

Hi dear students, I'm Padmini Chandan Raiker,

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Today I'm going to take up a module

from one of the courses of the

program of Bachelor of Science for

3rd year students in the subject

of chemistry in the Semester 6.

The course code is CHC110 and

the course title is organic chemistry.

This module is from the unit name,

reactions, and rearrangements.

And the name of my module is

Comparison of Clemmensen reduction.

Ann Wolff kishner reduction.

This is the outline of my module,

which consists of learning outcomes,

introduction, Clemmensen reduction,

its examples, wolf kishner reduction,

its examples, comparison of the two

methods and then the references.

At the end of this module,

students will be able to gain knowledge

about the two methods used for the complete

reduction of carbonyl functionality to

alkanes and they will be able to draw

comparisons between the two methods.

Most of the methods used for the

reduction of carbonyl functionalities,

that is, aldehydes and ketones,

yield the corresponding alcohols. That is

aldehydes give primary alcohols and

ketones give secondary alcohols.

There are various methods used for the same.

For example, catalytic hydrogenation,

metal hydride reduction, etc.

But the same functionality that is

carbonyl functionality of aldehydes

and ketones can be completely

reduced to methylene group.

That is  $\text{C}=\text{O}$  can be

completely reduced to  $\text{CH}_2$  group.

And this can be achieved using

mainly two methods.

Clemmensen reduction or Wolff

Kishner reduction,

and we're going to see both

these methods in this module.

First, we will see what

is Clemmensen reduction.

Clemmensen reduction is a chemical

reaction of aldehydes and ketones,

which yield corresponding methylene

compounds using amalgamated

zinc in hydrochloric acid.

So here carbonyl functionality

from aldehydes or ketones will be

completely reduced to a methylene

group using acidic conditions.

This reaction is named

after a Danish chemist,

Eric Christian Clemmensen.

He was born on August 12,

1876 in Ordence, Denmark.

He joined the pharmaceutical company Parke,

Davis and Co in Detroit, Michigan.

For the Clemmensen reduction,

he received his PhD in 1913 from

the University of Copenhagen.

This is the general reaction

of Clemmensen reduction.

So, you can see here

there is a carbonyl substrate.

$RC=OR'$ .

Now here  $R'$  can be

a hydrogen or an alkyl

group. Such a substrate

when reacted with zinc amalgam in HCl

gives the corresponding alkene so

the carbonyl functionality here

has been reduced down to  $CH_2$  group.

The original Clemmensen reduction

conditions are particularly

effective at reducing aryl alkyl ketones,

such as those formed in a

Friedel Crafts acylation.

Example acetophenone.

which has an aryl group

as well as an alkyl group.

So, acetophenone can be easily

reduced using Clemmensen reduction.

The two step sequence of Friedel Crafts

acylation followed by Clemmensen reduction

constitutes a classical strategy for

the primary alkylation of arenes.

To give a clarity on this statement,

let me first explain to you one of the

limitations associated with Friedel

Crafts alkylation. In Friedel Crafts

alkylation an aromatic compound,

say for example benzene, is reacted with

alkyl chloride in presence of anhydrous

$\text{AlCl}_3$ . In this reaction the alkyl group

gets attached onto the benzene ring.

Now the problem arises when you

want to get a product in which

the carbon group is attached through

a primary carbon which is adjacent to

a secondary or a tertiary carbon.

This happens because this particular

reaction involves an intermediate

which is a carbocation.

Whenever a primary carbocation is

formed and there is a possibility for

it to get rearranged to a more stable

secondary or a tertiary carbocation,

it readily does so.

So, for that I have taken one example here.

So, benzene is there which is reacted with.

n-propyl chloride in presence of

anhydrous  $\text{AlCl}_3$ . So the expected

product is n-propyl benzene,

but that is not formed.

What is formed is isopropyl benzene.

Why it happens?

It is because of the carbocation

which is formed in this reaction

in this reaction a primary carbocation is formed which then rearranges

to a secondary carbocation.

And, this secondary carbocation acts

as the electrophile which reacts with

benzene to give the isopropyl benzene.

So how to prepare n-propyl benzene?

n-propyl benzene is to be prepared using

two step sequence of Friedel crafts

acylation followed by Clemmensen reduction.

So, first benzene is to be acylated using

the Friedel Craft acylation reaction.

Then the acylated product is to be

reduced using Clemmensen reduction

and this will give us

n-propylbenzene. In place of

Clemmensen reduction,

one can also make use of

Wolff kishner reduction.

With aliphatic or cyclic ketones,  
modified Clemmensen condition using  
activated zinc dust in an anhydrous solution  
of hydrogen chloride in diethyl ether or  
acetic anhydride is much more effective.

As mentioned earlier, this particular  
process is best suited for aryl alkyl ketones.

For non-aromatic ketones, not so much.

Now the substrate which is used  
in the reaction to be reduced  
should be tolerant of this strongly  
acidic conditions used in this reaction,  
which uses 37% of HCl.

Whenever the substrate is having a,  
say for example,

acid sensitive protecting groups

like acetal or silyl ethers

then this method cannot be used.

In this slide you can see some examples.

Acetophenone is there

which is an aryl alkyl ketone.

So acetophenone when subjected to

Clemmensen reduction using amalgamated

Zinc in HCl gives ethylbenzene.

Carbonyl group which is shown in red colour

has got converted to a methylene group

CH<sub>2</sub> shown in blue colour.

In the next example we have benzaldehyde

which is an aromatic aldehyde

which when subjected to Clemmensen

reduction using zinc amalgam in HCl

It is giving us toluene wherein

CH double bond or group has got

converted to CH<sub>2</sub> group then.

Meaning one hydrogen is already there.

So we get to lean there.

The next example,

we have four hydroxy three

methoxy benzaldehyde.

This when subjected to clemmenson

reduction we have aldehyde functionality.

I'd add functionality there.

So the idea that functionality has  
got converted to CF<sub>3</sub> group there.

In the last example,  
you can see one naphthyl methyl  
into I'll octane one on this when  
reacted with amalgamated sinking  
HCL gives 2 octyl naphthalene.

So here also.

The carbonyl functionality shown in red  
colour has got completely reduced to a  
methylene group shown in blue color.

So till here we have seen  
Clemmensen reduction.

So Clemmensen reduction is used  
for the complete reduction of.

Carbonyl functionality is like aldehydes  
and ketones using acidic conditions,  
so in this.

Carbonyl functionality  
of aldehyde and ketones.

In the presence of acidic condition

will get reduced completely

reduced down to methylene group.

Next let us see what is Wolf kishner reduction.

The Wolf kishner reduction is a reaction used

in organic chemistry to convert carbonyl

functionalities into methylene groups.

Condensation of the carbonyl compound,

with hydrazine forms

the hydrazone and treatment with base

induces the reduction of the carbon

coupled with oxidation of the hydrazine to

gaseous nitrogen to yield corresponding alkane.

It was reported by Nikolai

Kishner and Ludwig Wolff.

Ludwig Wolf was born on 27th September 1857.

And was a German chemist.

He studied chemistry at the

University of Strassburg,

where he received his PhD from Rudolph

Fittig in 1882. He became professor

of analytical chemistry at the

University of Giza in 1891 and held

this position till his death in 1919.

In 1911 he published a new reaction,

now known as the Wolff Kishner Reduction.

His name is also associated with

the chemical reaction known as

the Wolff Rearrangement.

Nikolai Kishner was born on 27th November

1867 and was Russian chemist in 1901

Kishner was appointed full

professor at Department of Organic Chemistry

of the Tomsk Polytechnic University.

In 1913 he left his position and returned

to Moscow because of some health issues.

This is the general reaction

of Wolff kishner reduction,

so here you can see carbonyl substrate

which can be an aldehyde or ketone.

This when reacted with hydrazine

that is  $\text{NH}_2\text{NH}_2$  in the presence of

acid under refluxing condition.

The carbonyl functionality is getting completely reduced to a methylene Group.

So carbonyl compounds that are stable in strongly basic condition can be easily reduced to alkenes.

So if the starting substrates is containing a base sensitive group, then this method cannot be employed for the same.

So in this slide you can see acetophenone when reacted with hydrazine it gets.

The condensation reaction takes place.

A hydrazone is formed so condensation of the carbonyl compound, with hydrazine, forms the hydrazone and then the hydrazone need treatment of treatment with base induces the reduction of the carbon coupled with oxidation of the hydrazine to gaseous nitrogen to yield corresponding alkane.

These are the examples of wolf

kishner reduction in the first case

we have Octan-2-one.

When subjected to wolf kishner

reduction it is giving us octane.

The carbonyl functionality

has got reduced to CH<sub>2</sub>,

the next we have a complex molecule

which is having CHO group.

So nothing is happening to

the rest of the molecule,

only the CHO group is getting reduced

to give the corresponding product.

Also, in the third example,

Chors group is there,

it is getting reduced to give the

corresponding product without

affecting the rest of the molecule.

Let us see now the comparison

between the two methods.

First we will see what is the similarity.

We have seen that both these methods

are used for the complete reduction  
of carbonyl functionality to yield methylene group or alkane.

That is, we start with carbonyl compound,  
that is Aldehyde or ketone and that  
carbonyl functionality  $C=O$  is reduced to or  $CH_2$  group.

What is the difference between  
the two Clemmensen reduction uses  
acidic conditions and wolf kishner  
reduction uses basic condition.

So when acidic conditions are used?

And so in clemmenson reduction.

Acidic conditions are used.

So if any acid is acid sensitive,  
group is present in the compound,  
then that method cannot be used.

And if all if Wolf Krishna reduction.

In that product is having a  
base sensitive group then.

That's after it cannot be reduced  
using wolf kishner reduction.

So here I have one example in which a

substrate is there which is subjected

to both Clemmensen reduction as

well as wolf kishner reduction.

So the basic conditions of wolf

kishner reduction and the acidic

conditions of clemenson will both

cause the methyl Ester to hydrolyse.

So

the Ester group is sensitive to

both acidic as well as basic conditions,

so it is getting hydrolized in

both the cases.

The ketone group is also getting

affected in both the cases,

but Nitro group is getting affected only

in the case of Clemmensen reduction.

So the zinc amalgam in the Clemmensen

reduction will also reduce the

Nitro group to the corresponding.

These are the references.

This is 1 web reference. Thank you.