Basic Information:
Course Title: **COMPLEX FLUIDS**
Lecturer: Plamen Tchoukov, Ph.D., Assoc. Prof.
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Total Teaching Hours: 30 lecture hours

Annotation (up to 150 words)

The goal of the course is to introduce major developments and recent achievements in the interdisciplinary field of ComplexFluids, with emphasis on experimental and theoretical concepts and research methodology.

The course consists of two sections. The first section focuses on smart fluid systems containing finely tunable self-assembled nano- and microstructures. The lectures will present design principles of liquid formulations leading to well-defined bulk and interfacial complex species with tunable properties and various applications. Common research methods for their characterization will also be reviewed. The second section is devoted to microscopic thin liquid films as model systems for studying surface forces and the stability of foams, emulsions and colloidal suspensions, linking fundamental physicochemical knowledge with innovative applications.

The course is intended for PhD students, PostDocs and young researchers working in biophysics, biophysical chemistry, physical organic chemistry, polymers and biopolymers, liquid crystals, theoretical modeling of fluid media, and related fields.

Course content (brief description by topics or modules)

Part I. Amphiphilic molecules and self-assembly

Topic / Module 1: Introduction to complex fluids

- Definitions and classification
- Main types of complex systems: colloidal solutions, emulsions, foams, gels, polymer and biopolymer systems, liquid crystals.

Topic / Module 2: Amphiphilic molecules and self-assembly

- Structure and properties of amphiphilic molecules
- Hydrophobic effect and self-assembly
- Micelles, vesicles, and lamellar structures
- Critical micelle concentration (CMC) and methods for its determination

Topic / Module 3: Thermodynamics and Statistical Physics of Amphiphilic Systems

- **Free energy of self-assembly**
- Entropic and enthalpic contributions
- Intermolecular interactions
- Phase transitions and phase diagrams

Topic / Module 4: Experimental Methods for the Investigation of Complex Liquids

- Surface and interfacial tension
- Rheological measurements
- Light scattering (DLS/SLS)
- SAXS/SANS
- Microscopy methods (AFM, Cryo-TEM, CLSM)

Part II. Thin Liquid Films and Surface Forces

Topic / Module 5: Theory of Thin Liquid Films (TLF)

- Types of thin liquid films (TLFs)
- Thermodynamics of thin liquid films
- Hydrodynamics of thin liquid films
- Surface forces in thin liquid films: DLVO and non-DLVO forces
- Disjoining pressure isotherms and types of black films

Topic / Module 6: Microinterferometric Method for the Investigation of Thin Liquid Films

- Scheludko–Exerowa cell
- Modified cells for investigation of TLF
- Principle and schematic of the apparatus for TLF investigations

Topic / Module 7: Laboratory Exercise

- Preparation of foam films in a Scheludko–Exerowa cell
- Calculation of film thickness

Teaching and assessment methods:

Lectures / Individual study (in case of an insufficient number of students); Practical exercise. Assessment – Individual assignment and test.

Competencies acquired as a result of training:

Basic knowledge of amphiphilic molecules and their self-assembly in liquid media;
Knowledge of the main methods for the investigation of complex liquids;
Theoretical knowledge of the thermodynamics and hydrodynamics of thin liquid films (TLFs);
Practical skills for the preparation and investigation of foam films.

Literature:

1. Israelachvili, Jacob N. *Intermolecular and surface forces*. Academic press, 2011
2. Wennerström, H.; Evans, D. F. *The Colloidal Domain: Where Physics, Chemistry, Biology, and Technology Meet*; John Wiley & Sons, 2026
3. Butt, H.-J.; Graf, K.; Kappl, M. *Physics and Chemistry of Interfaces*; John Wiley & Sons, 2023
4. Exerowa, Dotchi, and Pyotr M. Kruglyakov. *Foam and foam films: theory, experiment, application*. Vol. 5. Elsevier, 1997

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