

so welcome you all to iit paul program myself punya murthy from department of chemistry  
iii govahati today we will study about the part two about alkenes the last class we have  
seen the part one of alkenes and structure nomenclature isomerism preparation and  
physical properties of alkenes today we will study about the chemical properties of  
alkanes alkenes are rich source of having  $\pi$  electrons therefore they undergo addition  
reactions the electrophiles to give the corresponding addition products

So today we are going to look at some of the common reactions the addition of hydrogen  
So addition of halogen addition of hydrogen highlight addition of sulfuric acid addition  
of water oxidation reaction

So there will be two types of reactions we will study oxidation of alkenes to diols and  
carboxylic acids then dicarbonyl compounds like all the  $\alpha$  ketones that is ozonolysis  
at the end we will study about the polymerization these are very important reactions and  
let us now focus on the addition of hydrogen as we have seen at the beginning of the  
hydrogenation of alkenes to alkanes and

So alkenes can readily be converted into alkanes using one equivalent of hydrogen for  
example if you have here ethylene and when you treat ethylene with hydrogen one molecule  
of hydrogen in the presence of catalyst like palladium platinum and nickel the hydrogen  
can undergo addition to the alkene you get alkane if you look at the reaction as i  
mentioned earlier the reaction stereo is specific the both hydrogen atoms come the same  
side of the alkene it can be the bottom side or top side the same addition takes place  
and in this reaction as i mentioned earlier what happens you have the metal surface the  
metal surface the hydrogen is absorbed first then your alkene also absorbed on the metal  
surface by you have the carbon carbon double bond there will be interaction between the  
bond and your metal now once for example when you pass hydrogen the hydrogen will be  
absorbed in the surface of the metal and when you add alkene the alkene now it can also  
absorb it can interact with your metal here the alkene here now the hydrogen whatever  
observed from the metal surface can be transferred to the alkene you will get the metal  
alkyl intermediate you have this kind of intermediate now another hydrogen when ah since  
if the reactions carried out in the presence of hydrogen pressure another hydrogen can  
bind here this hydrogen can transport again you will get your alkane this the both  
hydrogens are added the same side of the alkene the reaction is syn addition reaction  
stereo specific

So when you have do different substituents the reaction of course you will get the  
selective addition product

So the next example is addition to halogen you see electrophilic addition reactions and  
like when you have the alkene for example ethylene when you react ethylene with for  
example  $\text{Br}_2$  or chlorine under this uh iodine does not undergo addition with alkyne normal  
conditions however bromine readily undergo reactions in the presence of  $\text{CCl}_4$  when you  
carry out the reaction the bromine undergoes addition to give the vicinal dibromo  
compound and similarly chlorine also can be added you get one to digal alkanes

So in this reactions if you ah regarding the mechanism let us see the bromination  
reaction the alkene the double bond attacks the bromine you get bromonium intermediate  
So this bromine ion intermediate undergoes reaction with this  $\text{Br}^-$  that is a  
nucleophile it attacks this it can attack this carbon or that carbon suppose if it reacts  
here this anti to this bromine you will get this one to trans alkenes

So if you look at this compound this also stereo specific reaction this addition of the  
bromine takes place and the addition if you look at it and this is just opposite to this  
bromine you get this anti-addition product suppose if you react with this alkene trans to  
butane with bromine you will get this dibromo two three dibromobutane on the other hand  
if you have this cis-2 butane it can lead to mixture of enantiomers to you will study the  
stereo chemistry of this reactions in our ah in higher class depends upon the substrate  
when you have this kind of substrate then you can get stereoisomers you can get enone  
symbol in this case of course in this case you will get a compound which has planar  
symmetry and it is a meso compound we will study details on the the higher class the next  
reaction is addition of hydrogen catalyzed to alkenes this also uh electrophilic addition  
reactions just we have seen the addition of bromine to alkene is an example for  
electrophilic addition reaction and in this case the reactivity of alkyl halides is  
hydrogen iodide is more reactive compared to  $\text{HBr}$   $\text{HBr}$  is more reactive comparing to  $\text{HCl}$   
this is a reactivity order of hydrogen highlights towards alkenes now let us take  $\text{HBr}$  if  
you take if you react with the symmetrical alkenes

So you will get two bromobutane other hand if you take unsymmetrical alkenes for

example propane when you react with the propane with hbr

So you will end up with mixture of compounds there is a possibility of formation of these two compounds and however in this case this will be the major compound this will be a minor product

So let us see the mechanism of the reaction we can understand

So i mentioned this is an example for electrophilic addition reaction

So the alkene reacts with this hbr to generate the carbocation intermediate

So this carbocation intermediate reacts with the bromine v r minus the addition product

So if alternatively it can also form a primary carbocation

So in this case if the blue the carbocation reacts to the vr minus you get the primary alkyl halide

So there is a possibility of formation of both these carbocations however the secondary carbocation is more stable compared to the primary carbocation

So the formation of this predominant in this case therefore and we get this as a major product this because we will study in the higher class again that when you have the more substituted carbocation for example tertiary carbocation or secondary carbocation they are more stabilized by hyper conjugation as well as inductive effect and this therefore this more stable the concentration of this formation of this carbocation is higher than this therefore we get this is the major compound

So during 1933 the russian scientist is called markoniko he studied a reaction of a series of experiments with this substrate he found that he observed that and

So the electrophilic addition reactions like addition of hydrogen halide to alkenes and always the br minus the negative ion species undergoes addition to the carbon which has less hydrogen atoms and in this case if you look at it this has the one hydrogen atoms therefore the b r minus undergoes addition here and you get this a major compound this we call it as it follows the markoniko rule product

So depends upon the reaction conditions and alkenes can undergo addition with the hydrogen halides for example hydrogen bromide to give the second a more substituted alkyl bromide on the other hand if the reaction is carried out in the presence of like peroxides you get the opposite addition product otherwise regio isomer and let us look at this reaction when you react with propane with hydrogen bromide the presence of peroxide b you get a mixture of compounds this is a major product this minor product just we have seen the case of electrophilic addition reaction they always this is the major product however when you carry out the reaction the presence of peroxide this is going to be the major product this is going to be minor product this is called on the markoniko product and in this reaction particularly when you carry out the reaction the presence of peroxide you get this is the major product now let us look at the mechanism in this case what happens the peroxide let us take benzoyl peroxide when you heat the reaction the the peroxide can undergo homolysis the price of light also it can under homolysis to give a radicals

So this can lose carbon dioxide you get phenyl radical two molecule of methyl radical once you form this radical this radical can react with your hbr can lead to the formation of benzene and we are radical this b r radical now can undergo addition to the alkene and then on the other hand you can also undergo addition with this carbon then you will get the primary radical if you look at these two radicals as just we have seen when you have the secondary carbocation is more stable compared to the primary carbocation because it can be stabilized by hyper conjugation same thing here also and this secondary radical is more stable compared to the primary one

So the formation of this radical will be more comparing to that once you form this radical this radical can now react with another hbr

So this can abstract the hydrogen atom

So you will get alkyl halide primary alkyl halide and similarly this can react with hbr you can abstract the hydrogen atom

So you will get in this case secondary alkyl halide

So whenever you carry out the reaction in the presence of peroxide therefore we get this primary alkyl halide as major compound because the formation of the secondary radical in this case and you get this a major compound this is called anti markoniko product this was discovered by a harassing mayo during 1933 and they have discovered this addition of hydrogen halide to alkenes in the presence peroxides the they found that when the reaction is carried out in the presence peroxide always the primary alkyl halide is formed as a major product and however if you look at these two addition of hydrogen

highlights to alkenes the previous case as the electrophilic addition reactions and hydrogen iodide hydrogen chloride hydrogen bromide all can be added to alkenes but in this case under peroxide conditions only hydrogen bromide undergoes addition to alkene and the hydrogen iodide doesn't react under these conditions the bond is strong and in the case of hydrogen iodide and what happens when you generate the  $i$  radical this two  $i$  radical combine together you convert into  $i_2$  therefore this reaction particularly the addition of hydrogen hydrogen bromide works very well with alkene the perceptor oxide  $hcl$  and  $hi$  don't work under these conditions

So far we have seen as three types of three reactions first addition of hydrogen we have seen as is a stereo specific addition reaction then we have seen the addition of halogen it is a electrophilic addition reaction following that we have seen the addition of hydrogen halide to alkenes first we have seen the electrophilic addition reactions later we have seen the radical reactions where hydrogen bromide undergoes addition to alkenes to give the primary alkyl bromides now let us look at the addition of sulfuric acid to alkenes to give alkyl sulphates let us take propane as example when you treat propane with a cold sulphuric acid concentrated sulfuric acid cold conditions in the undergoes addition to gave and secondary alkyl sulfate as the major product in this reaction this reaction also involves electrophilic addition reaction and in this case what happens if you look at the mechanism as we have seen earlier the double bond attach this one you form a more stable secondary carbocation this carbocation reacts with to give the corresponding alkyl sulphide this also an example for electrophilic addition reaction and this carbocation is a planar molecule right this uh this can the sulfate uh this  $so_4^{2-}$  can undergo addition to the top side or bottom side of the carbocation but you will get the secondary alkyl sulphate the next example is addition of water alkene can undergo addition to water in the presence of a few drops of sulfuric acid to give secondary alcohol let us take this unsymmetrical alkene when you treat this alkene with water the presence of you drops of sulfuric acid it undergoes hydration to give secondary alcohol is the major product this also an example for electrophilic addition reaction regarding the mechanism you form oxonium intermediate and this undergoes reaction with our alkene So you generate the carbocation as we have seen earlier this carbocation now undergoes addition with your water nucleophile this can remove proton you get secondary alcohol the next example is oxidation reactions

So we are going to look at it two types of oxidation reactions first the oxidation of alkenes to dial using as potassium permanganate when you treat alkene with aqueous dilute called permanganate and as root zero degree this alkene can undergo oxidation to the corresponding dial digital dial in this case the hydrogen or the  $o-h$  group comes to the same side of the alkene this is in the addition reaction and the reaction conditions is very important you have to carry out the reaction mild reaction conditions using as aqueous dilute  $kmnO_4$  and cold reaction conditions then you can partially oxidize the alkenes to dial on the other hand if you oxidize the alkene using acidic  $kmnO_4$  or potassium digromate under heating conditions this alkene can be further oxidized the copposic acid as depends on the substrate in this case and it will be oxidized to acetic acid and carbon dioxide and it depends upon the reaction conditions if acidic there will be over oxidized to copper like acid if you carry out the reaction and mild react cold if you use zero degree temperature and very dilute potassium permanganate you can try to stop the oxidation reaction the dial stage on the other hand if you use strong oxidizing agent like acidic  $k_1O_4$  and warmer conditions and then it can undergo further oxidation into the corresponding carboxylic acid and it depends upon the substrate for example if you use this one you get acetic acid and carbon dioxide and you use this alkene if you apply this reaction conditions you get here ketone you get a stone plus acetic acid depends upon the substrate and you will get ketone or carboxylic acid or carbon dioxide So you will study the mechanism of this reaction uh in our higher studies detail but what happens basically in this reactions and this alkene let us take for example this ethylene and what happens it undergoes addition with your  $kmnO_4$

So  $km_1O_4$  plus seven state and what happens this alkene undergoes addition this electron comes to the manganese and this undergoes addition with this carbon and basically is a cycle addition two plus three cycle addition reaction you will get a cyclic intermediate first it forms this cyclic intermediate and depends upon the reaction conditions if very as if you use dilute aqueous  $k_1O_4$  and cold conditions and this what happens it undergoes hydrolysis you get the diol on the other hand if you use as acidic potassium permanganate a digrometer it undergoes cleavage you get aldehyde you get aldehyde that aldehyde

further reacts with water you have in aqueous medium you have water it can form and it further can be oxidized in copper like acid this is what happens here and it depends upon the substance and reaction conditions you can try to selectively convert into cis diol or the corresponding carboxylic acids the next example is ozonolysis alkenes can be readily converted into all the eighth key tones or carboxylic acid using ozone and in this reaction ozone undergoes addition with this alkene and forms first let me write the product in this case you will get the dye aldehydes and acetaldehyde and formaldehyde and if you look at the mechanism the alkene undergoes addition with ozone let us take ethylene in undergo cycle addition to give one car one comma three cycle addition reaction this is not stable intermediate it undergoes cleavage you can call this retro one three cycloaddition reaction you will have carbonyl oxide and a carbonyl group how this can further undergo cycle addition reaction this is called ozonoid the addition of ozone with alkene forms this gives this intermediate ozonoid once we have this one depends upon the reaction conditions for example if you use zinc in water it can be converted into two molecule of formaldehyde on the other hand if you treat with oxidizing agent like such as hydrogen peroxide it will be oxidized into formic acid So depends upon suppose if i take ethylene i will ah get two molecules of formaldehyde on the other hand this is a mechanism of the ozonolysis it undergoes one three comma cycle addition and once if we form this intermediate it again undergoes a retrocyclidation reaction to give this carbonyl group and carbon carbonyl oxy oxide species which undergoes further reaction to give this austenite this austenite when you treat with zinc water is converted into the corresponding aldehyde and instead of ethylene if you take other alkenes for example unsymmetrical alkenes like propene when you treat propene with ozone and the presence of you will get ah this intermediate addition of ozone with this propene can give ah this intermediate when you treat this intermediate with zinc you will get acetaldehyde and formaldehyde similarly when you react this substituted alkene for example this one then you treat with ozone and followed by zinc in this case you will get a stone and formaldehyde is a cleavage oxidative cleavage reaction you can selectively get the ketone and aldehyde it depends upon the substrates you will get the carbonyl compounds the next example reaction is polymerization

So all of us know and

So the polythene bags and plastic containers like crisp bottles as well as tv and computer cabins all are made of polymers they are one of the common uh polymers for example the polythene bags you know that polythene is made from polyethylene polymer and for example when you have ethylene and using a catalyst high pressure and temperature these three are very important and this alkene ethylene can be converted into a bigger molecule this one molecule is called monomer and when you have they can react together and particular conditions high temperature and pressure and catalyst and give the bigger polymer

So we write like this

So this is called polymer this is uh the material to make polythene bags and quiz bottles uh

So on and if you look at the industries and they produce about 80 million terms of polyethylene per year we use and of course is not biodegradable polymer but still be used and yearly they produce about 8 million tons of polyethylene for various applications and similarly when you go for further propene propene also can can be converted into polypropylene and under high pressure temperature and catalyst you can produce this parley propylene is produced about 50 million tons perrier and poly propylene for example bucket we use as a material and these are widely used and for various applications plastics and if this is a highest polymer and polyethylene based materials produce about 8 million tons per year and this is a second largest polymer is produced about 50 million tons per year and we use for various applications and let us conclude today what we have seen the chemical properties of alkenes we have seen ah 8 type of reactions first what we have seen we have seen the addition of hydrogen and that to alkenes that can lead to alkanes is a stereo specific reaction syn addition reaction then we have seen addition of halogen ah you can

So iodine doesn't undergo addition with alkenes however chlorine and bromine can undergo addition with alkenes and you get vicinal dihalo compounds we also use this to check whether the compound has alkene or not this when the compound have double bond they are called unsaturated compound ah this one of the test to check whether your compound is saturated alkane or unsaturated compound alkene and what we do when we treat this

compound with the bromine bromine is a reddish orange liquid and when you dissolve this compound in carbon tetrachloride add bromine if the color goes we tell that the compound is unsaturated this one of the classical test we use whether to check whether the compound is saturated unsaturated by adding bromine and what happens when you add bromine or chlorine and carbon tetrachloride that can readily undergo additional reaction with alkene to give visceral dihalides is the example for electrophilic addition reaction next we have seen addition of hydrogen bromide to hydrogen iodide hydrogen chloride also can be added to alkene to give the secondary or more more substituted alkyl halides and this also an example for electrophilic addition reaction by taking a hydrogen bromide we have seen and you can form this the more substituted bromo compound as a major product using electrophilic addition reaction and this because of you generate a more stable carbocation as intermediate that undergoes reaction with  $\text{Br}^-$  you generate the alkyl halide and

So the reactivity of these halides hydrogen bromide iodide is more reactive comparing to a hydrogen bromide hydrogen bromide is more reactive compared to hydrogen chloride then we have seen the peroxide effect in the hydrogen bromide addition reactions and under this condition only hydrogen bromide undergoes addition with alkene to give a primary alkyl bromide and under this kind of hydrogen chloride and as well as hydrogen iodide do not react with alkanes in the presence of peroxide and in the case of hydrogen chloride is very difficult to cleave the bond stronger than  $\text{HBr}$  bond and in the case of hydrogen iodide that iodine radical undergoes a dimerization can react with another iodine radical you get the iodine and however hydrogen bromide can be added to alkene to give the primary alkyl bromide in this case what happens you generate the radical intermediate first hydrogen then the bromide radical undergoes addition with your alkene you generate the secondary radical that is more stable comparing the primary radical therefore that secondary radical undergoes a reaction with even  $\text{HBr}$  to give the primary alkyl halide this called peroxide effect this was discovered by process Harass in 1933 in Chicago university and this called the peroxide effect and basically you get anti-Markovnikov product the case of electrophilic addition reaction always you get the Markovnikov product that more stable carbocation give the undergoes reaction with the negative part of this electro uh reagent then we have seen how you can convert alkene to alkyl sulphate in this case also the product is formed according to Markovnikov addition rule because the electrophilic addition reaction you generate the carbocation that undergoes reaction you give the alkyl sulphate you get the secondary alkyl sulfate as a major product then we have seen addition of water to alkene where you can make secondary alcohol under this condition what you have to do you have to treat with water in the presence of few drops of sulfuric acid the reaction takes place quite nicely you get the secondary alcohol and then we have seen the oxidation using potassium permanganate depends upon the reaction conditions you can selectively oxidize alkene to diol in addition basically both  $\text{OH}$  group comes the same side of the alkene and whatever we have seen all are very simple substances when you take for example cyclohexene then you can understand and you can get a syn addition product you get the diol the same side if you use aqueous dilute cold  $\text{KMnO}_4$  at zero degree you get the diol product one to diol product and on the other hand if you use uh slightly stronger reagent reaction conditions like acidic potassium permanganate or dichromate and then it can undergo further oxidation uh to give aldehyde that all the head can be further oxidized to carboxylic acid basically you get carboxylic acid the product in this case the potassium ammonite is reduced to manganese dioxide as a by-product of course the mechanism you will study in the higher class and then we have seen ozonolysis is a very good experiment to cleave the carbon carbon double bond to aldehydes or ketones or then you can use when you the ozone undergoes addition with alkene through 1,3 cycloaddition reaction to give the ozonide intermediate that arsenide when you do work up with the zinc or hydrogen sulfide they undergoes cleavage to give the corresponding aldehyde or ketones it depends upon the reaction conditions if you use of course oxidizing agent like hydrogen peroxide it also can be oxidized further into carboxylic acid on the other hand if you use reducing agents such as sodium or hydride the aldehyde also can be reduced to alcohol depends upon the reaction conditions and you can convert the alkene you can cleave then you can also further convert into ready uh alcohol or aldehyde ketone or carboxylic acids depends upon the work of procedure at the end we have seen polymerization how you can the alkenes can be converted into bigger molecule this the ethylene can be coupled together you make a bigger molecule that is polymer we use as like make very important commercial application

like plastic bags containers bottles as well as the computer and tv cabinets and  
So on we use and of course we use for plastic purpose and  
So mostly polyethylene is about just i mentioned about 80 million tons are produced  
annually in the world and similarly polypropylene is the second largest polymer is  
produced and that also be used for various applications and similarly other alkenes also  
can are converted into polymers we they find wide applications and these all polymers are  
made using different reaction conditions and higher temperature pressure and catalyst  
these are very important to get the polymer appropriate length and the particular  
stereochemistry also the polyethylene is ok but when you go for the other alkenes is the  
stereochemistry also very important they can be controlled using appropriate reaction  
conditions and with this i conclude today's lecture you

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