**Introduction to Mineral Processing**
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**Lecture - 57**
**Flotation Chemicals (Contd.)**

Hello welcome back. So, last lecture we discussed about the an ionic collectors some of the an ionic collectors. Now, we will discuss now the cationic collectors.

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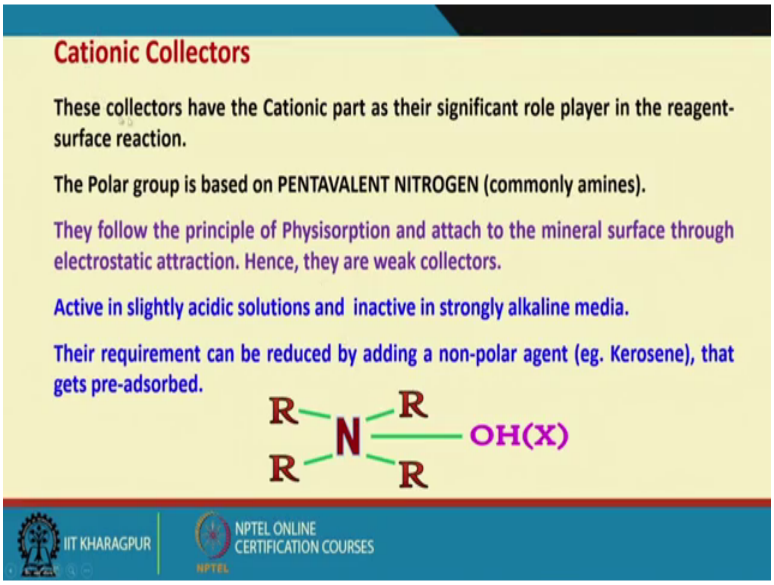


So, in this case these collectors of the cationic part as their significant role player in the reagent-surface reaction. In case of anionic collector is the anionic part which plays the dominant role in that; in controlling the reagent surface reaction or maybe to make the surface hydrophobic in cationic collectors. There is a cationic part which has which have the; which is the significant role player the polar group, because you have to have a polar and nonpolar group.

So, the polar group is based on pentavalent nitrogen is commonly called they are basically the commonly amines. So, they follow the principle of physisorption in anionic collectors they normally follow the process of chemisorption and for cationic collectors. They follow the principle of physisorption and attach to the mineral surface through electrostatic attraction.

And when the electrostatic attraction is there it is not a basically a surface reaction based your attachment. So, they are weak collectors; that means, that your the bonding strength is weaker it is active in slightly acidic solutions; I mean the pH has to be a little bit acidic and inactive in strongly alkaline media. So, their requirement can be reduced by adding a nonpolar agent, that is a kerosene that gets pre adsorbed so; that means, the cationic collectors or the anionic collectors there many times they are basically very costly chemicals.

So, in case of cationic collectors it has been found that the amount of this or the requirement of these cationic collectors can be reduced by adding a nonpolar agent that is a kerosene that gets pre adsorbed onto the surfaces of my minerals and this is how the structure is. So, most now.

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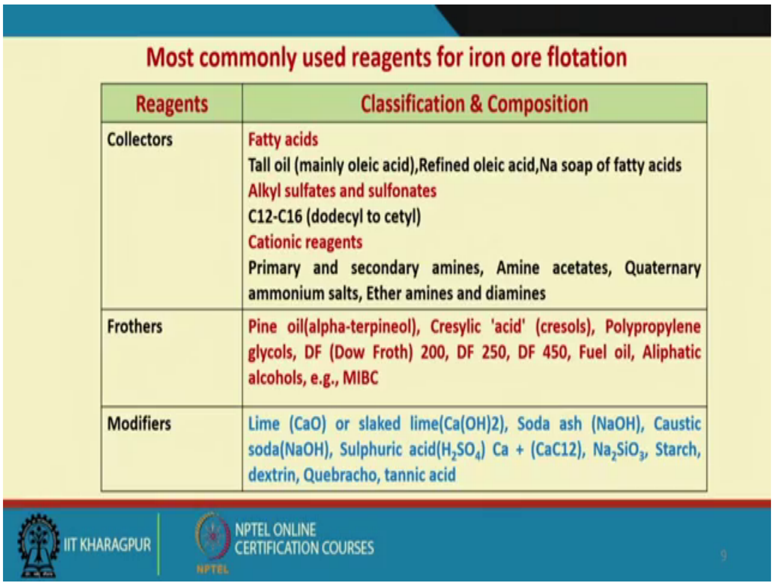


Let me give you the examples of your some collectors and frothers and modifiers. So, frothers we have not discussed yet we will discuss in the your next topic is the frothers, but these are the iron ore beneficiation these days very important and these are the most commonly used reagents for iron ore flotation. So, the reagents basically work as a collector we can use fatty acids.

Then tall oil mainly oleic acid, Refined oleic acid, sodium soap of fatty acids then even alkyl sulfates and sulfonates C 12-C 16 dodecyl to cetyl components. The cationic reagents primary and secondary amines, amine acetates, quaternary ammonium salts, ether amines and diamines what I wanted to show here that even for an iron ore flotation why do you need. So, many varieties of collectors as I said that all iron ores are not identical it is a geological formation which decides that, what are the different types of impurities; are there even within the iron ore matrix what are the surface properties of an iron ore and then what is the ore of that what is that mineral.

What is the principal mineral for that iron ore; like it could be hematite it could be magnetite it could be other the varieties of minerals who are from your iron ore can be extracted. So, even for iron ore you see that. So, many varieties of collectors are there. So, it is the challenge to the mineral processing community or the mineral processing people that, what is that; right how do I; what is the right selection of that collector; it may happen that none of them may not be adequate enough for your iron ore. So, in that case you have to do research and you have to find out a new collector.

So, depending on other conditions like what is that pH of your water, what is that temperature of your water? What is that machine you are using? What is that mechanism of mixing between the particle and the fluid this will all decide that also take part in the decision making process of selecting a right kind of collector dont worry about. Now what is the frother and what is the modifier? but you see that even they are also a group of chemicals which are used for various purposes in the flotation process, but here also you see that there are varieties of frother they are being used for.

A typical mineral that is your iron ore flotation and these are called the modifiers you also see that there are. So, many varieties of that modifiers also we will use.

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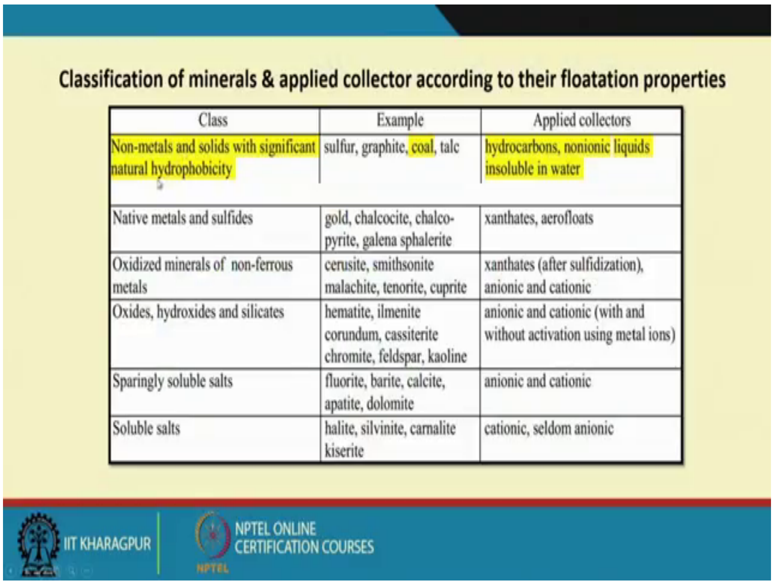


| Class | Example | Applied collectors |
|---|---|---|
| Non-metals and solids with significant natural hydrophobicity | sulfur, graphite, coal, talc | hydrocarbons, nonionic liquids insoluble in water |
| Native metals and sulfides | gold, chalcocite, chalco-pyrite, galena sphalerite | xanthates, aerofloats |
| Oxidized minerals of non-ferrous metals | cerusite, smithsonite malachite, tenorite, cuprite | xanthates (after sulfidization), anionic and cationic |
| Oxides, hydroxides and silicates | hematite, ilmenite corundum, cassiterite chromite, feldspar, kaoline | anionic and cationic (with and without activation using metal ions) |
| Sparingly soluble salts | fluorite, barite, calcite, apatite, dolomite | anionic and cationic |
| Soluble salts | halite, silvinite, carnalite kiserite | cationic, seldom anionic |



This is this slide we I wanted to show you that classification of minerals and applied collector according to their flotation properties what do my flotation properties; that means, how quickly my mineral surface they respond to my chemicals that is called the flotation properties like as I say that coal is a naturally hydrophobic material; that means, it is much more easier to float it to separate it using a froth flotation process, but there are certain other minerals like your say phosphates of different origins they may have carbonates various types of carbonates and when you add some chemical all of them may try to float.

So, what will happen ultimately you are not rejecting any material. So, it is very difficult to separate from each one of them and then they are you need a targeted your chemical as a collector as a frother as a modifier like that and then that has to be used at an optimum amount and then you have to create that environment. So, that the these chemicals get added to the surfaces of those materials.

So, when you talk about the machine component we will talk bit of that. So, nonmetals and solids with significant natural hydrophobicity; that means, the particles the minerals which are having a significant natural hydrophobicity example is your like yours sulfur graphite coal talc the applied collectors are hydrocarbons non ionic liquids insoluble in water these are only general guidelines.

Then for native metals and sulfide minerals example like gold chalcocite chalcopyrite galena sphalerite for all these normally the xanthate aerofloats they are used as collectors oxides oxide minerals of non ferrous metals like cerusite smithsonite malachite tenorite cuprite for that normally it has been observed that the xanthates after sulfidization process and, then the both anionic and cationic collectors they work oxides hydroxides and silicates like example is hematite, ilmenite, corundum, cassiterite, chromite, feldspar, kaoline, for these the anionic and cationic with and without activation using metal ions can be used as applied as collectors.

Sparingly soluble salts like your fluorite, barite, calcite, apatite, dolomite, anionic, and cationic collectors both can be applied, but where I will use anionic and cationic and what type of collector; that is a part of your expertise soluble salts like your halite silvinite carnalite kiserite can be cationic and seldom anionic collectors are used for that purposes. Now the next part will be going towards the frother it is another group of chemical, we call it frother and here also I wanted to show you that how the frother basically works and what is a frother? So, I thought that let me explain you a bit also about this.

Now what is the role of the frother if you remember the video what I had shown you in a laboratory model flotation process that the bubbles are coming up and then there is a froth is basically being formed and then you are taking it out manually, but in an industrial scale operation, what happens many times he uses scrapper mechanically scrapper mechanically driven scrapper to take out this or maybe there is some other ways that is the froth naturally comes out from that.

But what it implies that the froth has to be a stable the froth has to remain as a froth stage for a while otherwise; the bubbles may burst again and then entire your particles which you have floated they may go back to the your suspension again another criteria is that if the froth is too stable it is too adamant; that means, the froth becomes more viscous then the natural flow ability of that froth will be reduced and then you will have difficulty in taking out that froth. So, there are two boundary conditions that is called a stability of the froth.

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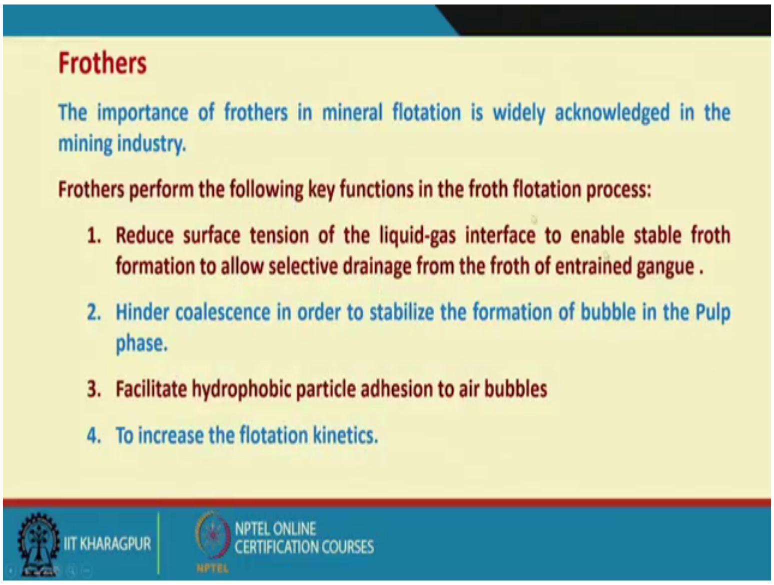


So, the importance of frothers in mineral flotation is widely acknowledged in the mining industry because we are dealing with large volume of materials.

But you need time. So, frothers perform the following key functions in the froth flotation process one is it reduces the surface tension of the liquid gas interface to enable stable froth formation; that means, the liquid gas interface the surface tension has to be your reduced. So, that the froth is stable to allow selective drainage from the froth of entrained gang another thing is that; when the bubbles are going off in between the avoid spacious between the two bubbles there is some unwanted material may be entrained into that.

So, when you are when the froth is stable; that means, when you give some time for these bubbles to be in a stationary condition and to the top of your flotation cell then these entrained particles have an opportunity to go back to the suspension or to the pulp it also helps you in a manner that it hinders coalescence in order to stabilize the formation a bubble in the pulp phase it also facilitates hydrophobic particles adhesion to air bubbles; that means, it should help in doing all these and to increase the flotation kinetics the kinetic means at what rate the particles are being floated.

First and they can be floated the more the capacity of that machine per unit volume you will be getting. So, the frother plays a very important role in the froth flotation process and thats why it is called a froth flotation because it has to form a froth now when.

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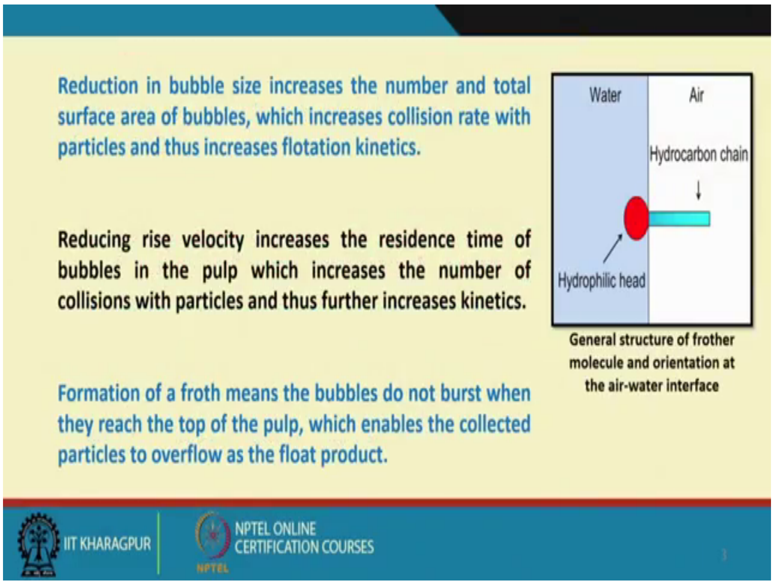


You are generating a bubble what will happen now the bubble size also plays an important role now the reduction in bubble size increases the number and total surface area of bubbles, it is similar to your particle breakage like if I have 1 ton of material with an average particle size of 1 meter I will have very less number of particles, but the same material if it is broken down to 1 millimeter I will have enormous amount of or say infinite number of your particles. So, what will happen.

So, if I reduce the bubble size it increases the number and what essentially it does and is like your 1 ton of material having an average size of 1 millimeter will have much more surface area than 1 ton of material coming from a particle size having a average particle size of 1 meter. So, it is like that when the bubbles are very big you have lesser number of bubbles and your lesser surface area. So, ideally for the froth flotation process.

The particle are very fine sizes, because the particle has to be liberated the liberation demands that the particle has to be ground to very fine sizes. So, when the particle sizes are very fine. So, your effective surface area of the particle are huge. So, if the surface area of my bubbles are not adequate enough with the surface area of my particles then what will happen; when many particles will remain in the suspension it will not have a chance to get attached to the bubble surfaces and that is what I have writ[ten]- written the reduction in bubble size increases the number and total surface area of bubbles, which ultimately increases collision rate with particles and thus increases flotation kinetics.

That is how fast we can take out or my float my total available wanted minerals into my the into the vessel of my flotation machine it will depend on what is that bubble particle sizes and then how fast they are being generated and how quickly they are what is their velocity at what velocity they are coming up that your rising velocity of the bubbles, because the mode of transport of my hydrophobic materials or minerals is through the bubble particle attachment and if the bubble surface area is not.

Adequate enough in relation to the surface area of my hydrophobic materials, then the kinetics will suffer reducing rise velocity increases the residence time of bubbles like what will happen; if the bubbles they rise at a very slow velocity. So, what will happen the bubbles will require more residence time and in the pulp. So, the if the bubbles they require more residence time.

So, what will happen; no now the residence time of bubbles in the pulp which increases the number of collisions with particles and thus further increases kinetics, because the particles to get adhere to the surfaces of the bubbles it also required some time, but before that if the my bubbles are rising too fast there will be many a new surfaces of my bubbles which does not have any which may not have any particles. So, the kinetics will be slow. So, the rising velocity of these bubbles.

So, many times he can control it by using a frother formation of a froth means the bubbles do not burst when they reach the top of the pulp and as soon as they reach the top of the pulp it should not burst it should burst after some time, but before that you can you should be able to take out all those your bubbles which are carrying my hydrophobic minerals. So, formation of a froth means the bubbles do not burst when they reach the top of the pulp which enables the collected particles to overflow as the float product I will show you some videos also that is how the bubbles are being transported like if it is like your overflow air type of mechanism you can have. So, you need some residence times of the froth before they reach between.

Between the they reach the top of the pulp level and they are collected they are transferred they are basically taken away taken out from my vessel. So, during that time the bubbles should not burst and that is what is called your stability of the froth; however, frother works you see the general structure of frother molecule and orientation at the air water your interface like the upward of water and then here the your hydrophilic head should be your projected that is this part should be in solution and then there is the air. So, that is the hydrocarbon chain should be projected ok. So, that is the general structure of.

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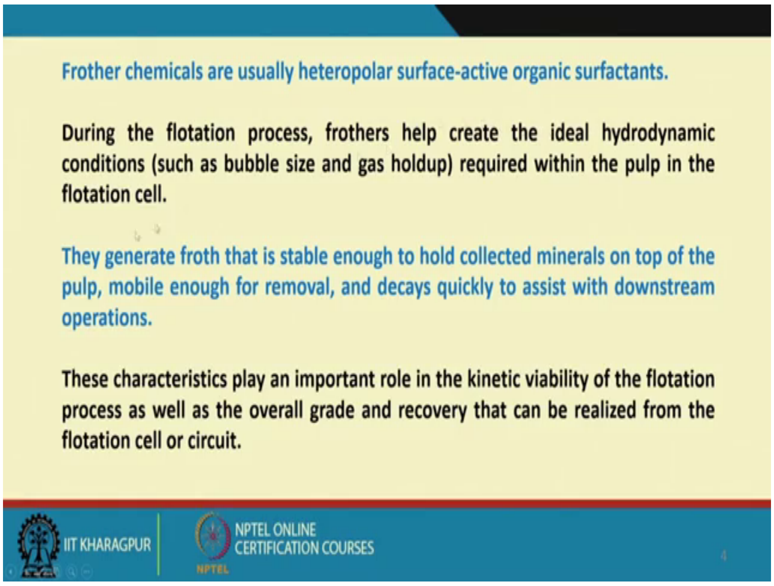


Frother chemicals are usually heteropolar surface active organic surfactants like your collectors it should it is also a hetero polar like your ionic collectors they are heteropolar it has got a polar group and a non polar group and they are generally surface active organic surfactants.

So, during the flotation process frothers help create the ideal hydrodynamic conditions such as bubble size and gas holdup. So, the frothers basically they help in controlling the kinetics of the process how now they can help you in controlling the bubble size and the gas hold of; that means, froth stability. So, as I have written that frothers help create the ideal hydrodynamic conditions if it is selected or if it is designed properly required within the pulp in the flotation cell the generate froth; that is stable enough to hold collected minerals on top of the pulp.

At the same time it is not a holding there should be mobile enough for removal, because if they big if they make the froth highly viscous it is very difficult to take it out and it should decay quickly to assist to a downstream operations see how beautifully it has to be designed that initially it has to control the your kinetics by controlling the bubble sizes then it should give you certain amount of stability once it reaches the top of the pulp, I mean this should not burst immediately at the same time it should control the your flowability of your pulp that is your froth and then once there transferred the decay should be there; that means, there should burst after that, because otherwise and the downstream processes if they remain again in the bubble stage say suppose I have to go for filtration process like I want to take out my water recycle back my water or the dewatering processes if it is still the bubbles are there it will be hugely inefficient.

Process that the filtration or dewatering process will be hugely inefficient. So, before that it has to burst. So, it is like you are controlling with a remote that at what speed my makers should be driven at what conditions and all this. So, basically the entire kinetics of your flotation process is controlled by the appropriate selection of the frother and it is doses. So, all these characteristics play an important role in the kinetic viability of the flotation process as well as the overall grade and recovery that can be realized from the flotation cell or circuit and with your collectors can selectively make the surfaces of your minerals hydrophobic thats fine, but now once they are hydrophobic.

Then the bubbles the way you generate you may not have proper control on the bubble sizes only by mechanical means. So, these are frothers also as a chemical they can control the your bubble sizes and. So, that your particle bubble attachment is proper and then you can also it should be also able to monitor the your rising velocity of the bubbles and it should give certain amount of stability in the froth phase.

But the stability should not be too high. So, that they are not getting decayed; because otherwise it will have a your adverse effect on the downstream processes like your dewatering stages. So, the frother is a very key component in a froth flotation process which controls the basically the economics of the entire froth flotation process because it controls the overall grade at recovery curve as it is controlling essentially the kinetics of the flotation process.

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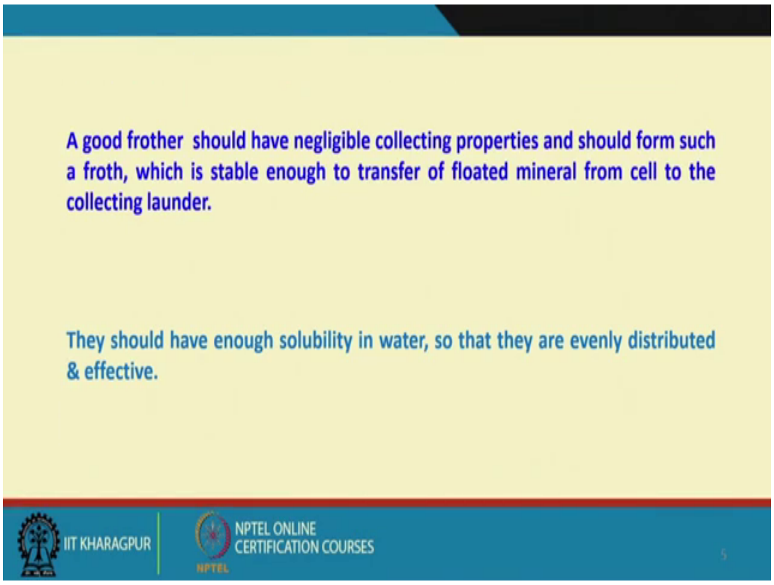


A good frother should have negligible collecting properties and should form such a froth, which is stable enough to transfer a floated mineral from cell to the collecting launder. These are I have discussed already this would have enough solubility in water. So, that they are evenly distributed and effective if they are insoluble then you cannot distribute them effectively. So, all these properties a frother should have.

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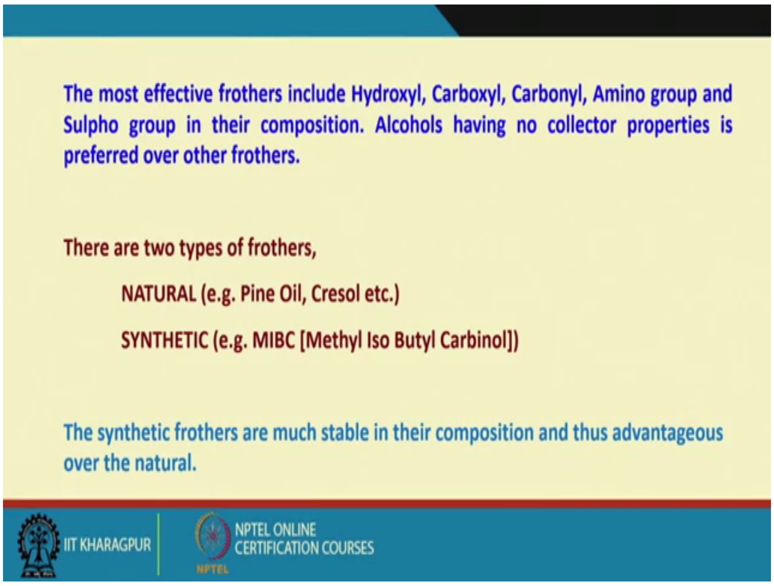


Now, what are the some of the examples of most effective frothers; they include a hydroxyl carboxyl carbonyl amino group and sulpho group in their composition alcohols having no collector properties is preferred over other frothers the normally the alcohols they are being used as frothers.

Now, there are two types of frothers one is natural frothers; that means, what do we can get it from natural your resources example is the pine oil cresol etcetera and the synthetic one that is a man made one because it has to serve. So, many purposes the natural frothers may not serve all these purposes at it is most effective way. So, there the role of synthetic frothers come into picture one good example of synthetic frother is M I B C or it is called Methyl Iso Butyl Carbinol.

The synthetic frothers are much stable in their composition and thus advantages over their natural, because the frothers coming from natural resources they vary in composition they may have other impurities as well because their purity may vary, but the synthetically made frothers these problems are not there and. So, they are advantageous over their natural, but naturally the cost of synthetic frothers much more higher than their naturally available frothers we will continue this topic that is your flotation chemicals a next lecture also till then.

Thank you very much.