On Plastic Waste Management
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Lecture – 03
Plastics – Types (Contd.)

Ok, so welcome back. So, this is we are starting now the third module of week – 1. So, we will continue our discussion on the types of plastics, which we were doing in the previous module. And I hope to complete that discussion in this particular module and then we will try to get into other topics. So, so far if you remember what we have done, we have talked about what is plastic, we started looking at the types of plastic. And also different types of classification of plastic, based on usage, based on material.

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So, to continue that discussion we talked about what is plastic, we also looked at way of presently focus on types of plastic and then this particular week, we will also look at the usage and global statistics, which will be in the next module.

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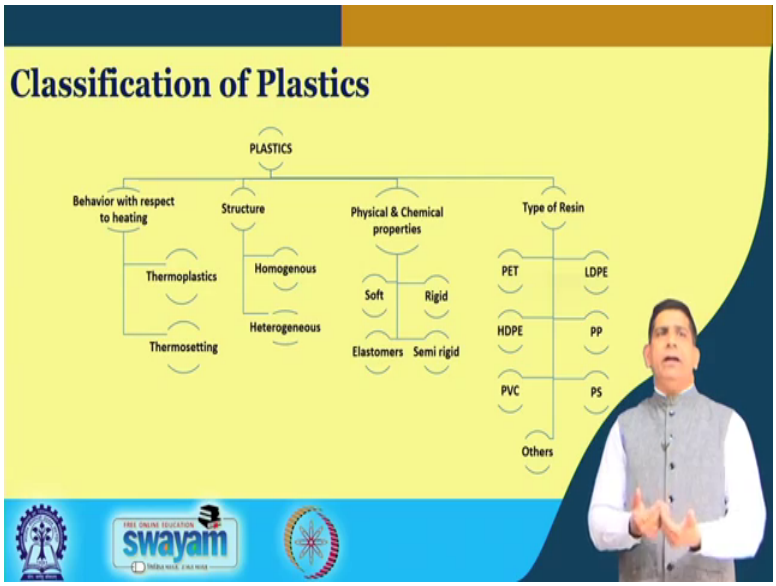

So, this was the last slide that you were looking at in the previous module. So, which when we talk about plastic, you can have where you can look at from a heat perspective with respect to how it will react to heat that is what the behavior. Then we also talked about the, a structure, then we talked about the physical, chemical properties, and types of resin, so that is where we stopped in the previous module.

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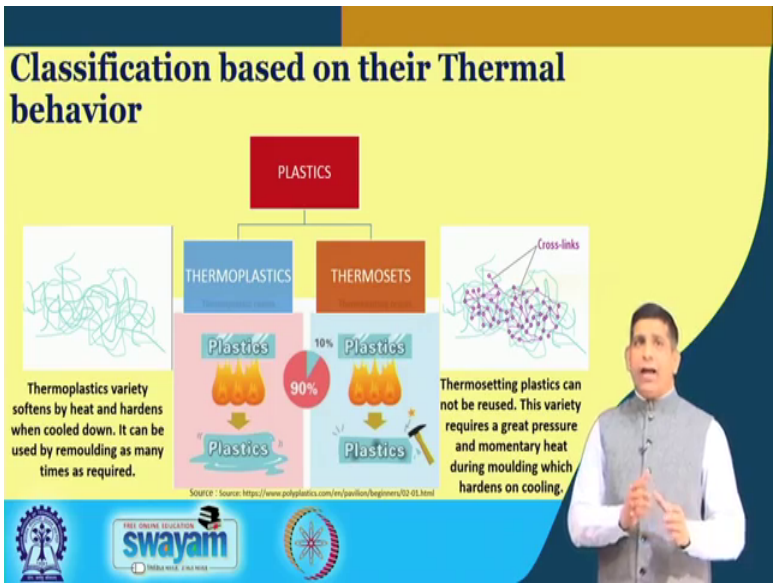

So, continue that discussion in terms of thermal behavior, when we talk about thermoplastics or thermoset plastic. It is a thermoplastics it is a bit of variety which

softens by heat and hardens when cooled down. So, if you if you apply heat to it, it will soften, it will become soft and then when the heat is removed, when we cool it down, it is it will become hard again.

So, it can be used by remolding as any times as required, so that is what its, its you can you can remold it, and use it for a different application, you can make different products out of that. So, thermoplastics is that particular category.

Thermosetting plastic, it cannot be reused so that is the so if we have more and more thermoplastics actually, it is better for recycling industry. Thermosetting plastic it is very difficult you cannot really reused. This variety requires a great pressure and momentary heat during molding, which hardens on cooling. So, you cannot really use it that easily.

So, it is essentially you can use it in a waste to energy. You can you can reuse it within the same product, but if you want to make new product after say molting, this plastic out there it does not, does not work that way. So, thermoplastics easy to recycle, thermoset plastic better maybe for waste to energy plants, so that is what when we talked from the plastic waste management; so that is why these things are important when we when we were looking at into different options for plastic waste.

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So, thermoplastic it can it may be melt it before passing into a gaseous phase state, allow plastic deformation when it is heated, chemical composition do not change, they are

brittle and glassy, they are soluble in certain solvents as well in the presence of certain solvent, good resistance to creep. So, it is can be remolded and made different products out of that from a thermoplastics.

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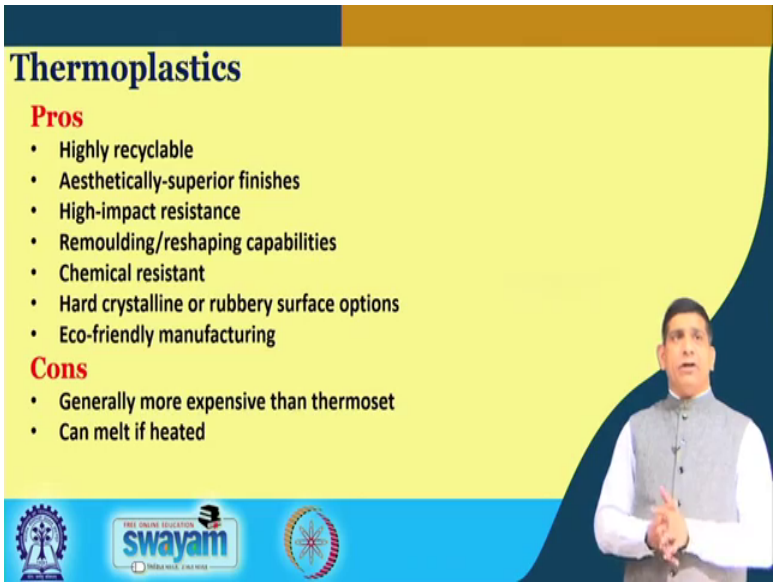

So, it is highly recyclable, it is highly recyclable, it is you can have better finish because of the material property, you can have a superior finish nicer finished, high impact resistance, you can remould, reshape. It is chemical resistance, it is a hard crystalline and rubber surface options both options are there you can make it hard, you can make it soft. You can just play with the temperature do that process.

Eco friendly manufacturing, because you can be recycled much easier. What are the drawbacks? It is more expensive of course, because see it is giving you so many options of course, it will be expensive. So, it is more expensive than thermoset, because and it can melt if heated.

So, if you are using it in your setting, where things gets heated up. So, it is if you are heating it, and then it can melt. So, it can be like cannot be used in a scenario, where it can potentially melt while in use, so that is where you need to be careful about that.

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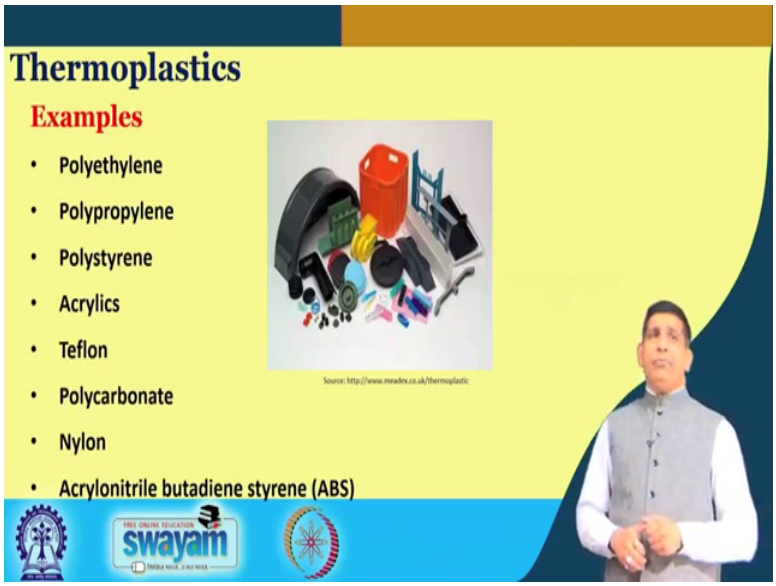

What are the examples? We can polyethylene, polypropylene, polystyrene, acrylics, teflon, polycarbonate, nylon, ABS, which is at Acrylonitrile Butadiene Styrene. So, all these different materials that you see it is these, these are all thermoplastics. So, this is what the thermoplastics we use for.

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Thermosets they are soluble in alcohol and certain organic solvents, when they are in thermoplastic a stage. This property is utilized for making paints and varnishes from these plastics. They undergo irreversible chemical process, they are durable, they are

strong and hard, they again they can you can make beautiful colors. They are mainly used for engineering applications of plastics. So, most of the engineering applications that you are use see is mostly thermoset plastic, which is very difficult to recycle.

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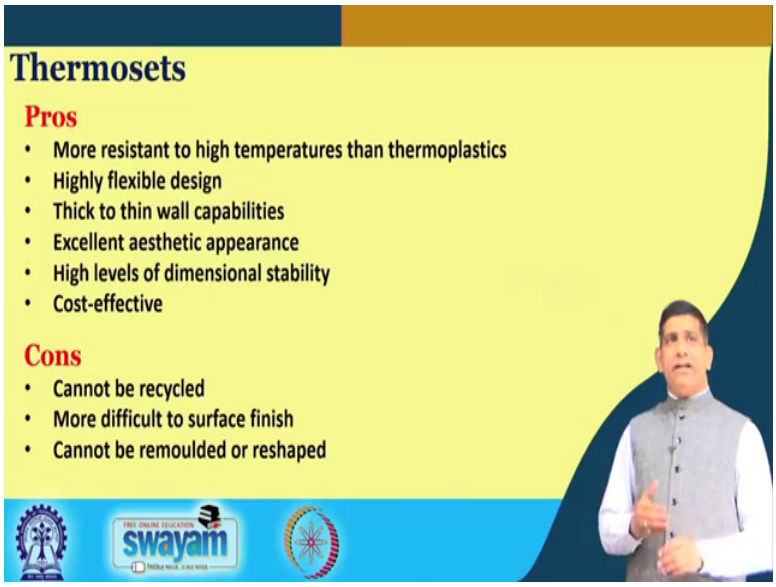

But, there are more resistance to high temperature, it will not melt so it was not melt. Then thermoplastic, it is highly flexible design; you can design it in a different ways. It thick to thin wall capability, you can make it very thick, very thin.

Excellent aesthetic again, it is some of the things are same, you can make nice looking at high levels of dimensional stability, because it is again does not melt. So, even I will not have effect of heat cost-effective, it is relatively cheaper as compared to that.

A problem with this cannot be recycled, so that is kind of a drawback it cannot be recycled more difficult for giving a good surface finish. Cannot be remoulded or reshaped. So, once you made it that is it cannot really do many things with that, so that is of course the drawbacks with that but again at the same time a it is every both thermosets and thermoplastics both have different kind of applications as you saw for thermoplastic.

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Similarly in the thermosets, we use it for epoxy, polyurethane, unsaturated polyesters, phenolic, silicone, so all those different applications that you have where the thermo sets are used. Lot of for the construction application for the your construction application, for different machine parts, where things may get really heated up, and so that is where thermoset plastics and most useful.

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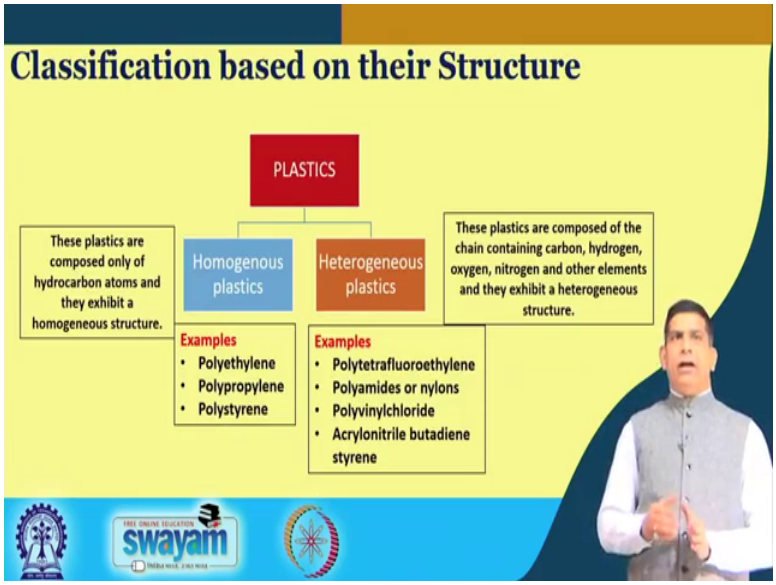

Then thermoplastic, so that is based on the how it is behavior against temperature. And if you are so that is the if you remember the last slide from previous module in the first

slide in the first module in this module, which was the same, way we were looking at the different kind different types of classification.

So, if we looked at classification based on behavior against temperature, now in this particular slide, we are looking at classification based on their a structure. So, based on the structure of the plastic, so whether it is a homogeneous or heterogeneous. So, homogeneous plastic this plastics are composed only of hydrocarbon atoms, and they exhibit a homogeneous structure. So, what are those polyethylene again polyethylene, polypropylene, polystyrene, they are homogeneous.

Now, what is heterogeneous plastic? These plastics are composed of the chain containing carbon, hydrogen, oxygen, nitrogen and other elements and they exhibit a heterogeneous structure. So, the structure is not homogeneous, there is a verb like it is a heterogeneous structure. Examples includes polytetrafluoroethylene, polyamides or nylons, polyvinylchloride, and then ABS these are the heterogeneous plastics. So, this is a homogeneous versus heterogeneous plastic.

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And then if you look at from physical and chemical properties, there are rigid plastic, which is very practice strongly HDPE tubs, polypropylene cups, PET pallets. They are very rigid. They will with and then you have semi-rigid plastic, which is LDPE films, flexible ducts, where you can have that is can move around a little bit, PVC sheets. So, these are semi-rigid.

Then you have a soft plastic. Children's toys if you have looked at toys, those ducts and other stuff that is made out of plastic, those are soft plastic. Rattles, fishing baits, because fishing baits has to be soft and then elastomers. Elastomers or polys polyiso polyisoprene, polybutadiene, polyisobutylene. So, there are those are elasto, it is like a elastic plastic. So, it is a more elastic properties, so it is not at all it is actually totally opposite to rigid.

So, as we go from or from like a from the left to right, we are saying first rigid plastic, then the semi-rigid, soft plastic, and they elastomer. So, as you move along you are looking at the elasticity of the material actually going up, so it is becoming more and more flexible and every different types of these different types of plastics, at different applications as we know.

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So, rigid plastic will be the plastics with a high modulus of elasticity is modulus of elasticity based on your a strength of material quartz. You know what is what is modulus of elasticity, it is a ratio of a stress versus a strain.

So, stress will be on the top a numerator, a strain will be in the denominator and we get a stress divided by strain gets the modulus of elasticity, it basically tells us how a strong, how rigid that material is high modulus of elasticity, they retain their shape under exterior is stress applied at normal and moderately increased temperature.

Semi rigid, these plastics have medium modulus of elasticity. They can elongate under pressure come under and the elongation that is there under pressure completely disappears, when the pressure is (Refer Time: 10:13) removed. So, it is kind of have little bit of plasticity there as well. So, you can you can apply some pressure things will things may elongate and once the take the pressure off, it will kind of come try to come back to its original shape and size.

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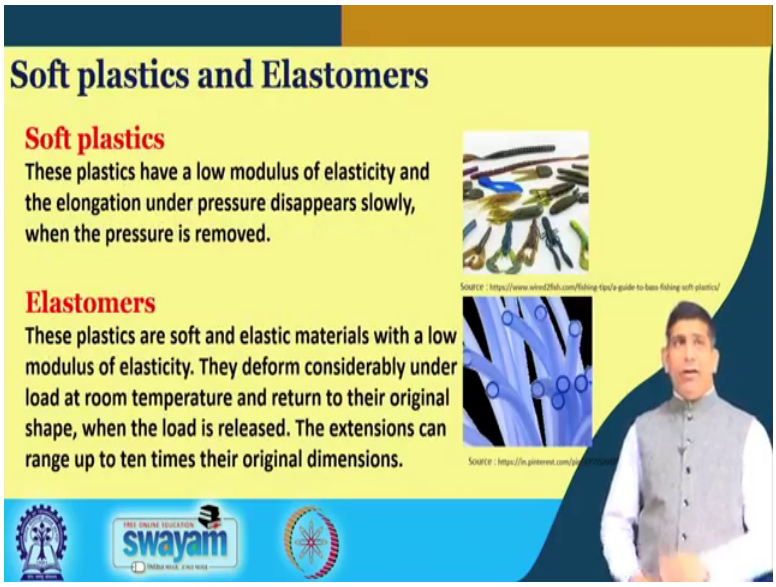

Then soft plastic, this plastic has a very low modulus of elasticity and they elongation under pressure disappears slowly. So, you can you put if you elongate it under pressure, and then you take the pressure off, you will have a slowly this coming back to the normal shape and size, so in the so that is what the soft plastic is all about.

And then you have elastomers, which is soft and elastic material with very very low modulus of elasticity. They deform considerably under load at room temperature and return to original shape, when the load is released. So, the extensions can range up to ten times their original dimension.

So, think about the rubber band and also of these stretchable things you can stretch, and once the pressure is removed it kind of comes back to the original shape. So, those are your elastomers. As the name suggests elasto, elasto means they are elastic. Elastic means, which is which can be easily stretched, and then it tries to come back to its original shape (Refer Time: 11:28) and the pressure or is taken off.

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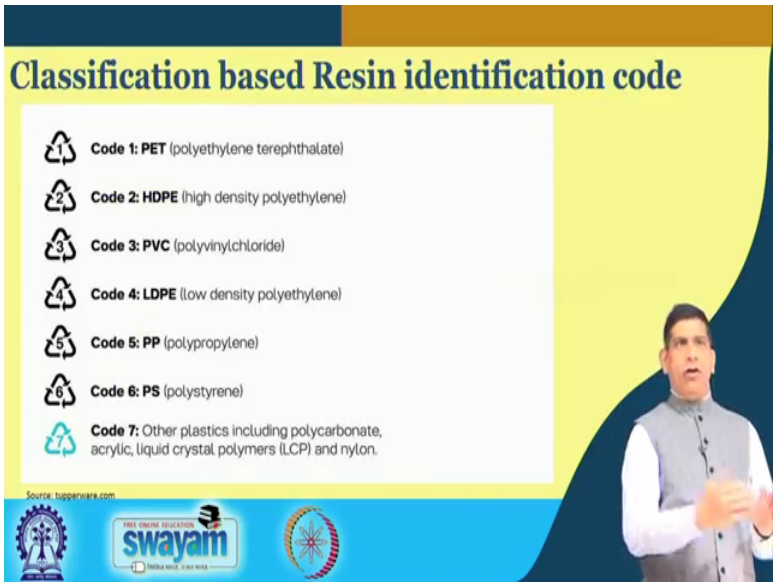

Then we were talking about the form if you remember from the first slide of this particular module, we were looking at the different resin types. And I was telling you in the last module towards the end I was trying to remind you about the number coding, so that is what they over here on this particular slide.

We are looking at the number coding, where you have the code-1, which is a PET material. And then you have you we have code-2, which is the HDPE. PET-it is the Polyethylene Tetra thalate. Then we have HDPE, which is high density high density polyethylene material.

We have PVC's which is number-3. Number-4 is LDPE, which is low density polyethylene, then PP poly propylene. Number-6 is polystyrene. And then 7 is basically all other plastics including polycarbonate, acrylic, liquid crystals, polymers in LCP, nylon all those things together is our number-7.

So, as we go from if you look at from number-1 from number-1 to number-7 as you go down the list, it becomes economically it becomes less and less incentive to recycle those. PET is the most recyclable material, easy to recycle and economically it makes sense. HDPE is next (Refer Time: 12:52) PVC, then LDPE, then PV and polystyrene.

So, this number coding is very very important, when we look at the plastic waste. Because, when we will try to try to manage this plastic waste in a scientific way, one of

the things we would we should look at, and we will probably have to look at in coming years or decades is trying to separate this plastic based on this different code.

Some countries they are already doing that which when we try to separate PET, HDPE and PVC, LDPE they are try to separate those. At least PET and HDPE is separated from rest, because those two are easily recyclable, and makes good value of economically it makes a lot of sense to recycle those as opposed to others. Sometimes PP, PS and other plastics it is better to send it to a waste to energy planned will talk about that when we go into the waste management part of it as opposed to trying to recycle this material.

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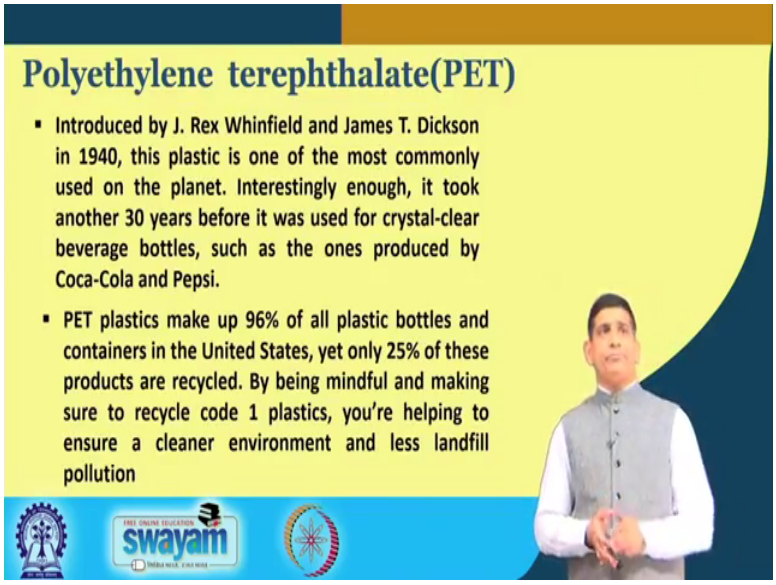

So, PET what is that we will try to it in some of these material, we will try to look at. What is PET? It is this plastic is most commonly used in on the planet right now. It took another. So, introduced by J Rex Whinfield and James T Dickson in 1940 this plastic is another most commonly used on the planet. It took under 30 years, because it was used for crystal clear beverage bottle.

So, in 1940 it kind of it was used kind of bet says the ones produced by Coca Cola and Pepsi. So, initially the reason for that, which initially, the plastic what they were trying to use the glass bottle. So, if sorry the beverage containers were mostly using the glass bottles. And when the in 19 if I remember correctly around 1969, 1970 at that particular time though kind of make sense 1940 plus 30 is 1970. So, 1969 Coca Cola did a study, which we kind of refer to that in our LCA course that Coca Cola did a study where they

looked at whether it is, whether it is better to replace these glass bottles with plastic bottles for packaging of this beverage drink. Because they where they started making these plastic bottles, and the PET bottles and then it was lighter, lighter means comparative glass, it was light material, it was a light material means, it will be less heavy less heavy means, less cost on transportation. And will help them to reduce the cost a little bit. So, that was the reason, they were trying to go for a plastic bottle.

So, PET plastic now today here kind of makes up 96 percent of all plastic bottles in container in US, and only 25 percent of those are actually getting recycled. So, when you think about plastic waste of course, in India we have a bigger problem. But other countries are also not doing a very good job into plastic recycling. As you if there are some countries, we are doing wonderful job, but US, which we probably expect much better than 25 percent. It is, a if we can, if we can help in terms of recycling these code one plastic, actually we are helping in to cleaner environment less landfills pollution and that is very much needed.

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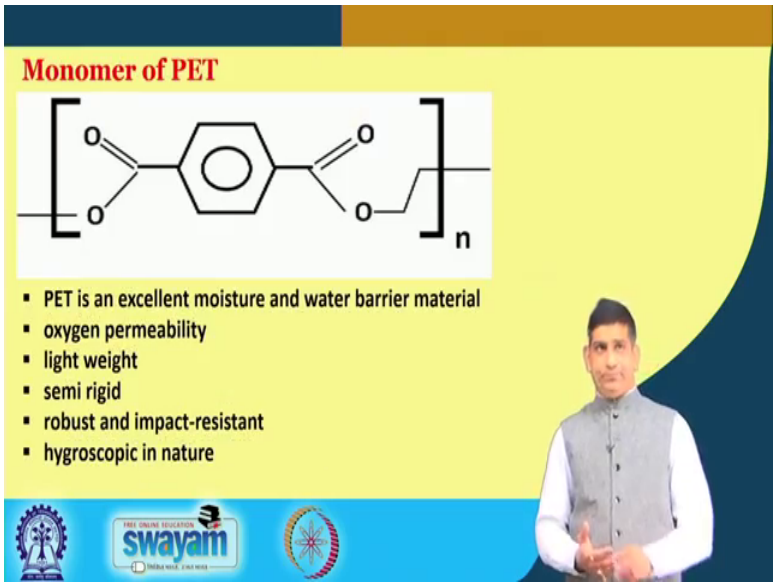

So, it is a monomer of PET. PET is an excellent moisture, moisture and water barrier material. It is oxygen permeability is it is very low, it is kind of keeps, it is a lightweight, it is a semi rigid, robust an impact resistance, and it is a hygroscopic in nature. So, that is a kind of helps in it is usage as different kind of applications, where it is used.

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So, this is essentially the kind of gives you and monomer of PET. So, what we use it for PET is beverage container, water bottles different types of containers for like a our food containers did something supplies as you can see on this picture particular picture. And you will see that number 1 PET that sign along with that as well.

Here you see a picture of tomato ketchup right there, it which if you can look at that particular picture over here; we have this tomato ketchup bottle. This tomato ketchup bottle is not only the PETE material, it has the PETE, but at the same time, it has a layer in between as well. We are trying to we do not want the gas movement to trap the gas and moisture movement, it has a 2 layer of PET and in between it has again a material in between which kind of keeps it the our tomato ketchup fresh. And so that is the, because many times when you buy this tomato ketchup, it will say almost, it is expiry date will be a year from them a year or sometimes more from that particular date of manufacture.

So, the reason to keep it fresh and nice, we have a layer of insulator kind of material in between and then there is 1 PETE, 2 PETE and before layer in between and that is how this plastic those models are made. Now, and for catch up and similar application so which is actually a mixed plastic, but more predominantly it is PETE, but it is not 100 percent PETE, so that is what I wanted to point out to you.

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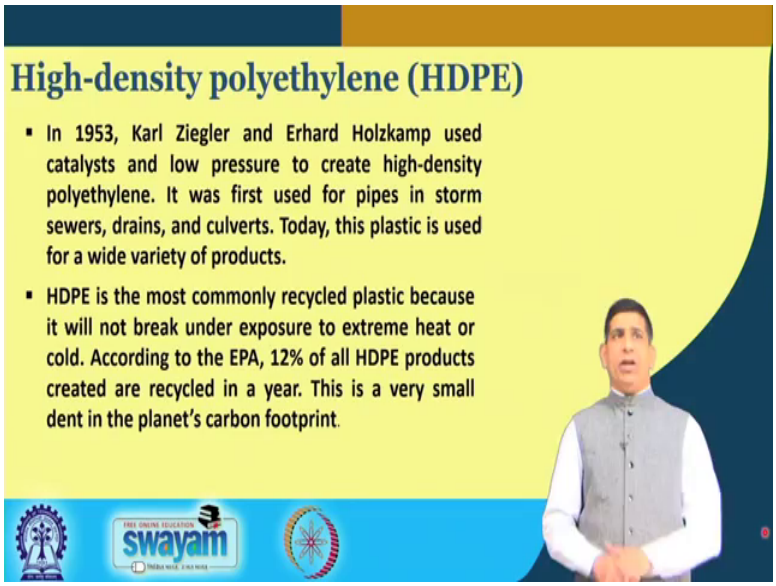

Then next more popular is HDPE. Again 1953, it came about you do not have to memorize many of these as stuff like kind of put the name of the people and all that. I do not think will have questions along that line. But it is always better to have some general idea about when the plastic actually came into being. It is a most commonly recycled plastic, because not to break under exposure to extreme heat.

According to EPA only 12 percent of is recycled if you can, it is a US data. The reason for that is in Indian scenario finding this data is also very difficult. So, we will, we are trying to dig into the data and to find how much, we have what percentage of PET is recycle, what percent of HDPE is recycle, in India, we do not have those data easily available.

So, again those of you who are taking, this course and have some information. As I said in the very beginning in the intro video of this course, there is not, there is no textbook on this particular course. And so when I decided to offer it, it was not that not only for it, it is a team learning. I want you guys to actively participate and bring some information put it on the discussion board, which we can discuss. And so there might be where at the end of the course, I also want to learn much more about plastic waste than what I know as of today, because it will be it and it will be a team effort.

And where whatever you learned will we all get, whatever I know I will to share with you. So, let us see here with each other and reach our knowledge and plastic waste

management plastic in general, so that we can take care of for this plastic pollution in the country. And meet the goal of our country which our prime minister already announced, but that by 2022, we will not use any single use plastic. So, there and we will of course, we need to cut down the usage of other plastic as well to reduce the plastic pollution from getting into, the ocean getting into, the water getting into, our food chain.

You may have heard recently there have been a studies, which has saw that many of the salt. Salt that without salt, there cannot be any food is not it you can you take a food, it like your regular meal without pinch of salt, you need salt. If salt is not there by mistake, if we forget to add salt to our dal or our curries, it is becomes tasteless, we need to add some salt to make it really taste to a good.

And many of these salt varieties have been said out to salt product, which is available in the market different brands when tested had micro plastics in them. So, you and I do not want plastic in our body, because it will get in create different kind of disease, we also do not know what kind of disease it can create. Because since it is a newer thing, but it is showing up in the food chain, it is showing up in the fish it is showing up in salt. So, those of us those of you who think that oh I am a vegetarian a that our this instructor is keep on talking about fish, fish I do not take fish I do not a stay in West Bengal.

So, West Bengal fishes are kind of our national food, but should not call it national food, but fish is essential you with in many of the meals. But it is kind of very common practice to have fish almost every day, but in other if you even, if you are a vegetarian, and you do not take fish at all you cannot eat without salt is not it. You need some salt. And the salt microplastics are showing up there, so that is why we need to increase the recycling rate, we need to let manage the plastic waste properly.

And for that if you find some information, which is not being covered in this particular course, put it on the discussion board. We will like to have a good discussion on it. And of course, we will have some live session, where we can if you put something on discussion board; we can discuss it on the live session as well so that will be really fun. And it will learn something new as we make progress in this particular course.

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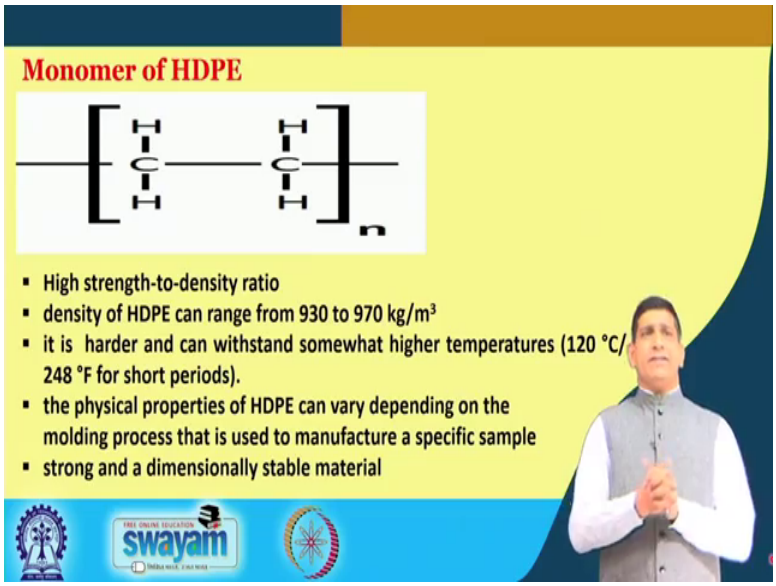

So, this is it how the monomer of HDPE. So, for each of the type we have put this there structures and other stuff for you to look at just to get an idea. The density range is close to almost 1000 kg per meter cube. So, 930 to 970 kg per meter cube, it is harder, it can withstand high temperature in 120 degree centigrade. And the physical properties can vary depending on the moulding process to make the specific sample is strong, and it is a dimensionally stable material, so that is why you see HDPE application in most of the study like your buckets and your liquid big, big, big tumblers, big drums, you see mostly HDPE is used for those applications.

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In common application that you will mostly, you will see for those kinds of containers and in milk bottle, your soap containers as soap sample and all those as mostly HDPE material. That again you leave to you have to look at number 2. Whenever you look at, these plastic look at the number; and if it is number 2, it is HDPE.

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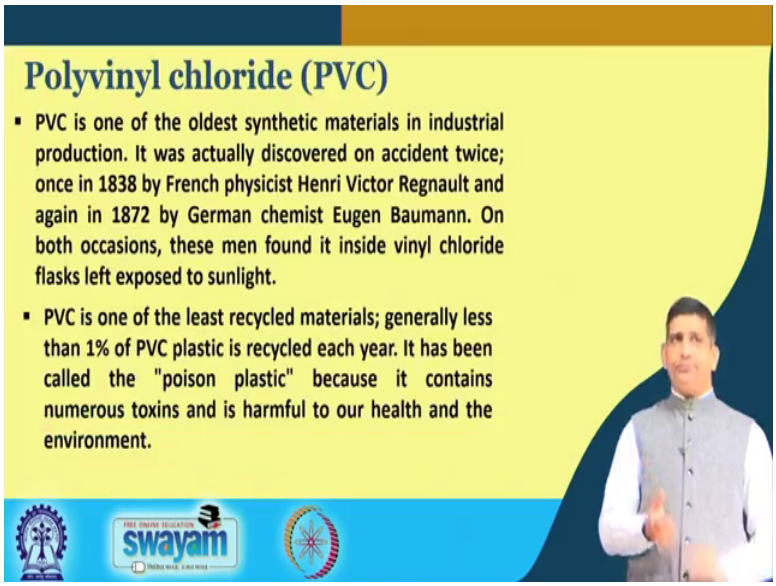

Polyvinyl chloride, it is the oldest synthetic material; it was actually discovered by accident in 1838 by one French physicist Henry Victor Renault. And then again in 1872 by German scientist huge involvement on both occasion they found it inside vinyl chloride flask and left, left exposed to sunlight.

So, they had the vinyl chloride exposed to sunlight. And they found it there. PVC is one of the least recycled material generally less than 1 percent is recycled, it has been called the poison plastic because it contains numerous toxic and harmful to our health and the environment. So, PVC is what we need to think about like how to manage PVC plastic waste in a much better way. So, that this tag of poison plastic is it is not good. So, we need to kind of think about how to manage that PVC most of the time it cannot be recycled very easily.

So, it can be reused, but it cannot be recycled very easily. So, for that kind of material having some sort of waste to energy process, another process does help where you can use this PVC again polyvinyl chloride. So, it has a halogen. So, you need to be really very, very careful in terms of when you use it for waste to energy, you need to have a

very high temperature, so that you do not have dioxins and furans being formed which is formed in the presence of halogens. Halogens are what are those halogens, chloride, bromide, iodide, fluoride, those are called halogens compound halogens halogen elements which is it is there in one a particular group of the periodic table, which we have learned about in our high school and other stuff.

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So, this is so this is like a polyvinyl chloride. It is a do you kind of use the application of polyvinyl, it is you can use it for the leisure application, you use for cables, for packaging, for pipes, for windows, for floorings, you have tensile roofs, you have medical applications. So, PVCs are used a lot and recycle the least. So, it is this is what needs our focus again.

This kind of this makes our sense in terms of if you are still wondering why our course is just still discussing about the type of plastic and all that, it is essential. It is are because you this kind of information is needed to make a good decision in terms of the plastic waste management. So, these are kind of background information is needed.

As I keep on saying that when we talk about any waste management or any plan that we make we need to do a good diagnosis of the problem. And this is what we are trying to do we trying to get the background information, so that we will have a good diagnosis of the problem.

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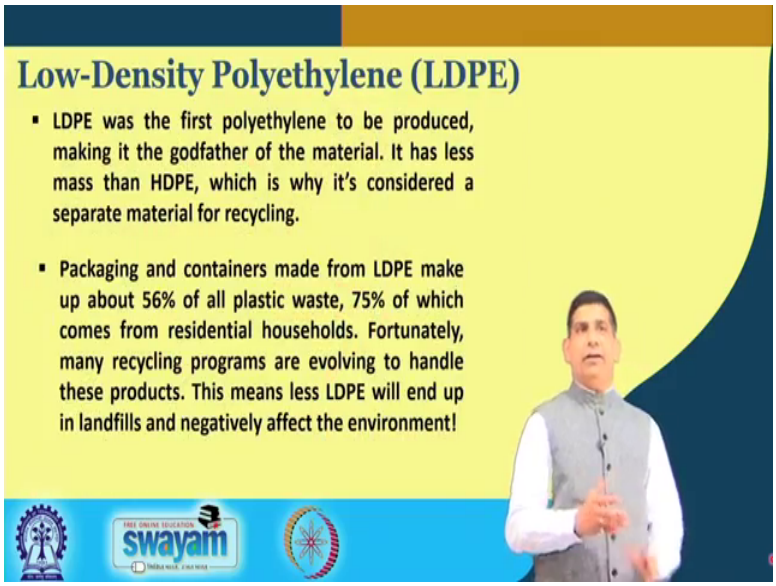

Then LDPE it is the first polyethylene to be produced making to the godfather of the material. It has less mass than HDPE that is why it is considered separate material for recycling. Packaging and containers are made for LDPE which is 50 percent 56 percent of all plastic waste, 75 percent of which comes from residential household. So, a lot of packaging material and containers are LDPE.

So, there are a lot of recycling programs to handle this product this means less LDPE we will end up in the landfill and that is what we want and that is the goal of the project of any good waste management system.

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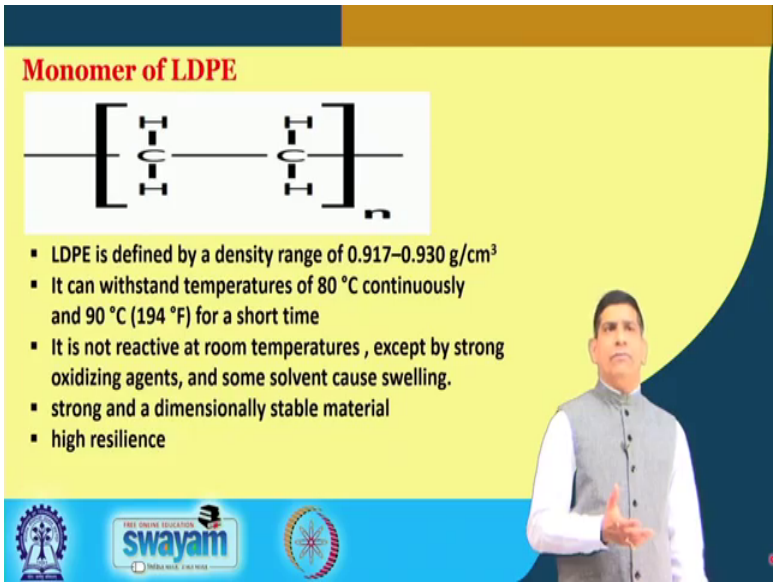

LDPE, it is a very low density; density is defined, then it can withstand temperature up to 80 degrees. It cannot it is not reactive at room temperature except by strong oxidizing agent, so that is why it is used a lot of household application is strong and dimensionally stable material high resilience and that kind of shows you the.

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So, this is the application lot of a bags, you have a different kind of containers, the tin containers, wrappers and all those things as you can see on this picture, they are mostly LDPE material, low density polyethylene material.

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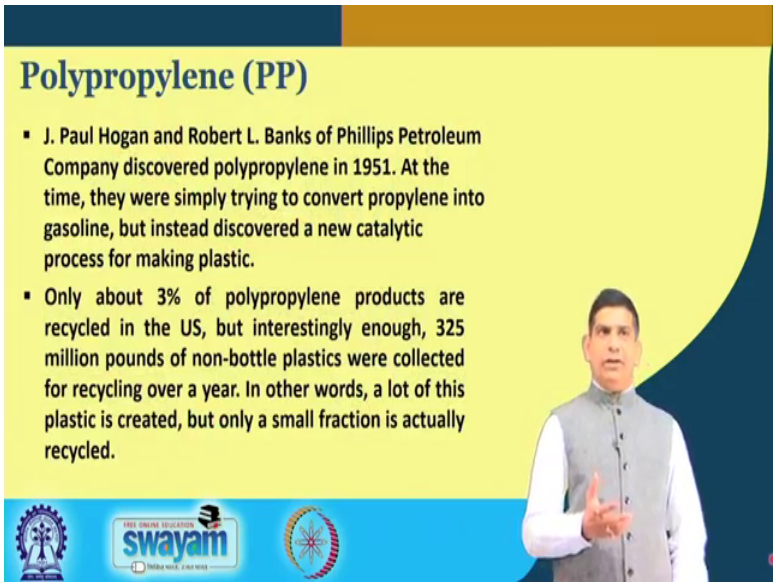

Polypropylene which is 3 percent of the polypropylene products are recycled in US. 350 million pounds were collected for recycling over year, but lot of this plastic is created, but only a small fraction is actually recycled. So, that is what so polypropylene again a we have to it needs to be recycling and better management practices needs to be looked into that.

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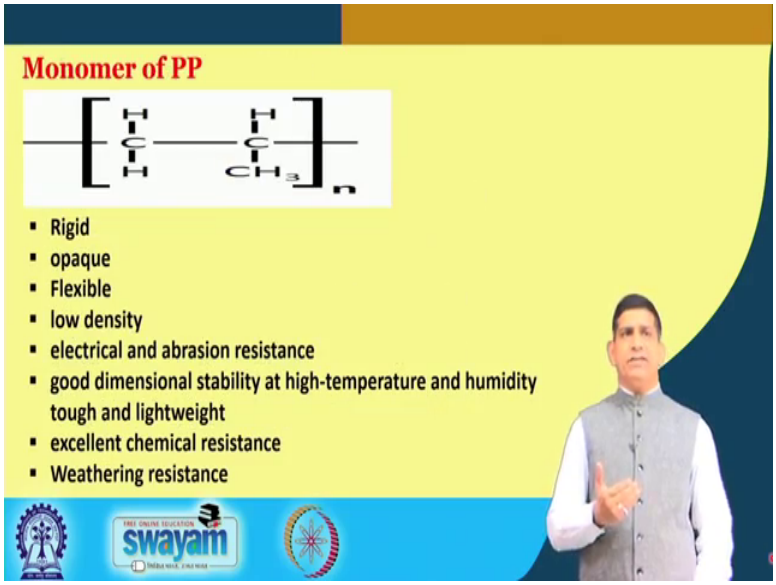

It is rigid; it is opaque; it is a flexible, low density; it is electrical and abrasion resistance, good dimensional stability, excellent chemical resistance, weathering resistance so that is

and as you can see the monomer it is a C with 2H, and then we have a CH 3 which is like a methyl group is there as well, so that is on the polypropylene site.

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And you can you use it for a different application for the food containers for some furniture's from an industry, application in cosmetics, you have medicine and health. So, different applications are there in terms of use of polypropylene in our day-today effector.

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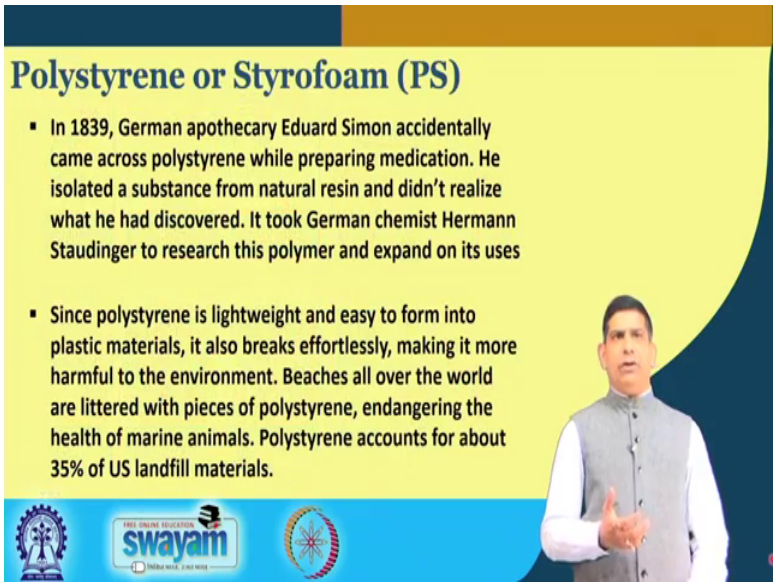

Polystyrene or styrofoam which is again 1839 accidentally came across that we say we did it some research on polymers. So, polystyrene is very lightweight and it can easily form into a different plastic material, breaks effortlessly. It is a more harmful for the environment beaches all over the world are littered with pieces of polystyrene. So, it is a in endangering the health of marine animals. Polystyrene accounts for about 33, 35 percent of the us landfill material. So, these are essentially stereo forms.

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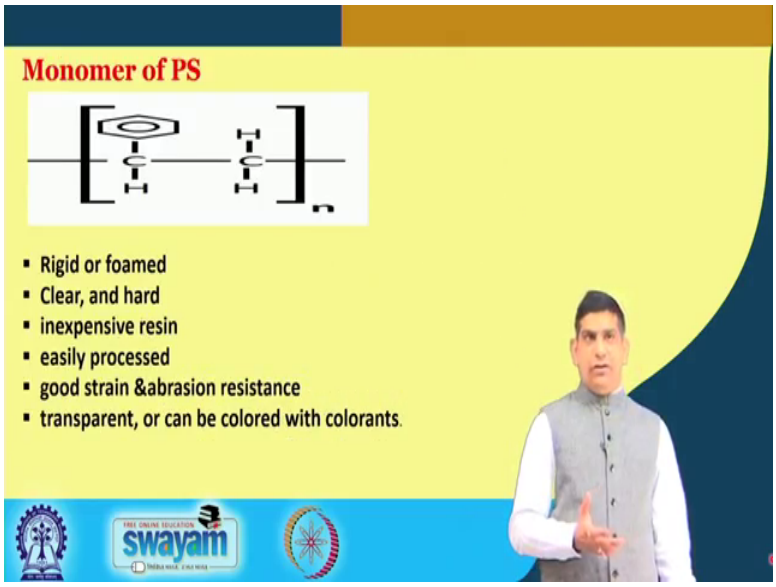

So, again the as you can see the monomer is different. It is a rigid formed, clear, hard, inexpensive resin, easily processed, good abrasion resistance transparent, and can be colored with different colors in there as well.

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So, applications differently you can see those single use per containers. Single use bowels, plates, which you and I many times users in our for a party and other stuff. And when you go to a restaurant these days, they will give you the leftover say they will ask you whether you want to take the leftover home, and they use these kind of this kind of stuff as well. So, lot of polystyrene used very poor recycling. And use we see it basically getting into our oceans and water very easily.

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And so these we are all different six types and then we whatever is not included in these we call it other and miscellaneous plastic. The remaining plastics are polycarbonate, polylactide, acrylic a like a ABS like acrylonitrile butadiene styrene, fiberglass, nylon, these are different types of plastics, there are different types of ministry cycling program. Many of these plastics actually it is very difficult to recycle ah

Many BPA products like bisphenol a products fall into this category. It is best to avoid this plastic for food products. We do not want BPA in our food. It is not easy to break down this plastic they are exposed to how and unless they are exposed to high temperature. So, it is becomes very very difficult to them to recycle.

So,. So, again the stuff for the plastic we will talk about in the plastic waste we will kind of talked about different methods of dealing with plastic waste, but the things that cannot be recycled sometimes it is just easy for us to put it in a different treatment like a thermal treatment could be an option. We are talking about plastic to oil; we are also talking about plastic roads. So, those things can be used over there.

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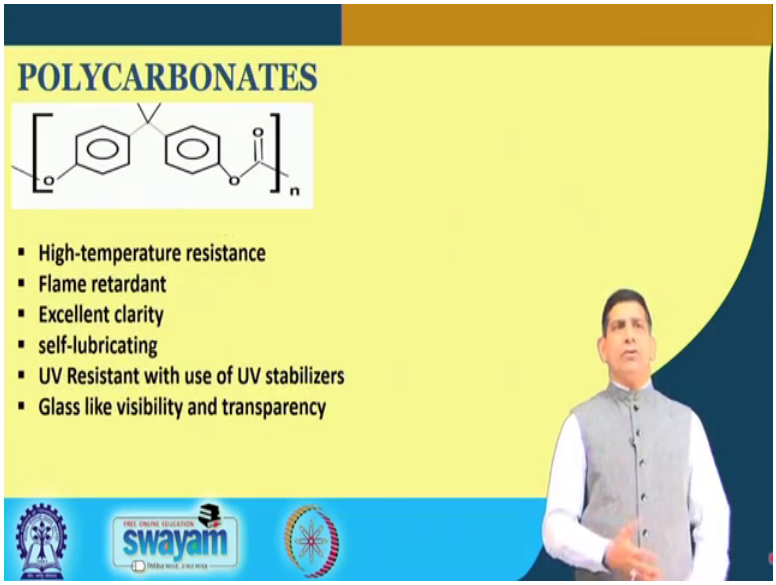

So, this is one example polycarbonate – high-temperature resistance, flame retardant, excellent clarity, UV resistance and the glass like material.

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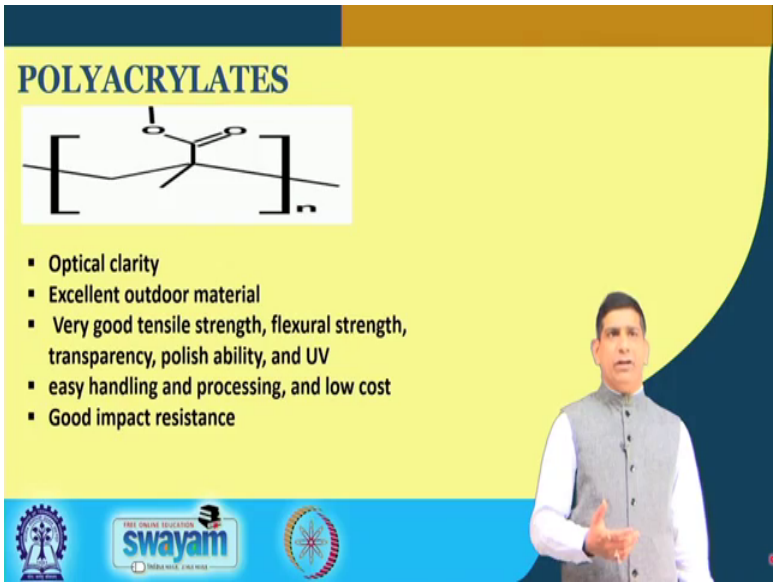

Polyacrylates again the structure is different. You have optical clarity, excellent outdoor material, good tensile strength. It can resist UV, easy handling, good impact resistance.

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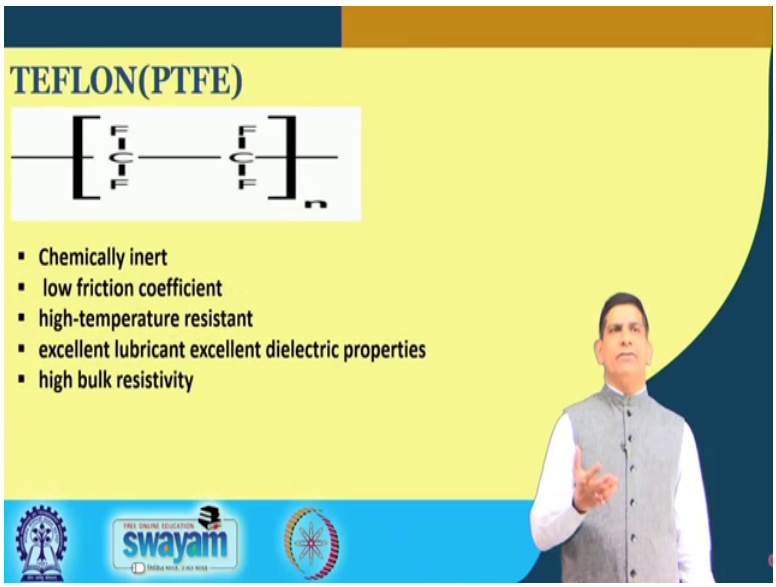

Teflon another chemically inert; Teflon, we use Teflon coated material excellent lubricant, excellent dielectric properties, high bulk resistivity.

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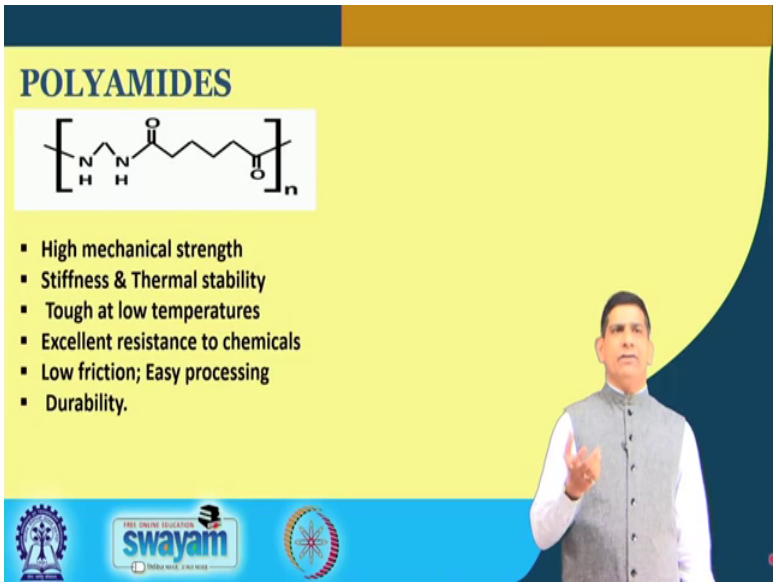

Then polyamides again high mechanical strength, thermal stability, tough at low temperature, so all the different types of plastics variety and variety of plastics are out there.

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Probably sometimes we do not in a realize ABS, flexible design, good surface quality, dimensional stability, brilliant gloss retention.

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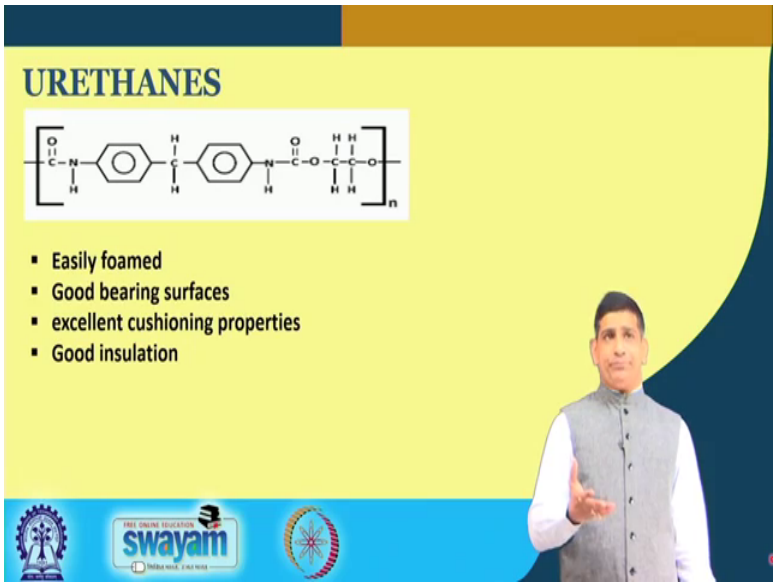

Urethanes, easily form, good bearing surface, good insulation. So, these are all those different types of plastics which is out there. So, we will kind of for this in this particular module, we try we what our goal was to look at different types and that is what we have tried to do. And then in the next video will start in the next module that would be week 1, week video number 3 is what we are completing now. So, week video number 4 will be the next one. And there we will start looking at the usage.

So, we so far the first module was looking at what is plastic. And the second and third video this is the last towards the end of the third video, we try to look at what are the types. Now, in the fourth and fifth video, we will look at uses and different types of uses and some of the numbers like what is the how much is plastic is produced globally, different types, and how much it is produced in India.

So, again any question feel free to put it in the discussion board, and we will be very happy to answer. And any suggestions any feedback do that as well.

Thank you. And I will see you again in the next video.