Syllabus for Multi-Disciplinary Minor (MDM) Degree

In

Dyestuff Technology

Under the

National Education Policy (NEP 2020)

(2023-2024)

Offered by

Department of Speciality Chemicals Technology

Institute of Chemical Technology
(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra

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A. Preamble:

Department of Speciality Chemicals Technology (earlier Dyestuff Technology) was established in 1944 under the stewardship of Prof. K. Venkataraman, the then director of Institute of Chemical Technology (ICT, formerly known as UDCT), University of Mumbai. The department has trained more than 1000 undergraduate students and over 500 postgraduate students.

While the dyestuff technology has had its origins during the second world war, today its influence is felt across various domains such as agro, fertilizer and perfumery industry to name a few. The speciality chemicals technology is a multi-billion-dollar industry. And, with the advent of rapid shifting of the manufacturing of colorants from west to east makes it a highly promising industry for future innovations, research & development and sustainability. It is pertinent to note that dyestuff technology is the backbone of the entire organic process technologies of industrial relevance.

The department is a unique centre of learning that offers an advanced curriculum in tune with the latest industrial and academic developments. Not only has it produced a new generation of talented technologists and bright researchers, it has also led to an effective industry-academia relationship.

The department currently engages on niche areas of research like fluorescent dyes for sensing and sensitizers for DSSC besides the high-performance textile colorants and DFT computations, design and synthesis of graphene derivatives and their applications; energy storage materials, flame retardants, bio-probes, waste stream treatment, advanced catalysts, semiconductor materials, anticancer materials, sensors and surfactants, macro molecule synthesis, green processes for intermediates, dyes, and specialty chemicals, fragrance molecules, agrochemical synthesis, bioactive molecules and functional colorants. The outstanding research work (reported over 1000 publications) carried out by these stalwarts has created a permanent impact on dyestuff and allied industries, globally and locally.

Accordingly, this minor degree course in dyestuff technology has been designed to encompass different aspects of dyestuff technology with relevance towards fundamental & applied components, research & development and allied aspects. A major goal of these courses is to provide a solid overview of various fundamental & applied perspectives related to the dyestuff technology. This would enable the student to pursue higher degree courses in this department and also make them industry relevant towards employment. Thus, the course has been designed for a total of 14 credits as per the requirements of a minor degree and as per the national education policy guidelines.

B. Programme Outcomes:

Programme Specific Outcomes (PSOs) Multidisciplinary Minor Degree

PSO1	**Intermediates & dyestuff products analysis**: Able to apply analytical techniques for intermediates & dyestuffs safety, quality assurance and regulations
PSO2	**Innovations in intermediates & dyestuff development**: Able to translate emerging sciences in developing innovative intermediates & dyestuff products
PSO3	**Intermediates & dyestuff technology knowledge**: Apply the knowledge of mathematics, science, chemical engineering and dyestuff technology fundamentals to the solution of complex problems in intermediates & dyestuff chemistry & technology
PSO4	**Design/Development of Solutions**: Design solutions for complex intermediates & dyestuff technology problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PSO5	**Dyestuff Technology:** Able to translate emerging science in developing innovative dyestuff products

C. **Recommended batch size: Minimum 15; Maximum 35**

D. **Duration: Three years**

E. **Eligibility criteria:**

Students enrolled in the Bachelor of Chemical Engineering and Bachelor of Technology programmes of Institute of Chemical Technology will be eligible. The allotment of minor degree programme will be as per the policy of the institute

F. **PEDAGOGY/TEACHING METHODS:**

Lecture/Discussions: These sessions will discuss the subject matters of the course
Experiential Learning: The sessions will involve hands on training.
Tutorials: Problem solving/case studies/relevant real-life applications/ student presentations/home assignments/individual or group projects

G. **Evaluation:**

Theory course

Continuous Assessment Test (CAT): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group discussions, report submission and seminar/presentation could also form part of the continuous assessment.
Mid-semester: Total 30 Marks (Theory paper)
End-semester: Total 50 Marks (Theory paper)

Practical course

Continuous assessment: 50 Marks
Performing given experiments as per the instructions, submission of lab journal on time, viva-voce, group/personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.
End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

H. Structure of the Multidisciplinary Minor Courses:

Multidisciplinary Minors: Intermediates & Dyestuff Technology										
Semester	**Course Code**	**Subject**	**Credits**	**Hrs./Week**			**Marks for various Exams**			
				L	**T**	**P**	**CA**	**MS**	**ES**	**Total**
SEM-III	DYT1012	Unit Processes: An Introduction to Dyestuff Technology	2	1	1	0	20	30	50	100
SEM-IV	DYT1022	Physico Chemical Aspects of Colorants	2	1	1	0	20	30	50	100
SEM-V	DYT1032	Technology of Intermediates & Dyes - I	4	3	1	0	20	30	50	100
SEM-VI	DYT1042	Technology of Intermediates & Dyes - II	2	1	1	0	20	30	50	100
SEM-VII	DYP1052	Estimation of Intermediates & Chromatographic Procedures	2	0	0	4	-	50	50	100
SEM-VIII	DYP1062	Synthesis of Intermediates & Dyes	2	0	0	4	-	50	50	100
		TOTAL	**14**	6	4	8				600

I. Instructors: (Tentative)

Semester	**Course Code**	**Subjects**	**Faculty**
III	DYT1012	Unit Processes: An Introduction to Dyestuff Technology	GSS
IV	DYT1022	Physico Chemical Aspects of Colorants	NS
V	DYT1032	Technology of Intermediates & Dyes - I	SaS
VI	DYT1042	Technology of Intermediates & Dyes - II	NaSa
VII	DYP1052	Estimation of Intermediates & Chromatographic Procedures	GaS
VIII	DYP1062	Synthesis of Intermediates & Dyes	SuS

List of instructors:
NS: N. Sekar
GSS: G.S. Shankarling
SuS: Surajit Some
SaS: Satyajit Saha
NaSa: Nabanita Sadhukhan
GaS: Garimella Subrahmanyam

I. Detailed syllabus:

MDM	Course Code: DYT1012	Unit Processes: An Introduction to Dyestuff Technology	Credits = 2		
			L	T	P
	Semester: III	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

HSC (Science) and 1st yr chemical engg/chemical tech

List of Courses where this course will be prerequisite

Physico Chemical Aspects of Colorants, Technology of Intermediates & Dyes – I & II, Estimation of intermediates & chromatographic procedures and synthesis of intermediates & dyes

Description of relevance of this course in the B. Tech. Program

- To make the students understand chemistry of various intermediates used for chemical industry in general and dyestuff industry. In particular, to make them understand the unit processes and their relevance in chemical industries.
- To enable them to analyses and identify the proper synthetic and industrial method and choose accordingly the further processes to make intermediates.
- To develop in them capacity understand proper selection of the chemical processes based on economy and ecological aspects

Sr. No	Course Contents (Topics and Subtopics)	Required Hours
1	Chemical feedstock for Dyestuff industry- Basic Raw materials **a.** Fossil feedstock **b.** Petroleum and coal based raw materials **c.** Importance of BTX	05
2	Chemistry of Benzenoid intermediates- **a.** Electrophilic aromatic substitution reaction **b.** Orientation in aromatic substitutions	05
3	Introduction of Functional groups into benzene and technology involved **A.** Basic Unit processes a. Sulphonation b. Nitration c. Reduction d. Halogenation **B.Sulphonation:** (i) Reaction phenomenon and conditions (ii) Sulphonating agents and solvents (iii) Work up and Material of construction (iv) **Substitution in benzene and substituted benzene** (v) Plant and process flow (vi) Safety and process control parameters **C. Nitration:** (i) Reaction phenomenon and conditions (ii) Nitrating agents and solvents (iii) Work up and Material of construction (iv) Substitution in benzene and substituted benzene (v) Plant and process flow (vi) Safety and process control parameters, Run away reactions **D. Reduction:** (i) Reducing agents	05

	(ii) Reduction methods (iii) Selection of best method for Benzene and substituent (iv) Process and workup (v) Safety aspect **E. Halogenation** (i) Basic nucleophilic and Electrophilic substitution (ii) Reaction and MOC	
4	Naphthalene Introduction a. Nomenclature, Reactions, Reactivity rules	05
5	**Chemistry: Naphthalene intermediates** **a.** Synthesis of naphthalene **b.** Substitution pattern **c.** Reactions possible and criterion for the same	05
6	Technology and Reactions of naphthalene **a.** Nitration **b.** Sulphonation **c.** Halogenation **d.** Reduction (Key points are similar to benzene)	05
	Total	**30**
List of Textbooks/Reference Books		
1	Industrial organic chemistry, Weissermal K., ArpeH.J.VCH, Weinheim, 1993	
2	Organic synthesis, Smith M B, Tata McGrow Hill, NY, 2nd Ed, 2004	
3	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995	
4	Chemistry of synthetic dyes vol I, Venkatraman K., NY 1952	
5	Organic Chemistry,Clayden, Oxford Univ. Press, 2001	
Course Outcomes (Students will be able to…..)		
CO1	*Understand* the basics of dyestuff industry in terms of raw materials utilized (K2)	
CO2	*Apprehend* basic benzene and naphthalene chemistry (K2)	
CO3	*Analyze* the various methods for synthesis of different intermediates used in dyes (K2)	
CO4	*Know* the various technology and safety aspects for reactions (K2)	
CO5	*Identify* the substrates and chemistry to synthesize desired product (K2)	

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	3	1
CO2	1	2	2	2	1
CO3	1	3	3	2	2
CO4	3	2	3	2	1
CO5	1	3	2	3	2
Course	1	3	2	2	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution

MDM	**Course Code:** DYT1022	**Course Title:** Physicochemical Aspects of Colorants	**Credits = 2**		
			L	**T**	**P**

	Semester: IV	Total Contact Hours: 30	1	1	0
List of Prerequisite Courses					
HSC (Science); Dyestuff Technology: An Introduction					
List of courses where this course will be prerequisite					
Technology of Intermediates & Dyes – I & II, Estimation of intermediates & chromatographic procedures and Synthesis of intermediates & dyes					
Description of relevance of this course in the B. Tech. Program					
Students will be able to understand the relation between the chemical structure and the colour.					

Sr. No	Course Contents (Topics and Subtopics)	Required Hours
1	Origin of colour in organic molecules. Chromatic and achromatic colors. Red shift, blue shift, hyperchromic effect, solvatochromism, halochromism. Beer-Lambert's law, absorptivity, oscillator strength, , and half band width.	02
2	Early theories of color and constitution - empirical correlations between the chemical structures and their color. Chromophores, auxochromes, distribution rules, chromogens. $n \rightarrow \pi^*$, donor-acceptor, acyclic and cyclic polyene, and cyanine type chromogens	02
3	Resonance theory of color, failures of resonance theory. Steric effects in electronic absorption spectra – some general considerations.	02
4	Perturbational molecular orbital theory: Alternation of the electronegativity of an atom in an even alternant system. Alteration of the electronegativity of an atom in an odd alternate system, Dewar rules. Other empirical approaches to substituent effects, Mesomeric and field effects, Correlation between the frequency shift of a substitution and the Hammett substituent constant	02
5	Simple donor-acceptor chromogens: general characteristics – donor group, unsaturated bridge, acceptor group. The carbonyl acceptor – merocyanine types of compounds.	02
6	Complex donor-acceptor chromogens: classes of complex acceptor residues, donor substituted quinones. Donor substituted azo compounds. Color and constitution of simple azo dyes. Steric effects, and azo-hydrazonetautomerism in azo dyes	02
7	Color and chemical constitution of indigoid dyes. Introduction to cross-conjugated chromophores. Chromogens based on acycyclicand cyclic polyene systems: general characteristics with examples. Cyanine type chromogens.	02
8	Di- and triaryl methane colorants, heterocyclic analogues of di- and triaryl methane colorants. Simple color and constitution relationships.	02
9	Essentials of computational colour chemistry – brief introduction to one particle system. Schrodinger equation. Particle in a box.	02
10	Two particle system, Many particle systems – HartreeFock theory. Basis sets.	02
11	Electronic Structure theory. Molecular orbitals and light absorption. Semiempirical methods,	02
12	Limitations of HartreeFock method, Computational complexities in post HartreeFock (wavefunction based methods).	02
13	Introduction to Density Functional Theory and its application in colour chemistry	02
14	Excited State calculations, Configuration Interaction Singles.	02
15	Time Dependent Density Functional Theory.	02

	Total	30
List of Textbooks/Reference Books		
1	Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing	
2	Company, New York, 1977	
3	Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., Academic Press, 1952	
4	Chemistry of Synthetic Dyes – Vol III, Venkataraman, K., Academic Press, 1972	
5	Colour and Chemical Constitution of Organic Dyes, Griffiths J., Academic Press, 1976	
6	Quantum Chemistry, Chandra A. K., Tata McGraw Hill, 1979	
Course Outcomes (Students will be able to…..)		
CO1	*Understand* the constitution of different colorants (K2)	
CO2	*Analysis* the correlation of proposed absorption and observed absorption (K2)	
CO3	*Identify* the colour changes with different classes of molecules (K2)	
CO4	*Understand* the detail properties of colour changes with respective structural changes (K2)	
CO5	*Assess* the technical importance of colour chemistry (K2)	

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	1	2	2	3
CO2	1	1	1	1	2
CO3	1	2	2	2	2
CO4	1	2	3	3	2
CO5	2	2	3	3	3
Course	1	2	2	3	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution

MDM	**Course Code:** DYT1032	**Course Title:** Technology of Intermediates & Dyes - I	**Credits = 4**		
			L	**T**	**P**
	Semester - V	**Total Contacts hours = 60**	**3**	**1**	**0**
List of Prerequisite Courses					
HSC (Science); Dyestuff Technology: An Introduction					
List of Courses where this course will be prerequisite					
Technology of Intermediates & Dyes-II, Estimation of intermediates & chromatographic procedures and Synthesis of intermediates & dyes					
	Description of relevance of this course in the B. Tech. Program The subject is intended to make the students learn about the azo chromophore, their synthesis and properties as well as several dyes related to azo chromophore. The course will also focus on discussing the properties of several azo dyes as well as their synthesis routes and their structural importance along with the recent trends in the azo dyes as well as their technical importance				
Sr. No	**Course Contents (Topics and Subtopics)**		**Required Hours**		

1	Chemistry, Technology & Manufacture of Acid Dyes	12
2	Chemistry, Technology & Manufacture of Direct Dyes	12
3	Chemistry, Technology & Manufacture of Reactive Dyes	12
4	Chemistry, Technology & Manufacture of Basic Dyes	12
5	Drawbacks of Ionic Dyes	12

List of Textbooks/Reference Books	
1	Chemistry of Synthetic Dyes, Lubs H. A., NY 1995
2	Chemistry of azo colorants Vol I and Vol II- P. Zollinger
3	Chemistry of Synthetic Dyes – Vol I, II, IV, VI Venkataraman, K., Academic Press, 1952
4	Synthesis and Application of Dyes, Rys and Zollinger
5	The Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Co
6	Industrial Dyes – Chemistry, Properties, Applications, Hunger K. (Ed), Wiley-VCH, Weinheim, 2003

Course Outcomes (Students will be able to…..)	
CO1	*Explain* and define the classes of dyes, substrates (K2)
CO2	*Understand* the variety and chemistry of dyes and their application (K2)
CO3	*Overview* of recent trends in the field of dyes containing azo groups (K2)
CO4	*Differentiate* the techniques of diazotization and variations available (K2)
CO5	*Design* the synthesis of novel azo based dyes (K3)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2	3	2	2
CO2	1	3	2	3	3
CO3	1	2	3	2	2
CO4	1	2	3	3	3
CO5	1	3	3	3	3
Course	1	2	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution

MDM	**Course Code: DYT1042**	**Course Title: Technology of Intermediates & Dyes - II**	**Credits = 2**		
			L	**T**	**P**
	Semester: VI	**Total Contact Hours: 30**	**1**	**1**	**0**

List of Prerequisite Courses
HSC (Science); Dyestuff Technology: An Introduction; Technology of Intermediates & Dyes - I
List of Courses where this course will be prerequisite
Estimation of intermediates & chromatographic procedures and Synthesis of intermediates & dyes
Description of relevance of this course in the B. Tech. Program
The students will be introduced to the different chemical and technological aspects of non-ionic dyes

Sr. No	**Course Contents (Topics and Subtopics)**	**Required Hours**
1	Chemistry & Technology of Disperse Dyes	06

2	Chemistry & Technology of Oxidation Colorants	06
3	Chemistry & Technology of Vat Dyes	06
4	Chemistry & Technology of Sulfur Dyes	06
5	Drawbacks of Non-ionic dyes	06
	Total	**30**
List of Textbooks/Reference Books		
1	Industrial Organic Chemistry, Weissermal K., Arpe H. J., VCH, Weinheim, 1993	
2	Organic Chemistry, Clayden, Greeves, Warren, Oxford University Press, 2001	
3	Chemistry of Synthetic Dyes – Vol I, II, IV, VI Venkataraman, K., Academic Press, 1952	
4	Synthesis and Application of Dyes, Rys and Zollinger	
5	The Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Co	
6	Industrial Dyes – Chemistry, Properties, Applications, Hunger K. (Ed), Wiley-VCH, Weinheim, 2003	
Course Outcomes (Students will be able to….)		
CO1	*Define* and state different terminologies related to non-ionic dyes	
CO2	*Describe* and explain the chemistry and technology of non-ionic dyes	
CO3	*Applications* of non-ionic dyes	
CO4	*Outline* the synthesis & technology of various commercially important products	
CO5	*Develop* methods for the synthesis of various intermediates	

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	2	3	1
CO2	1	1	2	3	2
CO3	1	2	3	2	2
CO4	1	2	3	3	2
CO5	1	3	3	3	3
Course	1	1	2	3	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution

MDM	**Course Code: DYP1052**	**Course Title: Estimation of Intermediates & Chromatographic Procedures**	**Credits = 2**		
			L	**T**	**P**
	Semester: VII	**Total Contact Hours: 60**	**0**	**0**	**4**
List of Prerequisite Courses					
HSC (Science); Physico Chemical Aspects of Colorants					
List of Courses where this course will be prerequisite					
Synthesis of intermediates & dyes					
Description of relevance of this course in the B. Tech. Program					
Students will understand the significance of uses of these materials & procedures in the chemical industry					
Sr. No	**Course Contents (Topics and Subtopics)**		**Required Hours**		

1	a) Estimation by volumetric titrations of inorganic raw materials such as i) sodium sulphite ii) sodium sulphide iii) zinc dust b) Analyze the purity of primary aromatic amines such as i) aniline ii) sulphanilic acid iii) chloroanilines c) Estimation of azo coupling compounds by azo coupling method d) Estimation of azo dyes by $TiCl_3$ and titrations such as i) Sunset Yellow ii) Ponceau 4R iii) Orange II iv) Tartrazine e) TLC technique – preparation of TLC plate, finding rf value, separation of a mixture of two coloured organic compounds, detection of colourless compounds, separation of a mixture of a coloured and colourless compound and two colourless compounds	10 10 10 15 15
	Total	**60**
List of Textbooks/Reference Books		
1	Vogel's textbook of quantitative chemical analysis, G. H. JEFFERY J. BASSETT J. MENDHAM R C. DENNEY, Longman Scientific & Technical, 5th Edition	
2	Chromatography: Basic principles, Sample preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk	
Course Outcomes (Students will be able to….)		
CO1	*Estimate* the amount of inorganic and organic compounds present (K4)	
CO2	*Analyse* the purity of the amines used for dye synthesis (K3)	
CO3	*Check* the presence of coupling components for dye synthesis (K3)	
CO4	*Understand* the principle behind chromatographic techniques – TLC, paper and column – used for the separation of organic compounds (K2)	
CO5	*Apply* these techniques whenever separation of organic compounds needs to be done (K4)	

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	2	2
CO2	1	3	2	3	2
CO3	1	2	3	3	2
CO4	1	2	3	2	1
CO5	1	3	3	3	3
Course	1	3	3	3	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution

MDM	Course Code: DYP1062	Course Title: Synthesis of Intermediates & Dyes	Credits = 2		
			L	T	P
	Semester: VIII	Total Contact Hours: 60	0	0	4

List of Prerequisite Courses
HSC (Science); Technology of Intermediates & Dyes – I & II
List of courses where this course will be prerequisite
None
Description of relevance of this course in the B. Tech. Program
Students will understand the significance of uses of these inorganic raw materials in the chemical industry

	Course Contents (Topics and Subtopics)	Required Hours
1		60
	Preparation of any unit processes like i) nitration ii) sulphonation iii) ammonolysis iv) reduction v) oxidation vi) halogenation etc. on benzene, naphthalene and anthraquinone intermediates	30
	Preparation of some dyes such as: i) Acid dyes ii) Direct dyes iii) Reactive dyes iv) Basic Dyes	15
	a. Diazotization and coupling of any azo dye and their applications	15
	Total	**60**

List of Textbooks/Reference Books	
1	Fundamental Processes of Dye Chemistry by Hans Eduard Fierz-David And Louis Blangey
Course Outcomes (Students will be able to…..)	
CO1	Ability to synthesize different intermediates, and ionic & non-ionic dyes (K3)
CO2	Able to purify and isolate the intermediates, ionic & non-ionic dyes (K3)
CO3	Differentiate the methods of synthesis of different classes of dyes (K3)
CO4	Design the synthesis of dyes (K3)
CO5	Develop practical skills in the synthesis, separation and isolation of the ionic & non-ionic dyes (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)					
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2	3	3	3
CO2	1	3	3	3	3
CO3	1	1	2	2	2

CO4	1	2	2	3	3
CO5	1	3	3	3	3
Course	1	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution