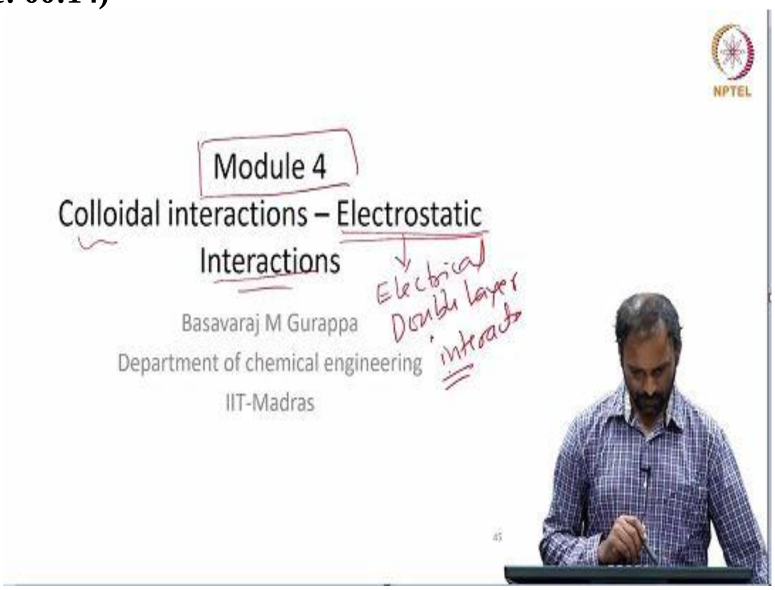
Colloids and Surfaces
Prof. Basavaraj Madival Gurappa
Department of Chemical Engineering
Indian Institute of Technology Madras

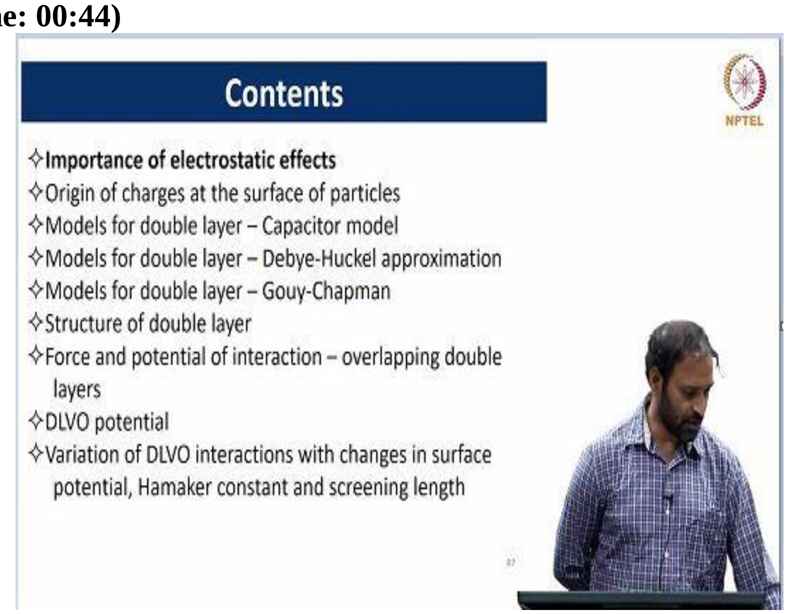
Lecture - 27
Colloidal Interactions: Introduction to Electrostatic Interactions/Electrical Double Layer Interactions

(Refer Slide Time: 00:14)



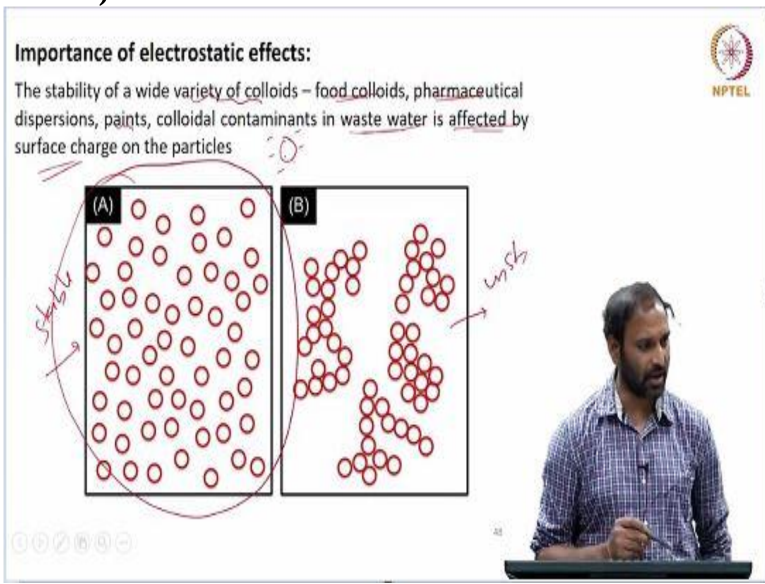
So the next module is module 4, in which we are going to look at, again, colloidal interactions. But looking at what is called as, electrostatic interactions, they are also called as electrical double layer interactions that is what we are going to do it for the next few lectures.

(Refer Slide Time: 00:44)



That is going to be the contents? We will start with one by one. Today we will most likely look at the importance of electrostatic effects and origin of charges at the surface of particles. And if you have some time we will also try and look at models for electrical double layer. So, coming to the importance of electrostatic effects. Any thoughts? Why is there a need to look at electrical double layer interactions or electrostatic effects in dispersions some thoughts? So, due to some surface charges there can be attraction or repulsion.

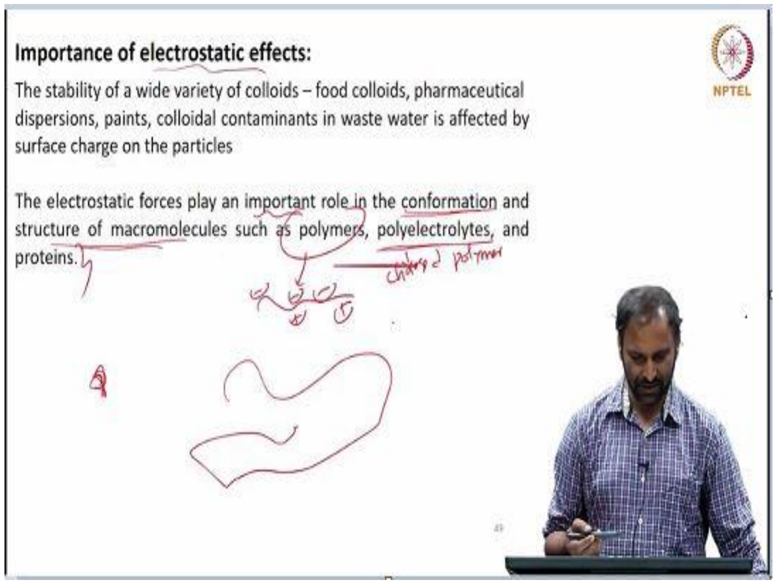
(Refer Slide Time: 01:38)



So, it turns out that these interactions are very important. Because one of the example could be the stability of a variety of colloids. Be it food colloids you look at you know, colloids which are found in know pharmaceutical dispersion paint as well as waste water may have a lot of contaminants which will have the colloidal dimension length scale and the stability of all such things are affected by the surface charge on the particles.

So, this is an example of a stable system, unstable system. So, if you want to think about you know, having a stable colloidal system, one of the ways of achieving that would be by incorporating charge on the particle surface. So, that is 1 example.

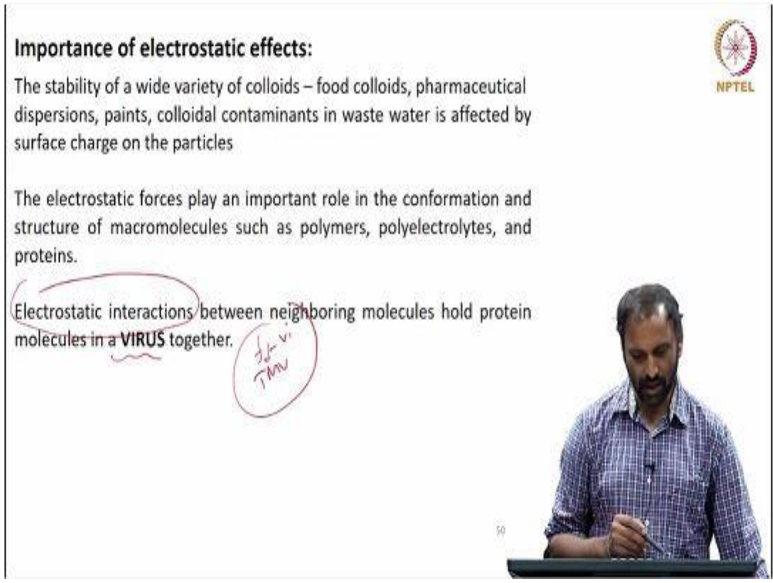
(Refer Slide Time: 02:38)



So, the electrostatic forces also plays an important role in the conformation and structure of macromolecules. So, if you look at several charge systems, that is polyelectrolytes, which are charged polymers or you could have polymers with you know, ions adsorbed onto the surface, or you could have proteins, which are charged and the kind of confirmation that they take in solution that means whether they would be in a extended configuration or they would coil up.

So that is determined by the surface charge that the these molecules may have, so there is therefore there is a lot of interest to look at you know, electrostatic effects in charge polymers and uncharged proteins with an intention of understanding what is the structure of these you know, macromolecules or structure of these entities when you put them in solution, that is one another reason to look at charge effects in the systems.

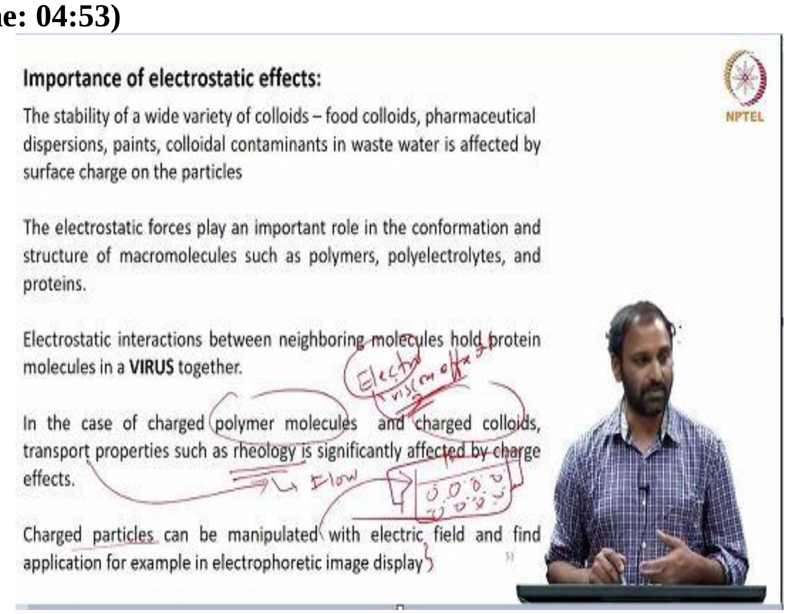
(Refer Slide Time: 03:54)



Third is if you look at people use a lot of virus particles as molecules systems. In the initial class, we talked about ft virus you know TMV particles like this. Now, so these in these virus essentially is made up of made by the self assembly of a large number of molecules. And so, basically the neighboring molecules, from which the virus are, you know, made off, they are actually held together by electrostatic interactions.

So, that means the electrostatic interaction between the, molecules of adjacent layers, you know, in a virus are held together, because of the electrostatic interactions between, you know, the between the molecules that make up these virus particles.

(Refer Slide Time: 04:53)



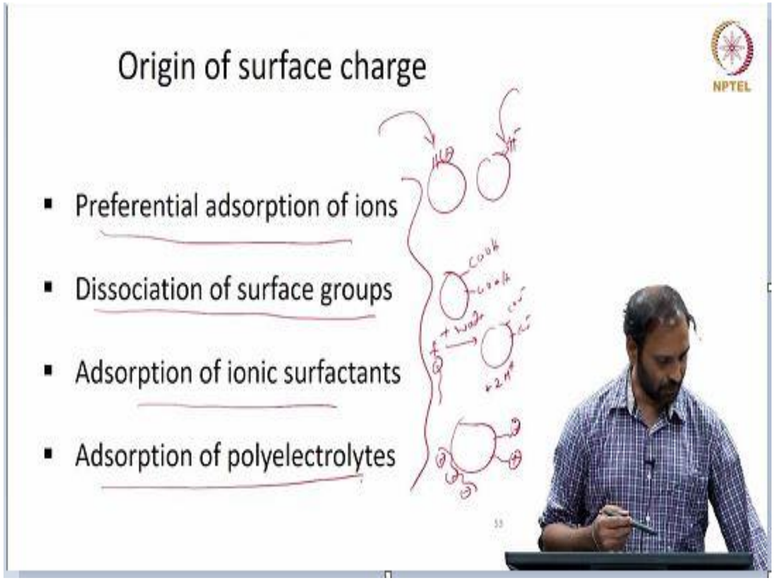
The other examples could be that if you look at measuring rheology are the flow behavior of you know solutions or flow behavior of multicomponent mixtures if it has like say polymers or charged colloids it has been found that in the transport properties such as viscosity is indeed affected by whether you have a dispersion with charged particles or uncharged particles people talk about what is called as a electro viscous effect.

In which we can know one studies what is the contribution of the charges or the particles to the viscosity of the dispersions and finally, people also use particles dispersed the charged particles dispersed in a medium and you can actually manipulate the spatial organization of particles. So, if I have next a container and say that they have charged particles. Now, when you are trying to use such a system for display applications.

What you should be able to do or you should have a control about the way the particles organized in the solution that will lead to a definite display that one wants. And one of the way to do that would be that I take this dispersion and apply an electric field, thereby I can modulate the spatial organization of particles in the solution. So, therefore, in electrophoretic display panels, one uses charged particles and I can control their organization by applying in the field.

Therefore, there is also a lot of interest to understand such phenomena how do charge particles behave in electric field, what leads to you know, the changes in the display behavior. So, problems like that. So, that is to tell you that you know, there are various fields. Or there are various reasons why one could be looking at charge effects. If you come to the origin of charges, we have discussed this in the initial stages.

(Refer Slide Time: 07:21)

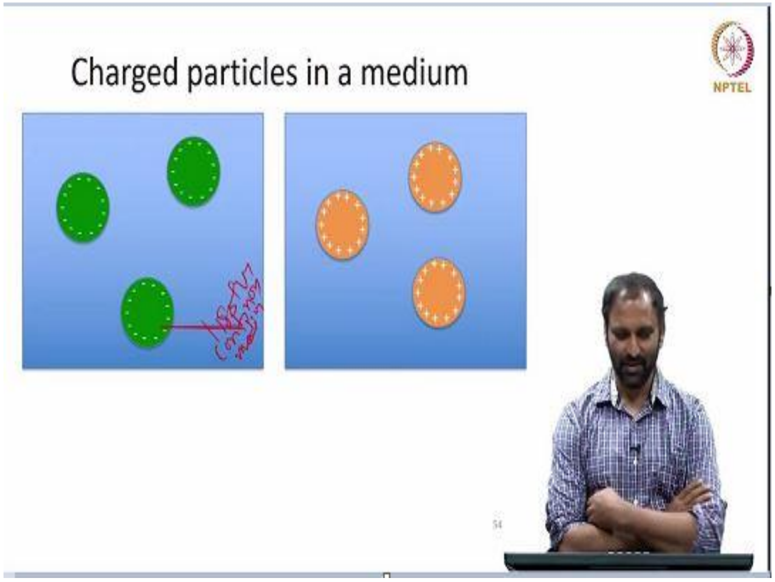


People typically talk about 4 different mechanisms by which the particles can acquire charge, preferential adsorption of ions, adsorption of ionic surfactants, both you look cationic anionic and adsorption of charged polymers, the 4th mechanism is dissociation of surface charges we have talked about these things, you know, so, if I say that I have a particle which has know COOH group, if I put them in water what will happen is you have COO - CO - + 2 H plus.

So, that is a dissociation of the surface charges leading to the charges in the particle surface similarly, we looked at you know adsorption of you know maybe H plus ions or adoption of H minus ions, you know can make either a particle positively charged or negatively charged. Similarly, I could have a case where I have a particle and then if I add a charged surfactant, it could go on sit onto the particle surface.

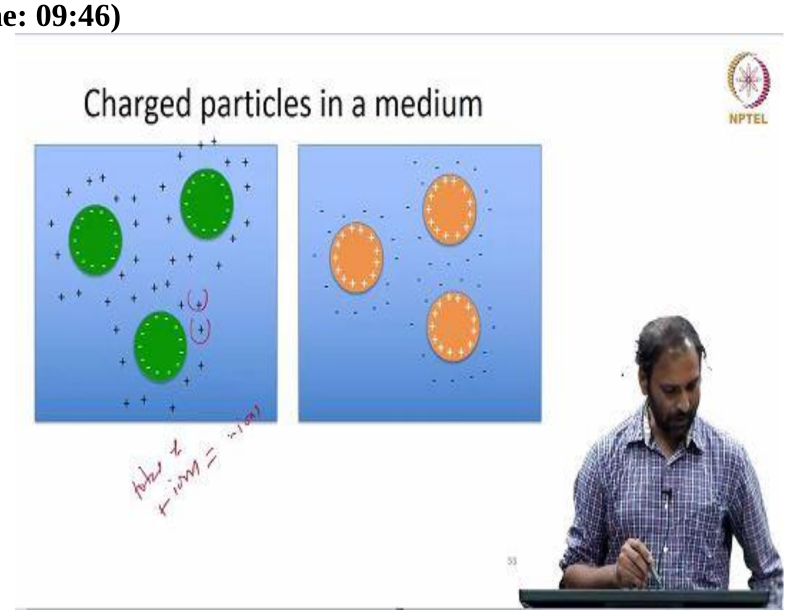
And I could either acquire a positive or negative charge depending upon whether you are working with the cationic surfactant or in anionic surfactant. Similarly, the charged polymer can also go on sit on the particle surface and then make the surface either positively or negatively charged. We have discussed this already earlier. So I just I am just trying to quickly.

(Refer Slide Time: 08:57)



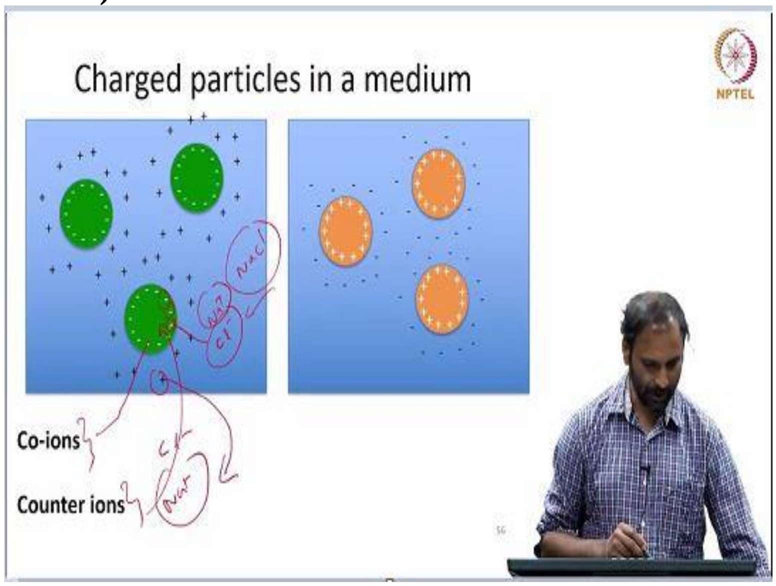
Now, when you have charged particles in the medium, so what is depicted here is particle which is negatively charged and particle that is positively charged. And you can think about this could be a dispersion medium. Or a solvent or a continuous medium, so do you think this is a correct picture? So if one asked you to imagine charged particles in a fluid. Do you think this is the correct picture? Maybe somebody says maybe yes, somebody says yes, I would say no.

(Refer Slide Time: 09:46)



The correct picture is this, it should imagine that you have charges in the particle surface, plus, you also have so this the system as a whole has to be electrically neutral. So, if you take solution the total number of positive ions or positive charges should be equal to the total number of negative ions in the solution. So, if you take a charge stabilize dispersion, if I count the total number of positive charges should be equal to the total number of negative charges.

(Refer Slide Time: 10:30)

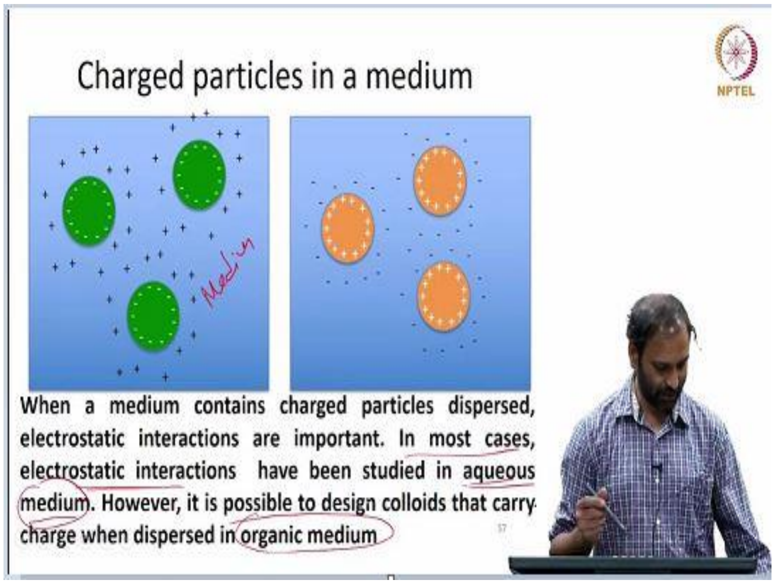


So, people talk about 2 terms, which you should remember something was a co -ions and a counter-ions. So, co-ions are the ions, which have the same polarity as the charges on the particle surface. So, if I have in this case, I have a particle which is negatively charged? If I put in like say NaCl into the system, I am going to have Na plus and Cl minus, there is the Cl minus has a same polarity as the charges on the particle surface.

Therefore, in this example, co-ions is going to be Cl minus in this case, the co-ions is going to be Cl minus and counter ions are the charges which have which are opposite to the polarity on the part of the surface in this case, Na plus which comes from the NaCl that I have added plus also the other ions that come because of the dissociation both of them are counter ions in this case. So, therefore, whenever you talk about charged particles in a medium, you should know there will be co-ions and the counter-ions.

Which respectively are the charges which have the same polarity as the particles as a charge of the particle surface and the opposite polarity as what is there on the particle surface.

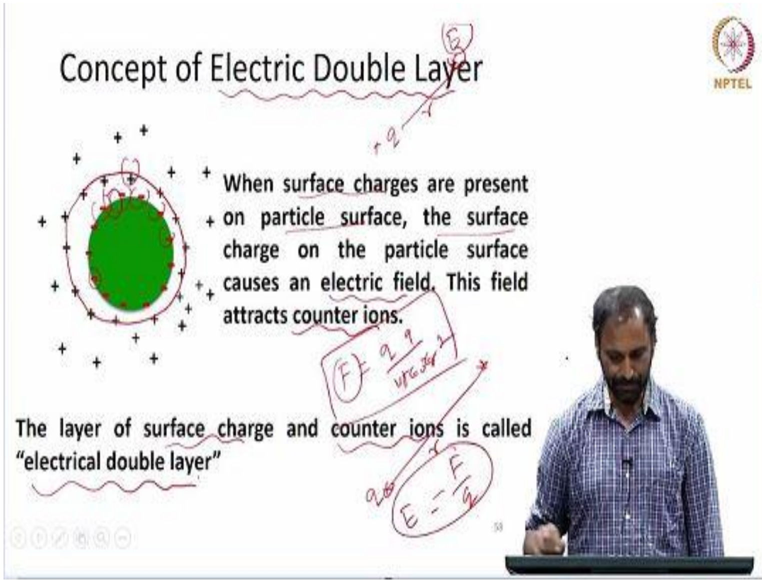
(Refer Slide Time: 12:17)



If you look at that ratio, it turns out that as I said, this is a charged table display charge dispersion and some medium. If you look at all the body of work that has gone in colloid literature on charged particles in a fluid, it turns out that in most cases electrostatic interactions have been studied in aqueous system or aqueous medium and you will see very little work on of course, there is a body of work but you will not see much literature all studying electrostatics in organic medium.

Although it is possible to design particles that have charges when you put them in organic solvents, if you look at the bulk of the work has been done using aqueous medium as a continuous phase you know as compared to organic medium. That is the point that I wanted to make.

(Refer Slide Time: 13:27)



Briefly, I want to mention electrical double layer, what is electrical double layer? This is going to be important because we are going to talk about this enough for several lectures you know, in the next few weeks or so. So, whenever you have charges on a particle surface, that is what is depicted here this is charges on the particle surface. The surface charge on the particle surface causes an electric field.

So, whenever you have a point charge, we know that you know, if I look at you know, think about at any particular location E or any particular location, I can calculate what is the electric field. So, it is given by a simple. So, if F is q 1 q 2 divided by 4 pi epsilon 0 epsilon r, if that is the coulomb's law r square. So F = q 1 q 2 divided by 4 pi epsilon 0 epsilon r square. If that is the force between the 2 charges, now if I ask a question is to at a distance R from q 1, what is the electric field is actually given by F / q.

If it is, let us say that I take a simple case when I have 2 equal charges. And if I want to ask a question as to at any location the distance R from this charge the electric field is given by E is F / q and this electric field that is generated because of the charges on the particle surface, what it will do is it will attract the counter-ions. Therefore, if you look at this picture, so, there is a layer of charges on the particle surface in the immediate vicinity there is a layer of counter-ions.

And these counter-ions are attracted to the charges on the particle surface, because of the electric field that is created because of the charges on the particle surface. So, therefore, there is a layer of ions on the particle surface and there is a layer of ions in the immediate vicinity of the charge surface. So, these 2 layers of charges put together, they what are called as, electrical double layer, the layer of surface charge and the counter-ions in the solution. That is what is called as a electrical double layer.