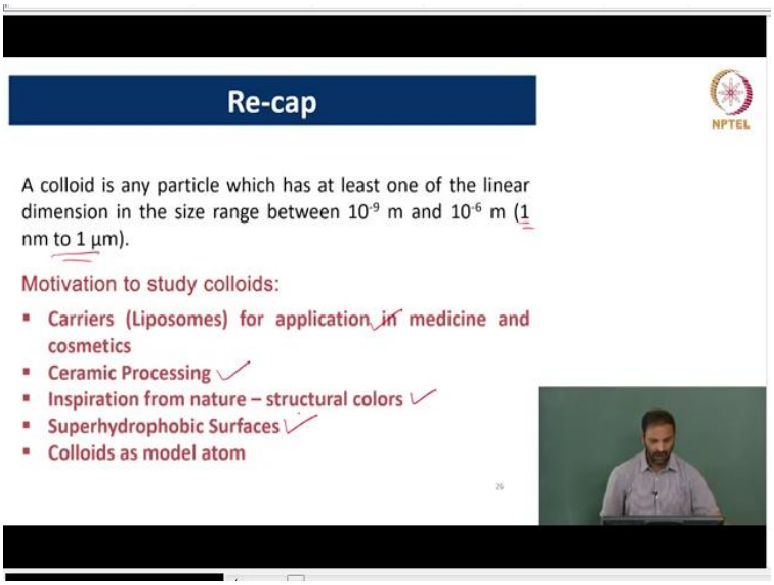
Colloids and Surfaces
Prof. Basavaraj Madivala Gurappa
Department of Chemical Engineering
Indian Institute of Technology-Madras

Lecture-02
Colloidal Dispersions, Terminology and Classification

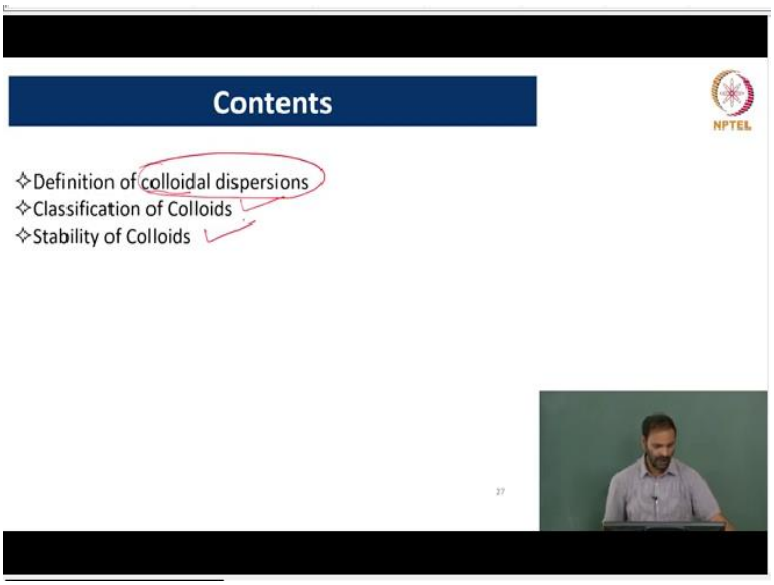
(Refer Slide Time: 00:13)



Okay, so we will do a quick recap of what we have done in the yesterday's class. So, we defined what is a colloid, we just mentioned that it is any particle which has at least one linear dimension in the size range between 1 nanometer to 1 micrometer. Then we went through several examples in which I illustrated the motivation to study colloids, namely we looked at liposomes, which are used as carriers, you know for transporting things in medicine and cosmetic industry.

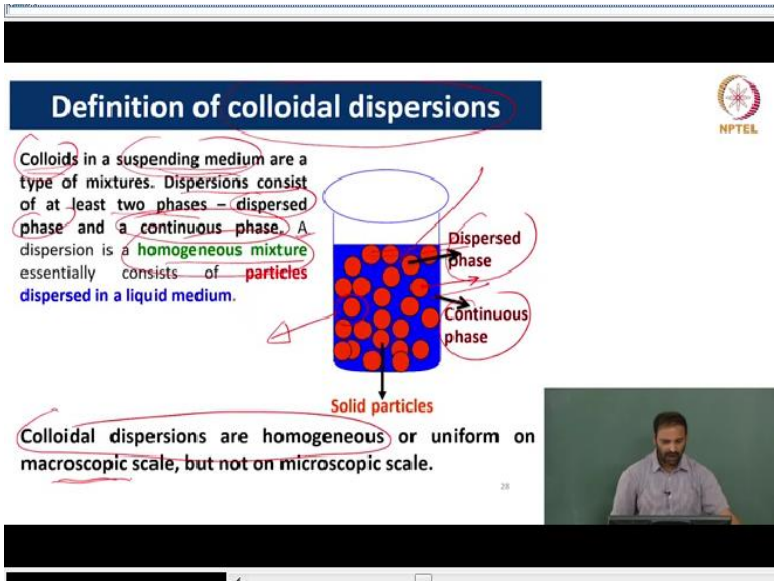
We looked at ceramic processing, inspiration from nature way we looked at structural colors, and super hydrophobic surfaces plus, I ended up talking about colloids as model atom to understand the phase behavior in materials and how do we use colloids as a model system to look at such things okay, that is what we have done so far.

(Refer Slide Time: 01:12)



So, what I will do today is hopefully these 3 topics okay. I have defined what is a colloid okay, we are going to look at what is a colloidal dispersion to begin with, then we will briefly talk about classification of colloids. And also we look at what is called as a stability of colloids or stability of colloidal dispersions okay, that is the plan for this lecture.

(Refer Slide Time: 01:43)



So, colloidal dispersion is essentially defined as if you have colloids in a suspending medium right. Therefore, now you have 2 components, you have colloid and you have suspending medium. So, in the picture here. So, you have these red things. These are the colloidal particles okay. And the blue thing is the suspending medium. Now we have, as I said more than 1 phase now okay.

And these dispersions essentially consists of at least 2 phases, there could be more, I will be looking at particles plus some other thing plus a fluid okay, there could be more than 2 as well okay. And typically, these particles, you know, which are present in such medium they are what are called as a dispersed phase okay, that is these red particles here, they are the dispersed phase and the liquid medium or a fluid medium in which the particles exist.

It is what is called as a continuous medium okay. And of course, whenever you say a colloidal dispersion, a dispersion is a homogeneous mixture. What I mean by homogeneous mixture is that, imagine that I have this container. I take out a small sample volume, okay I take I go here and I take up a small sample volume and find out what is like say the number of particles present in that volume okay.

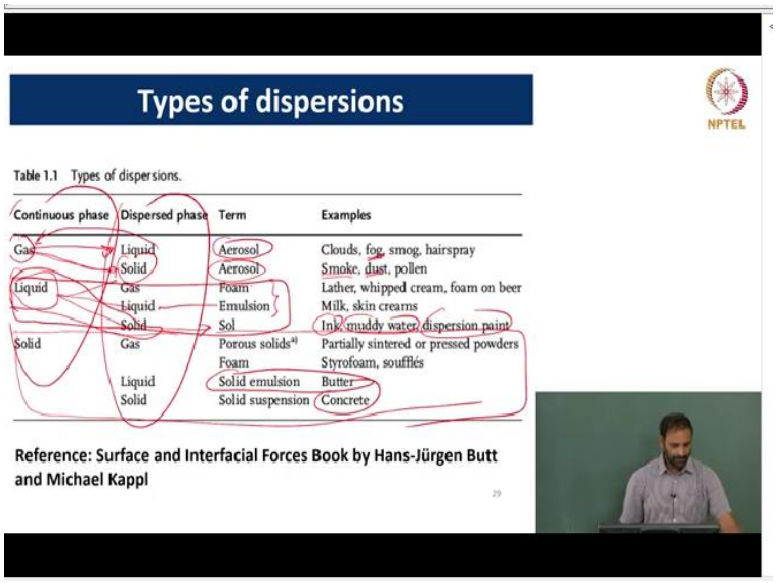
Now I go to another region, I take out the same volume of fluid okay, if the number of you know, particles that you have in these 2 regions are essentially similar okay. You cannot say exactly same, but if they are similar in number, then I can say, it is a homogeneous mixture, right, that means there are no continuous medium rich, you know, regions and a dispersed phase rich medium okay.

So, therefore, the particles are homogeneously dispersed throughout the medium okay. So, therefore, you can say that colloids are actually homogeneous. If you look at them on a what is called a macroscopic scale, okay when I say macroscopic scale. I could think about, like say some small volume of, you know, the of course the dispersion as a whole, that is macroscopic. And of course, if I take a few ml of fluids or a few microliters of fluids, it is hope, you know, homogeneous macroscopically.

However, if I go to the microscopic scale or if I go to the length scale which is of the order of particles are smaller than that, there is not actually homogeneous right because you have a solid and the liquid, you know, are 2 different phases that exist right. Therefore, a colloidal dispersion it is a homogeneous mixture of at least 2 phases, dispersed phase and a continuous phase. And of

course you can have cases where I may have more than 2 phases as well okay, so that is what is called as a colloidal dispersion.

(Refer Slide Time: 04:57)



So in the previous example, okay I said that the dispersed phases a particle right. But the dispersed phase can be of any different type okay. So, therefore, you can have different types of dispersed phases. And, of course, different phases, different types of continuous phases well right. So, if I have a continuous phase of gas okay and you may have liquid as dispersed phase okay.

If you have a system like that okay then, you would have heard of a term called aerosol, do you heard of this term right. So, aerosols essentially what will happen is, like, say, if you let say for example fog, right, fog is you have water droplets which are condensed right, these are water droplets condense which exist in ambient air okay, there is actually a dispersion of a liquid in gas, right. So, similarly, I could have a solid in gas okay.

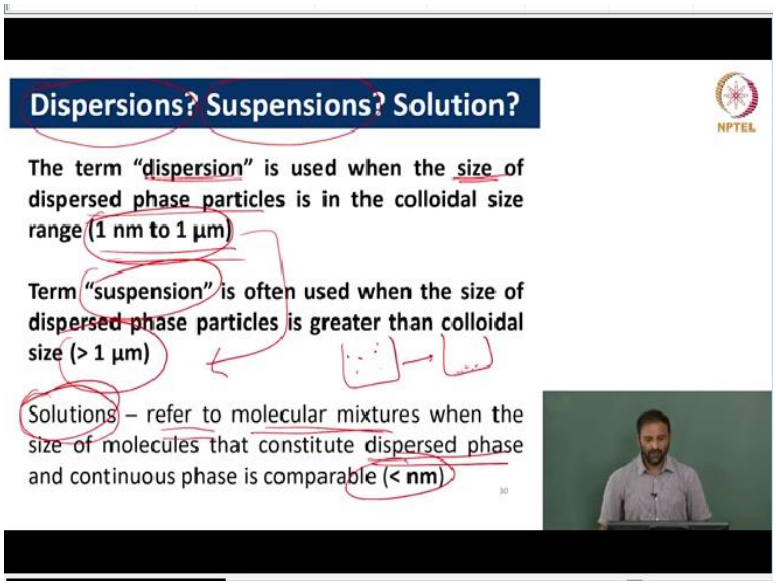
This could be you know the vehicular emissions you know the particulate matter that are emitted by vehicles. So, if you have solid particles in these emissions okay, that dispersion ambient air again is an example where the dispersed phase is solid and the continuous phase is a gas right. So, for example smoke, dust, even pollen rain right, the particles that are you know of plant origin, when they are in air.

That is an example of aerosol. Of course you could have continuous phases, as a liquid and the dispersed phase could be either gas liquid or a solid okay, now in colloid course, mostly you are going to look at this system right. In most of the course that I am going to teach okay, you want to have a solid particles dispersed in a liquid. They are what are called as sol okay example of sol are ink. If you take muddy water which is actually example of clay particles in water okay, or if you look at paint.

For example right, so all these are examples of sols, in which the dispersed phase is a solid and the continuous phase is a liquid, of course, there is a lot of interest in looking at emulsions and foams right. So, emulsions are liquid in liquid dispersions and foams are gas in solid dispersions, again you know there are several examples that are listed here. We will mostly not look at cases where, you know, your continuous phases is solid okay.

There are other people who look at such systems, you know, for example, an example of a solid emulsion okay, could be liquid and solid okay. For example, butter is an example of that okay, a concrete, which is solid and in solid dispersion, right. So, but of course these things people in other fields worry about for in classic colloids course, we will mostly look, at systems, where your dispersed phase is either gas or liquid or solid okay. And the continuous phases is liquid okay, that is what we are going to look at mostly.

(Refer Slide Time: 08:24)



Now, so you will, when you when you read up literature on colloids you will see that there are several people who use a the term colloidal dispersions or you know, colloidal suspension. So, I just want to make you know terminology clear. So, whenever people mentioned the term dispersion. Typically, the term dispersion is used when the size of the dispersed phase is in the colloidal size range.

That is 1 nanometer to 1 micrometer, so whenever somebody says a colloidal dispersion okay, then that size range has to be in the colloidal size limit okay. And whenever somebody mentions a suspension typically the size of the particles are larger than a micrometer okay. So, if I want to compare dispersions and suspensions, I can say that because of the fact that the particles in the dispersion are smaller in size.

They exhibit a better stability for sedimentation, that means the things in a dispersion are more likely not to settle. Whereas, the suspension because the particles are larger than a micron, the gravity may come into picture. If you have a container which is filled with particles as a function of time in a suspension, you may see things settling at the bottom. However, dispersions may exhibit you know better stability, against sedimentation okay.

And you should also know a little bit about true solutions or solutions which it actually refers to a molecular mixture okay. So, you can think about you take water and put in the salt right, or you

take water and add a little bit of sugar right. So, in which case you what you get is a molecular solution. In this solution so typically the size of the dissolved species okay, it is comparable to the size of the dispersed phase itself or continuous phase itself, right.

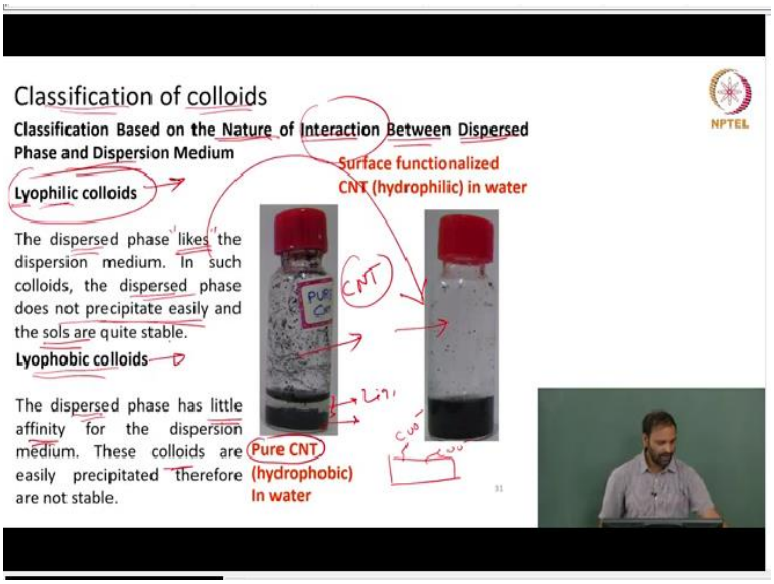
That means, if I take salt, put it in water, if I look at you know the salt molecules right or Na + and Cl - the size of that is very much comparable to the size of water molecules that you have in the system right. So, whenever the size of the dispersed phase of the continuous phase is comparable. That is when you refer to as what is called as a true solution okay. So, is the distinction clear yeah, hmm, yeah. No, no.

So, see lets go back here, so the question is something like this, so he is asking a question. Look, we mentioned that the dispersed phase has to be in the colloidal size range right, he is asking a question is to what about the continuous phase, does it also have to be in the colloidal size range, right. See, when you say the continuous phase, right. So, when you talk about, like say this case, where we had let me just do something okay, okay.

Let's look at this example, right, I am going to look at this example okay, where you have a dispersion of a solid, gas liquid or solid in a liquid right. Now these are the dispersed species right. This is a continuous phase okay, now the fact that the continuous phase is liquid. If you take liquid, you know, which will have some molecules right if I take water or any organic solvent or you know any fluid right, it will have some molecules, obviously the size of those molecules would be less than a nanometer right.

So, whenever we talk about colloids right. So, what we are talking about is the size of the dispersed phase okay. So, in this case continuous phase is liquid automatically the length scale or size of the molecules are definitely even less smaller than a colloidal length scale okay. Is that answer your question. Yeah, yeah, yeah, we will talk a little bit about that. Yeah, so his question is, do they exhibit Brownian motion, so we will talk a little bit about that in the few lectures to come.

(Refer Slide Time: 13:12)



Now we will move on to something called as classification of colloids. There are different ways of classification. In fact, you can even think about this particular table also as a classification, right, this is a classification based on the type of the dispersed phase and the continuous phase right, you can also think about, you know in along those lines okay. Therefore, if you want to classify colloids based on the type of the dispersed phase and the continuous phase.

I can, you know, classify them into several different classes like emulsions foams, sols, aerosols, you know, things like that right. So, the other ways of looking at classification is based on the nature of interaction between dispersed phase and the continuous phase okay. Again, we will talk a little bit more about interactions in the coming lectures. For today, what we will do is when I say interaction the only thing that I mean, is whether the dispersed phase.

And the continuous phase, like each other, or they do not like each other okay, so very loose term okay. So, therefore, in colloids, what are called as lyophilic colloids okay. Lyophilic colloids, lyo means liquid, philic means you know something that likes a liquid okay. So, therefore, in such colloids the dispersed phase likes the dispersion medium okay. The dispersed phase likes the dispersion medium.

So, in such colloids the dispersed phase does not precipitate out easily okay, if you put such particles in water, it does not precipitate out or it does not settle down, or it does not aggregate

and form large clumps okay. And the sols are quite stable okay. An example is given something here. I will tell you what exactly this vial is in a while. And what is called lyophobic colloids, the dispersed phase has little affinity okay.

There may be some affinity towards the dispersion medium or it may not like it okay. And these colloids they easily precipitate out of the solution. And therefore, such dispersions are typically not stable okay. So, what you are looking at the vial 1, what we had done is we went to one of our colleague's lab we got CNT right, carbon nanotubes, which are commercially available.

We took, these particles, we put them in water okay, we try to mix them okay. As I said, typically for mixing people use either sonication or high energy mixing or manual shaking okay depending upon the kind of system that you are working with okay. So, therefore, these are pure CNT okay, or CNT as received right in water okay, no matter what you do, you mix them and leave it for a while, you can clearly see.

There is a phase separation right that there is a liquid here. That is water and then all the particles are at the bottom okay. So, this is an example of what is called lyophobic colloids. I can also call them as hydrophobic because in this case, the dispersion medium is water okay, they are example of hydrophobic colloids which do not disperse in water and they would like to phase separate okay.

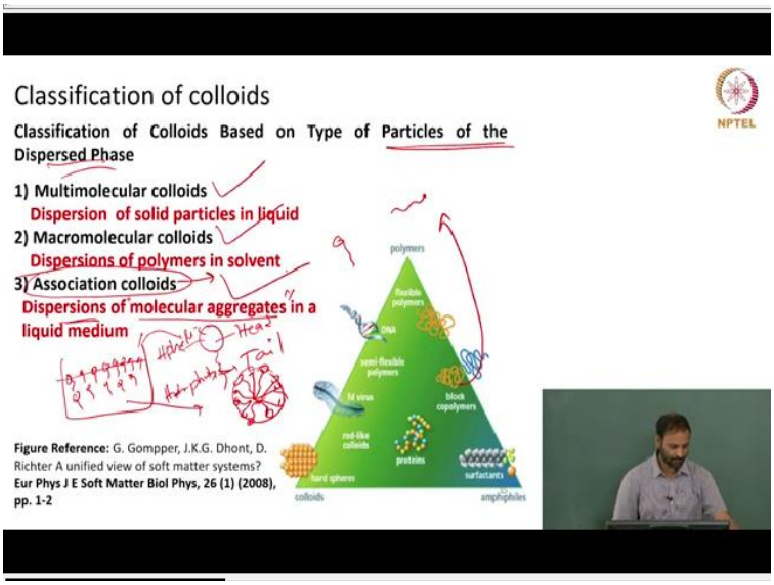
Now, in this vial what was done is, we took exactly same particles, as received. And then we did what is called as a surface functionalization okay. Again, the details are not important. The surface functionalization is done as simple as taking these CNT particles put them in an acid solution okay and then sonicated for some time. So, the idea is you have the CNT molecules and on these molecules, you can form some acid groups okay, maybe COO - or something like that okay.

Now we take such particles, put them in water and then they happily disperse okay. So, therefore, whether a particle is a hydrophilic colloid or a hydrophobic colloid, or lyophilic colloid or lyophobic colloid. It really does not depend on the type of the colloid that you are

working with okay, what it really matters what is the, the surface functionalization right that is important.

And we will talk a little bit about that in the coming classes as well okay. So, therefore, in this kind of classification based on the nature of interaction medium between the dispersed phase, and the continuous phase. When I say the nature what I mean is, whether the particles likes the dispersion medium or does not like, depending upon that in classify them as lyophilic colloid and lyophobic collides okay, that is one.

(Refer Slide Time: 18:36)



So, we can also ahh classify colloids based on the types of particles, you know that are dispersed okay, I shown this triangular diagram, you know, in the last class, so you have polymers here. What is shown here is a colloid okay. Now, what can you say about this particular picture. What can you say about this particular picture okay. So, while you guys think okay the third apex is amphiphiles right.

What it actually tells you is that if you take any colloidal particle okay. This colloidal particle is essentially made up of a lot of atoms right or the molecules. Whenever I say I have a gold particle okay. Of course it is made up of several gold atoms okay right. Therefore, so if you have such solid particles okay, which are dispersed in a fluid. It is what is called as a multimolecular

colloids, because each particle is made up of a large number of atoms or the molecules okay, which are essentially dispersions of solid particles in a liquid okay.

Examples could be as I said right. If I have water with, say, gold particles or you know, the CNT, you know that I talked about or any kind of solid particles in a fluid. That is an example of what is called as a multimolecular colloids, second type of, you know, dispersed species the people work with. It is what is called a macromolecular colloidal, which essentially are dispersions of polymer in a solvent okay.

So, the polymer another name for polymer is macromolecule right, a large molecule, which is essentially made up of a large number of repeating units right, that is what we talked about in yesterday's class. And the third type of colloids what are called as association colloids. Any thoughts. What, association colloids could be okay. The name already tells you something right okay, they are formed, because of association okay.

So, these are dispersions of what are called as aggregates, which are formed, because of association of molecules okay, any examples what is that surfactant molecules right. So, what you do is if you have water right all of you know about what is called as a micellization. Where you have heard of term right micellization. So, if you take water and I add surfactant molecules.

Surfactant molecules as I said are typically you know represented like a head and a tail okay, this head is typically hydrophilic, tail is hydrophobic. Now, when you put such molecules in water, what will happen is initially, you will have some free molecules okay. And because of the fact that they are amphiphilic. Some of them may go to the interface. I go on adding more and more surfactant right. More and more free molecules may form here.

And of course and more and more occupied the interface. When you add enough that the entire interfaces completely occupied the surfactant molecules. Anything more that you add okay, it will go and form, what are called as molecular aggregates, what are called as micelles right. Typically, you know they represent micelles like this right okay, all the tail groups are held together at some common location.

And you have head groups that face water, okay because you have water right. This is a hydrophilic group and hydrophilic group, you know, is happy being in water right. So, therefore, so these aggregates are formed, because of association of several number of molecules that come together okay. So, that could happen if you are working with surfactants it could happen if you are working with, you know, as I said, these block copolymers and things like that okay.

So, a lot of amphiphilic molecules, when you put it in either water or any other fluid they form molecular aggregates, which are examples of what are called as association colloids okay. So, therefore, depending upon the types of the particles of the dispersed phase, you can classify colloids into multimolecular colloids, macromolecular colloids and association colloids okay. So, that is, you can think about this as another way of classifying collides into different types.