Spring 2024

CHEM 702-102: ST:Green Chemistry

Omowunmi Sadik

Spring 2024: Chem 702 Green Chemistry & Sustainability

NJIT New Jersey Institute of Technology

THE COLLEGE OF SCIENCE AND LIBERAL ARTS

THE DEPARTMENT OF CHEMISTRY AND ENVIRONMENTAL SCIENCE

Course Syllabus

3 credits, Wednesdays from 6:00 – 8:50 PM, FMH 108

Instructor: Professor Sadik, sadik@njit.edu, Office Hours: Wednesdays @ 3:00 – 4:30PM, T 151C

Course Description

This course provides an interdisciplinary perspective that includes chemists, economists, environmental engineers, and social scientists as instructors. The course integrates Green Chemistry with Sustainability, emphasizing societal, economic, environmental, and governance (SEEG) perspectives. Students will learn: i) how to design products and processes that minimize or eliminate the production and use of hazardous substances, ii) the 12 principles of Green Chemistry, and iii) how these principles can be used to develop sustainable catalysts, green solvents, degradable materials, reduce waste, reuse materials, and design safer processes, and products while ensuring sustainability. In addition, students will have the opportunity to interact with leaders of Green Chemistry & sustainability, as well as learn about the success stories, toxicology, microbial degradation, and greener pharmaceutical designs for recycling, degradation, and other contemporary topics.

Prerequisites: Basic understanding of introductory general chemistry

Course Objectives

This course will broaden students' understanding of the issues to which advanced training in chemistry can be applied and simultaneously increase their ability to formulate critical research questions on the daunting challenges of the 21st century concerning food, energy, and human and planetary health. Sustainability and sustainable development are desirable characteristics of today's industrial society. Not only do we need resources and successful economic development to achieve sustainability goals, but we also need to limit the impacts of human activities on the Earth's ecosystems and the global environment. Green Chemistry holds great promise for sustainable development.

Delivery Format: Class lectures, participation in CES Department colloquia on relevant topics, classroom visits by Green Chemistry and Sustainability luminaries, group discussions, and videos.

Number of Credits: 3

Learning outcomes

- Understand the need and role of chemicals in society
- Learn the chemical disasters that occurred in the past and their causes.
- Qualitatively and quantitatively examine the impacts of chemical products and processes on human health and the environment.
- Understand 12 principles of Green chemistry and identify their individual impact.
- Understand how Green chemistry can be used to reduce waste, reuse materials, design safer processes and products, and ensure sustainability.
- Apply green chemistry principles before and during experiments.
- Evaluate atom economy, E-factor, process mass intensity, and differentiate between percentage yield and atom economy.
- Perform Life cycle assessment of commercialized products.
- Learn basic concepts of toxicology.
- Analyze materials, their properties, toxicity, and regulatory requirements before using them in any process and finding safer substitutes.
- Develop skills and analyze alternative routes for conventional procedures requiring toxic substances.
- Appreciate SEEG perspectives and how green chemistry is transforming chemistry on a global scale and advancing UN Sustainable Development Goals.
- Appreciate the success stories and real cases that employed green chemistry.
- Recognize the importance of analytical methods in the real-time monitoring of a chemical product and process.

Assessment of Learning Outcomes

Grading Policy: The final grade in this course will be determined as follows:

A	100 - 90%	**C**	74 – 70%
B+	89 - 85 %	**D**	69 - 65 %
B	84 - 80 %	**F**	Below 65 %
C+	79 - 75%		

Grading Criteria

Mid-Term 1	25 points
Mid-Term II	25 points
*Group Discussion/Class Participation	20 points
Term Paper and Class Presentation	30 points

Total	100 points

*Students must submit their contributions to the group discussion for grading at the end of each group session. All submissions must be on Canvas, no emails!

Chem 702 emphasizes top-ranked professional skills that students need to succeed, such as Collaborative teamwork, Critical thinking, Interpersonal communication, and Trans-disciplinary thinking.

Group Discussion:

The purpose of a **Group Literature Discussion** is to examine carefully and sometimes evaluate a research work or an aspect of a research work of literature. This provides a way for students to engage in critical thinking and reflection as they read, discuss, and respond to research literature. Collaboration is at the heart of this approach. Students reshape and add to their understanding as they construct meaning with other readers. The Instructor will assign a literature paper prior to the class meeting, and this will be discussed in a group setting in class. Students are also free to suggest any topic or paper that they would like to be used during the class group Discussion. Students should submit their contributions to the group discussion for grading at the end of each Group Session.

Class Participation

Class participation includes, but is not limited to, class engagement, attendance, and response to questions during class (up to 20 points). This is a discussion-driven and student-centered class. They are expected to be actively involved in discussions and other class activities that would generate the robust energy needed for a successful conversation. Active participation includes completing assignments on time and being present for impromptu class discussions and quizzes. Students who record four or more unexcused absences will receive no points for class participation. It is strongly advised that a student must use all means available to contact the Instructor if he/she must be excused from class in an emergency. When a class is missed, it will be his/her responsibility to find out what was discussed.

Term Paper and presentation:

You will select a specific Green Chemistry Principle, choose a related topic to that principle, research the issues involved, and propose a sustainability approach for solving the chosen problem**.** The length of the term paper or proposal should be at least 5 pages. The report will include:

- Objective of the work
- Background/Literature Review
- Approach, including the Green Chemistry principle chosen
- Chemical basis of the method (instrumental and mechanistic)
- Chemical/Engineering Redesign, optimization and validation validation
- Circular economy encountered
- Possible problems that may be encountered
- How to address these problems

The term paper must be formatted according to the 6th Ed. American Psychological Association(APA) format. 6th Edition APA Style Format can be found at: http://owl.english.purdue.edu/owl/resource/560/02/.

COURSE CONTENTS

Lecture	Topic	
Jan 17	**Introduction to Green Chemistry Principles and Sustainability** Role of Green Chemistry for sustainable development, SDGs (Baseline Survey)	
Jan 24	**Waste Production and Disposal Issues** Environmental Health and Safety Issues and why we need Green Chemistry 12 Principles of Green Chemistry (Quiz 1)	
Jan 31	**Metrics: How do we know its Green?** Reaction yield (theoretical, actual, and percentage yield) E-Factor, Atom Economy, Effective mass yield, LCA, RME, Mass Intensity, Problem SolvingMass Productivity, SEEG questions (**Group Discussion**)	
Feb 7	**Social Dimensions of Green Chemistry** **Social Perspectives** (Dr. Maurie Cohen) **Designing Green Synthesis -1** VOC issues, Solvent selection guide, solvent-free processes, solvents obtained from renewable resources (Quiz 2)	
Feb 14	**Designing Green Synthesis - 2** Material selection: Solvents, Catalysts, Reagents and Strategies, Processes, Safer-by Design **Group Discussion)** (Working with and without solvents):	
Feb 21	**Green Solvents** Ionic Liquids, Supercritical fluids, Fluorous Biphasic Solvents, and other solvents Comparing the Greenness of Solvents (Quiz 3 and Review) Survey 2	
Feb 28	Sustainable Chemistry and Engineering (Guest Speaker) **Energy Requirements for Reactions** Energy efficiency: Using alternative sources of energy: photochemical energy, microwave irradiation, and ultrasonic energy (Mid-Term I)	
Mar 6	**Toxicology**: Introduction, Chemical Dosage, and Exposure (Dr. Genoa Warner) **(Group Discussion)**	
	Spring break (March 10-16, 2024)	

Mar 20	**Catalysis and Green Chemistry** Green Catalysis, Photocatalysis, Sonocatalysis, Real-time monitoring with analytical methods **(Quiz 4)**	
Mar 27	**Electrochemical Synthesis** Designing Future Products with Reduced Toxicity: Industrial Case Studies (Videos and Group Discussions)	
Apr 3	**Economic Perspective** (Dr. Zeyuan Qiu) (**Quiz 5 and Review)** DYO: Applying Green Chemistry and Sustainability Principles to your research EPA Presidential Green Chemistry Challenge Awards	
Apr 10	Emerging Greener Technologies Nano, Bioplastics, Biopolymers, and Evaluatin g Technologies (MidTerm II)	
Apr 17	**Biotechnology-enabled remediation** (Dr. Mengyan Li) **Group Discussion** Bringing it all together, Is sustainability possible (Term Paper Due)	
Apr 24	Selected Class Presentations on Term Paper Topics (Final Survey)	
May 1-9	Reading Days and Final Exam Week	

Recommended Texts

- Green Chemistry Fundamentals and Applications
  Suresh Ameta and Rakshit Ameta, 385 pages, Published by Apple Academic Press, 2013, ISBN-10: 1926895436, ISBN-13:978-1926895437
- Green Chemistry: An Introduction Text, 2nd Edition, Mike Lancaster, 344 pages, published by the Royal Society of Chemistry, 978-1-84755-873-2
- Sustainable Catalysis: Challenges and Practices for the Pharmaceutical and Fine Chemical Industries, Peter J. Dunn (Editor), K. K. (Mimi) Hill (Editor), Michael J. Krische (Editor), Michael T. Williams (Editor), ISBN: 978-1-118-35451-3, April 2013, 440 Pages.