Industrial Inorganic Chemistry
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Lecture – 57
Activated Carbon

Hello. Good evening everybody.

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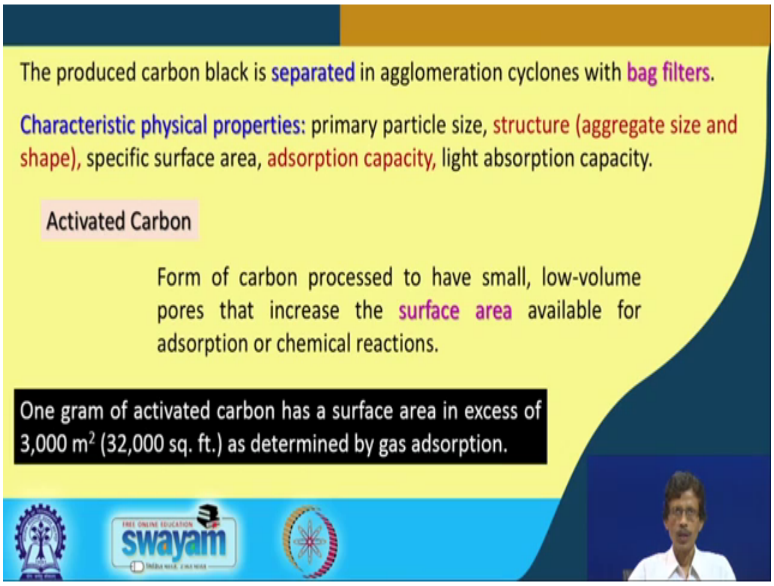

So, we are talking about the carbon black and the processing of that particular carbon black. What we have seen that we can get some amount of carbon black by burning the corresponding carbon based material. So, once we have that particular produced form of that carbon black and it can be separated basically. Because the separation is always a useful task to find that how quickly we can get all these thing nicely. So, they are separated that is why agglomeration cyclones is a technical term basically that call it as numerated form with bag filters. The use of bag filters can be helpful to separate these carbon blacks nicely from there. So, once we have this carbon blacks in our hand, we can then typically see, what are the corresponding useful physical properties which are most useful when we characterize these different types of carbon black materials.

So, the first one is basically the primary particle size. So, particle size should be always be very important. So, in the nanometer sizes, what are the different particle sizes we can have; depending upon that we can have their different uses. Then, these are the particles.

So, particles must have some structure. So, how this structures are different from the other that can be seen by knowing their aggregate size because in some cases, these particles are in the aggregated form; they are not well separated and we cannot get the individual particles those very small particles. So, the aggregate size is also important because most of them are regularly aggregated and that aggregate size is also important and also the shape.

So, the shape of the aggregate basically; so, both these two things that the both the size and shape of the aggregate is important when we talk in terms of the corresponding structure of the carbon black. Then obviously, the most important part if we talk simply the adsorption behavior or adsorption property of that carbon black is that the specific surface area. How quickly we can spread the entire powdery mass or the particular mass in a particular surface area with the use of very small amount say, 1 gram. So, that surface area is therefore is a very important aspect of characterizing this material, then obviously, the adsorption capacity because some of this carbon blacks are very useful in the decolonization of some metal or the adsorption of some chemicals or absorption of some catalyst. And finally, the light absorption capacity because zinc are ideally very black material and black materials always can have the typical light absorption behavior and depending upon the different types the different forms of these carbon black material, we can have different variety of this absorption behavior.

So, based on those light absorption capacity, we can characterize a type 1, type 2 or type 3 in a such way of the different of these carbon black material. So, after this carbon black material, what we can now think of is that corresponding one where the powdery form of the carbon can be activated. That means, if we talk in terms of the corresponding surface characteristics to increase the surface characteristics as that we can increase the adsorption behavior of those carbon particles; how we can activate the carbon. So, what we have? You have some adsorbed material already they are found the surface of this carbon black material. So, if you can remove those adsorbed material, the oily material, gas molecules or some greasy material. We get the most active points around the all the carbon surface of that particular carbon.

So, we get the activated carbon. So, how we can define this? So, the definition the text book definition will be like this. Basically a form of carbon which we can process basically; why we process it? Because to have small low volume pores, we want to have very small fine pores and the low volume pores basically we cannot have very big pores such the liquid or the gas can go and track those pores that increase basically the surface area available for adsorption or chemical reactions.

So, two most important thing, we will consider is that the availability of those pores and which are very small and low volume in nature for adsorption of gas or liquid molecules as well as sometime is the chemical reaction. Suppose, we go for some surface active reactivity so, the chemicals a and b can be adsorbed on that particular surface and on the solid state surface basically, we can have that particular reaction. We can go that particular reaction to see that a and b is reacting on that surface at room temperature or we can put that particular material on a (Refer Time: 05:45) or any other support in the air oven at around 100 degree centigrade or more or higher temperature such that we can get the product which can be c or c plus d which can ultimately be removed from the carbon surface. Then, the typically what should be the value for this surface area? So, 1 gram of activated carbon or we characterize that also that whether we have a quality activated carbon in our hand after the preparation.

So, it should have a surface area in excess of 3000 meter square. So, 3000 meter square is a ideally a very good amount of surface area which is equivalent to 32000 square feet as determined by the gas adsorption. So, the surface area can be determined through the amount of gas which is getting a adsorbed because the gas can have also the surface or the volume which can be determine that particular amount of activated carbon, where it is utilized for gas adsorption.

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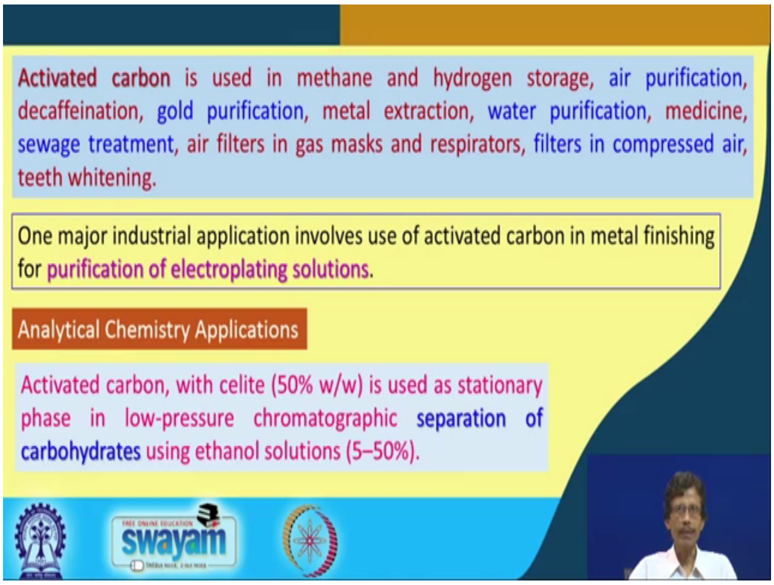

So, this activated carbon, where we use or it finds its application is very useful in nature also because the first of this category is used in the gas storage.

Nowadays, we are very interested to know that how this particular one which is filled in some cylinder, which is filled in some container that activated carbon is there in some amount methane or hydrogen we can store. So, this particular carbon can be useful in storing the gas molecules. Then, also it can be used for air purification because this basically functioning as the filter. So, if you some tracked column and the air is passed to that column, the extraneous matter which should do not want the unwanted molecules the gas apart from your nitrogen, oxygen which are the main constituent of air, they are moving away from that particular activated charcoal surface, but which are there can be adsorbed on that particular surface.

Then, decaffeination: so, decaffeination; so, caffeine is a molecule which we can remove from some of the material like the tea material or the coffee material. So, the caffeine concentration can be decreased, if we allow to pass that particular activated carbon. For passing of this material and that can be adsorbed; so, caffeine can be adsorbed. Then, some unwanted material can also be absorbed by this activated carbon during your gold purification process; that means, very pure quality of gold if you want to get, you can use that activated carbon.

Then metal extraction is also there; that means, during purification process also obviously, we can also use it for water purification because the water can also be pass through some activated carbon. Because the activated carbon is definitely a activated form of the carbon which can nicely take care of the impurities which were present in the water, definitely it is the potable water or the drinking water. Then in the medicinal industry for while making the pharmaceutical compound, the capsules, the tablets even in the tonics also; we can go for the different purification processes.

Then sewage treatment; if you want to treat the sewage by activated charcoal the some amount of toxic material can be removed and then, the sewage can be delivered in the river or in some other pond or any other area, but the toxic material or the huge contaminant which are not good which are harmful contaminant that can be removed. Then, the use of these in gas masks and respirators as their filter; obviously, the packed one in some definite form, in column or in some seats also can be also useful for filtering air also.

Then filters in compressed air; if the air is also we are using in the compressed form, where we ventilate the building ventilate corresponding room also. So, compressed air is passed which can be pass through a column packed with activated carbon. Then teeth whitening; that means, there is a some kind of abrasive in nature. So, is basically the surface is being cleaned when is the abrasive is soft abrasive, not the hard abrasive because the activated carbons are not very hard powdery material unlike your talc or any other compound. Then one most important industrial application which involves the use of activated carbon in metal finishing; that means, if we go for some electroplating process, then purification of the electroplating solution suppose we want to deposit nickel platting, we want to go for the gold plating or we want or go for the silver plating.

So, initially what you can have? We have the corresponding solutions of the nickel salt or the silver salt or the gold salt, but if we are getting those directly from the industry, then that can be not very much pour until and unless we get it in the pure form from the butler chemicals. So, that can be purified once you pass that particular electroplating solutions through activated carbon. Then, we see since we are talking about the removal of these thing that means, the choice for all these cases is that how we increase the corresponding purity of that particular materials. So, definitely this particular use of this activated carbon can have some important application in analytical chemistry.

So, how analytical chemistry can be benefited through the use of activated carbon; one such is that when this particular carbon along with the selite. Selite is also a filtering material or the filtering substrate is like a clay like material, so if we mix it with 50 percent weight by weight mixture or that selite an activated carbon and that can be used as a particular stationary phase. So, that is being used for the stationary phase for low pressure chromatographic separation of carbohydrate. So, if we have a mixture of carbohydrates and if we want to go for separation technique and that separation technique is very useful by using only the selite which is a material which is a earth like material that the sand type material and the activated carbon, the both selite and activated carbon mixture can be useful for filling the column chromatography is not that you have to use some alumina or you have to use silica gel.

So, for carbohydrate separation it is that particular activated carbon, 50 percent of that will be very useful for the separation using a event which is your ethanol solution in the range of 5 to 50 percent depending upon the concentration of that mixtures of the carbohydrates taken for separation.

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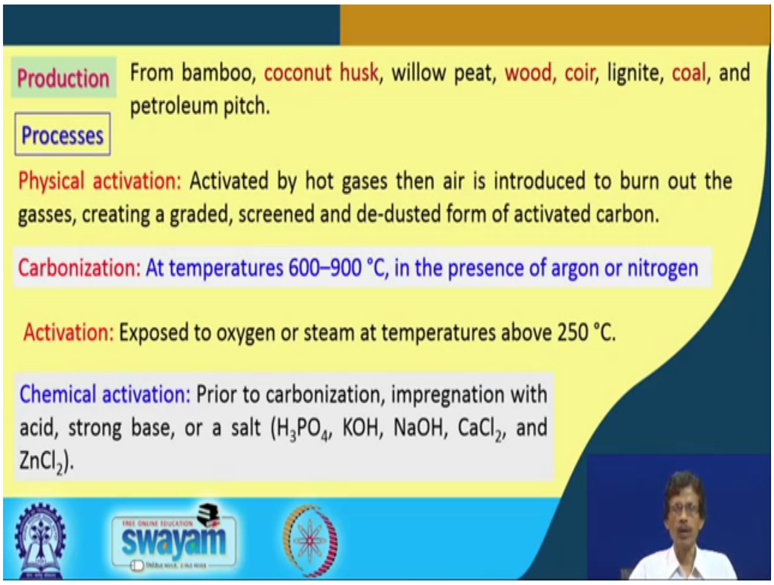

Then, we see that how we use or how we go for the production. What are the raw materials we can have for the production of that activated carbon is that the any carbonaceous material is the bamboo, then the coconut husk also, the coconut shell also, the willow peat, the wood based material, wood also direct any kind of wood the coir the coir the lignite simply coal also and the petroleum pitch.

So, this particular material can be used for processing of this production of activated carbon. So, first of this category is the physical activation, where the physical activation goes with the activated by hot gases; then air is introduced to carbon. So, first basically pass some hot gas and then, typically hot air is also introduced and we burn the material and when we burn it, the gases which are there creating a graded screened or de-dusted form of activated carbon.

So, to burn out the gases basically what gases is coming out in presence of excess air, the gases can be burned out such that those gases will not be used for clogging the pores of the activated carbon. Because the pores should be free. There should be no other material which can be clogged or which can be blocked those pores. So, that can also be burned.

So, those materials can also be burned because particularly you see that we are handling the petroleum pitch or the coal those are not very pure material in your hand. So, depending upon the material what you are using and its purity and its cleanliness basically, we have to be careful for burning away the gases which are produced immediately and then the dust material is also de-dusted. So, form. Therefore, we get as your corresponding activated carbon form. Then, typically the Carbonization process; what is that carbonization process at a temperature, what is the temperature required for the carbonization process of the raw material, is that we burn the material. So, we have to have the corresponding one. So, if it is a hydro carbon type of thing.

We know that the sugar material the sugar simply sugar, what we take if we burn the sucrose. If we burn the sucrose, you have to remove the hydrogen and you have to remove the oxygen as water material water from that particular sucrose, leaving behind only the carbon. So, the sucrose can be charred. So, that charring is the simple example of your carbonization. So, depending upon the different material what you are handling for this particular carbonization process your temperature can be different So, at a temperature of 600 to 900 degree centigrade, it is required for carbonization of this all different varieties of this material and in the presence of some inert atmosphere used by the nitrogen that means, the nitrogen gas or argon. That means, we will not use oxygen or any other thing for that particular burning process at this particular stage.

So, only inert atmosphere burning at a high temperature giving you the procedure, the carbonization process then, once you get that carbonized form is that means, the sucrose is giving (Refer Time: 16:46) behind the carbon only. So, carbon mass is in your hand, then you have to go for the corresponding activation. So, during that particular activation process, what we get it is exposed to oxygen or steam; either oxygen or steam at a temperature only at 250 degree centigrade.

So, the steam is passed or oxygen is passed over the particular processed carbonized form of that carbon and is getting activated. So, this is the activation procedure for your preparation. Then, also we need some time that we need the chemical treatment; otherwise, your purity is not very high. It is not highly activated because the level of activation can have a different parameter. So, level of activation if it is less, we have to go for chemical activation. So, prior to carbonization basically the impregnation with acid, what you can have or strong base or a salt. So, any acid we can use for treating the surface which we think that they are terminated by some amount of bases or by base if we think that some acid is living behind during the burning process or simply the salt the salt washing. So, what are those acids? So, phosphoric acid mostly we use or the bases like potassium hydroxide or sodium hydroxide can be used or finally, the salts like calcium chloride or zinc chloride can be used for chemical activation of activated carbon.

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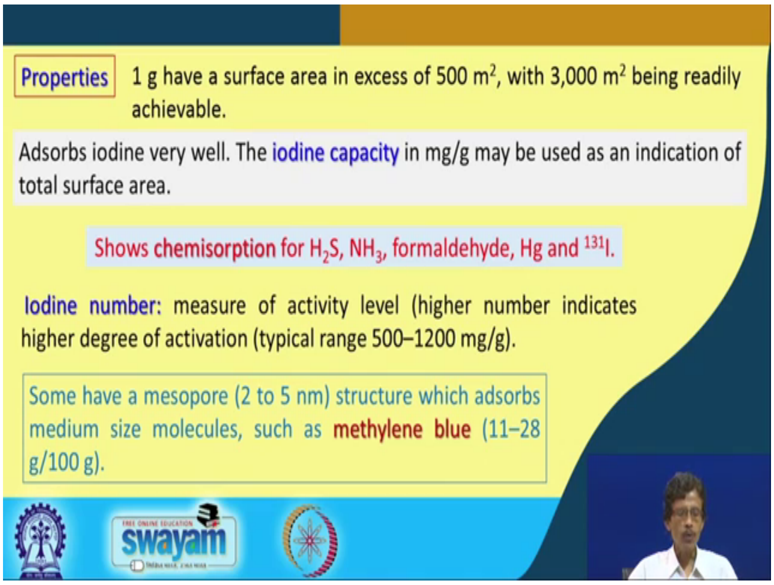

Then, we just simply consider what are those different properties in your hand and we can consider how they are used. So, we already we have seen that what range we get for the corresponding surface area. So, typically if we get a range of 500 meter square, we are happy that we have a activated carbon sample in our hand. So, 1 gram of sample can cover a 50 meter square surface area, we are happy that we have a activated carbon sample. But you can go up, you can improve the corresponding activity of the carbon material by moving from 500 to 3000 meter square which can be achieved quite easily. Then, once we find that either you have a activated charcoal in your hand.

So, definitely we will try to see the check the activity. So, adsorption behavior: an adsorption behavior with simply the iodine; iodine the iodine the solid mass of iodine which we know that iodine can be sublime very easily. So, iodine vapors. So, adsorption of iodine vapor can be considered, but if we consider that the solid iodine is being adsorbed in terms of a milligram per gram. So, that can be considered as the iodine capacity of activated carbon and is used as an indication of the total surface area; how much surface area you have; how much surface you can cover with 1 gram of your activated carbon that can be determined by this particular technique of determining iodine capacity.

So, not only iodine, but also the other chemicals gases like your H 2 S, ammonia can show chemisorption. So, chemisorption's is nothing but is a chemically absorbed form.

So, a chemically useful bonding parameter hydrogen bonding or any other thing. So, chemically they are interacting, they are not the physical adsorption. So, chemical adsorption or the chemisorptions is a typically one different type than the physisorption. So, physisorption is a different type of that chemisorption and we can see that H2S ammonia like acids simply formaldehyde the formalin like liquid; mercury has also the metallic liquid form and the iodine; iodine of 131 isotope, sometime the isotopic separation can also be achieved that means, this particular iodine 131 can show also the chemisorption.

So, if we try to enrich that particular isotope, we can go for this particular type of chemisorption by your activated carbon what you can prepare industrially. Then, once we get that particular capacity that particular reactivity that means, it can absorb of iodine. So, iodine number we can determine for any kind of activated carbon what do we have prepared.

So, it basically measure the activity level that means, how much it is active. Higher number indicates higher degree of activation and therefore, typically we can have a range of 500 to 1200 milligram per gram of activated carbon or active carbon can be useful basically when you see that milligram per gram is the reporting parameter. So, from 500 to 1200 is basically the unit; that means, that much amount of iodine in milligram quantity can be adsorbed by your activated carbon material.

So, we have seen that this carbon material; that means, the activated carbon have different pores. Now, if we talk in terms of the pore sizes basically. So, what are those different sizes of pore; one is mesopore. We know that some material we call as the mesoporous carbon or mesoporous charcoal or mesoporous activated carbon. So, some have a mesopore structure. So, structure is also a different type of structure, but the pore size is also important which is from 2 to 5 nanometer. So, if the activated carbon can have a mesoporous structure typically throughout the entire material of size of 2 to 5 nanometer and which can be used for adsorption of molecules of not very big size. So, a typical industrial problem or any other problem in all this thing is that typically the die adsorption, we use the die in industry for some useful purposes physically the die adsorption.

Because the sometime we use the die in industry for some useful purposes, then the excess dry which has not been used for that particular use has been washed away. So, the water which is used for your washing liquid so, the washed water can have the corresponding liquid which is getting contaminated by the amount of di present in it. So, how to remove that particular dye from that water is typically a challenge from the environmental point of view also because the water which is mixed with that particular di, we cannot dump it to the environment, into the river water or the sea water or the pond water.

So, we cannot dump it; we cannot throw it and at the same time we cannot store it in within the industrial area. So, it requires a huge land and huge pond type of thing or all this thing. So, we try to trap it by the use of activated carbon. So, one such most important molecule is the methylene blue, as a typical chemist or inorganic chemist or organic chemist you know the structure of the methlylene blue. So, methylene blue is a very flat molecule having 3 rings ring adjacent rings are there. So, this molecule basically can go when you pass the methylene blue through that of your activated carbon, it can be adsorbed.

So, a range say when you use 100 gram of activated carbon, it can adsorb 11 to 28 gram of methylene blue. So, not much methylene blue is there in the waste water. So, waste water treatment or the industrial effluent water treatment can be achieved by the use of this activated carbon for the removal of this dye or any other dye like that of your methyl orange or methyl red.

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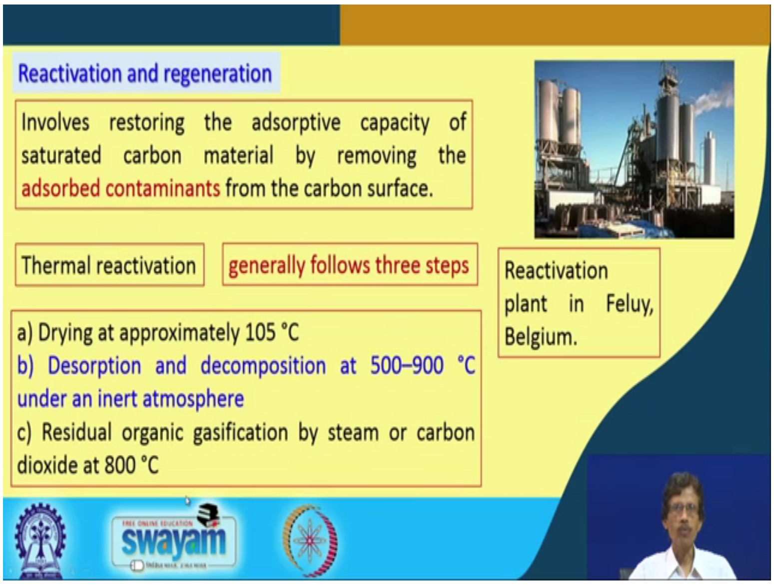

Then, we see that once your activated carbon is clogged with those material that means, it is the material which has the all the pores has been clogged with that particular removal process.

Now, we want to get back that particular material that means how to reactivate or regenerate that particular activated carbon. It involves basically the process involve by restoring the adsorbed capacity. So, we want to restore the corresponding adsorbed capacity of the saturated carbon material by removing the already adsorbed contaminants; that means, if we are handling that particular activated carbon for methylene blue adsorption.

So, methylene blue molecules are still sitting on that particular carbon, the activated carbon. So, we have to remove those methylene blue molecules from that carbon surface. So, if we can have some non destructive process of removal of the methylene blue, we can take out that methylene blue from that particular adsorbed blocks of those activated carbon, such that we can use those methylene blue molecules for some useful purposes. So, that will give you how we reactivate or regenerate that particular material.

So, industrially very big units are used. The tank like arrangements are also been used for your regeneration of activated carbon because this particular columns basically are filled with those carbons which have already adsorbed some chemicals or some gases or some other liquids. So, this figure shows some reactivation plan in Belgium Feluy, the place is from Feluy, where we have the corresponding reactivation plan. So, this is the basically huge plans. So, industrial inorganic chemistry can also be useful for setting up or use or running up this particular plan for regeneration of the activated plan carbon. Then, we can go for that particular technique that how we reactivate that material is that of your thermal reactivation. So, generally follows basically 3 steps; how we get these?

So, we can have 3 steps like a, b and c. So, first of them is that drying only at approximately 105 degree centigrade. Then, that particular temperature if the adsorbed molecules can be removed from that particular material, this temperature at the range of 105 degree centigrade is fine; otherwise, we can go for a higher temperature at that particular in the range of 500 to 900 degree centigrade under an inert atmosphere. So, desorption and decomposition of that compound.

So, clearly look at this particular point that we are looking for desorption of say methylene blue molecules from that particular surface. But at the same temperature if that particular molecule is not thermally stable at a higher temperature above 500 degree centigrade, what happens that molecule will be degraded that molecule will be broken into its individual part even for carbon has carbon dioxide or hydrogen as water.

So, a high temperature regeneration process, the thermal reactivation process will not give us back the molecule which has been adsorbed. Then, the third process is your residual gasification by steam or carbon dioxide at 800 degree centigrade. So, residual organic gasification, we can do by simply passing water or steam and carbon dioxide at higher temperature of 800 degree centigrade when the adsorbed molecule can be pushed out from the surface of the activated carbon.

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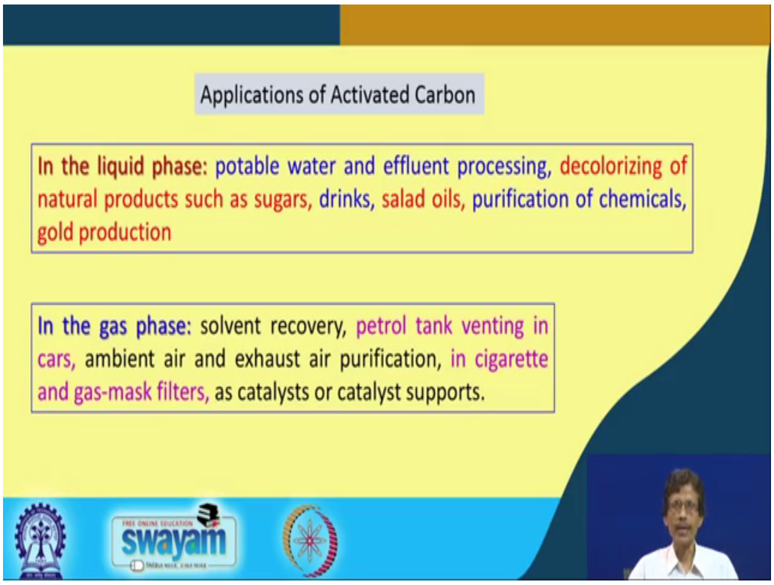

So, these techniques are very useful for this regeneration of this activated carbon and if we just quickly see that application of those activated carbon in matter when we see that in liquid phase, we can use those activated carbon as a potable water and effluent processing. Then, decolonization of the natural products such as sugars, drinks, salad oils, purification of chemicals, different types of chemicals also we can purify for the liquid phase purification process as also the gold production that we have seen. Earlier also that the contamination from the gold solution can be achieved by treatment with activated carbon and in the gas phase the procedure is also not very complicated is also simply.

We can use for the solvent recovery that means, if we try to recover the pure solvent which has already being contaminated by gas phases. Then, petrol tank venting in cars also, ambient air and exhaust air purification that already we have discussed that activated carbon can be used as the filtration technique for purification. In cigarette and gas mask filters also we can use and also finally, the most important thing is the use of these as catalyst itself for some catalytic cracking or any other thing on the surface or typically the catalyst surface; that means, the powder is catalyst material can be supported on this particular activated carbon which gives a huge surface area. So that means, we are spreading the catalyst in a very huge area and then, we can go for the corresponding catalytic reaction or the catalysis ok.

Thank you very much.