Industrial Inorganic Chemistry
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Lecture – 48
Inorganic Solids: Glass

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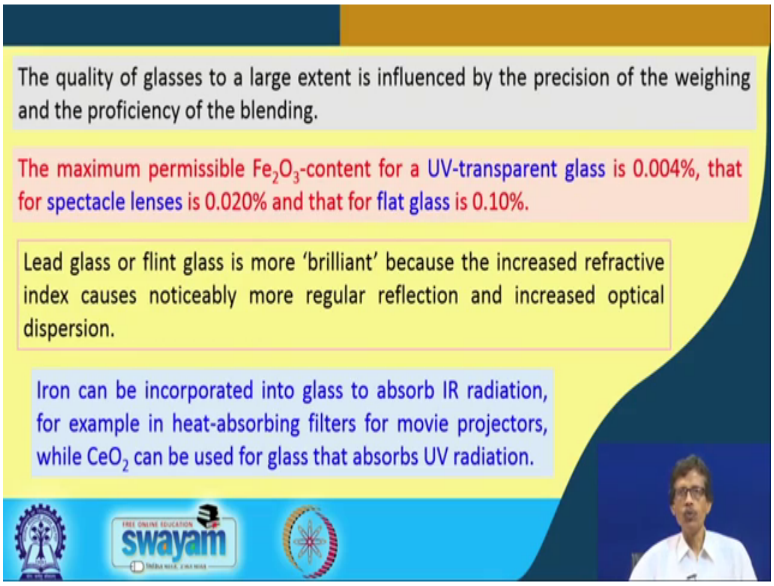

Hello, welcome back to the class where we are continuing with the glassy material and what we have seen that two types of oxides what we can have. So, apart from that we can have some other transition metal ion base oxides and if we add say Fe 2 O 3 the corresponding iron oxide which is ferric oxide.

And when we add basically the nature of this glass how we can improve the nature of the corresponding glass through the addition of only Fe 2 O 3; that means, you can have some maximum permissible level, when we can have a particular type of UV transparent glass apart from all other material what we mix together the Fe 2 O 3 content of that is just only 0.004 percent.

And that will give you a very good quality of UV transparent glass and if we want to make the spectacle glasses the reading glasses in that particular case it can go up to 0.02 percent and then for another variety which is known as the flat gas variety and that for flat glass variety it goes up to 0.1 percent of the Fe 2 O 3 content. Similarly once we have considered in our previous time that lead glass or flint glass is more brilliant that is why you consider them as the crystal cut glasses, they are very much shiny and they are brilliant also because of increased refractive index.

So, since the grease particular glass material having some higher values of your refractive index causes noticeable more regular reflections. So, basically is very shiny and it is reflecting light back very nicely that is why is brilliancy is also more regular refraction increased optical dispersion.

So, these two optical properties we consider through the introduction of led dioxide into the glass components. Then iron can be incorporated just now what we have seen as Fe 2 O 3. Similarly any other iron salt also we can use, but particularly that should be converted to is corresponding oxides.

Because the oxides will be in your hand and which will be mixed together in the glassy material because we are talking about a network structure a three dimensional huge network structure only made up of some metal iron or silicon center attached to the oxides only.

So, if we can incorporate iron then the glass can be useful for absorbing ir radiation for example, in heat absorbing filters for movie projections or the movie projectors also while if we go for cerium oxide cerium in the tetravalent states, cerium is lanthanide group elements. So, cerium oxide can be used for glass which again absorbs your UV radiation.

So, you see the modifying the different oxides when case you get that the addition of a Fe 2 O 3 the UV transparent glass; that means, UV is passing through their particular material, but when you move to cerium oxide if the glass the same glass material can be your UV absorbing material or UV absorbing glass. So, depending upon your need or the industrial demand we can modify we can change the composition and we can get the desired quality of those glasses industrially.

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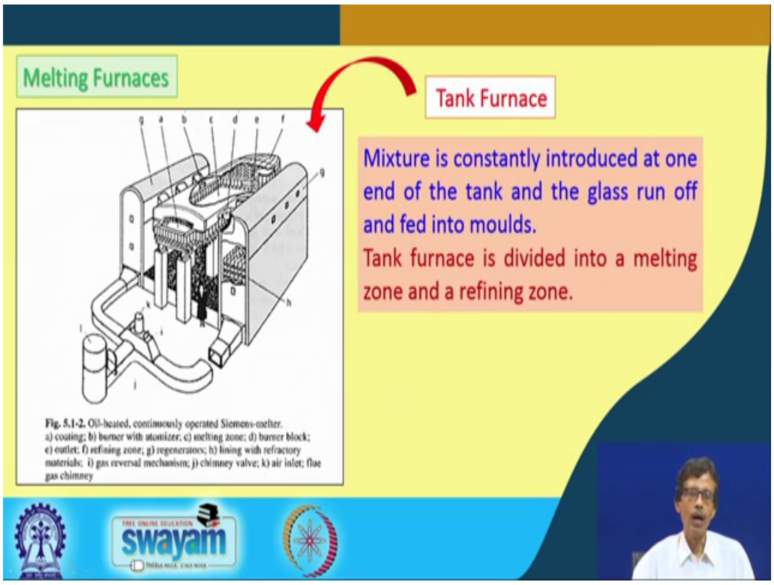

So, how we get? So, we know now the temperature the basic material what we are mixing now how we mailed them in the furnaces. So, basically the name of the furnace and some block diagram do not worry about the detail for drawing up all these things, but only you should know you should be able to tell that what furnace you know for this particular process. So, is basically a basically these are all corresponding trade secrete or the patented items at one time, but it's not now, it has a typical textbook item for your study.

So, it is there in your book also the (Refer Time: 04:46) book also that oil heated continuously operated Siemens Melter. Siemens is a German company so that German company they are utilizing it for that making your sample of this glass material. So, there are different component basically starting from your a which is your quoting then burner, then melting zone the lining with reflect to the materials, then gas reversal mechanism chimney valve air inlet and the flow gas chimney.

So, whole unit basically how a particular type of melting furnace looks like that is my basic idea to show you this particular material or this particular diagram. So, you have the burner with atomizer you have the melting zone your melting zone is c basically, so this is the central part the central part is your melting zone.

Then you can have the burner block so these are the corresponding blocks these blocks are the burner blocks at the below. Then outlet also you have the ease your outlet and the refining zone and the regenerators where we have seen that we can regenerate some part of this material which are not crystallizing it out from that particular furnace.

So, we use a tank furnace for making these particular type of glass material what Siemens was using at that particular time. So, mixture is constantly introduced at one end of the tank and the glass run off and fade into the molds because you have to put the molten condition of the glass of the melt of the glass two different modes such that it gets the corresponding saves or the regular saves as per your molds.

The tank furnace is divided into a melting zone and refining zone that is why you have c is your melting zone and f is the refining zone c and f so two zones are there which are one is your melting zone and another is your refining zone.

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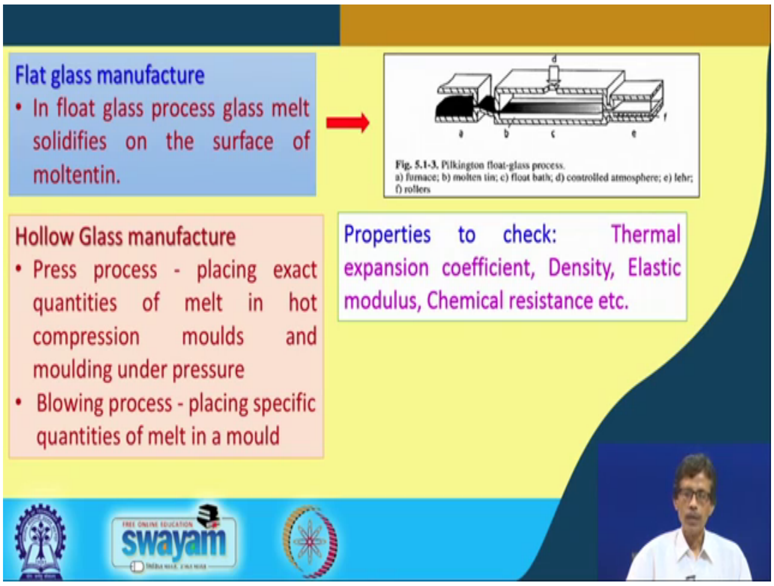

How we make then the flat glasses? So, flat glass also known as the float glass is float glass process the glass melt solidifies on the surface of the moltentin. So, moltentin is the corresponding material what where do you get basically the corresponding material is the solidified there. So, moltentin is nothing, but where the corresponding material the glassy material or the which can be solidified is getting over is a surface is covered and then it getting solidified.

So, another important glass making company in our country also it is in West Bengal also near Asansol in a West Bengal we all know there is a Pilkington glass factory. So, Pilkington is the person's name who introduced that particular thing; that means, making of this float glass process. So, basically from these raw materials the Pilkington process is made up of this particular one where is we get the corresponding flat glass.

So, we have is the furnace we have the molten tin this is the molten tin so molten tin is there then float bath then controlled atmosphere and the corresponding layer and the roller. So, finally, we have the roller such that you get the corresponding glass as the sheet from those flat materials. Then another variety of glass is the hollow glass and the manufacturing process is depends on two types; one is the press process and another is the blowing process. So, in the first category where we consider it as the press process where we put the exact amount of the melt in hot compression mould. So, you have the mould which is the hot compression mould and moulding is done under pressure.

So, basically the molten thing and how we mould it basically and we get somewhere that particular hollow glass variety and other type and other process we basically use the blowing process the placing specific quantities of the melt in the mould and we go for the blowing. And the way we get the different varieties of these glassy material or the glass samples we now take their properties.

So, the properties how we take check there that already we have seen that what are the properties will be looking for similarly for all the different types of glass material whether you are making a flat glass or whether you are making a flint glass or a hollow glass. Will be looking at their properties in terms of their thermal expansion coefficient the density the elastic modulus and; obviously, the chemical resistance that how strong they or how they are repelling the chemical attack.

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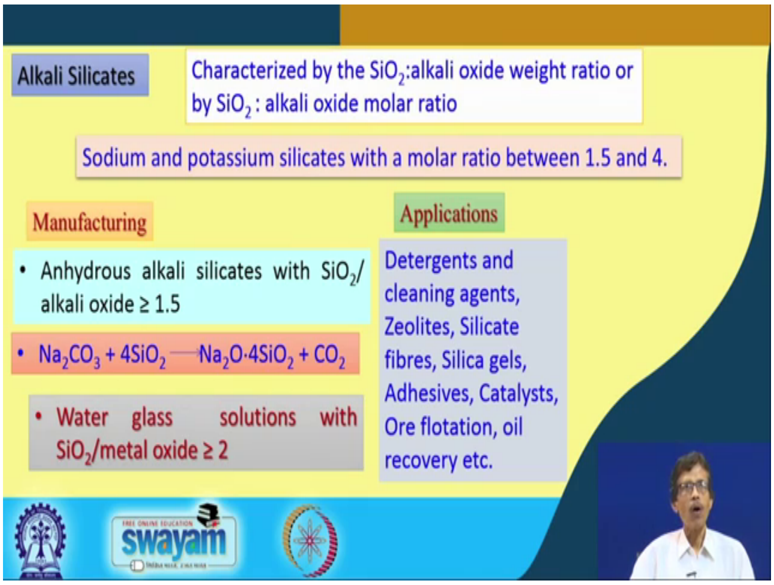

Now, we will see that how alkali silicates? The most simplest possible silicates what we can have. It is the procedure where we have the alkali oxide that mean the sodium oxide or the lithium oxide mixing with a SIO 2. And therefore, we can add either the molar ratio or the mole ratio process or the wet ratio process either you can add by weighing or by doing add the corresponding weight in terms of the different numbers of moles.

When we you mix it in terms of the moulds we can have a very good idea about the number of silicon centers what you can have a number of other centers or are the corresponding sodium variety or the corresponding formula of the material. So, it gives you if you depend on only on the sodium oxide or the potassium oxide you will be getting sodium and potassium silicates, where the molar ratios are varying between 1.5 and 4.

Then the typical manufacturing process what we get over there, the manufacturing process is basically nothing, but your corresponding anhydrous alkali silicates we have with SiO 2 is to alkali oxides the corresponding sodium oxide or potassium oxide is greater than equal to 1.5.

And therefore, the reaction already I told you that you have the reaction is that you get the sodium silicate, but now the higher amount of this particular one; that means, you can have the corresponding higher amount of silicon; that means, you have more number of

SiO_2 in the system. So, Na_2O and 4 of SiO_2 is not that is simple formula of sodium silicate, but you can have a corresponding one is that is basically 1 is to 4.

So, that one formula weight of that sodium carbonate with that of your silicon dioxide or SiO_2 can give rise to this particular material with the elimination of carbon dioxide. Then for a water glass solutions where the corresponding ratio is greater than equal to 2 and they have also some good applications because these are soluble in water, so these sodium silicate that can be binder that can be filler so some other materials.

So, you see you get a sodium salt of silicate and all we know that most of the sodium compounds of the corresponding inorganic samples or the metal ion samples are soluble in water, that we know from our early days or the childhood days or the school days that all these sodium salts will be soluble in water. So, as a result you have the corresponding sodium silicate sample, so definitely the sodium silicate sample will be soluble in water.

So, it can be very easily used as the detergent work can be a binder for the dark material or the material what is going out during planning process. Then the different types of cleaning agents we use it can be a good constituent of zeolites. So, will see zeolites how we make your zeolites very important molecule in organic material.

Then silicate fibers the glass fibers also are known as silicate fibers, silica gels we can have silica gels are the typical dehydrating agents and you get these particular silica gels that mean the silica gel material of different types sometimes it can be impregnated; that means, that the position of the cobalt samples are there; that means, which are colored silica gel because when we put this silica gels for a dehydrating agent in the desiccator or in industrially some desiccant material because the silica gels also come with the pharmaceutical materials.

So, any dry atmosphere starting from the room to your pharmaceutical material or the medicine we use some small packets of these silica gel. So, those how we make these silica gel, so is a huge application and huge industrial demand on making silica gel. Sometime this material can also be used as adhesive catalyst also because the catalyst support also ore flotation also that ore is mixed with this.

And since these are lighter material it can take up this ore at the top of the particular material or part of the corresponding reaction vessel where the ore will be floating. Then oil recovery then the oil drilling material it can also use as the oil drilling material that we also considered some time.

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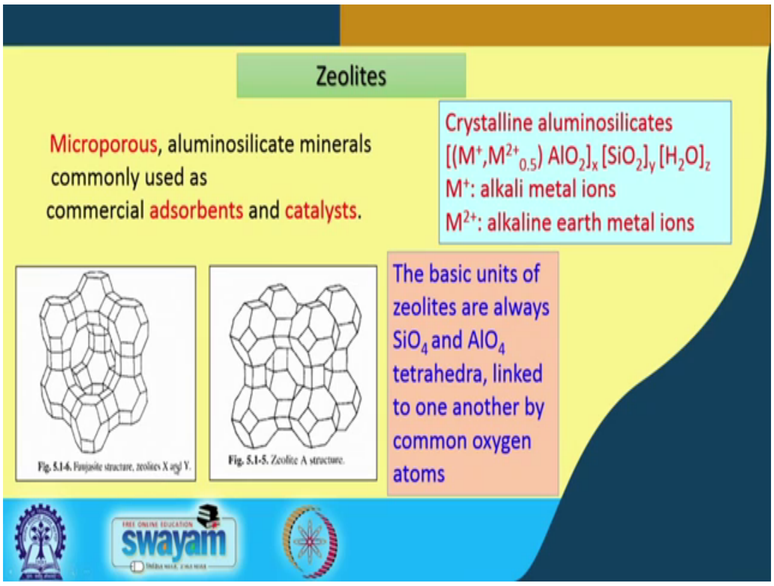

Now, we go to the zeolites and these zeolites what will be talking now is a very important class of molecules or the compounds in organic compounds because it has huge application because these zeolites will have a huge or tremendous application, but these are nothing, but. So, far we are talking about the silicates and now these are basically the corresponding one where we can go for aluminium silicate.

So, will be substituting those silicate points or the silicon junctions basically those silicate junctions will be replaced by aluminium or the aluminate system; that means, l o 3. So, that l o 3 part of this particular one that surroundings can change these and these are of mineral origin; that means, it is naturally occurring material used as commercial adsorbents and catalysts.

Though just now the way we have seen just now is for your silica gel making the solid material out of your water glass, that silica gel is also a very good adsorbent and this silica gel of different sizes the particle sizes are different even when the particle sizes are different the pore sizes are also different and those pores are also very much useful for the separation process also.

So, the first thing which is commercially utilized is your adsorption. So, they are very good adsorbents like your silica gel what they are absorbing when you use silica gel in desiccator or in any other place where we want to trap or you want to trap basically or you want to take out those moistures as available in the atmosphere that is why it is a drying agent as a desiccant also.

So, how silica gels are desiccant? Because the water molecules what are available over there will enter those ports. So, those pores will be all filled with those water molecules and that is why if you have a indicating silica gel where the color change can take place which is the cobalt based compound, the corresponding cobalt compound is given; that means, the cobalt chloride that tetrachloride of cobalt compounds the co CFO 3 minus can be added.

So, tetra chlo ride cobalt 2 is there and when it attacks with the water molecules say then it did not go for the corresponding Sacco species which is different pink in color. So, some is blue which is in dry when you put the silica gel the colored silica gel when is the dried form we put in oven basically when you dry it we see the blue silica gel and small bits of those silica gels basically we put in the desiccator.

And when it is living it is putting in there and sometimes it can also be used within the instruments also particularly the (Refer Time: 16:36) spectro photometers and all other cases where we need a very dry environment or the dry atmosphere for to keep that particular spectro photometer on the spectro meter FTIR spectrum meters. So, when it absorbs water basically the blue color of that cobalt sample changes to the pink color and that is why we know that this corresponding adsorption and power has decreased and is almost gone.

So, we have to recharge the thing after putting the material into the oven, when it again goes back to that particular color of blue where we can use it once again for it’s desiccant behavior. So, the absorption of water molecule similarly anything it can absorb. So, as a very good commercial adsorbent the zeolite can be used and the idea is also coming from the simple and the very cheap one the silica gel because the same silica gel we can also use for chromatographic separation by looking at the column.

So, if you have a chromatographic column filled with some silica gel which we consider in the silica powder of different mess size sometimes it is known commercially it is available as 60 to 120 mess size. So, that will be useful for trapping or separating some of the compounds suppose some inorganic complexes we are trying to separate having three different isomers in a mixture what do we have synthesized in the laboratory.

What do we do because they have very different difference in the colors when we put on the silica gel column on some organic solvents the acidonitrile or dichloro methane, we get the separation of these as the different colors and we take out with the some eluting agent or eluting solvent the process we call is that the elution and through that elution process we take out one after another of all these three isomers. So, that is why it can also be separated.

So, if you know consider the same idea or same knowledge we can use for separating a mixture of gases suppose three components are there if we allow to pass through those pores only one particular type of gas; that means, one particular type of gas can be separated from the mixture in its purest form and sometimes these zeolites can also function as catalyst and sometimes it can function as also the catalyst surface because what we can have we get that particular one is the variety of silicates and the variety of silicates what do we get it can have a SiO bond and SiO bonds when it is there in presence of our silicic acid which is nothing, but your H 4 SiO 4; that means, you can have SiO H bond.

So, that SiO bond can have always the power to be converted in a corresponding SiO H form; that means, the material can be acidic one. So, if we can go for and some catalysis which is acidic catalysis or acid catalyst what we can have? We can have some silica gel, that we can also see that some reaction if it is catalyzed in the solid state when which is driven by acid catalysis we can put the solid sample over silica gel and we keep it for a while on that room temperature or at some elevated temperature sometime it is found that if we put in over in at a particular temperature simple air oven at 90 or 100 degrees centigrade.

We see some transformation, we see some color change and that is due to the catalytic effect of that silica gel or the zeolite for this particular conversion even in the solid state. So, these zeolites therefore, a very good variety and what we get as their typical aluminum silicates and the formula of it is that you can have the M plus M 2 plus of half amount half of the amount.

So, half of the amount and then AlO 2 and which is of the x times then SiO 2 of y times and what are object times. So, is the whole mixture what we have already we have we started our journey from silicate, material or silicon dioxide and make it sodium silicate to the introduction of NA 2 O or the sodium material in it and then we see that this particular thing can put some of the aluminium also. So, the presence of those aluminium as the aluminum oxide can change the material and the different shapes and structures basically can give rise to this particular type of zeolites.

So, when N is alkaline metal and m two plus is alkaline earth metals definitely they are the bivalent one like your calcium, like your magnesium, like your barium. So, what we get therefore, that the basic units of these zeolites are made up therefore, SiO 4 and though we are adding aluminum is the trivalent one and we are considering as AlO 3, but when it goes into the structure it also accepts one of the bond because the aluminum also favors the tetrahedral geometry.

So, the building blocks are basically of two types of different strain because the silicon oxygen bond is completely different from that of your aluminum oxygen bond even the bond enthalpy and the bond strains are all different for SiO and AlO. So, they are the different varieties of tetrahedron link to one another by common oxygen atoms.

So, one particular variety we see now how beautiful they look like and they faujasite structure with that the known as zeolite having a particular mineral variety which is known as the faujasite this faujasite is therefore, you can have two varieties of zeolites one is zeolite X and another is zeolite Y in our hand, but what sort of structure you have basically one of these building blocks if we look at nicely that this building blocks is not a cube, not any other time is basically a particular variety what we get and these nodes basically these junctions we call these we can have these different nodes basically.

So, when we look at this particular hexagon is the hexagonal cavity you can have because if you have a typical channel there you can have hexagonal cavity, but if we see from the other end this is a square. So, 1 square; 1 square; 1 square, so what we can have ? We can have a q we all know q had 6 square phases and you can have a typical octahedral type of thing octahedron is also we know it has 8 triangular phases.

So, you just look at these two structures and if we try to cut octahedron from the all the 6 vertices it was the octahedron you have 8 phases, but the number of vertices are 6. So, along with these six vertices and those 6 vertices are along the 3 axis which are x y and z. So, if we cut along this particular axis through that particular phase along the x axis along y axis or along z axis what you get because those z axis in octahedron they are all of symmetry of fourfold symmetry; that means, they are all c 4.

So, along the c 4 if you cut that particular vertex of the octahedron you generate a square over there.

So, all the 6 positions all the 6 points basically of the octahedron of the 6 vertices of the octahedron you can cut and they are on c 4 axis. So, they will all generate a square phase. So, basically by cutting that this particular unit the sphere type unit is known as cube octahedron. So, you have octahedron and along the three lines; that means, along the three axis x y z you cut it such that you each and every vertices you generate a corresponding square, which has the symmetry of that of your cube because q has all the 6 phases as q square because these two are interrelated is a cube octahedral symmetry is both having the symmetry of cube as well as the octahedral symmetry.

So, you get that and that basically that particular unit when it is there and lining up of all these unit because you see this particular one and when it is lined up above the other unit. So, the building block if you just simply consider in a simplest way that you have the cube octahedron and stacking up all the different q octahedrons over one another will generate some of the channels which is made up of only the square phase. So, you see the square phase you have the square phases the number of square phases can be more, but through this particular area you have only the squared channel and this is hexagonal

So, all this part; that means, the entire structure having only the windows if you consider these windows are basically either external or tetragonal or the square one. Similarly, another variety what we consider it as the corresponding one as the zeolite a; so this is the first part where you can have where you see that this is the x octahedron. And when the octahedron we cut it and generate the square phases all the corresponding 6 phases you can have and by doing so this particular one we generate this all the 8 triagonal phases already you have in the octahedron. So, all the 8 triagonal phases have been converted to the hexagonal phases.

So, the cutting is less here when you cut more your squares are different and the corresponding positioning or the arrangements basically off of different type giving it one other type of structure. So, the structurally they are all different you keep in mind, that zeolite a structure is completely different from zeolite x and y structures.

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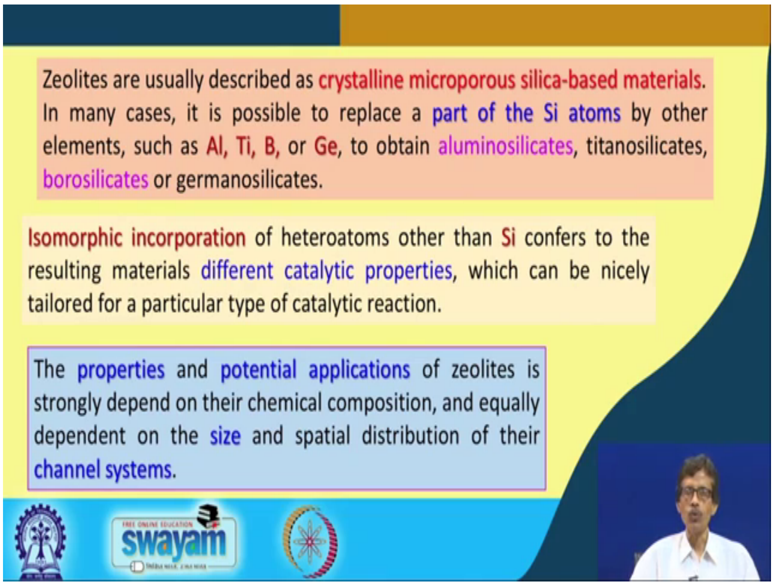

So, that will see now that how we go for these particular types of varieties; that means, the particular type of structures that zeolites are usually described as therefore, a crystalline micro porous silica based material. So, how you define what is silica ?

So, that SiO 2; So, SiO 2 based one other type of material we will be getting by the replacement of the position; that means, the nodal points and the nodes which are made up of the silicon center that is why the inorganic chemistry come into the picture very well, if we know that how silicones are there and how silicones are connected to the oxygen and in some other point it is the aluminum center which are connected to the oxygen centers. So, it is basically crystalline in nature micro porous and silica based material because some of the other part is your aluminum

In many cases it is possible to replace a part of the silicon atoms by other elements because some of these silicones also because these are basically the corresponding one where the silicon centers can also be replaced by aluminium can be replaced by titanium can be replaced by the boro silicate glasses by boron or sometimes can be replaced by germanium. When we replace it by aluminum we get aluminum silicates as we already know that the whole silicate structure some of them can be replaced while you make the glass that can be replaced by aluminum.

When we replace by titanium we get titano silicates when it is replaced by boron we get the boro silicates and when we get the germanium we get the germane silicate. So, when we consider that zeolites and the boro silicates; that means, that your glass material is also of some type of zeolites. So, because the boro silicates are also known as the typical glasses well known glasses, then isomorphic incorporation of heteroatom's other than silicon confers to the resulting material different catalytic properties; that means, when you go for titanium when you go for germanium the nature of that particular zeolite material or the zeolitic material is different and we will be changing the corresponding behavior in terms of its catalytic property.

So, they have different catalytic properties which can be nicely tailored basically for a particular type of catalytic reactions. So, if we consider we are going for some hydrogenation reaction or solid state transformation from one isomer to the other and one particular type of catalyst in the solid state is useful, but that is based on say either aluminum or is based on titanium. So, only that variety of zeolite will be useful for that particular catalytic reaction the properties and if we consider the their applications the properties and the potential applications we know we can make synthetically will see in our next class that we also be able to make synthetically in the laboratory.

Because our entire knowledge has come from discovering the material what is available from nature; that means, geological discovery gives us that particular material with along with the different types of silicate materials. So, the zeolites in our hand then we know we characterize it fully we know the structure and after characterization we try to get the information that how they have formed naturally that is why the natural science is; so interesting that how it has been formed.

So, once you know the process of forming even the high temperature high pressure reaction or a very huge timespan we can reproduce the same reaction in the laboratory or even in a huge industrial scale such that we can modify the different types of zeolites which are not naturally available; that means, nature has given some amount of zeolites, then we basically by knowing all the properties and all the making process of all these materials we can apply it our knowledge or information to make new types of zeolites in the laboratory. So, how they are dependent they are basically dependent on their chemical composition that is why we are very much interested to know what should be the corresponding property of all these zeolites if we substitute it by aluminum, if we substitute by titanium by boron or by germanium.

So, the chemical composition is always important so that is why in the 3 dimensional structure we have seen three types of these zeolites and the structurally if some of these positions are occupied by say titanium which is the transition metal ion 3D series. So, is occupied by titanium and we know that the titanium can function as a very good catalyst in small molecules also. So, is basically in a solid state network structure huge structure the titanium is present than that titanium can show some reactivity pattern to that of your titanium metal ion complex.

So, that is why the titanium base zeolite can show some interesting reactivity pattern which we cannot get from some other source and apart from that it can have the in solubility because these materials are insoluble most of the time in only water. So, we can have some solid state support and that some heterogeneous catalyst is also.

So, is equally dependent also not only the chemical composition, but they will be also dependent on the size; that means, the corresponding atomic size of titanium or say atomic size of the boron and the distribution of their channel system. Because just now we consider in our next class we further consider this as to how the channel is developed and those channels basically whether you have a tetragonal channel or the hexagonal channel because those channels are useful to take up those differences small molecules which can reside and which can pass through those channels ok.

Thank you very much.