Prof. Luigi Gentile
Coordinatore Interclasse
tel. 080 544 2033 -
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SYLLABUS – L-30

General information		
Academic subject	***Physical Chemistry of Materials + laboratory of, Module B (Soft Matter)***	
Degree course	*Science and Technology of Materials L-30*	
Academic Year	*Third*	
European Credit Transfer and Accumulation System (ECTS)		5
Language	*Italian/English*	
Academic calendar (starting and ending date)	*II semestre*	
Attendance	*Only for Labworks*	

Professor/ Lecturer	
Name and Surname	Luigi Gentile
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Department and address	*Department of Chemistry, University of Bari "Aldo Moro", streat Edoardo Orabona, 4, Bari (Italy)*
Virtual headquarters	*Microsoft Teams (If necessary)*
Tutoring (time and day)	Contact by email to make an appointment (generally Tuesday and Wednesday afternoon)

Syllabus	
Learning Objectives	The aim of the course is to provide a solid preparation on the chemical composition and physicochemical properties of surfactants and polymeric materials in solution (Soft Matter). Furthermore, the relationships between the supramolecular structure and the micro-and/or macroscopic properties will be hightailed. From the experimental point of view, the students will be able to prepare surfactant solutions and use scientific instruments. At the end of the course, the students will be able to: (i) to use scientific methods: rheology, dynamic light scattering, and surface tension; (ii) to analyze data to characterize the structure and properties of materials.
Course prerequisites	*General Chemistry, Mathematical Analysis, Physical Chemistry, Physics I and II, Methods of data collection, representation, and analysis.*
Contents	**Materials.** **Regular solution theory**. The lattice model. Bragg-Williams approximation. Binodal decomposition (nucleation and growth); Spinodal decomposition and phase diagrams. **Amphiphilic molecules: surfactants**. Thermodynamics of self-assembly processes. Effect of surfactants on surface tension (with practice in lab). Aggregate formation and critical packing parameter of the surfactants (with practice in lab). Lyotropic liquid crystals: principles of thermodynamic equilibrium and the phase rule. Surfactant-water binary phase diagrams. Helfrich's energy as a measure of the bending (stiffness) of the phospholipid double layers. Amphiphilic molecules in modern industries: pharmaceutical, cosmetic and food as well as the detergent industries. **Microemulsion systems**. Fluid interfaces. Winsor I (oil-in-water, O/W), Winsor II (W/O) and Winsor III (bicontinuous) microemulsions. The failure of the critical packing parameter in the description of microemulsion systems.

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Colloidal stability. Attractive Van der Waals interactions; Determination of the Hamaker constant in colloidal systems; electrostatic interactions; DLVO theory and the stability of colloidal systems.
Polymer solutions. Polymer types; Random coil dimensions; Conformation of real polymers: persistence length and contour length. Polymer Solutions: Flory-Huggins theory; the lattice model with coordination number Z-2; configurational entropy. State diagrams: asymmetric miscibility gaps for polymer/solvent systems; different polymers are immiscible with each other; block copolymers. Solvent chemical potential: goodness of the solvent. Effect of polymers on colloidal stability. The molecular weight of a polymer is related to its intrinsic viscosity by the Mark–Houwink equation. The overlap concentration (C*) of polymer blobs and the molecular weight.
Experimental techniques and material properties.
Surface tension and surface phenomena: The molecular origin of the surface tension and the operational definition; Wettability and Young's Relationship; Relationship between the critical micellar concentration (cmc) and the surface tension.
Diffusion: Fick's laws of diffusion; Stokes-Einstein equation; Permeability coefficient; Random walk; Static and dynamic light scattering; Diffusion coefficient measurement by Dynamic Light Scattering (with practice in lab).
Scattering: Small angle X-ray and Neutron scattering; Form factor and structure factor; Determination of the gyration radius; Relationship between the gyration radius and the hydrodynamic radius (the latter obtained from the diffusion measurements).
Rheology: The laws of elasticity (Hooke's law) and viscosity (Newton's law); Plastic and pseudo-plastic materials; Viscoelastic fluids; Maxwell's element. Rheological spectroscopy: principle of measurement, meaning of elastic, G', and viscous, G'', moduli and the characteristic time of the material. Characteristic trends for unbranched and cross-linked gel solutions. Newtonian fluids, non-Newtonian fluids, Einstein equation, non-ideal rheological behaviors (Bingham, shear thickening, shear thinning; thixotropy), rheological modifiers. Reptation theory for polymeric solutions.
Laboratory experiences.

The regular solution theory to construct state diagrams (computational).
The measurement of the surface tension of a surfactant to determine cmc and area per polar head.
The hydrodynamic radius determination of micelles from dynamic light scattering (DLS) measurements and the effect of size and aggregation on the rheological properties.
Monitoring of micelle shape transitions with the combined use of DLS and rheology (with comparison between rheometer and vibrational viscometer).

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<tr><td>Books and bibliography</td><td>Colloidal Foundations of Nanoscience, Eds. D. Berti, G. Palazzo, Elsevier, Amsterdam, 2014, pp.33-46;</td></tr>
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	Evans, F.; Wennestrom, H. In The Colloidal Domain: Where Physics, Chemistry, Biology, and Technology Meet, 2nd ed.; Wiley-VCH, 1999 *Israelachvili, J.N. In Intermolecular and Surface Forces, 2011*
Additional materials	

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
125	*32*	*15*	*78*
ECTS			
5	*4*	*1*	
Teaching strategy			
	Effective Multimedia Lecture Slides. Laboratory work is planned for small teams of students (group work). The lectures might be delivered in blended learning mode (mixed, frontal and distance teaching) based on contingent needs. The laboratory part will not be delivered in e-learning mode.		
Expected learning outcomes			
Knowledge and understanding on:	○ Colloids, polymers and surfactants ○ A basic theoretical framework to describe soft material properties (DLVO, Flory-Huggins, etc…) ○ Experimental techniques to characterize materials		
Applying knowledge and understanding on:	○ Correlation function analysis to determine diffusion coefficient and hydrodynamic radius (with practice in lab) ○ Analysis and interpretation of frequency sweep and flow curve in a qualitative and quantitative manner (with practice in lab) ○ Strategies to stabilize colloidal systems		
Soft skills	• Making informed judgments and choices ○ To analyse collected data during laboratory experience ○ Students engaged in “science talk” during laboratory activities. • Communicating knowledge and understanding ○ Students should be able to communicate their laboratory experience results in a proper written way. ○ Students should be able to communicate properly the theoretical concepts during the oral exam. • Capacities to continue learning ○ Analysis and interpretation of the acquired scientific data		

Assessment and feedback	
Methods of assessment	*Oral exam (70%) and evaluation of the laboratory reports (30%)*
Evaluation criteria	• *Knowledge and understanding* ○ Minimum level to pass the exam: lyotropic liquid crystalline and microemulsions phases e their main properties. ○ Intermediate level: states of aggregation of amphiphilic molecules in solution. ○ Advanced level: to predict packing state of the amphiphilic molecule (critical packing parameter and spontaneous curvature). To correlate supramolecular structure with macro and microscopic properties. The effect of the oil phase. • *Applying knowledge and understanding* ○ Minimum level to pass the exam: methods to study physicochemical properties of materials.

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	○ Intermediate level: correlated experimental data with the investigated supramolecular structures. ○ Advanced level: to identify phase behaviour and supramolecular structures from experimental data adopting scientific theories. To develop simple scripts (for instance Matlab) to analyse scientific data • *Autonomy of judgment* ○ Skills and abilities to carry out bibliographic researches and to find data. • *Communication skills* ○ All levels: Communication skills to clearly and proper explain scientific topics • *Capacities to continue learning* ○ During the exam, there will be questions to verify abilities to make connections.
Criteria for assessment and attribution of the final mark	Assessment of the experimental practice and methods (through laboratory reports) and theoretical notions (through an oral exam). To integrate chemistry, physics, and mathematics with respect to the program carried out will be assessed. Italian grading system: a scale ranging from 0 to 30, with 18 as a passing mark. A cum laude may be added to the highest grade (30 e lode), as a special distinction. From 1 to 17 → Students is not able to provide a basic description of the materials and techniques discussed during the course From 18 to 24 → Students are able to provide a basic view on materials and techniques From 25 to 27 → Students are able to provide a good description of the materials and techniques by using proper theoretical framework. From 28 to 30 cum laude → Students are able to provide an advanced description of the materials by using correlation between theories and data collected during experimental activities.
Additional information	