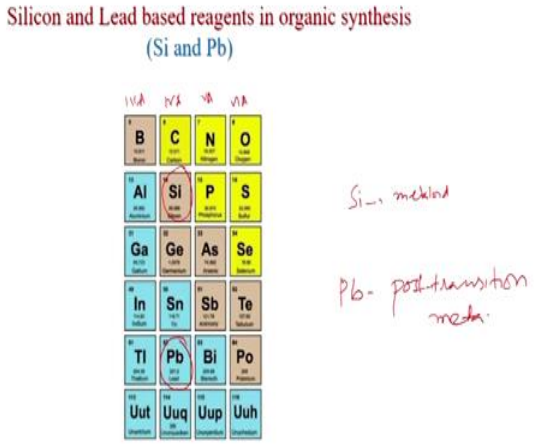
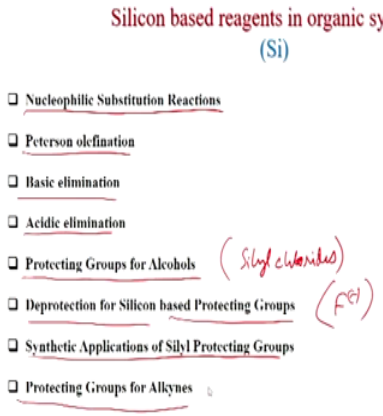
Reagents in Organic Synthesis
Professor Subhash Ch. Pan
Department of Chemistry
Indian Institute of Technology Guwahati
Lecture No. 18
Si and Pb Based Reagents in Organic Synthesis

(Refer Slide Time: 0:38)



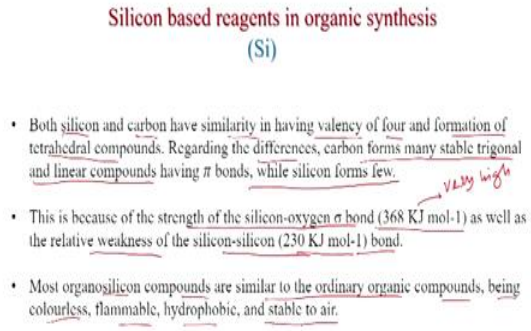
Welcome again. Today I will discuss silicon and lead base reagents in organic synthesis and if you see the periodic table so this is, right side of the periodic table, so this this 3A, 4A, 5A, 6A, so silicon is here and silicon is metalloid and silicon and lead both are in the same series along with carbon, so this is lead and lead is this is metal, this is post-transition metal.

(Refer Slide Time: 1:24)



So in the silicon-based reagents in organic synthesis we will 1st discuss Nucleophilic substitution reactions, then we will discuss Peterson olefination and in Peterson olefination there is basic elimination. Then we will discuss acidic elimination and protecting groups for alcohols, these are the silyl chlorides and deprotection also, deprotection for silicon based protecting groups with F minus will see, different chloride sources and scientific applications of silyl protecting groups that also we will discuss and protecting groups for alkynes that also we will discuss.

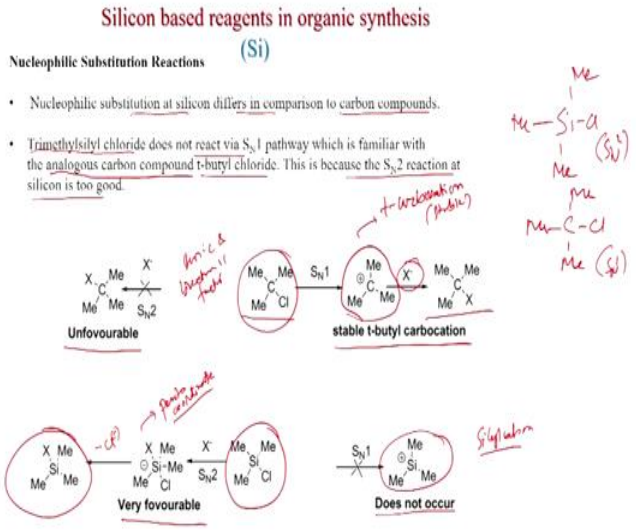
(Refer Slide Time: 2:13)



So, now 1st will discuss silicon-based reagents in organic synthesis, so as we have seen both silicon and carbons have similarity in having valence of four and formation of tetrahedral compounds regarding the differences, carbon forms many stable trigonal and linear compounds having pi bonds, while silicon forms few. So, this is very important difference this is because of the strength of the silicon oxygen Sigma bond of 368 kilojoules mole minus 1, so this is very high, the silicon oxygen bond is very strong.

As well as the relative weakness of the silicon silicon bond, so silicon silicon bond is very weak only to 30 kilos joule mole minus 1. Most organic silicon compounds are similar to the ordinary organic compounds being colourless, flammable, hydrophobic and stable to air, so they are colourless, flammable and stable to air but hydrophobic.

(Refer Slide Time: 3:19)



So we will discuss first Nucleophilic substitution reactions of silicon, a Nucleophilic substitution reactions at silicon differs in comparison to carbon compound, so this is very important that Nucleophilic substitution at silicon and carbon are different. Trimethylsilyl chloride, for example, does not react via SN 1 pathway, so this is Trimethylsilyl chloride which is similar with the analogous carbon compound tertiary butyl chloride, so this is tertiary butyl chloride when display silicon with carbon you get this chloride, this tertiary butyl chloride.

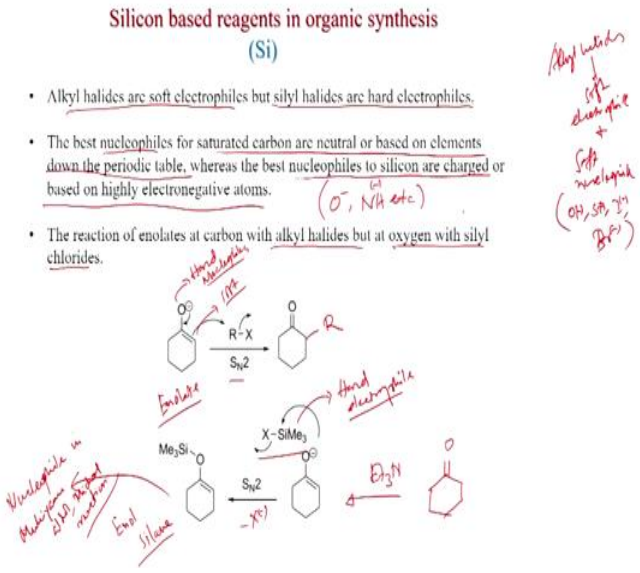
So, this reaction SN 1 that we all know, but this will react in SN 2 this is because the SN 2 reaction at silicon is too good, suppose this is the tertiary butyl chloride and with SN 1 pathway first the carbocation will form and this is tertiary carbocation we know, and that is stable and for that only this process is quite fast and after that the nucleophile or anion like x minus here, will attack and you get the product, so this is stable tertiary butyl carbocation intermediate.

On the other hand when this tetra-substituted carbon this halide does not react by SN 2 this we know unfavourable because of steric and electronic factor. On the other hand for silicon like this is Trimethylsilyl chloride this can react in SN 2 fashion and this is important because silicon negative charge which can take and it is penta coordinate.

So 5 substituents are here around silicon and silicon has a negative charge and this is a very favorable pathway and after elimination of CN minus you get this product, so this is very

important and SN 1 pathway that is the silyl cation like this way it does not occur because this is very favorable SN 2 pathway, so this is very important that tertiary butyl chloride reacts by SN pathway Trimethylsilyl chloride reacts in SN 2 pathway.

(Refer Slide Time: 6:12)



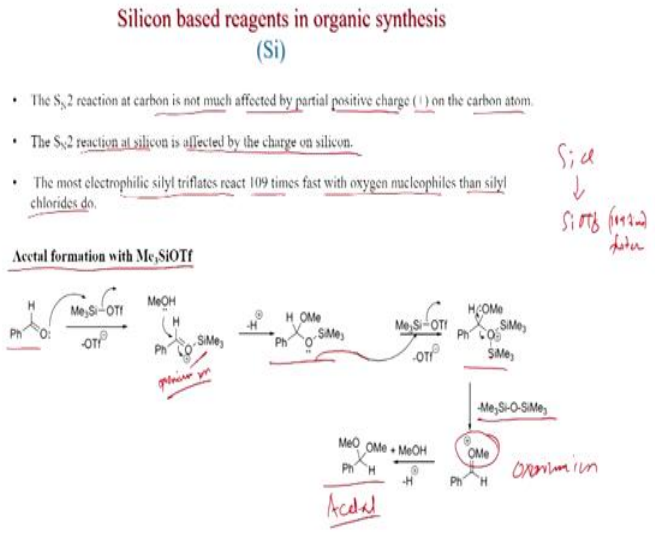
Alkyl halides are soft electrophiles but silyl halides are hard electrophiles, so this defines also we will see. The best nuclophiles for saturated carbons are neutral or based on elements down the periodic table, so this is important because alkyl halides, they are soft electrophile, and soft nucleophile only react, so what is the soft nucleophile? Like OH, SH, I minus, Br minus they are soft nucleophile, whereas the base nucleophile to silicon are charged or based on highly electro negative atoms like O minus, NH minus like this, so they are hard, hard nucleophile because silyl halides are hard electrophiles so hard nucleophile only reacts with silyl halides.

The reaction of enolates at carbon with alkyl halides but at oxygen with silyl chloride, so this is important, the reaction of enolates that we know that carbon with Alkyl halides at the carbon center but with oxygen it happens at the oxygen atoms, so this is the enolate and enolate we know that this is hard nucleophile, because this is electro negative atom and this one is soft, so when the reaction happens with R X the SN 2 reaction will happen at the carbon atom on the enolate, on the other hand when enolate reacts with silyl chloride because this is a hard electrophiles and this O minus is the hard nucleophile.

So the reaction will happen at O minus and O minus will react at this silicon and x minus will be leaving group and you get this Enol silane, so this is very important the generation of the

Enol silane because this compound enolates can be generated from cyclohexanone here with this like triethylamine, so you can get the enolates and then react with Trimethylsilyl chloride suppose you get the Enol silane and this Enol silane can be used as nucleophile. Suppose in Mukaiyama Aldol, Michael Reaction, so this chemistry is very well-known the enol silane chemistry and this is because the O minus is reactive with silicon because O minus is the hard nucleophile and Trimethylsilyl chloride is hard electrophiles.

(Refer Slide Time: 9:39)

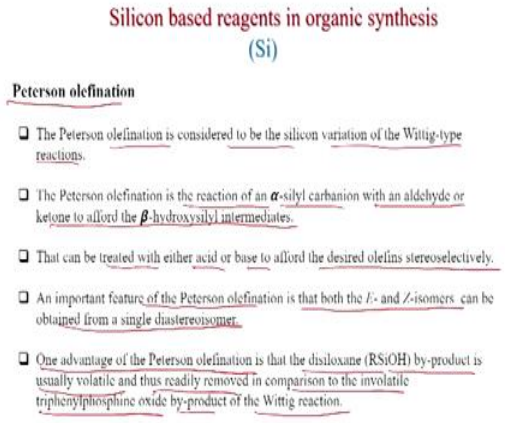


The SN2 reaction carbon is not much affected by Partial positive charge plus on the carbon atom, so this is also important and the SN 2 reaction at silicon is affected by the charge on silicon, so SN 2 reaction is at carbon is not much affected by the Partial positive charge whereas in silicon it is much affected. The most electrophilic silyl triflate react 109 times much faster with oxygen nucleophile than silyl chlorides, silyl chlorides to silyl triflate this can react 109 times faster.

Suppose an example is Acetal formation with Me3SiO triflate, suppose if you react benzal dehyde with Trimethylsilyl triflate first this oxygen reacts with silicon because this formation is always first, the energy is strong here and now this oxonium ion is generated, now methanol will react to generate this and again, this oxygen will react with another molecule Trimethylsilyl triflate to do a reaction and to generate an oxygen + charge here like this intermediate and then again an oxonium ion will generate with methoxy ion after elimination of this Me3Si-O-SiMe3.

So, this methoxy will form a double bond here and this will eliminate you get this oxonium ion again and then methanol will react to generate this acetal. So this is very important that SN 2 reaction carbon is not much affected by the charge whereas the SN 2 reaction at silicon is much affected by the charge as you have seen this chloride is replaced by the triflate, the reaction rate is much faster, for example, this acetal formation reaction.

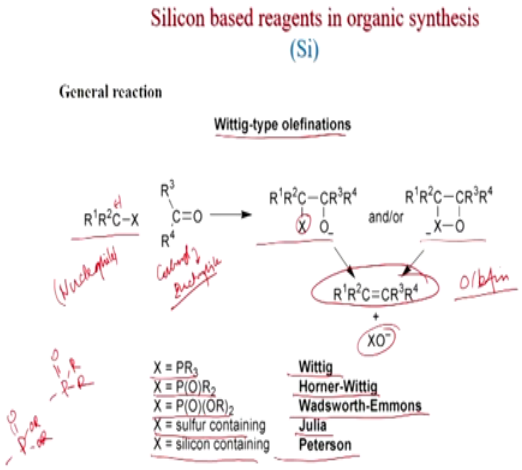
(Refer Slide Time: 11:52)



Peterson olefination is another reaction with silicon, the Peterson olefination is considered to be the silicon variation of the Wittig type reaction. The Peterson olefination is the reaction of an alpha silyl carbonion with an aldehyde or ketone to afford the beta hydroxyl silyl intermediates. That can be treated with either acid or base to afford the desired olefin stereoselectively, so this beta hydroxyl silyl intermediates will be formed and that you can react with either acid or base to generate the olefin and important feature of the Peterson olefination is that both E and Z isomers can be obtained from a single diastereomers.

So this is also important because acid and bases, two different mechanism operate and you can get both to define olefins so that is very important. One advantage of the Peterson olefination is that the disiloxane RSiOH by-product is usually volatile and thus readily removed in comparison to the involatile triphenylphosphine oxide by-product of the Wittig reaction, so this is also important we know that triphenylphosphine oxide is solid and it is very difficult to separate in the Wittig reaction. On the other hand this in the Peterson olefination the disiloxane that is usually volatile and that can be easily removed.

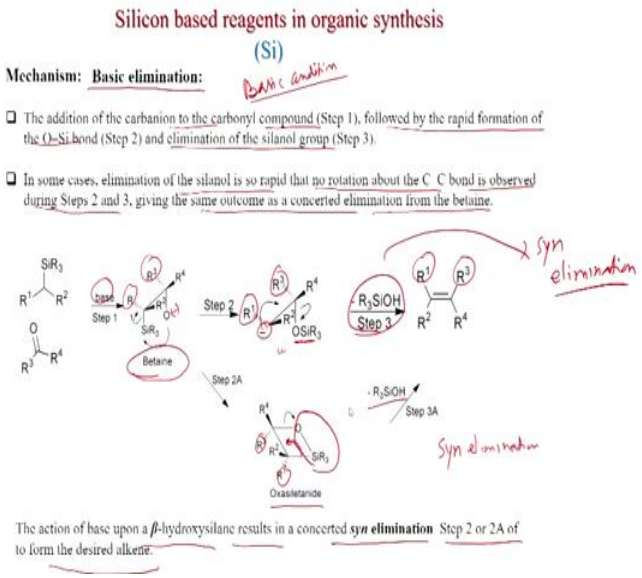
(Refer Slide Time: 13:17)



So we will see the Peterson olefination along with other the comparison of Wittig-type olefination so this one is nucleophile and this is the carbonyl compound it is electrophile and after this reaction you will get this beta hydroxyl compound with X here and this can cyclise also as you have seen in Wittig reaction and after that you get this olefin, so this is the main reaction, olefin is formed and XO minus is the by-product.

So X is equal to PR3 so here generally a NIN will be there X is equal to PR3 that is Wittig reaction, X is equal to P(O)R2 so this one that is Horner Wittig and P(O)OR2 to that we have seen that is the Wadsworth Emmons or we call Horner Wadsworth Emmons reaction. X is equal to sulphur containing then that is called Julia olefination we have already studied and today we will study s is equal to silicon containing that is the Peterson olefination.

(Refer Slide Time: 14:44)

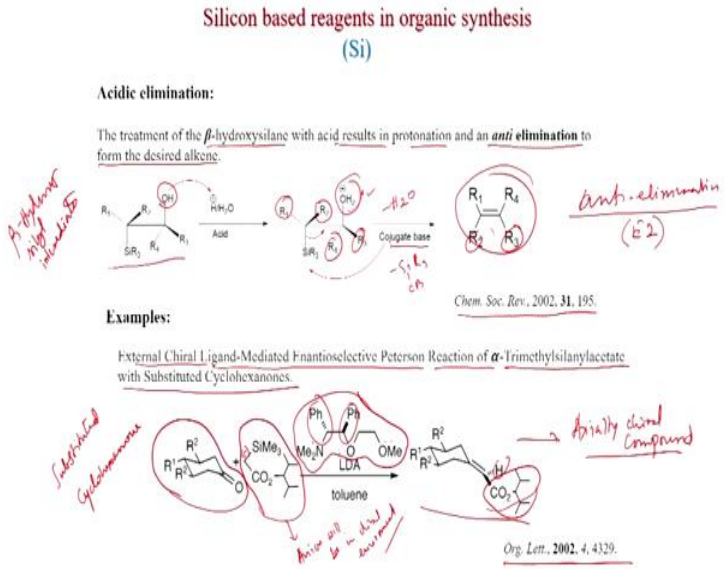


So what is the mechanism, first the basic elimination basic condition we will see what is the reaction mechanism so this is basic condition because that beta hydroxyl silyl intermediate can be treated with base or acid the addition of the carbon and to the carbon N compound step1 followed by the rapid formation of O silicon bond and elimination of the silanol group. So this is the reaction will happen here, this is the betaine intermediate you can see. In some cases elimination of the silanol is so rapid that no rotation about the C-C bond is observed during step 2 and step 3 giving the same outcome as a concerted elimination from the betaine.

So this process here you can see in the anion when base is there then O minus this anion will go to silicon and this O silicon bond will form as you can see here and there will be carban-ion and that is why they are telling this process should be very fast so the rotation along carbon carbon does not happen and after elimination you see this R1, R3 here also in the betaine they are in the same side and here also they are in the same side. So this is called syn elimination.

Also in the base this also can happen that oxasilitenide also can form when oxygen reacts with silicon without this carbon and this also a possible like Wittig reaction and here also R01, R3R in the same side and this after elimination like this show R3 SIOH will eliminate and you get this olefin, so this also syn elimination, so the actions of base upon a beta hydroxysilane results in a concerted syn elimination step 2 or step 2A to from the desired alkene, so whatever either step 2 or step 2A both will give you the syn elimination product.

(Refer Slide Time: 17:08)



In the acid elimination the treatment of the beta hydroxysilane with acid results in protonation and in an anti-elimination to form the desired alkene, so in the case of acid the anti-elimination will happen, suppose this beta hydroxyl silyl intermediate here because there is no acid, so this betaine will not form, also this silyl transfer will not happen because O minus is now OH and in presence of acid this OH will be protonated instead of a transfer, OH will be protonated to generate this so that it can eliminate as water so with acid this gets protonated and the acid conjugate base will attack silicon and you get this one.

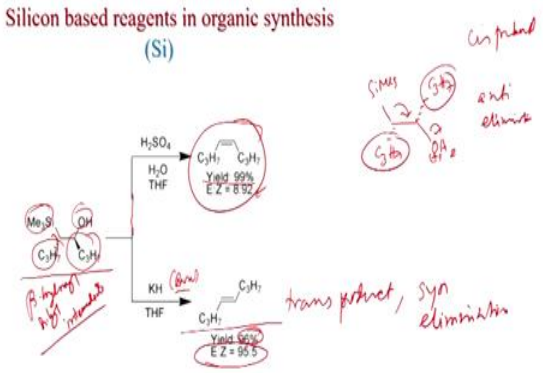
So, here you can see they are both in the trans and now R1 and R4 will be same side here because they are in this orientations same side R1 and R4 and R2 and R3 will be same side, so this is anti-elimination. Anti-elimination like E2 elimination like E2 process, so here the water is eliminated and minus SiR3 and conjugate base CB will be coordinated to silicon. So this is a review chemical Society review 2002.

Now we will see some examples, so this reaction Peterson olefination can be also done in enantioselective fashion, of course, if you get a chiral olefin because if you have axial chirality though there is no chiral center but if it is the molecule is axial chiral then it can be chiral compound. So external chiral ligand mediated enantioselective Peterson reaction of alpha Trimethylsilanylacetate which substituted cyclohexanones like this one this is substituted cyclohexanones.

Cyclohexanones substituted and this is the silyl reagent so you have to generate an anion with LDA and now if you put this ligand and if you see the structure of the ligand so anion will be in chiral environment like we have seen in sparteine and now this olefin will generate and this is an axially chiral compound and this hydrogen can be down CO2 ester.

This is the ester module this can be in the top and this work was published in Organic Letters 2002, so in the Peterson olefination if you generate the anion with LDA and then if you use ligand with like this ligand, 2 phenyl groups with any oxygen methoxy then the anion will be in the chiral environment and the product will be in the chiral.

(Refer Slide Time: 20:46)

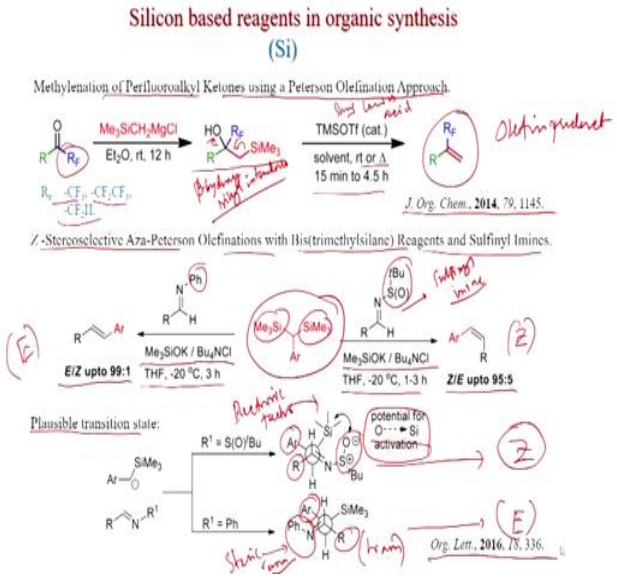


Suppose the syn anti-elimination that can be understood when we use this beta hydroxyl silyl intermediate so this is also beta hydroxyl silyl intermediate and now, if you put KH potassium hydride which is base, so what will happen? This product will form, because the syn elimination will happen and as you can see in the molecule they are in the same side so the syn elimination will give you trans product because in this geometry they are in the trans so this will give trans product and 96 percent yield which E/Z selectivity 95 is to 5, so trans product syn elimination.

On the other hand if you put acid like H2SO4 then what will happen? Then you have to give rotation, so this C3H7Si Me3 then after rotation it will be C3H7OH and now in acid the anti-elimination, so anti-elimination will happen and this anti-elimination as you have seen this will be protonated like this, water will be eliminated, then you get the Z products, so here Z is equal to 92 is to 8 so Z is major, so this is the cis product because in this orientation you can

see they are in the same side, so Z product will be major and the product yield is very high 99 percent so this reactions are very efficient.

(Refer Slide Time: 22:48)



Methylenation of perfluoroalkyl ketones using a Peterson olefination approach also is possible, so here the RF is this, RF is equal to CF3, CF2, CF3, CF2H like this and if you treat with this silyl Grignard reagent then you get beta hydroxyl silyl, so this is important, if you do Peterson olefination then this beta hydroxyl silyl compound or intermediate you have to generate.

This is the beta hydroxyl silyl with this reagent, in ether room temperature 12 hours and now if you treat with TMSO triflate, TMSO triflate is a Lewis acid, when it is strong Lewis acid so this is the acid mediated Peterson olefination in appropriate solvent room temperature heating 15 minutes to 4.5 hours you will get this olefin. So, here also this elimination will happen because this is Lewis acid this will react with the hydroxyl and the elimination will happen, so this is the olefin product is formed. It was published in JOC 2014.

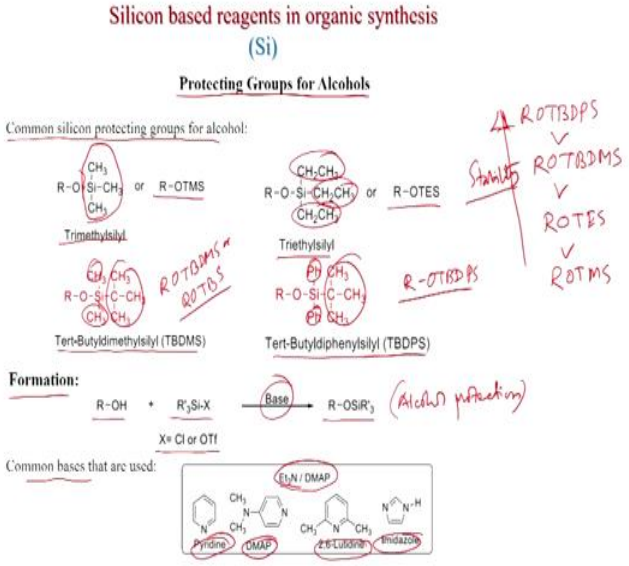
Z Stereoselective aza-Peterson olefination with bis Trimethylsilane reagent and sulfinyl imines, so this is the Bis Trimethylsilane to SIMe3 group is there and this is the sulfinyl imines, this is sulfinyl imines and with this sulfinyl imines and under basic condition you can see here Trimethylsilyl okay, so this is base in THF minus 20 degree centigrade and Z/E up to 95 is to 5, so Z is the major product so Z is formed, on the other hand if you replace the sulfinyl sided phenyl this is very interesting same imines but the end substituent is different earlier there was this was with sulfinyl group.

Now it is phenyl group and under the same condition ME3SiOK tetra butyl ammonium chloride THF minus 20 degree centigrade you get EZ is measured here in 99 is to 1, so this is very important if you change the sulfinyl imine to n-phenyl imine then the geometry of the olefin is changing, so what could be the mechanism, so the possible transitional state you can draw and this is because if you see the structure of sulfinyl imine there is oxygen.

So this oxygen is important, this oxygen we have earlier also seen that oxygen wants to make a bond with silicon because that bond is quite strong and that is why this takes the orientation like this because this potential for O silicon activation this wants to stay close to each other, this imine and this silyl and this will give because Ar and R in the close to each other, they are the syn so this olefin will be Z so this olefin will be Z.

On the other hand when R1 is equal to Ph that is the N Ph there is no oxygen so this will be trans, trans to each other, this 2 groups and now if you see the orientation Ar and R in the trans, so this will give you E olefin and this orientation is taking because of steric reason and here the electronic reason operating, so electronic reason, electronic factor is operating, so that this potential for oxygen to silicon activation is possible and that is giving Z product, so this work for published in Organic Letter 2016.

(Refer Slide Time: 27:11)



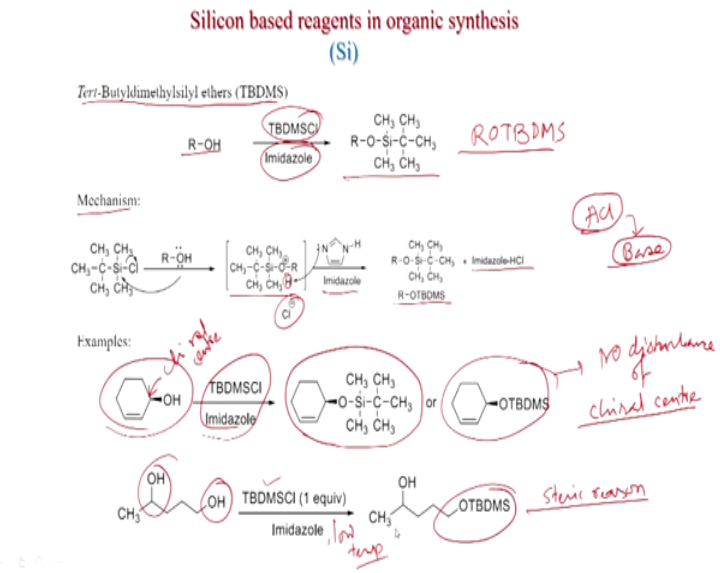
Now we will discuss protecting groups for alcohol, so silyl reagents have been used as protecting groups that we will see and this is very useful reagents, so this Trimethylsilyl chloride and we will see other also tertiary butyl dimethyl silyl chloride they have been developed by E J Corey and after that this has been used as protecting groups for mainly for

alcohol. Like Trimethylsilyl you can see this is the alcohol side, this is the silyl side, 3 methyl groups are present and this is called Trimethylsilyl R-OTMS.

Also ethyl group can be present on the silyl that is called triethylsilyl R-OTES. Also tertiary butyl 1 2 methyl group can be present that is called tertiary butyl dimethyl silyl and that is called ROTBDMS or ROTBS, this also called and tertiary butyl diphenyl, so this is diphenyl, tertiary butyl diphenyl silyl TBDPS, so this is the R-OTBDPS and also their reason is that the different group can be attached to silicon then they are difficulty in removal also, so TBDPS R-OTBDPS will be much more stable than R-OTBDMS and this will be much more stable than R-OTES and this much be more stable than R-OTMS, so this is the stability, stability.

Now, how it is formed the mechanism, so ROH, R3 Si X will be chloride, triflate, nearly they are commercially available this silyl chloride triflate and with appropriate base you can get R-OSiR3 so alcohol protection, so this is the alcohol protection. Common bases that are used like pyridine you can use, DMAP, sometimes combination of them, triethylamine DMAP, 2, 6 lutidine this is also strong base and imidazole, imidazole also used so they silyl chloride triflate can be used for alcohol protection.

(Refer Slide Time: 30:07)



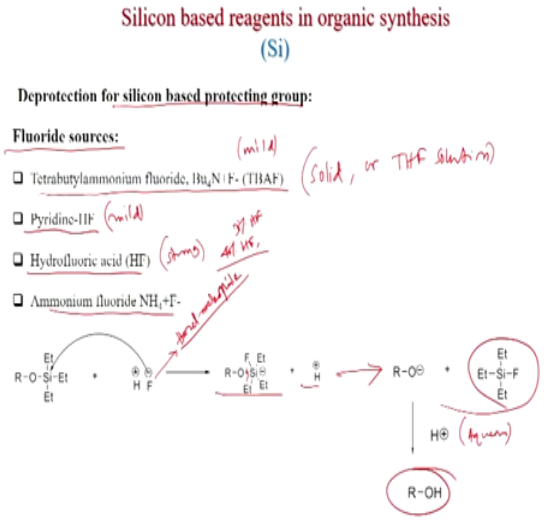
Now tertiary butyl dimethyl silyl ethers TBDMS, so this is the condition alcohol TBDMS chloride with imidazole base you get this ROTBDMS. So, this reactions are very easy to perform and the mechanism here it is that alcohol will react first is silyl and this chlorine will eliminate like this Cl minus and you get oxygen, there is a positive charge and the this H will

be taken by the imidazole here to get this neutral compound ROTBDMS plus imidazole, so because HCl is generated in this reaction and to quench the HCl you have to use the base.

So base is required to quench HCl and also this bases helping here from the oxygen positive charge this hydrogen proton is taken up by the imidazole, example suppose if you have this allylic alcohol, chiral allylic alcohol with TBDMS chloride imidazole you get this compound, alcohol protection by the TBDMS group it can be represented like this, also no disturbance of the chiral center.

So this is chiral center this is not disturbed, so this is very important that in this reaction the chiral center is not disturbed. Also if you have a secondary alcohol and primary alcohol then the primary alcohol will be reacted selectively with TBDMS chloride this is because of the steric reason because the silyl groups are quite steric so with TBDMS chloride imidazole may be at low temperature you can selectively protect the primary alcohol.

(Refer Slide Time: 32:27)



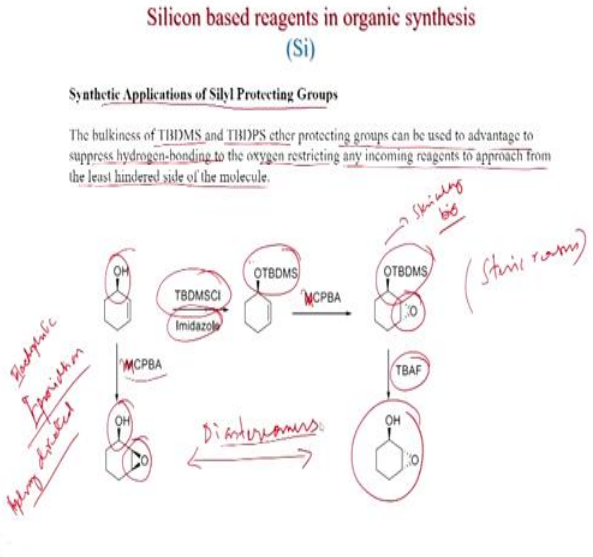
Deprotection of silicon-based protection group, so one of the major role for the good protecting group that it should be easily protected also it can be easily de-protected then only it is a good protecting group and this also follows in this cases. Fluoride sources are used for the deprotection of the silyl ethers like tetrabutylammonium fluoride which is TBAF, this is commercially available either as solid or THF solution.

Also pyridine HF can be used this is mild, this also mild and hydrofluoric acid, this is not mild this is strong condition, so you have to be careful with… Hydrofluoric acid, these are

solution in water 40 percent HF, 30 percent HF like this availability and ammonium fluoride also can be used NH4 plus F minus, so what is the mechanism? Mechanism is that minus F reacts with silicon, so like oxygen has a good reactivity for silicon F minus also have a good reactivity because F minus if you see the size.

So this is because of small size it is a hard nucleophile and because this F minus is hard nucleophile like O minus it can react with silicon and you generate this, the silicon has a negative charge plus H plus is formed and after elimination of this RO minus you get this trimethylsilyl fluoride, so this is the by-product and after aqueous workup you get the alcohol. So you can use different fluoride for the deprotection of silyl ether and these fluorides are commercially available and this deprotection can be easily performed, so that is why the silyl protection is a popular method in organic synthesis.

(Refer Slide Time: 34:51)

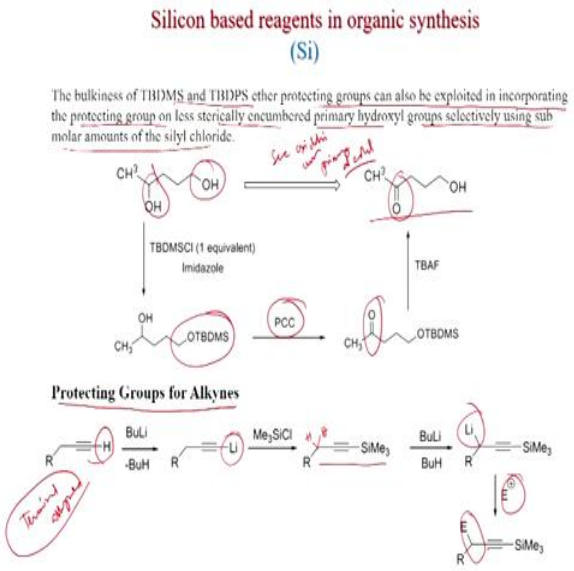


Synthetic application of silyl protecting groups, the bulkiness of TBDMS and TBDPS ether protecting groups can be used to advantage suppress hydrogen bonding to the oxygen restricting any incoming reagents to approach from the least hindered side of the molecule, so this is also important because silyl groups are bulky, so they can also effect, like this allylic alcohol, if you do reaction with mCPBA this m will be small meta-Chloroperoxybenzoic acid that is the epoxidation, so electrophilic epoxidation with mCPBA and this hydroxy is directing, so hydroxy directed, so this one is hydroxy directed because this hydroxy group react with the mCPBA and that is why it is coming from the same side of the hydroxy group.

So epoxide coming from the topside because hydroxy is the topside, so the topside attack and that is hydroxy deducted and now if you protect this OH group with TBDMS, TBDMS chloride if you treat and imidazole then you get this O TBDMS and this can be treated with mCPBA, so this is very important when you put mCPBA steric reason, mainly for the steric reason and because this silyl group is there that is not allowing mCPBA to interact with the oxygen, here oxygen is free, here is protected, so mCPBA cannot interact with this oxygen atom, so the direction is not there, so now what is the direction because this group is now sterically big.

So mCPBA now coming from downside and you get this down epoxide and this TBDMS group can be the protected to TBAF, so you get this compound. As you can see this and this they are diastereomers to each other, so this is very potent the allylic alcohol if you treat with MCPBA then the hydroxy group which directing the epoxidation you can get from the same side. On the other hand if the alcohol is protected with TBS group then this direction will not be operating. Only the steric effect will operate and in that case mCPBA will confirm the opposite side of the OTBS group and you get the other diastereomers.

(Refer Slide Time: 37:40)

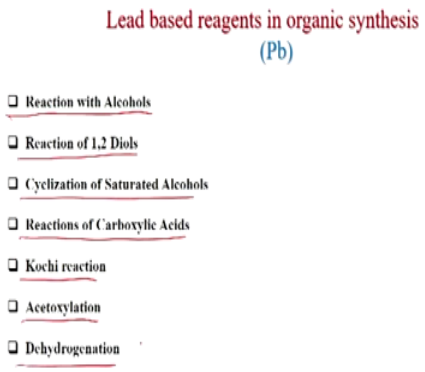


The bulkiness of TBDMS and TBS group ether protecting group can also be exploited in incorporating the protecting group on less sterically encumbered primary hydroxyl group selectively using sub molar amount of the silyl chloride. Like here secondary alcohol, primary alcohol is there, how to come back to the ketone, so though some oxidising reagent can do this oxidation but you can do with silyl protecting groups also and here you can

selectively protect the primary alcohol to generate this OTBDMS and PCC oxidation will generate this carbonyl compound and TBAF deprotection will generate this compound, so this is a formal secondary oxidation over primary alcohol, so primary is protected and then the secondary is oxidised.

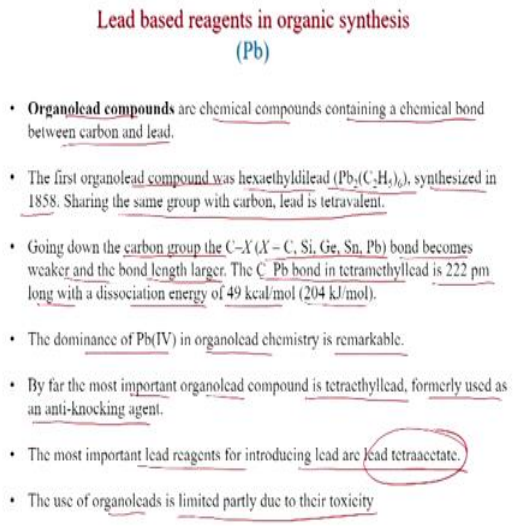
Also protecting group for alkynes this is also a good method, so this hydrogen is acidic with butyl lithium you get this lithium compound and now it can be treated with Me3SiCl to get this alkynyl silane and if you treat this compound with butyl lithium then this proton will be deprotonated and you get this lithiated compounds which can be treated with other electrophile to generate this compound, so this is very important because simply without this protection if you want to treat n butyllithium although this terminal alkynes, terminal alkyne will be deprotonated here so that way with silyl protection you can protect it and there you can functionalize this carbon center.

(Refer Slide Time: 39:28)



In the lead based reagents in organic synthesis will discuss reaction with alcohol then reaction of 1, 2 diols, cyclization of saturated alcohols, reactions of carboxylic acids, Kochi reaction, Acetoxylation reaction and dehydrogenation reaction.

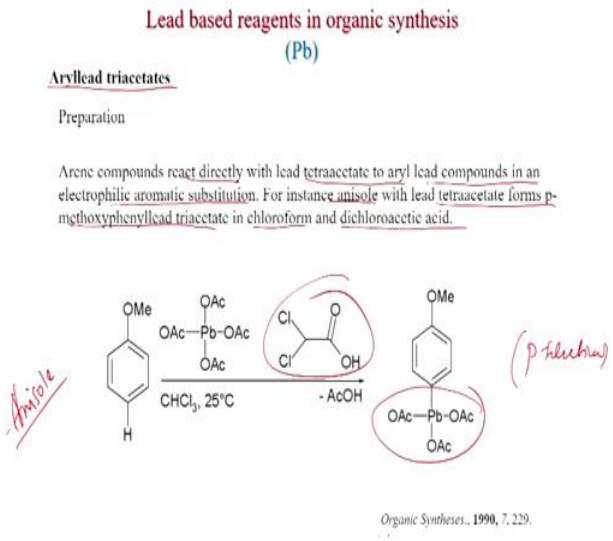
(Refer Slide Time: 39:52)



Organolead compounds are chemical compounds containing a chemical bond between carbon and lead. The first organolead compound was hexaethylenedilead Pb2 C2H5 whole 6 synthesised in 1858. Sharing the same group with carbon, lead is tetravalent. Also going down the carbon group CX equal to carbon, silicon, germanium, tin, lead bond becomes weaker and the bond length larger.

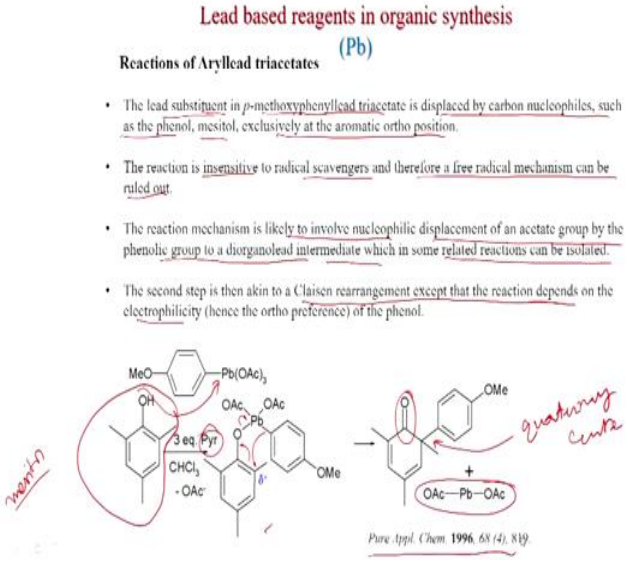
The C-Pb bond in tetra methyl lead is to 22 picometer long with a disassociation energy plus 49 kilocalorie mole, 204 kilo Jule per mole. The dominance of lead 4 in organolead chemistry is remarkable. By far the most important organolead compound is tetraethyl lead formerly used as an anti-knocking agent. The most important lead reagent for introducing lead are lead tetra acetate, this also we will discuss and use of organolead is limited partly due to their toxicity.

(Refer Slide Time: 41:02)



So first we will discuss aryllead triacetates, their preparation arene compounds react with lead tetra acetate to aryl lead compound in an electrophilic aromatic substitution for instance anisole with lead tetra acetate forms paara methoxyphenyllead tri acetate in chloroform and dicholoroacedic acid. So, this is the reaction for the generation of aryllead triacetate this is anisole, anisole reactant will arylleadacetate and this acid after elimination of acidic acid you get this compound aryllead triacetate, so this is para selective. This was reviewed in Organic Synthesis.

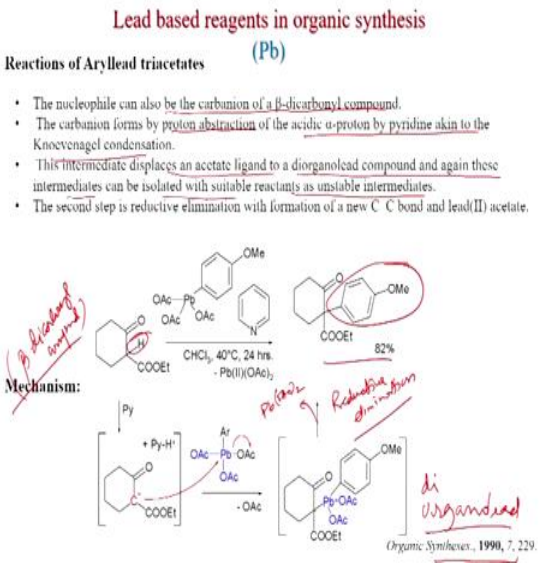
(Refer Slide Time: 41:49)



And now what type of reaction it can do, the lead substituent in para methoxy phenyl lead triacetate is displaced by carbon nucleophile such as the phenol, mesitol exclusively at the aromatic ortho position. The reaction is insensitive to radical scavengers and therefore, of free radical mechanism can be ruled out. The reaction mechanism is likely to involve nucleophilic displacement of an acetate group by the phenolic group to a diorganolead intermediate which in some related reactions can be isolated.

So this is the reaction you can see this is the compound mesitol while react with this para methoxylate triacetate in presence of base 3 equivalent pyridine, then this oxygen reacting with lead and one acetate, of course, will eliminate you get this intermediate and now the claisen type rearrangement will happen, the reaction depends on the electrophilicity because this carbon is electrophilic, the rearrangement will happen like this way and you get this is the lead diacetate is the by-product and this carbonyl group will be generated and this aryl group will come here, so this is the quaternary center is formed. So this is very nice that the 1st oxygen is a reacting and then the Claisen type rearrangement, this was report is pure applied chemistry.

(Refer Slide Time: 43:20)

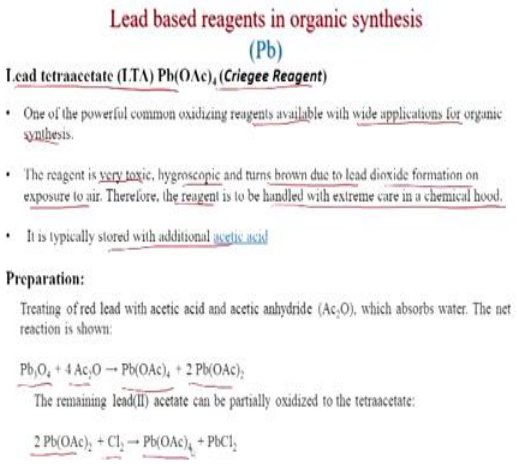


The nucleophile can also be carbonion of the beta dicarbonyl compounds. The carbonion forms by proton abstraction of the acidic alpha proton by the pyridine akin to knoevenagel condensation. The intermediate displace an acetate ligand to a diorganolead compound and again these intermediates can be isolated with suitable reactants as unstable intermediates. So this is the reaction that aryllead triacetate with pyridine and this is the beta dicarbonyl

compound, the arylation happens here so you can see this proton is displaced by this, so what could be the mechanism?

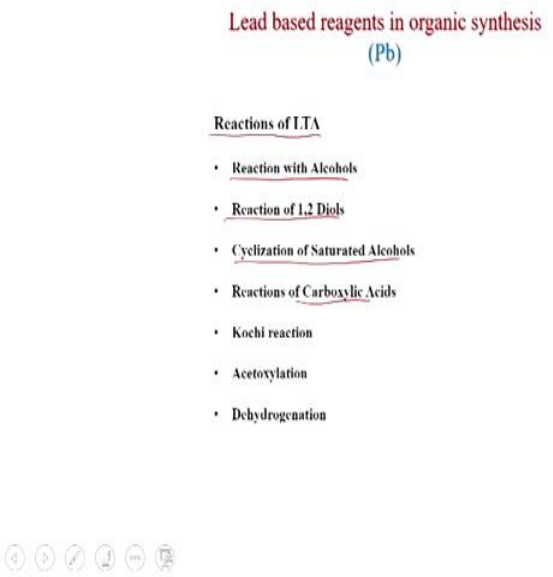
So, this reaction is efficient 82 percent yield, so what could be the mechanism? Now pyridine, of course, generate a carbanion here and then this reacts here and this organolead compound is formed, diorganolead compound lead is connected to two carbon groups here and now the reductive elimination because here also the radical pathway does not operate, so reductive elimination will happen and you get this diacetate and your compound, so this is an efficient method, it was reported in Organic Synthesis 1990.

(Refer Slide Time: 44:51)



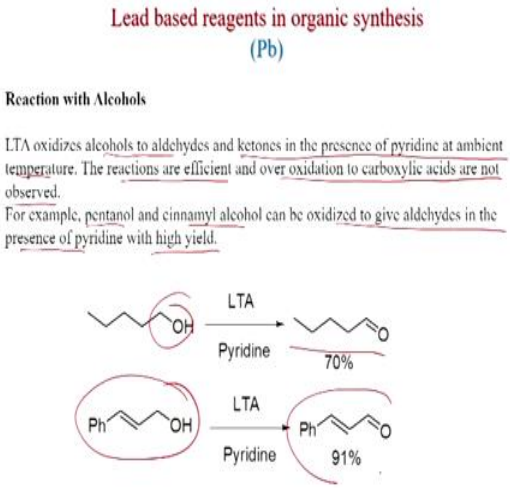
One of the powerful common oxidising reagent available with wide applications for organic synthesis, so this is lead tetra acetate and now we will discuss with it is called Criegee reagent. The reagent is very toxic hydroscopic and trans brown due to lead dioxide formation or exposure to air, therefore, the reagent is to be handled with extreme care in a chemical hood. It is typically stored with additional acetic acid and it can be prepared with this lead oxide and for acidic anhydride then this lead tetra acetate is formed and this is the by-product and this by-product again can be reacted with chlorine to generate this lead tetra acetate.

(Refer Slide Time: 45:33)



Now, we will discuss different reactions of lead tetra acetate, there are many reactions, it can react with alcohol to carbonyl reaction of 1, 2 diols where the cleavage will happen, cyclisation of saturated alcohols, reactions of carboxylic acids, Kochi reactions, Acetoxylation and dehydrogenation.

(Refer Slide Time: 45:57)



So, first we will discuss reaction with alcohol. LTA oxidises alcohol to aldehydes and ketones in the presence of pyridine at ambient temperature. The reactions are efficient and over oxidisation to carboxylic acid are not observed. So, this is very important, for example, pentanol and cinnamyl alcohol can be oxidise to give aldehydes in the presence of pyridine

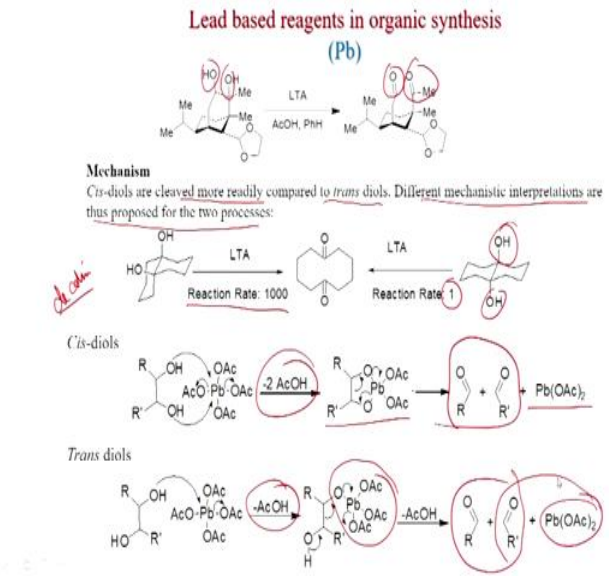
with high yield. So, this is important, the oxidation stops at the aldehydes, so suppose in pentanol was to pentanal in 70 percent yield, also cinnamyl alcohol goes to cinnamyl aldehyde in 91 percent yield.

(Refer Slide Time: 46:35)

Now we will discuss reaction of 1, 2 diols, so 1, 2 diols oxidative cleavage is observed to give aldehydes, ketones or both depending on the structure of the diols, so this is like sodium periodate oxidation, we have seen the oxidative cleavage, so lead tetra acetate similarly cleave the diols. Reaction involves a cyclic intermediate and cis 1, 2 diols exhibit greater reactivity compared to trans 1, 2 diols. The reactions are performed in organic solvent such as benzene, toluene, dichloromethane and THF.

When 3 or more hydroxyl groups are present on adjacent carbon atoms then the middle one is converted into formic acid, so this is also important like these diols then this cleavage happens you get two carbonyl compounds. Also if you see this structure there is a chiral OH here O benzoyl and this one is that diols, this cleavage happens and you get this aldehyde and this chiral center is not disturbed, so this is also very mild reaction.

(Refer Slide Time: 47:35)

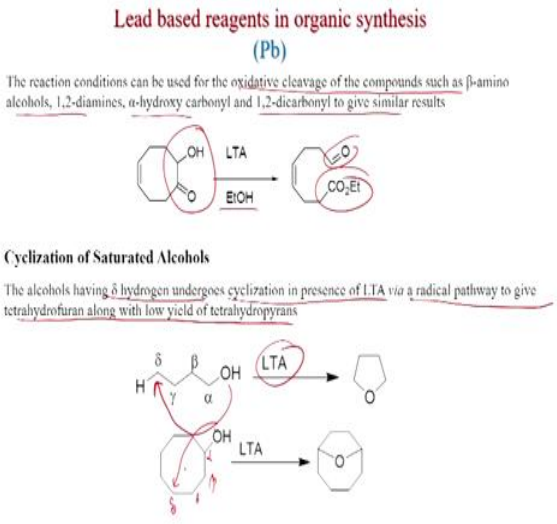


Also this diol you can see cleave give this ketones and aldehyde, so what could be the mechanism, now cis diols are cleaved more readily than trans diols. Different mechanistic interpretations are thus proposed for these two processes, so this is the cis diols, this is

decalin system, cis diols reaction rate 1000, on the other hand trans one, the reaction rate only 1, so trans diols very poor in this case, so mechanism will be different so what will happen with cis diols.

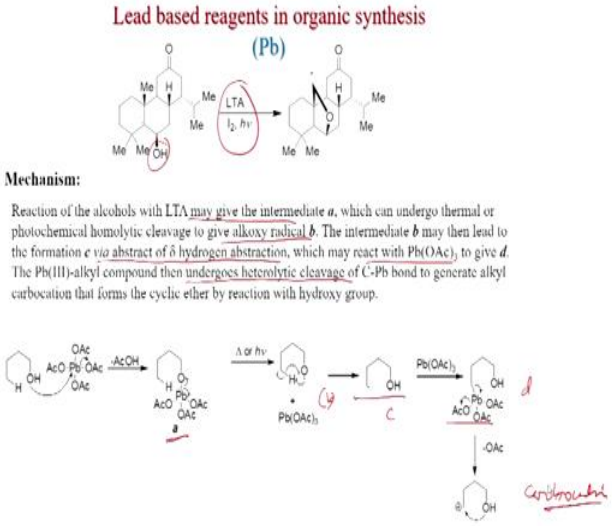
The 2 molecular acetic acids will eliminate this, five-member intermediate will form and after that this cleavage will happen like this way you get two carbonyl compound and lead diacetate. On the other hand, in trans cases this kind of intermediate will form this one, the OH reacting here after elimination of acetic acid, this intermediate is form and now the anti-elimination will happen, so like this way the cleavage will happen to get carbonyl compound and this lead diacetate.

(Refer Slide Time: 48:46)



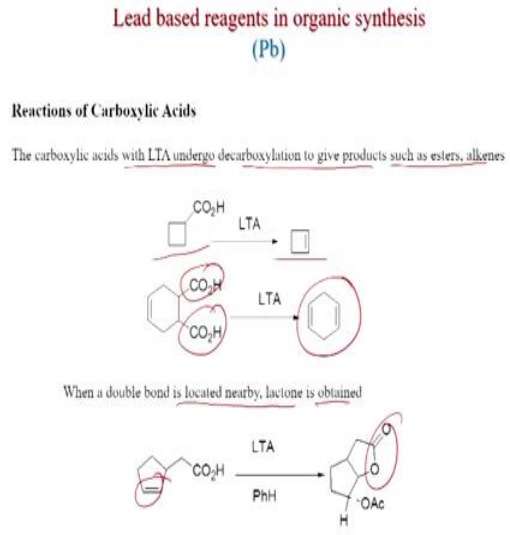
The reaction condition can be used for the oxidative cleavage of the compounds such as beta aminoalcohol 1, 2 diamines alpha hydroxy carbonyl and 1, 2 dicarbonyl to give similar result. Like this alpha hydroxy ketone with lead tetra acetate ethanol you get this ester here, this is aldehyde but this is ester and cyclisation of saturated alcohols, this is also an important reaction that you can get cyclisation if a delta hydrogen is there undergoing cyclization in presence of LTA via radical pathway to give tetrahydrofuran along with low yield of tetrahydropyran. So, this is Alpha, beta, gamma, delta then this cyclisation happens in the tetrahydrofuran. Here also alpha, beta, gamma, delta now this OH reaction here and you get this bicycle.

(Refer Slide Time: 49:41)



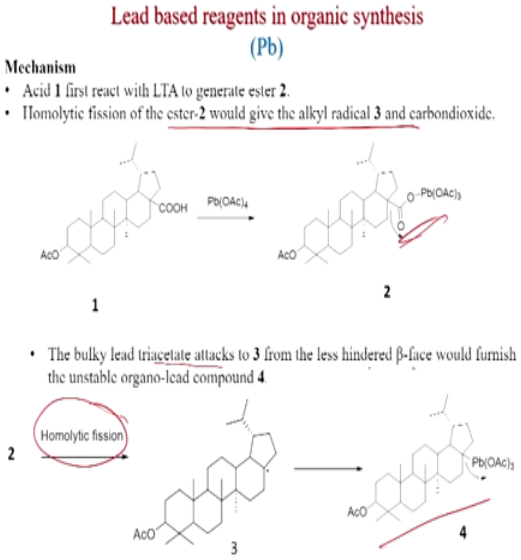
Also you can see this kind of compound there is OH here and there alpha, beta, gamma, delta this methyl group here it is making a tetrahydrofuran with lead tetraacetate in iodine and hυ, so what is the mechanism? Now this reaction of alcohol with LTA may give the intermediate a which can undergo, so this intermediate will form OH first react. This can form a radical now in presence of heating a light the alkoxy radical b will be formed, this alkoxy radical b will make a carbon radical via gamma hydrogen abstraction, so this is very important, which may react with lead triacetate to generate this and after so this is d, this is c and undergoes heterolytic cleavage so then a carbocation is formed, so this is important radical and then carbocation and then the cyclisation will give the tetrahydrofuran.

(Refer Slide Time: 50:47)



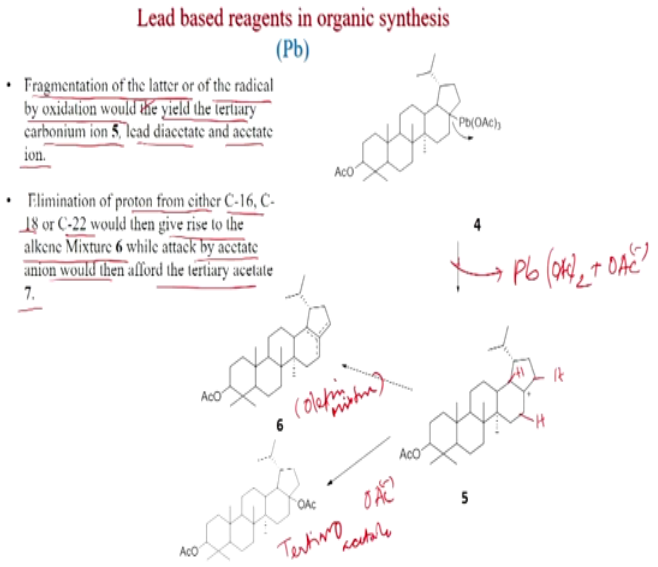
Reaction of carboxylic acid, carboxylic acid with LTA undergoes decarboxylation to products such as Ester, alkenes, so this one cyclobutanecarboxylic acid gives cyclobutene. Also this dicarboxylic acid gives the olefin. When a double bond is located nearby, lactone is obtained like this substrate you can see there is a double bond with LTA you get this cyclisation, lactone ring is forming and with a acetoxy.

(Refer Slide Time: 51:20)



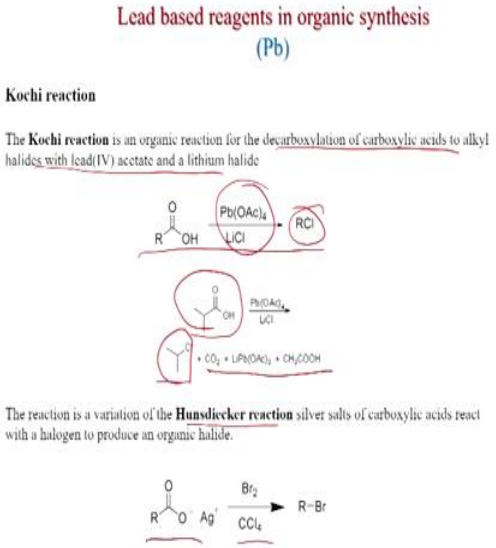
So what is the mechanism? So mechanism will be that this carboxylic acid 1st react with lead tetra acetate to generate this and then the bulky lead attacks 3 then this homolytic fission will happen, homolytic fission of the ester 2 give alkyl radical, so this is radical will form and after this radical is form, the lead tetra acetate will react to generate this intermediate 4 and it comes from the less hindered face.

(Refer Slide Time: 51:50)



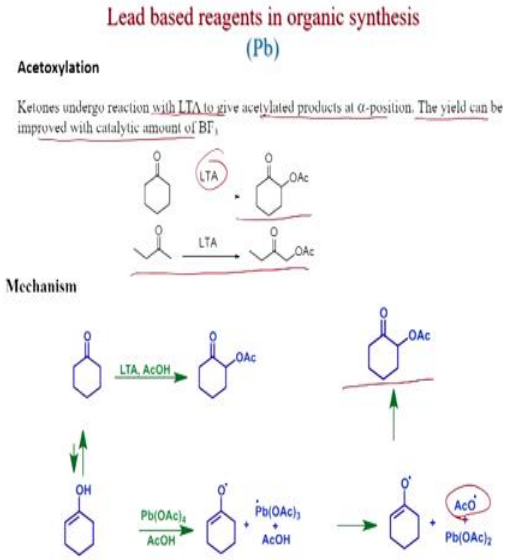
Fragmentation of the letter or of the radical by oxidation would yield the tertiary carbonium ion 5, lead diacetate and acetate ion, so this formation we have seen. Now the elimination of lead diacetate and acetate anion will give this carbocation and elimination of proton from either C16, C18 or C22 then give rise to the alkene mixtures 6 while attacked by acetate anion would then afford the tertiary acetate 7, so if you see this 5 there are possibilities of three olefin formation because three beta hydrogen is there and three olefin formation is possible, so that is the olefin mixture, olefin mixture 6 or the acetate anion which forms earlier can react with the carbocation to generate the tertiary acetate.

(Refer Slide Time: 53:06)



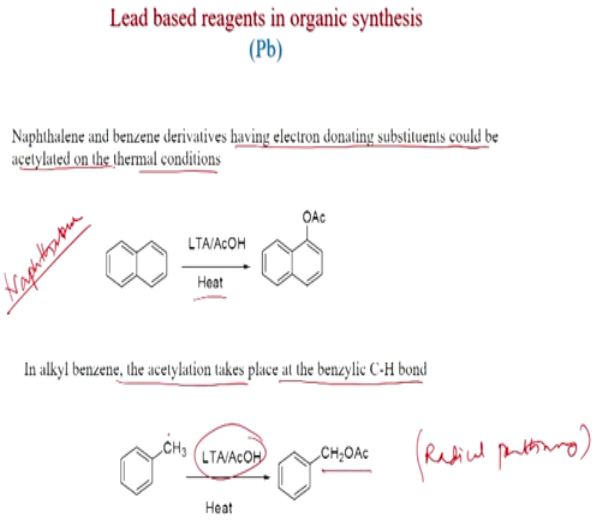
Kochi reaction is an organic reaction for the decarboxylation of carboxylic acid to alkyl halides with lead acetate and a lithium halide, so this is the reaction. lead tetra acetate and lithium chloride then you get the RCl. This is the example, this acid if you put lead tetracetate and then you get this chloride and these are the by-products, carbon dioxide and acetic acid at this lead compound and this reaction is a variation of Hunsdiecker reaction where silver salt of carboxylic acid reacts with bromine carbon tetrachloride to get the R Br.

(Refer Slide Time: 53:42)



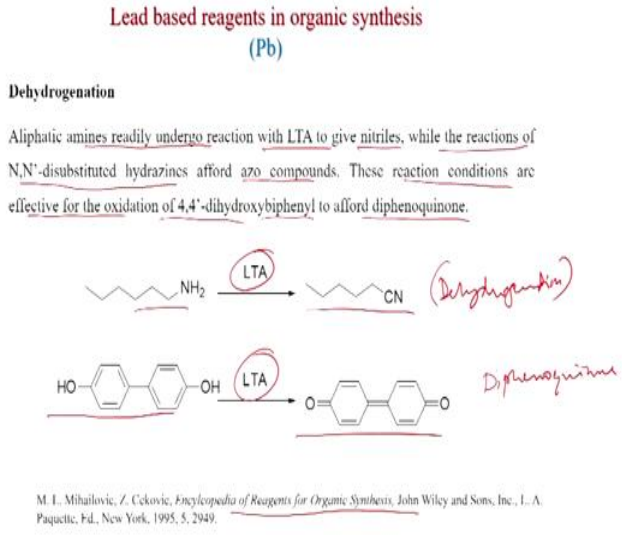
Acetoxylation, ketones undergo reaction with LTA to give acetylated products at alpha position. The yield can be improved with catalytic amount of BF3, so this is the reaction with related to acetate you get this. Alpha acetoxy carbonyl compound, cyclic ketone as well as… cyclic ketone can react, so what could be the mechanism is the enol is formed then this radical is formed so lead radical and this oxygen radical then the acetoxy radical is formed and then the acetoxy compound, alpha acetoxy carbonyl is formed.

(Refer Slide Time: 54:19)



Naphthalene and benzene derivatives having electron donating substituents could be acetylated on the thermal conditions like this naphthalene can be reacted related to acetate acetic acid heat you get this acetoxy compound. In alkyl benzene, the acetylation takes place at the benzylic C- H bond, so this bond is activated so this might be radical pathway and LTA with acetic acid you get this group CH2OAc.

(Refer Slide Time: 54:58)



Dehydrogenation, aliphatic amines readily undergo reaction lead tetra acetate to give nitriles while the reactions of N, N' disubstituted hydrazines afford azo compound, these reaction conditions are effective for the oxidation of 4, 4 dash dihydroxybiphenyl to afford

diphenoquinone, so amine giving here this nitride, so this dehydrogenation, so this is the dehydrogenation pathway and easily an amine can convert to nitride. Also this compound 4,4 –Dihydroxybiphenyl related to acetate you get this diphenoquinone, so this is a very important reactions and this was report in Encyclopedia of Reagents for Organic Synthesis.

So first today we have seen the silyl group and difference in substitution reaction and then we have seen their huge protecting group silyl protecting groups and generally they are protected in presence of a base and then can be deprotected easily with fluoride source. Then we have seen the Peterson olefination, Peterson olefination is very useful method for generation of cis and trans or syn or anti-olefin from the same diastereomers depending on the acid or basic condition. In basic condition syn elimination happens in the acetic condition, anti-elimination happens.

Then we have seen the lead compounds and lead triacetoxy aryl first the preparation and then we have seen the usefulness of this reaction that phenyl compound generally the radical path way does not operate in this cases and phenyl compound give this quaternary center carbonyl compound, so carbonyl compound form with a quaternary center. Also beta dicarbonyl compound can also be reacted and the quaternary center can be formed, arylation at the quaternary center.

Then we have seen the oxidation with lead tetra acetate, the lead tetra acetate is very useful reagent in organic chemistry, so lead tetra acetate it is called Criegee reagent also, so lead tetra acetate we have seen 1st oxidation of alcohol, primary alcohol goes to aldehyde selectively not over oxidation happens, cinnamyl alcohol goes to cinnamaldehyde. Then diol cleavage we have seen and we have seen the syn diol react 1000 times much faster than trans diols, so the mechanism is different for syn diol 5-member intermediate is formed in general.

Then we have seen the reaction, acetoxylation reaction with carbonyl compound, we have seen the alpha acetoxylation happen and we have seen the decarboxylation of carboxylic acids like cyclobutanecarboxylic acid, with lead tetra acetate generates the olefin. Then we have seen the Kochi condition, so Kochi condition is that if you treat with lithium chloride in the same condition carboxylic acids, lead tetra acetate, lithium chloride then you get the alkyl chloride, so the carboxylic acid is getting decarboxylated like Hunsdiecker reaction and halide is coming and lastly we have seen dehydrogenation like amines converting to nitrite and diols like conjugated diols they are converting to the dienones.