face-to-face Intensive Course on

RHEOLOGY OF DISPERSIONS

Principles and applications

Professor Tharwat Tadros

16-17-18th September 2013

Institute of Advanced Chemistry of Catalonia (IQAC-CSIC)
Jordi Girona, 18-26 – Barcelona 08034

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD · CSIC Consejo Superior de Investigaciones Científicas · IQAC Institut de Química Avançada de Catalunya · CENTRE QCI Química Col·loidal i Materials Avançats · TECNIO Be tech. Be competitive

RHEOLOGY OF DISPERSIONS

Principles and Applications

This intensive course is designed for research workers and professionals working with pharmaceuticals, paints, agrochemicals, personal care and cosmetics, printing inks, paper coatings, ceramics and detergents. It is targeted at formulation chemist, chemical engineers and research workers engaged in rheology of dispersions in both industrial and academic laboratories.

This course on rheology of dispersions, principles and applications, deals with the rheology of the solid/liquid (suspensions) and liquid/liquid (emulsion) types, rheology of thickeners and gels. The course will start with an introduction on the basic principles of rheology both steady state and oscillatory techniques. The various rheological parameters are clearly defined. Particular attention will be given to viscoelasticity and the models that can be used to describe it. The experimental techniques that can be applied for measurement of the various rheological parameters will be described. Lab demonstrations and experimental techniques are described to the candidates attending the course. The course deals also with concentrated systems and formation of three dimensional structural units. The rheology of concentrated suspensions, both stable and unstable systems is described. The rheology of emulsions will also be described with particular reference to interfacial rheology. Rheology modifiers of polymers, gels and particulate solids are described and their rheological behaviour is discussed.

COURSE OUTLINE

Monday, 16th September 2013

9:30	-	11:00	**Introduction and Definition of Rheology – Steady State Principles** Definition of stress, strain and strain (shear) rate. Types of rheological behavior in simple shear. Models for flow behavior: Hooke's and Newtonian Models. Non-Newtonian flow and models that can be used to analyze the flow curves. Time effects during flow: Thixotropy and negative thixotropy. Elastic overshoot and rheopexy.
11:00	-	11:30	Coffee break
11:30		13:00	**Viscosity Measurements – Steady State Regime** Measurement of viscosity as a function of shear rate. Capillary viscometers. Measurement of intrinsic viscosity for polymers. Capillary viscometers for non-Newtonians. Rotational viscometers: Concentric cylinder (Couette), Cone and plate, Parallel plate. The vane rheometer. The Brookfield viscometer and calculation of shear rate.
13:00	-	14:30	Lunch break
14:30	-	17:30	**Lab Demonstrations and Measurement Techniques**

Tuesday, 17th September 2013

9:30	-	11:30	**Viscoelastic Behavior** The Deborah number. Strain relaxation after sudden application of stress (creep). Analysis of creep curves. Viscoelastic liquids and viscoelastic solids. Mechanical models for describing viscoelasticity. Stress relaxation after sudden application of strain. Dynamic (oscillatory) techniques. Distinction between elastic, viscous and viscoelastic behavior. Analysis of oscillatory response for a viscoelastic system. Strain and oscillatory sweep for viscoelastic liquid and viscoelastic solid. The cohesive energy density concept.
11:30	-	12:00	Coffee break
12:00	-	13:00	**Viscoelastic Measurements** Constant stress (creep) measurements and the procedure required. Stress relaxation measurement and its procedure. Oscillatory measurements. Shear modulus measurement. Commercially available instruments.
13:00	-	14:30	Lunch break
14:30	-	17:30	**Lab Demonstrations and Measurement Techniques**

Wednesday, 18th September 2013

9:30	-	11:00	**Concentrated Systems and Formation of Three-Dimensional Structural Units** Volume fraction for ''dilute'', ''concentrated'' and ''solid'' suspensions. Interparticle interaction : Hard-sphere, ''Soft'' (electrostatic), Steric and van der Waals. Combination of interaction forces and theories of colloid stability. States of suspensions on standing and formation of three-dimensional structure units.
11:00	-	11:30	Coffee break
11:30	-	13:00	**Rheology of Suspensions** Dilute suspensions and the Einstein equation. Moderately concentrated suspensions with hydrodynamic interaction and the Bachelor equation. Rheology of concentrated suspensions and the Deborah number. Hard-sphere suspensions – Systems with double layer repulsion – Sterically stabilized suspensions – Flocculated systems. Rheological behavior of each system. Influence of polydispersity on rheology of suspensions. Examples of each system and their rheological response. Weakly flocculated suspensions. Strongly flocculated suspensions and analysis of their flow curves. The elastic floc model. Fractal concept of flocculation.
13:00	-	14:30	Lunch break
14:30	-	16:00	**Rheology of Emulsions** Interfacial rheology: Interfacial tension and surface pressure. Interfacial shear viscosity and its measurement. Interfacial dilational elasticity and its measurement. Interfacial dilational viscosity and non-Newtonian effects. Correlation of emulsion stability with interfacial rheology. Bulk rheology of emulsions and effect of disperse droplet viscosity. Experimental viscosity-volume fraction curves. Influence of droplet deformability on emulsion rheology. Viscoelastic properties of concentrated emulsions.
16:00	-	16:30	Coffee break
16:30	-	18:00	**Rheology Modifiers, Thickeners and Gels** Classification of thickeners and gels. Definition of a gel. Rheological behavior of gels: Stress relaxation after sudden application of strain – Constant stress (creep) measurement. Viscoelastic solid and viscoelastic liquid response for gels. Dynamic (oscillatory) measurement of gels. Classification of gels: Polymer gels – Solid particulate materials – Gels based on liquid crystalline structures of surfactants. Polymer gels: obtained by chain overlap. Gels produced by associative thickeners (hydrophobically modified water soluble polymers). Examples of associative thickeners and their rheological behavior. Influence of surfactants on the rheology of associative thickeners. Viscoelastic behavior of associative thickeners. Cross-linked gels. Particulate gels: based on long range repulsion or van der Waals attraction. Examples of swellable clays and finely divided silica. Organo clays (Bentones). Rheology modifiers based on surfactant systems.

COURSE DIRECTOR: PROFESSOR THARWAT TADROS

Tharwat Tadros was a senior research associate at ZENECA, formerly division of Imperial Chemical Industries (ICI). He was the leader of fundamental and applied research in the field of colloid and interface science. In the mean time he held positions as visiting Professor at Imperial College (London), Bristol and Reading Universities. This allowed him to supervise many Ph.D. students and post doctoral fellows. Presently, he works as a consultant in various applied fields of Colloid and Interface Science. He is actively engaged in research work in various disperse systems, including surfactants, suspensions, emulsions, nano-emulsions, nanodispersions, microemulsions, wetting spreading and adhesion and various multi-phase formulations (in the fields of surfactants and their phase behavior, personal care and cosmetics, agrochemicals, pharmaceuticals, disperse pigments, etc.). In particular he studies the properties of concentrated dispersions and their rheological behavior. He also performs research work in the field of adsorption with particular reference of polymeric surfactants. Application of polymeric surfactants for stabilization of emulsions, suspensions and nano-emulsions is one of his most recent research. Tadros gives training courses in various colloid and interface science fields in several institutions and industrial laboratories. He is the author of more than 300 papers and has edited several books on polymer adsorption and dispersion stability, surfactants, solid/liquid dispersions and polymers in colloid systems. He has written a book on surfactants in agrochemicals in 1994. More recently in 2005 he wrote a comprehensive text of applied surfactants. He has also written four books on ''Colloids in Agrochemicals'', ''Colloids in Paints'', ''Rheology of Dispersions'', ''Dispersion of Powders in Liquids'' (All published by Wiley-VCH, Germany) Dr Tadros is an Emeritus editor of Colloids and Surfaces and an Honorary editor for Advances in Colloid and Interface Science. He is now editor for two series published by Wiley-VCH: Colloid and Interface Science Series (six volume published) – Topics in Colloid and Interface Science with two volume published and one in preparation). He is also an Editor-in-Chief of ''Encyclopaedia in Colloid and Interface Science'' that will be published by Springer (Germany) during 2013. Dr Tadros was elected President of the International Association of Colloid Scientist in 1992. Due to his distinguished research, he has been awarded two medals from the Royal Society of Chemistry in the UK.

REGISTRATION

Registration fee: 400€ (includes attendance at all lectures, course documents and coffee breaks).

To register, please send an e-mail to **centreqci@iqac.csic.es** with your personal and company details and you will receive the payment details.

For all your queries, please contact us at:

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VENUE

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