ЦЕНТЪР ЗА ОБУЧЕНИЕ – БАН

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Basic Information:

Course Title:

Smart polymer systems and their application in medicine, biotechnology and membrane technologies

Lecturer: Prof. Dr. Darinka Christova

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Total Teaching Hours: 30

Annotation (up to 150 words)

The course aims to introduce the fundamental principles and cutting-edge scientific advancements in intelligent polymer systems, which exhibit reversible property changes in response to environmental fluctuations. The curriculum covers polymers and polymeric materials that dynamically adapt to external stimuli, including temperature, pH, and magnetic or electric fields. Key methodologies for synthesizing distinct classes of smart polymers are examined, alongside established techniques for characterizing and analyzing their behavioral shifts under varying external factors. Furthermore, the course highlights selected examples of innovative applications for these systems within medicine, pharmacy, biotechnology, membrane technologies, and environmental protection. Target audience: This course is specifically designed for doctoral students, postgraduates, and early-career researchers in polymer science, as well as investigators in interdisciplinary fields, including biophysics, biotechnology, and materials science.

Course content (brief description by topics or modules)

Topic 1: Introduction to smart polymer systems: fundamental concepts, definitions, and governing laws. Classification of smart / stimuli-responsive polymers.

Topic 2: Thermo-responsive polymer systems: primary representatives and mechanisms of action. Methodologies for synthesis and characterization. Impact of molecular weight and concentration on phase transition (lower critical solution temperature; LCST) and strategies for tuning/regulating LCST.

Topic 3: pH-responsive polymer systems: primary representatives, structural characteristics, and ionization behavior; methodologies for synthesis, functionalization, and characterization.

Topic 4: Electro-, magneto-, and multi-stimuli-responsive systems. Polymers responsive to electric fields, magnetic fields, and alternative external triggers. Preparation techniques, advanced characterization, and core physical properties.

Topic 5: Cross-linked smart polymers and hydrogels: mechanisms and methods for fabrication, primary representatives and structural classifications. Advanced methods for characterization gel structure and unique swelling/de-swelling properties.

Topic 6: Smart surfaces: key surface modification methodologies and fabrication techniques, advanced surface characterization tools and stimuli-responsive surface properties.

Topic 7: Biomedical applications: utilization of smart polymer systems in targeted drug delivery, tissue engineering, and medical diagnostics.

Topic 8: Biotechnological applications of smart polymers: applications in biocatalysis, protein purification, cell separation, and biosensors.

Topic 9: Advanced membrane technology applications: integration of smart polymers into responsive membranes for selective separation, water purification, and controlled filtration.

Teaching and assessment methods

On-site training

Assessment: preparation of literature essay (50% of the final grade) and oral exam (50% of the final grade)

Competencies acquired as a result of training (3–5 points)

1. *Theoretical knowledge:*
   - Understanding the fundamental physicochemical principles governing the behavior of smart polymer systems under the influence of external stimuli (temperature, pH, electric field, magnetic field, etc.).
   - Theoretical knowledge regarding the relationship between molecular mass, concentration and thermodynamic parameters in regulating phase transitions.
2. *Practical research skills:*
   - Skills in planning and conducting physicochemical studies to characterize responsive properties of smart polymers (swelling/collapse, phase separation).
   - Analysis and interpretation of experimental data obtained from advanced instrumental methods studying the stimuli-responsive behavior of smart polymer systems.
   - Innovative thinking and capacity for transferring fundamental scientific knowledge into applied technological solutions.

Literature:

1. Galaev, I., Mattiasson, B. Smart Polymers: Applications in Biotechnology and Biomedicine, CRC Press.
2. Urban, M. W. (Ed.) Handbook of Stimuli-Responsive Materials, Wiley-VCH.
3. Amoozegar, Z., et al. Smart Polymers: An Emerging Vista for Nanotheranostics, CRC Press.
4. Hossein, A., et al. Industrial Applications for Intelligent Polymers and Coatings, Springer.
5. Current papers in leading scientific journals (Progress in Polymer Science, Elsevier; Advanced Functional Materials, Wiley; Polymer Chemistry, RSC).