthesis, Wiley, 2022<br>Andreas Sebastian Bommarius, Bettina R. Riebel, Biocatalysis, Wiley, 2004 | |