**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**
I– Semester

Course Title: **Basic Polymer Chemistry**
(Course Code: 4312301)

| Diploma programme in which this course is offered | Semester in which offered |
|---|---|
| Plastics Engineering (Sandwich Pattern) | First |

## 1. RATIONALE

The plastic industry occupies a prominent position in the development of both industrially advanced and developing countries. Plastics are now becoming basic engineering material to replace steel because of their unique properties and low cost. Acquaintance of Basic polymer chemistry is essential to take up career in plastic technology. Students in this course will be skilled to use concepts of polymer chemistry used for engineering application in the field of plastics.

## 2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use concepts of organic chemistry in the field of Plastic Engineering**

## 3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Interpret the carbon structure present in the polymer.
b) Use relevant monomers and its functionality for different applications.
c) Interpret polymer properties based on geometric structures.
d) Use suitable polymer for different applications.
e) Select suitable polymerization technique for environmental sustainability.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme (In Hours) | | | Total Credits (L+T/2+P/2) | Examination Scheme | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | Total Marks |
| L | T | P | C | CA | ESE | CA | ESE | |
| 3 | - | 2 | 4 | 30* | 70 | 25 | 25 | 150 |

*(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.*

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

## 5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *These PrOs need to be attained to achieve the Cos.*

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. required |
|---|---|---|---|
| 1 | Identify different configurations of carbon. | I | 02 |
| 2 | Identify simple organic compounds containing C, H, O, N, S & Cl with Melting point & boiling point. | I | 04 |
| 3 | Undertake tests to identify monomers (Hydrocarbons, chlorinated monomers) | II | 04 |
| 4 | Undertake tests to identify monomers with several double bonds | II | 02 |
| 5 | Undertake solubility test for identification of Polymers. | III | 04 |
| 6 | Use flame test for identification of polymers. | III | 02 |
| 7 | Separate and Purify the given polymer. | III | 04 |
| 8 | Use experimental set-up for free radical polymerization. | IV | 02 |
| 9 | Examine Condensation Polymerization Reaction used in the creation of Nylon 6-10 | IV | 04 |
| | **Total** | | **28** |

***Note***

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

| S. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|---|---|---|
| 1 | Prepare of experimental setup | 20 |
| 2 | Operate the equipment setup or circuit | 20 |
| 3 | Follow safe practices measures | 10 |
| 4 | Record observations correctly | 20 |
| 5 | Interpret the result and conclude | 30 |
| **Total** | | **100** |

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Bunsen burner 85mm base, 142 mm height, Aluminum, /Brass/Steel | 2,6,7,8 |
| 2 | Purification set | 7 |

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 3 | Test tube (18 x 150 mm) Glass | 2,5,6 |
| 4 | Stirring rods as per requirement | 2,5 |
| 5 | Beaker (50 mL, 250 mL) Glass | 2,5,6,7 |
| 6 | Solvents and Chemicals as per requirement | 1,3,5,7 |
| 7 | Safety equipment (gloves, goggles etc) as per requirement | 3,6,7,8,9 |
| 8 | Ring stand and ring with wire gauze | 5,6,8 |
| 9 | Thermometer as per requirement | 6,7,8,9 |
| 10 | Capillary tube as per requirement | 2,7 |

## 7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfil the development of this course competency.

a) Work as a leader/a team member.
b) Follow ethical practices.
c) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

| Unit | Unit Outcomes (UOs) (4 to 6 UOs at different levels) | Topics and Sub-topics |
|---|---|---|
| **Unit-I**<br><br>**Organic Chemistry** | 1a. Explain principles of organic chemistry<br>1b. Make use of periodic table and element structure<br>1c. Identify bond types & different organic compounds.<br>1d. Compare various carbon configuration | 1.1 Organic chemistry: definition and scope<br>1.2. Periodic table and element structure (C, H, O, S, Cl, N, Si)<br>1.3. Types of Bond, Bond angle, Bond length, Bond energy, Electro negativity, Polar Bonds, Bond Polarity & Dipole moment<br>1.4. Configuration of carbon - SP-I, SP-II, and SP-III. |

| Unit | Unit Outcomes (UOs) (4 to 6 UOs at different levels) | Topics and Sub-topics |
|---|---|---|
| | 1e. Classify hydro carbons.<br>1f. Identify various functional groups<br>1g. Construct nomenclature of organic compounds | 1.5. Classifications of Hydro-Carbons.<br>1.6. Functional groups – structure and characteristics<br>1.7. Nomenclatures of Organic Compounds (IUPAC). |
| **Unit-II**<br><br>**Monomers** | 2a Explain monomers<br>2b Describe functionality of monomer<br>2c Classify monomers<br>2d Manufacturing of given monomers<br>2e Describe the purification process of given monomers.<br>2f Justify the selection of manufacturing process for a monomer.<br>2g Dispose monomer waste safely. | 2.1. Monomers – Definition, use, functionality, types<br>2.2 Manufacturing of Monomers - Ethylene, Vinyl and Styrene<br>2.3. Purification of Monomer<br>2.4 Dispose monomer waste safely. |
| **Unit-III**<br><br>**Polymers** | 3a Explain polymers<br>3b Describe polymerization and degree of polymerization<br>3c Explain effect of functionality on polymer structure<br>3d Compare polymer structure of given polymers<br>3e Classify the given Polymers<br>3f Dispose polymer waste safely. | 3.1. Polymer: Definition and use<br>3.2. Polymerization and degree of polymerization.<br>3.3. Effect of functionality on Polymer Structure.<br>3.4. Polymer Structure- Linear, branched, cross-linked, Random, alternating, block, graft and Stereo regular polymers<br>3.5. Classification of Polymer based on: Structure, Repeating unit, Applications, Source, Nature and Processing<br>3.5 Dispose polymer waste safely. |
| **Unit-IV**<br><br>**Polymerization** | 4a Describe the steps in polymerization<br>4b Classify addition polymerization reactions to produce polymer<br>4c Compare poly condensation and poly addition polymerization<br>4dExplain rearrangements and stereo polymerization<br>4e Select suitable polymerization technique for environmental sustainability. | 4.1. Polymerization steps – Initiation, Propagation and Termination<br>4.2. Polymerization reactions<br>4.3 Addition Polymerization reactions: Free radical polymerization, Ionic Polymerization, Co-ordination polymerization<br>4.4. Condensation Polymerization Reactions: Poly condensation polymerization, Poly addition polymerization, Rearrangements and Stereo Polymerization<br>4.5 Polymerization technique for environmental sustainability. |
| **Unit – V**<br><br>**Copolymerization** | 5a Describe co-polymerization<br>5.b Compare free radical and icon polymerization reactions | 5.1. Co-Polymerization: Definition and use<br>5.2. Co-Polymerization reactions:<br>a. Free radical polymerization - Ionic polymerization, Co-poly condensation polymerization |

| Unit | Unit Outcomes (UOs) (4 to 6 UOs at different levels) | Topics and Sub-topics |
|---|---|---|
| | 5c Compare free radical and co-poly condensation reactions<br>5d Justify the use of co-poly condensation polymerization for the given application | 5.3 Dispose polymer electronic waste safely. |

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A | Total Marks |
| I | Organic Chemistry | 10 | 08 | 04 | 03 | 15 |
| II | Monomers | 06 | 06 | 03 | 02 | 11 |
| III | Polymers | 10 | 06 | 07 | 05 | 18 |
| IV | Polymerization | 12 | 06 | 06 | 08 | 20 |
| V | Copolymerization | 04 | 02 | 02 | 02 | 06 |
| **Total** | | **42** | **28** | **22** | **20** | **70** |

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare student reports as asked in experiments.
b) Perform experiments as mentioned.
c) Prepare list of Polymer suppliers along with brands, specifications, prices, terms and conditions.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b) Guide student(s) in undertaking micro-projects.

c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.

d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.

e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

f) Guide students on how to address issues on environ and sustainability

g) Guide students for using raw material data sheet.

## 12. SUGGESTED MICRO-PROJECTS

***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the microproject should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Functional Group: Prepare a chart for types of functional groups.

b) Monomer: Prepare a chart for types of monomer.

c) Polymer: Prepare chart for classification of polymers

d) Prepare chart to illustrate industrial applications of monomers and polymers.

e) Visit any plastic industry and prepare report on monomers and polymers used.

## 13. SUGGESTED LEARNING RESOURCES

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 1 | Textbook of Organic Chemistry | Chawla HM, Soni P.L. | Sultan Chand & Sons, New Delhi, 2019, 8180547676 |
| 2 | Textbook of Organic Chemistry | Bahl Aun & Bahl B.S | Sultan Chand & Sons, New Delhi, 2019, 9789352837304 |
| 3 | Textbook of Polymer Science | Fred W. Billmeyer | John Wiley & sons, Singapore,2009, 978-0-471-03196-3 |
| 4 | Polymer Science | Govariker V.R | New Age International Pub, Delhi, 2019, 9788122438130 |
| 5 | Polymer Science and Technology | Fried J.R | Prentice Hall, Delhi,2014, 9780137039555 |
| 6 | Textbook of Organic Chemistry | Bansal R.K | New Age Publications, New Delhi, 2020, 978-81-224-3967-0 |
| 7 | Polymer Science and Technology | Ghosh Pramamoy | Tata McGrow Hill Education Pvt. Ltd, Delhi, 2010, 9780070707047 |
| 8 | Polymer Chemistry | Charles E. Carraher Jr. | CRC Press, Delhi, 2017, 9781498737388 |

## 14. SOFTWARE/LEARNING WEBSITES

1. https://pubchem.ncbi.nlm.nih.gov/periodic-table
2. http://www.chem.uiuc.edu/GenChemReferences/nomenclature_rules.html
3. https://byjus.com/jee/chemical-bonding/
4. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch103-allied-health-chemistry/ch103-chapter-5-covalent-bonds-organic-functional-groups-and-biological-molecules/
5. https://www.toppr.com/guides/chemistry/polymers/classification-of-polymers/
6. www.sciencedirect.com

## 15. PO-COMPETENCY-CO MAPPING

| Semester I | Basic Polymer Chemistry (Course Code: 4312301) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | POs and PSOs | | | | | | | | | |
| **Competency & Course Outcomes** | **PO 1** Basic & Discipline specific knowledge | **PO 2** Problem Analysis | **PO 3** Design/ development of solutions | **PO 4** Engineering Tools, Experimentation &Testing | **PO 5** Engineering practices for society, sustainability & environment | **PO 6** Project Management | **PO 7** Life-long learning | **PSO 1** An ability to apply principles of material selection, product & mold/die design and development in plastic engineering. | **PSO 2** An ability to conduct safe and environment friendly manufacturing and recycling of plastic products. | **PSO 3** (If needed) |
| **Competency** **Use concepts of organic chemistry in the field of Plastic Engineering** | 3 | - | - | 3 | 2 | - | 2 | - | - | - |
| **Course Outcomes** 1. Interpret the carbon structure present in the polymer. | 3 | - | - | - | - | - | 2 | - | - | - |
| 2 Use relevant monomers and its functionality for different applications. | 3 | - | - | 3 | 2 | - | 2 | - | - | - |
| 3 Interpret polymer properties based on geometric structures. | 3 | - | - | - | 2 | - | - | - | - | - |
| 4 Use suitable polymer for different applications. | 3 | - | - | 3 | 2 | | 2 | - | - | - |
| 5. Select suitable polymerization technique for environmental sustainability. | 3 | - | - | - | - | - | - | - | - | - |

Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO/PSO.

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

### GTU Resource Persons

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