## Reactive Intermediates: Carbene and Nitrene Prof. Rajarshi Samanta Department of Chemistry Indian Institute of Technology, Kharagpur

## Lecture – 13 Reaction of Carbene (Contd.)

Hello, everybody. Welcome to the course that Reactive Intermediates Carbene and Nitrene. Here we are studying now various types of reactions of the reactive intermediate Carbene species. We have studied its addition reactions and after that we are continuing with the different type of insertion reactions. In the last class we have studied that how a carbon hydrogen bond that can be inserted into a carbon species.

We have understood that how this carbon hydrogen bond from various type of electronic nature can be inserted into the carbon species through concerted manner. Today we will discuss that the generation and reactions of elites by carbenoid decomposition. So, additionally we will understand that different type of heteroatoms or the different type of nucleophiles how they can insert into a carbene species.

As per example when there is a carbonyl group or any other nucleophilic functional group that is near to the carbenoid carbene carbenoid carbon then that can nicely react to give certain intermediate by intramolecular bonding ok. So, over all what we will form that obviously, these types of reactions can be intramolecular or intermolecular. But what will form that the heteroatom that can nicely interact or that can react to the electron deficient carbene species ok. As per example if we see the carbonyl ylide formation ok.

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So, the carbonyl group if we see so this oxygen's they are having this lone pair. Now if we take the corresponding diazo compounds now in presence of different transition metals what it will do that if these diazo compounds they can nicely form the carbenoid species ok. And once it will generate the carbenoid species. So, the from the carbonyl group that oxygen which is neclephilic now that can react to this electrophilic centre of this carbenoid and give these type of system.

Now, once it will form now this ylide that can now react with different way. As for example if there is any double bond these can give the cycloaddition if this type of product or it can give by this type of product ok. Or it can give so this can react over here and this oxygen can from this double bond this it can come. So, overall it can give the corresponding epoxide product ok. So, there are various way that it can proceed ok. So, like here it is going for cycloadditions and in this case it can goes like this hydrogen can come and these bond can come out over here ok.

So, it can give this type of olefin or even this negative charge that can react over here and then it can give the corresponding epoxide. So, if you see now few examples of this type of carbonyl ylide, how they behave under this type of transition metal catalyst to provide these metallocarbines and how they proceed ok. So, as per example we take the substrate as the carbon precursor these diazo compound we have taken. Now if there is ester moiety which is having this olefin this is important.

So, now in presence of rhodium 2 here it is rhodium 2 acetate ok. So, this will generate the metallocarbene ok. So, once you have generated this then you have these oxygen lone pair over here ok. So, that can react over here and once it will react over here. Then obviously, that will form the ylide ok. And write in this way this is the negative here it is positive ok. Now you see this is nicely placed for 3 plus 2 cycloaddition. This ylide is there and this olefin is there. So, it can go this 1 3 dipolar cycloaddition to give this fused product ok.

So, what we have generated? We have generated this metallocarbenes from these daizo 3 2 compound which is having these ester moiety with the olefinic part. And in presence of rhodium to acetate these will generate these carbonoid species and once it has generated the carbenoid it is having this oxygen with some lone pairs. And this oxygen now this is nucleophilic enough to react or to attack to this electrophilic centre. Once it will react it will give this ylide and once this ylide will form these can react with the corresponding olefin to provide this product.

Next, we will see another similar type of reactions where in spite of taking the olefin as intramolecular way we will take that alkyne for the corresponding dianofile to do such kind of reactions ok.

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So, what we will take? We will take the corresponding diazo compound has the carbene precursor ok. And now, we have this lactomoeity with it and if we have this in presence

of again rhodium to acetate. And we have these alkyne with us now this alkyne can react with the corresponding ylide in intermolecular way ok. So, now, if we treat these with rhodium 2, first what it will generate ok. So, now, this oxygen is nucleophilic enough to react over here; so to provide the corresponding ylide ok.

And we have now this alkyne as dienophile ok. Now this alkyne so it can react through this again 3 plus 2 cycloaddition reactions can happen and give the final product ok. So, we will get this fuse product as the final product in this particular reaction; one interesting reactions where the ylide formations followed by the sigmatropic rearrangement will happen; that we will see now.

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For example, if you take these ether as the starting material with the corresponding diazo compound as the carbene precursor ok. So, now you have taken the rhodium 2 acetate as the catalyst and what it will form this oxygen lone pair here this nucleophilic enough to react to the corresponding metallocarbene centre. And once this electro after this electrophilic carbon centre where it will react after formations of this metallocarbine so this will generate ok. Now this ylide this is ready to attack for the further 2 3 sigmatropic rearrangement.

So, what is this? This is 1, 2, 3. So now 1, 2 so if we see now this can attack over here this is and this bond can sigma bond can break ok; so this is the 2, 3 sigmatropic rearrangement, because this sigma bond that is forming through 2 and 3 and what is

breaking from there we have started the counting. That is 1 here that is 1 so these bonds that is breaking over here, and the new bond forming through here, and here is it clear ok. So, if it forms these if it goes via this 2, 3 signatropic rearrangement then the product will be ok.

So, then the product final product will be the insertions followed by the sigmatropic rearranged product that is nothing, but these product ok. Next we will see in another example where similar type of concept has been used to get a advanced intermediate for the natural product gambieric acid. So, we will see that here R is the silvl group some protecting group which can protect the corresponding hydroxyl group ok. So, now, again here this oxygen that is having the corresponding lone pairs.

So, after formations of these metal metallocarbene here they have used copper 2 salt as the metal catalyst for generations of these carbenoid species. And once it will generate so this will form ok. So, and this one will be the negative ok. So, now, again we will make 1, 2, 3, 1, 2, 3, and here also 1, 2. So, here what we have we will see that these sigma bond will break and the new sigma bond will form between these two.

So now, if we see that how this rearrangement will happen. So, it can attack over here then ok. So finally, the 2 3 sigmatropic rearrange a product will form here also to provide the key intermediate of the natural product gambieric acid ok. So, this is the major product and this is the A-ring fragment ok.

So, overall all these cases we have seen that how this oxygen's whether it is from carbonyl or from ether that forming these ylide. And then different type of reactions are happening in some cases it is going like a cycloadditions in some cases it is going as for the different type of sigmatropic rearrangement reactions.

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Now, we will see that how this sulfonium ylide that can form. So, now what we will see the corresponding sulfonium ylide. Here also similar like oxygen or other nucleophiles. So, sulfur that can attack to the corresponding carbenoid to generate the carbon sulfur bond and to form these sulfonium ylide and that can also again proceed various different type of reactions.

As per example we take these theophylline substituted theophylline and in presence of these diazo ester and rhodium to acetate as the transition metal catalyst. Then it will form the stable ylide ok. So, here I would like to mention the reference that is chemical review from their ok. So next, in similar way another sulfur containing substrate where sulfur can react in intramolecular way to the carbenoid to form the corresponding cyclic compound ok.

Here n equals to 0 1 2 3 and in presence of rhodium 2 acetate again. In similar way here the diazo ester that was that reacts in intermolecular way here it will react in intramolecular fashion to provide the corresponding sulfonium ylide ok. Ok next in another example where recently 1 and 2 workers they have reported this work. They have taken this diazo compound where it is flagged with the aryl ring and the ester ring using this thioether under rhodium 2 species.

Again it will give the sulfur ylide that is this one ok. So, after that the tautomerizations and followed by sigmatrophic rearrangement we will give the desired product. So, what is the next after tautomerization what it will give? So, it will give so once it is having so nicely the 2 3 sigmatrophic rearrangement can happen. I have already mention what is this 2 3 sigmatrophic rearrangement ok. So, once this 2 3 sigmatrophic rearrangement will happen this will generate these particular product this particular substrate ok.

Once we will keep this then the 1 3 right shift 1 3 added shift will give or the rearborizations that will finally, give this product ok. So, finally, what this will give? So, this is the reactions of these thioether that here the sulfur that can react as the nucleophile to this metallocarboid species. And once it will react that will proceeds to the after the tautomerizations that we will proceed through 2 3 signatrophic rearrangement followed by this rearomatizations will give the final product ok.

Next we will see different type of oh insertion reactions ok.

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So, far we have seen that how the carbene species can be inserted into a carbon hydrogen bond or how that as a nucleophile how the carbonyl or the ether or thioether they can react of form ylide and different type of reactions can happen. So, here oxygen that is the like normal alcohol whether that can be also inserted; we will check that one. As per example if you take this particular substrate ok. So, in presence of copper 1 catalyst that can be inserted to give the cyclic these product ok. Here this alcohol OH is getting inserted into the corresponding carbenoid species ok. Similarly when there is the amine that can be also inserted nicely into the carbenoid species that is also sufficiently necleophilic to attack to the carbenoids. So, as per example we take this diazo compound as the corresponding precursor of the carbine; then if we take the amine as necleophile in presence of rhodium 2 acetate. Then that amine they can react or they can attack to the carbenoid formed carbenoid metallocarbenoid and that will give ok.

So, now these can be in a keto enol tautomerism can happen and give this enol form of this keto compound 1, 3 diketo compound ok. So, what we have learnt so far that different type of insertion reactions are possible with the carbene species as the carbene species that is electron deficient and highly reactive. They can be inserted in various type of bonds as per example it can be inserted into the carbon hydrogen bonds or it can be inserted into a other nucleophiles also it can react with other nucleophiles also. As per example it can react with the ketos it can react with the ethers it can react with the thioethers or it can react with normal alcohol OH group or even it can react with amines and with that.

Thank you very much.