RESEARCH PROJECTS
at the Faculty of Chemistry of MCSU in the academic year 2017/2018

Department of Physicochemistry of Solid Surface

Dr Małgorzata Zienkiewicz-Strzałka

Project 1: Investigation of role of silver nanoparticles on spectroscopic properties of bioactive compounds.

The dispersions of silver nanoparticles and some other types of noble metal nanoparticles display intense colors due to the effect of plasmon resonance absorption (SPR) in the UV-VIS range. The surface of a metals generates free electrons on the surface. Phenomenon of surface plasmon resonance is a collective excitation of the electrons in the conduction band very close to the surface of the nanoparticles. Electrons are limited to specific vibrations modes by the size and shape of particle. Therefore, metallic nanoparticles have characteristic optical absorption spectra in the UV-Vis region depending on their morphology. Why not recognize this phenomenon closer? In this project the influence of silver nanoparticles on the bioactive compounds will be evaluated. The stable silver nanoparticle solution will be prepared by environmental-friendly technique and used for spectroscopic behavior of nitrogenous bases and dies. The participant will receive a deeper insight into the problem of optical spectroscopy, transmission electron microscopy and nanotechnology.

Department of Interfacial Phenomena

Dr hab. Aleksandra Szcześ

Project 1. Study of the functional properties of selected commercial detergents.

The proposed research will include the detergents ability to reduce surface tension and to stabilize oil in water emulsions as well as the hard water influence on these properties. Furthermore, the effect of detergents on human skin will be determined.

Dr hab. Katarzyna Szymczyk

Project 1. Fluorescence study of micellization of nonionic surfactants used in pharmaceutical industry.

The function of surfactant micelles in pharmacology is of vital significance particularly owing to their ability to increase drugs permeability through biological membranes. To achieve proper understanding how these molecules behave, description of surfactant micelles at the molecular level is required. The aggregation number of surfactant micelles, which indicates the number of surfactant molecules making up a micelle, represents one of the experimental characteristics describing micelles. Along with the hydrodynamic size and shape of micellar aggregates, it provides important information about the micellar structure. Therefore the aim of the project is to determine the

aggregation number of the micelles of nonionic surfactants whose applicability in preventing protein aggregation in biotherapeutic formulations is well known by fluorescence probing methods.

Project 2. Solubilization of pyrene by single and mixed surfactant micelles.

Environmental applications of surfactants have been growing in recent decades due to their unique properties as solubilizing agents. Polycyclic aromatic hydrocarbons (PAHs) tend to be strongly incorporated within the micellar core because the hydrocarbon region forms a liquid-like region with a viscosity that is approximately an order of magnitude greater than that of liquid hydrocarbons of similar chain length. As pyrene is chosen as model PAHs, because of its abundance and hydrophobicity in the polluted soils, the aim of this project is to determine the interactions between pyrene as well as single and mixed surfactant micelles by fluorescence probing methods.

Dr hab. Agnieszka Ewa Wiącek

Project 1. Hydrophilic/hydrophobic character of natural or synthetic polymers developed by plasma processing and modified by biological substances.

Switchable wettability can be a convenient parameter providing information on the surface properties, that is why determination of hydrophilic/hydrophobic character of the polymer surface is extensively used in different branches of industries. Wettability and work of adhesion to surfaces will be obtained on the basis of measurements of contact angles using a contact angle meter GBX (France) equipped with humidity-controlled chamber and digital camera. Then, the results will be interpreted based on the surface free energy and topography parameters.
Low-temperature plasma processing is typically used for cleaning, etching, crosslinking, surface activation and as a pre-deposition process. The plasma treatment results in a physical and/or chemical modification of the first few molecular layers of the polymer surface, while retaining the same properties of the bulk phase. Plasma treated polymer surfaces have usually better adhesive features and therefore stable coating can be created. On the other hand, modification by biological substances can improve antibacterial properties, inherent haemostatics and polymer biocompatibility. These advantages allowed to obtain new attractive biomaterials from the same polymer differing in properties for a wide spectrum of applications: pharmaceutics, medicine and food packing industry.

Prof. dr hab. Anna Zdziennicka

Project 1. Influence of alcohols on the aggregation process of chosen biosurfactants.

Due to their interesting properties (high surface activity, specificity of action, temperature stability) biosurfactants are more and more widely applied in various fields of industry. They are often used in a mixture with different compounds. The aim of this research project is determination of the effect of alcohol on the critical micelle concentration of a chosen biosurfactant. For this purpose the measurements of surface tension, density and dynamic viscosity of aqueous solutions of a biosurfactant and

alcohol mixture as a function of surfactant concentration will be made. On the basis of CMC, the standard Gibbs free energy of micellization will be also determined.

Project 2. Influence of ionic strength and pH on the adsorption properties chosen cationic surfactants.

Cationic surfactants are very popular surface active agents which are often used as a component of the mixture of different compounds. For example the presence of inorganic substances can influence on their adsorption at the water-air interfaces. Therefore in this study on the basis of the measurements of surface tension and pH of aqueous solutions of a chosen cationic surfactant as a function of neutral salt concentration, the Gibbs surface excess concentration of a cationic surfactant and the standard Gibbs free energy of its adsorption will be determined at the water-air interface.

Dr Małgorzata Jurak

Project 1. Biomimetic systems for studying structure and interactions in cell membranes

Some model membranes will be developed for studying membrane properties, structure and interactions between their particular components as well as for investigating effect of biologically active compounds on the membrane behaviour. For such purposes the Langmuir monolayers on the liquid subphase and the Langmuir-Blodgett/Schaefer films on the solid support will be used. These biomimetic systems can allow for determining the nanoscale lateral organization of lipids to get better insight into the biological functions of phase separated domains. Their coexistence and lateral distribution within the membrane play a key role in many cellular processes such as apoptosis, membrane fusion and signal transduction.

dr Joanna Krawczyk

Project 1. Surface and colloid chemistry of systems including natural surfactants.

Natural surfactants are of significant importance in the cosmetic and personal care industries, hard surface cleaning, and agricultural products. Their so wide industry and bio-chemical applications result from their mildness, good biodegradability as well as the possibility of their preparation from natural and renewable resources. Additionally, they are to a larger and larger extend used as substitutes for other surfactants that are often not environmentally friendly and possess much worse surface and aggregation properties. Thus the main goal of the project will be a thermodynamic analysis of the surface and aggregation properties of the chosen natural surfactants based on different renewable materials widely applied in industry, biochemical and cosmetic fields. For this purpose the surface tension, fluorescence intensity as well as dynamic light scattering measurements will be made.

Project 2. Influence of the solute composition on the aggregation properties of natural surfactants used in medicine and as food additives.

The use of natural surfactants is constantly increasing and is associated with their good physicochemical and dermatological properties. Hence, they are more and more often

used as main ingredients of cosmetic and pharmaceutical formulations as well as food additives. Because of so wide application they have the direct contact with our bodies, which is particularly important especially at a certain surfactant concentration called as a critical micelle concentration (CMC). Hence, the purpose of this project will be the study of the aggregation properties of selected natural surfactants in different solvent media. This purpose will be accomplished by the spectrofluorimetric measurements of the selected systems including a natural surfactant and different solvent additives.

dr Konrad Terpiłowski

Project 1. Surface properties of polymers after low pressure plasma treatment.

Plasma treatment change surface topography and apparent surface free energy. The work will be included surface plasma treatment using plasma obtained from many gases (air, argon, nitrogen…). The surface characterisation will be taken by contact angles, optical profilometry and spectroscopy**.**

Project 2. Deposition of polymers on plasma activated supports.

Solid supports will be treated by plasma gases and polymers solutions will be deposited on activated supports. Properties of obtained layers will be characterised by contact angle measurements and apparent surface free energy determination. Moreover topography of obtained layers will be evaluated by optical profilometry and SEM.

Laboratory of Optical Fiber Technology

Mgr Małgorzata Gil

Project 1. Optical fiber amplitude sensor for detection of hazardous substances – study of useful polymers materials

The main objectives of the research are to make a detailed analysis of thermal, mechanical and optical properties of commercially available and modified polymers. Selected polymer/polymers will be applied as an outer coating on silica optical fiber then by entering it to the dangerous environment the measurements of the optical response of the sensor will be done.

Project 2. Conductive polymers for optical fibers sensors

The aim of the research is to fabricate a polymer optical fiber, which can lead to both light and electricity. The project provides the selection of commercially available monomers, which after polymerization will show good electrical conductivity. Selection of polymers will rely also on their processsability. The project, in addition to carrying out basic physicochemical research of the selected polymers, will be carried out also to optimize their polymerization.

Dr Paweł Mergo

Project 1. Radiation influence on the optical fibers usable in nuclear power plants – study of useful polymers

The main objective of the project is to produce a polymer optical fiber for detecting the ionizing radiation. Under the project selection of polymer materials will be made which, under the influence of that radiation will change its properties, thereby changing the optical signal received by the detector. In addition, they physicochemical tests in order to check whether ionizing radiation on the test material is reversible or not will be carried out. An important element of the research will also be aging studies.

Project 2. Aging tests of optical polymers

The aims of the project are aging tests of polymers used in optical fiber technology. In this project polymer optical fibers will be placed in a climate chamber. Based on mechanical and thermal studies, the impact of changing environmental conditions on the physicochemical properties of optical polymers will be evaluate.

Department of General and Coordination Chemistry

Dr hab. Wiesława Ferenc, Prof. UMCS

Project 1. The new complexes of *d*- and *4f*- electron metals with selected organic ligands

The aim of the Project is:

- to prepare the new transition metal complexes with the selected organic ligands such as: carboxylic acids, 2-amino-4,6-dimethylopyrimidine, hydantoin and nitroisatin;
- to determine their formulas with the use of XRF and elemental analyses
- to record their FTIR, UV-VIS and XRD spectra;
- to study their thermal stability using the TG, DTG, and DSC techniques;
- to measure their magnetic susceptibility by Gouy (77-303 K) and SQUID-VSM (2-300 K) methods.

Dr hab. Beata Cristóvão

Project 1. Synthesis, structures and properties of new Cu(II), Ni(II), Zn and lanthanides(III) complexes with N,O-donor ligands

Recently, polynuclear 3d, 4f and 3d-4f metal complexes are attracting considerable attention in view of their wide range of potential applications in many fields, including chemistry, physics, biology, materials science and nanotechnology. Schiff bases derived from the condensation of diamines with aldehydes have two cavities of different

dimensions and these ligands are very selective for certain metal ions owing to their ionic radii.

The aim of the research work is as follows:

- ❑ Synthesis of N,O-donor ligands
- ❑ Synthesis of Cu(II), Ni(II), Zn(II) and lanthanides(III) complexes with Schiff base ligands
- ❑ Determination of their structures.
- ❑ Studying their spectral, thermal and magnetic properties
- ❑ Investigation of the influence of the electron configuration of different metal centers in homo- and heteronuclear complexes on their structure and properties

Dr hab. Renata Łyszczek

Project 1. Influence of synthesis conditions on structure, thermal and spectroscopic properties of lanthanide-organic frameworks

Metal-organic frameworks are new class of porous materials constructed from metal ions and bridging organic ligands. These multidimensional coordination polymers are widely investigated due to their fascinating properties connected with robust and porous structures, unusual architectures and functional properties.
The Project consists of two main stages:
1) Synthsis of seleceted lanthanide complexes with 2,6-naphthalenedicarboxylic acid (as bridging ligand) in different conditions (precipitation method, solvothermal method and solvothermal technique with microwave heating).
2) Characterization of the obtained in the solid state compounds by using different methods (infrared spectroscopy ATR-FTIR, thermal analysis TG-DSC and TG-FTIR (analysis of gaseous products of decomposition), diffraction methods in purpose to determination their composition, structure and functional properties.

Department of Inorganic Chemistry

Dr hab. Monika Wawrzkiewicz

Project 1. Anion exchange resins for removal of acid, reactive and direct dyes from aqueous solutions and wastewaters

Wastewaters originating from the textile, cellulose, paper, chemical, tanning, food and cosmetic industries containing dyes are a hazardous source of natural environment contamination. Even small amounts of dye (of the order of a few ppm) are undesirable as they colour water making it look unaesthetic and disturb life processes in water. Most dyes do not undergo biodegradation, deteriorate light penetration into water and inhibit photosynthesis, increase chemical and biological demand for oxygen. Some dyes are toxic and sometimes even carcinogenic and mutagenic towards living organisms and they should be carefully removed.
Purification of wastewaters containing dyes becomes more and more important and is aimed at avoiding potential threat for the environment and legal consequences. Therefore decolourization of these wastewaters before their reaching water outlets is a

must. The research carried out so far show that application of various types of adsorption methods and sorbents in purification of wastewaters from dyes gives good economic effects, possibility of designing simple, modern and small energy consuming technological installations. Anion exchange resins satisfy the requirements for effective sorbents, among which the most important are: large sorption capacity towards most dyes, possibility of regeneration and large effectiveness independent of process conditions (pH, temperature, large range of dyes concentration). Application of anion exchangers makes it possible, not only to separate dissolved substances based on the selective interactions but also to concentrate impurities load to create a water circulation in the technological process.

The aim of the project included the studies leading to:

- establishment of interaction mechanism in the dye-anion-exchanger system depending on phase contact time, initial concentration of dye in the system, shaking rate, pH reaction, temperature as well as kind and concentration of auxiliaries (NaCl, Na_2SO_4, Na_2CO_3, CH_3COOH, surface active substances);
- determination of sorption kinetic parameters based on the pseudo-first order and pseudo-second order equations as well as determination of which process decides about sorption rate (intraparticle diffusion or film diffusion);
- determination of effectiveness of model and real textile wastewaters decolourization taking into consideration kind of used anion exchanger and phase contact time;
- determination of adsorption isotherms and corresponding parameters using different adsorption models;
- determination of the most effective reagent desorbing dye from the anion exchanger;
- calculation of working ion exchange capacities based on the column breakthrough curves;
- characterization of changes in the anion exchangers structure after sorption by registering infrared spectra.

Dr Anna Wołowicz

Project 1. Evaluation of heavy metal ions removal/recovery from acidic solutions using ion exchanger of a new generation

Extensive application of metallic compounds in industrial and agricultural sectors gives an inevitable rise of their emission and dispersion into the environment and on the other hand caused depletion of their reserves and natural resources. Therefore the removal and recovery of noble and heavy metals from wastewaters, by-product and metals-containing scrap materials is of special concern today. Among of physicochemical methods of removal and recovery of metal ions, the adsorption, ion-exchange and membrane filtration are the most frequently used for this purpose but one of the most effective is ion exchange.
The main object of this work will be development of the effective removal/recovery methods for selected metal ions e.g. Pd(II), Co(II), Ni(II), Zn(II), Cu(II) using a new generation of ion exchangers. The batch and column methods will be used and effect of

different experimental parameters will be taken into account. The ion exchanger characteristics and mechanism of metal ion sorption before and after sorption process will be done using a suitable methods. The kinetic, equilibrium and thermodynamic studies as well as the possibilities of metal desorption and ion exchanger reused will be also considered.