- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.
- Use of ICT tools to show the structure of carbohydrates and protiens.

### Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

**Keywords:** Biological importance of carbohydrates, Proteins, isolation, Lipids.

## 11.2.2. Course Code: ANALYTICAL CHEMISTRY (DSE-AC2) Course Title: Green Chemistry

**Total Credits: 04 (Credits: Theory-02, Practical-02)**
**(Total Lectures: Theory- 30, Practical-60)**

**Objectives:** Our society is becoming more and more environmentally conscious. The concern of environmental pollution, depleting resources, climate change, ozone depletion, heaps of landfills piling up, legislation getting more restrictive with stringent environmental laws, and rising costs of waste disposal are increasing. Sustainable practices have emerged as a response to these concerns. Green chemistry represents the direction in which chemistry should be heading. It is not a new branch of chemistry but the way chemistry should be practiced. Green chemistry innovations and applications in education have not only benefited the environment but have been beneficial to businesses' economic and societal goals, too. Because it is undergraduate students who will be the community's scientists of the future, this is possible.

### Learning Outcomes:

By the end of this course, students will be able to:

- Understand the 12 principles of green chemistry and will develop knowledge of toxicity, risk, and hazard of chemical substances.
- learn about atom economy and how it differs from percentage yield. Students will apply stoichiometric calculations to green chemistry applications.
- Learn to design safer chemicals, products and processes that are less toxic, than current alternatives. Hence, they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harm you"
- Learn about the benefits of utilizing catalysts and biocatalysts, the use of renewable feedstocks that improve energy efficiency and protect the environment, and green solvents for leading reactions.
- Learn about the applications of Green Chemistry.

## Unit 1: Introduction to Green Chemistry

What is Green Chemistry? Environmental laws, pollution prevention Act of 1990, Need for Green Chemistry, Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

(Lectures: 03)

## Unit 2: Application of Green Chemistry Principles

Principles of Green Chemistry and Designing a Chemical synthesis.

**Concept familiarization and application of green chemistry principles using specific examples:**

1. Prevention of Waste/ by-products; waste or pollution prevention hierarchy

2. Green metrics to assess greenness of a reaction: Calculation of atom economy of the rearrangement, addition, substitution and elimination reactions; Calculation of E-factor for industrial processes

3. Prevention/ minimization of hazardous/ toxic products

4. Safer Solvent and Auxiliaries: Problems associated with conventional reaction media, Some Common Green solvents: Introduction, Application, Advantages and Disadvantages of green solvents in organic synthesis (taking suitable examples). Special emphasis on the following:

**i.** Super Critical Fluids (with special reference to carbon dioxide)
**ii.** Water: Concept of In-water, and on-water reactions (with special reference to synthesis of terpinol and linalool in water, Benzoin condensation, Heck reaction)
**iii.** Ionic Liquids: Physical Properties and Classification of Ionic Liquids (with special reference to Diels Alder reaction and Coumarin synthesis in ionic liquids)
**iv.** Biomass derived Solvents: Physicochemical properties, Use of Glycerol and its derivatives (Mizoroki–Heck reaction) and 2-Methyltetrahydrofuran (Suzuki–Miyaura reaction).

5. Design for energy efficiency: Phenomenon of accelerating organic reactions by using the following Green Chemistry tools (taking suitable examples) and its advantages:

i. Mechanochemistry
ii. Ultrasound assisted reactions: Taking examples like Simmons Smith reaction, Diels–Alder reaction,
iii. Microwave assisted reactions: Special emphasis on solvent-free synthesis- copper phthalocyanine and aspirin, In-water reactions-Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction;
iv. Electrocatalysis: Taking examples like adiponitrile synthesis, synthesis of 3-bromothiophene.
v. Visible light induced Reactions: with examples such as, syntheses of caprolactam, vitamin D3, and *cis-trans* isomerization of alkenes

6. Use of renewable starting materials: Illustrate with few examples such as biodiesel, bioethanol, polymers from renewable resources (PLA from corn), Synthesis and properties of 2-Methyltetrahydrofuran, furfural and 5-Aminolevulinic acid (DALA) from levulinic acid

7. Avoidance of unnecessary derivatization – careful use of blocking/protecting groups (taking specific examples like selective oxidation of aldehydic group and synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G

8. Catalysis and green chemistry Introduction to Catalysis (including concept of selectivity, turnover frequency and turnover number), Types of Catalysts: Heterogeneous catalysis and homogeneous catalysis (H-beta and zeolites in organic synthesis), General catalytic cycle for heterogeneous catalysis; Asymmetric catalysis (Monsanto route to L-dopa via asymmetric hydrogenation, synthesis of carbapenhem via Asymmetric reduction); Photocatalysis (with special reference to $TiO_2$); Biocatalysis (Synthesis of adipic acid/catechol using biocatalyst) and Nanocatalysis (oxazole synthesis using nanocatalyst)

9. Design for degradation: (Illustrate with the help of examples: soaps and detergents, pesticides, polymers)

10. Real Time monitoring of chemical processes using inline, offline and online techniques

11. Inherently safer design/chemistry: Principle and subdivision of ISD, Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol, Asahi Process)

(Lectures: 21)

**Unit 3: Real world case studies based on the Presidential green chemistry awards of EPA**

- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.
- A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic out of pressure treated wood.
- An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.
- Healthier Fats and oils by Green Chemistry: Enzymatic Inter esterification for production of No Trans-Fats and Oils.
- Using a naturally occurring protein to stimulate plant growth, improve crop quality, increase yields and suppress disease.

(Lectures: 06)

**PRACTICALS (Credits: 02, Laboratory Periods-60)**

**Characterization by m. pt., U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method should be done (wherever applicable).**

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.
2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, Solubility, Combustion Test, Density, Viscosity, Gel Formation at Low Temperature and IR can be provided).

3. Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
4. Extraction of D-limonene from orange peel using liquid $CO_2$ prepared form dry ice.
5. Mechanochemical solvent free, solid–solid synthesis of azomethine using *p*-toluidine and o-vanillin/p-vanillin (various other combinations of primary amine and aldehyde can also be taken).
6. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
8. **Designing and conducting an experiment by utilizing the products and by products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey. Some representative examples:**
    - Use of nanoparticles as catalyst for a reaction
    - Benzoin converted into Benzil and Benzil into Benzilic acid by a green method
    - Use of azomethine for complex formation
    - Rearrangement reaction from Benzopinacol to Benzopinacolone
    - Conversion of byproduct of biodiesel to a useful product
    - Spot tests for qualitative inorganic analysis for cations and anions, and qualitative organic analysis for preliminary test and functional group analysis.

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- Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi.
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### Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power Point Presentations
- Interactive Sessions

### Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

**Keywords:** Green Chemistry, 12 Basic Principles of Green Chemistry, Atom Economy, Waster Prevention, Catalyst, Solvent Free synthesis, Green Solvents.

## 11.2.3. Course Code: ANALYTICAL CHEMISTRY3 (DSE-AC3) Course Title: POLYMERS

**Total Credits: 04 (Credits: Theory-02, Practical-02)**
**(Total Lectures: Theory- 30, Practical-60)**

**Objectives:** To acquaint students with knowledge of molecules and macromolecules. To study about molecular weight determination and the solution properties of polymers.

### Learning Outcomes:

By the end of this course, students will be able to:

- Learn about the molecules, macromolecules and polymers
- Learn about properties of polymer solutions.
- Learn about the differentiation between molecule and polymer.
- Learn about the properties of polymers.