Industrial Inorganic Chemistry
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Lecture – 56
Carbon Modifications: Glassy Carbon, Foamed Carbon, Carbon Black

Welcome back to this class where we were talking about the different types of inorganic materials. So, now, will see one most important material is your carbon material. So, what are the different types of carbon which will be utilized for industrial use? As you all know that people can have the consideration that carbon ok.

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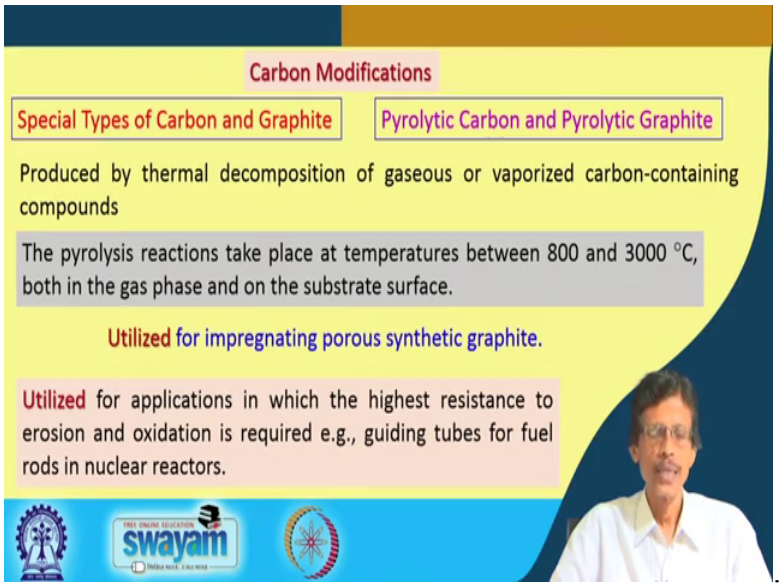

This carbon is the basic material for giving you all the different types of organic molecules. But when you have the organic molecules which is not only the simple carbon, you can have also hydrogen, you can have oxygen, you can have the nitrogen.

But when we talk the carbon inorganic carbon material, which will be useful for industrial use is that the different forms or the different modifications. What we know these different modifications, we know from our early childhood that the carbon is available in the diamond form, in the graphite form, and in recent time we know that the carbon can be up dent in the corresponding C 60 C 70 form which you all know that they are the corresponding buck minster fullerene.

So, these are different modifications or the different forms basically, but now will see in this particular class, that what are the different types of all these carbons are useful industrially. Because, the inorganic chemistry based industry is always produce large amount of carbon the carbon black sale, but the special types of carbon starting from that carbon as a filler material to that of your active ingredients as active catalyst. So, the two varieties basically will be looking for the special types of carbon basically and the different types of graphite's. Because, we know that huge use of graphite is that of the electrode material.

So, if we want to make the graphite's, the different types of graphite because nowadays in the era of the Nano materials we make the all the Nano particles. So, the carbon Nano particles the carbon different types of material from that and like that of your C 60 or 7 C 70, the graphite can also be converted to the graphene material. Because the graphite we all know they are C 6 layers. So, the continuous C 6 layers you can have on the graphite and if we can remove one such layer from that graphite surface we get the corresponding graphene material.

So, people are working on that graphene material also very much to have some good utilization and good application in terms of its corresponding research or industrial applications. So, industry the corresponding inorganic industry then inorganic chemistry industry will be devoted to make the new forms of this graphite's which can be available cheaply, and how form that graphite people can make the graphene or any other very special type or the sophisticated material out of these. So, right now from the very basic material we let us see how we can have the different types of carbon material and the graphite material.

So, one such is that the pyrolysis, we know that how we burn a corresponding wood material or the wood substance. So, if we burn the wood material or the wood substance by pyrolysis, we all know that the pyrolysis can give you the corresponding n product at the charcoal. So, other material can also come out which we all know that the pyroligneous acid, the pyroligneous acid; that means, the liquid form of that during that particular charring or the burning process can be taken out and from some chemicals we can identify from there and we can isolate all those chemicals out of this.

At presently what will be looking for is the product as the burning product of the wood material or any other starting material, that will see that what are the material you can use for making the pyrolytic graphite is one form. And another form is your pyrolytic graphite, because the pyrolysis can be directed to get the graphite material in your hand. So, another particular form of the specialized form. So, produced by that corresponding pyrolysis is the thermal decomposition of gaseous or vaporized carbon containing compounds. So, different carbon containing compounds, it can be a very simple wood material or the corresponding any other type of hawk's material.

So, any carbon containing material can be burned such that only the carbon part is living behind other material will be burned as oxides. And taking the proper precaution that, we do not want to burn the carbon as carbon monoxide or carbon dioxide because we want to leave it as carbon itself. So, this pyrolysis reactions which take place at a particular temperature which is very high also, depending upon your starting material or the raw material or the feedstock. What material we are utilizing for getting this particular type of carbon is important. So, a range from 800 to 3000 degree centigrade is important for both in the gas phase and on the substrate surface.

So, if you go for the corresponding gas phase condition; that means, if you burn something which can live behind your carbon. And your carbon surface the powder form of the carbon is getting activated, that will see that will give rise to the variety which is known as your activated carbon. So, at this point you try to remember that, what particular temperature will be useful such that you can live behind with the carbon product from any other very cheaply available raw material for burning process. So, this can be utilized for impregnating porous synthetic graphite.

So, the pyrolysis reaction basically can be available for getting some graphite. Because the graphite we have told you that this you have the continuous 6 member C 6 rings. So, continuous layers of that C 6 rings will give you the graphite and you have the inter planar connectivity through the pi interactions. So, those layers we can have and definitely those layers basically you can have either the planar size or the longitudinal part you can have the pores. So, basically if large number of pores are there and the pores are free to absorb something you get the something porous synthetic graphite through this particular process.

Then it can be utilized for application in which the highest resistance to erosion or oxidation is required that is guiding the tubes for fuel rods in nuclear reactor. So, those carbon varieties basically can be utilized as we have seen that for making the synthetic graphite that can also be utilized for making the fuel rods in nuclear reactors. So, is very high temperature withstand is should be there and it should also be very highly stable. So, the tubes should be there guiding the tubes guiding tubes basically for fuel rods in nuclear reactors we use those graphite material.

So, graphite as I told you that it can be also be a very useful electrode material for our simple application of dry cells we all know, that the central rod is your graphite rod. So, making of those graphite's for making those dry cell batteries one of the utilization is your inorganic carbon material as the graphite rod.

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So, if you have then further application of this material that it can have because the carbon is very innocent material it will not harm anything to anywhere. So, if biologically it is comfortable; that means, it can have excellent biocompatibility, then one variety that mean isotropic variety of your pyrolytic carbon articles or carbon material can be used in health sciences, for making some useful material based on the carbon. So, is the carbon is the material which can be used for your heart flaps or heart valves. So, artificially when we try to make this heart flaps or heart valves the carbon, can be your active ingredient for somehow with along with some other material. So,

carbon can be your active ingredient for making those, because it has very excellent biocompatibility and also in making some other prosthetic devices which we can put inside our body.

So, if some part some organ or some functioning thing has went wrong we can substitute those by using this particular carbon material for implantation. Now, we see two varieties of carbon which are known as your glassy carbon and foamed carbon, we know that the glassy carbon is well known to us we known as GC. GC is a useful electrode material. So, not the graphite electrode, but is also the glassy carbon electrode for some electro chemical measurements we quite often we do in the laboratory for cyclic voltammetric measurements.

We use GCE like your platinum electrode or other platinum wire electrode or the platinum disk electrode; we can also use simply the GCE the Glassy Carbon Electrode also. And, that carbon in the foam form is known as the foamed carbon. And not very high temperature only thousand degree centigrade is fine. So, at high temperature pyrolysis can produce at a temperature of 1000 degree these two varieties of carbon.

So, what are those starting material basically not anything carbon containing material or carbonaceous material can be utilized for making this material, but some polymer material. So, scrap polymer materials which we throw away basically so, the burning of the polymer material, the plastics you see the utilization very useful utilization of those plastic material can be done by making or getting that particular thing in the carbon form.

So, if you have some used thermosetting polymer, because thermosetting polymers we know that they are very useful and we can use those thermosetting polymers for different purposes different household use or any other uses. So, throw away thermosetting polymers can be burned is a burning process very simple process for this industrial process is the burning process. So, the raw material which is used for that making those carbon material is very cheap one, then polymers rendered non melting by chemical treatment.

So, some of these polymers basically because otherwise if it is there in the molten condition is very difficult to burn that and the pyrolysis also can be hampered. So, this particular variety the first variety the glassy carbon variety is non graphitizable

modification; that means we are not able to convert that; that means, it is not being able to convert it to a graphite form. So, we cannot have the graphite modification out of these procedures. So, is the different procedure for getting your glassy carbon. So, the form what we are getting having a small crystallites.

So, it is basically the very very small particles are there. So, the positioning of those particles not that of your graphite type giving you the glassy form as a glassy that is basically a sintered form. So, it is basically a sintered form of carbon with a different structure, which has having a ribbon structure. Since, it has a different structure compared to your graphite or diamond or C 60 and the crystallites are there with a maximum diameter of those crystallites at only 10 nanometer, you get a glassy carbon variety out of that and then that strong intertwining of the carbon ribbons. So, the corresponding binding of those carbon ribbons.

So, this is initially you have the ribbon thing and then intertwining of those ribbons is basically very much similar to that of your formation of the polymer coil is not that polymer coil, because the polymer is completely different this is the carbon now. So, one carbon one carbon one carbon is the attachment of all the carbon particles they are giving you a corresponding ribbon structure and ribbon structure then particular winding of this thing can give you the corresponding. Polymer coil type structures, where we apply now like other varieties that application of the glassy carbon now like that of your graphite.

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Because, we want to know very quickly that what are the materials we can have how we can apply that material for some useful purpose and the applications. Otherwise the charm the benefit of this particular course will not be there, we should know very well that how we can utilize those material, what is your product and how the products can be applied for some useful purposes.

So, this application for the glassy carbon is that for the different types of laboratory analytical procedures, because that activated charcoal or any other thing can used an as I told you that GCE. We can use in making the corresponding electrode for simply cyclic voltammetric measurements.

So, which is one of the electrode for your CV measurements the cyclic voltammetric measurements we use glassy carbon. Then metallurgical industries also getting benefited out of that then semiconductor industry also, semiconductor industry can also use the glassy carbon or the foamed carbon for their application. Then the different medical sciences, if we have some use of those glassy carbon material, then also the aerospace industry because this material can be utilized for making the aerospace material for making some aeroplanes or any other models, or any other things so, is a component of the corresponding aeroplane or the airship or the aerospace material.

Then the second variety is your foamed carbon that is also once again like that of your glassy carbon is non graphitizable. So, that non graphitizable material can have the corresponding cell structure like that of your polymer foam and is remains intact upon careful carbonization.

So, the initial structure of the polymer foam is retained and during that particular careful carbonization because the corresponding remaining part is your the carbon particles or the carbon structure. And, the corresponding density is lower than point one gram per centimeter cube can be achieved and can be obtained. And, now we see the second variety; that means, the foamed carbon variety and that foamed carbon variety, how we can utilize for different applications.

First like that of your glassy carbon is still your metallurgical industry, then for utilization in foundry technology, then one most important thing is the fire protection. Because, if you have this carbon and the carbon based material if you use for a silting

material that the fire protection silting material even will for if you can use that carbon cloth.

So, that carbon cloth type of material can be useful, because we cannot burn it, because we require very high temperature to burn those carbon material. Even for the smaller particles the Nano particles of carbon can also be useful if you are not burning it if it is catches fire at a particular temperature then it is wrong. Otherwise, it can also be very much useful for fire protection, then for production of the catalyst. Because the surface the heterogeneous solid sate surface of the carbon particles in the foam form can also be useful itself as a catalyst surface.

Some cracking some decomposition can be achieved on that particular surface, because that particular surface is completely different, if it is a heated surface or chemically soaked surface that can show different reactivity pattern. And also that particular surface the foamed carbon surface can also be utilized for your catalyst support. So, catalyst can cover that particular surface and can be utilized and that particular surface should be inert one.

So, the inert foam based carbon based, foamed carbon based surface can be utilized for your catalyst support also, then different types of industrial laboratory applications. So, carbon can be your material for making different laboratory items or different laboratory identifications for that particular purpose.

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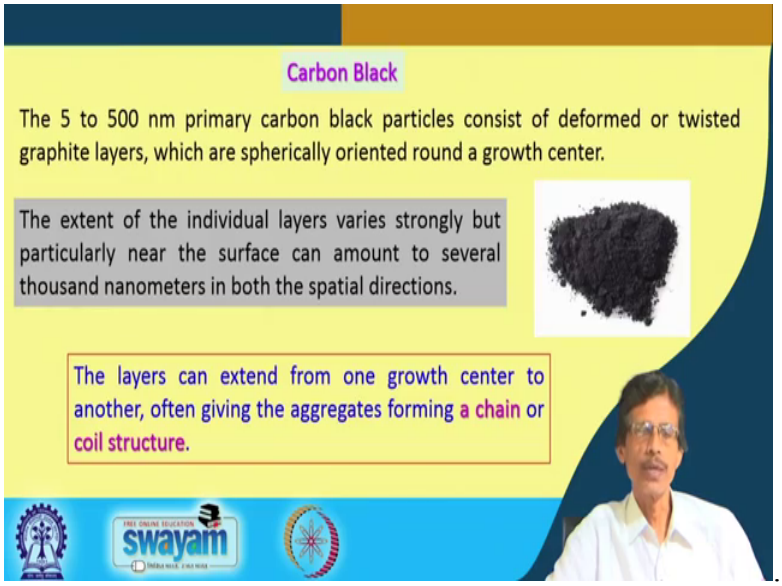

Then we move to the form another form basically known as carbon black now, what is that carbon black? Because large number of companies in our country also we handle them making of this carbon black as the carbon powder. So, anything any black material or any black component or black surface always we try to think all the time, that whether it is made up of carbon or not. Because, large number of areas we are utilized for utilizing Essen of that particular carbon black, how we use as carbon black is the black color also.

So, this carbon black will find somewhere in our future classes that can also be a very useful pigment material inorganic pigment material based on carbon black itself only. So, is like that of your pyrolusite manganese dioxide which is also a black powder. So, if you have a black powder and if you want to use that is a pigment or a paint we can use that simply that particular black as your carbon black.

So, how industrially we can produce that black carbon that we see now. So, the particle size so, you fix the corresponding particle size from 5 to 500 nanometer. So, this 500 nanometers; obviously, they are little bit of bigger type, but the surface characteristics will be different when you go to the bigger sizes of those particles.

So, range from 5 to 500 nanometer primary carbon black particles, we are not modifying anything that is why we are not modifying it to a secondary form is a primary one. Whatever we produce by charring, by burning, by pyrolysis we take that as your starting material for your carbon black. So, it is consist of deformed or twisted graphite layers, what are these carbon black? So, these carbon blacks by definition also you should try to remember nicely, if somebody asks you what is carbon black? Why the name is such that is carbon black? What type of material it is? It is basically is not of regular structure of graphite.

So, you have the deformed structure when you know that the structure that actual form the regular form of graphite is a layered structure. So, if the layered structure is not there the layered structure is broken, we will have the corresponding deformed structure and if there is some twisting. So, winding of that thing so, twisted form of the layer. So, layer is getting twisted. So, the twisted form that particular graphite layer, which are spherically oriented round a growth center.

So, is a small centre is there and if your winding is that the winding of the deformed graphites material is there such that, you get a small particles depending upon the nature of how many layers you have you will end up with this particle size of 5 to 500 nanometer.

So, that is the most important part of it that, how you go for the deformed and the twisted form of that graphite layer through a centre or the core or the nucleating point from which your carbon black is being formed. So, this is the corresponding example that is very much is well known everybody should know that, either you open up a textbook or you go to the internet site that the wiki page, you should know what should be the material. And, by looking at the material if you are expertised or well-trained you should able to detect it as ok. This is your carbon black particle not any other black material like that of your manganese dioxide pyrolusite or any other mineral type of material.

So, it is carbon black because if you take if you take it in the hand also your weight is a very light one you can consider it as the corresponding carbon black, because what we use from our laboratory use also from our school days the activated charcoal for decolorizing some material in the sugar industry also. The charcoal or the carbon black or the charcoal black is utilized for getting a colorless syrup of the sugar the molasses.

So, this particular carbon black what you can have the extent of the individual layer. So, one layers after another who have strongly, but particularly near the surface can amount to several 1000 nanometers. So, if you have from 5 to 500 nanometer then it can reach up to several 1000 of nanometers in both the spatial directions. So, you can have the change in the different spatial directions and you can have bigger sizes of those particles for some spatial use or the spatial purpose application. So, these layers basically the layers of this deformed graphite layers can extend from one growth center to the other.

So, what we are talking about one particular growth centre, it can move from one growth centre to the other and those two centers basically or more than two centers can now aggregate. So, this aggregation basically can give rise to a chain structure or the coil structure. So, basically starting from the graphite layer the deformed graphite form then twisting and then coiling. So, all these things will be there within these particles of this carbon black. So, that is why they have very useful application for their different use.

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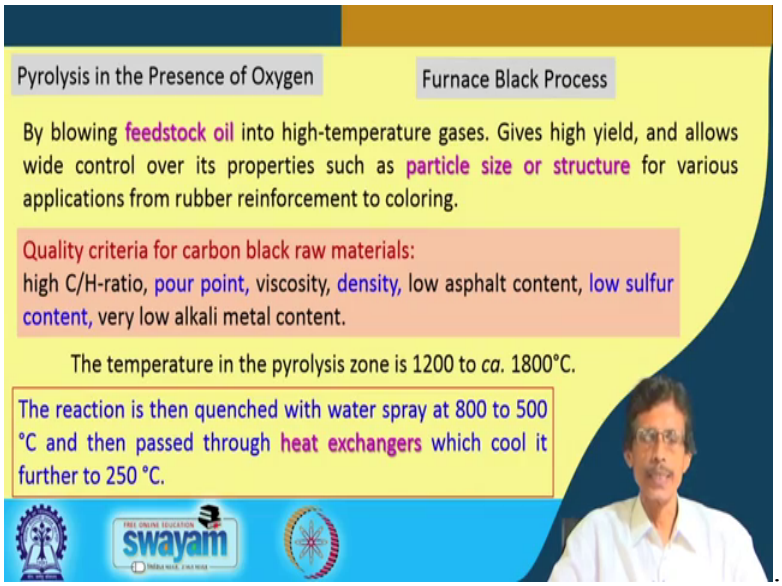

So, we go for pyrolysis for the production in presence of oxygen. So, we use oxygen and in presence of oxygen we try to burn it. So, what we get basically the product what will be getting over there is the corresponding black carbon black, we will be utilizing furnace so, that is why it is a furnace black process.

So, furnace black process will be utilized for getting that particular carbon black by blowing feedstock oil, because oil we try to burn it also that is another carbon based organic compound into high temperature gases, which gives basically high yield and allows wide control over it properties, why we are burning oil? So, feedstock oil any cheap quality oil can be utilized like that of your burning of the polymer material. So, oil burning can give you a control on the particle size or the structure is not random is not erotic also say particular type of size.

So, if you want to get a particular size of 50 nanometer or 60 nanometer by this particular process. If once the process is standardized because standardization of that procedure is important to get a particle size repeatedly. So, reproducibility that particular procedure is standardized when we consider that ok, by closing your eyes you go for that particular process will be able to get that product, the same product, same particle size, and the same structure. For the different types of application one such good application is in the rubber industry. As you all know that all the car tyres to electron tyres to all the

different forms of tyres is there and those tyres the color of those tyres are black, why they are black, why you are not having a red tyre or a white tyre.

If you want to make a white tyre you have to add the corresponding rubber can be fixed with the zinc oxide. And zinc oxide is a pretty costly one and it will not have other quality. So, the rubber technology the rubber industry will be very much dependent on getting this particular carbon black material. Because, the carbon black once we use it as the corresponding electrode material and that electrode material you know that it has a corresponding electrical conduction, that is why it is used as a electrode.

So, the electrical conduction your thermal conduction all will be useful when a car tyre is rotating is heated out and when it is there in the ground surface you have the corresponding connectivity with the road. So, that particular temperature can be dissipated if you have a very conducting materials. So, addition of those carbon particles within the rubber material whether you have a synthetic rubber material or a natural rubber material under the category what we study as the polymer chemistry or the polymer science basically.

So, this particular carbon can go for the reinforcement; that means, the strength of that particular rubber material is getting changed. The properties are also changing the thermal conductivity, the electrical conductivity if we consider all these things that the properties are changing to ultimately to coloring, why you are tyres are black that why I am asking. So, ultimately to coloring that is why all are in black in color. So, the carbon black raw materials that we will be looking for that what sort of carbon black material, what you have prepared.

So, you can have a very high carbon is to hydrogen ratio. Such that not much of the hydrogen is there; that means, hydro carbons we all know that methane which is the C H 4 which is the hydro carbon basically. So, you have one carbon 4 hydrogen. So, carbon is to hydrogen ratio is pretty high that is why your hydro carbon we do not have, we cannot make that particular one you can have it you can use that particular methane as the feedstock only thing that, you have to remove the corresponding hydrogen's available on the carbon.

So, if you have a high carbon is to hydrogen ratio for that that will be a most useful one as your carbon black material. Then pour point, where you can have the different points

of the different porous thing is there, then viscosity, the density, the low asphalt content. So, asphalt among the asphalt should be less, low sulfur content also that can degrade your material characteristics of the carbon, and very low alkali metal content; that means, the sodium and potassium if you have as the contaminant, it should be removed from there, because you have from the starting material the sodium and the potassium in your hand.

So, once you get that basically that thing you go for the temperature to the pyrolysis. So, the pyrolysis is being achieved at a very high temperature not closed 2000 it is closed to 2000 sometime it is from 1200 to 1800 degree centigrade. So, high temperature burning of the raw material is achieved starting from 1200 to 1800. And, when we utilize this basically the reaction then once you burn it everything is finished and certain time is allowed for that burning process, the reaction is then coincide with water spray.

So, will utilize best water spray is basically being utilized for washing also for the washing purpose from there also and a temperature of say 500 to 800 degree centigrade. So, water temperature can also be very high and then ultimately further cooling; that means, it is step wise cooling. Suddenly we are not going for a chilled condition ; that means, if you have a temperature of 1200 to 1800 degree centigrade, then suddenly if we go to the room temperature, that we are not allowing before that at high temperature condition in the range of 800 to 500 basically is the range basically upper range is 800 and lower range is 500, in that particular range of temperature is useful for water washing.

Basically, then putting water basically so, the no further reaction can take place at that particular temperature. So, basically always we call it as a quenching of the thermal reaction. And, then some heat exchanger; that means, it can take further amount of heat and for useful purpose also that heat exchangers what we use, that if we want to use some boiler attached to that heat exchanger. So, the boiler water can be heated up for some useful purpose. So, we should not lose the heat which is available with that particular material. So, heat exchangers are there which can cool further to 250 degree centigrade.

So, in the presence of those heat exchangers that temperature of those furnace black material is reached to 250 degree centigrade. Now, ultimately it is conveyed and it is

processed and then ultimately it reaches the corresponding room temperature. So, that basically gives us the idea that how furnace black can work for the production of your corresponding carbon black.

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So, in your next class we will just consider what are the utilization of these things; that means how they can be separated out from these and how they are utilized for the different useful purposes ok.

Thank you very much.