

Thesis topics, 2026/27/1st semester

Dr. Levente Novák:

Synthesis and characterization of functionalized macromolecules (Chemistry or chemical engineer MSc, 1 person, 1 free place)

The properties of macromolecules are strongly influenced besides their chemical composition by other factors, as e.g. the structure of the carbon chain, the molecular weight and weight distribution of the polymer, spatial position of certain functional groups and their mutual distance. Macromolecules functionalized by suitable groups can be excellent ligands for different metal ions and the complexes so formed possess several advantages over the complexes of small molecules (decreased diffusion rate, easy separability, specific selectivity, kinetic stability). The synthesis of these macromolecules with specific properties is performed partly by linking together monomeric units, partly by the modification of existing polymers (called platforms).

Purification of the product from the starting materials and the byproducts of the reaction is an important step. Following the synthesis and the purification we will investigate the main properties of the macromolecules formed and/or the behavior of their most suitable metal complexes for a given area of application (colloidal catalysis, environmental protection, magnetic contrast agents).

Dr. Eszter Mária Papp-Kovács

Investigation of Competitive sorption of Rare Earth Ions on Bentonite and Zeolite: Thermodynamic, Kinetic, and Mechanistic Approach (Chemistry or chemical engineer BSc/MSc, 1 person, 1 free place)

Rare earth elements are essential in modern technology and often occur with radioactive elements. This work studies competitive sorption of rare earth ions on bentonite and zeolite under different chemical conditions, applying isotherm and kinetic models. The results will support understanding REE environmental behavior.

Investigation of Parameters Affecting the Adsorption of Radioactive Contaminants on Clay-LDH Sorbent Systems (Chemistry or chemical engineer BSc/MSc, 1 person, 1 free place)

The aim of this thesis is to synthesize clay-layered double hydroxide (LDH) composite sorbents and investigate the factors affecting the binding of radioactive contaminant ions. The sorbents will be characterized using structural and surface-chemical techniques (XRD, SEM, BET, FTIR). Adsorption of radioactive ions will be measured under varying pH, ionic strength, and temperature using gamma spectrometry, and kinetic and isotherm models will be applied to evaluate adsorption processes. The study aims to develop an efficient and stable sorbent for reducing environmental radioactive contamination.

Radioanalytical Study of the Regenerability and Stability of Clay-LDH Sorbents
(Chemistry or chemical engineer BSc/MSc, 1 person, 1 free place)

The aim of this thesis is to investigate the regenerability and long-term stability of clay-LDH composite sorbents in experiments with radioactive isotope adsorption. Structural characterization of the sorbents will be performed using XRD, FTIR, and SEM, and surface properties will be analyzed using BET measurements. By evaluating the adsorption of radioactive ions over multiple cycles, the regenerability of the sorbents and their suitability for immobilizing radioactive contaminants will be assessed. The research contributes to the development of environmentally friendly, reusable technologies for radioactive waste management.

Surface Modification and Structural Analysis of Bentonite and Zeolite for Selective Rare Earth Ion sorption (Chemistry or chemical engineer BSc/MSc, 1 person, 1 free place)

Bentonite and zeolite are inexpensive natural sorbents that can be improved by surface modification for REE removal. This study prepares modified samples (acid-activated, pillared, phosphate-treated), characterizes them, and tests their sorption performance. The goal is to link structure to sorption behavior.

The "Rare earth metal research group" is mainly concerned with the coordination chemistry of metal ions (alkaline earth, rare earth, some transition and metal ions of major group 13) that are important from a biological point of view (essential and toxic) and can be utilized in medical imaging diagnostics (e.g. magnetic resonance imaging (MRI), positron emission tomography (PET), etc.) and therapy (nuclear medicine). We synthesize open-chain and macrocyclic polyaza-polycarboxylate, polyphosphonate, polyphosphinate, picolinate, amidate and more recently 8-oxocholinate chelators, their complexes of metal ions, and study their physico-chemical properties (equilibrium, formation and dissociation kinetics, contrast

enhancement ability etc.) and structure. More recently, we are working on the design, synthesis and characterization of ligands those complexes can act as "smart" or bimodal (MRI - PET, MRI - optical, etc.) probes.

As far as the applied techniques concerned, we use pH-potentiometry (equilibrium measurements), UV-visible spectrophotometry (equilibrium and kinetic measurements), spectrofluorimetry (equilibrium and kinetic measurements), as well as on one- and multidimensional and TD NMR (^1H , ^{13}C , ^{17}O and ^{31}P), mass spectrometry and HPLC (analytical and preparative) techniques.

Dr. Gyula Tircsó

Design, synthesis and characterization of new ligands for the complexation of metal ions of biomedical importance (Chemistry or chemical engineer BSc/MSc, 1 person, 1 free)

Complexes of the lanthanide ions (Ln^{3+}) have been utilized in medical applications due to their widespread magnetic, photophysical, and nuclear properties. Owing to their toxicity the Ln^{3+} ions are must be chelated using multidentate ligands. Beside the traditional pendant arms, the picolinate metal binding moiety is explored more extensively nowadays. The proposed project therefore aims at the development and synthesis of a monopicolinate based chelator derived from the 2,2'-oxybis(ethylamine) diamine possessing three acetate pendant arms (OBE3APA). The research will focus on the synthesis of the ligand and characterization (stability, formation and dissociation kinetics) of their complexes formed with metal ions of biomedical relevance (Bi^{3+} , Gd^{3+} , Sc^{3+} etc.).