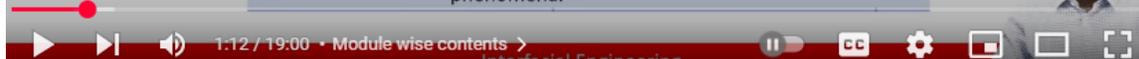


Introduction



Module 1	Introduction: Colloid and Surface Chemistry Introduction to interfaces, importance of surface for small particles
Module 2	Capillarity and surface tension Basic concept of capillarity and surface tension; contact angle; Young-Dupre equation; Laplace equation; Kelvin equation
Module 3	Surfactants & Micelles Introduction, surface excess quantities, Gibbs adsorption isotherm equation, Spreading of surfactant on aqueous surfaces, CMC, micro emulsions.
Module 4	Liquid-Solid interfaces Colloidal dispersions; The properties of colloidal dispersions; Emulsions, Emulsion stability and selection criteria; Van der Waals, Electrical double layer and DLVO forces of interactions; Electrokinetic phenomena.



So, the module 1 will be mainly dealing with, you know, introduction to interfaces, okay, and we'll try to emphasize on importance of surface, okay. So, you know, coming from, you know, I mean, right from the macro objects and to the Nano objects, Nano sized object, how surface plays a vital role, okay, so those aspects we will try to cover in the module one we will try to give you enough examples applications, you know, so that we can motivate you further on this topic and the module two is all about the capillarity and surface tension. We will first start with the basic concept of capillarity and surface tension.

We will try to understand more about the surface tension and three-phase contact angle. Three-phase contact angle and surface tension both go together simultaneously. So, we will also talk about various techniques that measure the three-phase contact angle if surface tension is known or surface tension if three-phase contact angle is known. And after that we will also look at you and know many of the, you know, popular equations that we deal with in this topic. For example, Young-Dupré equation and its application. Laplace equation, again the application of Laplace equation is what known as Kelvin equation. So, those aspects we will try to cover in the module 2. Then we will move on to module 3. In module 3, we will look at mainly look at surfactants and micelles.

We also call micelles as association colloids because micelles are nothing but aggregation of surfactants as a self-assembled to form micelles. They generally exist, you know, the size varies between, let's say a few nanometer to, I mean, a few tens of nanometer up to hundred nanometer. So, such aggregate structure is also called as association collides. So, we mainly deal with surfactants and micelles and we start with introduction and then we will try to give enough insight into what is known as surface

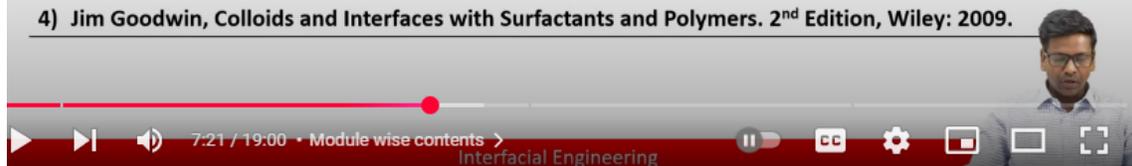
excess quantities. There is something called a positive surface excess, negative surface excess, right? And what are their consequences? We will see them and after that, we move on to Gibbs adsorption isotherm equation, a very famous equation. This gives you the relationship between the chemical potential and surface tension. We will look at that after the surface excess quantity.

Then we will slowly move on to, you know, the tendency of surfactant that goes in absorbing the interfaces you know then that brings an important topic called CMC which is critical micellar concentration so we will understand how one can measure CMC for various substrations, okay, we will also discuss various techniques that you can use to identify or to measure the CMC, after that we will try to cover what is known as micro-emulsions, okay micro nano emulsions are emerging topics within this, you know, interfacial engineering domain, the last but not least is the little solid interfaces, here we will start with colloidal dispersions you know basic concepts behind colloidal dispersions then the properties of colloidal dispersions how by tuning the properties of colloidal particle you can even change the quality of dispersion, emulsions, emulsion stability criteria and those aspects. After that we will also look at different types of forces. For example, what is known as Van der Waals force, DLVO force and electrical double layer interaction and all that. The last but not least in this model is electro-kinetic phenomena. In this chapter, topic, we will also provide enough insight into what is known as zeta potential, how it is different from surface potential and what technique can be used to understand the zeta potential of any given colloidal system when you disperse them into any known medium, usually aqueous medium. And we will also look at various models that are available to describe the distribution of the potential as a function of the distance from the object. And with this I think we will complete important aspects of interfacial engineering starting from module 1 up to module 4.

(Time: 07:21)

Suggested reference materials:

- 1) Geoffrey Barnes and Ian Gentle, *Interfacial Science: An Introduction*. 2nd Edition, Oxford University Press: 2011.
- 2) Paul C. Hiemenz, Raj Rajagopalan, *Principles of Colloid and Surface Chemistry*. Marcel Dekker, Inc.: 1997.
- 3) Jacob N. Israelachvili, *Intermolecular and Surface Forces*. 3rd Edition, Academic Press, London: 2011.
- 4) Jim Goodwin, *Colloids and Interfaces with Surfactants and Polymers*. 2nd Edition, Wiley: 2009.



Now, I would like to discuss the various reference materials that are available. For example, Geoffrey Barnes and Ian Gentle. This is a textbook on interfacial science itself. And this book contains almost all the modules or topics that we discussed throughout this course. So, it can be used as a textbook and then we will also look at what does one can refer to as Hiemenz and Raj Rajgopalan book. The title of the book is Principles of Colloid and Surface Chemistry.

Then comes Jacob, N. and Israelachvili, *Intermolecular and Surface Forces*. This is a very important book when you want to understand the fundamentals of intermolecular and surface forces. It is a very popular book, and it provides all required fundamentals behind the intermolecular and surface forces. The last but not least is the book authored by Jim Goodwin. And this book is entirely especially for if you want to understand surfactants, polymers a little more in detail. and collides with a little more in detail you can always refer to this book, okay, so these four books are, you know, can be referred to as we, you know, cover these as we move along with this course, right,

(Time: 09:03)

Introduction



What is an interface?

- It is the boundary between two phases where the properties of the material differ from those of adjoining phases.
- Usually constituted by two immiscible fluids - liquid-gas, liquid-liquid or liquid-solid.
- MD simulations prove that the thickness of the liquid-liquid is $\approx 1\text{nm}$.
- However, thickness of some polymer-polymer interfacial region is few tens of nm.

Applications of interfacial phenomena	
Chemistry	Adsorption, chromatography, ion exchange, membrane-based separation, etc.
Chemical Industries	Adhesives, beverages, catalysis, cosmetics and personal care products, dairy products, emulsions, etc.
Environmental science	Aerosols, cloud-seeding, fog, sewage treatment, water purification, etc.
Imaging technology	Flat-panel display, printing ink, etc.
Petroleum engineering	Floatation, oil recovery, ore enrichment, etc.

Interfacial energy is one of the important parameters. E.g., γ of water-air is 72 mN/m while the γ of water- CCl_4 is 45 mN/m at same temperature.

γ of PEO
– dextran is 1

Interface may control transport between the phases, e.g. Liquid-Liquid extraction, heterogeneous catalytic reaction.



So next i would like to give you a short introduction, first let's understand what is an interface, let's ask the question what is an interface, okay, so interface is just it's nothing but a boundary that separate two adjoining bulk phases for example let's say we have what is known as air water interface here air is one bulk phase and water is another bulk phase, the boundary that separates these two bulk phases is called interface, usually, interface is constituted by two invisible fluids example liquid gas, foam is a very good example for such application then we have liquid-liquid interface for example if you are placing any alkane let us say oil on water it is an invincible mixture so this water and oil being a liquid-liquid mixture, we call such system is also in such system also will, you know, will exhibit interface, a boundary in between. And we have liquid-solid interface.

This example is, you can take an example of colloidal dispersion where you have solid and liquid boundary and, you know, that essentially deals with liquid-solid interfacial phenomena. So we have various liquid-solid, you know, fluid fluid interfacial aspects so one can depending on the application one can understand, you know, further in detail ,usually the alkane and water system let's for example any alkane let's say you have hexane and water or decane and water usually the the boundary you know although we could see the boundary to naked eye, the thickness of the boundary, the interfacial zone usually very very small in dimension usually in nanometer level, okay, it was using MD simulations also people have predicted the thickness of the liquid liquid interface boundary which is usually between - one nanometer typically you know goes up to few nanometer okay, and to also motivate you further, you can take any other further you can take an example of let's say instead of water- oil interface system if you take water- water interface, for example let's say i take a polymer two invisible or two incompatible - incompatible polymers which means that I dissolve polymer type A in water and polymer

type B in water and if I mix them together that also exists in two phase okay so you will get two immiscible mixtures okay, interestingly what is the thickness of this boundary when it comes to water- water emulsion, people have predicted measured that it is a few tens of nanometer okay so It is a very interesting fact, right? For alkyl water, it is very low, but for water in water system, it is quite high, right? And I want to throw some of the numbers so that you can relate quickly yourself. Say, for example, what is the interfacial tension of air-water system, okay? It is 72 milliNewton per meter. What if I replace air with carbon tetrachloride? In that case, the interfacial tension, itself changes drastically, that is 45 mN per meter. So, the change is due to the various intermolecular interactions between different types of molecules.

So, that essentially tells the importance of the interfacial phenomena. Okay, so I have listed, so I have also given highlighted here, you can also see here, that what is the, you know, the interfacial tension of, let us say if I repair two different polymer, I mean water-water system, water in water emulsion or two different polymer systems, let us say PUO in water and dextran in water. they also phase separate, you can also, you know treat them as a any system like water oil and water alkane system, you see the interfacial tension of such system is one micro Newton per meter which is at least three to four orders lower than any alkane water system, okay, so this essentially tells about the, you know, importance of interfacial system, one has to study why one has to study uh interfacial phenomena, right, uh so i listed several application to motivate you probably you can uh, you know, go through this uh application, uh you know, whatever i have listed here ,right uh.

(Time: 14:26)

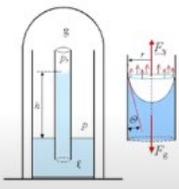
Motivation

Why should we study interface phenomena?

➤ It is a inter-disciplinary subject that deals with the surfaces and the related phenomena.

Some examples of interfacial phenomena

Xylem tissue consists of a variety of water-conducting cells.



Capillary rise

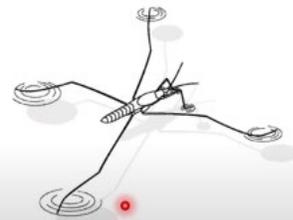


Spider web

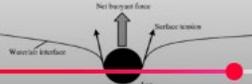
Spinneret glands produce sticky threads

Tensile strength of spider is stronger than the same weight of steel and has much greater elasticity.

The legs have tiny hairs that repel water and capture air



Water strider



14:26 / 19:00 • Interfacial phenomena >

Interfacial Engineering

Mark M. Denney et al. | Journal of Experimental Biology

So, here I would like to motivate you further by discussing some of the naturally occurring interfacial phenomena which we often see in our day-to-day life. The first one is capillary rise. If you can see that the water rises through the capillary column the level of the water goes up and this is actually due to the surface tension between the water and the surface and this capillary effect is also seen in many natural system like plant or even the trees, there the water which is collected at the root level ,is conducted from the root and then it is distributed through the root and distributed to all the branches and leaves is because of this capillary effect through the xylem tissue.

The xylem tissue consists of a variety of water conducting cells. Each cell is acting like a capillary tube in itself and those actually conduct water and then it supplies all the water up to the branches and leaves of the tree okay this is very important phenomena and after that we look at the spider web, how spider builds this form uh is basically uh because i mean basically uh using the sticky threads that it generates through its gland ,so nature offers them, a gland which actually generates the sticky threads ,okay, and the beauty of this thread is, you know, the inter it actually manifests both intermolecular and intramolecular interaction okay so between the junction the sticky thread provides very good you know there is a strong interaction between the thread among among the thread itself at the same time, this web is not just hanging in the air, right it is also connected to the surface so it also share the strong intermolecular attraction between the thread and the surface because of which the spider web exists. It is a good example of both inter as well as intermolecular interaction. The last one is the water strider. How insects walk on the water? It is because of what is known as the tiny hairs that exist around its legs and that repel water and capture air because it captures more air molecules in the pockets, they actually generate net ion force and because of which the insects can overcome the gravity and any other force that acts downward and due to that the rocks can freely walk on the surface right so this is a good example of interfacial system and there are several examples one can give you know the tears of wine is because of the Marangoni effect, The drop of water, when you stop the flow of water, there is a water drop that tends to, you know, deny, I mean, it doesn't fall easily.

(Time: 17:50)

Motivation: Some common interfacial phenomena



Tears of wine: [Marangoni effect](#)

Flow due to Surface-tension gradient



Drop of water: Surface tension effect

[The life of a bubble](#)



It's because of the surface tension effect. Once the droplet grows in size, once the gravity becomes dominant, it overcomes the surface tension force then this droplet falls down so this effect is surface tension effect and the tears of wine you would often wonder why it collects tears of wine is because of the marangoni effect I have listed some of the, I have provided some link here so that you can understand, you know, several science experiments, okay, that involve surface tension and other interfacial phenomena, okay. So, we will stop here. We will continue from the next lecture. Thank you.