Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture – 26
Classification of Pyrolysis

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Welcome back to the lecture series in bio energy. So in the last class we talked about the pyrolysis process where we talked about when we burn certain things in the absence of oxygen and at a temperature on the 500°C you can transform any material having either a liquid phase or a solid phase or a gaseous phase and these kind of transformation are used by nature or through geological eras have led to the formation of coal natural gas different kind of natural oils as one go down the rocks underneath the earth one can see such deposits.

Just to recap in the last class what we talked about, we talked about natural processes how gases how pyrolysis has taken place, we talked about the volcanic eruptions where suddenly all of a sudden the lack of oxygen things got burned down. And then we talked about how under heavy pressure and high temperature deep inside the earth crust through centuries and billions of years different forms of energy materials have formed.

Further we talked about how this pyrolysis technology is being mimicked in the lap and I give you a schematic showing you that in an organized chamber or a nitrogenated chamber where you are essentially using these two gases to make the whole environment inert you can keep any kind of sample you can keep any kind of national fibers or natural materials and you can paralyze them by burning it over a period of time.

Now there we talked about two interesting aspects what will be the rate of raising the temperature say for example, a sample in a room temperature is it a headset 30 degree centigrade and I wish to burn it at 500 degree centigrade the question is how you are going to change the temperature you can change it in a stepwise fashion 30, 40, 50, 60 or you can even slower it down further 32, 31, 32 likewise or what you can do you can just shift the temperature very fast.

Based on that in the last class we talked about flash pyrolysis where you raise the temperature at a phenomenal rate instead of a staircase model you almost go like this within few seconds you raise the temperature say from 30 to 500 such flash pyrolysis or the term which is used for such a drastic increase is termed as flash pyrolysis depending on the rate of change of temperature or the slope.

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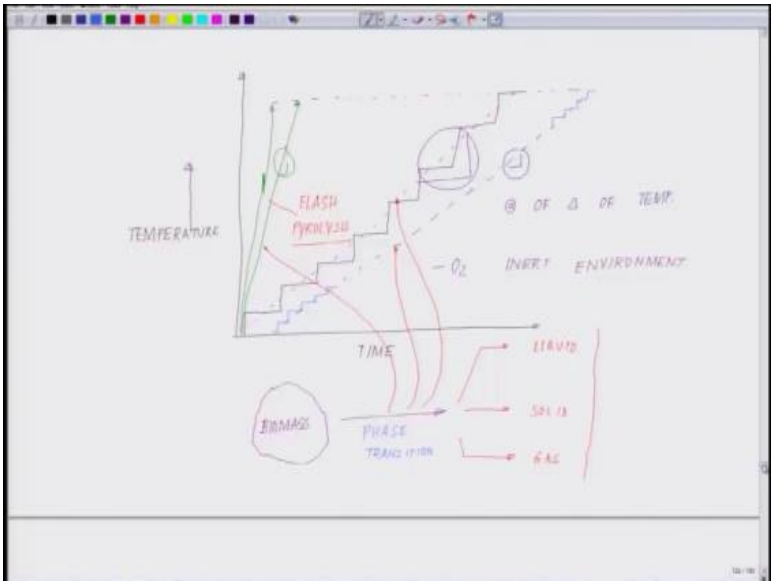

So for example just if you look a slide so depending on for example how you are raising the temperature with respect to time. So on this scale we have time and on this scale you have temperature okay, for depending on how we are increasing it can increase in a stepwise fashion as I was mentioning you over a period of time whatever you will be your temperature you are setting.

So for example this is the temperature you are setting up to which you have to reach you can do it like this you can even make it more slower you can go like this and eventually at some point you will reach here or you can raise it like this or you can even if you have such gadgets you can raise it even further. So what you are essentially seeing out here is you are changing the slope of the rise if this is the slope.

So if I draw a line like this out here average increase over a period of time what you are essentially doing is you measure the slope and out here I draw up instead of making it look that stepwise so every time you are changing the slope or in other word and this could be even almost only line like that if it goes straight in the exact y-axis okay what you are seeing is the rate of change of temperature and depending on how you are changing the temperature these kind of situations are called flash pyrolysis.

So this is a recap what I wish to share the slide because depending on the rate of change of temperature which you are exposing the material and all throughout keep in mind you are doing all these things in absence of oxygen. So in an inert environment or reasonably inert environment. So depending on the rate of change of temperature the phase transition in the material is going to change in other words what does that mean that means say for example you have a material like this which you want to pyrolyzed this is your raw material or some form of biomass what you are obtaining depending on.

So this is your biomass depending on which route you are following say for example you follow this route of increase or you follow this route of increase or you follow this route of increase the feet will vary you may get liquid, solid or gas this is not in order just I am telling you these are the possible sale. So in other words and the highlighting feature is there is a phase transition in the material to happening and this phase transition is essentially nothing but rearrangement of the overall structure in terms of its bonds joining, making and breaking of bonds.

So this rearrangement and the distance between the molecules is controlled by the rate of increase of the temperature based on that what I will do now we will classify the different kind of

wealth water developed through pyrolysis process and here it is noteworthy that these kind of things have been formed in nature to billions of years whatever natural gas what we observed what are the different kind of inflammable liquid fuels what we see what the or the coal or other such carbonized material in high temperature in lack of oxygen they have formed.

So again I am returning the fact that what we are trying to do now we are trying to create a synthetic condition to make something equivalent to a code or something equivalent to a oil what nature has done in billions of years the reason why I am repeating this fact because there is a philosophical shift till this time since industrial revolution or discovery of coal use of coal as a fuel, use of petroleum as a fuel, use of natural gases of real man has continuously used the resources which have developed through billions of years of geological evolution.

But today man is trying to evolve these compounds in the lab which bio large is one of the biggest dream and definitely a biggest crime of mankind because they are daring to think in the way how nature has developed these kind of things over billions of years and that is why I am highlighting that the whole area of bio energy is in itself is we are tweaking or we are trying to emulate what we are trying to mimic what evolution has done in billions of years.

And this is no easy challenge this is one big challenge that in order to solve our energy problem or in order to safeguard nature instead of exploiting me nature we are now following a different route a different track a different trajectory okay so coming back to what are the different feeds you can have.

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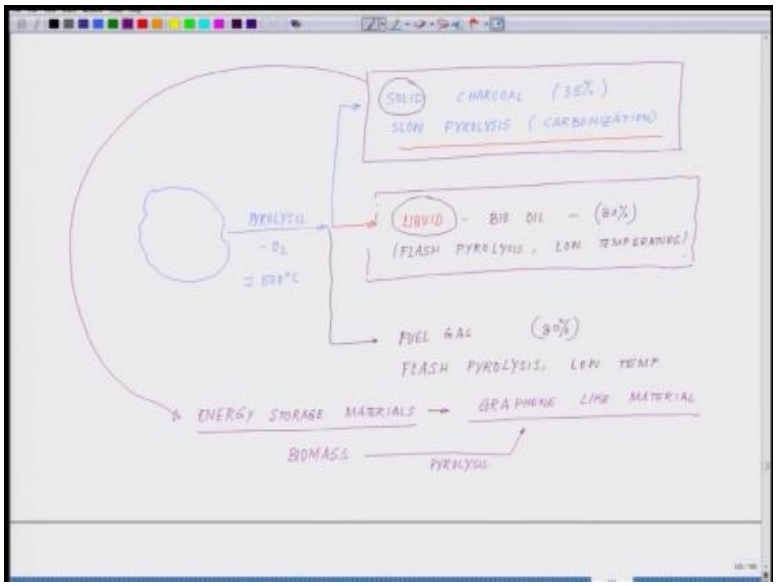

So possibilities are there so you have this kind of material out here and you are by realizing them pyrolysis in the absence of oxygen okay and approximately reaching a temperature of 500°C the first solid material what you can obtain which is basically something like a charcoal okay and the easy for such charcoal formation is around 35 person. So it means you take 100 gram you only so if you have hundred grams of this material you get 35% of it okay and this is slow pyrolysis or also called carbonization slow pyrolysis are also called carbonylation process.

So in other word this is the process if we talk about a slow process then this is essentially is this kind of rice what you see out here this is the kind of a very slow processor maybe much, much lower much, much slower like this and this time scale you can always change okay, you can have it in minutes you can have it in 100 years like ways okay like this slowly, slowly there is a transition.

So there is no such flash transition taking place out here so this is a slow pyrolysis process which is called carbonization the second option is that you convert it into liquid form which is having an efficiency of around 80% which is far better than having a solid transformation and this

happens as by flash pyrolysis and this needs a low temperature okay the range of 500 or 600 likewise okay.

And the third option is one is it so we have the solid fuel we have the liquid feel the form of bio-oil then in products real gas which also has an efficiency of around 85% transformation and this also requires flash pyrolysis which happens at low temperature okay so these are the three feet of either you can make charcoal out of it or you can make oil out of it or you can make gas out of it.

So in terms of the charcoal part the first part what we have talked about out here this apart from formation of charcoal it has some very innovative applications in terms of energy storage materials. So such pyrolysis process in the laboratory condition could be used to make energy storage materials in terms of energy storage materials we will not talk about in this class probably in the next class we will talk about you can make materials like graph like materials.

In other word dressing like materials so in the forum there was an interesting question which was asked. So which I wish to share with you people that we are graphing comes in the bio energy as matter of fact nature through evolution has evolved most of the materials what we are now discovering in our laboratory conditions. So this kind of Tran’s function which is a special transformation will come later on to that this kind of transformation say for example we get very cheap and good quality of graphene's.

So think very holistically on one hand we are using biomass tube and generate energy in terms of energy we are mostly talk about electrical energy. So then you mean some modules which is also derived from nature to store that form of energy and that is the answer to the wise gentleman who asked me that question that why where it is falling.

So I am trying to bring it very holistically in front of you that not only energy production is should be our last goal you have to think how to store that energy without that all our efforts to generate energy will be futile, because if you cannot store it then we cannot for the time when you do not have energy we are running short of our raw materials we should have some source to store it and use it we can make it much more portable we can send energy capsules to larger.

So we will talk about this specifically how from so this section what we will be talking about not in this lecture we talked about how certain biomass could be converted into graphene like materials or maybe superior, than graphene materials by the process of pyrolysis okay. This is one aspect what we will be dealing with and we will have a bit of a laboratory demonstration how this could be done.

So there will be one class which I will be dedicated probably at the sag end of the curves we're practically how this is being done will be demonstrated in the form of a video okay. And how those could be charged that material how we can form different kind of sells out of it and you can store energy you can store charges into it and you can use it to run different kind of devices okay.

This is one aspect second aspect what we will be dealing now is the second aspect which is this part okay the flash pyrolysis at low temperature to transform the biomass to bio oil this process and what are the salient features that is what we are going to talk.

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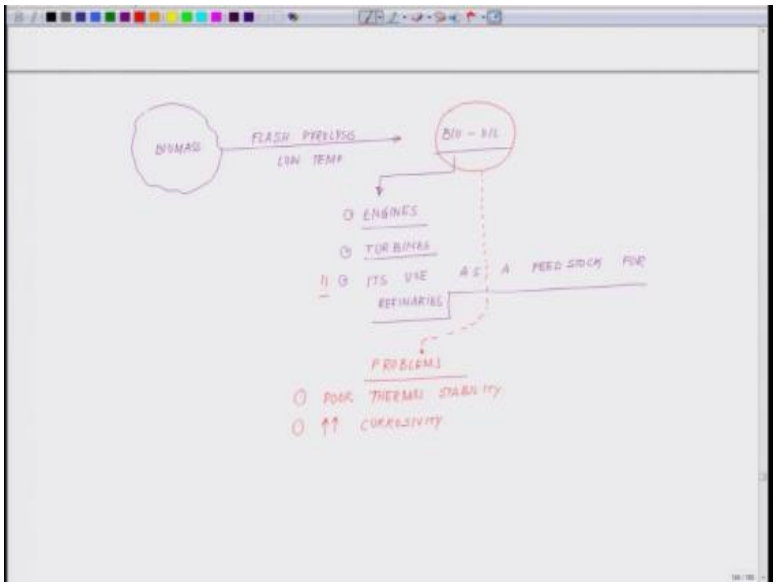

So now we just cut down other stuff so here you have the biomass and through flash pyrolysis you are making at low temperature you are making bio oil. So such oils could be before we get into the process and the drawbacks such oil could be used in engines turbines so when I am talking about your lines to realize again the same situation when you are running a turbine you are generating electricity and when you are generating electricity you needed another bio sustainable or biocompatible material for the storage of such electricity.

And that is where our couple of minutes what I was discussing with you that how we could use these kind of materials to vitalize then make them charge storage devices that will come very high and be out here okay. So you can run ancients you can run turbines and it is also used let us use as a feed stock for refineries and of course there are issues which has to be taken care and we will come to that this is one of the challenging aspect.

But the problem it comes with certain such by oils water formed out here what we are talking about comes with certain inherent problems and now we will talk about and why especially is this part the use is not so easy the problems what such oils come our okay. So the first issue is they had war thermal stability okay and there is a huge amount of corrosivity. So what we mean by thermal stability and corrosivity in terms of thermal stability most of the time the thermal stability happens.

Because if your sample has certain amount of oxygen trapped in it and presence of oxygen not only lead to instability in the molecule itself, but it also leads to the oxidation or corrosivity in the engines where you are using them. So most of these bio oils which are formed from biomass comes with this inherent problem of having a corrosive nature and having thermal instability.

Now think slightly differently every time I am bringing you back to the evolution the kind of natural oils what we get or from patrol or other things why those do not suffer from these problems thermal stuff instability or cola security we use patrol we use diesel right diesel engines we have patrol engines with two stroke engine in a four stroke engine based on how much power we are generating why this natural products on natural soil does not suffer all these problems.

And the reason to ask you this question is that that is the way one has to think how to advance the research in transformation technology or in terms of how your conversion technology of biomass to bio says. So as a novice are as I mean an expert one if one has to think that how I am going to convert it the first thing one has to understand how geologically Dean's wills are formed if you know how they have formed it.

So again it is not a easy thing to answer why it is not an easy thing to answer because we cannot go back in time I cannot go or you cannot go billions of years back in time to figure out how this phase transitions have taken place, but through our geological studies we can at least try to make some smart guesses possibly this has happened possibly this has happened possibly this has happened.

Now if we talk about corrosivity how possibly nature when it found patrol or patrol reservoir form or diesel and all these things were formed how these freed themselves from oxygen how they never had the coal acidity. So think you have to think in a way how oil is being extracted, so those of you who have some idea and those who do not have this just to give you a feel. So generally what happens if you think that I will just make a drawing.

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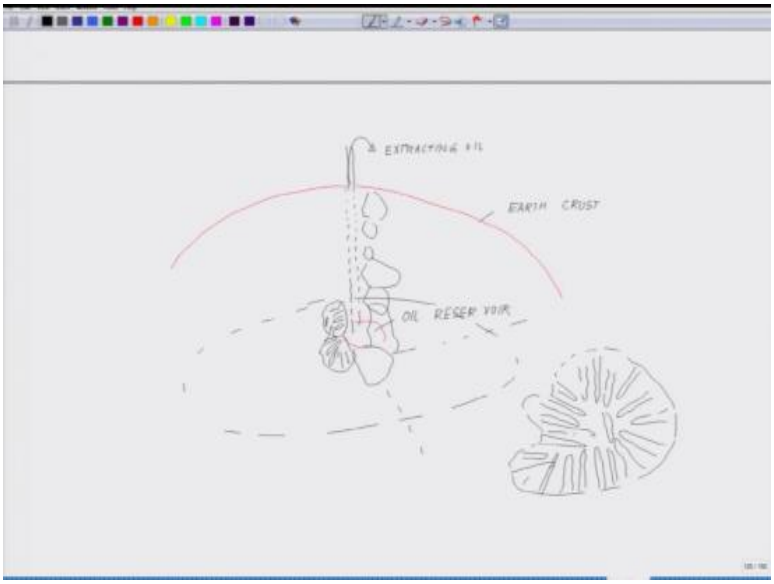

So to your imagination will become like if this is the earth craft okay and say for example is a part of the earth. And suppose somewhere here you have the oil okay so what generally you see from the top is that there is something which is coming out from the earth crust and possibly something has gone down like this and which is pumping the oil out of it right so it comes out and then it goes to the refineries.

So let me put the common feature earth crust okay and so it is a surface so here you have the oil reservoir and hear you are extracting oil okay now whenever you think of such situation what comes in your mind do you think that just like a water well you have a well like this. And there is a lot of water filled in it, or something else comes in your mind, actually as a matter of fact the way all of you have seen our well from where we take out water actually oil wells are not like that.

The way it is actually is say for example so the earth crust is the rocks, and likewise in also going down so in this region if you see all the rocks which are there all these rocks if you magnify it all these rocks are porous rocks. And all their cavities they have cavities all over these rocks okay these cavities are filled with oil.

So as it this is a huge rock with a lot of test tubes a lot of small cavities in the form of test tubes which are actually filled with oil. So unlike what you see in a water well it is not like this something like this okay. So now what happens when you are putting that oil borer into it crushed to that and all these rocks are filled with so much oil all started oozing out and you siphon it out.

So what I wanted to put here is the way you think you takeout water from the well is not the way or it is present now what is the information we are gathering out of it I will come just soon after this what is the information you are gathering what I will do. Now before I get, so remember this diagram what I do for you on the slide that these rocks which are present here are having tons of test tube or not just to give you an idea give you a feel it is not really test tube it is just like similar to testing as if there are small reactor vessels on the rocks which are filled with oil.

So it is something like this so the whole area may have tons and tons of rocks which are filled with oils now keep this information in mind and let us see what all has to be done in order to extract oil.

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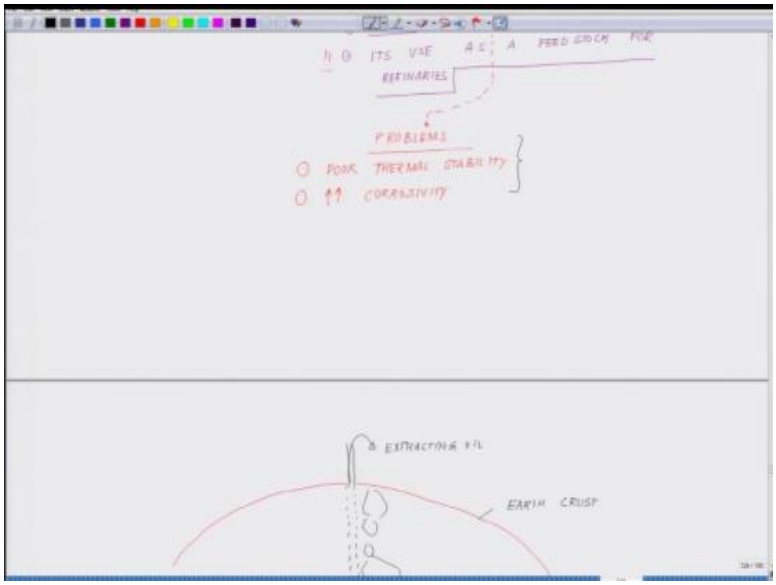

In order to make this oil what we are getting to reduce or the bypass this problem of thermal stability and corrosivity I will comeback because there is a significance to this drawing what I do for you.

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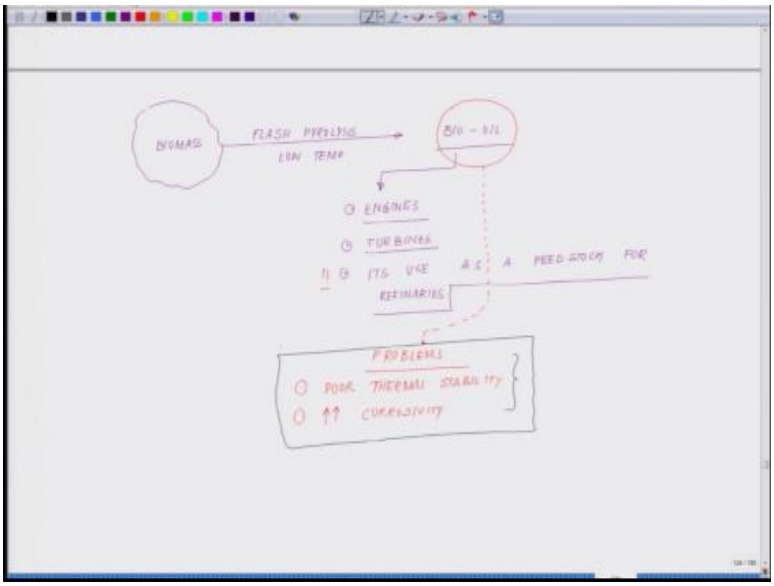

So in order to bypass so where we started we started like this these are the problems and the question which I posed to you is why in nature the oils what we get in the form of patrol gasoline or gases they are not corrosive what makes them so pure and soon pristinely assumable as compared to the bio oil what we are making in the lab and there I posed the question kilo if one has to understand or advance the conversion technology then one has to think the way nature may have evolved this processes of oil formation and oil storage and we'll come back to that okay thank you.

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