Nanotechnology in Agriculture
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Lecture-08
Classifying Nanomaterials Based on Chemical Nature

So now from here what we will do we will move on to the second level of classification which is your chemical nature of classification.

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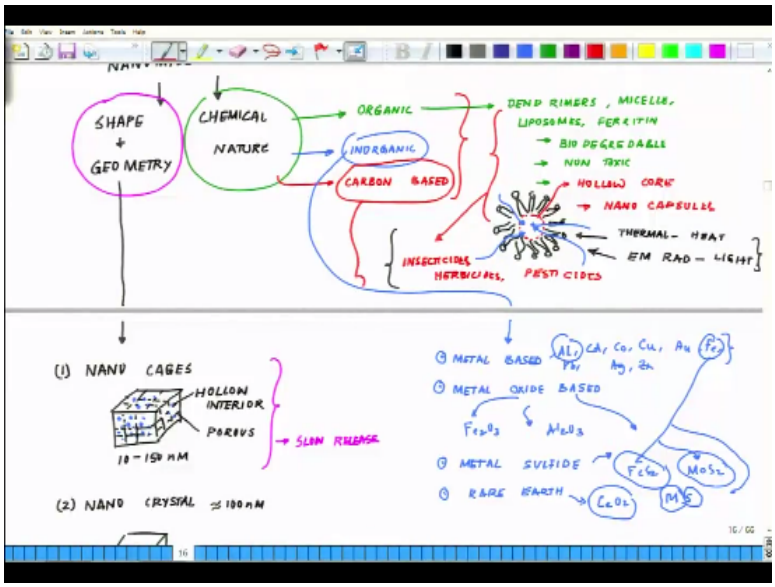

Chemical nature of classification, they could be classified into 3 categories, 1 is their organic origin, second one is inorganic origin, third one is carbon waste ok. So there are 3 different classes in terms of their chemical classification, in terms of organic nanomaterial that could be dendrimer, micelle, liposomes, and ferritin are commonly known as organic nanoparticles or nanomaterials ok. So organic one concludes dendrimer, micelle, liposomes, ferritin.

So these are commonly known organic nanoparticles and these nanoparticles are biodegradable, mostly non toxic and such particle such as micelle and liposomes has a hollow core, so if you see a micelle it will be something like this, these are the lipid moieties or hydrophobic moieties which are making the micelle, if you look at the centre the central cavity is all hollow, hollow centre cavity or the hollow core ok.

And also known as nano capsule and are sensitive to thermal and electromagnetic radiation such as heat and light and there also known as nano capsules and these are very important

from agricultural perspective in terms of release of say insecticide, herbicides, pesticide, those all could be encapsulated inside and they could be used for slow release ok. So these are also called nano capsules and are sensitive to these all sensitive to thermal and electromagnetic radiations ok.

In terms of heat and electromagnetic radiation also light ok. So these are some of the very unique characteristics made in ideal choice or any kind of delivery systems and this delivery system has a carrying capacity, say stability could be tuned according to our needs and requirements ok. Then comes your inorganic rather in the commutating which includes your inorganic nanoparticles or nanomaterials includes metal-based.

You have metal oxide based, so metal-based and metal oxide based includes mostly inorganic nanoparticles or nanoparticles that are size from metals 2 nanomaterial sizes either by destructive or constructive method or metal base nanoparticle almost all the metals can be synthesise into nanoparticles and the most commonly metals for nanoparticle synthesis are aluminium, cadmium, cobalt, copper, gold, iron, lead, silver, zinc.

And in terms of metal oxide based, metal oxide based nanoparticles are synthesised to modify the properties of the respective metal-based nanoparticles and for example if you see iron here Fe2O3, you have Al2O3 aluminium, you have different other such metal based systems which are there. This also includes a series of metal sulfide base which will be dealing pretty frequently than you have rare earth base.

So these are all different kind of nanomaterial which are either metal based or metal oxide based or metals sulfide, metal sulfide could be same if we talk about iron FeS2, if we talk about rare earth, we are talking about CeCo2 cerium oxide, FeS2 iron sulfide, we will talk about say molybdenum sulfide, MoS2, which is a material very very similar to graphene oxide ok, similarly we will talking about some of the other sulfides where metal is represented M here.

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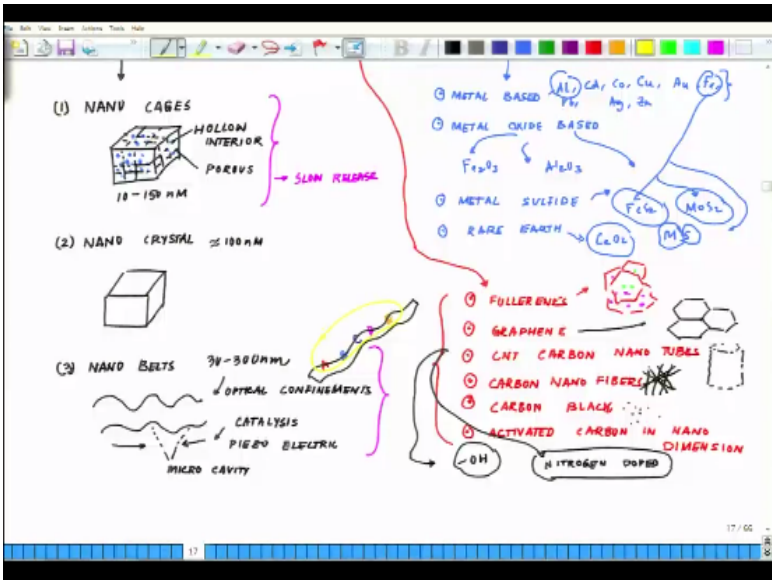

And sulfide is written as S, so there are different kind of sulfide compounds will be dealing in the inorganic section and then we will be talking about now the carbon based which is a huge group as an artifact or carbon based and this is lot of these journeys have started. So the carbon based nanomaterials are classified under fullerenes, graphenes, then you have carbon nano tubes CNT, or carbon nano tubes.

Then you have carbon nano fiber, then you have carbon black and then you have activated carbon in nano size and a nano dimension. So these are the different categories when you talk about fullerenes, or talking about buckminsterfullerene such kind of a cage of carbon, it is something like geodesic dome it is a kind of gauge wire you can entrap different kind of moieties like this where as if we talk about the graphene.

We are talking about a 2 dimensional sheet of carbon ring something like this, we talk about carbon nano tubes, we are talking about a hallow tube of carbon something like this, so when we talk about carbon fibres these are just like nano fibers we talked about, this will be the fibrous like this and then carbon blacks are nothing but particles, an activated carbon is also similar to the particle.

Now most of this carbons could be further functionalized or could be derived by a functionalizing then with OH group, so increase their interaction with water, their properties of hydrophobicity could be modulated by having functionalizing them with OH and they could be derivatized as nitrogen doped, the different techniques which have been developed deriving them with nitrogen doped technique.

And much of this carbon which are arise in nature, normally has a rose through geological era where most of the biomass through ages, through millions of years under pressure and high temperature underneath the earth crust that transform into things like coal, things like diamond, graphite, and if you take this material and follow the techniques of pulling out nanomaterials you will see all these materials are filled with nanomaterials.

In nature we have graphene or graphene kind of the stuff present in the coal. So this is all happen through ages or exposing these biomass which are rich in carbon, and partly nitrogen little bit of 16+nitrogen and other compounds increase amount and this high temperature, low oxygen and high pressure through the ages have led to conversion of the biomass into some form of nanomaterial.

The reason why I am highlighting this part is while we will be talking about synthesis you will appreciate that much of the synthesis which we will be talking about in terms of the physical mode of transformation where we have to give mechanical pressure, heat, light is nothing new because nature has already made nanomaterials by exposing the raw material to high pressure, high temperature, lack of oxygen and (()) (12:47) other combinations of this.

Only thing is that in the natures laboratory these are happen but time was never a constraint, time always remain in almost in finite order but in our lifetime time is already constrain. So when we talk about synthesis we had to emulate nature and at time we have to become more smarter than nature in terms of compressing time because you know achieve it and of course such thing to get a large scale would not be that easy.

Because nature has produced them through many, many, many 1000 of years ok. So talk about carbon, carbon is carbon nanomaterial are one of the very promising candidate for decorating them with different kind of moieties what we wanted to tell you, say for example rather talk about the nano ribbons I told you that these are the different ways you can really modulator the nano fibers.

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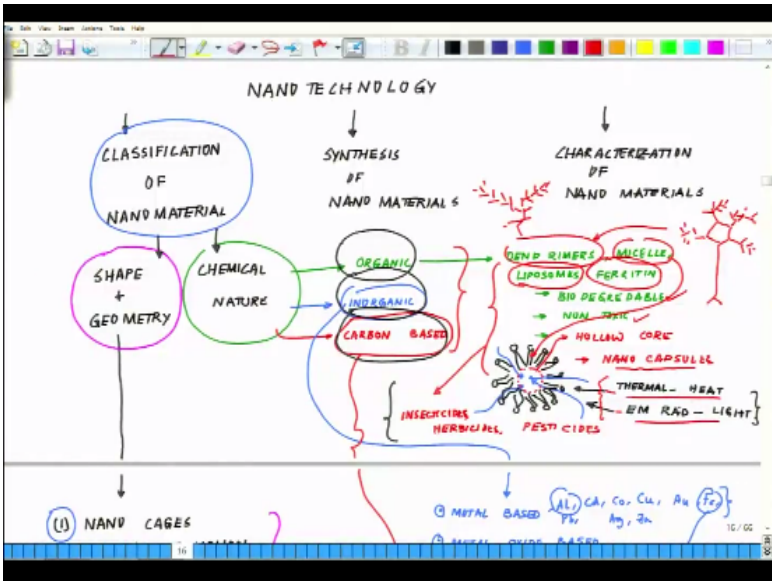

Similarly when we talked about nano composites I told, so say for example your core composites is carbon and on top of carbon you are doing all these kind of decorations, say nitrogen phosphorus and all this kind of thing, it is possible, but of course one has to ensure when we are functionalizing the carbon like this we have to ensure these, this functionalization of carbon leads to when exposed to the area of delivery or site of delivery.

It should be able to deliver easily without much problem, so that is very very critical. So to summarise the different kind of classification nanomaterials what we have talked as of now so they could be classified under 2 heading either based on shape and geometric or based on their chemical nature. In terms of the shape and geometry we talked about nano cages, or hollow interior coarse material of 10 to 150 nanometres.

We talked about nano crystals, we talked about a nano crystal could be even a sphere hallow sphere, we talked about nano belts, we talked about nano fibers, we talked about nanoparticles, we talked about nano tubes, we talked about nano wires, talked about quantum dots, we talked about nano composite and I mention about nano diamond and all are the different forms of nanomaterials.

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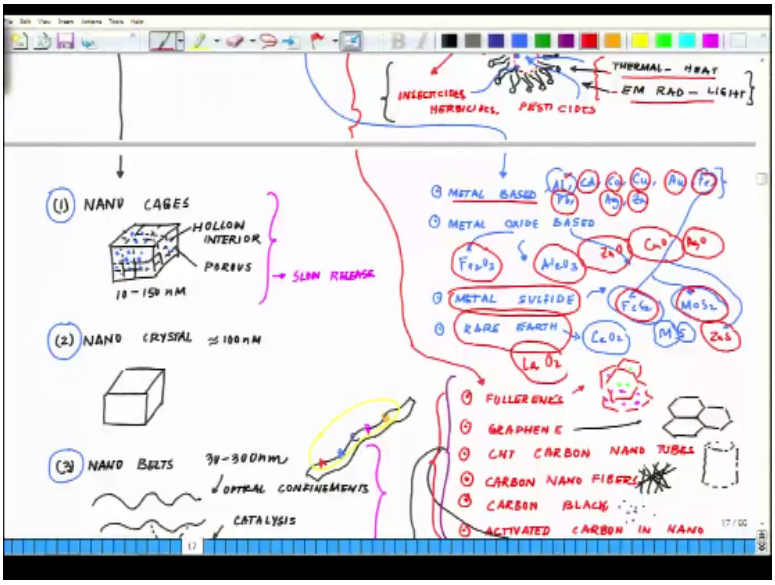

In terms of their chemical classification they are either organic base or they will be inorganic base or they will be carbon based. In terms of organic base they could be that dendrimers, something like this, like a dendri tree neuron if you look at a neuron it is something like this ok, it is a (()) (16:41) if you look at the dendri tree is a well spread out something like.

So this is what dendrimer are then micelle I have already shown you the pictures of the micelle, and liposomes which is pretty similar, and ferritin iron binding clusters ok and these are mostly bio degradable as I mention and these are non toxic and they have hollow core there also sometimes called nano capsule in terms of when we talking about micelle or the liposome and their properties of the degradation their opening it could be regulated by thermal or electromagnetic radiation ok.

So you can expose into light then they may open up fast relief in piece the intensity of light develop in up more. So there are several modifications what you can do with these kind of nanomaterials, then we talked about the metal based nanomaterials or the inorganic nanomaterial and within inorganic we talk about metal based while we talk about aluminium, cadmium, Cobalt, copper, silver, iron, zinc, silver.

Zinc, lead, similarly in terms of the metal oxide base Fe2O3, Al2O3, ok then you have zinc oxide ZnO, copper oxide Ceo, these are the different nanomaterials which will be discussing in our in terms of applications in agriculture then silver oxide or several of them and in terms of the third category is the metal sulfide we will talking we talk about them in terms of iron pyrite FeS2, molybdenum sulfide.

And any other metal sulphide, zinc sulphide likewise ok ZnS then we will talk about rare earth, cerium oxide or you now (()) (18:56) lanthanide series La, rare earth oxides ok, lanthanide series. So then the third category what we discussed is the carbon based system and within the carbon based system as we talked about fullerenes, graphene, which is fullerene is about fullerene C60 and all those kind of very complex, cage compounds of carbon.

So dimensional cage compounds of carbon OH is the nearest one which could be achieved was with the molybdenum where you could have the strong cage of molybdenum ok, then you have graphene, then you have carbon nano tubes, these are the hallow tubes and you have carbon fibers, and you have carbon black and you have activated carbon in nano dimension ok. And these could be functionalized with OH group.

These could be functionalized with carboxyl group depending on your requirements, what you wanted use them for a functionalized with OH group for their solubility in water, they could be derivatives as nitrogen dobed carbon material for different applications. So this is the overall classification.

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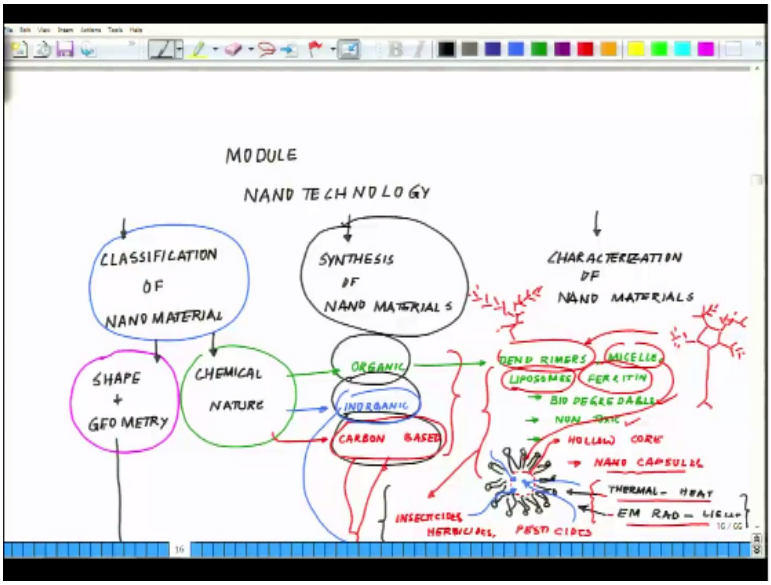

Now from here what we will do we will move on to the synthesis of nanomaterials where we will be talking about 3 different synthesis techniques, physical, chemical and biological origin ok. So next we will move on to the synthesis, thank you.