MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION

Federal State Autonomous Education “Ural Federal University named after the first President of Russia B.N. Yeltsin”

Institute of New Materials and Technologies

Signed and Approved

Vice-rector for Research

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V.V. Kruzhaev

«\_\_\_» \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2018 г.

COURSE PROGRAM

**PHYSICOCHEMICAL BASES OF PRODUCING POLYMERS AND THEIR PROPERTIES**

|  |  |  |  |
| --- | --- | --- | --- |
| **Specialty code** | **Major** | **Training program** | **Qualification** |
| 02.00.06 | Chemical Sciences | High-molecular compounds | Researcher.  Research Instructor |

[Yekaterinburg](http://context.reverso.net/%D0%BF%D0%B5%D1%80%D0%B5%D0%B2%D0%BE%D0%B4/%D0%B0%D0%BD%D0%B3%D0%BB%D0%B8%D0%B9%D1%81%D0%BA%D0%B8%D0%B9-%D1%80%D1%83%D1%81%D1%81%D0%BA%D0%B8%D0%B9/Yekaterinburg) 2018

1. **GENERAL CHARACTERISTIC OF COURSE**

1.1 Specialized discipline “Physicochemical bases of producing polymers and heir properties”

promotes mastering of the main professional competencies and their components. Also it is aimed at an in-depth studying of the basic sections of High-Molecular Compounds Chemistry and Physical Chemistry: methods of the synthesis and study of the properties of polymers and polymer composite materials.

1.2 After mastering this discipline, the graduate student must acquire the following competencies:

**General professional competencies (GPC):**

* the ability to carry out independent research activities in the relevant professional field using modern research methods and information and communication technologies (GPC-1);
* readiness to organize the work of the research team in the field of Chemistry and related sciences (GPC-2).

**Professional competencies (PC):**

* the ability to conduct independent research and obtain scientific results that meet the established requirements for the content of Candidate of Sciences thesis in Chemical Science in discipline (scientific specialty) 04.06.01 Physicochemical bases of producing polymers and heir properties (PC-1);
* readiness to present scientific results on the topic of thesis in the form of publications in peer-reviewed scientific publications, reports at scientific conferences,   
  to referee and edit scientific articles on specialty 04.06.01 Physicochemical bases of producing polymers and heir properties (PC-2).

**2 STRUCTURE AND DISTRIBUTION OF STUDY HOURS**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Names of the discipline | semester | The amount of time devoted to mastering the discipline | | | | | | |
| Face-to-face hour | | | | Independent work hour | Certification in discipline (test, exam) | Total hours/point of credits |
| Total | lectures | practical lessons | laboratory works |
| Physicochemical bases of producing polymers and heir properties | 6 | 4 | 4 |  |  | 104 | Examination, 6 semester | 108/3 |
| Total number of hours | | 4 | 4 |  |  | 104 |  | 108/3 |

#### 3 COURSE CONTENTS

|  |  |  |  |
| --- | --- | --- | --- |
| № | **Section, topic** | Credit value | |
| hours | point of credits. |
| 1 | **Section 1. Introduction.** The specifics of the polymer state as a section of chemical science. General differences in the structure and properties of high-molecular compounds from low-molecular ones. Natural polymers and their varieties, methods of isolation from natural raw materials and identification, methods of modification. Cellulose, chitin, chitosan and their prodvodnye. The usage of natural polymers. | 1 |  |
| 2 | **Section 2. Chemistry of polymers and polymer composite materials.** Synthesis of monomers and polymers. Linear and branched polymers. Polyconjugated polymers: chemical structure, molecular and supramolecular structure of typical polyconjugated polymers: polyacetylene, polydiacetylenes, polyanilines, polyphenylene vinylene, polythiophenes, etc., the concept of their electronic structure. Chemical and electrochemical modification of polyconjugated polymers. Structural modification and supramolecular structure. Hyperbranched polymers and dendrimers, their synthesis and structural features.  Crosslinked polymers. Types of crosslinked polymers. The formation of three-dimensional structures in the process of synthesis and chemical transformations in macromolecules. Stitched rigid and elastic polymers. Mesh options. Types of crosslinking agents and structural features of the nets. The effect of cross-linking on the mechanical properties of crosslinked elastomers.  Chemical modification of polymers. The main laws of modification of polymers. Reactivity of functional groups of macromolecules and low molecular weight compounds. Chain effects and neighboring groups, configuration and conformational effects. Substitution reactions in the polymer chain. Compositional heterogeneity. Polymer structuring reactions and their features. Changing the properties of polymers as a result of structuring. Intermolecular reactions and the formation of three-dimensional networks. Reactions of addition, cleavage and isomerization.  Destruction of polymers and composite materials. The main types of destruction are chemical, thermal, thermo-oxidative, photo-and mechanical. Aging polymers. Stabilization of high-molecular compounds. Mechanical destruction kinetics of polymers. The limit of mechanical destruction and the reasons for its existence. The concept of the resistance of polymers and composite materials to external influences. Flammability of polymers and PCM. The main processes occurring during combustion in the condensed and gas phases. Methods of reducing and increasing the flammability. | 24 |  |
| 3 | **Section 3. Polymer systems.** Polymer blends. The mixture of polymers as a matrix for the production of polymer composite materials (PCM), the specificity of the synthesis of PCM with their use. Multicomponent polymer blends. Mechanical properties of polymer blends. Static, dynamic, impact strength. Elasticity. Resistance to fatigue. The mechanism of hardening of two-phase mixtures of polymers. The influence of various factors on the mechanical properties of polymers. The role of the particle size of the dispersed phase. Dependence of properties on the ratio of components. The effect of Tc elastomer. Compatibility of polymers and mechanical properties of mixtures. The effect of compositional homogeneity of copolymers on their mechanical properties. Rheology of polymer-polymer systems. True and colloidal solutions of mixtures of polymers, the mechanism of mixing and the types of phase structures in mixtures of polymers.  Block copolymers as polymer hybrids. Double-block, three-block, polyblock and star block copolymers (BSP). Methods for obtaining BSP. Differences in the properties of BSP from statistical copolymers and from mixtures of polymers. Thermoplastic elastomers - a unique class of materials based on BSP. Structure and properties of thermoplastic elastomers. Examples Block copolymers in solutions. Effect of solvent on the morphology and properties of BSP. Mixtures of block copolymers with other polymers. Different cases of using BSP as components of mixtures. Block copolymers and graft copolymers as interfacial additives promoting compatibility (compatibilizers) . | 29 |  |
| 4 | **Section 4. Polyelectrolyte gels.** Getting gels by radical polymerization. Obtaining microgels by emulsion polymerization methods. Properties of polyelectrolyte gels. Theoretical description of the polyelectrolyte gel. Behavior of gels when changing the quality of the environment. The influence of the ionic composition on the degree of swelling of the gel. Features of biophysics gels. | 1 |  |
| 5 | **Section 5. Physics of polymers and polymer composites. Structure and properties of amorphous, crystalline and oriented polymers.** Structural models. The main methods of orientation of polymers and evaluation methods. Model concepts of mixtures of polymers and polymers with functional ingredients introduced into their composition.  Classification of polymer composite materials and polymer nanocomposites. Types of materials: polymer-polymer mixtures, PCM, reinforced with continuous, short fibers and lamellar fillers, dispersion-filled PCM, foam polymers, multicomponent PCM.  Fiber-forming polymers and fiber polymer composites, production methods and structure. Type, form and basic properties of reinforcing fillers: continuous glass, carbon, boric, organic, etc. Fibers, threads, plaits, roving, tapes and fabrics; short fibers, mats of them; flat structure fillers. Physical chemistry of fillers. Types and properties of matrices (thermoplastic and thermosetting polymers, polymer-polymer blends). Methods of obtaining polymer composite materials.  Electrical, optical and magnetic properties of polymers and PCM. Electrical properties of dielectric polymers and conductor polymers. Dielectric polarization and dipole moments of polymers. Dielectric permeability and dielectric loss, dielectric strength of polymers and PCM. Electrification of polymers and electrical breakdown. Doping of polyconjugated polymers: synthetic metals and methods for their preparation. Electrical and optical properties of polyconjugated polymers.  Magnetoresistance of polymers and PCM. PCM with high and low values of complex dielectric and magnetic permeability, the relationship between composition and structure, methods of determination.  Optical properties of polymers: light transmission coefficient, spectral transmittance, light resistance, light scattering, refractive index and optical voltage coefficient and optical non-thermal resistance. Factors determining the level of these indicators. Aging optical polymers.  Thermophysical properties of polymers and PCM. The density of polymers. Features of thermal expansion of polymers. Heat capacity. Thermal conductivity and thermal diffusivity of polymers and PCM. The influence of the basic parameters of polymers and other PKM ingredients on their thermophysical properties.  Friction and wear of polymers. Features of polymers friction. Nature and mechanism of friction. The law of friction, the influence of contact time, sliding speed and temperature. Polymer wear. The connection phenomena of friction and wear.  Permeability of polymers. Gas permeability of polymers. Diffusion in polymers. Sorption of gases and vapors. Ion exchange. Selective permeability of polymeric materials, methods of determination  . Physical properties of PCM: strength, fracture toughness, fatigue endurance Elastic and viscoelastic properties of PCM. Models describing the dependence of the modulus of elasticity of the PCM on the characteristics of the components. Thermal expansion, thermal and electrical conductivity of PCM. Features of the dependences of the physical properties of PCM on the type of filler and distribution of fillers in the composite material.  Interfacial phenomena at the polymer-polymer interface, polymer-solid. Adhesion. The influence of the form, chemical and physical state of the surface on the properties of PCM. Appretati. Methods for chemical and physical modification of PCM components. Nanocomposites. Fillers with nanometer size particles. Structure and properties of nanocomposites. Nanocomposites with new optical, electronic, magnetic, electrical and other functions using carbon nanotubes, fullerenes, metals and metal oxides. The concept of the use of polymers and PCM in functional and intelligent (smart) structures. Polymeric materials used to obtain them: the relationship between their layout, external influences and response. | 18 |  |
| 6 | **Section 6. Research Methods of Polymers and Polymer Composite Materials.** Experimental methods for studying the structure of macromolecules in solution (viscometry, light scattering, sedimentation, birefringence). Polymer spectroscopy: PC, ATRM, KR. Specificity of methods and problems solved with their application. Fluorescence analysis of polymers. Electron and nuclear paramagnetic resonances. The spin label method. NMR high and low resolution. Thermophysical methods. Dilatometry. Differential thermal analysis. Calorimetric methods. Mass spectrometry. X-ray analysis of polymers. The study of the size and orientation of ordered regions of crystalline polymers. Long periods in polymers. The specifics of the study of mixtures of polymers and PCM. Optical and electron microscopy. Physico-mechanical methods. Thermomechanical method. Non-destructive PCM research methods. Dynamic methods. Dielectric and mechanical spectroscopy. Electrophysical methods for studying the properties of polymers and PCM. Tunnel microscopy. Transport methods for the study of polymers. Reversed and gel permeation chromatography. | 18 |  |
|  | Totally | 108 | 3 |

**4 base of materials for current academic performance Evaluation and interim assessment**

**The list of credit issues (audited competences GPC-1, GPC-2, PC-1, PC-2)**

1. Natural polymers and their varieties, methods of isolation from natural raw materials and identification, modification methods.

2. Thermodynamic classification of phase transitions. Stable and metastable phases.

3. Polymer structuring reactions and their features. Change of properties of polymers as a result of structuring.

4. Chemical modification of polymers. The main regularities of polymer modification. Reactivity of functional groups of macromolecules and low-molecular compounds.

5. Destruction of polymers and composite materials. The main types of destruction: chemical, thermal, thermo-oxidative, photo- and mechanical. Aging of polymers.

6. Flammability of polymers and PCM. The main processes occurring during combustion in the condensed and gas phases. Methods for reducing and increasing the combustibility.

7. Compatibility of polymers and mechanical properties of mixtures.

8. Thermoplastic elastomers - a unique class of materials based on BSP. Structure and features of the properties of thermoplastic elastomers.

9. Properties of polyelectrolyte gels. Theoretical description of polyelectrolyte gel.

10. Classification of polymer composite materials and polymer nanocomposites.

11. Type, shape and basic properties of reinforcing fillers: continuous glass, carbon, boric, organic, etc.

12. Electrical, optical and magnetic properties of polymers and PCM.

13. Structure and properties of nanocomposites.

14. X-ray diffraction analysis of polymers. The study of the dimensions and orientation of ordered regions of crystalline polymers. Large periods in polymers.

**5 METHODICAL AND INFORMATION SUPPORT**

**5.2 Electronic educational resources**

* 1. Local scientific library: <http://lib.urfu.ru>
  2. Local scientific library catalogues: <http://lib.urfu.ru/course/view.php?id=76>
  3. Electronic catalogue: <http://opac.urfu.ru/>
  4. Electronic search systems: <http://lib.urfu.ru/mod/resource/view.php?id=2330>
  5. Open resources: <http://lib.urfu.ru/course/view.php?id=75>
  6. Subscription: <http://lib.urfu.ru/mod/data/view.php?id=1379>

**5.3 Information and reference systems and search systems**

1. ScienceDirect: <http://www.sciencedirect.com>;
2. Web of Science: <http://apps.webofknowledge.com>;
3. Scopus: <http://www.scopus.com>;
4. Reaxys: <http://reaxys.com>
5. Searching system EBSCO Discovery Service <http://lib.urfu.ru/course/view.php?id=141>