Nanotechnology in Agriculture

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Lecture-07
Classifying nanomaterials Based on Shape and Geometry

Welcome you all to the course in application of Nanotechnology in agriculture. So we have introduced the basics of agriculture, the use of different kind of chemicals in the form of pesticides, herbicides, fertilizers in the modern day agriculture. So this module concerned with current state of art or state of art of nanotechnology where will be dealing with the classification of nanomaterials we dealing with the different kind of are the broad classification of synthesis techniques which are being used.

The third aspect what will be dealing out here will be the different characterization tools which have been employed in characterizing the nanomaterials, in understanding their physical, chemical properties and their surface properties. So this whole fragment or this whole module is a kind of a walkthrough with different technologies of nanoscience. So if we see nanotechnology.

So it goes back to one of the famous quotes from Richard Feynman he says there is a lot of room at the bottom, what that essentially means is that as you really go down in upper size if you recollect in the very first module where I give you an explanation of how the nano structured they look it, they have bulk structure and you can break it down to smaller and smaller and smaller pieces.

Your expose surface area is to volume ratio is really going to go half, and that exactly where lies the catch that you have lot more surface for reactivity, so in other word in the nano domain the reactivity of material is exceptionally high. So in that context Feynman quoted that there is plenty of room at the bottom and with the onset of modern day nanomaterial synthesis realise there are 2 broad approaches what can be dealt.

The one of the approach is top down approach, the other one is the bottom approach and most of the synthesis techniques are classified under these 2 heads which is top down or bottom up. So we did talk about top down approach we are essentially talking about taking a bulk

material. Say for example all of you must have seen where wheat is being grounded to make the flour. So what is wheat is wheat is a bulk material.

So what you are doing you are putting in a mill could be a ball mill or any other kind of mill or it could be a grinder like this. So you are bringing down the size by of the constituent by grinding it. In other another word you are putting mechanical pressure, we are quite putting gigantic amount of pressure to make it powdery or depending on what level of grain size you can make it coarse, you can make it fine.

You can make it very fine ok, now this could also been achieved with other material by putting thermal energy, by putting other form of energies. So that basically you are breaking up big stuff a bulk material into smaller size which is top down approach, where of the bottom of approach is where you are taking small atoms, so have to say small atoms are there, you should be some kind of a salt and you are self assembling them in a reaction vessel to form smaller particles by the simple process of self assembly or directed assembly or template assembly.

All sorts of made of technique which lead to assembling or clustering or quisling of handful of atoms in a certain geometry or maybe in a dynamic geometry, we talk about this what you meant by certain geometry or in a dynamic geometry. In a dynamic symmetry they are changing their shape confirmation or the arrangement of the particle depending on their state of existence ok.

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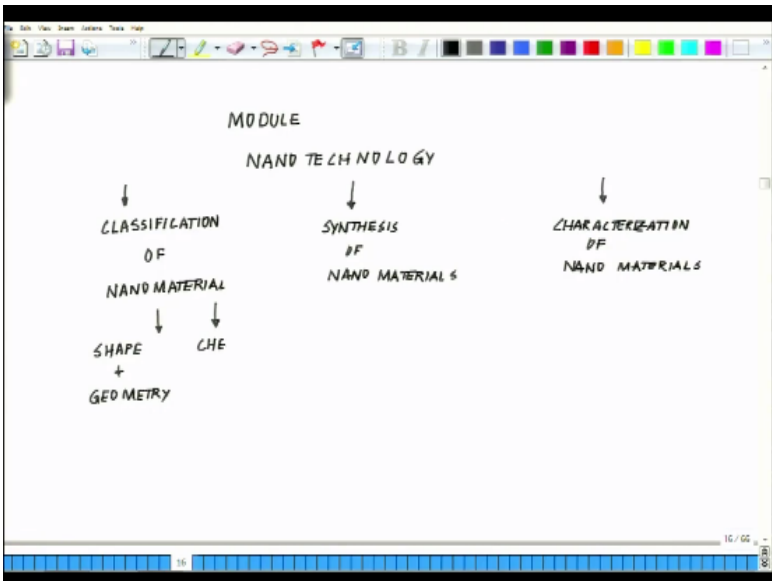

So these are the broad, broad ways how we can look as a layman how we can make nano structure. So formally start of it so this module will be dealing with nanotechnology and whether nanotechnology will be dealing with classification of nanomaterials, then synthesis of nanomaterials and the third section will be dealing with characterization of nanomaterials.

Now in terms of classification of nanomaterials then these could be classified into 2 groups based on their shape or geometry and secondly based on their chemical nature ok, if we classify them based on their shape and geometry they could be classified under so I am moving on to this part they could be either called as nano cages ok. So this nano cages first code in 2002 discard kind of nanomaterials is halo interior.

And porous wall container metallic nano particle in size, their size ranges from 10 to 100 nanometre, it is something like think of a cube and inside it you are having the nanoparticle sitting, something like this ok. So in all words what you have done is essentially something like this we have entrap the molecules inside it and mostly it has as I mention this class of nanomaterials is halo interior that is hallow.

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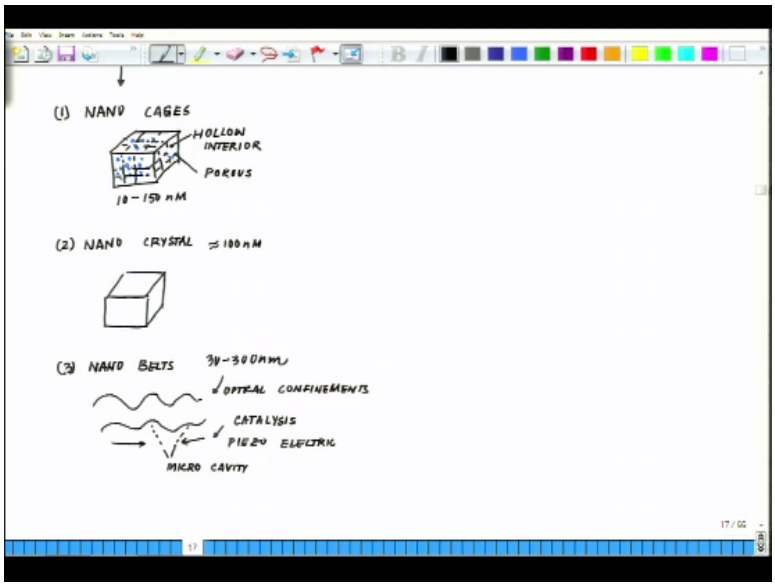

And it is porous wall, pretty porous wall and containing metallic mostly metallic nanoparticles are present in them and their size range varies from 100 to 150 nanometre ok. So then come the next one which is nano crystal, these are of different shapes of crystals it could be the easiest to draw with cubic crystals something like this, cubic shape the basic crystalline structure and they are approximately 100 nanometre ok.

Then comes nano belt these are ribbon like structures something like this nano belt is thin and flat sheet of ribbon like structures. So that are typically 30 to 300 nanometre depending on at what size you wanted to pick your nanomaterials for your specific purpose and nano belts with rectangular cross section and well defined crystalline process, enable it to attain unique optical confinement as very interesting optical confinements.

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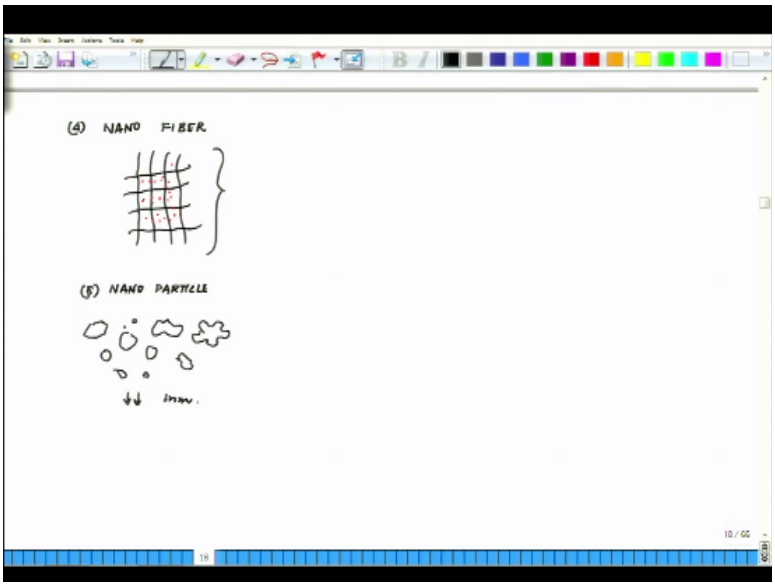

And it is micro cavities and it could use for the catalyse and it has lot of piezoelectric properties, think of it because we can compress them ok, so that gives it tremendous scope of piezoelectric features, it could be pretty extensively for catalyse and it has lot of these micro cavities. Next is the nano fibers, fourth one is nanofiber. The nanofiber is nano fibrous mesh or a network like this.

Something like this and it is a 2D mostly it is a 2D mesh and having a diameter less than around 100 nanometres ok. So each one of this having pretty small diameter and these could be used for different kind of biomedical application as well as for fertilizers release as well as several other release of active compounds ok essentially what you are doing, you are wrapping the particles like this in this nano fiber mesh.

Next is we have nanoparticles the name itself says these are simple particles of different shape they could have geometry like this, they could have a flower geometry like this, all sorts of geometry will observe in them. So these are the nanoparticles and there is where you can really go down with the size, you can really go down to 1 nanometre easily in these kind of particles.

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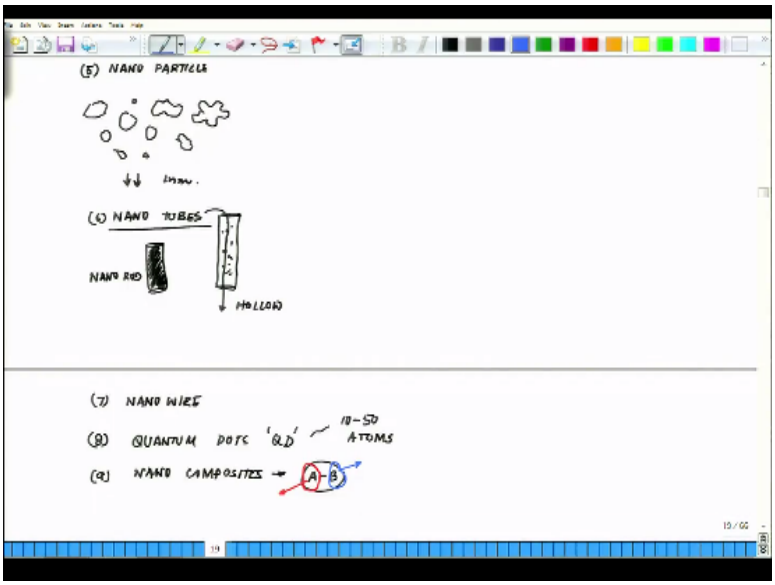

Because you are not restricted by any kind of spreading out in this stuff, so then you have nano tubes. So the nano tubes as the name itself indicates so nanoparticles are the one which typically can be reduced to 1 nanometre or maybe in a less than that. That is where you have lot of room to reduce the size. Next is the nano tube, as the tube says so these are something like cylindrical structure like this.

As a microscopic tube with the diameter which is measured in nanometre less than 100 nanometre and nano tubes are mostly follow this whole part is empty, so we can still stop into it, on the contrary nano rod if you talk about is a solid structure. So you could have tubes in 2 ways like either like this which is solid, nano rod whereas when we talk about the tube it is the hollow cavity moving through ok.

Then we talk about nano wires which is similar to ribbons though again there are different nomenclature introduced by different people in the pretty early phases of nanotechnology. So nano wire is a smart 1 dimension nano structural material with a dimension of 10 to the power -9 meters ok, then comes quantum dots. So quantum dots is which is represented QD quantum dots.

So quantum-dot is a nano crystal of semiconducting material small enough to exhibit quantum mechanical properties and their excitons are confined in all the 3 dimension, these exhibit strong size dependent optical and electronic properties and quantum dot can contain

few as 100 to 100000 atoms within a quantum dot volume with a diameter of 10 to 50 atoms, when we talk about quantum dot we are talking about 10 to 15 atoms atomic solutions.

And they have very very interesting semiconducting properties, electrical properties and they have tremendous potential but you control their size is a real real challenge ok. So it is not really easy to handle anything between 10 to 50 atom and uniformly obtaining 10 to 50 atoms over a period of time. So quantum dot on one hand is a very promising stuff, but we think quantum dot is not something so very trivia it means lot of I would say practical iteration to reach to the point of obtaining uniform quantum dots ok.

From here we move onto nano composites, so nano composites are multiphase material where at least one of the constituent phase has 1 dimension less than 100 nanometres, so for example if the composite of A and B then one of them either they are A or B suppose I say A it should have that nano dimension with it that is 100 nano meter, the promise of nano composite lies in their multifunctionality.

So you could have the functionality of this and you could have the functionality of B, so both could exhibit different kind of functions and the possibility of realising unique combination of properties and achievable with traditional Pristine material.

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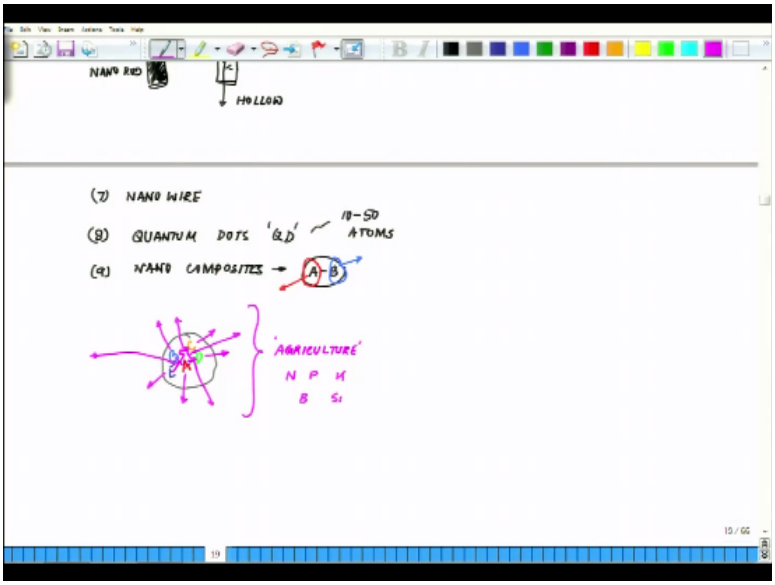

So essentially what you are doing say for example of a composite of say the B, A C, D and if you could really manage to get the phase conditions right, then what you are catering is a very exotic material with properties of this properties of this properties of this properties of

this properties of this as well as their interactive properties which emerging out because of their interaction.

So these are some of the material which have to found application if I had to say in agriculture. This is what we are looking forward to in terms of having a compact fertilizer capsule like you know you have for example nitrogen phosphorus, potash and you know say boron, Silicon you know likewise.

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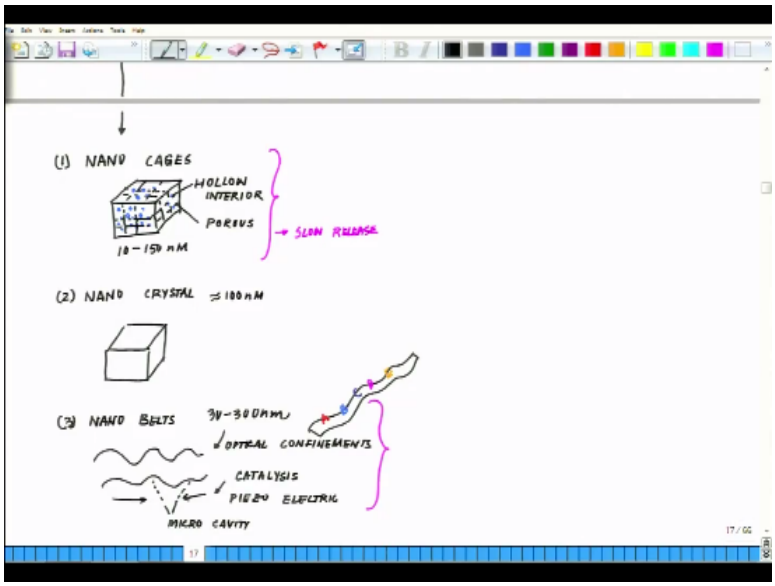

So nano composite the whole area of nano composite and confining nano composite into some form of say nano cages for say slow release or active ingredient or confining them in some form of nano belts. Say for example decorating a nano belt with different kind of material as we are mentioning say A, B, C, D, E and with the amount of surface area what is available for it to react rectangular cross section as I mention.

These could have profound impact in terms of using them as material for futuristic agriculture, both from insecticidal, pesticidal and all other wide area of application ok. So this is basically what we talked about is the structure we are classifying nanomaterial based on their shape and based on their geometries. And there are many more small nano diamonds and all these kind of thing than you have beads and all.

For those nomenclature but at the end of the day what you have to realise that different kind of nanoparticles or nanomaterials depending on the chemical motive which is present there, their self assemble in a unique way and we are just in the process of understanding some of

these, so today what I have been covering out here in terms of the different shapes may be 10 years down the line or even 5 years down the line. There will be many more such shapes coming through and maybe a different kind of classification which will emerge through ok.