University of Mumbai

DEPARTMENT OF CHEMISTRY

(AUTONOMOUS)

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M.Sc. in Industrial Polymer Chemistry

CONTENTS

DEPARTMENT OF CHEMISTRY (AUTONOMOUS)

1. A PROFILE

The University Department of Chemistry, University of Mumbai, established in the year 1967, conducts Choice Based Credit System (CBCS) 4-SEMESTER- courses in Physical, Inorganic, Organic and Analytical Chemistry, leading to the award of M. Sc. degree of the Department of Chemistry, University of Mumbai. In addition, it also conducts program leading to Ph. D. degree. The Department is a recipient of DST-FIST and UGC-SAP grants. The Department has been conferred autonomous status from the academic year 2009-10.

Since inception of the department, over 2000 students have taken their Master's degree by papers; more than 250 students have been awarded doctorates, and more than 150 students have taken their M. Sc. Degree by research. Under the M. Phil. programme, 50 teachers from affiliated colleges have received their degrees. After autonomy of the department, over 381 students have taken their Master's degree by papers; more than 93 students have been awarded doctorates, and more than 16 students have taken their M. Sc. Degree by research. It is indeed a pleasure to report that alumni of the department are holding key positions in the industry and academic institutions.

The Department is actively engaged in organizing Refresher Courses for college teachers sponsored by U.G.C. and the State Government. It also conducts workshops for teachers for effective, smooth teaching and uniformity in the implementation of the revised syllabi from time to time. The Department has organized several National and International conferences. In addition, the Department along with other reputed institutes and registered societies jointly organizes lectures, workshops and research scholars' meet, science day etc. for the benefit of teachers and students. The Department also offers consultancy services to the industry, whenever solicited. Every year the Department organizes lectures under Dr. R. C. Shah Memorial Lectureship endowment and Dr. A. B. Kulkarni Lectureship endowment, which are delivered by eminent chemists of the country.

A Post-graduate institution is judged not only by maintenance of high teaching standards, but also by its focus on research activity. Though plagued by problems of infrastructure in terms of senior academic positions, the Department has consistently endeavored to raise its standards. The Department runs projects received from the various national funding agencies such as UGC, DST, CSIR, DAE etc. and also from the Industries. It is heartening to point out that members of the faculty have been receiving appreciative comments on their research articles/reviews in standard journals.

2. LOCATION

The Department is housed in Lokmanya Tilak Bhavan and the ground floor of Sant Dnyaneshwar Bhavan in the Vidyanagari campus of the University of Mumbai. The Vidyanagari Campus is accessible from both the Central Railway (Kurla) and Western Railway (Santacruz) by the BEST Bus routes. The bus route Nos. 313 and 318 plying between Santacruz (East) and Kurla (West) pass via Vidyanagari. Additionally route Nos. 37 (between Kurla & J. M. Mehta Marg), 181 (between Seepz-Wadala), 213 (between Santacruz - Pr. Thakre Udyan), 306 (between Santacruz - Mulund). 312 (between Seepz & Pratiksha Nagar), 374 (between Goregaon-East & Anushakti Nagar), 449 (between Dharavi Depot & Kandivali Bus St.-East) pass via Vidyanagari.

3. LABORATORY FACILITIES FOR PAPER AND RESEARCH STUDENTS

There are four M. Sc. Paper Laboratories well equipped with the necessary instruments/ infrastructure to perform experiments in Analytical, Inorganic, Organic and Physical Chemistry.

All the research students are comfortably accommodated in the various research laboratories.

There is a computer laboratory equipped with twelve computers with internet connection.

The Department is well equipped with the necessary infrastructure and sophisticated instruments. A 300 MHz NMR and CHN analyzer have been procured through the DST-FIST program. GC-MS instrument has been procured through UGC-SAP program. In addition, the department has FTIR, UV-Visible spectrophotometers, Spectrofluorimeter, HPLC, GC, Digital Polarimeter, Ion meters, Electro-chemical workstations, CVD, Catalytic Hydrogenator, Microwave Oven, Auto-titrator, Ultrasonic reactors, TG/DTA, AAS, GPC and XRD. The department has also acquired new technological devices such as Audio-Visual system, LCD Projector, E-Beam System, Media Imager and Visual Presenter. Internet access is provided to the staff and research as well as paper students.

The Department has a seminar room with seating capacity of 60.

4. LIBRARY

The Department has its own library on the ground floor of Sant Dnyaneshwar Bhavan. In addition, Jawaharlal Nehru Library, which is a central library at the Vidyanagari campus, is well equipped with books, journals, periodicals and Encyclopedias of Chemistry. There is a separate facility for carrying out literature survey. The students enrolled in the Department can avail of reading as well as lending facilities.

5. HOSTEL ACCOMODATION FOR STUDENTS

Six rooms in Boy's hostel and Eight in Girl's hostel are reserved for the Department students. These hostel rooms are allotted as per the University rules.

6. FACULTY OF THE DEPARTMENT

[1] NAME: Dr. M. M. V. Ramana

- **DESIGNATION:** Professor and Head

PAPERS PUBLISHED:	**85**	**Ph. D STUDENTS GUIDED:**	**35**
PATENTS:	**100**	**Ph. D STUDENTS UNDER GUIDANCE:**	**09**
BOOKS:	**01**	**RESEARCH PROJECTS:**	**01**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**16**	**CONSULTANCY PROJECTS:**	**01**

- **KEY AWARDS & HONORS:**
  - Daxina Fellow (Govt. Of Maharashtra)

- **RESEARCH INTERESTS:** Synthetic Organic Chemistry: New methods / methodologies / Reagents, Synthesis of Natural Products / Bioactive Compounds, Optical Activation, Domino Reactions, Liquid Crystals.

KEY PUBLICATIONS:

1. $CsOH/\gamma\text{-}Al_2O_3$: A heterogeneous reusable basic catalyst for one pot synthesis of 2-amino-4, 6-diaryl pyrimidines. A. Nimkar, **M. M. V. Ramana**, R. R. Betkar, P. B. Ranade, B. Mundhe. ***New J. Chem*****,** 2016, **40**, 2541-2546**.**
2. Chalcones: Potential antidengue targets *in silico*approach.**M. M. V. Ramana**, P. B. Ranade, R. R. Betkar, A. Nimkar, B. Mundhe.***Journal of Computational Methods in Molecular Design.*** 5(2015), 3, 104-105.
3. In vitro DNA binding studies of antiretroviral drug nelfinavir using ethidium bromide as fluorescence probe.**M. M. V. Ramana**, R. R. Betkar, A. Nimkar, P. B. Ranade, B. Mundhe, S. Pardeshi. ***J. Photochem. Photobio B: Biology*****,** (2015), 151, 194-200.
4. Green synthesis of thiazolo [2, 3-a] isoquinolines using silica sulphuric acid under microwave irradiation. **M. M. V. Ramana**, P. B. Ranade, R. R. Betkar, A. Nimkar, B. Mundhe. ***Heterocycl. Lett*****,**(2015), 5, 451-457.
5. Synthesis of a novel 4H-pyran analog as minor groove binder to DNA using ethidium bromide as fluorescence probe.**M. V. Ramana**, R. R. Betkar, A. Nimkar, P. B. Ranade, B. Mundhe, S. Pardeshi. ***Spectrochim. Acta, Part A*****,** (2015), 152, 165-171.
6. Resolution of Clopidogrel Bisulfate's Racemic Precursor by Direct Crystallization: A Simple, Economical and Environment Friendly Approach for Clopidogrel Bisulfate **M. M. V. Ramana**, Rajesh K. Rao**.** ***International Journal of Pharmaceutical Sciences Review and Research*** 24 (2014)44, 271-275.
7. Synthesis of ferrocene derivatives exhibiting low temperature mesomorphism. Dinesh N.Navale, Santosh W.Zote, and **M.M.V.Ramana*****, Liquid Crystals*** 40 (2013) 1333- 1338.
8. Synthesis of polycyclic heterocycles through domino Knoevenagel intramolecular hetero Diels–Alder reaction under solvent free and microwave irradiation conditions.**M.M.V.Ramana**, Vishwanath V. Kenkare & Dinesh N Navale, ***Journal of Chemical and Pharmaceutical Research***,5 (2013):71-75.
9. Oxidative fragmentation of 1, 5-cyclooctadiene derivative: A new entry into 14-membered macrocycle related to cembranoid group of diterpenoids.**M.M.V.Ramana**, Shrimant V. Rathod, M.S.Raje. ***Journal of Chemical and Pharmaceutical Research***5(2013):109-111.

10. Annulation strategy for the biomimetic synthesis of cis-fused diterpenoids. Shanta S. Bhar and **M.M.V. Ramana*, Tetrahedron Letters,***47(2006), 7805-7807.

[2] NAME: Dr. A. V. Karnik

- **DESIGNATION:** Professor

PAPERS PUBLISHED:	**41**	**Ph. D STUDENTS UNDER GUIDANCE:**	**06**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**16**	**RESEARCH PROJECTS:**	**03**
Ph. D STUDENTS GUIDED:	**15**	**CONSULTANCY PROJECTS (IN PROGRESS)**	**01**

- **KEY AWARDS/HONORS:**
  - Performance based Incentive award, University of Mumbai.
  - Elected Fellow of Maharashtra Academy of Science

- **RESEARCH INTERESTS:** Chiral Chemistry, Synthetic Organic Chemistry, Heterocyclic Chemistry.

KEY PUBLICATIONS:

1. Chiral Heterocycle-based receptors for Enantioselective Recognition. Vaibhav N. Khose, Marina E. John, Anita D. Pandey and Anil V. Karnik. Symmetry **2018**, 10, 34; doi:10.3390/sym10020034.
2. Sui Generis Helicene-Based Supramolecular Chirogenic system: Enantioselective Sensing, Solvent Control, and Application in Chiral group transfer reaction. Mohammed Hasan, Vaibhav N. Khose, Victor Borovkov, and Anil V. Karnik. ACS Omega **2017**, 2, 592−598
3. Tailor-Made Supramolecular Chirogenic System Based on Cs‑Symmetric Rigid Organophosphoric Acid Host and Amino Alcohols: Mechanistic Studies, Bulkiness Effect, and Chirality Sensing. Mohammed Hasan, Vaibhav N. Khose, Anita D. Pandey, Victor Borovkov, and Anil V. Karnik. Organic Letters, 2016, 18, 440-444.
4. Reversal of enantioselectivity induced by the achiral part of an organocatalyst in Diels-Alder reaction. Trupti S. Tawde, Swapnil J. Wagh, Jai V. Sapre, Vaibhav N. Khose, Purav M. Badani and Anil V. Karnik. Tetrahedron: Asymmetry, 2016, 27, 130-135.
5. Sterically Congested Chiral 7,8-Dioxa[6]helicene and Its Dihydro Analogues: Synthesis, Regioselective Functionalization, and Unexpected Domino Prins

Reaction. Hasan, Mohammed; Pandey, Anita D.; Khose, Vaibhav N.; Mirgane, Nitin A. and Karnik, Anil V. European Journal of Organic Chemistry, 2015, 3702-3712.

6. Asymmetric Diels–Alder Reaction Involving Chiral Benzimidazoles as Organocatalysts. Nitin A. mirgane, and Anil V. Karnik. Chirality, 2011, 23, 404-407.
7. Synthesis and in vitro antibacterial evaluation of tetracyclic-ortho-fused 4Hnaphtho[1′,2′-5,6]pyrano[3,4-d](1,2,3)selenodiazole and its derivatives. A. V. Karnik, A. M. Kulkarni, N. J. Malviya and B. L. Jadhav. European Journal of Medicinal Chemistry 2008, 43, 2615-2617.
8. Cascade enantioselective synthesis of γ-aryl-γ-butyrolactones with a delayed stereoselective step. Anil V. Karnik and Suchitra S. Kamath, Tetrahedron 2008, 64, 2992-2996.
9. Enantioselective Benzoylation of α-Amino Esters Using (S)-1-Benzoyl-2-(racetoxyethyl) benzimidazole, a Chiral Benzimidazolide. Anil V. Karnik and Suchitra S. Kamath. J. Org. Chem., 2007, 72**,** 7435-7438.
10. Furo-Fused BINOL Based Crown as a Fluorescent Chiral Sensor for Enantioselective Recognition of Phenylethylamine and Ethyl Ester of Valine. Sunil P. Upadhyay, Raghuvir R. S. Pissurlenkar, Evans C. Coutinho, and Anil V. Karnik. J. Org. Chem., 2007, 72, 5709-5714.

[3] NAME: Dr. (Smt.) M. Karve

- **DESIGNATION:** Professor

PAPERS PUBLISHED:	**35**	**Ph. D STUDENTS GUIDED:**	**03**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**03**	**RESEARCH PROJECTS COMPLETED:**	**01**

- **RESEARCH INTERESTS:** Solvent Extraction, Solid phase Extraction, Environmental Analysis.

KEY PUBLICATIONS:

1. Cyanex272 impregnated on Amberlite XAD-2 for separation and preconcentration of U(VI) from uranmicrolite (leachates) ore tailings, **M. Karve** and K. Pandey, ***J. Radioanal. Nucl. Chem.* 285**(2010)627-633.
2. Octadecyl bonded silica membrane disk modified with Cyanex302 for preconcentration and determination of traces of cobalt in urine by flame atomic absorption spectrometry, **M. Karve** and R. V. Rajgor, ***Anal. Lett.* 42** (2009) 2520-2532.
3. Octadecyl bonded silica membrane disk modified with Cyanex302 for separation and flame atomic absorption spectrometric determination of nickel from tap water and CONSULTANCY effluent, **M. Karve** and R. V. Rajgor,***J. Hazard. Mater.* 166** (2009) 576-580.
4. Selective separation of Scandium(III) and Yttrium(III) from other Rare Earth Elements using Cyanex302 as an extractant, **M. Karve** and B. Vaidya, ***Sep. Sci. Technol.* 43**

(2008) 1111–1123.

5. Amberlite XAD-2 impregnated Organophosphinic acid Extractant for separation of Uranium(VI) from rare earth elements, **M. Karve** and R. V. Rajgor, ***Desalination* 232** (2008) 191-197.
6. Amberlite XAD-2 impregnated with Cyanex302 for separation of traces of thorium(IV), **M. Karve** and R. V. Rajgor, ***Sep. Sci. Technol.* 42** (2007) 2255-2273.
7. Solid phase extraction of lead on octadecyl bonded silica membrane disk modified with Cyanex302 and determination by flame atomic absorption spectrometry, **M. Karve** and R. V. Rajgor, ***J. Hazard. Mater.* 141** (2007) 607-613.
8. Extraction of U(VI) with Cyanex 302, **M. Karve** and C. Gaur, ***J. Radioanal. Nucl. Chem.*, 273** (2007) 405-409.
9. Solvent extraction separation of scandium(III) with Cyanex272 as an extractant M. Karve and B. Vaidya, Indian J. Chem, 45A (2006) 2658-2660.
10. Hydrochemistry of Mithi River and associated sediments, Mumbai, T. Gurav, **M. Karve**, and D. Chandrasekharam, ***Journal of Indian School of Mines***, **1** (2006) 33-41.

[4] NAME: Dr. S. S. Garje

- **DESIGNATION:** Professor

PAPERS PUBLISHED:	**50**	**Ph. D STUDENTS GUIDED:**	**07**
PATENTS:	**01**	**Ph. D STUDENTS UNDER GUIDANCE:**	**05**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**05**	**RESEARCH PROJECTS:**	**02 (Completed) 01 (in progress)**

- **KEY AWARDS/HONORS:**
  - BOYSCAST Fellowship, DST
  - Performance based Incentive Award, University of Mumbai.

- **RESEARCH INTERESTS:** Materials Chemistry, Organometallics, Nanomaterials, Development of molecular precursors for nanomaterials and thin films, Nanocomposites and their applications

KEY PUBLICATIONS:

1. Preparation of Iron sulfide nanomaterials from Iron (II) thiosemicarbazone complexes and their application in photodegradation of methylene blue., J. S. Suroshe, S. Mlowe, **S. S.**

Garje, N. Revaprasadu, J. Inorg. Organomet Polym., **28 (3)** (2018) 603-611.

2. Lead (II) halide cinnamaldehyde thiosemicarbazone complexes as single source precursors for oleylamine-capped lead sulfide nanoparticles., S. Masikhane, C. Gervas, S. Mlowe, A. S. Pawar, **S. S. Garje**; N. Revaprasadu, J. Mater. Sc.: Mat. Electronics, **29 (2)** (2018) 1479-1488.
3. Zinc thiosemicarbazone complexes: Single source precursors for alkylamine capped ZnS nanoparticles., A. S. Pawar, S. Mlowe, **S. S. Garje**, M. P. Akerman, N. Revaprasadu, Inorg. Chim. Acta, **463** (2017) 7–13
4. Synthesis and characterization of CdS nanocrystallites and OMWCNT-supported cadmium sulfide composite and their photocatalytic activity under UV light irradiation., A. S. Pawar, **S. S. Garje** and N. Revaprasadu, Mater. Chem. Phy., **183** (2016) 366- 374.
5. Preparation of CdS Nanoparticles from Thiosemicarbazone Complexes: Morphological Influence of Chlorido and Iodido Ligands., A. S. Pawar, S. C. Masikane, S. Mlowe, **S. S. Garje** and N. Revaprasadu, European J. Inorg. Chem., **(3)**, (2016) 366-372.
6. Capacitive behaviour of functionalized carbon nanotube/ZnO composites coated on glassy carbon electrode., J. S. Suroshe and **S. S. Garje**, J. Mater. Chem. A, **3 (**2015) 15650–15660.
7. Bismuth(III) dialkyldithiophosphates: Facile single source precursors for the preparation of bismuth sulfide nanorods and bismuth phosphate thin films., J. B. Biswal, S. S. Garje, J. Nuwad and C. G. S. Pillai, J. Solid State Chem., 204 (2013) 348-355.
8. Synthesis and X-ray single crystal structure of a cadmium(II) acetophenone thiosemicarbazone complex and its use as a single-source precursor for the preparation of CdS nanocrystallites and thin films., A. M. Palve, P. V. Joshi, V. Puranik and **S. S. Garje**, Polyhedron, **61** (2013) 195-201.
9. Preparation of ternary metal chalcogenide ($M_{1-x}Fe_xS$, M = Cd and Zn) nanocrystallites using single source precursors., S. D. Disale and **S. S. Garje**, J. Organomet. Chem., **696** (2011) 3328-3336.
10. A new route to antimony telluride nanoplates from a single-source precursor., **S. S. Garje**, D. J. Eisler, J. S. Ritch, M. Afzaal, P. O'Brien, and T. Chivers, J. Am. Chem. Soc., **128** (10) (2006) 3120-3121.

[5] NAME: Dr. N. G. Shimpi

- **DESIGNATION:** Associate Professor

PAPERS PUBLISHED:	**59**	**Ph. D STUDENTS UNDER GUIDANCE:**	**09**
PATENTS:	**04**	**RESEARCH PROJECTS:**	**05 (Completed) 03 (in progress)**
Ph. D STUDENTS GUIDED:	**05**	**CONSULTANCY PROJECTS COMPLETED:**	**01 (in progress)**

- **KEY AWARDS/HONORS:**
  - AICTE Career Award for Young Teachers (CAYT).
  - Young Scientist Award by APA, New Delhi

- **RESEARCH INTERESTS:** Conducting polymers, Nanomaterials, Biodegradable Polymers and Green Chemistry approach for nanomaterials synthesis.

KEY PUBLICATIONS:

1. Green synthesis of zero valent colloidal nanosilver targeting A549 lung cancer cell: In vitro cytotoxicity, M. Jha, **N. G. Shimpi,** 16, 115124, 2018.
2. Microwave assisted one pot three component synthesis of propargylamine, tetra substituted propargylamine and pyrrolo[1,2-*a*]quinolines using CuNPs@ZnO–PTh as a heterogeneous catalyst, A. P. Shah, A. S. Sharma, S. Jain, **N. G. Shimpi,** 42. 8724-8737, 2018.
3. Biodegradation of Isotactic Polypropylene (iPP)/Poly(lactic acid) (PLA) and iPP/PLA/Nano Calcium Carbonates Using *Phanerochaete chrysosporium,* **N. G.Shimpi**, M. Borane, S. Mishra, M. Kadam, S. S. Sonawane, Advances in Polymer Technology, 37 (2), 21691, 2018.
4. Influence of functionalized calcium carbonate nanofillers on the properties of melt-extruded polycarbonate composites, S. J. Charde, S. S. Sonawane, S. H. Sonawane, **N. G. Shimpi,** Chemical Engineering Communications, 2018.
5. Synthesis of $CaSO_4$ nanoparticles and its effect on PA6/$CaSO_4$ nanocomposite for investigation of thermal and viscoelastic properties, G. Barman,S. S. Sonawane, K. L. Wasewar, A. P. Rathod, S. H. Sonawane, N. G **Shimpi** 21(11), 39-44, 2017.

6. Polyaniline/Zinc Oxide Nanocomposite as Room-Temperature Sensing Layer for Methane, T. Sen, S. Mishra, S.S. Sonawane, **N. G. Shimpi,** Polymer Engineering And Science, 2017
7. Polypropylene/nTiO_2 Nanocomposites Using Melt Mixing and Its Investigation on Mechanical and Thermal Properties, **N. G. Shimpi**, S. Shirole, S. Mishra, Polymer Composites, 38 (7) 1273-1279, 2017.
8. Effect of Organically Modified Montmorillonite (OMMT) on Biodegradation of PS:PLA and PS:PLA:OMMT Using *Phanerochaete chrysosporium,* **N. G.Shimpi**, M. Borane, M. Kadam, S. Mishra, Polymer Composites, 38 (7) 1292-1301, 2017.
9. A β-cyclodextrin based binary dopant for polyaniline: Structural, thermal, electrical, and sensing performance, T. Sen, S. Mishra, **N. G. Shimpi,** Materials Science and Engineering B, 220, 13-21, 2017.
10. Optimized Synthesis of nTiO_2 Using *Murraya koenigii* Leaf Extract and Its Application in iPP–EPDM Blends, **N. G. Shimpi,** S. Shirole, Y. Suryawanshi, S. Mishra, Advances in Polymer Technology, 36 (2), 21595, 2017.

[6] NAME: Dr. R. M. Kamble

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**25**	**Ph. D STUDENTS UNDER GUIDANCE:**	**06**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**01**	**RESEARCH PROJECTS COMPLETED:**	**02 (Completed)**
Ph. D STUDENTS GUIDED:	**02**		

RESEARCH INTERESTS: Design, Synthesis and characterization of novel organic materials as semiconductors for applications in Organic Electronics like Organic Light Emitting Devices (OLEDs) and Solar cells.

- **KEY PUBLICATIONS:**

1. Design, Synthesis, Opto–Electrochemical and Theoretical Investigation of Novel Indolo[2,3-*b*]naphtho[2,3-*f*]quinoxaline Derivatives for *n*–Type Materials in Organic Electronics. **Rajesh M. Kamble**, Bharat K. Sharma, Azam M. Shaikh and Sajeev Chacko, ***Chemistry Select***, **3**, (2018) 6907−6915 (DOI: 10.1002/slct.201801208)
2. Synthesis, Opto-electrochemical and Theoretical Investigation of Pyrazino[2,3-

b]phenazine Amines for Organic Electronics. Deepali N. Kanekar, Sajeev Chacko and **Rajesh M. Kamble**, ***Chemistry Select***, **3**, (2018), 4114−4123 (DOI: 10.1002/slct.201800562)

3. Electrochemically synthesised xanthone-cored conjugated polymers as materials for electrochromic windows. H. F. Higginbotham, M. Czichy, B. K. Sharma, A. M. Shaikh, **R. M. Kamble** and P. Data, ***Electrochimica Acta***, **273**, (2018), 264−272 (doi.org/10.1016/j.electacta.2018.04.070)
4. Synthesis and Optoelectronic Investigation of Triarylamines based on Imidazoanthraquinone as Donor–Acceptors for n-type Materials. Bharat K. Sharma, Azam M. Shaikh, Sajeev Chacko and **Rajesh M. Kamble**, ***J. Chem. Sci.* 130(5)**, (2018), 49. (https://doi.org/10.1007/s12039-018-1443-2)
5. Synthesis, Optoelectronic and Theoretical Investigation of Anthraquinone Amine−Based Donor−Acceptor Derivatives. Azam M. Shaikh, Sajeev Chacko and **Rajesh M. Kamble**, ***Chemistry Select***, **2**, (2017), 7620−7629 (DOI: 10.1002/slct.201701475)
6. Synthesis and Studies of Imidazoanthraquinone Derivatives for Applications in Organic Electronics. Bharat K. Sharma, Swati Dixit, Sajeev Chacko, **Rajesh M. Kamble** and Neeraj Agarwal, ***Eur. J. Org. Chem.* 30**, (2017), 4389−4400. (10.1002/ejoc.201700769)
7. Novel electroluminescent donor-acceptors based on dibenzo[*a*,*c*]phenazine as hole transport materials for organic electronics. Azam M. Shaikh, Bharat K. Sharma, Sajeev Chacko and **Rajesh M. Kamble**, ***New J. Chem.***, **41**, (2017), 628−638. (DOI: 10.1039/c6nj03553a)
8. Synthesis and opto-electrochemical properties of tribenzo[a,c,i]phenazine derivatives for hole transport materials. Azam M. Shaikh, Bharat K. Sharma, Sajeev Chacko and **Rajesh M. Kamble**, ***RSC Advances***, **6**, (2016), 94218−94227. (DOI: 10.1039/c6ra20964e)
9. Synthesis and Optoelectronic Investigations of Triarylamines based on naphtho [2,3-*f*]quinoxaline-7,12-dione core as Donor-Acceptors for n-type materials. Azam M. Shaikh, Bharat K. Sharma, Sajeev Chacko and **Rajesh M. Kamble**, ***RSC Advances***, **6**, (2016), 60084−60093. (DOI: 10.1039/c6ra11149a)
10. Synthesis, Photophysical and Electrochemical Studies of Acridone-Amine based Donor-Acceptors for Hole Transport Materials. Bharat K. Sharma, Azam M. Shaikh, Neeraj Agarwal and **Rajesh M. Kamble**, ***RSC Advances***, **6**, (2016), 17129−17137. (DOI: 10.1039/c5ra25115j)

[7] NAME: Dr. V. R. Patil

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**35**	**Ph. D STUDENTS GUIDED:**	**13**
PATENTS:	**30**	**Ph. D STUDENTS UNDER GUIDANCE:**	**04**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**04**	**RESEARCH PROJECTS COMPLETED:**	**03**

- **KEY AWARDS/HONORS:**
  - Prof. B. C. Haldar Memorial Research Award
  - Best Researcher & Academician Award (Bionano Frontier & University of Mauritius)

- **RESEARCH INTERESTS:** Light emitting polymers, Water soluble polymers, biosynthesis of nanoparticles.

KEY PUBLICATIONS:

1. In-Situ Nanoparticle Embedding for Authentication of Epoxy Composites, **Advanced Materials,** Amol V. Pansare, Shyam R. Khairkar, Amol A. Shedge, Shraddha Y. Chhatre, Vishwanath R. Patil, Amit A. Nagarkar, **[Manuscript No. adma.201801523, Manuscript in Press].**
2. Recent Development of Crown Substituted Polyfluorenes for Blue Light Emitting Devices in Organic Electronics, Meenakshi M. Rananaware, Vaijayanti D. Ghase, Vishwanath R. Patil, Polymer Bulletin, (**Manuscript in Press,** POBU-D-17-00596R1).
3. Photophysical properties of new fluorene‐based conjugated polymers containing polyphenylene−substituted dendronized core, Rupashri K. Kadu, Pramod B. Thakur, Vishwanath R. Patil, Polymer Bulletin (2018), doi.org/10.1007/s00289-018-2401-3.
4. Microwave assisted novel synthetic route for polyfluorenes containing triphenylamine and solubilizing alkyl moiety for blue emitting diodes, Alok V. Mishra, Khushboo B. Chandorkar and Vishwanath R. Patil, Polymer International, 67, (4), 405–413, 2018, DOI: 10.1002/pi.5521.
5. Discrete Anticancerous SeNPs-Macromolecule Binding Manipulated by Hydrophilic Interaction, Amol V. Pansare, Amol A. Shedge, Vishwanath R. Patil, *Int. J. Biol. Macromolec.*, 2018, **107**, 1982-1987.
6. Novel methoxy spirobifluorene and alkyl substituted diphenylacene based organic blue light emitting polymers for application in organic electronics, **Rhushirajeshwari M. Chalke** and Vishwanath R. Patil, *Polymer***,** 123, 355-365, (2017). doi.org/10.1016/j.polymer.2017.07.034.
7. New approaches towards the synthesis and characterization of alkoxy substituted spirobifluorenes and spirosilabifluorenes for organic optoelectronics, **Rhushirajeshwari M. Chalke** and Vishwanath R. Patil , *Journal of Macromolecular Science, Part A-Pure and Applied Chemistry*, 54(9), 556-564, (2017). https://doi.org/10.1080/10601325.2017.1309249.
8. New Strategy for Synthesis of Polyphenylene Substituted Dendronised Monomers Containing Fluorene Unit and Study Their Properties, Rupashri K. Kadu, Vishwanath R. Patil, **Polycyclic Aromatic Compounds**, **(Available Online)** http://dx.doi.org/10.1080/10406638.2015.1129974.

9. hsDNA Minor Groove Binding, Photocatalytic Activity, in vitro Breast and Colon Cancer Cell reducing function of Greener SeNPs, Amol V. Pansare, Dnyaneshwar K. Kulal, Amol A. Shedge and Vishwanath R. Patil, ***Dalton Transactions*, 2016, 45, 12144–12155,, DOI: 10.1039/c6dt01457g, (2016).**
10. Green synthesis of Anticancerous Honeycomb PtNPs clusters: their Alteration Effect on BSA and hsDNA using Fluorescence Probe, Amol V. Pansare, Dnyaneshwar K. Kulal, Amol A. Shedge, Vishwanath R. Patil, **Journal of Photochemistry & Photobiology, B: Biology, 162,** 473–485 (2016) **Doi:10.1016/j.jphotobiol.2016.07.021** (**2016).**

[8] NAME: Dr. S. Sachar

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**08**	**Ph. D STUDENTS UNDER GUIDANCE:**	**02**

- **RESEARCH INTERESTS:** Solubility and stability properties of therapeutic drugs in the pre-formulation stage by complexing with different surface active agents, Surface modifications of nanoparticles, Colloidal Chemistry and its applications, e.g. in nanotechnology and bio-medical field.

KEY PUBLICATIONS:

1. Understanding Toxicity of nanomaterials in the environment: Crucial tread for controlling the production, processing and assessing the risk. Shweta Sharma, Surinder Kumar Mehta, Ankush Parmar, Shilpee Sachar, *Nanomaterials in Chromatography: Current Trends in Chromatographic Research Technology and Techniques* 2018, Pages 467–500.
2. Synthesis of bare and surface modified TiO_2 nanoparticles via single source precursor and insights into their interactions with Serum Albumin, A. Ansari, S. Sachar and S. S. Garje, *New Journal of Chemistry*, 2018, DOI: 10.1039/C8NJ02253D.
3. Mechanistic insights into the interactions of magnetic nanoparticleswith bovine serum albumin in presence of surfactants, Delina Joseph, Shilpee Sachar, Nand Kishore, Sudeshna Chandra, **Colloids and Surfaces B: Biointerfaces** (2015), 135, 596–603.
4. Synthesis and characterization of arsenic trioxide nanoparticles and their in vitro cytotoxicity studies on mouse fibroblast and prostate cancer cell lines, Vaibhav Jadhav, Shilpee Sachar, Sudeshna Chandra, D. Bahadur, Purvi Bhatt, **Journal of Nanoscience and Nanotechnology** (2015), 15, 1-7.
5. Cellular Internalization and Detailed Toxicity Analysis of Protein Immobilized Iron Oxide Nanoparticles, Purva Sanganeria, **Shilpee Sachar**, Sudeshna Chandra, Dhirendra Bahadur, Pritha Ray and Aparna Khanna, ***Journal of Biomedical Materials Research: Part B - Applied Biomaterials***, (2015), 103, 1, 125–134.
6. Energetically favorable interactions between Diclofenac Sodium and Cyclodextrin molecules in aqueous media, S.K.Mehta, K.K.Bhasin, **Shilpee Dham**, ***J. Colloid Interface Sci***., (2008), 326, 374-381

7. Interactions between Quaternary ammonium compounds and cyclodextrins in aqueous media, S.K.Mehta, K.K.Bhasin, **Shilpee Dham** and M.L.Singla, ***J. Colloid. Interface Sci***., (2008), 321: 442-451.
8. Micellar behavior of dodecyldimethylethyl ammonium bromide and dodecyltrimethyl ammonium chloride in aqueous media in the presence of Diclofenac Sodium, S.K.Mehta, K.K.Bhasin, Anil Kumar and **Shilpee Dham**, ***Colloids and Surfaces A: Physicochem. Eng. Aspects*** (2006), 278: 17-25.
9. Effect of temperature on critical micelle concentration and thermodynamic behavior of dodecyldimethylethylammonium bromide and dodecyltrimethylammonium chloride in aqueous media, S.K. Mehta., K.K. Bhasin, Renu Chauhan, **Shilpee Dham**, ***Colloids and Surfaces A: Physicochem. Eng. Aspects*** (2005) 255: 153–157.
10. Behavior of rifampicin in association with β-cyclodextrin in aqueous media: a spectroscopic and conductometric study, S. K. Mehta, K. K. Bhasin, Neena Mehta, **Shilpee Dham**, ***Colloid Polym Sci*** (2005) 283: 532–538.

[9] NAME: Dr. S. D. Pawar

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**25**	**Ph. D STUDENTS UNDER GUIDANCE:**	**02**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**01**	**RESEARCH PROJECTS COMPLETED:**	**02**

- **RESEARCH INTERESTS:** Synthesis of Inorganic complexes, Environmental Chemistry, Solvent extraction.

KEY PUBLICATIONS:

1. Extraction and Separation Study of Mo(VI) and W(VI) using organophosphorous extractant, D. V. Chavan and S. D. Pawar, **International Letters of Chemistry, Physics and Astronomy**, 48, 2015 87-94.
2. Extraction studies of Zn(II) from salicylate medium using Cyanex-923 extractant in toluene, S. U. Gaikwad and S. D. Pawar, **Journal of the Indian Chemical Society**, Vol. 92, 2015, 65-69
3. Solvent Extraction Studies of Mo(VI) and W(VI) using Organophosphorous extractant, Cyanex 925, J. N. Iyer, D. V. Chavan and S. D. Pawar, **International Journal of Chemistry**, 4(3), 2015, 225-230.
4. Extraction studies of Lanthanum(III) from sodium salicylate medium using trialkyl Phosphine oxide, S. D. Pawar, **International Letters of Chemistry, Physics and Astronomy** 54, 2015, 143-149.

5. Extraction studies of Thorium(IV) from sodium perchlorate medium, R. R. Lakhan and S. D. Pawar, Research Journal of Chemistry and Environment, 19(7), 2015, 27-31.
6. Extraction studies of Uranium(VI) from sodium perchlorate medium, R. R. Lakhan and S. D. Pawar, Asian Journal of Chemistry, 28(3), 2016, 687-690.
7. Solvent extraction of Titanium(IV) from salicylate medium using Cyanex-923 Extractant, S. D. Pawar, South Asian Journal of Multidisciplinary Studies, 3(1), 2016, 76-88.
8. Extraction Studies of Scandium(III) Metal Ion Using Cyanex-923. S. D. Pawar, Journal of Applicable Chemistry, 4(5), 2015, 1546-1551.
9. Extraction and separation studies of U(VI) from salicylate media using neutal organophosphorous extractant, Cyanex-923 in toluene, S.M. Ghag, **S.D.Pawar**, ***Research Journal of Biotechnology***, Vol. 6 (2), May 2011, 24-28.
10. Extraction of Copper(II) from Sodium salicylate medium using neutral organophosphorus extractant Cyanex-923 in toluene, S.U.Gaikwad and **S.D.Pawar**, ***Journal of the Indian Chemical Society***, Vol. 87, No.10, October 2010, 1279-1281

[10] NAME: Dr. P. M. Badani

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**16**	**Ph. D STUDENTS UNDER GUIDANCE:**	**02**
RESEARCH PROJECTS:	**01 (in progress)**		

RESEARCH INTERESTS: Molecular modeling, reaction dynamics and non-covalent interactions.

KEY PUBLICATIONS

1. Exploring unimolecular dissociation kinetics of ethyl bromide through electronic structure calculations, N. R. Gulvi, P. Patel and **P. Badani,** *Chemical Physics* 505 (2018) 55.
2. Mechanistic and kinetic insights of reduction of indophenol by sodium borohydride: A theoretical study to explore the effect of solvent of solvent and counter ion, P. Patel, S. Lingayat, N. R. Gulvi, and **P. Badani,** *Chemical Physics* 504 (2018) 13
3. Mass spectrometric and charge density studies of organometallic clusters photoionized by gigawatt laser pulses, **P. M. Badani**, S. Das, P. Sharma and R. K. Vatsa.
   Mass Spectrometry Review 36 (2017) 188
4. Chiral Base-catalyzed Asymmetric Diels-Alder Reaction: Achiral Flexible Heterocyclic Arm Induced Unusual Reversal of Enantioselectivity, T. Twade, S. Wagh, J. V. Sapre, V. N. Khose, **P. M. Badani**, A. V. Karnik , *Tetrahedron: Asymmetry* 27 (2016) 130
5. Ionization of methyl iodide clusters using nanosecond laser pulses: Detection of multiply charged positive ions, negative ions and energetic electrons., S. Das, P. Sharma, **P. M. Badani** and R. K. Vatsa,

RSC Advances 5 (2015) 8887.

6. Generation of multiply charged tin and carbon ions in low intensity Coulomb explosion of tetramethyl tin clusters: Role of screening effects, **P. M. Badani**, S. Das, P. Sharma and R. K. Vatsa, *International Journal of Mass Spectrometry* 358 (2014) 36.
7. Evidence for charge-induced dipole reaction in laser ionized van der Waals clusters: A case of Fe^{2+} reacting with argon atoms inside a cluster, **P. M. Badani**, S. Das, P. Sharma, KRS Chandrakumar and R. K. Vatsa, *RSC Advances* 4 (2014) 2339.
8. Diverse photochemical behavior of dibromodifluoromethane (CF_2Br_2) monomer and cluster under gigawatt intensity laser fields, S. Das, **P. M. Badani**, P. Sharma and R. K. Vatsa, *RSC Advances* 3 (2013) 12867.
9. Photoionization of atomic and molecular clusters doped with low ionization energy molecules: Effect of laser wavelength, intensity and cluster composition, **P. M. Badani**, S. Das, P. Sharma & R. K. Vatsa, *International Journal of Mass Spectrometry* 348 (2013) 53.
10. Interaction of xenon clusters with nanosecond laser pulses: A size-dependent study.
    S. Das, **P. M. Badani,** P. Sharma and R. K. Vatsa, *Chemical Physics Letters* 552 (2012) 13.

[11] NAME: Mr. R. G. Thorat

- **DESIGNATION:** Assistant Professor
- **RESEARCH INTERESTS:** Synthetic Organic Chemistry

[12] NAME: Mr. B. B. Popatkar

- **DESIGNATION:** Assistant Professor
- **RESEARCH INTERESTS:** Development of new methods in Organic Chemistry

[13] NAME: Dr. S. T. Manjare

- **DESIGNATION:** Assistant Professor

PAPERS PUBLISHED:	**20**	**Ph. D STUDENTS UNDER GUIDANCE:**	**05**
PATENTS:	**01**	**RESEARCH PROJECTS COMPLETED:**	**01 (Completed) 01 (in progress)**

- **KEY AWARDS/HONORS:**
  - Post-doctoral Research Fellow from Institute for Basic Science in Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea.

- **RESEARCH INTERESTS:** Synthesis and Bio-applications of Chalcogen-based Small Molecular Probes, Synthesis of Organometallic Compounds and Their Applications in Organic Synthesis.

KEY PUBLICATIONS:

1. *Bis(chalcogenones) as pincer ligands: isolation and Heck activity of the selone-ligated unsymmetrical C,C,Se–Pd pincer complex,* Ninad Ghavale, **Sudesh T. Manjare**, Harkesh B. Singh and Ray J. Butcher, **Dalton Trans., 2015**, *44*, 11893–11900.
2. H^{+}–Assisted Fluorescent Differentiation of Cu^{+} andCu^{2+}: Effect of Al^{3+}–induced acidity on chemicalsensing and generation of two novel and independentlogic gating pathways, Yonghwang Ha, Dhiraj P. Murale, Changsuk Yun, **Sudesh T. Manjare**, HyungjunKim, JuhyounKwak, Yoon Sup Lee, David G. Churchill, ***Chem. Commun***.,**2015**, 51, 6357.
3. Selenium- and Tellurium-Containing Fluorescent Molecular Probes for the Detection of Biologically Important Analytes, **Sudesh T. Manjare**, Youngsam Kim, David G. Churchill, ***Acc. Chem. Res.*****2014**, *47,* 2985−2998
4. A selective fluorescent probe for cysteine and itsimaging in live cells, Youngsam Kim,Minsuk Choi, SeokjunSeo,**Sudesh T. Manjare**, Sangyong Jon David G. Churchill, **RSC Adv**., **2014**, *4*, 64183–64186.
5. Selective and Sensitive Superoxide Detection with a NewDiselenideBased Molecular Probe in Living Breast Cancer Cells, **Sudesh T. Manjare**, Sungsoo Kim, Won Do Heo, David G. Churchill ***Org. Lett***. **2014**, *16*, 410−412.
6. Facile meso-BODIPY Annulation and Selective Sensing of Hypochlorite in Water, **Sudesh T. Manjare**, Jin Kim, Yunho Lee, David G. Churchill ***Org. Lett***. **2014**, *16*, 520−523.
7. Fluorescence probing of the ferric Fenton reaction via novel chelation, Dhiraj P. Murale, **Sudesh T. Manjare**, Yoon-Sup Lee, David G. Churchill ***Chem. Commun***.,**2014**,*50*, 359−361.

8. Novel selective and reversible Zn^{2+}–assisted biological phosphate "turn–on" probing via attenuation of ligand hydrolysis through stable aryl–hydrazonesalicylaldimine conjugation, Olga G. Tsay, **Sudesh T. Manjare**, HyungjunKim, Kang Mun Lee, David G. Churchill***Inorg. Chem.*** (**2013)**, *52*, 10052−10061.
9. Redox Reaction between Main-Group Elements (Te, Sn, Bi) and N-Heterocyclic-Carbene-Derived SeleniumHalides: A Facile Method for the Preparation of Monomeric Halides, **Sudesh T. Manjare**, SangeetaYadav, Ray J. Butcher, Harkesh B. Singh,***Eur. J. Inorg. Chem***. (**2013)**, 5344–5357.
10. Oxidation of Carbene Derived Selenium Diiodide with Silver Tetrafluoroborate: Isolation of Iodonium Ion Complexes with Selenones, **Sudesh T. Manjare**, Ray J. Butcher, Harkesh B. Singh***Eur. J. Inorg. Chem***. (**2013)**, 2161–2166.
Facile Synthesis of Benzazolin-2-chalcogenones: Nature of the Carbon-Chalcogen Bond, **Sudesh T. Manjare**, Sagar Sharma, Harkesh B. Singh, Ray J. Butcher***J. Organomet. Chem.*** **(2012)**, *717*, 61-74.

[14] NAME: Mr. A. K. Kadu

- **DESIGNATION:** Assistant Professor

- **RESEARCH INTERESTS:** Electrochemistry: Development of sensors, nano-composites for sensors and catalyst.

KEY PUBLICATIONS:

1. Potentiometric Determination of Proton-Ligand Dissociation Constant of 1-[2-(2-Hydroxybenzilidene) Hydrazono]-1-Phenylpropan-2-One Oxime and Formation Constants of its Complexes with Cobalt, Nickeland Copper in Dioxane-Water System, **A. K. Kadu** and R. G. Deshmukh***, Journal of Chemistry and Chemical Sciences,*** Vol.6(5), 433-442, May 2016.
2. Synthesis and Characterization of Co(II), Ni(II), Cu(II) and Pd(II) Complexes of 1-[2-(5-bromo-2-hydroxybenzilidene)hydrazono]-1-phenylpropan-2-one oxime, **A. K. Kadu** and R. G. Deshmukh, ***Journal of Chemical, Biological and Physical Sciences,*** JCBPS; Section A; August 2016 – October 2016, Vol. 6, No. 4; 1196-1204.
3. Evaluation of Proton-Ligand Dissociation Constant of 1-(2-(1-(2-Hydroxyphenyl) Ethylidene)Hydrazono)-1-Phenylpropan-2-One and Formation Constants of its Complexes with Cobalt, Nickel and Copper in Dioxane-Water System by Potentiometry, **A. K. Kadu**, Sharad S. Sankhe, P. S. Kamble, ***International Journal for Research in Applied Science & Engineering Technology,*** Volume 5 Issue IX, September 2017.

- **RESEARCH INTERESTS:** Coordination Chemistry, Electrochemistry, Green Chemistry.

[15] NAME: Dr. A. K. Srivastava

- **DESIGNATION:** UGC-BSR Fellow

PAPERS PUBLISHED:	**101**	**Ph. D STUDENTS UNDER GUIDANCE:**	**06**
M.Sc (BY RESEARCH) STUDENTS GUIDED:	**10**	**RESEARCH PROJECTS COMPLETED:**	**06**
Ph. D STUDENTS GUIDED:	**21**		

- **KEY AWARDS/HONORS:**
  - Best Teachers Award, Govt. of Maharashtra
  - Thomson Reuters Research Excellence: India citation Award as 'The best cited author in Chemistry from India'

- **RESEARCH INTERESTS:** Electrochemistry: Development of Sensors and Supercapacitors based on nano-composite materials; Chromatographic method development in the field of pharmaceutical, environmental and forensic science

KEY PUBLICATIONS:

1. Performance of palladium nanoparticle–graphene composite as an efficient electrode material for electrochemical double layer capacitors, R. A. Dar, L. Giri, S. P. Karna, A. K. Srivastava, **Electrochim. Acta**, 196, 547–557, 2016.
2. Simultaneous determination of ciprofloxacin and paracetamol by adsorptive stripping voltammetry using copper zinc ferrite nanoparticles modified carbon paste electrode, M. P. Kingsley, P. K. Kalambate, A. K. Srivastava**,** RSC Adv.,6, 15101-15111,2016.
3. Potentiometric stripping analysis of arsenic using a graphene paste electrode modified with thiacrown ether and gold nanoparticles, B. J. Sanghavi, N. S. Gadhari, P. K. Kalambate, S. P. Karna and A. K. Srivastava, **Microchim. Acta**, 182, 1473–1481, 2015.
4. Enhancement of the energy storage properties of supercapacitors using graphene nanosheets dispersed with macro-structured porous copper oxide, R. A. Dar, G. A. Naikoo, P. K. Kalambate, L. Giri, F. Khan, S. P Karna, A. K. Srivastava, **Electrochim. Acta,** 163, 196 – 203, 2015.
5. High performance supercapacitor based on graphene-silver nanoparticles-polypyrrole nanocomposite coated on glassy carbon electrode, P. K. Kalambate, R. A. Dar, S. P. Karna, A. K. Srivastava, **J. Power Sources**, 276, 262 – 270, 2015.

6. Adsorptive Stripping Voltammetry for Trace Determination of Quinalphos Employing Silicon Carbide Nanoparticles Modified Glassy Carbon Electrode, N. G. Khare, R. A. Dar, A. K. Srivastava, **Electroanalysis**, 27, 503 – 509, 2015.
7. Adsorptive stripping differential pulse voltammetry determination of rivastigmine at graphene nanosheet-gold nanoparticle/carbon paste electrode, P. K. Kalambate, M. R. Biradar, S. P. Karna, A. K. Srivastava, **J. Electroanal. Chem**., 757, 150–158, 2015.
8. Simultaneous electro-catalytic oxidative determination of Ascorbic acid and Folic acid using Fe_3O_4 nanoparticles modified carbon paste electrode, M. P. Kingsley, P. B. Desai, A. K. Srivastava, **J. Electroanal. Chem**., 741, 71-79, 2015.
9. Simultaneous voltammetric determination of paracetamol and domperidone based on a graphene/platinum nanoparticles/Nafion composite modified glassy carbon electrode, P. K. Kalambate, B. J. Sanghavi, S. P. Karna, A. K. Srivastava, **Sens. and Act. B**, 213, 285-294, 2015.
10. Green synthesis of a silver nanoparticle – graphene oxide composite and its application for As(III) detection, Riyaz, A. Dar, N. G. Khare, D. P. Kole, S. P. Karna, **A. K. Srivastava**, **RSC Advances**, 4 (2014) 14432 - 14440.

[16] NAME: Dr. K. R. Gore

- **DESIGNATION:** DST-INSPIRE Faculty

PAPERS PUBLISHED:	**06**	**Ph. D STUDENTS UNDER GUIDANCE:**	**02**
PATENTS:	**01**		

- **KEY AWARDS/HONORS:**
  - Max Planck Post Doctoral Fellowship, Germany.
  - DST-INSPIRE Faculty Award

- **RESEARCH INTERESTS:** Synthesis and *in vivo* Applications of Modified Small Interfering RNAs.; Development of Conditionally Fluorescent Probes for Detection of Biologically Important Molecules.

KEY PUBLICATIONS:

1. Synthesis, Gene Silencing, and Molecular Modelling Studies of 4'-*C*-Aminomethyl-2'-*O*-Methyl Modified Small Interfering RNAs.**Gore, K. R**.; Nawale, G. N.; Harikrishna, S.; Chittoor, V; Pandey, S.; Höbartner, C; Patankar, S; **Pradeepkumar, P.I.*Journal of Organic Chemistry(2012)***, 77(7),3233−3245
2. Incorporation of 4'-*C*-Aminomethyl-2'-*O*-Methylthymidine into DNA by Thermophilic DNA Polymerases. Nawale, G. N.; **Gore, K. R**.; Höbartner, C.; **Pradeepkumar,**

P.I*Chemical Communications(*2012), *48*, 9619−9621.

3. Influence of 2′-Fluoro versus 2′-*O*-Methyl Substituent on the Sugar Puckering of 4′-*C*-Aminomethyluridine.**Gore K. R**.; Harikrishna, S.; Pradeepkumar, P. I. ***Journal of Organic Chemistry****(2013)*, 78, 9956−9962.
4. Design, Synthesis, Biophysical and Primer Extension Studies of Novel Acyclic Butyl Nucleic Acid (BuNA). Kumar, V.; ***Gore,* K. R**.; Pradeepkumar, P. I.; Kesavan, V. ***Organic and Biomolecular Chem*istry** (2013), 11, 5853−5865.
5. Unique Structural Features in DNA Polymerase IV Enable Efficient Bypass of the N2 Adduct Induced by the Nitrofurazone Antibiotic. Kottur, J.; Sharma, A.; **Gore, K. R**.; Narayan. N.; Samanta, B.; Pradeepkumar, P. I.; Nair, D. T. ***Structure*** (2015),23, 56-67.
6. The N^2-Furfural Deoxyguanosine (fdG) Adduct Does Not Alters The Structure of B-DNA. Ghodke, P. P.; **Gore, K. R**.; Harikrishna, S.; Samanta, B.; Kottur, J.; Nair, D. T.; Pradeepkumar, P. I. ***Journal of Organic Chemistry***(2016), *81*, 502−511 *(Joint First Author)*.

7. TOPPERS / NET / SET / Ph. D / POST-DOCTORAL FELLOWHIP STUDENTS

M.Sc ALL BRANCHES TOPPERS- 2016-17	**SET QUALIFIED STUDENTS-2016-17**
1. Ms. Ansari Sabrin (Physical Chemistry; 7.16 CGPA) 2. Ms. Shaikh Nilofer (Inorganic Chemistry; 7.57 CGPA) 3. Ms. Pooja Zanje (Organic Chemistry; 8.86 CGPA) 4. Mr. Kisan Gupta (Analytical Chemistry; 8.39 CGPA)	1. Ms. Poornima Acharya 2. Mr. Divyesh Shelar 3. Ms. Rajashree Prajapati 4. Mr. Sarfraz Shaikh 5. Mr. Jatin Lade 6. Mr. Sachin Golhe 7. Ms. Shaikh Aksh Hina 8. Mr. Mangesh Pingale 9. Mr. Amit Surve
NET-LECTURERSHIP QUALIFIED STUDENTS-2016-17	**NET-JRF QUALIFIED STUDENTS-2016-17**
1. Mr. Ganesh Pavale 2. Mr. Aleem Ansari 3. Mr. Rupesh Mestri 4. Ms. Poornima Acharya	1. Mr. Siddharth Kamble 2. Mr. Navin Yadav 3. Mr. Sachin Dhodi 4. Mr. Ega Sai Prasad Somashekar

LIST OF STUDENTS AWARDED Ph. D DEGREE- 2016-17	**LIST OF STUDENTS PURSUING POST DOCTORAL STUDIES-2016-17**
1. Mr. Metangale Ganesh Santu Sunanda 2. Ms. Jayashree Gopalakrishnan 3. Ms. Shubhangi Nitin Nikam 4. Ms. Chandorkar Khushboo Bhalchandra 5. Ms. Jadhav Sheetal Dhondiram Shalan 6. Mr. Ranade Prasanna Bhalchandra Bhagyashri 7. Mr. Balaji Chintaman Mundhe	1. Dr. Mohammed Hasan (Estonia) 2. Dr. Amey Nimkar (Israel) 3. Dr. Pramod Kalambate (China) 4. Dr. Anita Pandey (India)

8. Mr. Amol Sitaram Kisabai Pawar 9. Mr. Marathe Suyog Madhav Swati 10. Mr. Nayan S. Gadhari 11. Mr. Parab Bharat Vaman Lilavati 12. Ms. Mondkar Poonam	

8. ABOUT IRMRA

Indian Rubber Manufacturer's Research Association, popularly known, as **IRMRA** is Premier National Research and Development organization registered in 1958 under societies act XXI of 1860 to provide hand holding scientific and technological support to the Indian Rubber & Allied Industries. Presently, **IRMRA** is functioning under the administrative control of Ministry of Commerce & Industry, Govt. of India. The institute is functioning in two locations situated at Wagle Industrial Estate, Thane – 400 604. Institute is funded by Ministry of Commerce & Industry, Govt. of India to create state of art R&D center to support Rubber Industries & end users to improve the quality of rubber products. **IRMRA** has modern state of art scientific and analytical facilities and is fully equipped with infrastructure for design & development, testing and certification, process optimization, technical consultancy, third party inspection, training, reverse engineering and allied aspects in quality and eco compliance for rubber and allied products. IRMRA is contemplating to establish its regional centers in different parts of country to cater the needs of clusters. To begin with, Eastern and Southern Regional Centers are being set up in West Bengal and Andhra Pradesh respectively.

The testing laboratories of **IRMRA**, including mechanical and chemical are accredited by National Accreditation Board for Testing & Calibration Laboratories (NABL), Quality Council of India, Ministry of Commerce & Industry, GOI, in compliance with ISO/IEC 17025:2005. In addition, the institute is certified for Quality Management System complying with ISO 9001:2008 and institute is recognized by DSIR as Scientific & Industrial Research Organization (SIRO). The institute is also accredited by NABET as Business Membership Organization (BMO) under Diamond Grade.

The institute is engaged in pursuit of research in all major areas of rubber and polymer Technology having qualified, trained and experienced scientists with doctoral and master's degree holders from premier universities / IITs. **IRMRA**, Thane is involved in conducting various R&D programmes either sponsored by industry and or government organizations such as DST, BARC, DBT, CSIR, NAIP, ICAR, IGCAR, MOD etc. in the area of product development, process development / optimization, application development, development of standard test methods, waste recycling etc.

IRMRA Headquarter

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Wagle Industrial Estate,
Thane - 400 604, Maharashtra

IRMRA Extension Centre, Thane (Old)

Plot No. B-88, Road No. 24
Wagle Industrial Estate,
Thane - 400 604, Maharashtra
.

Indian Rubber Manufacturers Research Association
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9. FACULTY

Dr. K. Rajkumar, Director, IRMRA
M. Sc (Chem), **M. Tech** in Rubber Technology from IIT Kharagpur, **Ph. D** (Polymer nanocomposites) from Bharathiar University, Coimbatore, **MBA** in Operation Management.

EXPERIENCE: About 20 years of experience in rubber industry. Dr. Rajkumar has developed several critical products for nuclear and defence sectors. More particularly, development of rubber gauntlet as a part of indigenization was well appreciated by the senior official of BARC. Dr. Rajkumar also secured an award from ICAR, Ministry of Agriculture, Govt. of India for his outstanding contribution in completion of project of ―Design and development of Rubber Dam for water sheds. Development of shock vibration isolation mounts, estimation of life of SV mounts, development of hydraulic mounts, development of alternate materials including bio source based materials etc. are some of his major areas of interest. He has undertaken several assignments like specification development, product development, reverse engineering and consultancy work

Niteesh Kumar Shukla, Assistant Director
M. Sc. (Chemistry) from Delhi University, **M. Tech** (Rubber Technology) from IIT Kharagpur.

EXPERIENCE: About 8 years of experience in Testing and Development of Rubber Products. He is actively involved in many projects including International and sponsored projects by NAIP, CPPRI and DST. Keenly involved in Defect investigation of PCR, commercial, Aircraft tyres and Rubber Composites. He has presented many technical papers in the various Conferences.

Suchismita Sahoo, Assistant Director
M. Sc. in Chemistry (Polymer) from Utkal University in 2004
M. Tech in Rubber Technology from IIT Kharagpur in 2006

EXPERIENCE: 10 years of experience in rubber industry. Prior to joining IRMRA, worked with John Deere India Pvt. Ltd as Materials Engineer and led multiple development projects in rubber and plastic, failure analysis of rubber components, material selection and specification for rubber parts.

Mr. T. V. Sethumadhavan, Assistant Director
Masters in Chemistry from Mahatma Gandhi University. **M. Tech** in Polymer Technology from Cochin University of Science and Technology.
Diploma in ―Electrical Insulation Technology conducted by Indian Electrical & Electronics Manufacturer‘s Association (IEEMA).

EXPERIENCE: Industrial R&D experience of over 22 years in the rubber and other polymers in versatile fields.

Dr. Bharat Kapgate, Senior Scientific Officer
M. Sc. (Organic Chemistry), **Ph. D** (Rubber Chemistry & Technology) from VNIT. Nagpur.

EXPEREINCE: Prior to Joining IRMRA 5 years of experience in research on rubber nanocomposites (during his Ph. D period) and 2.5 years of teaching as Assistant professor at Engineering College.

Mr. Gnana Sandeep, Senior Scientific Officer
B. Tech; **M. Tech**. (Polymer Science & Technology)

Mr. Manohar Nawale, Senior Scientific Officer
M. Sc, Chemistry from University of Mumbai.

EXPEREINCE: More than 20 years of experience in testing and R & D in rubber and allied materials

10. IRMRA AT A GLANCE: Activities, Instrumental Facilities & Achievements

- **ACTIVITIES**

• Quality Control Testing	• Reverse Engineering	• Failure Analysis
• Raw Material Analysis	• On Product Testing	• Environmental Testing
• Flammability Test	• Sealant Testing	• Restricted Component Testing
• Product Development	• Industrial Consultancy Project (ICON)	• R & D Activities

- **INSTRUMENTAL FACILITIES**

Acetone Extraction Apparatus	Particle Size Analyser	Rubber Process Analyzer RPA 2000	Wallace Rapid Plastimeter
Passenger tyre Endurance Machine	Truck tyre Endurance Machine	Tyre Shearography Machine	Tyre Profilometer
Rolling Resistance Machine	Tyre Uniformity Machine	Universal testing machine	Open Mill
Banbury	Hot Feed extruder	Cold feed extruder	Autoclave
Calendaring (3 roll)	Rubber injection molding unit	Rubber Compression Molding	Plastic Compression Molding
Plastic Injection Molding Unit	Planetary Mixer (for Latex)	Latex Thread Extrusion Unit	CNC Machine
Dipping Units for Latex Goods	Surface Drilling Machine	Barbender plasticorder pl 2200	Twin screw extruder

INSTRUMENTAL FACILITIES (CONTD.)

Fourier Transform Infrared Spectroscopy (FTIR) (HATR)	Carbon Hydrogen Nitrogen Sulfur Analyzer (CHNS Analyser)	Zwick Universal Testing Machine– 500 KG capacity	Dunlop Tripsometer
Weather o Meter	Thermogravimetric Analyser (TGA)	IRHD (Dead Load Hardness Tester)	Universal Testing Machine Instron with video extensive meter
Inductive Couple Plasma (ICP)	Differential Scanning Calorimeter (DSC)	Hardness Test (Shore A/Shore D)	Micro Hardness
VICAT/SDT. Softening Point	Surface Area Analyzer (by BET method)	DIN Abrader	Ross Flexing Machine
Cryogenic chamber	Impact Testing (IZOD/CHARPEY)	High Voltage Test upto 40 KV	Goodrich Flexometer
Melt Flow Index	U.V. Exposure	Ozone Chamber	Drum Friction Test (For Belt)
Gas Chromatograph-Mass Spectrometer	Low Temperature Retraction	De-Mattia Flexing	Dynamic Mechanical Analyser
UV Spectrophotometer	Carbon Black Dispersion Tester	Scott Flex Test (For Belt)	Gamma Chamber
Electrical Insulation Resistance Test	Humidity Chamber	Servo Hydraulic Machine	Air/Gas Permeability Tester

HPLC / GPC	BROOKFIELD Viscometer	Rheometer R100	Mooney Viscometer

- **ACHIEVEMENTS**

➢ **PROJECTS COMPLETED**

1. Design & Development of Rubber Dams for Watersheds
   Awarded by National Agricultural Innovation Project (NAIP) under Indian Council of Agricultural Research (ICAR), Ministry of Agriculture, Govt. of India, funded by World Bank

2. A value chain for coconut, fibre and its by-product: Manufacture of dissolved products of higher value and better marketability to enhance the economic returns of farmers (Coir Project)
   Awarded by National Agricultural Innovation Project (NAIP) under Indian Council of Agricultural Research (ICAR).
3. Radiation effects on styrene-butadiene-ethylene-propylenediene monomer-multiple walled carbon nanotube nanocomposites: vulcanization and characterization.
4. Development of NBR Based Polymer Nano-Composites for High Temperature Application
5. Use of Electron Beam Radiations in Rubber Products especially Tyres, Belts, etc.- BRNS, BARC.
6. Design and Development of critical rubber products for defense applications-Sponsored by MOD, Govt. of India.
7. Development of critical rubber compounds for nuclear applications-Sponsored by Department of Atomic Energy, Government of India.

➢ **KEY PUBLICATIONS**

1. A Novel Approach for Control of Water flow in Watershed Managements for Agricultural Growth of the Country: Rubber India, P. Roy Choudhury, S. K. Chakraborty, Manasi Nath, **2008,** 8, 49-53**.**

2. Design & Development of Rubber Dam: Rubber Chem. Review, P. Roy Choudhury, Manasi Nath, Bhagabat Bhuyan, **2008,** Vol. XXXVII, No.6, 29-32.

3. Design Criteria in Developing Fabric Reinforcement for Geo (Rubber) Check Dams, 10th Annual General Body Meeting (AGM), organized by Indian Fibre Society (IFS), held at CIRCOT, Mumbai on 27th September **2008,** S. K. Chattopadhyay and A.K Bharimalla.
4. Advances in Production Technology in Agrotextiles, Agrotextiles; Emerging opportunities, organized by Federation of Indian Chambers of Commerce and Industry (FICCI), and SASMIRA held at Hotel Intercontinental, The Grand, Mumbai, on 1st October **2008,** S. K. Chattopadhyay and S. Sreenivasan.
5. Design and Development of Fabric Substrate for Flexible Rubber Dams, The International Conference on Technical Textiles and Nonwovens, organized by IIT Delhi, from 11 to 13th November **2008,** M. K. Talukdar, S. K. Chattopadhyay and B. P. Pal.
6. Innovative Application of Technical Textiles in Civil Engineering International Seminar on Innovative Applications of Textiles, organized by College of Textile Technology, Kolkata from 2-3rd December **2008,** M. K. Talukdar and S.K Chattopadhyay.
7. Newer Developments in Production of Textile Reinforcements for Rubbers, 20th Rubber Conference organized by IRMRA, on 19-20th December **2008,** S. K. Chattopadhyay.
8. Application of FEA Concept in Rubber Product Design – A General Approach with a Case Study, S. R. Chandran, B. Bhuyan, K. Rajkumar, Rubber Chem. Review, **2008**.
9. Bonding evaluation of technical textile with rubber for rubber dam application: Technical proceedings of 5th International Conference a/c Rubber Expo IRE, **2009,** P. Roy Choudhury, S. K. Chakraborty, Manasi Nath.
10. Modified coconut pith – a novel rubber additive for rubber industry, Rubber Chem Review, K. Rajkumar, P. Ranjith. P. Thavamani, **2010**.
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12. Effect of DOP as Dispersion Medium on MMT- nano Clay in NBR Polymer Matrix, K. Rajkumar, P. Ranjan, L. R. Pillai, P. Thavamani, P. Pazhanisamy & P. Jeyanthi, Indian Journal of Applied Research, **2010.**

13. Mechanical & thermal properties of treated coir pith-rubber composites, Rubber Chem Review, K. Rajkumar, P. Ranjith, P. Thavamani, **2011**.

18. High Temperature Resistance Properties of NBR Based Polymer Nanocomposites**,** K. Rajkumar, N. Kumari, P. Ranjith, S. K. Chakraborthy, P. Thavamani, P. Jeyanthi, & P. Pazhanisamy**.** International Journal of ChemTech Research, **2011.**
19. Case study: Going for eco-friendly rubber, K. Rajkumar P. Ranjith, P. Thavamani, **2012**.
20. Cost effective nitrile rubber compound for footwear application using eco-friendly treated coconut pith filler, RUBBER INDIA, K. Rajkumar, P. Ranjith, V. M. Arunkumar, K. Anas, P. Thavamani, **2012**.

19. Mechanical, Thermal, Electrical and Morphology Characterization of Ethylene Propylene Diene Monomer - Nanoclay Composites**,** K. Rajkumar, P. Thavamani, P. Jeyanthi and P. Pazhanisamy Chem Sci Trans., **2013**.
20. Effect of Nanosilica on Ethylene Propylene Diene Monomer Rubber Nanocomposites, K. Rajkumar, C. Dwiwedi, P. Thavamani, P. Jeyanthi and P. Pazhanisamy, International Journal of Innovative Research & Development, **2013**.

14. An Eco-Friendly Rubber-Textile Composites for Construction of Rubber Dam to Use in Watersheds Application**,** K. Rajkumar, P. Thavamani, Chandresh Dwivedi, Pankaj Regar, International Journal of Advanced Research in Engineering and Technology, **2014.**
15. Mechanical, thermal and morphological analysis of EPDM/ polypropylene coconut pith composites, RRPL, Abitha**,** K. Rajkumar, **2014**, 5 (2).
21. Studies on effect of coconut pith on reclaimed EPDM/recycled PP composites**,** V. K. Abitha, K. Rajkumar, P. Thavamani, Research & Reviews In Polymer, **2014**.

22. Physico-mechanical and Thermal properties of Hydrogenated Nitrile Rubber based polymer Nano silica composites**,** K. Rajkumar, C. Dwiwedi, P. Thavamani, P. Pazhanisamy & P. Jeyanthi, International Journal of Scientific & Engineering Research, **2014**.
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24. Fatigue Life Estimation of an Elastomeric Pad by ε-N Curve and FEA**,** B. Suryatal, H. Phakatkar, K. Rajkumar, P. Thavamani**,** Journal of Surface Engineered Materials and Advanced Technology, **2015**.

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26. Comparative studies in dispersing nanoparticles in a styrene butadiene rubber matrix via different blending methods, A. V. Rane, V. K**.** Abitha, P. S. Suchithra K. Rajkumar**,** Journal of Nano Research, **2015**.
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16. Micro-roughening of polyamide fabric using protease enzyme for improving adhesion strength of rubber-polyamide composite, *S.* Periyasamy, G. Krishna Prasad, S. K. Chattopadhyay, A.S.M. Raja, K. Raj Kumar and S. Jagadale, J. Polym. Eng., **2016**. *(Collaborative Research with CIRCOT, Mumbai)*

- **PATENTS**

1. **"**A Novel Adhesive Activated Polyester Fabric Substrate for Rubber Composites and The Process for Producing the Adhesion**"**

   Application No.:- 493/MUM/2010

2. **"**A Novel Flexi Check Dam for Efficient Use of Water in Agriculture"

   Application no.: 1461/MUM/2011

LIST OF CRITICAL PRODUCTS DEVELOPED AT IRMRA

1. Development of Polymer Booting (sponsored by M/s. BARC, Mumbai)
2. Development of Rubber and Lead-Rubber Bearing for Seismic application for BARC
3. Development of TPE (Thermoplastic Elastomer) (sponsored by M/s. BRNS)
4. Use of Electron Beam Radiations in Rubber Products especially Tyres, Belts etc. – BRNS, BARC
5. Development of Pneumatic Mount (sponsored by Ministry of Defence)
6. Development of Rubber staves for Navy, Vizag
7. Design and Development of acoustic Rubber Tiles for HQ ATVP, Navy, Govt. of India.
8. Failure Analysis of Phosphoric Acid Tank lining compound for RCF (Rashtriya Chemicals and Fertilizers Ltd.), Govt. of India.
9. Development of pneumatic fender (tube less) for Navy, Mumbai.
10. Ageing studies on rubber compound and elastomer isolator to estimate the life of bearings using Arrhenius Model (MOU with BARC)
11. Development of Rubber compound (material development) sample having chemical resistance to Tributyl Phospate and n-Dodecane (30/70 v/v). sponsored by Indira Gandhi Centre For Atomic Research, Government of India, Department of Atomic Energy, Kalpakkam
12. Development of a special elastomeric compound material suitable for Nuclear Power plants to work in high temperature and pressure
13. Development of Master Slave Manipulator M-8
14. Development of rubber Gauntlet for nuclear application
15. Vulcanizing of Arming Device holder for Defense Sector
16. Waste Utilization of tyre crump in different application (sponsored by DST, Govt. of India)

11. IRMRA QUALITY CREDENTIALS

Sr. No.	Name	Agency
1.	**ISO/IEC 17025:2005** Accredited for Chemical & Mechanical Testing.	NABL
2.	**ISO 9001:2008** Certified for management system	TUV NORD
3.	Bureau of Indian Standards **(BIS)** recognized for Tyre and Non-tyre rubber product testing	BIS
4.	National Accreditation Board for Education & Training **(NABET**) Accredited for 04 days LMS training	Quality Council of India **(QCI)**
5.	SIRO recognized research laboratory by Department of Scientific and Industrial Research **(DISR)**	Ministry of Science & Technology, GoI
6.	Center for Military Air worthiness & Certification **(CEMILAC)** Approved Testing house	Defence Research and Development Organization **(DRDO)**
7.	Directorate General of Mines Safety **(DGMS)** recognize testing house	Ministry of Labor & Employment, GoI
8.	Rubber Skill Development Council **(RSDC)** Affiliated for training	RSDC
9.	Business Membership Organization **(BMO)**	Quality Council of India **(QCI)**

12. NEED OF INDUSTRIAL POLYMER CHEMISTRY EDUCATION & ELIGIBILITY

- There are about 7000 units comprising of 30 large scale, 300 medium scale and around 6500 small scale and tiny sector units. Rubber is one of the major industrial polymers. Indian Rubber Industry is expected to grow at over 8% per annum in this decade and the industry is envisaged to grow at the rate of 8% per annum. The per capita consumption of rubber in India is only 800 grams compared to 12 to 14 kilos in Japan, USA and Europe. The prospect of growth is further enhanced by a boom in the vehicle (automobile) industry, improved living standards of the people and rapid over-all industrialization. There exists a huge scope for expansion and development and exports in coming years. However, the largest part of the industry includes unorganized small & medium scale rubber industries. Unlike metal and plastic, rubber products are very complex and require a high expertise starting from raw material selection to processing techniques. Rubber product manufacturing involves multiple steps, a single rubber product contains more than 10-15 different ingredients, their mixing and molding requires highly skilled man power. The rubber industry is has a huge demand for the skilled manpower to up lift the level and status of rubber industry. Very few institutes in India offer an educational course on rubber technology; most of them offer courses on chemistry / chemical engineering / mechanical engineering that do not serve the need of the industry.

- In view of this IRMRA in collaboration with Department of Chemistry, Mumbai University offers—"***M. Sc. Industrial Polymer Chemistry"*** for fresh graduates to grow their career in rubber & allied polymer industries.

- Any student who has completed B. Sc. in Chemistry can apply for this course. Admission will be given on the basis of merit.

13. M. Sc. CHOICE-BASED CREDIT SYSTEM (CBCS)

The Choice-Based Credit System (CBCS) has been introduced for the Master's Program from the Academic Year 2016-17. A minimum of **96** credits have to be earned by students across four Semesters. Semesters I and II form the First year of the M. Sc. programme and comprise the courses from four branches while Semesters III and IV are in the second year of the M. Sc. programme in the respective specialization chosen by the student at the time of admission to the M. Sc. Course.

The Salient features of Choice-Based Credit System (CBCS) are as follows:

Credit: One credit shall be equal to one hour teaching per week per semester for 15 weeks.

M. Sc. Course:

- Ordinarily, M. Sc. Course shall be given four teaching hours per week per paper. Each paper shall have 4 credits.

- There shall be four papers of 4 credits each per semester.
- Thus there shall be 16 theory lectures per week.
- There shall be 8 credit practical components for M. Sc.
- Two hours of laboratory component per week shall be considered as 1 credit. Thus, students shall perform 16 hours of practical per week per semester for 15 weeks.

M. Sc. Program: Ordinarily, M. Sc. Program shall consist of 96 credits over four semesters.

Courses: There shall be four types of courses:

(i) Core Courses
(ii) Elective Courses
(iii) Optional Courses
(iv) One-skill based Courses

Core Courses: Core-courses shall be offered by parent department.

- Core courses being the absolute necessity for a master's degree in a subject, shall be never less than 75% for any of the semesters.
- Semester I & II shall have 100% core courses.
- Semester III & IV shall have three theory papers (12 credits) each on core courses.
- Semester III shall have 8 credits of practical component. Students shall perform 16 hours of practical per week for 10-15 weeks.
- Semester IV shall have 8 credits of Project component. For this, students shall perform 8 hours per week practical work for 10-15 weeks.

Elective Courses:

- Elective Courses shall be offered by parent departments.
- 2 Elective courses shall be compulsory in semester III. One Elective course shall consist of 2 credits. This shall necessitate 4 lectures per week for 15 weeks for 2 elective courses. One paper of 4 credits shall be divided into 2 sections to accommodate 2 Elective papers of 2 credits each.

Optional Courses:

- These shall mean to facilitate students to acquire broader vision outside his/her discipline.
- Optional courses shall be courses chosen by the student from other than his core subject. These can be from the same faculty or from any other faculty.
- Optional courses shall be of 2 credits each. One paper of 4 credits shall be divided into 2 sections to accommodate 2 optional courses.

Skill-based Courses:

- The student shall complete one skill-based course any time during 4 semesters.
- Skill-based courses shall be offered in summer vacation/winter break/Diwali break or shall be conducted on Sundays and Holidays.
- Each skill-based course shall be of approximately 100 hours duration and there shall be 75% attendance compulsory for the course.

- There shall be internal assessment in an appropriate form; students shall be given grades such as A, B, C, D; A being the highest and D being the lowest. Students shall be required to get minimum C grade to qualify for the M. Sc. Degree.
- The marks of the skill-based course shall not be considered for calculation of CGPA of M. Sc. Degree. However, the skill-based course successfully completed by the student shall be mentioned on the final grade sheet.
- Separate fees shall be collected for skill-based courses, the quantum of which shall depend upon the nature of the skill-based courses.

Choice-Based Courses:

- It shall be made mandatory to offer two Elective courses in the third semester and 2 Optional Courses [OC1 & OC2] in the fourth semester.
- The Optional course shall be interdisciplinary in nature.
- Each department shall offer 2 Optional courses for the benefit of students from other disciplines. There shall be a total of 4 lectures required per week for optional courses. There shall be a fixed slot for this component where lectures from core courses and Elective courses shall not be held.
- The Head of the Department shall communicate the internal marks for OC1 and or OC2 for the students from other departments to the head of their parent department. The internal marks for all the courses shall be communicated to the COE by the parent departments only.

The structure:

- **Semester I:** Theory papers of 4 credits each only on core subject.
  8 credits for practical component.
- **Semester II:** Theory papers of 4 credits each only on core subject.
  8 credits for practical component.
- **Semester III:** Theory papers of 4 credits each only on core subject.
  One theory paper of 4 credits on 2 Elective courses. 8 credits for practical component.
- **Semester IV:** Theory papers of 4 credits each only on core subject.
  One theory paper of 4 credits on 2 Optional courses. 8 credits of Project component.

Admission to M. Sc. Choice-Based Credit System (CBCS) Course

Admission to departments where entrance examination will not be necessary, the admission shall be decided only on the basis of T. Y. B. Sc. Norms give below:

[1] T. Y. B. Sc. Marks component for Mumbai University Students

a) The marks secured by the student, without grace marks, with as a single major subject out of 600 (Sem V & VI) shall be considered.
b) Students securing first class and above shall be given priority over students not securing second class at T. Y. B. Sc. examination.
c) The CGPA shall be considered if the marks are equal.
d) All things being equal, the students with first class shall be given priority over the students who have been declared passed in First Class with grace marks/ Second Class with as a single major subject out of 600 (Sem V & VI).
e) The students offering two major subjects, "The Subject Applied for Master's Degree" as one of the subject at T. Y. B. Sc. be admitted in order of merit by considering marks secured in "The Subject Applied for Master's Degree" at only.

f) In case of there is a tie in (a), (b), (c), (d) or (e), aggregate marks without grace marks out of 600 shall be considered.

g) In case of there is a tie in (a), (b), (c), (d) or (e), then all students tied at the rank shall be admitted.

The final merit list will be displayed on the website of the University and also on the Notice Board of the Department.

[2] <u>For other University students:</u>

Marks declared by the concerned University at T. Y. B. Sc. Examination and as shown in mark sheet "The Subject Applied for Master's Degree" will be considered for preparing the merit list as per quota available for other University students.

<u>Examination</u>

All examinations for all semesters are conducted by the respective departments for the students admitted in the departments.

The examinations shall be of two kinds:

I. Internal assessment II. End Semester Examination

Internal Assessment: The internal assessment for theory papers shall be for 40% marks.

End-Semester Examination: The end semester assessment shall be for 60% marks for theory papers and 100% for practical examination.

14. SYLLABI FOR M. Sc. CHOICE BASED SYSTEM (CBCS) FOUR-SEMESTER COURSE IN INDUSTRIAL POLYMER CHEMISTRY

SEMESTER-I

Course Code	Title of the Course	No. of Credits	No. of hours per SEMESTER	Examination		Total Marks
				Mid-Sem Marks	End-Sem Marks	
IPCHEM 101	Physical Chemistry-I	4	60	40	60	100
IPCHEM 102	Inorganic Chemistry-I	4	60	40	60	100
IPCHEM 103	Organic Chemistry-I	4	60	40	60	100
IPCHEM 104	Analytical Chemistry-I	4	60	40	60	100
IPCHEM 105	Physical Chemistry Practical-I	2	-	-	50	50
IPCHEM 106	Inorganic Chemistry Practical-I	2	-	-	50	50
IPCHEM 107	Organic Chemistry Practical-I	2	-	-	50	50
IPCHEM 108	Analytical Chemistry Practical-I	2	-	-	50	50
	Total	24			Total	600

*** Practical component involves 16 h per week laboratory work for 15 weeks.**

SYLLABUS: SEMESTER-I

IPCHEM 101: PHYSICAL CHEMISTRY-I

Unit-I THERMODYNAMICS-I **[15L]**

State function, exact and inexact differentials, Internal energy, Enthalpy, Heat capacity, Relation between C_p and C_v, Limitations of first law of thermodynamics, Joule-Thomson experiment, Joule-Thomson coefficient, Joule-Thomson coefficient for real and an ideal gas, Inversion temperature

Absolute temperature, Spontaneous or irreversible process, Entropy, Thermodynamic equation of state, Maxwell relation, Helmholtz and Gibbs free energy, Third law of thermodynamics, Nernst heat theorem, Determination of absolute entropies, entropy changes in chemical reaction, residual entropy.

Unit-II FUNDAMENTAL ASPECTS OF QUANTUM CHEMISTRY **[15L]**

Introduction: Historical background, Old Vs New Quantum Theory, Heisenberg's Uncertainty Principle, The wave nature of matter

Fundamental Background:Postulates of Quantum Chemistry, Commutators of operators, Properties of Linear and Hermitian operators, Operators for the dynamic variables of a system such as position, linear momentum, angular momentum and total energy, Expectation Value,

Progressive and standing waves, Conditions on the wave function and its interpretation, Normalization and orthogonality, Separation of variables, Obtaining Schrödinger's time independent wave equation from Schrödinger's time dependent wave equation.

Application of Quantum Chemistry in Translation motion: Particle in one dimension box: Differential equation and its solution, Graphical representation of wavefunctions and probability densities, Normalization and orthogonality of wave functions. Even and Odd Functions.

Particle in a two and three dimensional box: Differential equation and its solution, Degeneracy, Energy level Diagram.

Unit-III PHASE RULE AND ITS APPLICATIONS **[15L]**

Phase rule, Phase diagrams and their classification, Lambda transitions.

Two component system: Vapor pressure – composition diagrams, Phase diagrams for partially miscible liquids for two components, Critical solution temperature, influence of foreign substances on CST, fractional distillation of Zeotropic and Azeotropic mixtures.

Three component systems:

Type I-Formation of one pair of partially miscible liquids: Graphical representations, binodal curves, plait point, influence of temperature-System showing real critical solution temperature, System showing no real critical solution temperature.

Type II-Formation of two pairs of partially miscible liquids.

Type III-Formation of three pairs of partially miscible liquids, Influence of impurities, Ternary Azeotropic mixtures, Preparation of absolute alcohol by azeotropic elimination of water.

Unit-IV CHEMICAL KINETICS **[15L]**

Accounting for the rate laws: simple reactions, temperature dependence of reaction rates, consecutive reactions,(rate determining step approximation and steady-state approximation), unimolecular reactions – Lindemann-Hinshelwood mechanism.

Kinetics of complex reactions - Chain reactions, polymerization reactions, explosions, photochemical reactions.

Fast reactions: Study of kinetics by flow methods, relaxation methods, flash photolysis, magnetic resonance method, shock tube method.

**Derivation not expected*

Note: Numerical and theoretical problems from each Unit- are expected.

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13. Sydney T. Bowden, *The phase rule and the phase reaction*, McMillan and Co. Ltd., London, 1938.
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15. G. L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
16. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.
17. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.

List of Books for further reading:

1. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
2. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
3. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
4. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
5. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
6. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
7. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
8. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.

IPCHEM-102: INORGANIC CHEMISTRY-I

Unit-I INORGANIC REACTION MECHANISMS [15L]

(i) Rate of reactions, factors affecting the rate of reactions; techniques for the determination of rate of reactions.

(ii) Mechanisms and factors affecting the (I) ligand substitution reactions of (a) octahedral complexes with and without breaking of metal-ligand bond, (b) square planar complexes – trans-effect, its theories and applications and (c) tetrahedral complexes; (II) Redox reactions: inner and outer sphere mechanisms.

(iii) Complimentary and non-complimentary reactions.

(iv) Isomerization and racemization reactions.

Unit--II ORGANOMETALLIC CHEMISTRY [15L]

(i) Recapitulation of classification of organometallic compounds, electron counting and eighteen electron rule.
(ii) Sixteen electron rule.
(iii) Synthesis, structure and bonding of the following organometallic compounds:
(a) Alkyl and Aryl derivatives, (b) Carbenes and Carbynes, (c) Alkene complexes, (d) Alkyne complexes, (e) Allyl complexes, (f) Cyclopentadiene complexes and (g) Arene complexes (sandwich and half sandwich complexes).

Unit-III CHEMICAL BONDING **[15L]**

(i) **Hybridization:** Derivation of wave functions for the following orbital hybridisation types: sp (BeH_2); sp^2 (BF_3); sp^3 (CH_4) considering only sigma bonding.
(ii) Molecular Orbital Theory (LCAO-MO approach) for Electron deficient and Electron rich species.
(iii) Hydrogen bonding: concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.
(iv) Bent's Rule: Reactivity of molecules: e.g. chlorofluorides of phosphorous, fluoromethanes, etc.

Unit-IV CHEMICAL REACTIVITY **[15L]**

(i) Hydration of cations and anions, Latimer equations, acidity of cations and oxocations, basicity of anions and oxoanions, classification of mono and polyatomic ions on the basis of pKa with predominance diagram. Classification of oxoacids, structural anomalies.
(ii) Recapitulation of hard soft acids and bases (HSAB) principle, Acid-base strength and softness and hardness; Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases; Superacids and bases.
(iii) Redox properties of the elements:
Latimer diagram: Construction of the diagram, non-adjacent species and disproportionation.
Frost Diagram: Construction and interpretation.
Pourbaix diagram of Iron in natural water.

References:

Unit-I

1. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
2. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
3. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
4. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
5. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001

Unit-II

1. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th Ed., Wiley Interscience, 2009.
2. R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd Ed., New Age International Pvt. Ltd., 2000.
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6. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.

Unit-III

1. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.

2. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.

3. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The BenjaminCummings Publishing Company, 1989.

4. K. L. Kapoor, A textbook of Physical Chemistry, Volume 4, McMillan, 2001.

5. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.

6. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.

7. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.

8. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.

9. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

10. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.

11. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.

Unit-IV

1. G. Wulfsberg, Inorganic Chemistry, Viva Books Pvt. Ltd., 2002.

2. B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Ed., John Wiley & Sons, Inc., 2001.

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6. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.

7. R. L. Madan and G. D. Tuli, Inorganic Chemistry, 5th Ed., S. Chand, 2012.

8.. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley, 2012.

9. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.

10. http://www.meta-synthesis.com/webbook.html

IPCHEM 103: ORGANIC CHEMISTRY-I

Unit-I PHYSICAL ORGANIC CHEMISTRY **[15L]**

1.1 Acidity-Basicity:

Different concepts and examples, Factors affecting acidity & basicity. Electrophilicity and Nucleophilicity; Ambident Electrophiles and Nucleophiles, Relationship between nucleophilicity and basicity.

1.2 Non-kinetic Methods of determining reaction mechanism:

Product profiles, Detection and identification of intermediates by chemical/trapping and spectroscopic means. Evidence from catalysis, cross-over experiments, isotopic labeling, Kinetic isotope effect-primary & secondary isotope effect, Stereochemical studies.

1.3 Linear Free Energy Relationships:

Effect of structure on reactivity, Hammett equation, substituent and reaction constants, Through conjugative effects of substituents, Linear free energy relationships in the determination of reaction mechanism, Taft Equation, steric parameter.

Unit-II STEREOCHEMISTRY [15L]

2.1: Symmertry operations and symmetry elements:

Symmetry Operations, identification of principal axis, symmetry elements, definition and examples of molecules with different elements of symmetry including σ_v, $\sigma_h\sigma_d$

2.2 Molecules with tri and tetracoordinate chiral centres:

Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centres and their relative configurational stabilities.

2.3 Molecules with two or more chiral centres:

Configurational nomenclature, Constitutionally unsymmetrical molecules: Erythro-threo and syn-anti systems. Constitutionally symmetrical molecules with odd and even number of chiral centres: enantiomeric and meso forms, concept of stereogenic, chirotopic and pseudoasymmetric centres.

2.4 Axial and Planar chirality:

Principles of axial, planar and helical chirality, Stereochemical features and configurational descriptors (R, S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spiranes, biaryls (including BINOLs and BINAPs), ansa compounds, cyclophanes and helicenes.

2.5 Prochirality:

Concept of prochirality, homotopic enatiotopic, and distereotopic ligand and faces: criteria based on symmetry and substitution/addition of molecules with different elements of chirality. Notation of prochirality, notation for molecules with pro-pseudo asymmetric centres. Notation for molecules with presence of a chiral and a pro-chiral centres. Top-right mnemonic.

Unit-III METHODS OF C-C BOND FORMATION USING THE CARBONYL FUNCTON [15L]

3.1 Reactivity of carbonyl group, Enols and enolates- Regioselective kinetic and thermodynamic enolate formation using LDA. Different types of aldol condensations under acid and base catalysis.

3.2 Generation of dianion derived from active methylene compounds and regioselective C-C bond formation on unstabilized site.

3.3 Mechanism, stereochemistry and applications of the following reactions: Acyloin, Benzoin, Claisen, Darzen, Dieckmann, Knoevenagel, Mannich, Michael, Robinson Annulation and Stobbe.

3.4 Enamines as enolate equivalents. Metalloenamines, Synthesis of enamines and selected C-C bond formation.

Unit- IV SPECTROSCOPY [15L]

4.1 UV-Visible Spectroscopy:

Recapitulation of basic concepts and sample handling. Woodward-Fieser rules for calculation of λ_{Max} of conjugated dienes, polyenes, enones and aromatic carbonyl compounds.

Problems based on Woodward-Fieser rules.

4.2 IR Spectroscopy:

Recapitulation of basic concepts and sample handling. Group frequencies and their use in detection and identification of functional groups.

4.3 PMR Spectroscopy:

Recapitulation of basic concepts and sample handling. Prediction of structure of organic compounds based on the use of chemical shift and J values.

4.4 Mass Spectrometry:

Recapitulation of basic concepts and sample handling. Fragmentation Pattern of major classes of organic compounds, Retro-Diels Alder reaction, McLafferty rearrangement and ortho effect.

4.5 Structure determination of organic compounds involving individual or combined use of the above spectral techniques.

References Books:

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S. H. Wilen and L.N. Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
9. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons.
15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.
16. Organic Spectroscopy-Principles and Applications-Jagmohan, Narosa Publication.
17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.
18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.
19. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
20. Physical Organic Chemistry, Neil Isaacs
21. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty

IPCHEM 104: ANALYTICAL CHEMISTRY I

Unit I: Concepts of Analytical Chemistry **[15L]**

1.1	Concepts of Analytical Chemistry: Classification of Analytical Methods: An overview of Classical methods, Types of Instrumental methods	[2L]
	Selection of an analytical methods and their performance criteria.	[2L]
1.2	Concepts of optical methods: Electromagnetic spectrum, transitions, components in optical instruments, sources, description of LASER, wavelength selectors, monochromator functioning, effective band width, detectors and description of diode array type detector.	[6L]
1.3	Atomic Absorption Spectrometry: Principle, interferences, use of electro thermal analyser, hydride generator and cold vapour for trace metal analysis. Importance of electro thermal analyser for analysis of	[5L]

biological samples, level of detection; hydride generator for environmental samples and cold vapour technique for mercury analysis.

	Unit II: Atomic and molecular spectroscopy	**[15L]**
2.1	Molecular transitions, derivative and dual wavelength spectroscopy. Application to trace analysis (d-d transition and charge transfer), biological samples and simultaneous determinations.	[5L]
2.2	Atomic Emission Spectroscopy based on plasma source, advantages of plasma source. Applications in geo-analysis, metal samples, agriculture and food samples and environmental analysis.	[5L]
3.3	Infrared spectroscopy: Concept of Fourier Transform Spectroscopy, instrumentation, advantages of FTIR and applications. Non-dispersive IR for detection of environmental gases.	[5L]
	UNIT III: Separation methods	**[15L]**
3.1	Solvent Extraction and Solid Phase Extraction: Recapitulation of basic concepts of solvent extraction and solid phase extraction. Liquid anion and cation exchangers. Mechanism of extraction. Extraction equilibria of metal chelates. Factors favoring solvent extraction of metal chelates. Sorbents.	[7L]
3.2	Chromatography: General classification of chromatographic methods. Concept of plate and rate theories: efficiency, resolution, selectivity and separation capability. Broadening of chromatographic peak and van Deemter equation. Optimization of chromatographic conditions.	[8L]
	UNIT IV: Column chromatography techniques	**[15L]**
4.1	Gas Chromatography: Principle of GLC and GSC; Instrumentation: carrier gas supply, sample introduction systems, packed & capillary columns; choice of detectors and comparative account of TCD, FID, ECD & thermionic detector. Temperature programming;	[4L]
4.2	Applications in various fields.	[3L]
4.3	High Performance Liquid Chromatography (HPLC): Types of liquid chromatography, column efficiency in LC; Instrument for LC: mobile phase reservoir and solvent treatment systems, pumping systems, sample introduction systems, columns, Detectors: UV, RI, EC and diode array. Modes of separation: partition, adsorption, ion exchange and size exclusion.	[5L]
4.4	Applications in various fields.	[3L]

Texts/ References:

1. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.
6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.

8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.
10. P. G. Swell and B. Clarke, *Chromatographic Separations, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.
19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.
20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.
21. Solid phase Extraction- Principles, Techniques and Applications, N. J. K. Simpson, Marcel Dekker, New York, (2000).

IPCHEM 105: PHYSICAL CHEMISTRY PRACTICAL-I

Instrumental Experiments:

Conductometryand Potentiometry

1. Titration of a mixture of trichloroacetic acid, monochloroacetic acid and acetic acid with sodium hydroxide conductometrically.
2. Verification of Ostwald's dilution law and determination of the dissociation constant of a weak monobasic acid conductometrically.
3. Study of the effect of substituent on dissociation constant of acetic acid conductometrically.
4. Determination of concentrations and amounts of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
5. Determination of solubility product of silver chloride potentiometrically using a concentration cell.
6. Determination of the formula of the silver-ammonia complex by potentiometric method.
7. Determination of *pK* values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode.
8. Determination of acidic and basic dissociation constants of an amino acid and hence the iso-electric point of the acid.

IPCHEM-106: INORGANIC CHEMISTRY PRACTICAL-I

Synthesis, Purification and Analysis of the following Inorganic Preparations:

1. Potassium trioxalatochromate (III)
2. Bis(enthylenediammine) copper (II) sulphate
3. Hexammine nickel (II) chloride/sulphate
4. Potassium dioxalato cuprate(II) dihydrate
5. Potassium trioxalatoaluminate(III) hydrate

References:

1. A. I. Vogel, Vogel's Text Book of Quantitative Inorganic Analysis, 6th Ed., Pearson Education, 2000.
2. J. D. Woolins, Inorganic Experiments, Wiley-VCH Verlag GmbH and Co., 2003.
3. W. G. Palmer, Experiments in Inorganic Chemistry, Cambridge University Press, 1954.
4. G. Raj, Advanced Practical Inorganic Chemistry,
5. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 and 2, Academic Press, 1967.
6. G. Marr and B. W. Rockette, Practical Inorganic Chemistry, Van Nostrnad Reinhond, 1972.
7. G. Pass and H. Sutcliffe, Practical Inorganic Chemistry, 2nd Ed., Chapman and Hall, 1985.

IPCHEM 107: ORGANIC CHEMISTRY PRACTICAL-I

One step preparations (0.5 to 1.0 g scale):

The candidate is expected to perform any 10 of the following preaparations and submit the crystallized preparation and TLC analysis of the purified product, mp, % yields, etc.

1. Bromobenzene to p-nitro bromobenzene
2. Nitrobenzene to m-dinitrobromobenzene
3. Benzoin to Benzil
4. Anthracene to Anthraquinone
5. o-phenylenediamine to 2-methyl benzimidazole

6. o-phenylenediamine to 2,3-diphenylquinoxaline
7. Anthracene-Maleic Anhydride adduct
8. p-bromoacetanilide to p-bromoaniline
9. 5,5-diphenylhydantoin from urea and benzil
10. p-benzoquinone to 1,2,4-triacetoxybenzene
11. 2-naphthol to BINOL
12. o-phenylenediamine to benzotriazole

References:

1. Elementary Practical Organic chemistry Part-I small scale preparations, A.L. Vogel (Longman)
2. Laboratory Manual of organic chemistry, B.B. Dey and M.V. Sitaram revised by T.R. Govindachari (Allied Publishers Ltd.)

IPCHEM 108: ANALYTICAL CHEMISTRY PRACTICAL-I

Non-Instrumental Experiments:

1. Calibration of a 10 mL pipette by weighing at room temperature and reporting the result with statistical data.
2. Determination of Manganese from pyrolusite by potassium permanganate method.
3. Estimation of vitamin C by titration with potassium bromate.
4. Determination of number of nitro group in organic compound by titanium method.
5. Separation and determination of Fe (III) and Mg (II) /Zn (II) using ethyl acetate /ether as a solvent.
6. Separation of Zn (II) and Mg (II) in a mixture using anion exchanger.

SEMESTER-II

Course Code	Title of the Course	No. of Credits	No. of hours per SEMESTER	Examination		Total Marks
				Mid-Sem Marks	End-Sem Marks	
IPCHEM 201	Physical Chemistry-II	4	60	40	60	100
IPCHEM 202	Inorganic Chemistry-II	4	60	40	60	100
IPCHEM 203	Organic Chemistry-II	4	60	40	60	100
IPCHEM 204	Analytical Chemistry-II	4	60	40	60	100
IPCHEM 205	Physical Chemistry Practical-II	2	-	-	50	50
IPCHEM 206	Inorganic Chemistry Practical-II	2	-	-	50	50
IPCHEM 207	Organic Chemistry Practical-II	2	-	-	50	50
IPCHEM 208	Analytical Chemistry Practical-II	2	-	-	50	50
	Total	24			Total	600

***Practical component involves 16 h per week laboratory work for 15 weeks.**

SYLLABUS: SEMESTER-II

IPCHEM 201: PHYSICAL CHEMISTRY-II

Unit-I THERMODYNAMICS-II **[15 L]**

Partial molar quantities, chemical potential for ideal gas, gas mixtures, Gibbs free energy of mixing, entropy and volume of mixing, Gibbs-Duhem equation, Variation of chemical potential with pressure and temperature.

Excess functions (Chemical potential, Gibbs free energy and enthalpy function), Equilibrium constant and its dependence on temperature and pressure.

Unit-II APPLIED ASPECTS OF QUANTUM CHEMISTRY **[15L]**

Application of Quantum Chemistry in Vibrational motion:

The one-dimensional harmonic oscillator: Classical and Quantum mechanical treatment, Hermite polynomials**,** Wave functions, probability densities, and energy levels

Application of Quantum Chemistry in Rotational motion:

Spherical polar coordinates, Separation of variables, The rigid rotor: Legendre functions, energy levels and wave functions*.

Application of Quantum Chemistry in Atomic system:

The hydrogen atom and hydrogen-like ions, Reduction of the two-particle problem to two one-particle problems, Solutions to R(r), $\Theta(\theta)$ and $\Phi(\phi)$ equations*, Hydrogen-like orbitals, sketches of wave functions (ψ) and probability densities ($|\psi|^2$), polar plots of angular parts, orbital and spin angular momentum, spin orbitals.

Unit-III APPLICATIONS OF THERMODYNAMICS AND ELECTROCHEMISTRY [15L]

Experimental techniques for determination of thermodynamic quantities: Bomb Calorimeter, Coffee Cup Calorimeter, Differential Scanning Calorimeter.

Exergonic and endergonic reactions, Thermodynamics of ATP, applications of thermodynamics to ultra-purity and controlled purity (Zone Refining and zone levelling).

Debye-Hückel theory of strong electrolyte, ionic atmosphere, activity coefficients of electrolyte solutions-Debye-Hückel limiting law, extension to higher concentrations.

Electrolytic conductance and ion-ion interactions, Debye-Hückel-Onsager equation, validity of equation, Debye-Falkenhagen effect, Wien effect, weak electrolyte and Debye-Huckel theory.

Determination of thermodynamic functions of cell reaction.

Electrochemistry in water and effluent treatment.

Unit-IV MOLECULAR REACTION DYNAMICS [15L]

Collision theory, steric factor, activated complex theory, reaction coordinate and transition state, thermodynamic aspects, reaction between ions, salt effects, dynamics of molecular collisions.

Homogeneous catalysis – enzyme catalysis, Michaelis-Menten mechanism, acid base catalysis.

Heterogeneous catalysis – Examples: hydrogenation, oxidation, cracking and forming.

****Derivation not expected***

Note: Numerical and theoretical problems from each Unit- are expected

References:

1. Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., Oxford University Press, 2002.
2. K. J. Laidler and J. H. Meiser, *Physical Chemistry*, 2nd ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
5. G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
6. D. A. McQuarrie and J. D. Simon, *Physical Chemistry - a molecular approach*, Viva Books Private Limited, New Delhi, 1998.
7. S. Glasstone, Text Book of Physical Chemistry, 2nd ed., McMillan and Co. Ltd., London, 1962.
8. Derek Pletcher, *Industrial Electrochemistry*, London New York.
9. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
10. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
11. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
12. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
13. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.
14. R. K. Prasad, *Quantum Chemistry*, 2nd ed., New Age International Publishers, 2000.
15. D. O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemists, 2002.
16. Samuel Glasstone, *An introduction to electrochemistry*, East West edition, New Delhi.
17. G. L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
18. D. R. Crow, *Principles and Applications of Electrochemistry*, 4th edition, Blackie, London, 1994.

19. J. O'm. Bockris and A. K. N. Reddy, *Modern Electrochemistry*-Vol. 1 and 2, Plenum press, New York.
20. R. A. Robinson and R.H. Stokes, *Electrolyte Solutions*, 2nd Edition, Butterworths, London 1959.
21. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.
22. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.

List of Books for further reading:

1. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
2. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
3. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.

IPCHEM-202: INORGANIC CHEMISTRY-II

Unit-I **SOLID STATE CHEMISTRY AND NANOMATERIALS** **[15L]**

(A) Solid State Chemistry

(i) Recapitulation of basic solid state chemistry.

(ii) Structures of compounds of the type: AB [zinc sulfide (ZnS), nickel arsenide (NiAs)], AB_2 [fluorite (CaF_2), antifluorite (Na_2O), rutile (TiO_2) and layer structures viz., cadmium chloride ($CdCl_2$) and cadmium iodide, (CdI_2)].

(iii) Principles, merits and demerits with suitable examples of: ceramic method, precursor method, sol-gel method, microwave synthesis for the preparation of inorganic solids.

(B) Nanomaterials

(i) Introduction to nanomaterials.

(ii) **Preparative methods:** Chemical methods, Biological methods; Role of capping agents.

(iii) Applications of nanomaterials in electronics and biomedical field.

Unit-II **MOLECULAR SYMMETRY AND GROUP THEORY** **[15L]**

(i) Symmetry elements and symmetry operations, product of symmetry operations, Cartesian coordinate system and symmetry elements.

(ii) Symmetry classification of molecules: point groups, mathematical requirement for a point group, systematic assignment of point groups to molecules.

(iii) Identification of molecular point groups of molecules having low symmetry, high symmetry and special symmetry.

(iv) Descent in symmetry of molecules with substitution.

(v) Group multiplication tables, classes of symmetry operations.

(vi) Symmetry criteria for optical activity, Symmetry restrictions on dipole moment.

Unit-III **ENVIRONMENTAL CHEMISTRY** **[15L]**

(i) **Chemical Toxicology:**
toxic chemicals in the environment, biochemical effects and speciation of toxic elements like arsenic, lead, mercury and cadmium; antidotes for the toxic elements. Biochemical effects of fluoride and pesticides.

(ii) **Radiation pollution:**
Sources and biological implication of radioactive pollutants.

(iii) **Solar energy:**
Use of solar energy in space heating and water heating; Production of electricity

using solar trough collectors, Power tower and solar pond; solar energy for driving vehicles.

(iv) **Power from other sources:**
Hydro power, Wind power, Geothermal energy, Ocean thermal energy conversion (OTEC), Tidal power.

Unit-IV **BIOINORGANIC CHEMISTRY** **[15L]**

(i) **Biological oxygen carriers:**
Myoglobin, hemoglobin, hemerythrene and hemocyanine. Biochemical effect of cyanide, Hill equation, Bohr effect and their implications.

(ii) Reactions of dioxygen in biological system with examples of peroxidase, monooxygenase, superoxide dismutase and oxidase reactions.

(iii) **Nitrogen fixation:** Nitrogenase, Hydrogenases.

(iv) **Metal ion transport and storage:** Ionophores, transferrin and Ferritin.

(v) **Metal ions in medicines:** cis-platin and related compounds.

References:

Unit-I

1. A. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, 1987.
2. L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co, 1977.
3. H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.
4. C. N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed., Cambridge University Press, 1997.
5. Lesley E. Smart and Elaine A. Moore, Solid State Chemistry – An introduction, 3rd Ed., Taylor and Francis, 2005.
6. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.
7. S. K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.
8. G. Cao, Nanostructures and Nanomaterials- Synthesis, Properties and Applications, Imperial college Press, 2004.
9. C. N. R. Rao, A. Muller and A. K. Cheetham, The Chemistry of Nanomaterials-Synthesis, Properties and Applications, Volume-I, Wiley VCH, 2004.

Unit-II

1. K. V .Reddy, Symmetry and Spectroscopy of Molecules, 2nd Ed., New Age International Publishers2009.
2. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, 1998.
3. A.S. Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI- Learning, 2010.
4. F. A. Cotton, Chemical Applications of Group Theory, 2nd Ed., Wiley Eastern Ltd., 1989.
5. G. Raj, A. Bhagi and V. Jain, Group Theory and Symmetry in Chemistry, 3rd Ed., Krishna Prakashan, 2010.
6. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
7. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East-West Press Pvt. Ltd., 2014.

Unit-III

1. A. K. De, Environmental Chemistry, 7th Ed., New Age International Publishers, 2007.
2. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, 3rd Ed., Narosa Publishing House, 2013.
3. S. S. Dara and D. D. Mishra, A Textbook of Enviromental Chemistry and Pollution Control, S. Chand & Company Ltd., 2012.
4. D. Banerjea, Coordination Chemistry, Tata Mc Graw Hill, 1993.
5. S. K. Banerji, Environmental Chemistry, 2nd Ed., Prentice-Hall of India, 2005.
6. R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause and R. L. Strong, Chemistry of Environment, 2nd Ed., Academic Press, 2005.
7. J. E. Girard, Principles of Environmental Chemistry, 2nd Ed., Jones and Bartlett publishers, 2011.
8. H. Kaur, Environmental Chemistry, Pragati Prakashan, 8th Ed., 2014.

Unit-IV

1. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, 1st Indian Ed., Viva Books, 1998.
2. D. Banerjea, Coordination Chemistry, Tata Mc Graw Hill, 1993.
3. R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, 1984.
4. J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.
5. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Publications, Mill Valley, Caligronic, 1994.
6. G. N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri & Sons, 1988.

IPCHEM 203: ORGANIC CHEMISTRY-II

Unit-I PHYSICAL ORGANIC CHEMISTRY AND AROMATICITY [15L]

1.1 Transition state theory, Arrhenius equation and its application to estimate E_{act}, Hammond's postulate, Principle of microscopic reversibility, Kinetics v\s Thermodynamic control.

1.2 Influence of solvent polarity, solvent scales (Y-scale), solvatochromism, (Z and ET Scales), ionic strengths and salt effect, Acid-base catalysis, Bronsted catalysis equation.

1.3 Structural, thermochemical and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems, DRE and REPE, London Diamagnetism, Diamagnetic exaltation and concept of closed configuration.

1.4 Application of HMO theory to monocyclic conjugated systems, Frost-Muslin diagrams, Huckel's $(4n+2)\ \pi$ electron rule, Exceptions to $(4n+2)\ \pi$ electron rule and 4n rules.

1.5 Aromatic, Antiaromatic and Homoaromatic compounds upto 18 carbon atoms. Aromaticity of benzenoid systems, heterocycles, metallocenes, azulenes, annulenes conjugated molecules with exocyclic double bonds and tropylium cations.

Unit-II ELIMINATION AND NUCLEOPHILIC SUBSTITUTION REACTIONS [15 L]

2.1 Types of elimination reactions, $E_1$and E_2mechanisms.

2.2 Orientation of elimination reactions: Saytzeff and Hoffmann rules. E_2reactions of vinyl halide, E_1cB mechanism.

2.3 Pyrrolytic elimination: Chugaev reaction, Cope reaction, Hoffmann's and Pyrrolysis of acetates.

2.4 Aliphatic nucleophilic substitution at sp^3 carbon: S_N1, S_N2, S_Ni, S_NcA reactions. Ion pair in S_N1, reactions, Stereochemistry of all the above reactions, Factors affecting these reactions: substrate nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group.

2.5 Nucleophilic substitution reactions at sp^2 (vinylic) carbon.

2.6 Aromatic nucleophilic substitution reaction: S_NAr, S_N1, Benzyne mechanism, ipso, cine and tele substitutions, vicarious substitution.

Unit-III OXIDATION-REDUCTION [15 L]

3.1Preparation of reagents (wherever applicable), mechanism and applications of the following:

Epoxidation, Baeyer-Villiger Oxidation and Oppenauer Oxidation.Oxidations using Osmium Tetroxide, Lead Tetraacetate, Periodic acid, Selenium dioxide, PCC and PDC.

3.2 Dehydrogenation with DDQ and TCQ, and Ozonolysis

3.3Preparation of reagents (wherever applicable), mechanism and applications of the following:

Wolf-Kishner reduction, Clemmensen reduction, Meerwein-Pondorff-Verley reduction, Birch reduction, Reductions with $NaBH_4$, $LiAlH_4$ and DIBAL.

3.4Homogeneous reductions: Wilkinson's catalysts and related systems.

Unit-IV REACTIONS AND REARRANGEMENTS [15 L]

4.1 Mechanism, stereochemistry (if applicable) and applications of the following:

Arndt-Eistert reaction, Baylis-Hilmann reaction, McMurry Coupling, Mitsunobu reaction and Mukiyama esterification, Woodward Prevost Hydroxylation.

4.2 Mechanism, stereochemistry (if applicable) and applications of the following:

Cope rearrangement, Claisen rearrangement, Dienone-Phenol rearrangement, Favroskii rearrangement, Fries rearrangement and Tiffeneau-Demjanov rearrangement.

4.3 Ester hydrolysis (all 8 mechanisms of acid and base catalyzed hydrolysis)

References:

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
9. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
13. Mechanism in Organic Chemistry, Peter sykes, 6^{th} edition onwards.
14. Physical Organic Chemistry, Neil Isaacs
15. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
16. Comprehensive Organic chemistry, Barton and Ollis, Vol 1, Page No. 215-240.

CHEM 204: ANALYTICAL CHEMISTRY-II

Unit-I ELECTROANALYTICAL CHEMISTRY **[15L]**

1.1 Ion selective potentiometry: Basic concept, solid state, precipitate and liquid-liquid membrane, enzyme and gas sensing electrodes with applications. **[8L]**

1.2 Introduction to modern voltammetric techniques viz., Differential pulse polarography, Cyclic voltammetry and Stripping (cathodic & anodic) voltammetry. **[7L]**

Unit-II SPECTROSCOPIC METHODS **[15L]**

2.1 **Magnetic resonance spectroscopy**:

Basic principles, instrumentation and sample handling, Quantitative applications of proton NMR, Introduction to Carbon–13, Phosphorous-31 and Fluorine-19 with applications. **[8L]**

2.2 **Mass spectrometry**:

Recapitulation, instrumentation; ion sources for molecular studies; electron impact, chemical ionization field ionization, field desorption, fast atom bombardment and MALDI sources. Mass analyzers: quadrupole, time of flight and ion trap, Applications. [**7L]**

Unit-III MISCELLANEOUS TECHNIQUES **[15L]**

3.1 **X-ray spectroscopy:**

Principles, instrument components and applications of X-ray fluorescence, absorption and diffraction methods. [**8L]**

3.2 Introduction to surface analytical techniques. **[3L]**

3.3 **Electron Spectroscopy for Chemical Analysis:** Principle, Instrumentation and applications. [**4L]**

Unit-IV AUTOMATION IN CHEMICAL ANALYSIS AND ELECTROPHORESIS **[15L]**

4.1 An overview of automated instruments and instrumentation, process control analysis; **Types of automatic analytical systems:** Flow injection analysis, automatic organic elemental analyzers, Gas monitoring equipment. **[8L]**

4.2 Electrophoretic methods [**7L]**

References:

1. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.
6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.
8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.

10. P. G. Swell and B. Clarke, *Chromatographic Separations, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.
19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.
20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.

IPCHEM 205: PHYSICAL CHEMISTRY PRACTICAL-II

Non-Instrumental Experiments:

Thermodynamics, Phase Rule and Reaction Kinetics:

1. Determination of heat of solution of benzoic acid by solubility measurements.
2. Determination of heat of solution of salicylic acid by solubility measurements.
3. Study of three-component system: Water-Acetic acid-Chloroform.
4. Study of three-component system: Water–Toluene-Acetic acid.
5. Study of variation of solubility of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product. (Complexometric titration with EDTA)
6. Determination of equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
7. Investigation of the reaction between acetone and iodine.

IPCHEM-206: INORGANIC CHEMISTRY PRACTICAL-II

Analysis of Complex Materials:

1. Devarda's Alloy: Cu by EDTA method, Al by Gravimetry using oxine.
2. Cu-Ni Alloy: Cu by iodometric method; Ni gravimetrically by DMG method.
3. Solder Alloy: Sn gravimetrically by oxide method; Pb by EDTA method.
4. Lime Stone Ore: Loss on ignition; Ca by EDTA method.
5. Haematite Ore: Acid insoluble residue; Fe by redox titration.

References:

1. A. I. Vogel, Vogel's Text Book of Quantitative Inorganic Analysis, 6th Ed., Pearson Education, 2000.
2. J. D. Woolins, Inorganic Experiments, Wiley-VCH Verlag GmbH and Co., 2003.

3. W. G. Palmer, Experiments in Inorganic Chemistry, Cambridge University Press, 1954.
4. G. Raj, Advanced Practical Inorganic Chemistry,
5. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 and 2, Academic Press, 1967.
6. G. Marr and B. W. Rockette, Practical Inorganic Chemistry, Van Nostrnad Reinhond, 1972.
7. G. Pass and H. Sutcliffe, Practical Inorganic Chemistry, 2nd Ed., Chapman and Hall, 1985.

IPCHEM 207: ORGANIC CHEMISTRY PRACTICAL-II

Separation of Binary mixture by micro-analytical technique

Separation of binary mixture using physical and chemical methods. Identification of one of the compounds and checking its purity by TLC. Preparation of the derivative of one of the compounds. The following types are expected: (i) Solid-Solid (ii) Non-volatile liquid-Non-volatile liquid (iii) Water-soluble/insoluble solid-Non-volatile liquid with compounds from the same or different chemical classes in all three categories.

The candidate is expected to carry out separation of 10 mixtures.

References:

1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)

IPCHEM 208: ANALYTICAL CHEMISTRY PRACTICAL-II

Instrumental Experiments:

1. Non aqueous titration: Determination of sodium benzoate / glycine by using perchloric acid in glacial acetic acid by potentiometry using glass-calomel system.
2. Determination of glucose by Folin-Wu method.
3. Determination of nitrite in a water sample by colorimetric method.
4. Determination of chromium and manganese by simultaneous spectrophotometry.
5. Determination of silica by Molybdenum Blue method.
6. Flame Photometric determination of Li /Na/K by standard addition method.

SEMESTER-III

Course Code	Title of Course	No. of Credits	No. of Hours	Examination		Total Marks
				Continuous Evaluation	End SEM	
IPCHEM 351	Basics of Polymer, Rubber & Additives	04	60	40	60	100
IPCHEM 352	Rheology & Processing Rubbers	04	60	40	60	100
IPCHEM 353	Testing of Rubber-Raw & In-Process materials	04	60	40	60	100
IPCHEM 354	Industrial Polymer Chemistry Practical-I	04	-	-	100	100
IPCHEM 355	Industrial Polymer Chemistry Practical-II	04	-	-	100	100
IPCHEM 356 EC-I	Biopolymers and Bio composites	04	60	40	60	100
IPCHEM 357 EC-II	Polymer Nano Composites	04	60	40	60	100

No. of CREDITS: 24 **TOTAL MARKS: 600**

Note: Students will have to select one of the electives i.e. IPCHEM 356 EC-I or IPCHEM 357 EC-II
Practical component involves 16 hour per week of laboratory work for 15 weeks

SYLLABUS: SEMESTER III

IPCHEM 351: BASICS OF POLYMERS, RUBBER AND ADDITIVES

Unit I POLYMERS & POLYMERIZATION TECHNIQUES [15L]

Polymers: monomer, oligomer and polymer, Average Molecular Weight, Molecular weight, Distribution & Poly dispersity Index, classification of polymers, structure of polymer. Types of polymerization.

Polymerization Techniques: Mass Polymerization, Bulk Polymerization, Solution Polymerization, Emulsion Polymerization, Suspension Polymerization, Mechanisms with explanation. Characteristics, Relative advantages and disadvantages.

Classification of Polymers: Natural and synthetic polymers, Biopolymers, thermoplastic, thermosets, Elastomers, Fibers etc.

Structure Property Relationship in Polymers: Structure of polymers, amorphous, semi-crystalline and crystalline states in polymers, glass transition, melting and crystallization temperature. Effect of structure on the chemical, mechanical, electrical and optical properties of polymers.

Unit II GENERAL PURPOSE RUBBER [15L]

Natural Rubber (NR): Origin – Natural Rubber Latex, tapping, processing, properties and applications – Conversion of Latex into dry rubber – Properties of dry rubber – Classification based on technical specifications – Modifications of Natural Rubber

Styrene-Butadiene Rubber (SBR): Introduction, polymerization, types of SBR, structure & property variation in Emulsion SBRs and Solution SBRs. Compounding, Processing, Applications.

Polybutadiene Rubber (PBR): Manufacture, Structure and Properties of Polybutadienes, Processing and Applications.

Synthetic Polyisoprene (IR) Rubbers: Preparation of Synthetic Polyisoprene (IR) Rubbers, Properties, IISRP Numbering System, Processing, Applications.

Unit III SPECIAL PURPOSE RUBBER [15L]

Preparation, properties and Application of: Nitrile Rubber & modified NBR (HNBR & XNBR), Butyl Rubber & Halogenated butyl rubbers, Polychloroprene Rubbers, Ethylene Propylene Rubber and Ethylene Vinyl acetate copolymers – Elastomers based on modified polyethylene (chlorinated polyethylene & chlorosulphonated polyethylene), Acrylate rubbers, Polysulphide rubbers, Hydrin rubbers, Silicones and Fluroelastomers etc.

Rubber blends: miscible and immiscible blends,

Thermoplastic Elastomers – **Preparation, properties and Application of**: SBS and SIS Block copolymers, Thermoplastic Polyurethane elastomers, Thermoplastic-co-polyesters, Thermoplastic elastomers based on Plastics, Dynamic Vulcanization

Unit IV NON-RUBBER ADDITIVES [15L]

Part A: Vulcanizing ingredients & other additives: Vulcanizing ingredients & their sequence of mixing: Activators and Accelerators: mechanisms of action. Other cure systems based on metal oxides, peroxides, etc. retarders, inhibitors anti-reversion agents.

Part B: Fillers

Carbon black-Its preparation, structure, properties and their effect on rubber properties

Silica fillers & coupling agents, Other fillers: Clay, Calcium carbonate, titania etc. Nano-fillers:

Reinforcement by filler: Reinforcement, Factors influencing elastomers reinforcement, fillers characteristics, main effects of fillers on vulcanizate properties, Influence of fillers characteristics on the cross linking process, Filler incorporation, the role of bound rubber, reinforcement and crosslink density.

Part C: Processing aids & other additives: Processing aids, plasticizers, process additives, release agents, Other additives like colourants, blowing agents, factice, Fire Retardants,

Antistatic Agents, Deodorants and Reodorants, Biocides and Fungicides etc. **Antidegradants:** Introduction, Autoxidation of Hydrocarbon Polymers, Amine & Phenolic Antioxidants & other types, Antizonants, Prevention of Ozone Attack with the use of waxes & saturated polymer for Ozone Protection.

References:

1. F. W. Billmeyer Jr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
2. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, 1988.
3. M. Morton, Rubber Technology, Chapman Hall, 1995.
4. J. Brydson, Rubber Chemistry, Butterworths, 1978
5. B. Kothandaraman, Rubber Materials, Ane Books, 2008.
6. I. Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
7. B. Kothandaraman, Rubber Materials, Ane Books, 2008.

IPCHEM 352: RHEOLOGY AND PROCESSING OF RUBBERS

Unit I RHEOLOGY OF RUBBERS **[12L]**

Definition of Rheology, Rheological Perspective, The importance of nonlinearity, Solids and liquids, Components of rheological research: Rheometer, Constitutive equations, Complex flows of elastic liquids.

Unit II COMPOUNDING & MIXING TECHNIQUES **[12L]**

Rubber mixing mechanism, mixing machinery - Open mill mixing – Internal mixers – Continuous mixers – Factors affecting mixing – Flow behaviour of rubber compound, processibility test, Latex compounding and mixing. Troubleshooting.

Unit III POSTCOMPOUNDING PROCESSING **[12L]**

Calendaring: Sheeting –Skim coating – Fractioning – Topping – Doubling – Profiling – Spreading – Roll configurations – Control of thickness. Extrusion; Ram type – Screw type – L/D ratio and its influence – Hot & cold feed extruders – Pin barrel extruder – Twin screw extruder – Criteria for machine selection. Troubleshooting.

Unit IV MOLDING & VULCANIZING TECHNIQUES **[12L]**

Molding: Mold design, Compression, transfer and injection moulding – Blanks & pre-heating techniques, preparation of surfaces for bonding. Curing: Autoclaves, Hot air chambers, curing of built up articles, continuous vulcanization, L.C.M. (Liquid Curing Media), Fluidized Bed, microwave curing. Hand building and forming equipment for tank, pipe lining, roller covering. Troubleshooting.

Unit IV FINISHING OF RUBBER PRODUCTS **[12L]**

Equipment‘s for flash and spew removal – Cryogenic techniques – Hand trimming – roller trim, buffing, tumbling, punching, grinding, shot blasting, painting, lacquering – Guards, Trip devices, Photoelectric and pressure sensitive devices – Maintenance of guards.

References:

1. Dr. B. R. Gupta, Rheology of Elastomers.
2. H. A. Barnes, J. F. Hutton and K. Walters, An Introduction to Rheology, Elsevier, 1989.

3. Rubber Processing, James L. White, Hanser Publishers, 1995.
4. C. M. Blow and C. Hepburn, Rubber Technology and manufacture, Butterworths, 1982.
5. C. W. Evans, Practical Rubber Compounding and processing, Applied Science, Publishers, London, 1981.
6. J. L. White, Rubber Processing Technology Materials, Principles, Hanser Publication, New York, 1995.
7. Kleemann, Weber, Elastomer Procesing, Hansar, 2005.

IPCHEM 353: TESTING OF RUBBER: RAW & IN-PROCESS MATERIALS

Unit I PRINCIPLES OF TESTING **[15L]**

Principles of Testing, Standards and specification, Nomenclature- ISO and other standards, Laboratory Management System as per ISO/IEC 17025:2005 and Quality Management System as per ISO : 9001:2015.

Unit II RAW MATERIAL TESTING **[15L]**

Molecular weight distribution using GPC, Analysis of antioxidant, process oil and other additives by using GC GCMS, UV-Vis spectrophotometer, ICP-OES and DSC. Polymer identification by FTIR, Ash Content, Melting point, Moisture content and Specific gravity

Unit III TESTING OF RAW RUBBER & UN-VULCANIZED RUBBER COMPOUND [15L]

Viscosity Characterization – Brookfield Viscosity, Mooney viscosity, Mass, Density, Dimensions Compression plastimeter, plasticity retention index, rotation plastimeters, extrusion rheometer, Scorch and cure rate: oscillating disk rheometer, moving die rheometer, rubber process analyzer etc.

Unit IV PROCESS & QUALITY CONTROL **[15L]**

General considerations, sampling inspection, patrol inspection & validation, subjective inspection etc. New methods like Six sigma.

References:

1. Standard - ISO / IEC 17025:2005
2. Standard – ISO 9001:2015
3. C. D. Craver and T. Provder, Polymer Characterization, ACS Advances in chemistry Series, Volume 227, 1990
4. J. S. Dick, Rubber Technology Compounding and testing for Performance, Hanser Publisher, 2001.

IPCHEM 354: INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-I

1. Preparation of Phenol formaldehyde resin – novolak and resol / polysufide rubber
2. Determination of: acid value / hydroxyl value of given polymer sample
3. Determination of saponification value of given oil
4. Estimation of total alkalinity of the latex
5. Viscosity measurement by Brookfield viscometer
6. Molecular weight determination of polymer by GPC
7. Determination of volatile matter, dirt, ash content in Rubber from Natural sources
8. Estimation of Cu, Fe and Mn in rubber by ICP
9. Rubber identification pyrolysis and spot test by specific reagents (ASTM solution)
10. TGA of different rubber
11. DSC analysis of Rubber Compounds
12. Mixing behaviour of NR on two roll mill / carbon black filled NR / carbon black filled SBR / carbon black filled SBR & NR blend / carbon black filled EPDM / carbon black filled NBR
13. Extrusion characteristics of a filled rubber mix- NR Ex / SBR / NBR / EPDM
14. Calendaring of rubber mix

IPCHEM 355: INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-II

1. Identification and classification of natural rubber by using FTIR, Mooney, and other chemical methods.
2. Identification and classification of synthetic rubbers by using burning test, FTIR, Mooney, and other chemical methods.
3. Identification and classification of different type of carbon black
    a. DBP absorption
    b. IAN
    c. Surface area Calculation
4. Identification and classification of rubber compounding materials, namely, **Zinc oxide / Stearic acid / Sulfur / Antioxidants / Accelerators / Processing oils**
5. Evaluation of tyre tread compound by using abrasion resistance index, heat build-up and DMA.
6. Evaluation of properties of seal & gasket rubber compound
7. Tyre testing by Endurance, rolling resistance, plunger energy, bead unseat etc.
8. Testing of: LPG Hose, Pressure cooker rubber gasket / Hose testing / Mount / Conveyor Belt / Condom / Tube
9. Design & development of : Tyre tread material / Hose cover / Conveyor belt cover / Gasket compound / footwear compound / latex dipped products / mounts / rubber mats / door profiles / tube compound
10. Curing Process of Rubber Compound- NR filled / SBR filled / NBR filled / EPDM filled / BR filled
11. Curing Process of Rubber Compound- by transfer molding technique
12. Curing Process of Rubber Compound- by injection molding technique of metal to rubber bonded products
13. Curing Process of Rubber mounts / Rubber Gaskets / Rubber Seals / Rubber Gauntlets

ELECTIVE COURSES

IPCHEM 356: EC-I: BIOPOLYMERS & BIO COMPOSITES

Unit I BIOPOLYMERS & BIODEGRADATION [15L]

Biopolymers: Classification, Biopolymers from natural origin and mineral origin, isolation, properties.

Biodegradation: Mechanism of biodegradation (polyesters, polycarbonates, polyvinyl alcohol, polyurethanes and polyether's) factors influencing biodegradation. Types of biodegradable polymers – properties and application.

Unit II CHARACTERIZATION & TESTING FOR BIODEGRADABILITY [15L]

Test methods and standards for bio-degradable plastics, Criteria used in evaluation of biodegradable plastics, Description of current test methods – Scanning test for ready biodegradability, Test for inherent biodegradability, Test for simulation studies, Other methods for assessing polymer biodegradability.

Unit III BIOCOMPOSITES [15L]

Definition- classification- natural bio, fibre and nano fillers as reinforcement, biodegradable/ bio-based resins as matrices. Properties of biocomposites. Applications in automobile & buildings.

Unit IV APPLICATIONS OF BIOPLOYMERS [15L]

Biopolymer Films, Biodegradable mulching, Advantages and Disadvantages, Chemical sensors – Biosensors, Functionalized Biopolymer Coatings and Films, Applications of biopolymers in horticulture Food Packaging, Functional Properties, safety and Environmental aspects, Shelf life, Films and coatings in Food Applications, Materials for edible films and coatings, Biopolymer coatings for paper and paperboard, Bio-nanocomposite films and coatings

References:

1) R. Smith, Biodegradable polymers for industrial applications, Woodhead Publishing Ltd, CRC Press, 2005.
2) A. J. Domb, J. Kost and D. M. Wiseman, Handbook of Biodegradable polymers, Harwood Academic Publishers, 1997.
3) R. P. Wool, X. S. Sun, Bio-Based Polymers and Composites, Elsevier, 2005.
4) A. S. Singha and V. K. Thakur, Green Polymer Materials, Studium Press, 2012.
5) A. K. Mohanty, M. Misra and L. T. Drzal, Natural Fibers, Bio Polymers and Bio Composites, CRC Press, 2005.

IPCHEM 357: EC-II: POLYMER NANO COMPOSITES

Unit I COMPOSITES [15L]

Characteristics, advantages, and need of composites –Polymer composite materials, classification and theory of composite materials; Polymer matrices - thermoplastics and thermosetting plastics; Fiber reinforcement of elastomers - short and long fiber composites – Other additives

Unit II NANOMATERIALS USED IN POLYMERS [15L]

Nanofillers in bulk polymers - overview of potential nanostructured fillers - types - nanoparticles, nanofibers, nanotubes, nanosheets; surface features and layers and its modification. Techniques used to characterize nanostructured materials –XRD, AFM, etc.

Unit III CARBON NANOTUBES & THEIR APPLICATIONS [15L]

Structure of carbon nanotubes, processing methods for nanotube based polymer nanocomposites, nanotube alignment, characterization, properties and applications,

Unit VI PREPARATION & APPLICATION OF POLYMER NANO COMPOSITES [15L]

Preparations of polymer nanocomposites - melt blending, solution blending, latex coagulation, in-situ polymerization, characterization, properties and application.

Polymers in nanoelectronics, Magnetic polymer nanocomposites, Wear resisting polymer nanocomposites, Packaging, Bio-medical, surface coatings, etc.

References:

1) Yiu-Wing Mai and Zhong-Zhen Yu, Polymer Nanocomposites‖, Woodhead Publishing Limited, 2006.
2) K. Friedrich, S. Fakirov and Zhong Zhang, Polymer Composites from Nano to Macro‖, Springer 2005.
3) C. N. R. Rao, A. Muller, and A. K. Cheetham, The chemistry of Nanomaterials‖, Vol 1 & Vol. 2, Wiley-VCH, 2005.
4) J. H. Kao, Polymer Nanocompsoites, McGraw-Hill Publishers, 2006.

SEMESTER-IV

Course Code	Title of the Course	No. of Credits	No. of Hours	Examination		Total Marks
				Continuous Evaluation	End SEM	
IPCHEM 451	Design & Development of Rubber Products	04	60	40	60	100
IPCHEM 452	Latex Science & Adhesives	04	60	40	60	100
IPCHEM 453	Testing of Rubber Vulcanizates And Finished Products	04	60	40	60	100
IPCHEM 454	Research Project	08	*	80	120	200
IPCHEM 455 OC-I	Intellectual Property Rights & Cheminformatics	04	60	40	60	100
IPCHEM 456 OC-II	Research Methodology	04	60	40	60	100

No. of CREDITS: 24 **TOTAL MARKS: 600**

Students will have to select one of the optional courses i.e. IPCHEM 455 OC-I or IPCHEM 456 OC-II.

Practical component involves 16 hour per week of laboratory work for 15 weeks

SYLLABUS: SEMESTER-IV:

IPCHEM 451: DESIGN & DEVELOPMENT OF RUBBER PRODUCTS

Unit I FORMULATION DESIGN OF RUBBER COMPOUNDS **[15L]**

Basics of compounding, Approach for compounding, Selection of Rubbers, Fillers, Curing agents and Special additives in Rubber Compounding. Rubber compounds feasibility for static and dynamic application, Rubber compounds for general purpose, oil resistant, heat resistant, fire resistant and weather resistance purposes.

Unit II DESIGN & DEVELOPMENT OF TYRES **[15L]**

Different components of tyres and their compounding, Tyre materials & Tyre processing techniques**.**

Unit III CONVEYOR BELT TECHNOLOGY **[15L]**

Different types of conveyor belts, Mixing, Compounding and Calendaring, Building, Curing and Testing, Finishing and Packaging**. V-belt—Building**

Unit IV PRODUCT DEVELOPMENT OF HOSES **[15L]**

Different kind of hoses, Extrusion of cover, Reinforcement, curing by autoclave.

References:

1. Setright J. K., Automobile Tyres, Champan & Hall, 1972.
2. The Pneumatic Tire, (Ed) A N Gent & J D Walter, The University of Akron, August. 2005, published by NHTSA, DOT, USA
3. Elastomers: Criteria for Engineering Design, C Hepburn & R J W Reynolds, Applied Science Publishers, London, 1979.
4. Khairi Nagdi, Rubber as an Engineering Material: Guideline for Uses, Hanser Publishers, 1993.

IPCHEM 452: LATEX SCIENCE AND ADHESIVES

Unit I LATEX SCIENCE **[15L]**

Definition of Latex, classification, Latex particle size and distribution, stability and destabilization of latices, Comparison between latices and polymer solution. Characteristic and processing of natural rubber latex.

Unit II LATEX APPLICATION **[15L]**

Latex dipped products, latex foam rubber, latex thread, latex and textile based rubber products, latex based surface coating, latex and paper.

Unit III RUBBER BASED ADHESIVES **[15L]**

Natural rubber adhesive, butyl rubber and polyisobutylene, nitrile rubber adhesive, styrene butadiene rubber adhesive, thermoplastic rubber in adhesive, carboxylic polymers in adhesive, neoprene based solvent and latex adhesive, polysulfide sealant and adhesives

Unit IV RESIN BASED REACTIVE ADHESIVES **[15L]**

Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – Uses of adhesives in civil engineering, automobile, aerospace, electrical & electronic industries.

References:

1. D. C. Blackley, High Polymer Latices, Vol 1 and 2, Maclaren & Sons, 1966.
2. R. F. Mausser, The Vanderbilt Latex Hand book, 3rd Edn.
3. R. Waterman, R. F. Mausser & E. E. Miller, Vanderbilt Latex Book on Process and Compounding Ingredients, R T Vanderbilt Publishers.
4. K. O. Calvert, Polymer Latex and Applications, 1985.
5. I. Skiest (Ed), Hand book of Adhesives, Van Nostrand Reinhold, 1990.
6. Shields, Hand Book of Adhesives, Butterworths, 1984.
7. S. Paul, Surface Coatings, John Wiley & Sons, 1985.

IPCHEM 453: TESTING OF RUBBER: VULCANIZATES & FINISHED PRODUCTS

Unit I TESTING OF VULCANIZATES **[15L]**

Mechanical Properties: Different types of Hardness,(Shore A, Shore D, IRHD and micro hardness) tear, tensile, compression, application of test data, abrasion resistance, Shear, Creep & Stress relaxation, Resilience, Aging and uniaxial, biaxial compression test.

Thermal Analysis: Instrumentation, Polymer Identification, Compositional analysis, volatile matter, Rubber, Polymer blends, C-black & ash estimation using Thermal Analysis (TGA). Glass transition, Heat capacity, Thermal history of polymers, State of cure studies by using DSC and Thermal Mechanical Analysis (TMA)

Unit II ENVIRONMENTAL & DYNAMIC TESTING OF RUBBERS **[15L]**

Effect of environment – Oxygen, heat, ozone and swelling media

Fatigue – Flex cracking and cut growth – Heat buildup **Dynamic mechanical testing of rubbers—**Storage modulus, loss modulus, Tan delta, Natural frequency, transmittance and damping factor.

Unit III TESTING OF TYRE **[15L]**

Classification of tyre (automotive tyres, OTR and Aircraft tyres), Testing of tyres Destructive testing—High speed test, Endurance test, dynamic growth test & Plunger test, Nondestructive testing- Stiffness, Footprint, rolling resistance, Aging and tyre Shearography test.

Unit IV TESTING OF RUBBER PRODUCTS **[15L]**

Testing of rubber products like hoses, gaskets, automotive tubes, bearings, Testing of conveyor belts, V-belts and Mounts.

References:

1. P. K. Freakley and A. R. Payne, Theory and Practice of Engineering with Rubber, Applied Science Publishers Ltd., 1978.
2. E. F. Gobel, Rubber Springs Design, Butterworth-Heinemann Ltd., 1974.

IPCHEM 454: RESEARCH PROJECT

Each student will be assigned a project involving some design and fabrication work, as well as Theoretical and Experimental studies on some problem related to Rubber and Plastics Technology. Continuous internal assessment marks for the project will be given during Project

Review meeting. The student has to prepare and present a detailed project report at the end of the semester and give a presentation about the work done. End semester examination mark will include viva voce examination.

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OPTIONAL COURSES

IPCHEM 455 OC-I: INTELLECTUAL PROPERTY RIGHTS & CHEMOINFORMATICS

Unit-I **[15L]**

Introduction to Intellectual Property: **[2L]**

Historical Perspective, Different types of IP, Importance of protecting IP.

Patents: **[5L]**

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs: **[2L]**

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits: **[2L]**

Circuit boards, Integrated Chips Importance for electronic industry.

Copyrights: **[2L]**

Introduction, How to obtain, Differences from Patents.

Trade Marks: **[2L]**

Introduction, How to obtain, Different types of marks-Collective marks, certification marks, service marks, Trade names, etc.

Unit-II **[15L]**

Geographical Indications: **[2L]**

Definition, rules for registration, prevention of illegal exploitation, importance to India.

Trade Secrets: **[2L]**

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement: **[5L]**

Role of Judiciary, Role of law enforcement agencies-Police, Customs, etc.

Economic Value of Intellectual Property:

Intangible assests and their valuation, Intellectual Property in the Indian Context- Various Laws in India Licensing a technology transfer.

Different International agreements: **[6L]**

(a) World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT) , Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade related Services (GATS) Madrid Protocol

(iii) Berne Convention

(iv) Budapest Treaty

(b) Paris Convention

WIPO and **TRIPS, IPR** and Plant Breders Rights, IPR and Biodiversity

Unit-III **[15L]**

Introduction to Cheminformatics: **[5L]**

History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure elucidation.

Representation of molecules and chemical reactions: **[5L]**

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching chemical structures: **[5L]**

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit-IV **[15L]**

Applications:

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure-Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure-Spectra correlations, Prediction of NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, Analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-Based and Structure Based Drug Design, Application of Cheminformatics in Drug Design.

Reference books:

1. Andrew R. Leach & Valerie, J. Gillet, (2007), *An introduction to Cheminformatcs*. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) Cheminformatics: a text-book. Wiley-VCH.
3. Gupta, S.P. *QSAR and Molecular Modeling*, Springer-Anamaya Pub.: New Delhi.

IPCHEM 456 OC-II: RESEARCH METHODOLOGY

Unit-I LITERATURE SURVEY **[15L]**

Print: **[5L]**

Primary, Secondary, Tertiary sources,

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: **[5L]**

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: **[5L]**

The Internet and World Wide Web, Internet resources for chemistry, Finding and citing published information.

Unit-II DATA ANALYSIS **[15L]**

The Investigative Approach:

Making and recording Measurements, SI Unit-s and their use, Scientific methods and design of experiments.

Analysis and Presentation of data:

Descriptive statistics, Choosing and using statistical tests, Chemometrics, Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse, Basic aspects of multiple linear egression analysis.

Unit-III METHODS OF SCIENTIFIC RESEARCH & WRITING SCIENTIFIC PAPERS [15L]

Reporting practical and project work, Writing literature surveys and reviews, Organizing a poster display, Giving an oral presentation.

Writing scientific papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, Writing ethics, Avoiding plagiarism.

Unit IV: CHEMICAL SAFTEY & ETHICAL HANDLING OF CHEMICALS [15L]

Safe working procedure and protective environment, protective apparel, emergency procedure, and first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Reference books:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B., & Gooding, J. J., (2006), *Data analysis for chemistry*, Oxford University Press.
3. Topping, J., (1984), *Errors of observation and their treatment*, 4th Ed. Chapman Hll, London.
4. Harris, D. C., (2007), *Quantitaive chemical analysis*, 6th Ed., Freeman Chapters 3-5
5. Levie, R. de., (2001*), How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ Press 487 pages.
6. Chemical safety matters-IUPAC-IPCS, Cambridge University Press, 1992.
7. OSU safety manual 1.01

15. FEES FOR M. Sc. (CHOICE BASED CREDIT SYSTEM) COURSE

Open category

No.	Account Head	Amount (Rs.)
1.	Tuition fee	45000/-
2.	Laboratory fee	10000/-
3.	Registration form fee	25/-
4.	Registration fee	850/-
5.	Library fee	1000/-
6.	Gymkhana fee	200/-
7.	University sports and cultural activities	30/-
8.	Disaster Relief fund	10/-
9.	Group insurance	40/-
10.	Vice-Chancellor‘s fund	20/-
11.	e-Charges	20/-
12.	e-Suvidha	50/-
13.	Identity card fee	50/-
14.	Student welfare	50/-
15.	Magazine	100/-
16.	Utility	250/-
17.	Admission processing fee	200/-
18.	Other fees / Extracurricular activities	250/-
19.	Development fee	500/-
20.	Computer/Internet	500/-
	Total	**59, 145/-**

Refundable deposit:

1.	Caution money	Rs. 150/-
2.	Library deposit	Rs. 250/-
3.	Laboratory deposit	Rs. 400/-
	Total	Rs. **800/-**

***Examination fees per Semester:** Rs. 4000/-

The procedure for providing the Photo / Xerox copies of answer sheets and revaluation

- Students should submit their forms for photocopy ***(i.e. verification)*** / revaluation ***(i.e. rechecking)*** within ten working days from the date of declaration of the results or on issue of the statement of marks by the department.
- No application after the due date will be entertained on any ground whatsoever.
- The respective results will be displayed on the notice boards if any changes or otherwise.

Form fees for photocopies and revaluation	:	Rs. 10/-
Charges for photocopies	:	Rs. 100/- per paper
Charges for revaluation	:	Rs. 500/- per paper
For reserve categories charges for photocopies	:	Rs. 50/- per paper
For reserve categories charges for revaluation	:	Rs. 250/- per paper

1. Fees are payable by **cash** in the **Allahabad Bank, Kalina Branch, Wadia High School, Ground Floor, Opposite Vidyanagari Campus** within the stipulated period mentioned in the notification.
2. In case of fresh entrants to the Department, the tuition fees for the first year and the deposit become due on the date specified in the letter of admission.
3. Notice for the payment of the fees for the second year (SEMESTER- III and IV) would be put up on the notice board one week prior to the commencement of SEMESTER- III.
4. Fine for the late payment of the tuition fees for the post-graduate courses is fixed as Rs.5/- during the first week from the last date prescribed for payment of the tuition fees and Rs. 10/- per day after one week, subsequently.
5. Tuition fees once paid is not refunded.
6. The caution money deposit is refunded when a candidate leaves the Department. A claim for the refund of caution money deposit must be made in the prescribed form available in the Department along with the original receipt within one year from the date of leaving the Department, failing which the deposit will be forfeited.
7. Transference Certificate/ Migration Certificate will be issued to the student who wishes to join other college/University only after clearing all the dues.

The attention of students seeking admission to M. Sc. (Choice-Based Credit System) Degree course is particularly invited to the following rules relating to the post-graduate studies.

1. That they will be required to attend in **each SEMESTER-not less than** 75% of the total number of lectures delivered for each course.
2. That in addition to attendance at lectures and practicals, they will be required to carry out regularly the work assigned to them in the form of essays, problems, tutorials, etc. They shall be required to maintain a record in a properly bound journal. The work carried out by the students shall be reviewed by respective teacher/s at the end of each SEMESTER.
3. That the work that will be assigned to them in the form of essays, tutorials etc. shall be in addition to the practical work that they are required to do for examination.

The office working hours for students and visitors are from Monday to Saturday between 11.00 a.m. and 4.00 p.m. with half an hour recess between 1.00 p.m. and 1.30 p.m. The office will remain closed on all Sundays, Bank holidays and on second and fourth Saturdays.

16. CAREER OPPORTUNITIES IN CHEMISTRY

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Preface

It is being felt that meritorious students do not continue to study Chemistry at advanced level due to a variety of reasons such as better job opportunities in other steams. As knowledge of Chemical sciences plays a vital role in human society, it is essential that for a balanced society. It has good teachers and researchers in Chemistry both in academic and Industry. It was felt by the Mumbai Chapter of Indian Chemical Society that quite often students do not have a clear picture of the different avenues for chemists. In this booklet it is attempted to give a general picture where chemists can make their contribution in academics, research and in industry.

Indian Chemical Society Mumbai Branch conducts an Annual Aptitude Test in Chemistry to motivate students to take challenging careers in chemistry. Lectures on career guidance are also arranged especially for students of chemistry. The compilation was prepared by Dr. D. B. Naik, Applied Chemistry Division, BARC in order to provide information on career opportUnities in Chemistry especially at doctoral level. While every care is taken to ensure accuracy of information, students are requested to check the details with individual research institution. It is hoped that the present compilation will be use to young students in choosing a right career of their choice.

Indian Chemical Society (Mumbai Branch)

Career opportunities in Chemistry

Knowledge of Chemistry plays a vital role in human society. In the technological development of 20th century chemistry contributed immensely in synthesis of new and high purity materials, their characterization and applications, understanding of reaction mechanisms etc. Scientific and technological development has pronounced effect on health and comforts of human beings. In this developmental process, new materials and processes have been adopted which have led to the deterioration of the environment. For better environment management clean production processes and also methods for waste management have become most important. Irrespective of developments in other fields of science, chemical sciences will sustain its important role in human society. Present day chemistry is not just synthesis and characterization of substances. It encompasses physical and biological sciences. There is an ample scope to apply the knowledge of chemical sciences. The present statues of chemistry teaching in various academic institutions is summarized below.

1. **Chemistry teachers in schools:**
   Graduates in Chemistry with B. Ed., degree are employed to teach chemistry subjects to school students. As young children are curious about more and more of the natural processes, there is always excitement in teaching in schools. Sometimes, these teachers will be required to teach Mathematics and Physics also.

2. **Lecturers in colleges:**
   As an independent subject, chemistry is taught from first year junior college onwards. Usually post graduates in Chemistry teach in junior colleges. In degree colleges, as students major in Chemistry subject, Doctorates in addition to post graduates are employed to teach

chemistry. Recently, UGC (University Grant Commission) has started Lectureship exams. It is mandatory to clear these exams for getting employed as lectures. Some of the colleges especially in bigger cities are equipped with good laboratories where in it is possible to carry out research work.

3. Post graduate teachers Doctorates in different branches of chemistry teach post graduate students in different universities. In addition to teaching, there is scope to carry out research work and guide doctoral students.

Presently the emoluments for college as well as post graduate teachers are fairly attractive.

In India, very few of the University departments have good research facilities. There are quite a number of National Research Centres spread over the country where modern facilities are available to carry out frontline research.

1. Indian Institute of Science Bangalore, Bangalore 560 012

   Departments of Physical and Inorganic Chemistry, Organic Chemistry, Solid State Chemistry Unit-, Material Research Centre.

2. Indian Institute of Technology Bombay, Powai, Mumbai - 400 076.

   Department of Chemistry offers 5 years integrated and 2 years M. Sc. course in Chemistry. For integrated M. Sc. course admission is through JEE. For 2 years M. Sc. course entrance test is held in July. For admission to Ph. D. interviews are held in June and December.

   Financial assistance as teaching assistantship is provided. For post doctoral research, opportunities are available as research associate. Fields of research available are Bioorganic Chemistry, Bioinorganic Chemistry, Synthetic Organic Chemistry, Electrochemistry and Theoretical Chemistry.

3. Indian Institute of Technology Madras, Chennai - 600 036,
4. Indian Institute of Technology Kanpur - 208016,
5. Indian Institute of Technology Kharagpur - 721 302.

   Offers one 5 years integrated M. Sc. course in Industrial Chemistry and two years M. Sc. course in Chemistry. It also offers Ph. D. program in different fields of chemistry. Research fields are pharmaceutical and allied chemistry, industrial chemistry and material science.

6. Indian Institute of Technology Delhi, New Delhi -

   Offers 2 years M. Sc. in Chemistry, Entrance for M. Sc. is through a written test. It also offers M. Tech. course in Modern Methods of Chemical analysis for which entrance is through GATE and NET tests.

7. Indian Institute of Technology Gowhati -

   For integrated post graduate courses, candidates are selected by joint entrance test. IITs announce their Ph. D. programmes in different disciplines in National Newspapers every year in and candidates are selected after interview.

8. Indian Association for Cultivation of Science, Jadhavpur, Calcutta - 700 032.

   (Photochemistry, Organic Synthesis, Theoretical Chemistry, Biochemistry)

Council of Scientific Industrial Research (CSIR) (www.csir.ernet.in) has a number of laboratories spread all over country where chemical and allied research is carried out. Its head quarters is in New Delhi, CSIR, Rafi Marg, New Delhi, email: csirhq@sirnetd.ernet.in.

Some of the major research institutes of CSIR where opportUnit-ies for research in chemistry exist are given below:

1. Central Drug Research Institute

   Chathar Manzil Road, PB 173

   Lucknow - 226 001

   Development of new drugs and diagnostics, cellular and molecular studies to understand disease processes and reproductive physiology. Systematic evaluation of medicinal properties and natural products. Biochemical, Molecular Biological Chemical, pharmacological research.

2. Central Leather Research Institute

   Adyar, Chennai-600020

   clrim@giasmd01.vsnl.net.in www.clri.org

   CLRI conducts for AnnaUniversity courses in leather technology leading to B.Tech., M.Tech, and Ph.D. degrees. CLRI also offers number of short term and long term vocational programmes.

3. National Chemical Laboratory, Dr. Homi Bhabha Road, Pune 411 008

   Research in Advanced materials, Biotechnology, Catalysis, Organic Chemical Technology, Pilot plant studies, Biotechnology.

4. Indian Institute of Chemical Technology, Hyderabad - 500 007.

   Studies of agrochemicals, drugs and pharmaceuticals, inorganic chemicals and materials, Organic synthesis, polymers, catalysis, process development.

5. Regional Research Laboratory Trivandrum, Kerala - 695019

   To develop technology for optimum use of regional resources, to develop industry in the region through research, development and technology transfer, Photochemistry, Organic synthesis.

6. Regional Research Laboratory, Bhubaneshwar - 751013

   Research in problems relating to industry and raw materials of the region.

7. Central Electrochemical Research

   Institute Karaikudi 630006, Tamil Nadu

   Email: cecrik@cscecri.ren.nic.in

   Research in both the frontier areas of electrochemistry and the problems of relevance to Indian industry. It is playing a leading role in human resource development for the electrochemical and related industries. In this regard CECRI offers a variety of courses to scientific and technical personnel in industries, government and academic institutions.

8. Regional Research Laboratory, Jammu-Tawi 180 001

   Email: rrlj@nde.vsnl.net.in

   Drug and medicinal plants, introduction of exotic plants, plant chemistry, extraction and processing of drugs.

9. Central Salt and Marine Chemicals Research Institute,

   Waghawadi Road, Bhavanagar - 364 002

10. National Institute of Oceanography

    Miramar, Panaji Goa - 403004

    Email : ocean@csnio.ren.nic.in

    Investigations on physical, chemical, geological and biological oceanography

11. Central Glass and Ceramic Research Institute

    196, Raja Mallik Road, Jadavpur, Kolkata - 700032.

    Email: cscgcri@giascl.l.vsnl.net.in

    Research on synthesis and applications of speciality glasses.

12. Centre for Cellular and Molecular Biology

    (CCMB) Hyderabad - 500 007.

    Research in frontier and multidisciplinary areas of modern biology with a view of aiding biochemical and bioengineering

13. Indian Institute of Petroleum

    Dehra Dun - 248 005

    Email: iipddn@de12.vsnl.net.in

    R & D in the field of petroleum, natural gas and petrochemicals and utilisation of petroleum products.

14. National Environmental Engineering Research

    Institute Nehru Marg, Nagpur, 440 020

    Email: dirneeri@nagpur.dot.net.in

    Studies in Chemical, biological and microbiological research, instrumentations and field research; water, studies related to sewage and industrial waste, air pollution, industrial hygiene

15. Regional Research Laboratory, Jorhat, Assam 785 006

    Research in coal, petroleum, pulp and paper, natural product chemistry, cement, drugs, synthetic organic chemicals, essential oils, medicinal plants, material science.

16. National Metallurgical Laboratory

    Jamshedpur 831 007, Singhbhum Dist.

    Bihar Email: nml@csnnml.ren.nic.in

    Ore dressing, production, physical and chemical metallurgy

17. National Institute of Science, Technology & Development

    Studies Hill Side Road, New Delhi - 110 012

    Email: postmast@csnistad.ren.nic.in

Conducts research on technological and social change and resource planning and utilization for regional development.

3. Research Fellowships:

After post graduate degree in Chemistry, one can carry out research work leading to doctoral degree (Ph.D.) in University departments, CSIR laboratories, Indian Institutes of Technology, and other national centres. National Eligibility Test (NET) examination is held twice the year for selection and award of Junior Research Fellowships (JRF). A total of nearly 1000 are normally selected for the grant of fellowship both from CSIR and UGC. Award of SRFs and Research Associates is done through personal interviews by Expert Committees. Senior Research Associates (erstwhile Pool Officers) scheme is meant to support highly qualified S & T personnel through temporary placement.

4. Post-Doctoral Research Fellowships:

After completion of doctoral degree in various branches of Chemistry, these researchers can carry out post doctoral work at different institutes around the world. At many Universities and research centres, professors are able to offer these fellowships from their funds. Many a times this goes through individual contacts / previous acquaintances. With advent of internet these positions are advertised. There are some government as well as semi government agencies which offer fellowships to carry out post doctoral fellowships. Following are the few agencies.

1. Alexander von Humboldt Foundation Jean-
   Paul Str. 12, D-53173, BONN, Germany
2. German Academic Exchange Service
   (DAAD) New Delhi Office,
   176, Golf Links, New Delhi 110 003

In India, under CSIR research associate fellowship, one can carry out post doctoral research work in different CSIR laboratories and other research establishments. In recent years, Department of Atomic Energy has started offering a limited number of K. S. Krishnan post doctoral fellowship. Usually the advertisements come in National newspapers and the selected candidates carry out research in different DAE Unit-s. There is also possibility of candidates being absorbed in regular service.

5. Opportunities in Industry:

Besides the opportunities in academics, there is an ample scope in industry for chemistry graduates / postgraduates / Ph.D.'s. The role of chemicals in our day-today life is increasing dramatically from household goods, medicines, functional materials to environmental friendly technologies, etc. Several of technologies are being replaced with new ones, superior products are being launched in the market. Indian chemical industry too is responding to these changes. With increasing globalization and privatization several multinational companies have started their business in India. Well trained professionals in chemical sciences could help in building strong Indian Chemical Industry which will not only cater to domestic market but will also offer products at

competitive price in the international market. Specialists in each area would find opportunities in industry.

Organic chemists: Organic chemicals (bulk and fine), pharmaceuticals, agrochemicals, food products, development of new technologies, etc.

Inorganic chemists: Inorganic and metalloorganic compounds, inorganic materials for electronic industry etc.

Analytical chemists: Quality control employing modern instrumental techniques, better and efficient detection methods etc.

Physical Chemists: Research and Development departments in institution/industries dealing with modern materials including nanomaterials, catalysts, polymers, modern techniques for characterization of materials etc.

17. CAREER OPPORTUNITIES IN INDUSTRIAL POLYMER CHEMISTRY

Students from polymer and rubber chemistry background can find jobs in both private and public sectors.

In India the demand for trained personnel are soaring high in the recent times.

- Tyre industry
- Cycle tyre & tube
- Belt industry
- Footwear industry
- Adhesives & paints
- Cables & wire
- Latex
- Hoses

Employment opportunities Other than rubber manufacturing industries are:

- Automotive OEMs
- Civil
- Aerospace
- Railways
- Agriculture products
- Textile (rubber coated fabrics)
- Pharmaceuticals
- Mining & steel industries

18.PLACEMENT:

- 100% job assistance for successful candidates
- 100% job guarantee for toppers.

19. INSTRUCTIONS TO APPLICANTS:

INTRODUCTION

A candidate for being eligible for admission to the M. Sc. Degree in Industrial Polymer Chemistry must have passed the Bachelor of Science degree examination with Chemistry as a major subject with 6/3 Unit-s or an examination of another University recognized as equivalent thereto. The M. Sc. (By Paper) degree course in Industrial Polymer Chemistry is of four-SEMESTER duration. The structure of this course is as per the syllabus given on pages 44-82.

GENERAL INSTRUCTIONS TO APPLICANTS FOR FILLING UP THE APPLICATION FORM

Please read the handbook carefully before filling the admission form.

1. **Merit is the only criterion for admission and seats are reserved as per Government of Maharashtra's directives in this connection.**
2. **Admissions of students belonging to the reserved category i.e.**

   SC/ST/DT/NT/OBC/SBC etc. are as per Government of Maharashtra's directives.

   Application form must be accompanied by caste certificate issued by the Competent Authority. In case of OBC/SBC and DT/NT students, the requisite Non-Creamy

   Layer certificate issued in the Current Financial Year should be appended to the application. Application form without proper certificates will not be accepted.
3. **There are no agencies operating on behalf of the Department and there is no capitation fee or donation in regard of admissions. Be careful of any persons claiming to offer admission to the Department. No extraneous considerations should be brought to exert pressure on the admissions committee. It will be strictly dealt with. We take pride in fairness and openness in admissions and all matters and give justice to one and all.**
4. **Applications must be accompanied by**:
   a) ***Attested copies*** **of the mark-sheets of First, Second and Third Year B. Sc. examinations along with their originals.**

b) Date of birth certificate (H.S.C. passing certificate/School Leaving certificate etc.)

c) Students coming from the University other than University of Mumbai are required to obtain a provisional statement of Eligibility from the Eligibility Section, University of Mumbai, Dr. Ambedkar Bhavan, Vidyanagari, Mumbai - 400 098.

d) Account for any break in education should be mentioned in the form and the documentary evidence for the same must be provided along with the application form.

ADDITIONAL INSTRUCTIONS FOR FILLING UP THE APPLICATION FORM

1. Students are advised to indicate their order of preference for ***all*** the ***four*** disciplines (Organic, Analytical, Physical and Inorganic Chemistry). If a student indicates preference for only one specialization he/she will be considered ***only*** for that specialization on merit basis. ***No subsequent changes would be permitted***.

2. Applicants who have passed B. Sc. Examination from OTHER UNIVERSITIES should mention the aggregate marks secured by them in Chemistry (Theory and Practicals separately) at the First, Second and Third Year B. Sc.

After the scrutiny of admission forms submitted by the students, a synopsis showing the merit numbers of the students for different categories will be displayed on the notice board and on the web-site of the University. No individual correspondence will be made in this regard. It is the responsibility of the candidates to visit the notice Board and web-site regularly. It would be the responsibility of the student to check for any errors in the synopsis and point out to the Head of the Department in writing within 3 days of the display of the synopsis. No complaints will be entertained thereafter.

The detailed schedule for admission will be displayed on the same day. It would be the responsibility of the student to check the schedule and present himself/herself for admission on the day mentioned in the schedule.

Pleading ignorance about information displayed on the notice board and the web-site shall not be entertained.

APPLICANTS SUCCESSFUL IN GETTING ADMISSION WILL BE REQUIRED TO GO THROUGH THE FOLLOWING ADMISSION PROCEDURE:

1. **Submit the original Statement of Marks of T. Y. B. Sc. Examination.**

2. **Open Category/Reserved Category Students**: Pay prescribed fee of **Rs. 59,145/-** [including Rs. 850/-Registration fee and Rs.25/- for the form of Registration] in the Allahabad Bank, Kalina Branch, Wadia High School, Ground Floor, Opposite Vidyanagari Campus within the stipulated period and produce the receipt in the office of the Department of Chemistry.

3. In addition, all the students have to pay the refundable deposits of **Rs.** 800/- (Caution money: Rs. 150/- + Library deposit: Rs.250/- + Laboratory deposit: Rs.400/-)

CANCELLATION PROCEDURE

Cancellation of Seats makes a heavy demand on the time spent by the administration. Hence the following procedure must be scrupulously followed.

Application for cancellation of seat should be addressed to the Head of the Department in duplicate as per the Proforma B. Application for refund of fees should be addressed to the Registrar, University of Mumbai in Duplicate as per the Proforma C and submitted to the Head of the Department.

Kindly note that refund of tution fees will be given only if the student takes admission to one of the University of Mumbai's affiliated colleges.

Refund of tution fees will not be made if the student takes admission to any other college/institute, not affiliated to University of Mumbai, and/or does not take admission to any course.

Proforma – A

(Undertaking to be given by candidate who is unable to produce original certificates at the time of his / her admission round, as admission is already taken elsewhere)

UNDERTAKING

I ……have secured admission to M. Sc. (Choice-Based Credit System) (Four-SEMESTER- Course) at the Department of Chemistry, University of Mumbai on ……

I have not produced the following original documents at the time of my admission as I have already secured admission for……Course at ……. College/Institute.

(Please put X against ‗not submitted' document)

1. Original Mark sheet of the T. Y. B. Sc. Examination.

2. ……..……..

3. ……

I have produced the photocopies of the above documents, attested by the Head of the Institution (along with the certification) where my original documents are retained on account of my admission to that college/institute.

I hereby undertake to submit the original documents as mentioned above on or before (within **three** working days)……at Department of Chemistry, University of Mumbai.

I am aware of the fact that failure on my part to submit the original documents in given time results in cancellation of my admission without any refund of tuition fees as per the provisions of the admission rule.

Date : (Name of candidate with signature)

Place : Merit No.

Proforma- B

(Specimen Application form for cancellation of admission)

(To be submitted in duplicate)

Date:……..

To

The Head,
Department of Chemistry
University of Mumbai

Respected Sir,

Full name of Candidate:……

Branch:.....Date of Admission …….

Merit Number:……

Amount of fees paid: Rs. …….

Fee Receipt Number and Date:…… (Attach Photocopy)

I request you to kindly return my original documents.

……

Signature of candidate

Received the Original Mark Sheet of the T. Y. B. Sc. examination from the Admission Authority.

Signature of the candidate

Proforma- C

(Specimen Application form for refund of fees on cancellation of admission)

(To be submitted in duplicate)

Date:……..

To

The Registrar,
University of Mumbai

Sir,

I have cancelled my admission to the M. Sc. (Choice-Based Credit System) (Four-SEMESTER-Course). My details are as given below:

Full name of candidate:……

Branch:.....Date of Admission …….

Merit Number:……

Amount of fees paid: Rs. …….

Fee Challan Number and Date:…… (Attach Photocopy)

I request you to kindly refund the fees paid as per the rules.

Signature of candidate

For Office use only: Full address of the candidate :	Amount Paid, Rs.
	Amount Deducted, Rs.
Tel./Mobile No.:	Amount Refunded, Rs.
E mail:	Cheque No. & date
	Bank particulars

20. STATEMENT SHOWING THE NUMBER OF SEATS AVAILABLE FOR STUDENTS OF DIFFERENT CATEGORIES FOR ADMISSION TO M. Sc. DEGREE COURSE IN INDUSTRIAL POLYMER CHEMISTRY FOR THE YEAR 2018-19

Branch	Total Seats	Number of Seats for Reserved Category Students								Reserved 50%	Open 50%
		SC 13%	ST 7%	DT(A) 3%	NT(B) 2.5%	NT(C) 3.5%	NT(D) 2%	OBC 17%	SBC 2%		
Industrial Polymer Chemistry	25	2 + 1[@]	2	1	-	1	1	3+1[#]	1	13	11 +1*

3% seats are reserved for other University students (marked by *)

3 % seats are reserved for Physically Handicapped students (marked [#])

3 % seats are reserved for the following category students (marked [@])

1. Wards of the Central / State Govt. employees / officers who have been transferred
2. Wards of the present / past defence personnel
3. Students obtaining dexterity at National / State level Sports/ Cultural activities
4. Widow / Deserted female students
5. Wards of the Freedom Fighters