**Course SYLLABUS form**

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| **Basic data of the subject** |
| **Academic Unit:**  | **Faculty of Mathematics & Natural Sciences –** **Department of Chemistry**  |
| **Course title:** | **Polymer materials science and engineering** |
| **Level:** | **Bachelor** |
| **Course status:** | **Elective** |
| **Study year/Semester:** | **Second Year /Third Semester (II/3)** |
| **Number of hours per week:** | **2+1** |
| **Credit value – ECTS:** | **3** |
| **Time / location:** | **Chemistry Department** |
| **Lecturer:** | **Dr.sc. Arleta Rifati – Nixha, ass.prof.** |
| **Contact details:**  | **arleta.rifati@uni-pr.edu****Tel. +38649-801321** |
| **Course description** | The nature of polymer materials and polymer microstructure: including branching, networks, tacticity and copolymers. Polymer synthesis: step-growth and chain polymerizations. Kinetics of polymerization: the kinetics of step growth and free radical chain polymerizations; relationship to molecular weight. Statistics of step-growth polymerization: the use of statistics in describing molecular weight distributions in step-growth polymerization. Copolymerization: the kinetics of free radical copolymerization. Structure: chain conformations, amorphous polymers, and the morphology of semicrystalline polymers. Crystallization, melting and the glass transition: an introduction to crystallization kinetics, melting and glass formation. Polymer solutions: the Flory-Huggins theory and phase behaviour. The measurement of molecular weight: osmometry, light scattering, viscosity and size exclusion chromatography.  |
| **Course objectives:** | To provide students with an elementary understanding of the reaction mechanisms involved in polymer synthesis and the kinetics of these reactions. To teach students basic concepts of polymer chain architecture, structure and morphology, with particular emphasis on the relationship between chemical structure (chain architecture) and the morphology of the solid state (semi-crystalline vs. amorphous polymers). To provide students with a basic knowledge of the thermal properties of polymers, particularly the crystallization temperature and elementary aspects of crystallization kinetics, the melting temperature and the glass transition; to teach how these properties depend on structure. To teach students basic aspects of the solution properties of polymers, interactions and the relationship to chemical structure, including phase behaviour and the measurement of molecular weight. To teach students how the above material is related, the fundamentals of polymer structure/property relationships, so that they can make simple predictions for design. |
|  **Learning outcomes:** | After completing this course the student would be able to :* Given a polymer structure the student should be able to specify a general synthesis scheme and predict molecular weight averages as a function of reactant concentration and monomer conversion.
* A student should be able to calculate number and weight average molecular weight from a given distribution.
* Given a polymer, a students should be able to specify methods for the measurement of number and weight average molecular weight and also the entire molecular weight distribution.
* A student should be able to describe basic chain conformations and calculate the average chain end-to-end distance.
* Given micrographs of polymer materials the student should be able to identify the morphology and how it depends upon crystallization conditions.
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| **Contribution on student load (must correspond with learning outcomes)** |
| **Activity**  | **Hours** | **week** | **Total /hours** |
| Lectures | 2 | 15 | 30 |
| Exercise theoretical/laboratory | 1 | 15 | 15 |
| Practice work | / | / | / |
| Contact with lecturer/consultations | 1 | 5 | 5 |
| Field exercises | / | / | / |
| Mid-terms, seminars | 2 | 5 | 10 |
| Homework | 1 | 5 | 5 |
| Individual time spent studying (at the library or home) | 2 | 15 | 30 |
| Final preparation for the exam | 2 | 5 | 10 |
| Time spent in evaluation (tests, final exam) | 2 | 5 | 10 |
| Projects, presentations, etc. | 1 | 10 | 10 |
| **Total** |  |  | **125** |
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| **Teaching methods**  | Lectures, discussions, laboratory work. |
| **Evaluation methods** | Examination 1: 15%, Examination 2: 15%, Student presentation / seminar: 10%, Final examination : 60% ,Total : 100%. |
| **Literature:** |
| **Basic Literature:**  |

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1. Carraher's Polymer Chemistry (Ninth Edition), Charles E. Carraher Jr., CRC Press, 2013
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| **Additional Literature**  | 1. Polymer Chemistry. Proprieties and Applications. Andrew J. Peacock & Allison Calhoun. Carlhanser Verlag. 2006
2. Fundamentals of polymer engineering. Anil Kumar; Rakesh Kumar Gupta. Marcel Dekker, 2003.
3. The Elements of Polymer Science & Engineering. Alfred Rudin, Phillip Choi, Academic Press; 3 edition (December 31, 2012).
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| **Designed study plan - Lecture:**  |
| **Week** | **Lectures which will be held** |
| ***First week:*** | The nature of polymer materials and polymer microstructure: including branching, networks, tacticity and copolymers.  |
| ***Second week:*** | Polymer synthesis: step-growth and chain polymerizations. |
| ***Third week:*** | Kinetics of polymerization: the kinetics of step growth and free radical chain polymerizations; relationship to molecular weight. |
| ***Fourth week:*** | Statistics of step-growth polymerization: the use of statistics in describing molecular weight distributions in step-growth polymerization. |
| ***Fifth week:*** | Copolymerization: the kinetics of free radical copolymerization. |
| ***Sixth week:*** | Structure: chain conformations, amorphous polymers, and the morphology of semicrystalline polymers. |
| ***Seventh week:*** | Crystallization, melting and the glass transition: an introduction to crystallization kinetics, melting and glass formation. |
| ***Eighth week:*** | Polymer solutions: the Flory-Huggins theory and phase behaviour.  |
| ***Ninth week:*** | Chemical bonding in polymers – ionic (ionomers), covalent, coordinate, metallic (Metalocene polymers), hydrogen bonding. |
| ***Tenth week:*** | The measurement of molecular weight: osmometry, light scattering, viscosity and size exclusion chromatography. |
| ***Eleventh week:*** | Introduction to elastomers, history and applications Polymerization of diene and important elastomers Mastication of elastomers Rheology and engineering properties of elastomers Vulcanization methods Compounding of elastomers. |
| ***Twelfth week:*** | Synthesis, properties and Application of Heterochain thermoplastics. Thermosetting resins – phenolic resins, amino resins epoxy resins, silicone polymers, and cyanate ester resins. |
| ***Thirteenth week:*** | Degradation and stabilization of plastics: Biostabilizers, metal deactivators environmental aspects of polymers. |
| ***Fourteenth week:*** | Polymerization Reactor**.** Descriptive account of reactor systems used for the following polymers – polyvinyl chloride, polystyrene, polyethylene terephthalate, nylon-6, nylon-66, styrene-butadiene rubber, polypropylene, polyethylene,interpretation of reactor data. |
| ***Fifteenth week:*** | Reactor Selection and Control Considerations. Basic factors in reactor design, reactor selection, phase selection and reactor operations, role of various process, variables and related instrumentation, qualitative account of control engineering considerations in operation of batch and continuous polymerization process |
| **Designed study plan – Lab exercise:**  |
| **Week** | **Lab exercises which will be held** |
| ***First week:*** | Introduction to Lab practice. |
| ***Second week:*** | **Characterization of Polymers Using Solubility Behavior**  |
| ***Third week:*** | **Properties of synthetic polymers.***Solubility of polymers and their chemical stability. Elasticity properties of biopolymers.* |
| ***Fourth week:*** | **Properties of synthetic polymers.***' Disappearance ' of polystyrene polymer and determination of air in polystyrene.* |
| ***Fifth week:*** | **Water and polymers***Experiments with hydrogels and polyacrylate-superabsorbent polymers.*  |
| ***Sixth week:*** | **Natural polymers.***Preparation of synthetic fibers from the cotton cellulose.**Preparation of plastic from potato starch and milk proteins .* |
| ***Seventh week:*** | **Condensation polymerization.** *The Small-Scale Preparation of Thiokol Rubber (polysulfide rubber). Preparation of two types of polyesters.* |
| ***Eighth week:*** | **Polymerization and condensation of acetaldehyde.**  |
| ***Ninth week:*** | **Thermosetting polymers.***Phenol – methanal polymerization, urea – methanal polymerization.* |
| ***Tenth week:*** | **Addition polymerization.***Synthesis of polystyrene (styropor).* |
| ***Eleventh week:*** | **Cross – linked polymers.*****Synthesis of nylon*** *6/10 and nylon 6/6, polyester fibers and cross-linked polymers PVA&borax* |
| ***Twelfth week:*** | **Linear polymers.***Resorcinol – formalin resin.* |
| ***Thirteenth week:*** | Determination of plasticizer in PVC and epoxy polymer by IR or FTIR. |
| ***Fourteenth week:*** | **Viscosity of polymers.***Relative molecular mass* |
| ***Fifteenth week:*** | Preparation of synthetic rubber. |

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| **Academic policies and rules of conduct:** |
| Regular attendance of students in classes is desirable but in the exercises is mandatory. Compliance with the schedule of lectures and exercises is mandatory..  |