Nanotechnology in Agriculture
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Lecture-10
Biological and Chemical Approaches to Nanomaterial Synthesis

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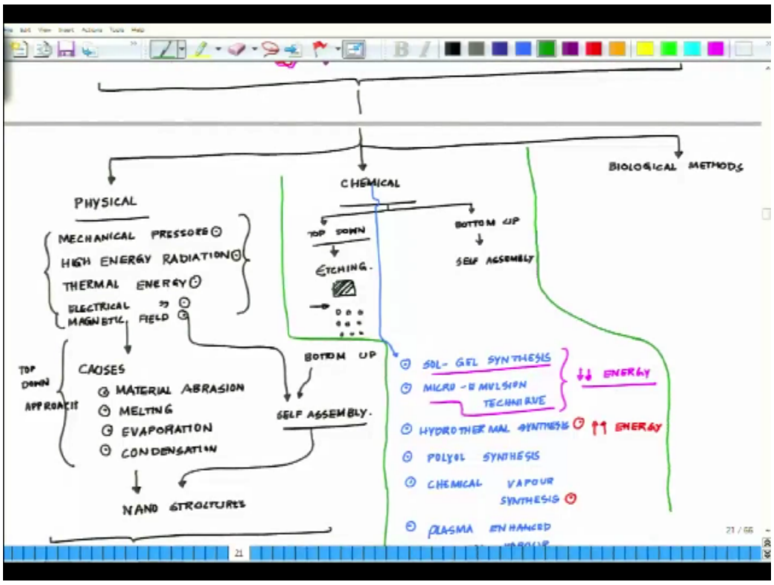

Now let us move on to the different chemical approaches which are being used. So again for the chemical approach there could be 2 things either you are using a bottom up approach or you are using a top-down approach, when we talk about top down approach we talk about itching. So you have a bulk material, say for example so again the 2 options you have either top down or bottom up.

So whatever be the technique when we are going out top down we are talking about itching, itching in a sense you are taking a bulk material and using some kind of acid or some kind of other chemical you are bringing on the size of it because of abrasive chemical action and then we talk about the bottom up approach we mostly talk about self-assembly of particles in the presence of capping agent and other agents do you know promote self-assembly.

So let us just differentiated ok, now talking about the chemical methods which are being employed, they fall under ok so the chemical methods are falling under these settings, so they have SOL gel synthesis, aerosol and gel will talk later about the detail of these kind of synthesis your SOL gel synthesis, then we have micro emulsion technique, micro emulsion technique followed by hydrothermal synthesis.

Then you have polyol synthesis followed by chemical vapour synthesis, then we have plasma enhanced chemical vapour deposition. So these are some of the broad classification of chemical synthesis of nanomaterials, SOL gel, micro emulsion, hydrothermal, polyol synthesis, chemical vapour synthesis and plasma enhanced chemical vapour deposition.

And if you look at these methods the last 2 like chemical vapour synthesis plus, minus chemical vapour deposition, even hydrothermal synthesis all these techniques requires really high energy. These are energy intensive just like your physical method where we talked about these techniques why do you need a significant amount of energy, here we are talk about high energy intensive processes. On the contrary when will look at these 2 techniques SOL gel or SOL gel synthesis, micro emulsion technique.

These in comparison with respect to a comparatively these are low energy intensive processes, once we talk in detail about this will highlight this fact why some of these techniques are low energy requiring where is the other ones are high energy requiring. So now we have discussed as of now or enumerated as of now the physical and chemical synthesis routes.

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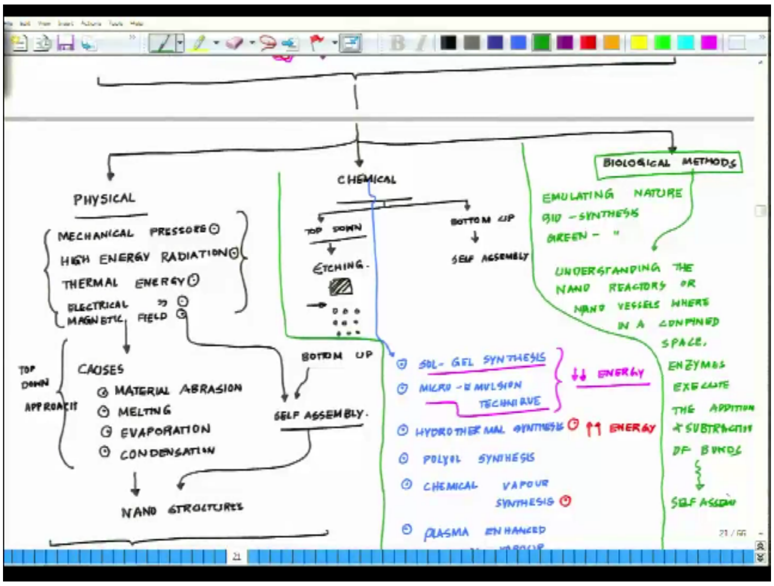

Now from here will move on to the biological route, now when we talk about the biological route why it is so critical that we understand the biological route, well if you look at nature the way nature functions let us take a simple example that plant world is the only place or only kingdom which can picks a nitrogen from the environment.

There is no other way you can fix nitrogen and there are these enzymes call nitrogenase which can trap the aerial nitrogen and convert it into some usable SOL, some usable form and that is why we are completely dependent on nitrogen fixing microbes which have a symbiotic relationship with legumes and other plants. So they are the one which enriches soil of nitrogen, otherwise there is no other way you can do it.

Now even as Layman if you think of it plant does not have a chemical vapour deposition technique or laser pyrolysis or some hydrothermal synthesis or any of these sophisticated so called sophisticated energy intensive tools to achieve this feet, what it does, it is developed a genome effect and its synthesized some very unique enzymes which could assist in transforming and peak around with this bonds of you know getting the nitrogen gas.

And transforming it attaching with some factor, so it assist in it and ensure that we get the desired result, but this it does in a simple room temperature or maybe you know I am at this point settings or delivering a talk at around 20 degree centigrade, the temperature of the room outside will be like around 30, 35 degree centigrade. So within the physiological level of plant can do this.

So in other words plant does these things without any extra requirements of energy in terms of high energy requirements or in very sophisticated tools. So in other word nature is our best guide to understand what we call as bottom up approach of nanoparticle synthesis as well as nature can teach us how it does the top down approach because think of it when we talk about a top-down so what we are talking about the bulk material out here.

Now suppose this bulk material is under the influence of a microbe, this microbes if you could increase the population of the microbes on it this can bring it down for small particles over a period of time. So it is possible that it could reach out the particle or it may consume it but then if we get this microbes which has consumed is particle and grind it together then be much more less intensive process and pull it out pull out those particles.

So are these feasible could we think in that way or as you told you as we discussed just now in the biological world the bottom up approach. So these are the principle or guideline in feature what provokes us to think that biological route of nanomaterials synthesis is the future where we could emulate nature, emulating nature because why we wanted to emulate nature is basically a biosynthesis or which is a green synthesis.

You are not using any caustic acid or any kind of caustic compound or any kind of harsh environment to achieve this kind of synthesis, yet you achieve your goal. So what biology has to offer is what we have to learn is understanding the nano reactors or nano vessels where in a confined space enzymes execute the addition and subtraction of bonds and thereby bringing about a self-assembly or even at times these enzyme could catalyse executes the breaking of bulk.

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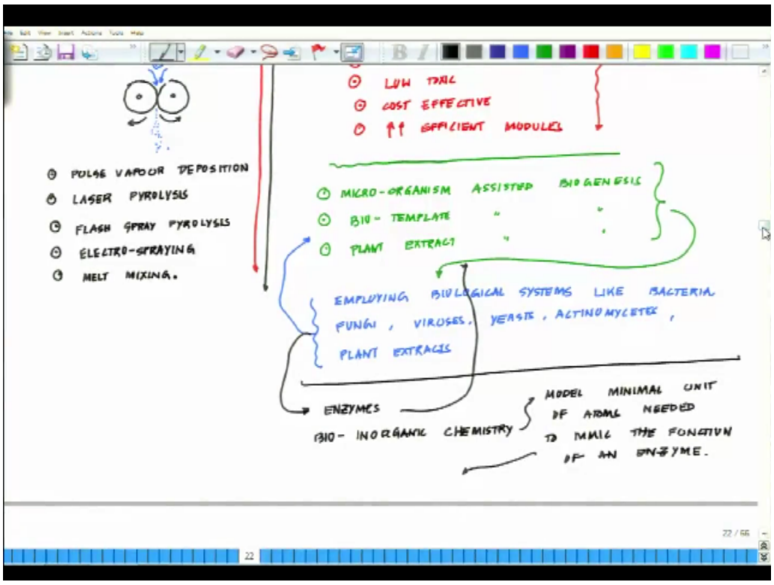

Thereby leading to small particles, so in other word what we are talking about in terms of biological route is we have to understand, so most of these provides environmental benign what is basically environmentally benign low toxic, cost effective and fairly efficient modules of synthesis and the biological routes which are currently widely explode includes microorganism assisted biogenesis, microorganism assisted biogenesis is one.

The second thing is bio template assisted biogenesis and we will talk in detail about this as well progressing in this area bio template assisted biogenesis, plant extract assisted biogenesis. So the logic is simple what is being followed out here is this employing biological systems, employ biological systems like bacteria, fungi, viruses which is kind of tricky viruses, yeast, actinomycetes and plant extracts to bring about the biogenesis or synthesis of these kind of nanomaterial.

Now one thing was realizing what you are essentially doing, the key idea is to is kind of if you look at it more much of these research in the initial area of research out here are of you are trying to extract much of the enzymes from the system, which will help in the synthesis of the nanomaterials. Now one area which florist in last 30-40 years tremendous amount of research has taken place is the area of by inorganic chemistry.

So of you look at the work which has been carried out in by inorganic chemistry you will realised there are people who have tried to module minimal unit of atoms needed to mimic the function of an enzyme.

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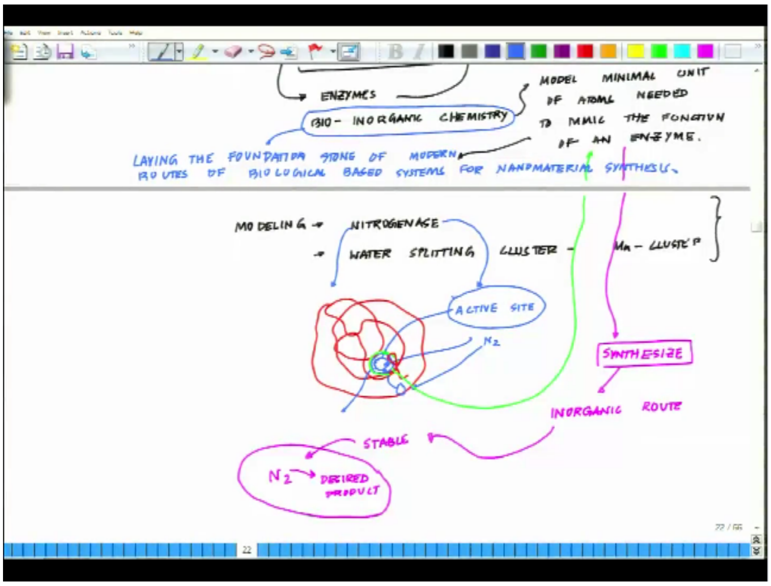

This tremendous amount of work which is gone in synthesizing such are you know say for example modelling nitrogenase, modelling and these are just some examples I am giving modelling, water splitting, clusters which is mostly consist of manganese, cluster essentially. So these are the approach which has been there not under the banner of nanotechnology which has been there where people have say for example just to make understand.

Say for example when we talk about an enzyme, so we talk about a huge protein moiety and within that protein moiety you have active site, say for example this blue is showing the active site ok. And say for example this is an example of say nitrogenase we have talked about it. So this is the active site of nitrogenase. Now what people have been trying is this is the site where say nitrogen gas is coming out.

Maybe some another site is binding and then there is a reaction which is happening and leading to transformation of the nitrogen and of course the enzyme is not getting used up, but people have trying to do for a while, say for example they wanted to understand this structure in atomic resolution and once they understand the structure in atomical solution what they try to do they wanted to synthesise this structure outside the system.

Not by biological route, by sample inorganic route and if you could get it in inorganic route then you can and if it is unstable inorganic approach stable route then you can actually produce or you can transform nitrogen to your desired product in a controlled environment. So if one can achieve these desire product ok, then much of our synthesis of urea, ammonia, the high energy processes will kind of will be kept at bay if you understand this.

So in other word what I wanted to highlight here is this, nanotechnology of course another banner of nanotechnology these are not there, this is one of the key areas of by inorganic chemistry, but if you look at some of the development of by an organic chemistry and if you follow up with the people even in India as well as abroad where worked extensively in this area for last 20 to 30 years.

You realise that they are nothing but figuring out low energy methods, modelling enzymes to create environmentally benign route to fix different kind of compounds which are needed for agriculture, today we are kind of standing at that beautiful needs to realise and appreciate the research which has undergone for last multiple decades in the area by inorganic chemistry. So I here I take the liberty it is say much of these by organic chemistry research of modelling the enzymes and synthesizing them is kind of laying the foundation stone of modern route of biological based systems for nanomaterial synthesis.

That is kind of is where much of these biological routes are heading they are very very energy-efficient system the way in the for system 2 the manganese cluster which traps the water molecule and spirit of the water molecules to generate hydrogen and oxygen is just a magic. There is no system which could do it so very efficiently, not only that think of the water channels.

If you could emulate water channel in terms of water purification, think of the way a nitrogen fixing bacteria or microbes traps the nitrogen from the air or areal trapping. So these are some of the marvels of biology and that is why I mention the beginning the idea is to this word is critical for you to appreciate emulating nature. This is what lies answer to most of our tricky question which otherwise is not easy to answer by any means.

Emulating nature the way nature does and we understand nature, the way does it then one day probably much of these techniques will merge towards biological technique which in other word which will be much more precise is very precise route and these will be in terms of the energy out here to compare it. So these will be energy low technique as well as small amount of raw materials to be needed.

And will be much more eco-friendly, but these biological methods are just in there in fancy we are slowly very slowly realising that what all we can do using biological tool and this is not a common genetic engineering and talk about slightly different that whole domain of bioinorganic chemistry and its application in nanomaterial synthesis. So this is broadly are the different methods under the heading of physical chemical and biological methods of synthesis.

Will go little bit after this in explaining very briefly about what is high energy ball milling, what is pulse vapour deposition, what is laser pyrolysis, what is flash spray pyrolysis, what is electric spraying and melt mixing. Then in the chemical route will talk about the SOL gel method, micro emulsion technique, hydrothermal synthesis, polyol synthesis, chemical vapour synthesis, plasma enhanced chemical vapour deposition.

And then in the biological routes we will talk about the microorganism assisted biogenesis bio template assisted biogenesis and plant extract assisted biogenesis ok. So closing here, in the next class will talk in detail about this techniques, thank you.