Industrial Inorganic Chemistry
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Lecture – 59
Fillers and Inorganic Pigments

Hello. Good evening everybody. So, we are talking about some inorganic materials which will be useful for different areas.

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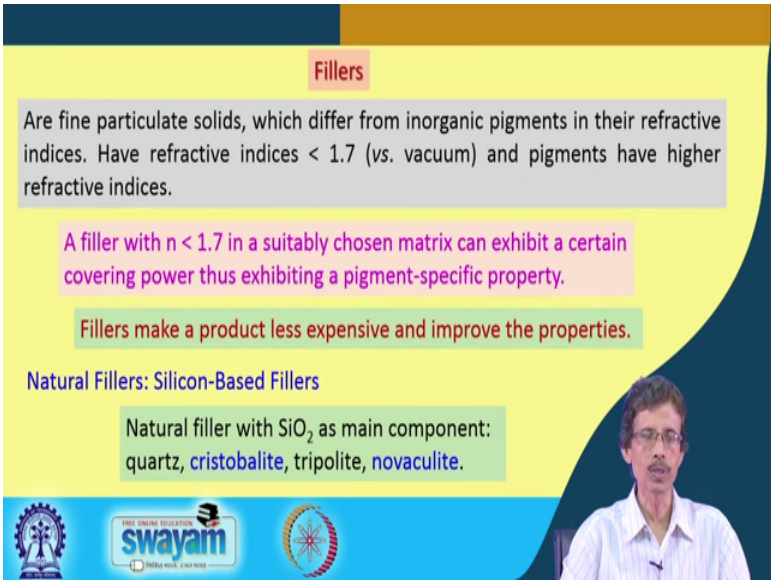

So, one such example is your inorganic fillers. What are you producing large amount for different purposes and as the name tells you that it is something which we want to fill. What are those? These are nothing but some very fine particles and the particular solid which differ from inorganic pigments because in today's class, we will also discuss about the different types of inorganic pigments. And how we define the different inorganic pigments which are interestingly very important and we produce a large amount of those pigments in industry.

So, they are different from the pigments in terms of the refractive index. So, if their refractive indices are less and which is less than 1.7 versus vacuum, what do you get is that the pigments have these quantity; that means, the refractive indices are higher that means, they have higher scattering power. So, if some inorganic material or some inorganic particulate solid is available having a lower magnitude of refractive indices, the those materials can be used as inorganic fillers. So, another thing is that a filler with that value of n that means, the refractive indices less than 1.7 is suitably chosen matrix can exhibit a certain covering power also like that of your paints what we will discuss today, that a amount a 1 gram or 1 kilogram, it can have some good covering power to a particular surface area.

So, thus exhibiting this material also can exhibit a pigment specific property. So, we can use this as the filler material to fill some cracks, some other open spaces and all these with this material now after that we can use the pigments. So, fillers also make a product which is less expensive therefore, and improve the properties of that particular texture what will be available when we use those pigments. So, if we want to reduce it the corresponding expenses for the painting and the surface improvement, we can use those fillers for that particular purpose. So, one such important example is your natural fillers and which are definitely silicon based fillers that means, you will have the silicon as the element like that of your silica or the silicon dioxide base your sand material.

So, that SiO 2 also can function as a very good natural filler which is as their your main component from all other things which is the typical varieties of those SiO 2 and having it different types of structures and solid state properties; one such is your quartz, then cristobalite, then tripolite and novaculite. So, these are the different forms of all these silica material which can be used as the filler material. So, when we have the corresponding construction or any other thing we know that with cement along with cement to use that silica material as the filler material.

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So, of the nationally occurring silicates like that of your quartz and others, talc is also another important compound and is also a very useful filler for this particular purpose and what is that talc? Talc is hydrated magnesium silicate that we all know. So, in terms of that particular one that the magnesium salt of silicate or the magnesium silicate what we get.

So, when we write in this form there are 3MgO.4SiO2 and H2O. But basically it is a magnesium silicates. So, magnesium di silica type of thing that Si2O5 type of thing can be trap some amount of magnesium that we use in our regular is also that is the talcum powder. So, it has a corresponding lamellar structure and when it is fuelled, its composition is typically of that of your magnesium silicate.

So, what would be your other natural types of fillers? So, other natural fillers is like that of your SiO2 and the talc, we can have the calcite which is calcium carbonate and dolomite we also know is a very good source for your calcium and magnesium, we can use dolomite for your some substitution for your cement material also and as well as your chalk material; that means, your calcium carbonate.

So, these 3 starting from your calcium based or calcium magnesium based material are also naturally occurring filler material, which are formed from also from the cells of marine microorganisms because marine microorganisms can go for the depositions of all this chalk like material, for their biomaterials and those bio materials after decaying or after death of those microorganisms can be deposited as calcium carbonate in calcite form or calcium carbonate in chalk form.

So, all of them since they are of origin of the maritime microorganisms, they have very loose earthly structure. Then, if we go from magnesium to barium, we can have the heavy spar what we have seen earlier that how we use the barium sulfate for the isolation of barium and other barium dependent compounds. So, the ore material the original or type of material which is naturally occurring that means, your barium sulfate can also be a useful filler material and smaller quantities of gypsum like that of your dolomite can also be useful.

So, calcium sulfate dihydrate which we also consider comparing to that of your heavy spar is the light spot because the density of that material the spar is the technically known name of that particular material, but it is lighter one. So, that is why you have a light spar material and that can also be processed for the filler material. So, you see that you can have so many available material, which can be processed for the filler material in this particular industrial in organic chemistry work.

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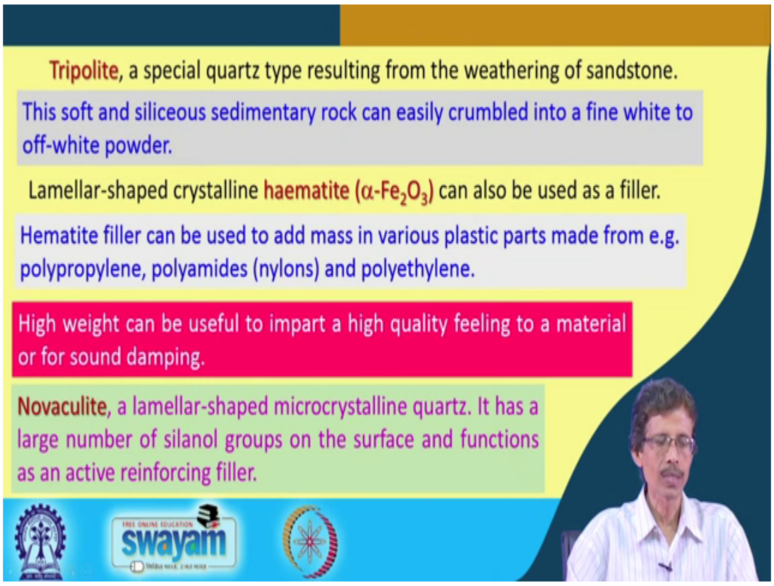

Then, I have given along with what one example is your Tripolite. So, that Tripolite is therefore, a special type of quartz structure having something which is coming out from the sandstone and the stand stone weathering is there that means, with time; that means, with water, with aging of the material like that sandstone, it gives the tripolite as the powdery material which can also used as your filler material. Then, this particular one definitely it can have a siliceous sedimentary rock material because your sandstone is nothing but your sedimentary rock variety and when it is particular the top of that particular sandstone is giving a powder like material so that can definitely be a soft material and can easily be crumbled into fine white to off white powder.

So, when it is coming out with weathering process of the sandstone material, the powder particles are coming out and then, they again can crumbled into a fine white or off white powder like material. So, basically it is not a very dry powder, but it can be a crumbled powder which can also be obtained, but it is a soft type from the tripolite material. Then, haematite can also be used as the filler material, what we get from the corresponding the ore material of iron that alpha haematite or alpha Fe 2 O3 which can also have a lamellar shaped crystalline material structure and can be used as the filler material.

So, what do you see that in terms of the structure that all them are having some lamellar type of structure because we are going for the layering process using this particular material. So, therefore, when this particular material whether it is haematite or other material quartz base or the silicon dioxide based can be have some particular structure which is lamellar shaped crystalline in nature.

Then, hematite filler when we use, it can add mass in various plastic parts also because within the plastics or the polymeric material or the rubber material, we can add all these things as the inorganic filler material. As we have seen earlier that when we are talking about the activated carbon material that means, the carbon powder the activated carbon or the charcoal dust also can be used in the rubber material for tire making or tire manufacturing process.

So, those are having some useful advantages in terms of thermal conductivity can also be considered as a corresponding filler material. So, likewise if we add hematite as a filler to other plastic materials like that of polypropylene, we know PP is the polypropylene polymeric material. Then, polyamides also the nylon; nylon 66 we all know that is well known polyamide polymers and polyethylene we know the ethylene material.

So, particularly these three categories can be used along with some hematite fillers such that you can have some composite type of material and it can increase the strength of the material for different types of use. So, the for polymer industry also we should also know what is that inorganic material and how we can add those inorganic material for giving the shape and structure of the different types of all these polymeric materials.

Then, apart from your light material we can have the high width can be useful to impart a high quality filling to a material for sound damping also. So, when sometime we can have the corresponding asbestos seeds or asbestos blocks which we use on the walls of some corresponding auditorium and the auditorium should have some mechanism, does that you do not have the corresponding reflection behaviour for the sound waves such that it can absorb those waves such that it can be a very useful material for sound damping.

So, this filler material can also be used along with some asbestos that for this particular purpose of sound damping then, the last one which is your Novaculite like that of your Tripolite. It is also having the same lamellar type of structure and it is the quartz verity and which is micro crystalline in nature and it has also some extra silanol groups. So, Si plus O edge groups are there at the surface and functions as very much active reinforcing filler material.

Since you have silanol groups and there silanol groups have some advantage, particularly sometime you will see the wetting behaviour and all other thing and it can also be very enforcing type of materials. So, it can give you the final product as a reinforced material by these inorganic filler materials. So, these are all examples of those finar metal filler materials inorganic filler materials what we can make and what we can produce for some useful application and purposes.

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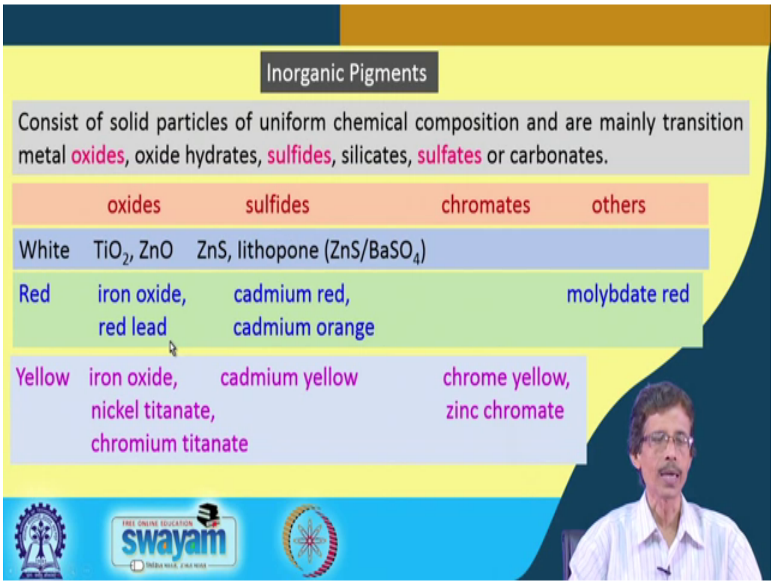

Now, we will move after this filler material, we will now go to that corresponding inorganic pigments. So, what are those inorganic pigments? Basically, so at this point we will also try to understand because these inorganic pigments are completely different from that of your dyes.

Because dyes are mostly organic compounds and organic dyes are of different colours, but when you have the corresponding inorganic pigments because it has a huge application from making some paints also, the inorganic material based paints and also the corresponding material, what we can put in ceramic material; what we can put in the enamel material and what we can put also some kind of polymeric material which can withstand high temperature.

Because this inorganic pigments are very stable and it can stable at a very high temperature such that its stability and all other thing that means, the degrading behaviour with time and with that weather also the most weather and all these thing would be very less. So, they are not degrading quite easily. What are those materials? So, inorganic pigments, we can also define in a way that these are solid particles.

So, those solid particles of uniform chemical composition, it is not a typical type of mixture of one part a and another component is b or another component of c; it is a not a mixture of a, b, c, but it can have a uniform chemical composition even if you know that it is a mixture of a, b and c of different percentages. Say the 30 percent of a; 40 percent of b and another 30 percent of c, you should know such that we can maintain that particular stoichiometry, the mixing stoichiometry for getting that particular pigment material of a mixed one.

So, uniform chemical composition that is why you can have and mainly transition metal oxides will be using, we will see also that how nicely we can have the transition metal oxide because we all know that the different types of transition metal oxides are the ore material or the mineral material, what we get from the arc crust or down to the earth. So, basically with some processing with some purification, we can directly use those uniformly sized metal oxides as the pigment material. So, what are those pigment materials, what we can see and what we can use for these purposes, we will see.

Then oxide hydrates; that means, some water of hydration or some hydroxide groups are they are along with the metal irons. You can have the sulfides also that means, the metal iron sulfides of the transition metals, then silicates, sulfates and the carbonate. So, basically all these an ionic parts what we are seeing here is the corresponding ore material for the corresponding metallic compounds, what is obtained as your own material for isolation of the metals. Now, we will not go for the isolation as the metal or some other alloys from that we will just directly use those as the corresponding pigment material.

So, if we broadly classify these four categories; one is oxide, another is sulphide, another is chromate and the others. Then, we will see that if we try to have a colour. So, how we can develop a white coloration out of those? So, we can have only the two types the oxides are one type and sulfides are one type. Those are mostly available which are cheap in availability; that means, the cost of making these or the cost of isolation from the ore material is also less.

So, we can use titanium dioxide the TiO2 from its all sources, we will see, what are those ores which can be used for making the white inorganic pigment? So, if we if I ask you that what is that that white inorganic pigment of oxide type, you can have 2 answer one is your titanium dioxide, another is a zinc oxide then, if we go for the sulfides which are again a white in colour zinc sulfide. So, both zinc oxide as well as zinc sulfide, they are white in colour and lithopone; lithopone is nothing but a mixed one. So, mixed pigment, which is mixed with your zinc sulfide along with some barium sulfide.

So, these are the white inorganic salts from your inorganic chemistry knowledge, what we know from our school days also that how we identify zinc oxide or zinc sulfide; that means, the identification of those material in your test tube in the laboratory classes, what we have seen that if we add some sulfide material or the sulfate material for the corresponding anions. We can identify zinc as zinc sulfide and the barium as barium sulfate through the addition of the corresponding sulfides and the sulfate anions to the available zinc 2 ion zinc 2 plus ion and the barium 2 plus ion because you are getting a white precipitate; it has some characteristic solubility behaviour with acid alkali or while in water.

So, that particular white precipitate when you dry, it can be used with some additives, some binder and all other thing to make it a pigment variety which is white in colour; then, if we go to the corresponding colour for the rate, directly we know that the iron oxide ore the hematite magnetite and all these are red in colour and also the red light which is Fe_3O_4. So, can be used as your red inorganic pigment then, for the sulfides you get that the cadmium red or the cadmium orange. Because sometime we can have will also see that the cadmium can also give you a variety which is yellow in colour and the mixing of these together that means, your red variety and the yellow variety can give you the corresponding orange variety.

So, mixing up all those material can control the corresponding coloration; that means the hue. We can control the hue of that colour by mixing of one particular compound; inorganic compound as available as one particular colour like that of your red can also be used with that of your yellow such that we can have a mixed colour and mixed you and mixed variety. Similarly, the molybdate red is also red in organic pigment. Then, for the yellow as just now we have seen that we can have also the cadmium yellow when we makes this yellow with red will get the corresponding orange variety.

So, the yellow variety of the corresponding oxide which is iron oxide can also give rise to the corresponding inorganic pigment type and this particular area of understanding or knowledge can also give you some idea that the corresponding ores categorized in terms of the corresponding colour or the coloured material; how you differentiate is a white colour material of that particular ore with that of your red and the yellow. So, iron oxide nickel titanate which is yellow in colour. So, very characteristic colour because the nickel solves what we know mostly give you the green to blue coloration; what is yellow in colour when it is getting as the corresponding salt has the titanate.

Similarly the chromium has titanate; they are yellow in colour and directly we get some the chromates also as the yellow form. So, which is your red chromate type of thing or the chrome yellow, we can call or the zinc chromate. So, chromates are mostly basically if we consider it from the sodium chromate or the potassium chromate, those are also yellow in colour. We get those as the corresponding yellow colour. But if and we go for the corresponding that little bit darker colour from the yellow that is your orange variety, we can go for some other compound starting from your chromate or the dichromate thing.

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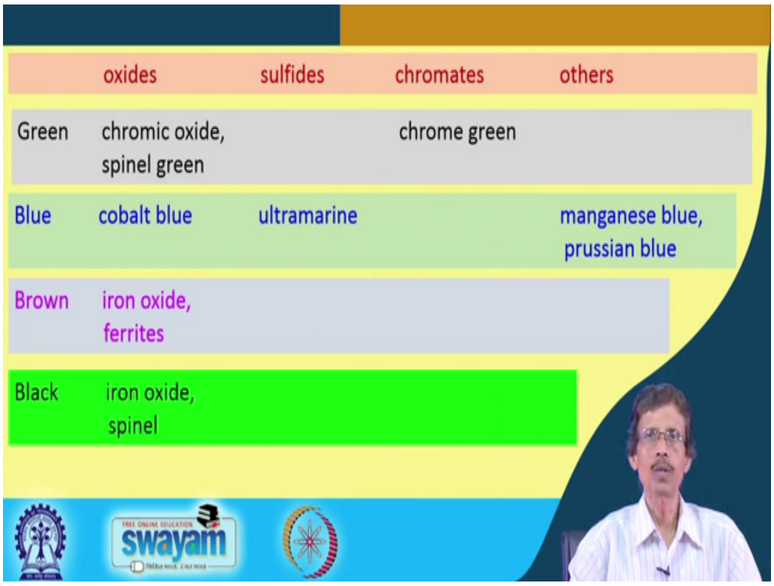

Then, all for also giving you the green colour; one is your chromic oxide and that chromic oxide and the spinel type of oxide which is also green and the chrome green is also your chrome. The chromium containing green inorganic pigment, then blue is typically the cobalt blue and ultramarine which is a typical aluminosilicate containing sulfide trap sulfide and the manganese blue and the Prussian blue which is ferrous of ferricyanide type of thing. Then, brown iron oxides and ferrites we can have that means, the brown is also very close to your corresponding orange and red coloration, but that we can have in our hand. Then, black we all know that your typical iron oxide Fe3O4 is the black in colour and some of the spinel type of oxides can give rise to the corresponding colorations.

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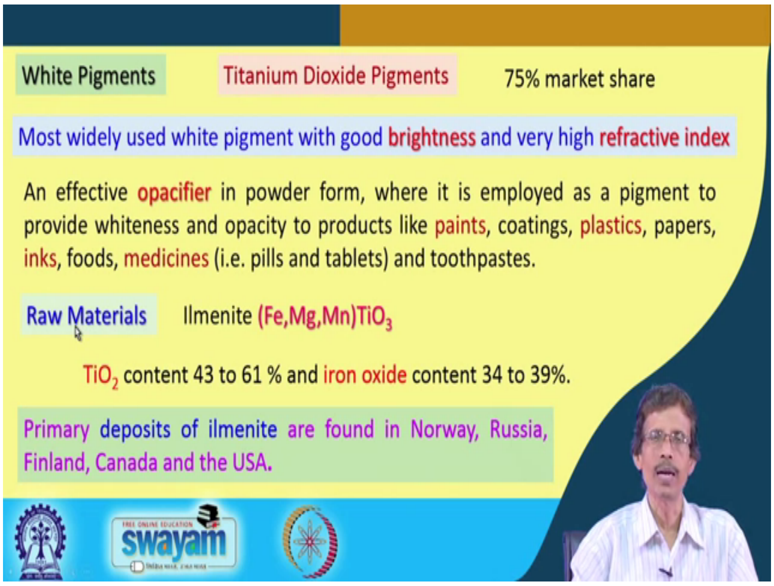

So, we will see that how we get the white pigment and white pigments are definitely you are therefore, the titanium dioxide pigment and that titanium dioxide is basically covered the 75 percent of the markets here. So, whatever white pigment inorganic pigment is available in the market and we use, mostly they are all titanium pigments and that is why they are all using it because of their good brightness and very high refractive index. Just now we have considered in comparing the filler with that of your pigment that your refractive index values are very much useful. It is also an effective of opacifier that means, an opacity is also high in powder form and is employed as a pigment. And provide whiteness and opacity to paints, coatings, plastics.

We can use in the plastics and paper also the white papers also, whiting’s also, the foods and the medicines for the different types of pills and tablets at a particular concentration which should not be harmful for your health and the different toothpaste which are white in colour. What raw material we can use for getting this titanium dioxide based pigment or inorganic pigment is your ilmenite. Ilmenite is nothing but your mostly your iron titanate, but along with that you can have magnesium and manganese. Where your titanium dioxide content is 43 to 61 percent and iron oxide content is the rest that means

34 to 39 percent. So, if you consider or if you add up these 2 so, we are not getting a total of 100 percent.

So, the remaining percentages of the other metal ions, you can have the magnesium or you can have the corresponding manganese. So, the deposit which countries are very rich in this particular ilmenite so, that they can have the industries based on this particular pigment type of material that means, the ilmenite based industry which is producing white inorganic pigment is the countries like Norway, Russia, Finland, Canada and USA because they have used deposits of ilmenite.

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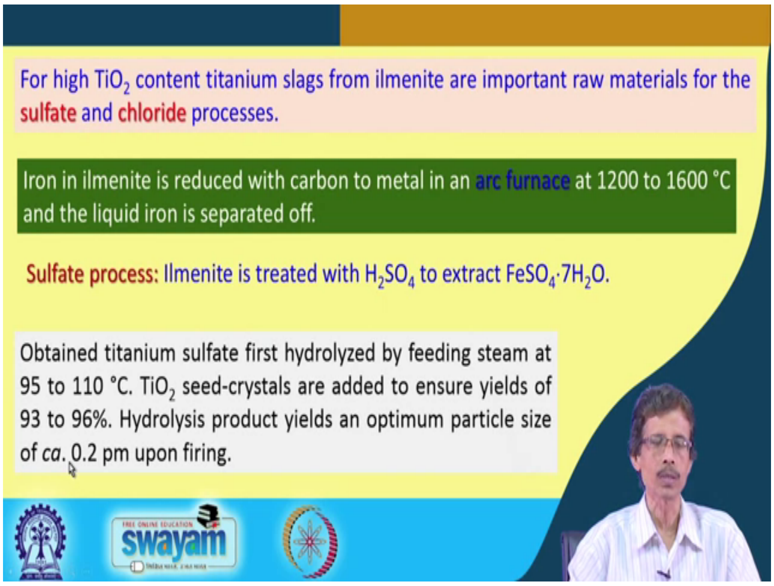

For a high titanium dioxide content titanium slags so, these high titanium dioxide containing titanium slags can also be used for making this inorganic pigments. So, when we get this slag, slag is the corresponding discarded material during the processing of the ilmenite for titanium metal itself. That time some very basic titanium dioxide, we discard it we throw away after that industrial processing for the titanium metal. We use them as a slag. But if we are very much careful enough to get that slag and process it for the corresponding titanium dioxide pigment that will be very much useful.

So, we can use two inorganic chemistry based or the solution based techniques which will be useful to get back that particular titanium, what we are throwing as slag material for getting your titanium dioxide white pigment through the processes which are your sulfate process and another is the chloride process. So, definitely the name is telling you that you have to convert the material initially to the sulfate salt and also the chloride salt through the use of very simple thing that the inorganic acids, the mineral acids, the sulfuric acid and the hydrochloric acid.

So, these two are very cheap sources of the corresponding acids, but you can make the value added material is your white pigment which is TiO_2 based. So, iron in the ilmenite which is there already we have seen is $FeTiO_3$ along with your magnesium and manganese. So, iron you have to remove otherwise that we will not impart the corresponding brightness, the corresponding opacity and the corresponding white colour in it.

So, we have to reduce that particular iron which is in the cationic formula because it is the iron titanate. So, iron is in the cationic form and definitely, we have to use it by carbon reduction in arc furnace. So, this is your arc furnace. On this arc furnace at a temperature of 1200 to 1600 degree centigrade, we will be using these and the liquid iron is separated off as iron is 0.

So, iron 0, once it is reduced at this particular temperature, it will remain as the liquid and that has to be separated out. So, the sulfate process is basically then gives us that ilmenite which treated with sulfuric acid to extract that iron which is again oxidized to that if iron as the ferrous iron as ferrous sulfate heptahydrate and that titanium sulfate first hydrolysed by feeding steam at a temperature close to the boiling point of water giving the hydrolysed product and we can also add titanium dioxide seed crystals can be added to ensure the corresponding yields of around 93 to 96 percent and hydrolysis products yields an optimum particle size of about 0.2 Pico meter upon firing. So, you get the material as sulfate, you hydrolyse it and then you charge it for the firing process to get the corresponding material as your TiO_2 material.

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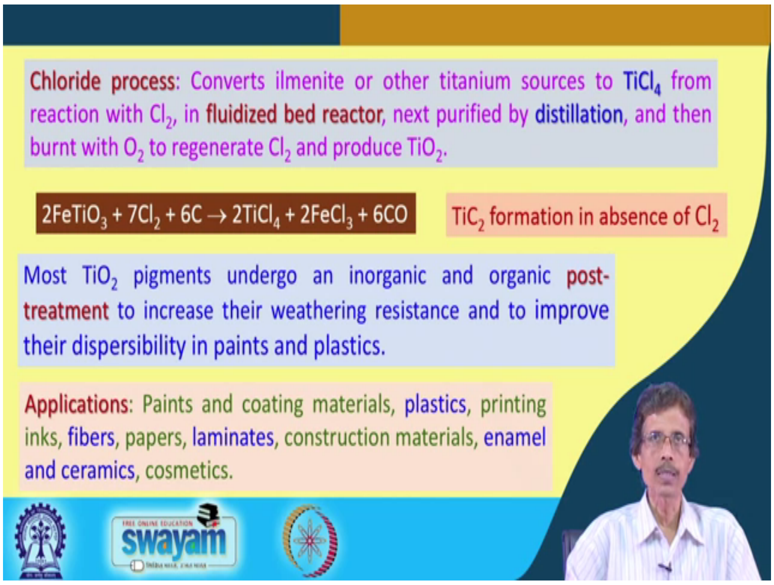

So, what about your chloride process? The Chloride process is nothing but it will try to convert your ilmenite the iron titanate basically and other titanium sources you can have large number of titanium sources, we can have nitrile, we can have ilmenite and all other different types of ore materials you have, but the basic idea for this chloride process is that you have to convert it to titanium tetrachloride. With the use of direct chlorine gas in fluidized bed reactor and is then, further purified for distillation for the pure quality of your titanium tetrachloride and then, it is burnt in oxygen to regenerate the free chlorine and produce TiO2 because it is giving back the TiO2 to you. So, when your this corresponding iron titanate that means, ferrous titanate is Fe 2 plus Ti O3 titanium in tetravalent state.

So, FeTiO3 when it is reacts with chlorine and the carbon, it is reduced that carbon that iron is reduced fast giving you some time the corresponding iron as the metallic form, but in this particular case that the chlorine is your oxidizing part that chlorine when it is giving you, it is oxidizing both titanium as well as your the chlorine titanium already in the tetravalent state will be converted to the tetravalent form of titanium chloride salt and your iron is the ferric chloride form and you get some amount of carbon as the corresponding carbon monoxide.

Because you are getting back some of these oxygen from your corresponding FeTiO3, but if we do not use this particular chlorine because the chlorine is your corresponding oxidizing agent and if you try to react its only that corresponding ilmenite as are n titanate with that of your carbon, we already seen as the some other useful material formation that will end up with the titanium carbide formation that we already I discussed earlier.

So, how to avoid the formation of titanium carbide that we also see here with the use of chlorine so, together chlorine, we use that corresponding carbon such that we can have both this titanium tetrachloride and ferric chloride and that can be separated those two can be separated by distillation. So, it can have that once you get these. So, once you get for the hydrolyzed form that hydrolyzed form which is producing your TiO2 in the pigmental form, it can have some corresponding post treatment and increase their weathering resistance that means, weather will not destroy; weather will not discard the material as a surface coating and improve the corresponding dispersibility in paints and the plastics.

So, the different areas what we can have now is that you can use in the paints and the coating material. So, that particular titanium dioxide the white compound can be useful for coating material, you can use in in plastics, you can use it in printing material like printing inks. Then, fibres papers, that we have already seen then laminates also. The lamination board also.

They are white in colour. We can very easily use that titanium dioxide. Then, construction material something we want to have some glossy type of surface. We already add some titanium dioxide based inorganic pigment white pigment. Then, the formation of the enamel surface and the ceramic surface most of them we all know that the white ceramic and the enamel based at the corresponding cookware is what we use in the kitchen they are all in white.

So, titanium dioxide is the most favoured material or the favoured inorganic movement for making those inorganic enamels or the ceramic materials and sometimes like that of your toothpaste, we can also add in different white corresponding the cream the corresponding paste and all these things for the cosmetic industry also.

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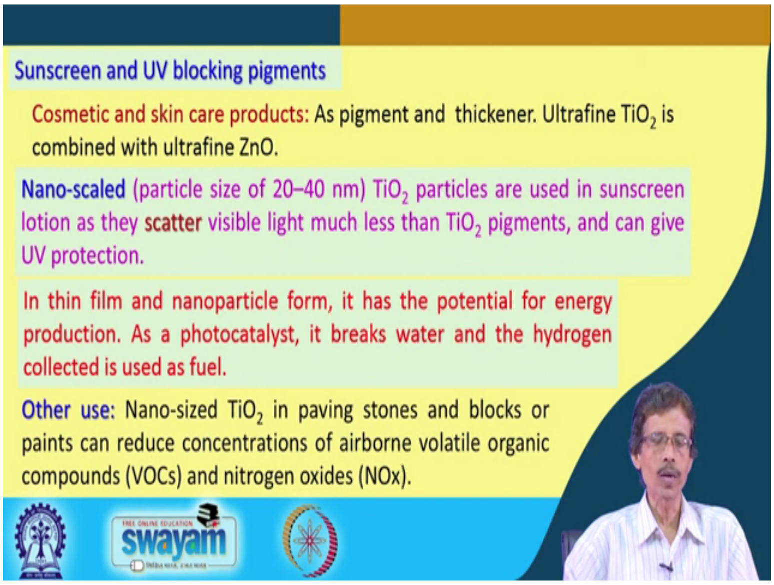

Because we all know that quickly we see how this titanium dioxide based material as the corresponding pigments which can be used for your sunscreen lotions or the sunscreen paints. So, the cosmetic industry they use very much of all these things for your skin care products and used UV blocking agents. So, something we are using as the very useful material as inorganic pigment material for your white material, but it can also some other useful purpose. So, it is also giving you a thickening and very small particles of titanium dioxide which can be combined with zinc oxide for this particular purpose. Then we go down the particle size, since we are using this for the corresponding cosmetic material which are different from that of your typical other type of inorganic pair paint material.

So, the size in the range of 20 to 40 nanometer will be useful for this particular lotion making formation and basically those particles are also useful to scatter the visible light and they scatter those visible light much less than the $TiO2$ pigments and can give therefore, your UV protection. So, the scattering is of that particular mechanism. So, visible light much less than of your titanium dioxide because the titanium dioxide pigment scattering of your visible light is more that is why it has the corresponding opacity and the white coloration. But in case of your particle size which is smaller in nature. So, you can corresponding it can scatter basically the UV lights also. So, it can function as a UV protection material.

So, in a thin film form and the nano particle form; that means, very thin layer in a corresponding lotion or the particles are very small. So, we do not have a very thick layer; only the thin layer you can have. Therefore, it has the potential for energy production also sometimes as a photo catalyst. The way we use this as the sunscreen lotion that can also be used as a photo catalysts or any surface which can be painted with that of your titanium dioxide paint can also be a typical surface for breaking water for hydrogen collection or hydrogen formation or hydrogen production for the fuel.

Then, another very useful use of this titanium dioxide the very smaller particles that the nanoparticles of titanium dioxide can also be useful for making the pavement stones that mean stone blocks or the blocks or the paints, which can reduce the concentration of airborne volatile organic compound because the surface of that titanium dioxide when the sun days are coming basically when it is activated photo chemically so that it can function as a photo catalyst only for breakdown of these organic compounds.

So, volatile; already they have the volatility if we are able to break them further, we can get rid of the corresponding contamination and corresponding that toxicity of those organic compounds, organic volatile compounds such that we can break in all these things. Similarly, we can also break the different nitrogen oxides between nitrogen that dinitrogen and oxygen that means, the nitrogen monoxide a no nitrogen dioxide can be broken in terms of your pure nitrogen and oxygen. So, these are the most useful use of all this titanium dioxide based material.

So, in our next class, we will see what other compounds we can see for these paints ok.

Thank you very much.