Welcome students, this module is from

the third year Bachelor of Science

program in the subject of chemistry

for the Semester 6 the course codes is

CHC-110. The title of the course is

Organic Chemistry Section A.

This module is from the unit chemistry

of enolates, the name of my module

is definition of enolate ion,

acidity of carbonyl compounds,

pk_a values, generation of enolate, ion.

Role of bases in enolate formation

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This is the outline of my module.

Which includes the introduction, definition

of enolate ion, acidicity of carbonyl compounds.

pk_a values role of bases

in enolate formation.

Generation of enolate ion

and finally, the references.

At the end of this module,

students will gain knowledge and

understanding of the enolate ion

acidity of carbonyl compounds.

pk_a values generation of enolate ions

and role of bases in enolate formation.

They will be able to write enolate

forms of different carbonyl compounds.

They will be also able to identify

acidic protons and solve problems

based on this knowledge.

We'll start with the introduction.

Enolates
are versatile reagents

for the formation of alpha

substituted carbonyl compounds and are

therefore important intermediates for

the synthesis of complex molecules.

They are rarely isolated,

and they are widely used as reagents

in the synthesis of organic compounds.

Let us.

When it comes to the reactivity

of carbonyl compounds,

there are two sides of reactivity.

The first side is the partially

positively charged carbonyl carbon.

Here you can see it.

This is the partially charged carbonyl

carbon which acts as the electrophile

and nucleophile can add to it,

giving the addition product.

This reaction comes under the category

of nucleophilic addition reaction.

Many carbonyl compounds also have

the second site of reactivity,

namely a hydrogen,

attached to a carbon which is

adjacent to the carbonyl carbon,

as in this case, this carbon.

Is adjacent to this carbonyl

carbon and this carbon is called

as the alpha carbon and hydrogen

present on this alpha carbon are

called as the alpha hydrogens.

These hydrogens are acidic in nature

and if a strong base is employed,

it can easily abstract these protons,

giving the corresponding products.

Let us now see the definition of enolates.

Base removes a proton from the alpha

carbon of the keto tautomer, forming an

anion which is called as the enolate.

The enolate ion has got two

resonance contributors.

As you can see here, the base

can abstract the acidic proton

and the electrons will go to the

Alpha carbon forming the carbonanion and this
Carbonanion the electrons present

here gets delocalized onto the oxygen,

giving the enolate ion.

In this enolate I mean you can

see that there is a double bond.

So in then there is a alcohol

and alcoholic group,

so all but that alcoholic group

is deprotonated, which is why 8.

That's why they need. In a lead.

Let us now see the acidity

of an alpha hydrogen.

Carbon and hydrogen have

similar electronegativities.

Which is the reason for this is

that the electrons between the

hydrogen and carbons are equally shared.

Consequently, a hydrogen bonded

to carbon is usually not acidic.

You can see here in the case of ethane,

the pk_a value is more than 60 these protons.

Are not acidic.

But a hydrogen bonded to an sp3

hybridized carbon that is adjacent to

a carbonyl carbon is much more acidic

than the aforementioned hydrogens,

as in the case of aldehydes,

ketones, esters, etc.

So here you can see the pk_a

values for the dissociation of

these alpha hydrogens present.

In the case of.

Aldehydes and ketones ranges

between 16 to 20.

And that of the alpha hydrogens

of esters is about 25. And

Lower the pk_a value higher

or the stronger the acid is

and higher the pk_a value.

Weaker is the acid.

So we know that a hydrogen bonded to an

alpha carbon is more acidic than hydrogen

bonded to other sp3 hybridized carbon.

That is the reason why the alpha hydrogens.

Present on the alpha carbon are acidic

and the hydrogens present on other sp3,

hybridized carbon,

like alkenes, are not acidic.

This is because the conjugate base

formed when a proton is removed

from an alpha carbon is relatively

stable and the most stable.

The conjugate bases,

the stronger is the starting acid.

To give a clarity on this,

let me write down the general reaction

when an acid reacts with the base.

The acid forms the conjugate base

and base forms the conjugate acid.

More stable.

The conjugate base is stronger

will be the acid.

Now here we can see that ethane is there

and if a base abstracts proton from

ethane it will give this carbanion.

In this kind of carbanion,

the electrons are localized.

So this becomes unstable because carbon

is not an electronegative element

and the acid form is a strong acid

because the pk_a value of this will be

low and what will happen is that this

acid will re protonate the carbonyl

formed, shifting the equilibrium

to the left hand side
reforming the starting alkene.

But when it comes to

Carbonyl compounds with alpha hydrogen.

When base abstracts the proton.

Carbon ion is formed in the case

of carbon and the electrons get

delocalised onto the oxygen.

And electrons are better accommodated

on oxygen than on carbon because oxygen

is more electronegative than carbon.

So because of this resonating

structures and especially the

stability of the enolate ion.

The conjugate base formed here is stable,

and that's the reason the starting

compound is acidic in nature.

Now we will see some pk_a values

of these carbon acids.

So you can see that there is

amide and Ester ketone.

Aldehyde.

So the PK values for amide and

Ester are higher in comparison

to ketones and aldehydes.

So what happens here is that in the case of

Amide and Ester

There are lone pair of electrons

present on nitrogen and oxygen,

so they also compete for delocalization

of electron onto the oxygen.

So when the carbon is formed,

electrons are not readily

delocalized onto the oxygen.

That is the reason the pk_a value for

these compounds are higher in comparison

to that of ketones and aldehydes.

Also the pk_a value of amide

is still higher than that of.

Ester, because in my mind there is

nitrogen which can more easily give away

its electron to the carbonyl carbon.

Because nitrogen is less electronegative

in comparison to oxygen present in Ester.

Now coming to ketone and aldehyde,

ketones are having slightly higher

as pk_a value in comparison to aldehyde

because in ketone you have

Alkyl group on both sides,

but in aldehyde there is hydrogen present.

in the functional group,

so hydrogen being smaller in size

does not come in the way of the base

when it tries to abstract the proton.

Also hydrogen does not add any

negativity to the compound like in the

case of ketones where alkyl group can give.

Electron density to the carbonyl

carbon via +I inductive effect.

If the alpha carbon is between two

carbonyl groups, the acidity of its

alpha hydrogens is even greater.

So here we have some few

examples with respect to that.

So in the first case we have a diester where

A methylene group is sandwiched

between two carbonyl groups.

So the pk_a value here is 13.3 because

there are two carbonyl groups around.

The second example.

We have a keto Ester,

so now there is just one Ester group.

There's just one oxygen.

And there will be

Only other delocalization,

meaning the Electro or this oxygen can

give electrons to the carbonyl group

only from one side the other side there

is alkyl group which it cannot do so,

so the pk_a value for this compound is 10.7.

The third example.

It's a diketone,

so the pk_a value is still lesser

in comparison to the keto Ester.

It is 8.9 and then we have.

Aldehyde and ketone group.

So since there is one aldehyde

group and one ketone group,

the pk_a value is the least for

this and in the last example

there are two Nitro groups.

Nitro groups are strongly electron

withdrawing groups and they exert

a very strong -I effect.

So the pk_a value is 3.6.

Now for the formation of enolate

ion base has to be employed.

So what are the different

bases that are being employed?

Some bases that have been used for

Enolate ion formation are sodium

hydride whose pk_a is greater than 45,

then sodium amide was pk_a
is almost equal to 34 and then we have

lithium diisopropyl amide whose pk_a is 36.

So we can see here that these are

very very strong bases that are

Needed to be employed for the

formation of enolate ions.

This is the structure of

Lithium diisopropyl amide,

which is also called as LDA.

So what is the role of this base?

Is the amount of carbonyl compound

converted to an enolate ion

Depends on the pk_a of the carbonyl

compound and the particular base

used to remove the alpha hydrogen.

The increase space conditions used for

the aldol condensation are not suitable.

To give a better clarity on this,

we have this reaction here, say,

suppose sodium hydroxide or sodium alkoxide

tries to abstract the alpha proton or the

alpha hydrogen or from cyclohexanone.

Only a small amount.

Off the corresponding enolate will be formed.

And the product.

Water, which is the conjugate acid.

Is a stronger acid then the starting

ketone with a pk_a value of 15.7.

So we know that in any acid base reaction,

the equilibrium favors the

dissociation of the stronger acid

and formation of the weaker acid.

So what will happen here is that this

acid will re protonate this enolate ion,

shifting the equilibrium

towards left hand side,

giving these starting ketone.

But when LDA is used to

remove the alpha hydrogen,

essentially all the carbonyl compound

is converted to the enolate ion.

Because the product acid is a much

weaker acid than the carbonyl compound.

Therefore, LDA is the base of choice.

So when LDA is used.

It will abstract the acidic proton.

And the corresponding carbonyl will be formed

which will resonate into the enolate ion.

And you can see here the

conjugate acid which is formed.

He's having a pk_a of 35, so it is a

weaker acid than the starting ketone,

so the equilibrium in this case will

shift towards the right hand side.

Also Aqueous opening these reactions

are not carried out in aqueous media.

The most preferred solvent

for this is THF Tetra, hydro,

furan and LDA is readily

soluble in tetrahydrofuran,

also sodium hydride or soda made.

They are not soluble in THF that much.

That is the reason why LDA is the best

base used for the formation of enolates.

We already have some examples

for the enolate formation,

so in the first case you can see

that this is the alpha carbon,

so the base will abstract the proton.

From here, give the corresponding carboanion.

Then the carbon will resonate into

the enolate form with the formation

of the corresponding conjugate acid,

which we know that is a weak acid.

So the equilibrium here also

shifting towards the right hand side,

giving the enolate ion in

sufficient quantity.

In the next example we have.

Dicarbonyl compound,

so the methylene group is sandwiched

between the two carbonyl compounds,

so these are acidic proton LDA

will abstract this proton with the

formation of carbon and now here you

have Ester on one side and on the

other side you have a keto group,

so the enolate will be formed towards

the keto group because that carbonyl.

Group is more electrophilic than the

one from the Ester functionality.

And also in this case also the same.

Conjugate acid is formed,

which is the weaker acid.

With this I come to the end of

this module in which we have seen

what are enolate ions we have seen.

What are alpha hydrogens?

We have seen the pk_a values of

some of the carbonyl compounds.

Then we have seen one of the bases

employed for the generation of enolates.

And we have seen some examples

of generation of enolate ions.

These are the references.

Thank you.