Nanotechnology in Agriculture
Prof. Mainak Das
Biological Sciences and Bioengineering and Design Programme
Indian Institute of Technology–Kanpur

Lecture-16
Characterisation Techniques for Physical and Chemical Surface Properties of a Material

So, welcome back to the lecture series in nanotechnology in agriculture, so we have talked about the characterization of the material in terms of characterizing the geometry, characterizing the size and morphology by using transmission electron microscopy, scanning electron microscopy and atomic force microscopy. Study people to go through what is scanning tunneling microscopy of course I will providing in the notes what is the detail of a scanning tunneling microscopy.

But I just want that as an assignment for you to looking to it. So apart from it will be going through another physical technique which is understanding the contact angle or understanding the hydrophilicity or hydrophobicity of nanoparticle. So say for example you have one kind of nanoparticle which interacts with water better as compared to the other one. How you can do it? How you can figure it out? What you can essentially do? you can do something called a contact angle measurements, so how do you it.

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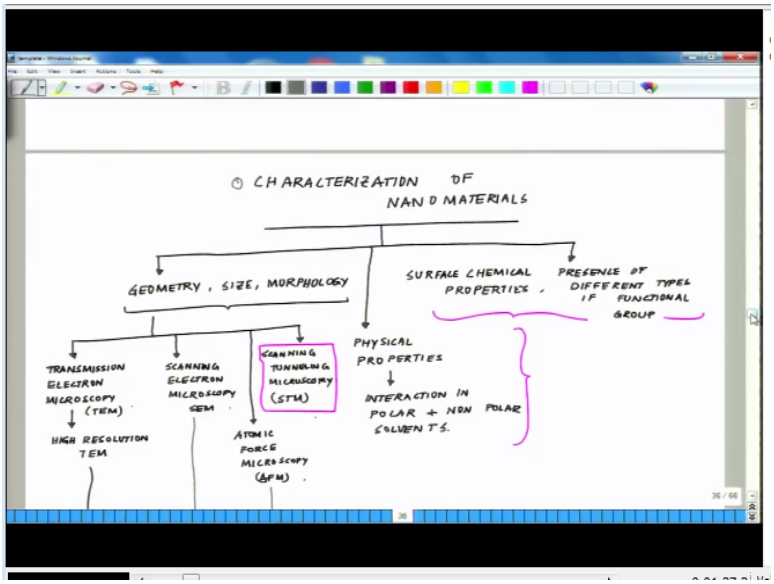
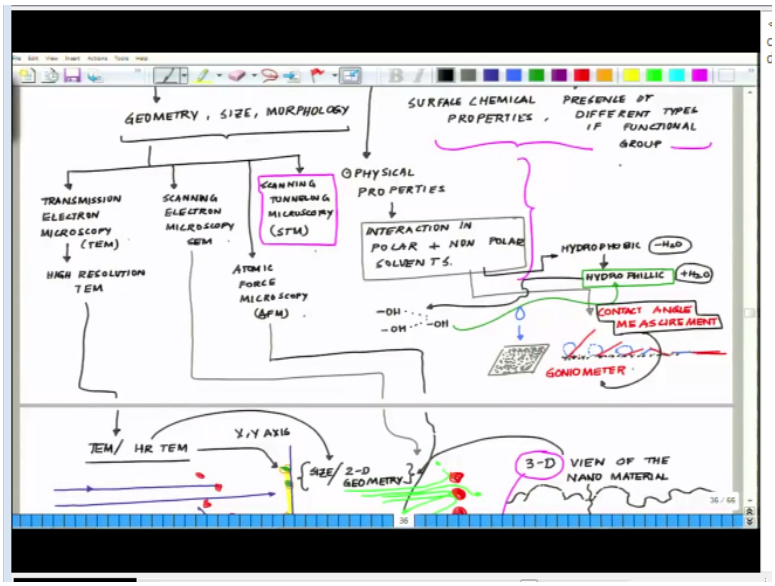


So, this is where we were characterization of materials transmission electron microscopy, scanning electron microscope, atomic force microscopy and scanning tunneling microscopy. **(Refer Slide Time: 01:38)**



Now you are talking about physical properties of interaction in the polar and non-polar solvents. So, say for example you have particular particle say make a film or you layer it something. These are the particle you are layering like that, so you performing a thin layer or a mono layer of the particle. And now say for example you want to use this for different kind of fertilizer release or some kind of insecticide release capsule or something.

Now once you form a layer of it on a substrate you put a drop of water droplet. Now the possibilities of the drop of water will be either the drop of water will remain like this on top it say for example this is a particle layer okay. So either the drop of water will behave like this or it will be even much more something like this or it will become like this or it will become like this or it will almost mix like this.

So, if you look at it with compare to the base start seeing what is the angle it is making, the angle is continuously changing almost and here it is almost mixing on the substrate. So now based on this angle you can calculate what will be it is hydrophilic nature and what will be its hydrophobic nature. So, this is done with an instrument called goniometer and this powerful technique is called contact angle measurements.

And having while we are saying this there is another point which I wish to highlight here you can change the hydrophilic or hydrophobic nature of a particle or of a material while introducing functional growth, say for example you want to make a material from say hydrophilic from hydrophobic, hydrophobic which is water heating, this is shown as water heating to hydrophilic which is water loving, what you have to do.

You have to introduce in that material you are adding multiple OH groups, this OH groups will eventually from hydrogen bonding and will let to a material which is hydrophilic in nature okay. So hydrophobicity and hydrophilicity are the functions of the functional groups which are attached to the material and which eventually decide how much it is going to interact with water okay. Now after this we move on to the surface chemical properties which includes among the surface chemical properties.

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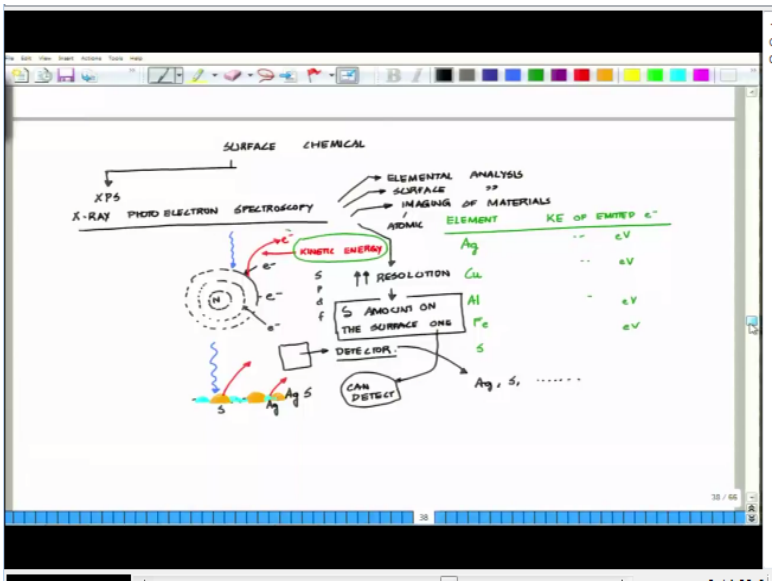

We talked about the physical, the major surface chemical property is which is used in all surface analysis is called XPS, so this is essentially x-ray, photo electron spectroscopy. So, the fundamental of x-ray photo electron spectroscopy is fairly simple say for example we talk about an atom okay. So this is the nucleus where you have the proton and neutron and here you are having the electron cloud around it in a simplistic sense okay.

These are the places where electrons are revolving around, now these electrons which are there. So, they have different orbital we know that s, p, d, f likewise, these are the different orbitals where these electrons are happing around it. Now these electrons which are hopping around and different electron cloud have different energies. So, in order for an electron for example I supply some form of energy out here into it.

And for this to eject out an electron for example and this electron form here is getting ejected out. It will eject out with a unique kinetic energy and that kinetic energy is essentially the energy at which it is being part of that atom, so you have to give x that amount of energy you know make it move out from it. So say for example something is hold there with x amount of bond energy. So, you have to give that –x amount of energy to pull that out from that zone that is unique.

This energy with which it is coming out from that particular atom is unique. So, you could develop a charge depending on element, so element say for example you have silver, copper, aluminum, iron, sulfur okay and in the next column you may have the kinetic energy of emitted electron of say for example some specific shell we are talking about mostly the outermost shells, so we talk about the outer most shell.

So, with what energy that electron is going to come out in electron gold, okay some some amount. Now say for example you give that much energy, so I have a surface like this, so I have a nanoparticle like this which is lying there. And say for example these nanoparticles have equally that they have sulfur and they have silver, and sulfur something like this. So, what will be saying on these particles you will have if I represent sulfur with orange that the sulfur atoms sitting out there.

And you will have the silver atom which I am representing in light blue, you will have this silver ion sitting out there okay, tones of them sitting like this okay. Now if you put a beam of electron certain kinetic energy or a spectrum of it. So, the outermost electron from here will be coming out from the sulfur, this is we are representing sulfur and this one as silver. So, the electron will

be coming out form each one of them at different electron hold which is of course we are talking about the outer most and you can go to the other one also much more core once.

But at this point we are just ensuring the electrons are in the outermost shell, now if you have a detector sitting out here which could measure that speed. Here you have a detector, then the detector will tell you what you are seeing whether it is silver, sulfur or something else. So, this is essentially x-ray photoelectron spectroscopy this is the fundamental and I want based on this I want you people to see any literature available online on x-ray photo electron spectroscopy.

But the fundamental of x-ray photo electrons spectroscopy is this and it is one of the most powerful surface characterization technique by which you can do the power of the technique is you can do a very simple elemental analysis. You can give a surface analysis you can talk about some form of an advance imaging or atomic imaging of materials. And most importantly it has very very high resolution in terms of the amount some delta amount on the surface one can detect.

You can detect a very very trace amounts on a substrate or on a surface and (()) (13:39) won the Noble prize for developing this X-ray photo electron spectroscopy theories and the instruments okay. So this is one of the most widely used technique and I always will recommend you wherever you get chance try to explore this technique okay.

The next in the line is after X-ray photo electrons spectroscopy you have XRD where you are detecting the crystal or amorphous properties of materials whether they are repeated units are not say for example if you go back nano crystals, we talk about nano belts.

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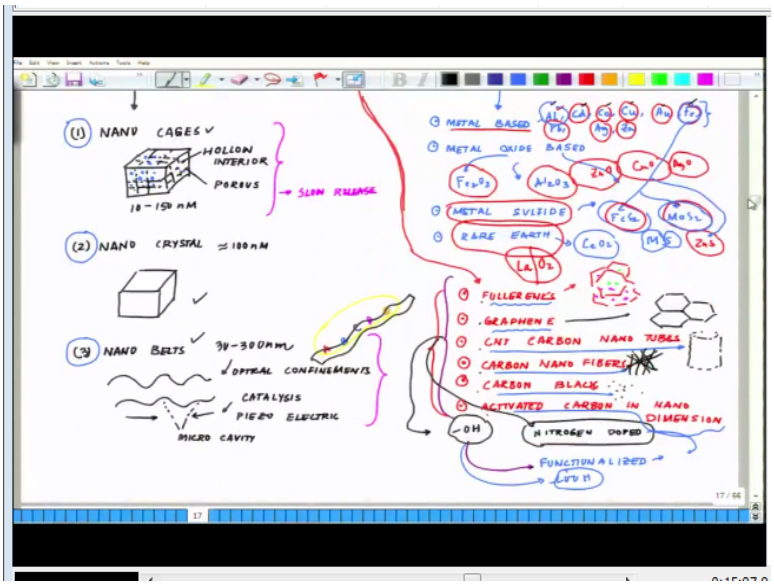

We talk about nano cages we talk about.

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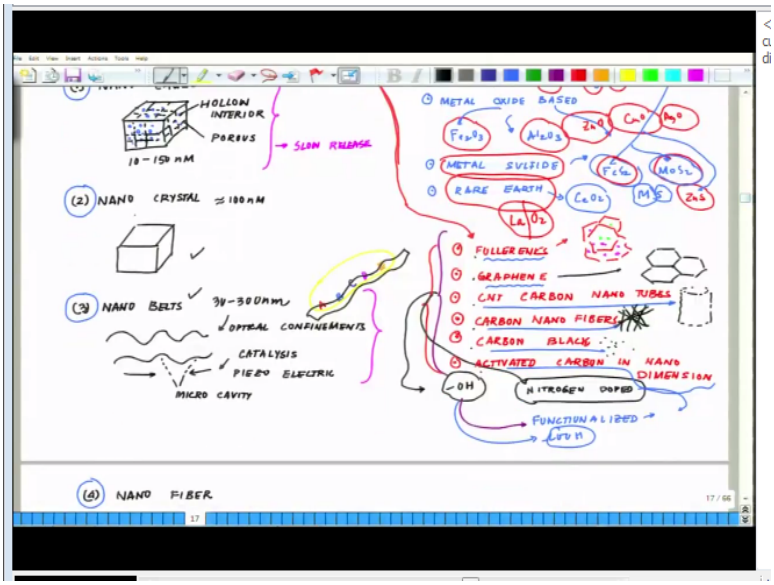

So, what will be the crystal structure how that crystalline crystallinity will work out whether they will be repetitive units to make crystals or it will be much more like amorphous where there very little repeatability in the structure okay. So these kind of whether these particles are crystalline or they are amorphous.

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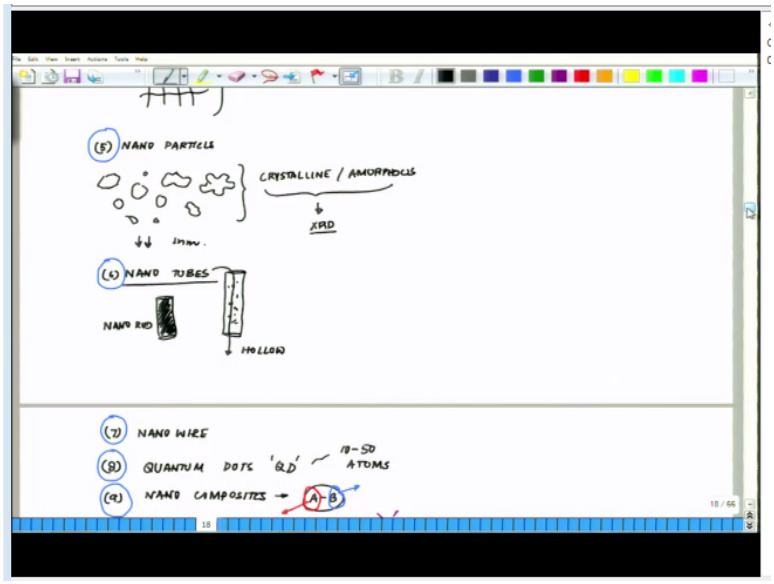

In order to understand that your best bet is x-ray diffraction, these stands for diffraction okay.

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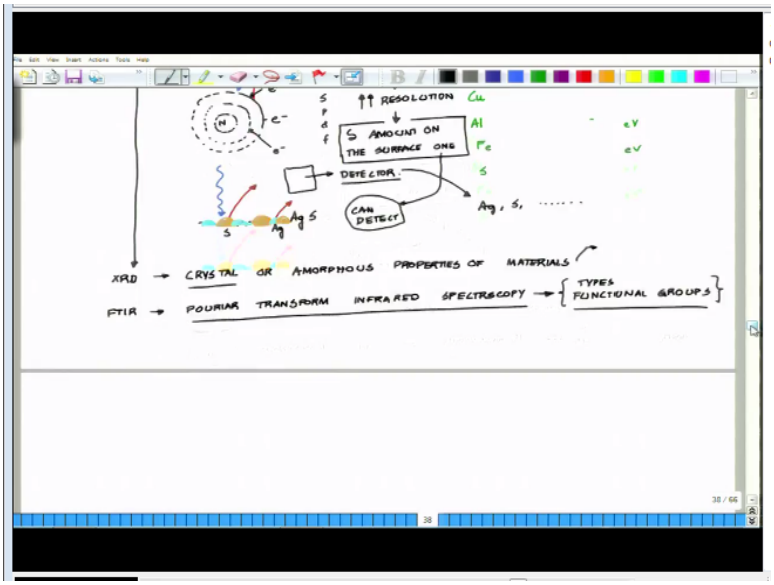

So, this is where you are using x-ray for determining the stereo chemical properties or in space how these atoms are arrange. This is the technique what you are using okay. The next in the line will be FTIR Fourier transform infrared spectroscopy. So this technique gives you a knowledge, so I am not getting into the depth of the technique which I will again leave for you to explore this technique gives you an idea.

Say for example what are the different kind of functional groups which are present on your sample, types of functional groups, say for example you are increasing the hydrophilicity of the

particle alright. So, what are the kind of functional groups which are present and all these details that you can obtain using Fourier transform infrared spectroscopy, this is the power of the technique.

So, we have to summarize what all you can do from this includes your the surface chemical techniques you have XPS, you have XRD, you have FTIR, prior to that you can do the physical properties, you can figure out in terms of their interaction with water. You can figure out the hydrophilicity and hydrophobicity of the surface using contact angle measurements and using the instrument called goniometer, apart from it in order to figure out the geometry size and morphology.

You have transmission electron microscopy, have a scanning electron microscopy. You have a scanning tunneling microscopy and you have atomic force microscopy.

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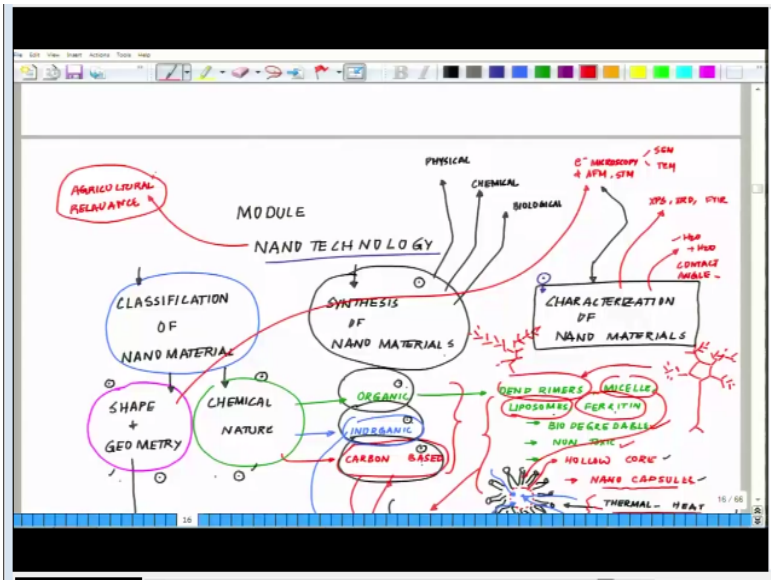

So, to summarize this part what we covered here is classification nanomaterial in terms of shape and geometry chemical nature in terms of chemical nature the organic nature, inorganic nature and carbon based nature. Then we talked about the synthesis where we talked about physical, chemical and biological and followed by that we talked about the characterization of nanomaterial in terms of figuring out the shape and geometry using different form of electron microscopy.

And AFM and STM which includes SEM and TEM then we talked about all the chemical ways of understanding the atomic architecture using XPS, XRD and FTIR. And then we talked about water heating and water loving properties in terms of contact angle. So that kind of covers our basic understanding of nanotechnology which will be need it to understand this course in greater details of how basically all the synthesis processes are taking place.

And how these synthesis could be done and what are the basic absolutely fundamental requirements for you to documentary your work in terms of how you classify your material, how you synthesize your material and how you characterize your material. And then of course introducing it to the its agricultural relevance okay.

So based on this frame work we will start our journey of different kind of nanomaterials which are currently under intense exploration for their application in increasing agricultural productivity water purification and myriad of other applications, thank you.