Transition Metal Organometallics in Catalysis and Biology
Prof. Prasenjit Ghosh
Department of Chemistry
Indian Institute of Technology – Bombay

Lecture - 42
Olefin Polymerization (Part-3)

Welcome to this course on Transition Metal Organometallics in Catalysis and Biology. In this course, we have been talking about Olefin Polymerization in the last few lectures. In particular, to begin with we had looked into various classifications of polymers that exist and these are primarily based on the polymer properties or their material properties. For example, if the polymer shows resistance to deformation.

And then after sometime with an increase in temperature they accept the deformation that is one kind of behavior and usually are called as thermoplastic. Similarly, there would be polymer which will be very flexible to deformation however later on when the deforming stress is removed it remembers and goes back to its original confirmation. So those are elastic in properties. So based on various polymer properties we have gone through several types of polymer classifications that one encounter in the world of polymer chemistry.

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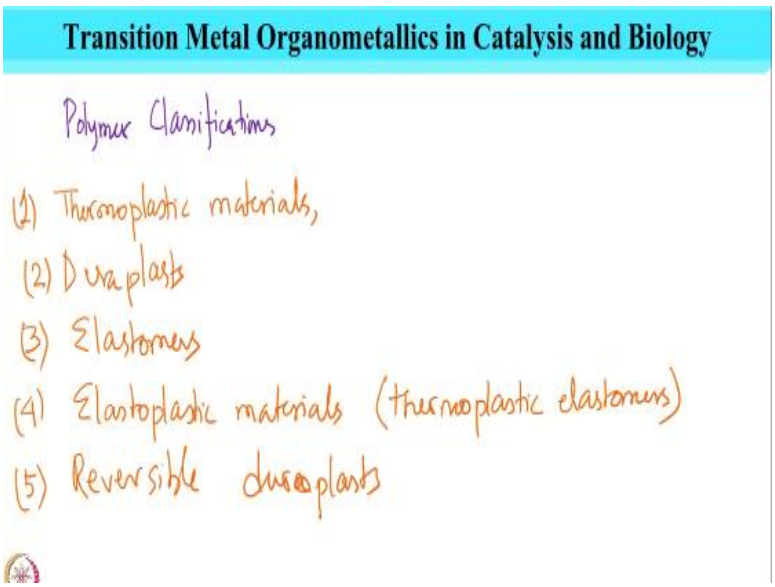

So in this context to begin with, in the last few lecture we had discussed about the following polymer types. So in this we have looked into thermoplastic materials, we have looked into duroplast next was elastomers. The fourth being elastoplastic materials or called

thermoplastic elastomers and the fifth is called reversible duroplasts. So we have looked into the classification of polymers based around this 5 classes.

And we had seen that this classification has mainly been done with regard to the polymer properties particularly with respect to applied stress and removal of stress also we have looked into the various composition or types of polymer required for producing this kind of different polymer types and they involve mainly the polymer with cross linking or polymer with branching or polymers with meshing.

So there is a deep routed structure function relationship of the polymer structure with that of the polymer properties. Now with regard to olefin polymerization the good thing is that all variety of this kind of materials can be produced from polyolefin and that is why polyolefin become so important.

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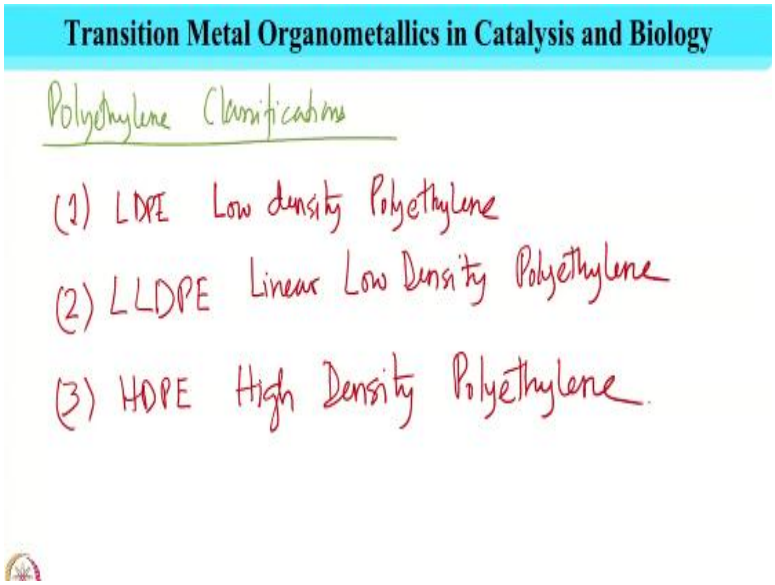

Now with regard to polyolefin in the previous class we subsequently focused on polyethylene classification and mainly this was done again mainly based on the density and the structure of polyethylene and they can be divided into 3 broad class types LDPE which is low density polyethylene then next one is LLDPE linear low density polyethylene and third one is HDPE high density polyethylene.

So we have seen that how these 3 varieties of polyethylene it can be classified based on the density, based on the structure and based also on their properties. Now in today's lecture what we are going to do is we are going spend some more time on polymer classification and

this is particularly not from the material perspective, but from the mechanism perspective or the chemistry perspective.

So the 2 classifications that we had presented earlier in the previous lecture are from the material properties that means that these are classified based on the properties or behavior that each of this materials exhibit whereas now we are going to look at the broad classification of polyolefin based on the mechanism or based on the process which are used for synthesizing this polymers.

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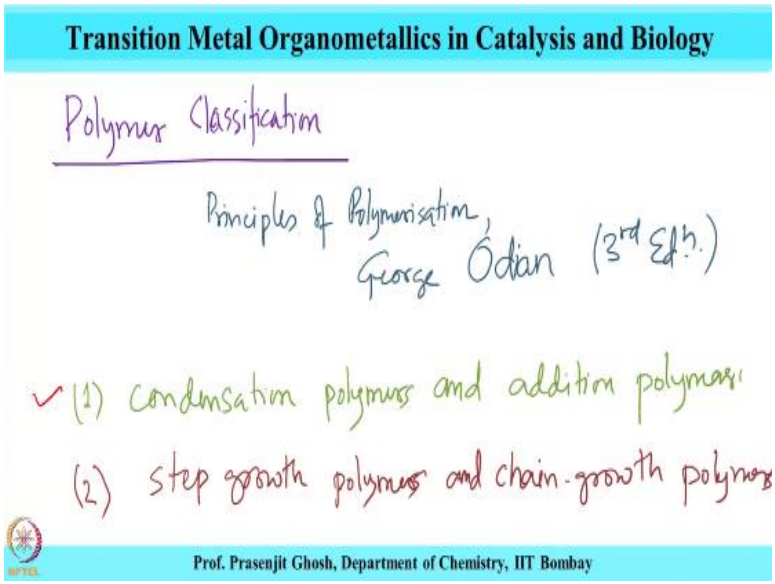

Now this portion would be taught from book which is very famous in polymer (()) (08:02) and request the audience or takers of this course the students to please refer to this book the title of the book is Principles of Polymerizations by George Odian and this is sort of very good book that talks about polymer particularly from the mechanism or their classification and the perspective.

And request the students to refer to this book for this part of the lecture 3rd edition. Now with regard to polymer classification the other common classification from the chemical perspective are of 2 types these are called either the first type is the polymers divided into condensation polymer and addition polymer. Now these divisions is primarily based on the process by which the polymers are synthesized.

If the polymers are synthesized by a condensation reaction then these are called condensation polymer and if the polymers are synthesized by addition reaction, addition of monomer

reaction and then this is called addition polymers. So let me just repeat the condensation reaction for producing condensation polymers occur between the condensation reaction between the monomers individual monomers.

Whereas addition polymers synthesized by addition reaction which also occur by addition of monomers. The difference between condensation reaction and addition reaction is due to the fact that our condensation reaction will have a small molecule bye product like elimination of water or any other small molecule bye product during the course of condensation between the monomers.

Whereas for addition polymerization there is no bye products which has evolved as a part of the polymerization process. So these division of condensation polymers and addition polymers are primarily based on the process which are used for producing the polymers. Now there are another way of classifying the polymers that is based on the mechanism by which this polymers are formed.

So the top one is the process by which the polymers form and the second one is based on the mechanism. So under this category the polymers can be divided into step growth polymer and chain growth polymer. So this particular division is based on how the polymers are made whether they formed in the steps like solely focuses on the mechanism how this polymers are produced or whether the polymers are produced in a chain fashion.

This kind of polymer are referred to as chain growth polymers. So the take home message is that polymers can be divided or classification of polymers can be carried out at least in from 3 perspectives. One from the material perspectives in that category the polymers are graded based on the properties that polymer exhibit and in that category we had looked into this thermoplastic, duroplast, elastomer, elastoplastic material and reversible duroplast.

So on that category from that perspective it can be divided into those similarly from the material perspective as well polyethylene can be divided into low density polyethylene or LDP or linear low density polyethylene LLDPE or high density polyethylene HDPE. Now apart from the classification which we had discussed earlier based on the material perspectives of the polymer properties.

There are 2 other forms of classification can also be applied for distinguishing polymers and these are from the chemistry perspective particularly one is based n the process by which this polymers are synthesized the other is by the mechanism by which this polymer are synthesized. So from the process perspective polymers can be classified again into 2 types one is called condensation polymer the other is called addition polymer.

And now condensation polymer as the name suggest is produced by condensation reaction between monomers which eliminate some small bye products like water during the process of condensation so that is why they are called condensation polymers which are formed due to condensation reaction with monomer with elimination of small molecules like water, alcohol and etcetera.

Similarly, from the process perspective the other classification is addition polymers. Addition polymers are similarly formed by simple addition of monomers to give the polymer and the second classification of polymer from the chemistry perspective is that of from the mechanism point of view and from this point of view again the polymer can be classified in these 2 types based on the mechanism which they follow for producing the polymer growth.

And the mechanism can be of step growth polymers where the polymer is formed as a step whereas as several steps whereas the other classification from the mechanism perspective is chain growth polymer where polymer grows as a part of growing chain. So with this interaction let me just focus on the various classifications from the chemistry perspective in today's lecture and to begin with let us start by looking at the condensation polymer and the addition polymer.

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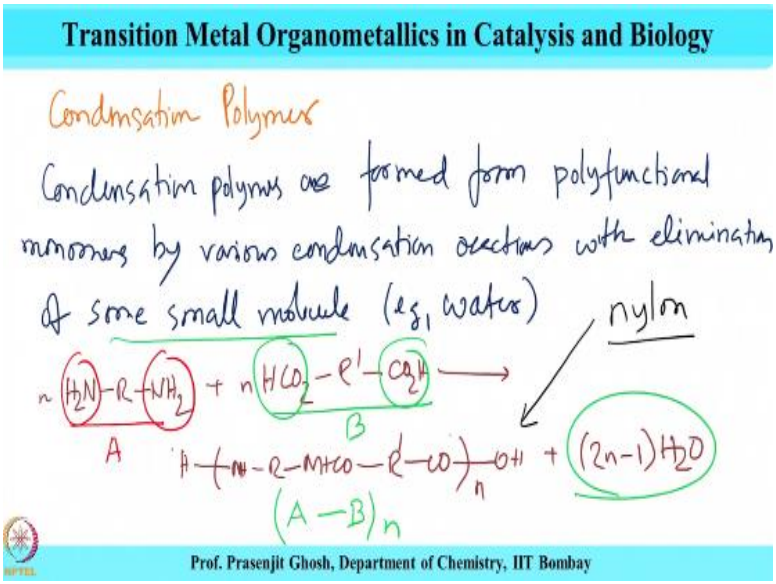

Condensation polymers, condensation polymers are formed from polyfunctional monomers by various condensation reactions with elimination of some small molecule example water and this is given by the reaction diamine + diacid giving in (()) (19:24) R dash co n OH + 2 n – 1 water. So the point to note in this is the following. What it says that condensation polymers are formed from polyfunctional monomer.

So there are 2 monomers over here for example this is A and it has 2 functional groups with this. So this is one type of monomer A and the second monomer is B, A because it is a different monomer and it also has 2 different functional group. So the polymer which is made out of fate is AB type polymer as a condensation reaction which happens and all of this condensation reactions to happens eliminates water.

So the small molecule elimination is very much there because it is a condensation reaction. So this reaction that we have just shown as a example of condensation reaction is a very famous reaction because this product was a big commercial success and it is called nylon polymer. So nylon was made by condensation reactions where diamine and diacid react to give AB type polymer.

So nylon was the big commercial success in 30s and 40s and had lot of applications everywhere. So this is a nice example where one can see this condensation polymer being made by condensation of 2 different monomers.

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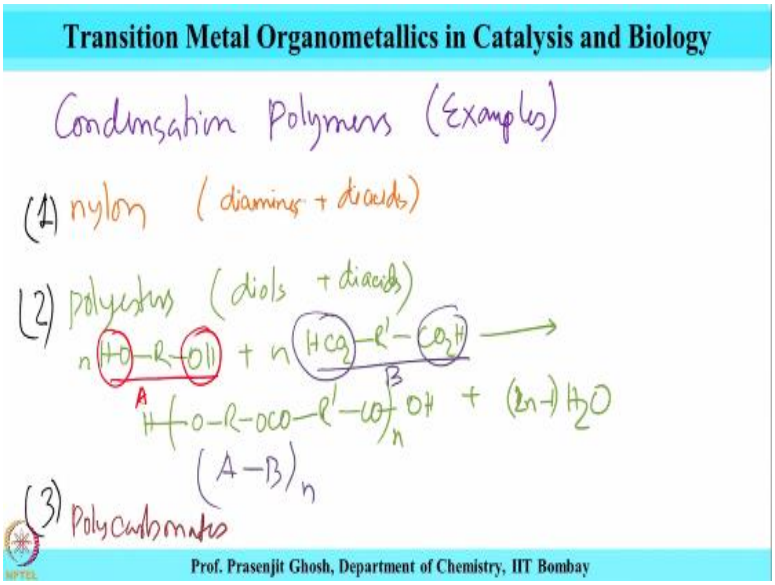

Similarly, another important example of condensation polymers would be examples we just saw nylon falls in this category and this was a big commercial success and this was made from diamine + diacid monomers diamine and diacid monomers condensation of these two to give nylon. Similarly, another big example of condensation polymers include variation of this and it includes diacid and diols and the product are polyesters acid and nylon (()) (23:05).

So this was also a big success at the time of its discovery. So there are about I mean to convey is that there are many process which are formed many important polymer which is formed through condensation process and this polymers are have huge commercial demands. For example, for the polyester the reaction is between so this is one monomer polyfunctional monomer H giving OH +.

So here also what we see is that there are 2 monomers one is monomer A which has hydroxy and these are polyfunctional it has hydroxy moieties whereas the second monomer which is monomer B. This is monomer B and this has diacid moieties and they give AB type of polymer. Another interesting polymer which will again that is also immensely successful commercially that comes out of this condensation polymer is polycarbonates. So these are some examples nylon then polyester then polycarbonates they arise out of condensation reactions and all of these are important commercial monomers.

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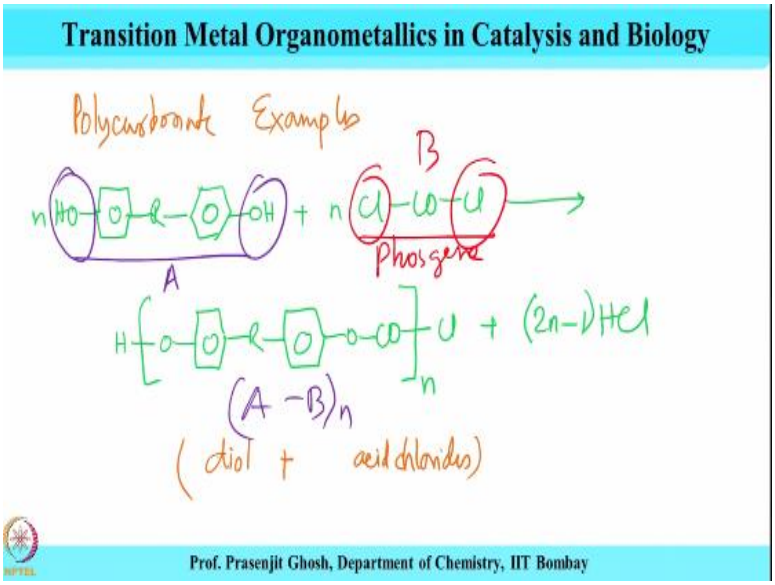

So let me just briefly give the process by which this polycarbonates are prepared. So these are diol cl n cl + 2n – 1 Hcl. So this polycarbonates over here is a reaction between the reaction between diol and diacid chloride and acid chlorides. So this is can be conceived (()) (27:50) diol and acid chloride. Here this is the important gas which is phosgene this is phosgene (()) (28:04) and this is monomer B with functional group (()) (28:12) and monomer A this is monomer A with again functional group at the end.

And what one gets is AB type of polymer condensation polymer. So with this, we come to the conclusion of today's lecture in which we have looked into various classifications of polymer based on material properties as well as based on the process and mechanistic perspectives. In this context we have discussed about condensation polymers with examples taking some commercially polymers.

Like nylon, polyesters, polycarbonates which are extensively used for commercial purposes and which are formed through condensation process. So with this we come to an end of today's discussion on polymer classification more of this polymer classification particularly from the chemistry process and chemical mechanism point of view would continue in the next class.

And I once again thank you for being with me in this course, in this today's discussion and I look forward to discussing more on this topic of polymer classification when we meet next till then goodbye and thank you.