



Course Name Introduction to Colloid and Interface Science and Engineering

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Next 

Module 1: "Introduction to Colloid"

Lecture 1: ""

The Lecture Contains:

- ☰ What is Colloid?
- ☰ What is Interface?
- ☰ What is Dispersion?
- ☰ What is Stable Dispersion?
- ☰ Types of Stabilities
- ☰ Stability of a System
- ☰ Steady States

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Module 1: "Introduction to Colloid"

Lecture 1: "What is colloid"

What is Colloid?

Colloid is a system containing entities having at least one length scale in between 1 nm and $1\mu\text{m}$ (Fig. 1.1). The word colloid itself originates from a Greek word meaning 'glue-like'.

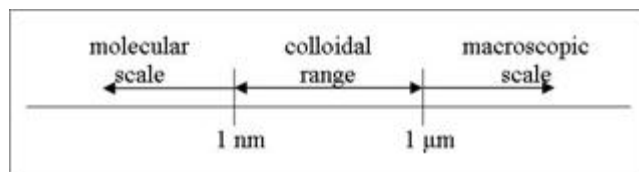


Figure 1.1 Range for the colloidal phenomena

Behavior of systems falling in this range depends on the thickness (dimensions) of the system. When the dimensions become small enough the behavior of the system begins to deviate substantially from what we observe in case of larger dimensions. This is the reason why the study of colloids needs to be done separately and their behavior cannot be expected to be similar to those of macroscopic objects.

To understand this, we consider a spherical particle of radius R (Fig 1.2). As the particle size is reduced, the surface area to volume ratio increases as R^{-1} . For particles small enough, like in colloids, this ratio becomes significantly large and a higher percentage of molecules lie at the surface. Thus, surface properties become very important.

Here as the size of the particle decreases, number of molecules on the surface increases in comparison to the bulk.

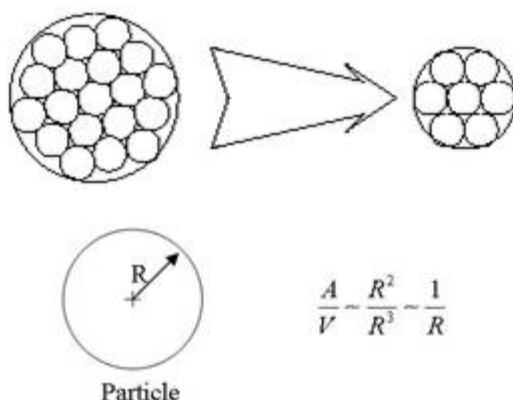


Figure 1.2 Effect of particle size on surface area

Module 1: "Introduction to Colloid"

Lecture 1: "What is interface"

What is an interface?

An interface is the surface of contact between any two condensed phases. It is not sharp in the sense that it cannot be clearly defined where a particular phase ends and the next begins. And unlike a mathematical surface, it is a diffused entity (Fig 1.3). Higher the miscibility of the two phases, higher the diffusion between the two surfaces. In the interfacial zone, there is a gradual change in density. An interface is in a sense a colloid because here we have a system in the range of $1\mu\text{m}$ or smaller.

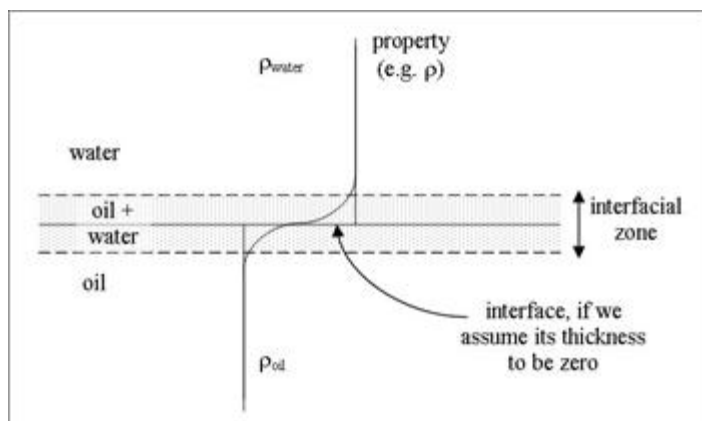


Figure 1.3 Water-oil interface

Module 1: "Introduction to Colloid"

Lecture 1: "What is dispersion"

What is a dispersion?

A dispersion is a collection of small particles in a matrix. It has at least two phases:

1. Dispersed phase
2. Continuous medium

The definition of a continuous phase is that if we start from any point in a continuous phase, we can return to the same point by moving along the same phase only. On the other hand, to go from one point to another of a dispersed phase, we must necessarily cross the continuous phase. For example, soap bubbles in water, where bubbles form the dispersed phase and water is the continuous phase.

What is a stable dispersion?

A stable dispersion is one in which the dispersed particles remain single entities and do not coagulate. Coagulation leads to phase splitting and a complete change in the properties of the system. In most situations we do not want coagulation to occur but there in certain situations it might be beneficial. For example, during purification of water, we want coagulation to occur so that all the impurities come together and can be disposed of easily.

Types of stabilities

1. Thermodynamic stability (Of Theoretical Importance)
2. Kinetic stability (Of Practical Importance)

A system is called thermodynamically unstable when there exists a state where the system will have lower energy than it currently has. A dispersion can be thermodynamically unstable, but can still be kinetically stable. If in a dispersion (even if it is thermodynamically unstable) the particles do not coagulate for a very long period of time, it is, for all intents and purposes, a stable dispersion, and is called kinetically stable.

Stability of a System

A system is a certain region on which we concentrate our attention. When we talk about the stability of a system, it is with respect to a particular attribute. A system may be stable with respect to a particular attribute, but may be unstable with respect to another. A system, in this sense, can be thought of as an entity having infinite attributes.

For example, consider a chalkboard eraser. In order to describe whether it is stable, a particular attribute like its color, position, orientation etc. needs to be chosen. Say, one selects its orientation as the attribute. Consider a symmetrical duster that is standing on a flat surface. Let Φ be the angle it makes with the vertical. At $\Phi = 0^\circ$, it is in a meta-stable state (fig 1.4). If it is very slightly perturbed it returns back to this position. But if the perturbation is a bit larger it topples to the globally stable state ($\Phi = 90^\circ$), because this state has lower energy.

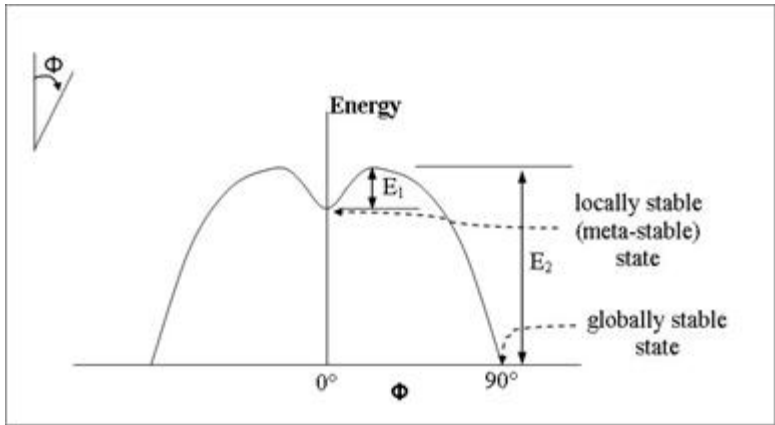


Figure 1.4 Energy diagram for a chalkboard eraser

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Lecture 1: "Stability of a system"

So a system can be in a locally stable (meta-stable) or in a globally stable state. Given sufficient time, a system in a meta-stable state would escape to a globally stable state due to random perturbations.

The probability that a system will remain in a particular equilibrium state is governed by the Arrhenius factor, $e^{-E/kT}$. Here, E is the energy barrier and kT represents the thermal energy.

In the example discussed above, the probability of the duster getting toppled and escaping to the globally stable state is proportional to $e^{-E_1/kT}$. Similarly, the probability that it gets flipped back to its original position is proportional to $e^{-E_2/kT}$. Since $E_2 \gg E_1$ it is much more likely that the vertical duster will fall down to reach the horizontal state. It is quite obvious that it is highly unlikely that once the duster reaches the globally stable state it will flip back to the meta-stable state. This agrees with what we see in real life, since we quite often see a vertical duster falling down to a horizontal position, but never does a horizontal duster stand up vertically. (Although, in real life, the duster generally falls down due to external factors and not random perturbations.)

Steady states

For a system, the states in which the system energy shows an extremum (maximum or minimum) are termed as steady states.

In case of open dissipative systems, we need the governing equations in order to study their stability, and the points of stability for such systems are generally referred to as steady states.

On the other hand, for closed systems the energy functions are usually available, and the points of stability for such systems are referred to as equilibrium states. Equilibrium cannot be attained in open systems.