University of Chemical Technology and Metallurgy
Centre of Materials Science

Proposal
for the participation in
“Material Science and Engineering Master Course”
Discipline “Advanced Materials” III Semester

A. Advanced Polymer Materials

Program; Hours: 30+10

Анотация

Програмата се предлага от чл.кор. дхн Христо Цветанов, от Института по полимери – БАН. Част от лекциите, които се предлагат са четени на английски език от него в следните университети:

1 Католически Университет, Льовен, Белгия, 1998
2. Технически Университет, Дрезден, Германия, 1996, 1998 и 2003
3. Университет на Байройт, Германия, 2000
4. Политехника, Гливице, Полша, 2004

В програмата се предвижда да вземат участие следните учени от лаборатория “Полимеризационни процеси”, които говорят свободно на английски език и са изнасяли многократно научни доклади и съобщения на английски език:

- Ст.н.с. д-р Станислав Рангелов
-н.с. I ст. д-р Христо Новаков
-н.с. I ст. д-р Ивайло Димитров (носител на наградата за талантлив млад учен “Проф. Марин Дринов”)
- н.с. I ст. д-р Петър Петров (носител на наградата за талантлив млад учен “Проф. Марин Дринов”)
- д-р Филип Димитров – през 2006 г. на специализация в Университета на Южна Калифорния, Лос Анжелес, САЩ.

Чл.кор. Цветанов предвижда постепенно лекциите да се поемат от един или двама по-млади колеги от по-горе споменатите учени, което е гаранция за приемственост и по-нататъшно качествено развитие на курсовата програма.

Курсът е съставен от 7 тематични блока и общо 20 теми, които обхващат най-важните аспекти на съвременната представа за “Advanced polymer materials” намерили място в научната литература за периода 1990 – 2006 г. Научно-изследователската тематика на колектива съвпада напълно или частично с проблемите, застъпени в блокове I-IV и VII.

В предлагания курс не се посочват часовете, но се предвижда 20-те теми да бъдат реализирани в рамките на определените 30 часа. Предвиждат се и 10 часа семинарни упражнения на територията на Института по полимери - БАН, които да конкретизират представената информация.

Lectures:

I. **Controlled polymerization methods as a tool for the preparation of advanced polymer materials.** *This part aims to teach the synthesis and polymerization methods for the design of precision polymers. The modern technology, especially nanotechnology requires excellent control over all aspects of polymer structure (molecular weight, polydispersity, number and position of functional groups, architecture, etc.)*

1) Living anionic polymerization
2) Living cationic polymerization
3) New synthetic techniques : Controlled radical polymerization: nitroxide mediated radical polymerization; atom transfer radical polymerization (ATRP); reversible addition-fragmentation chain transfer polymerization (RAFT)
4) Synthesis of block- and graft- copolymers

II. **Supramolecular polymer architecture as basis for novel applications.** *This block of lectures is extremely important for understanding the design of the most of the advanced materials. The intramolecular non-covalent interactions control the conformation of the polymer chain, its secondary structure, and, therefore, its overall shape. The intermolecular non-covalent interactions determine the aggregation of and microphase separation of polymers. Consequently, these noncovalent interactions give rise to hierarchial structure formation and exert an important influence on polymer material properties.*

1) Polymer chains in solution. Polymeric micelles and their higher aggregates
2) Flexibility and rigidity of macromolecules
3) Non-covalent interactions
4) Stimuli-responsive polymers and hydrogels

III. **Synthesis of biodegradable polymers and copolymers for drug delivery**. *This part is generally concerned with the use of novel, mostly in the field of nanoscience and nanotechnology, approaches in polymeric systems for medical and biological applications. The particular interest is the development of advanced materials designed and fabricated as bio-active and bio-compatible functionalized nanoparticles.*

1) Drug delivery by using polymeric micelles and polyplexies
2) Stimuli-responsive polymers for biomedical applications
3) Polymers in tissue engineering
4) Design and synthesis of novel biodegradable peptide based polymers

IV. **Applications of polymeric smart materials to environmental problems** *New methods for the reduction and remediation of hazardous wastes like* *carcinogenic organic solvents, toxic materials, and nuclear contamination are vital to environmental health. For this purpose polymeric smart materials are finding useful applications*

1) Soluble polymer-bound catalysts and substrates
2) Polymeric smart membranes, surfaces, and sensors

V. Reactive processing

In a reactive extrusion process, the synthesis or modification of polymeric material takes place simultaneously with the processing and shaping of the final product. This is an efficient and quite modern method for continuous polymerization of monomers and chemical modification of existing polymers, and is viewed as a complex reaction engineering process that combines the traditionally separated operations into a single process in a screw extruder.

1) Models of reactive processing

VI. **Nanofiber technology**

Nanostructured fibrous materials have been made more readily available due to recent advances in electrospinning and related technologies. The non-woven structure has unique features, including interconnected pores and very large surface to volume ratio, which enable nanofibrous scaffolds to have many biomedical and industrial applications.

1) Electrospinning of supramolecular structures

VII. Polymer composite

The broad diversity of molecular structures available in polymers leads to materials with combinations of properties that cannot be achieved with any other substance. On this basis, over the past three decades advanced polymer composites have emerged as an attractive construction material for new structures and multi-functional nanoparticles and surfaces as well.

1) Fiber reinforced polymers
2) Hybrid nonorganic/polymer structures

VIII. Advanced polymeric materials for optoelectronic applications

Polymers are widely used by construction of novel light emitting diodes (LEDs), photovoltaic diodes and circuits. The understanding of interfaces between polymer and other materials has led to an explosion of industrial applications in the field of polymer optoelectronics.

1) Electrically conducting polymers
2) Introduction to polymeric semiconductor materials. Organic photodiodes, organic transistors

Lab practice (10 hrs)

1) Temperature-sensitive smart polymers: poly(N-isopropylacrylamide) (PNIPAM). Study of the phase transition in semidilute aqueous solutions due to the low critical solution temperature (LCST)

properties. Cloud point determination by using UV-VIS spectrophotometer and thermostat.

2) Preparation of poly(ethylene oxide) (PEO) hydrogel and of stimuli-responsive hydrogel based on PEO and PNIPAM. Equilibrium swelling and determination of the loss- and storage-modulus. Determination of the apparent molecular weight between the cross-links by using Flory-Rehner and Flory-Bray equations. Use of special UV lamp, liophilizer, and Thermohaake 600 rheometer.
3) Preparation of biodegradable hydrogels from cellulose derivative. Ag/cellulose derivative hybrid hydrogels from Ag nanoparticles and hydroxyethylcellulose.
4) ATRP polymerization of methyl methacrylate and molecular weight determination of the polymer, characterized by low polydipersity. By using size exclusion chromatography (SEC ,Waters) and static light scattering (SLS, Wyatt).
5) We envisage also lab practice on one of the problems “electrochemical polymerization of aniline – polyaniline” or “electrospinnig”. The title depends on possible agreement with prof. L. Terlemezyan (polyaniline) or prof. I. Rashkov (electrospinning).