EMULSION AND NANOEMULSION
SCIENCE AND TECHNOLOGY

October 24–26, 2016
Malmö – Sweden

The Öresund bridge, Malmö–Copenhagen

CALMIA
EDUCATION CENTER

EMULSION AND NANOEMULSION

SCIENCE AND TECHNOLOGY

Emulsion and Nanoemulsion formation
Selection of emulsifiers
Emulsion and Nanoemulsion stability

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Course outline

Introduction
The definition and classification of emulsions. Definition of nanoemulsions and their advantages. Industrial applications of emulsions and nanoemulsions

Physical Chemistry of Emulsion and Nanoemulsion Systems
The interface and Gibbs dividing surface. Definition of interfacial tension and effect of curvature. Thermodynamics of emulsion formation and breakdown. Role of the stabilizer (emulsifier).

Interaction Energies Between Emulsion Droplets and their Combination
Van der Waals attraction. Double layer repulsion. Steric repulsion. Combination of van der Waals attraction and double layer repulsion (theory of colloid stability). Combination of van der Waals attraction and steric repulsion (theory of steric stabilisation).

Adsorption of Surfactants at the Liquid/Liquid Interface
The Gibbs adsorption isotherm and calculation of surfactant adsorption. Surfactant molecules orientation and effect of alkyl chain length and head group. Measurement of interfacial tension.

Mechanism of Emulsification
Energy required for expanding the interface and the role of the La Place pressure. Representation of the processes occurring during emulsion formation. Methods of emulsification. Mixers and high pressure homogenisers. Laminar and turbulent regimes.

Role of Surfactants in Emulsion and Nanoemulsion Formation
Surfactant adsorption and droplet size. The role of the interfacial dilational modulus. Interfacial tension gradients and droplet formation. The Gibbs-Marangoni effect and prevention of coalescence during emulsification.

Selection of Emulsifiers – The HLB and PIT Concepts
The hydrophilic-lipophilic balance (HLB). Calculation of the HLB number from surfactant composition. Davies approach of group numbers to calculate the HLB number. The phase inversion temperature (PIT) concept and its relation to the HLB number.

The Cohesive Energy Ratio (CER) and Critical Packing Parameter (CPP) Concepts for Emulsifier Selection
The Winsor R concept. Calculation of the interaction parameters from Hildebrand solubility parameters and Hansen concepts. Calculation of the critical packing parameter (CPP) from surfactant geometry. The CPP for spherical, cylindrical and lamellar micelles and its relation to the type of the emulsion formed.

Creaming or Sedimentation of Emulsions
The driving force of creaming or sedimentation. Calculation of creaming or sedimentation rates for dilute and moderately concentrated emulsions. Effect of disperse volume fraction on the creaming or sedimentation rate. Prevention of creaming or sedimentation.

Flocculation of Emulsions
Balance of attractive and repulsive forces. Flocculation of electrostatically stabilised emulsions. Fast and slow flocculation rates and the stability ratio. Flocculation of sterically stabilised emulsions. General rules for reduction of flocculation.

Ostwald Ripening of Emulsions and Nanoemulsions
Driving force for Ostwald ripening and dependence of solubility on droplet size. Reduction of Ostwald ripening by addition of highly insoluble oil phase and strongly adsorbed polymeric surfactant.

Emulsion Coalescence

Driving force for emulsion coalescence. Thinning and disruption of liquid film between the droplets. The concept of disjoining pressure for prevention of coalescence. Reduction or elimination of coalescence.

Phase Inversion of Emulsions

Catastrophic phase inversion produced by increasing the volume fraction of the disperse phase. Transitional phase inversion by changing the hydration of the surfactant on increasing temperature and/or addition of electrolyte.

Preparation of Nanoemulsions

Use of high pressure homogenisers. Application of phase inversion methods for production of nanoemulsions (low evergy emulsification). The phase inversion composition and phase inversion temperature concepts. Preparation of nanoemulsions by dilution of a microemulsion.

Steric Stabilisation and the Role of the Adsorbed Layer Thickness in Nanoemulsion Stability

Unfavourable mixing of hydrated adsorbed non-ionic surfactant or polymer layers (mixing interaction). Elastic (entropic interaction on adsorbed layer overlap. Total energy of interaction and importance of the adsorbed layer thickness in reducing the attraction minimum in the energy-distance curve. Explanation of the high kinetic stability of nanoemulsions.

Practical Examples of Nanoemulsion Systems

Nanoemulsions prepared using non-ionic surfactants and their preparation using the PIT concept. Effect of oil solubility on Ostwald ripening rate. Reduction of Ostwald ripening by incorporation of highly insoluble oil such as squalane. Nanoemulsions prepared using polymeric surfactants and their role in reduction of Ostwald ripening.

Eperimental Methods for Assessment of Emulsion and Nanoemulsion Stability

Determination of droplet size distribution of emulsions using optical microscopy, confocal laser microscopy and light diffraction techniques. Characterisation of concentrated emulsions using back scattering methods. Determination of droplet size distribution of nanoemulsions using dynamic light scattering (photon correlation spectroscopy, PCS). Assessment of creaming or sedimentation, flocculation, coalescence and phase inversion of emulsions.

Course Description

The formulation of emulsions and nanoemulsions, selection of emulsifiers, the stabilisation of emulsions and nanoemulsions and the control of their properties on application represent a challenge to most industries. It is essential to understand the physical chemistry of emulsions and nanoemulsions as well as the interaction forces between the emulsion droplets. The adsorption of surfactants at the liquid/liquid interface determines the interaction forces between the droplets as well as the mechanism of the process of emulsification. The various techniques that can be applied to prepare emulsions and nanoemulsions must be described at a fundamental level. The role of the emulsifier in determining the quality of the system must also be understood. The methods that can be applied for selection of the emulsifier must be described in order to achieve the desirable property of the system and its application.

This course starts by describing the various emulsion systems and the advantages that can be gained by formation of a nanoemulsion. Various lectures describe the processes of creaming or sedimentation, flocculation, Ostwald ripening, coalescence and phase inversions. The methods that can be applied to prevent the breakdown of the emulsion are described at a fundamental level. The methods that can be applied to prepare nanoemulsions are described. These range from application of homogenisers (high energy emulsification) to phase inversion techniques that allows one to produce the nanoemulsion by low energy methods. The high kinetic stability of the nanoemulsion is described in terms of the steric repulsion and the role of the adsorbed layer thickness. Some practical examples of nanoemulsions prepared using non-ionic surfactants or polymers are given. Finally the methods that can be applied for assessment of the physical stability of emulsions and nanoemulsions are briefly described.

The above course will be valuable for formulation chemists and chemical engineers involved in the preparation of emulsions and nanoemulsions. This covers a wide range of industries such as the food industry, cosmetics and personal care, paints, agrochemicals, detergents, etc. The course will also be valuable for researchers involved in research on emulsions and nanoemulsions.

Course lecturer

Prof. Tharwat Tadros

Tharwat F. Tadros obtained his Ph.D in 1962 at Alexandria University after which he was appointed to a lectureship in Physical Chemistry at that university. Between 1966 – 1969 he spent a sabbatical leave in the Netherlands to continue his research in colloid and interface science. Between 1969 - 1994 he worked at I.C.I. and ZENECA to lead a group of fundamental research in Colloid and Interface Science. He reached the highest scientific appointment of Senior Research Associate. In the mean time he was appointed visiting professor at Imperial College (London), Bristol and Reading Universities. In these 25 years he carried out research in various fields of surfactants, polymer adsorption and stability, emulsions, nanoemulsions, microemulsions, concentrated dispersions and rheology. He supervised many Ph.D students and postdoctoral research fellows. In 1992 he was elected President of the International Association of Colloid Scientists (IACIS).

Tharwat Tadros is the author, or a co-author, of around 290 published papers. He has edited nine books, and authored seven other books: “Surfactants in Agrochemicals” (1994), “Applied Surfactants” (2005), ‘’Colloids in Agrochemicals’’ (2009), ‘’Colloids in Paints’’ (2010), “Rheology of Dispersions” (2010) and ‘’Dispersions of Powders in Liquids’’ (2012), ‘’Formulation of Disperse Systems’’ (2014). He was editor of two series published by Wiley-VCH: “Colloid and Interface Science Series” (6 volumes set, published in 2006 - 2010) and “Topics in Colloid and Interface Science” (3 volumes, 2008 - 2013), as well as of the book “Self-Organized Surfactant Structures” (2011). In 2013 he edited the ‘’Encyclopaedia of Colloid and Interface Science’’ that was published by Springer in Germany. He has been Editor-in-Chief for “Colloid and Surfaces A” and for “Advances in Colloid and Interface Science” (both published by Elsevier).

Since leaving ZENECA, Tharwat Tadros worked as a consultant for various industries and has taught several courses in his specialized fields. He is still co-supervising many Ph.D. students at various Universities. Due to his distinguished research he was awarded two medals by the Royal Society of Chemistry (UK).

Course Fee and Payment

EUR 1800 (Discounted fee* EUR 1600)

**Discounted Course fee is valid for two or more enrolments from the same company, at the same time, for the same course. And for enrolments from Universities and Government Institutes.*

The course fee includes: Tuition, copies of all Power Point presentations, certificate and meals. Two Lunches, beverages at breaks and course Dinner the first day.

All registrations will be confirmed with a course schedule and some practical information.

We will send an ***Invoice*** to the amount of the Course Fee.

Accommodation is not included in the course fee.

VAT (Moms) will be added for applicants domicile in Sweden.

Course Location and Hotel

The course is held at

Radisson BLU Hotel, Malmö–Sweden

October 24–26, 2016

To obtain the reduced price for accommodation, reservations must be made through Calmia.

Weekday nights
SEK 1395 (about **EUR 150**) for a single or double room per night incl. breakfast and VAT.
Nights between Saturday/Sunday/Monday
SEK 950 (about **EUR 103**) for a single or double room per night incl. breakfast and VAT.

Radisson BLU Hotel
Östergatan 10
211 25 Malmö, Sweden
Tel. +46-40-698 4000
www.radissonblu.com/hotel-malmo

Transport Information

Copenhagen Airport, Kastrup, is the nearest international airport. There are trains running several times each hour (20 min. journey) from Copenhagen Airport to Malmö Central Station. The course location is only 5–10 min. away from the station in Malmö. The airport bus from Malmö Airport, Sturup, stops outside the station in Malmö.

Course Time Table

Registration on Monday at 08:30–8:45
The course ends on Wednesday about 16:00

How to register

- **On-Line registration**
  www.calmia.se
- **Mail**
  A Registration Form can be printed from each PDF-file

Registration must be made before September 24, 2016

Substitutions are allowed at any time from the same company or institute.

Cancellation

No refunds will be made for those who do not attend the scheduled course and/or cancel after September 24, 2016.

Questions

For General questions please contact:
Mrs G Tånge-Henderson
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For Scientific questions please contact:
Prof. Tharwat Tadros
Tharwat@Tadros.fsnet.co.uk

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Registration Form

Registration before September 24, 2016

Please print!

The number of participants is limited.

I wish to attend the course:

EMULSION AND NANOEMULSION SCIENCE AND TECHNOLOGY
October 24–26, 2016
Malmö – Sweden

Reserve on my behalf accommodation at the Radisson BLU Hotel in Malmö

From (date) ___________ To (date) ___________ Number of nights: _________

☐ Single room ☐ Double room ☐ Late arrival (after 18:00)

The hotel bill should be paid directly to Radisson BLU Hotel on the day of departure

Surname ______________________________

Given Name ______________________________

Job Title ______________________________ ☐ Ms ☐ Mr

Company/Institute ______________________________

Address ______________________________

Country ______________________________

Tel/fax ______________________________ E-mail ______________________________

Purchase Order number ______________________________ (If required by your company)

Invoice address if different from the one above:

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