Nanotechnology in Agriculture
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Lecture-09
Physical Approaches to Nanomaterial Synthesis

Welcome back to the course on nanotechnology applications in agriculture. So in this module exclusively will be talking about the nanomaterial synthesis, nanomaterial classification and the characterization tools which are being employed. So as you have already aware in the previous class we talked about the classification nanomaterials and in that just to have brief recap what we talked about.

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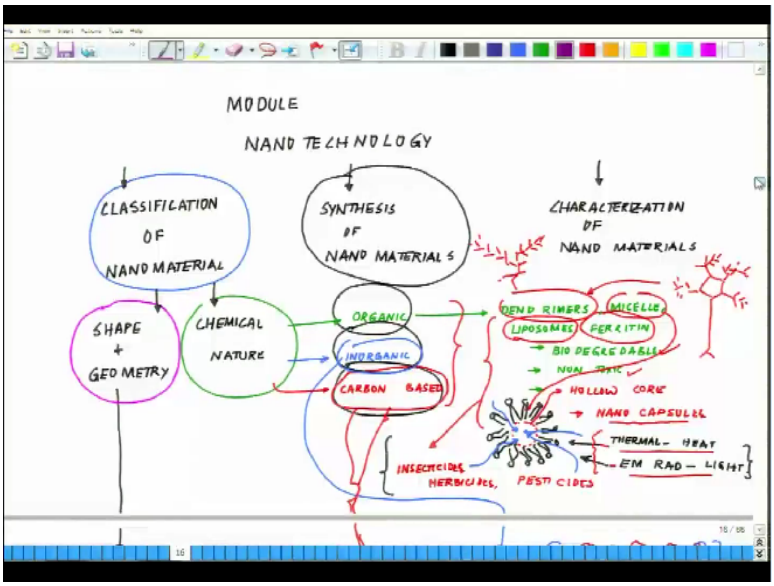

We talk about the shape and geometry based on which the nanoparticles having classified, we talked about the chemical nature based on which they have been classified.

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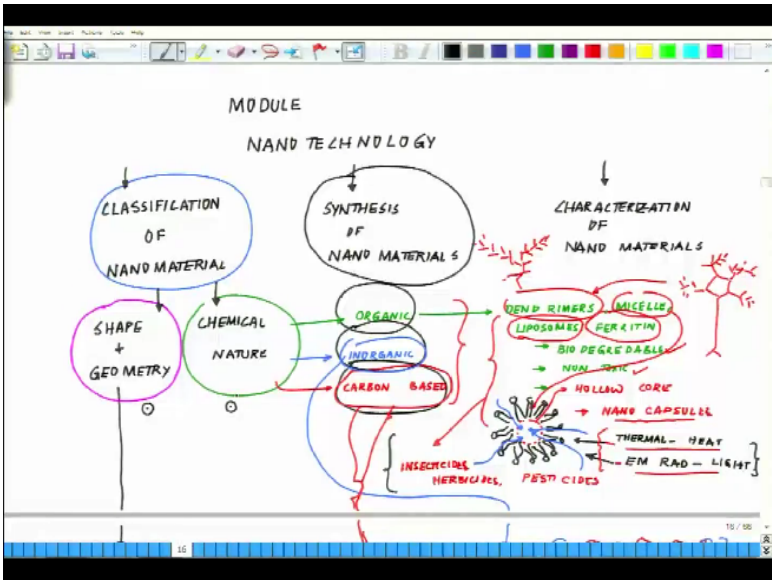

And we talked about nano cages, nano crystals, nano belts.

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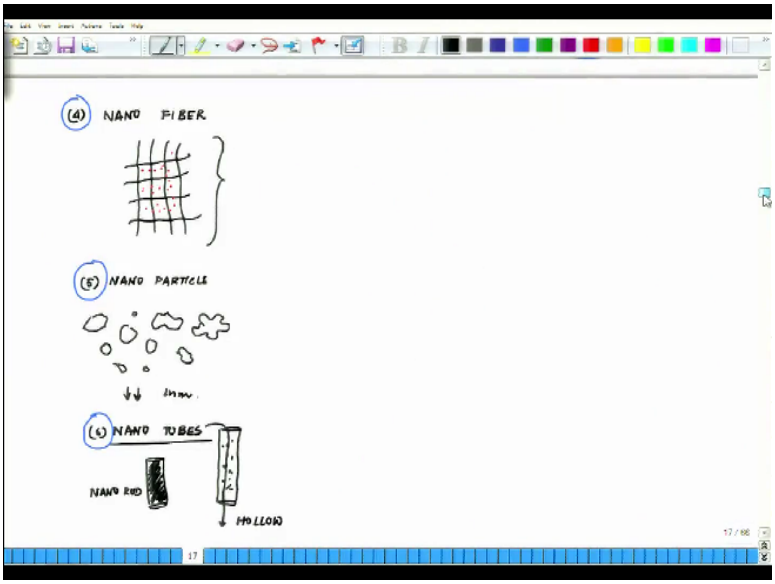

Nano fiber, nanoparticles, nanotubes, nano wires, quantum dots and nano composites.

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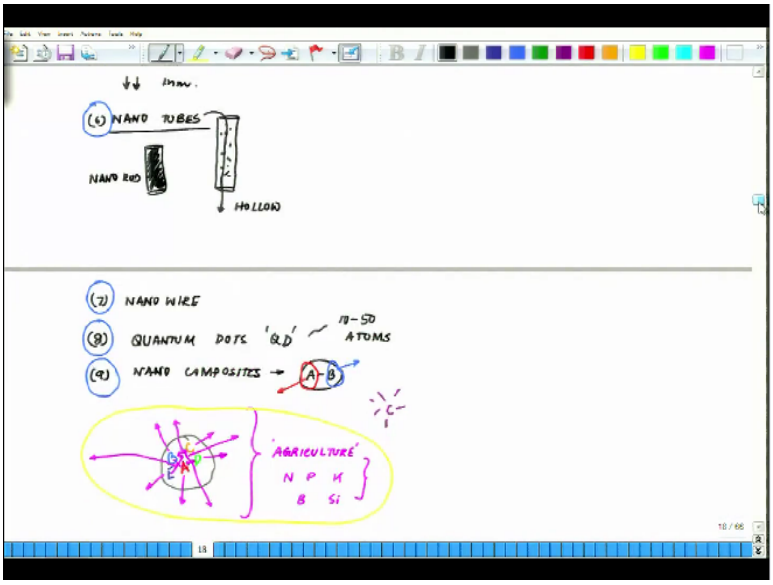

And I gave exclusive examples highlighting how each one of these could be helpful and one thing which I missed out in many of these structures are exceptionally helpful in developing next generation of biosensors for agricultural applications. Because when we talk about precision farming, where we are talking about pest on the soil assay, how precisely we have to apply the fertilizer in order to ensure a sustainable growth of the ecosystem.

Then we need to test, we need to have small sensors or micro sensors which would be used or utilised to detect the different contaminants in the soil. So one of the areas where tremendous amount of a stress has been put in precision farming is developing nano based sensors for agricultural applications. So the next classification route what you have discuss was the chemical nature where we talked about the organic, inorganic and carbon based.

And in the organic we talked about dendrimers, micelles, liposomes, ferritin and most of them are biodegradable and non-toxic and most of them have hollow force and they could be used as nano capsules to delivery any kind of active ingredient or any kind of agrochemicals at a specific site, not only that much of these organic nano capsules could be remain to open up or close according to the electromagnetic radiation or any other form of radiation like heat or some other source of energy.

Similarly in the same line we have the inorganic material which are mostly the aluminium, cadmium, cobalt, copper, silver, gold, iron, zinc, lead. So most of these metal-based are also used to deliver different forms of pesticides or they could even at times could replace the

pesticides in order to reduce the requirements of pesticides. So we have talked about these different forms of inorganic forms.

We talked about the metal sulphide, rare earth and metal oxide based once and then we talked about the carbon based on where in highlighted about fullerenes, grapheme, carbon nanotubes, carbon nano fibers, carbon dots activated carbon, nano diamonds and all these kind of other structures. So today what you will do will pick up this part where we talk about broadly about the synthesis of nanomaterials.

Let us start the synthesis of nanomaterials in terms of the synthesis when we talk about there are 3 broad classification of synthesis either it is a physical synthesis or it will be a chemical synthesis or it will be a biological synthesis. Now there may be time where we may be using 2 different techniques may be will be using physical and chemical physicochemical method of synthesis or chemicobiological methods of synthesis or biophysical methods of synthesis.

So or maybe we may use all the 3 physicochemical, biological route of synthesis, as more and more than technology is advancing these watertight compartments of synthesis of nanomaterial is slowly kind of you know the gap or the clear cut demarcation is slowly getting removed. They are almost on merging, but what is interesting to note here is that all these synthesis falls under 2 different approach.

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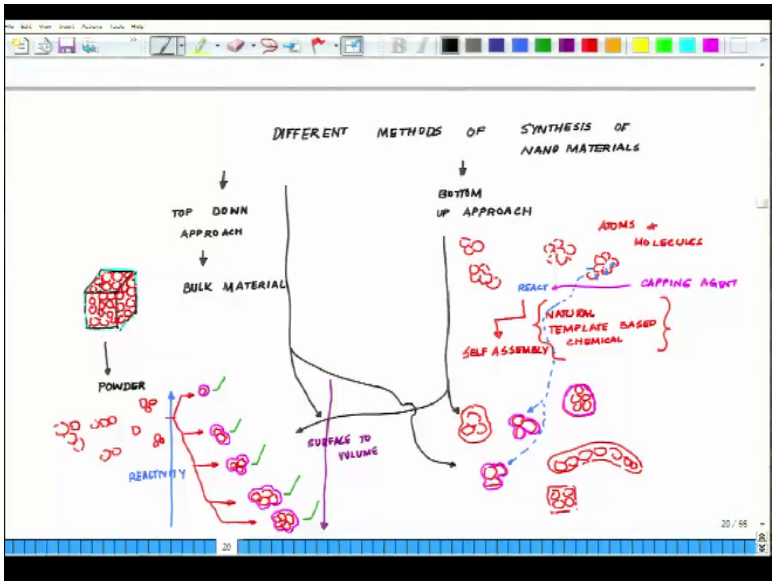

Whether it is a top down approach or it is a bottom up approach ok. So when we talk about a top-down approach so basic classification they could be classified into 2 groups start different

method of synthesis of nanomaterials ok. So either it will be a top down approach or it will be a bottom up approach, when we talk about a top-down approach, so essentially what we are talking about is we take a bulk material, something like this.

This is a bulk material which is filled with atoms which are constituting the bulk material, now this bulk material has exposed surface area like this, this is the exposed surface area you could see, now what we do is we take this bulk materials and we break it down inclusive powder, what we are getting is something like this, it could be uniform or you can categorise them, then you can fine tune them, you can filter them something like this depending on how precise or how precision filters you are having.

And based on that something like this ok, so depending on how final you go, you decide the size of the nanomaterial, say for example if each of the circle represents a single atom, then we are talk about a single atom out here, we talk about 2 atoms, we talk about 3 atom, 4 and 5 ok. So now we should look at it amount of surface which are available is for that particular volume is this much.

So if you realize as you are increasing the number of atoms your per unit surface to volume ratio is decreasing and if you are reducing the number of atoms your third unit surface to volume ratio is increasing. So the reactivity of so if you look at it as we go down with the size the reactivity is increasing in this order and the exposed surface area are here on the other side is decreasing like this.

So it is surface to volume ok, where out here it is the reactivity which is increasing. So this is a top-down approach where we take a bulk material, grind it by different techniques and bring it to the atomic resolution. Whereas on the other hand if you follow back bottom up approach what you doing here is you are already having small moieties like this in the form of salt, in the form of gels and whatsoever.

Now using you are having the atoms and the molecules at your disposal, you either some form of self-assembly either it maybe template-based or natural self-assembly or template waste self-assembly or chemical self-assembly grammatical rules what you can follow here by virtue of which you are creating specific structures say you create structure like this, what you talked about nano ribbons ok or you create structure like this.

What we talked about cubes, like ribbon like structure, you can create particles like this, you can have different kind of dimension, different kind of shapes like this ok. So this is the other approach where from a small components you can find them the way you do it is you can find these particles you are allowing them to react all they are reacting, you add some kind of agents in between which will give them something some kind of a capping agent what we call about which will give them some form of assistance to self-assemble in a certain way.

So depending on the type of capping agent which is used in a very small concentration as compared to the amount of nanoparticle, there is in a very very small concentration, but they help to separate out the particles in a way that suppose it is there is once to introduced the capping agent out here, they will help to separate out these particles in a certain way and it may be possible, you may receive something like this, something like this depending on what kind of capping agent you are using.

And as a matter of fact based on the capping agent in a synthesis where all the parameters are kept constant just by addition of different kind of capping agent we can vary the geometry of the particle very extensively, fairly extensively you can change the whole geometry of the particle because the catching agent is just like not only it separates out the atom, it creates a finite distance between the atoms and it create a certain kind of unique bond dynamics between the atoms.

So this is essentially a bottom up approach of synthesis of nanoparticles, so where you reach here which is or here same way or you reach like this out here you reach out here, so these are the 2 broad ways and under these 2 broad with the top down and bottom up approach what you are having are the broad classification nanoparticle synthesis which is your physical methods, chemical methods and biological methods.

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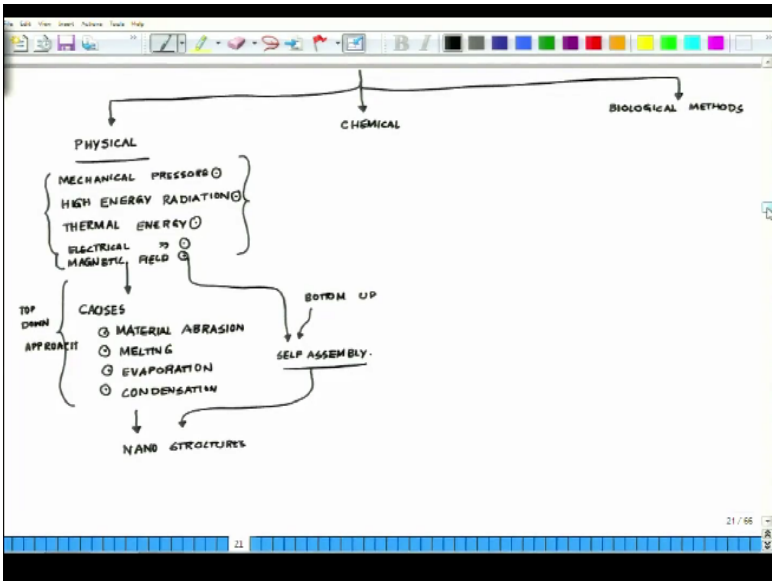

So when we talked about physical methods, so what we are essentially talk about is we are creating mechanical pressure or high energy radiation or thermal energy or electrical energy. These are the different routes we are following or these are the different forces which are employing and what they essentially do these different forces, they causes material abrasion, one aspect they may cause melting, evaporation because of this physical forces or they may have been cause condensation.

And this is how we generate nano structures, so what you are getting is in this physical technique is most, I want to see completely but mostly employed for if you look back to the previous slide we talked about mostly employed for top down approach. But that is not the complete fact, there may be a situation they could be used these physical forces could be used for this kind of self-assembly process also in the assistant self-assembly.

But mostly if you look at it the kind of physical forces we are talking about here are mechanical, pressure, high energy radiation, thermal energy, electrical energy. All could be used for both. So all these forces, so in other word when the physical forces are used for bottom up approach in that case that will cause this may cause in that situation self-assembly also.

When we are talking about bottom up approach, self-assembly leading to the formation of nanostructure. So this is where we are talking about bottom up approach and this is where we are talk about these kind of things happen in top down approach ok. So now what are the different physical tools which are, so this is how the process works either there will be

mechanical pressure, there will be high energy radiation or there will be thermal energy or their electric energy or even this even could use magnetic field ok.

It is possible that you can use magnetic field or the part of energy could be utilized to either self-assemble for bringing about some of these top down approach ok. Now what are the different physical techniques, so this is the whole basis how it happens.

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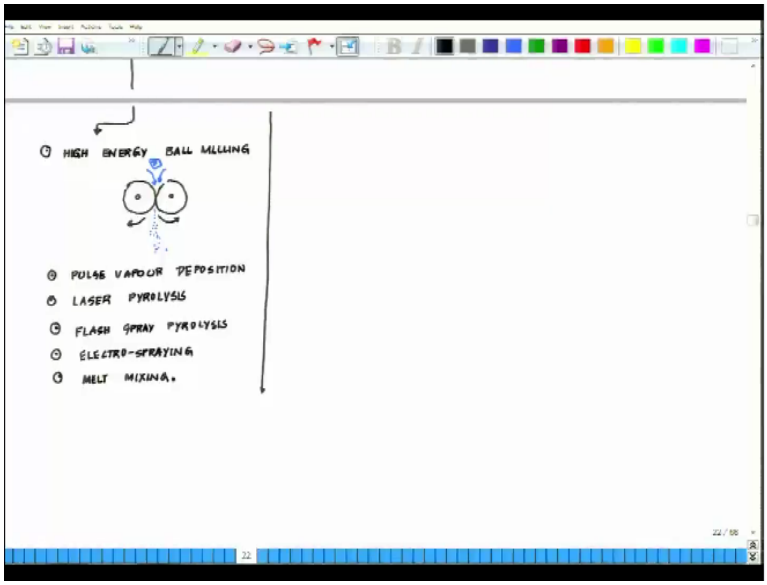

Now let us talk about the techniques the physical techniques which available. So one of the technique major technique is high energy ball milling ok, high energy ball milling. So when you talk about highly ball milling so this is basically say for example suppose you have 2 balls like this and we are moving at different directions ok. So this is where you are allowing your material, you know to grind you can control the speed of this.

So this is a material something like this, you can control the speed of these spares, you can control the size, you can control the contact area between them. So you can do lot of manipulation but this is something like an energy ball milling, will talk later about the pictures of this how they really work let us enumerate at this time what are the different techniques which are being used ok.

Next in the line is pulse vapour deposition, we will talk later about the detail of this technique ok pulse vapour deposition. To one point you will realise in most of these physical techniques they are pretty cost intensive technique, the third one is laser pyrolysis, they are pyrolizing

something using laser energy, then you have flash, spray pyrolysis followed by electro spring, then you have melt mixing.

So at that is point we are just enumerating all the different techniques which are available for physical mode of generating nanomaterials and then we will talk individual about these techniques, what they signify and how these could be used and what are the cost involved in it and what are the different kind of nanomaterials which may require this kind of pretty abrasive and pretty cost intensive techniques, and all of them are fairly cost intensive technique ok.