Unit-1

Date = 23/08/2025

Organometallic Chemistry (Reagents) & Organo Sulphur Chemistry (compounds).

OMC having (C-M) bond

Compounds having (C-S) bond.

- Reactivity of OMC depends on polarity of C-M bond.
- OMC are the compds having a formal metal-carbon bond. The nature of the M-C bond determines the reactivity of OMC.
- More is the polarity of the M-C bond, more is the reactivity of the OMC.
- The reactivity of OMC follow the trend as given below

C-K > C-Na > C-Li > C-Mg > C-Al > C-Zn > C-Cd > C-Hg.

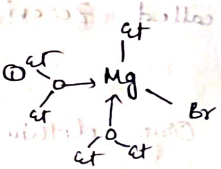
Grignard Reagent (Organomagnesium compd)

R-MgX

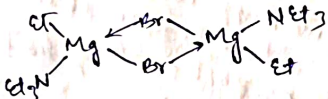
Alkyl Magnesium Halide

Structure

(1) The str. is found of EtMgBr is found to be



(2)



Str. (1) is formed when diethylether is taken as a solvent. On the other hand if triethylamine is used as a solvent str. (2) is formed.

Chemical RXNs of Grignard Reagent

RXNs of Grignard Reagent can be broadly classified into three categories given below —

(1) Double Decomposition RXN.

(2) Addition RXN followed by hydrolysis of addition prdt.

(3) Miscellaneous RXNs.

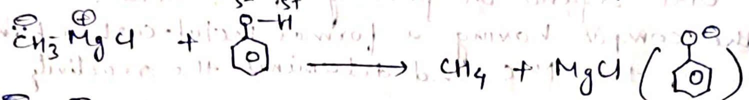
(1) Double Decomposition RXN

In this type of RXN, alkyl or aryl grp and $\overset{\oplus}{Mg}-X$ grp of Grignard Reagent is attached with $\oplus$ve or $\ominus$ve parts of attacking reagents respectively. Some examples of d.d.r are as follows-

(a) R.D.R of Grignard Reagent with compds having active H such as H—OH etc.

$\overset{\ominus}{CH_3}-\overset{\oplus}{Mg}Cl + \overset{\delta+}{H}-\overset{\delta-}{OH} \longrightarrow CH_4 + MgCl(OH)$

$\overset{\ominus}{CH_3}-\overset{\oplus}{Mg}Cl + C_2H_5-\overset{\delta-\ \delta+}{OH} \longrightarrow CH_4 + MgCl(C_2H_5O)$



$\overset{\ominus}{CH_3}\overset{\oplus}{Mg}Cl + C_2H_5-NH_2 \longrightarrow CH_4 + MgCl(C_2H_5NH)$

$\overset{\ominus}{CH_3}\overset{\oplus}{Mg}Cl + HC\equiv C-R \longrightarrow CH_4 + MgCl(\overset{\ominus}{C}\equiv C-R)$

Since in the above RXNs the Grignard Reagent reacts with the compds containing active H atoms forming methane molecule, this rxns are used for estimation of $-OH$, $-NH_2$ or $-SH$ in a given compd. The process is called Zerevitinov's Method of active H determination.

Date=28/08/2025

Organolithium = RLi (Alkyl Lithium)

Organo Zinc = R_2Zn

Organocopper = R_2Cu.

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C—Li > C—Mg > C—Cu > C—Zn

Higher Reactive

depends on the polarity of C—M bond.

$R-MgX + Cl-Cl \longrightarrow R-Cl + MgXCl$
Alkyl Chloride

$R-MgX + R-Cl \longrightarrow R-R + MgXCl$
Higher alkane

$R-MgX + NC-CN \longrightarrow R-CN + MgXCN$
Cyanogen
$\downarrow H_2O$
R—COOH

$CH_3MgCl + \underset{Cl}{\overset{Cl}{S}}=O \longrightarrow \underset{CH_3}{\overset{H_3C}{S}}=O + 2MgCl_2$

CH_3-MgCl Thionyl Chloride DMSO

(2) Addition rxn followed by hydrolysis

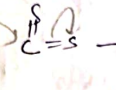
(a) $CH_3-MgCl + \frac{1}{2}O_2 \longrightarrow CH_3-O-MgCl \xrightarrow{H-OH,\ \text{Hydrolysis}} CH_3-OH + Mg(OH)Cl$

(b) $CH_3-MgCl + S \longrightarrow CH_3-S-MgCl \xrightarrow{H_3O^+} CH_3-SH + Mg(OH)Cl$
Thiol

(c) $CH_3-MgCl + C(=O)=O \longrightarrow CH_3-C(=O)-O^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-C(=O)-OH + Mg(OH)Cl$
Dry ice (solid)

(d) $CH_3-MgCl + C(=S)=S \longrightarrow CH_3-C(=S)-S^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-C(=O)-SH + Mg(OH)Cl$
Ethiyo acetic a

(e) $CH_3-MgCl + S(=O)=O \longrightarrow CH_3-S(=O)-O^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-S(=O)-OH + Mg(OH)Cl$
Methane sulphinic a

(f) $CH_3-MgCl +$  $\longrightarrow CH_3CH_2CH_2-O^-Mg^+Cl \xrightarrow{H_2O^+} CH_3CH_2CH_2OH + Mg(OH)Cl$
cyclopropane oxide

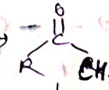
(g) $CH_3-MgCl + H_2C=O \longrightarrow CH_3-CH_2-O^-Mg^+Cl \xrightarrow{H_2O^+} CH_3-CH_2-OH$

(h) $CH_3-MgCl +$  $\longrightarrow CH_3-CH(CH_3)-O^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-CH(OH)-CH_3$

(i) $CH_3-MgCl +$  $\longrightarrow CH_3-C(CH_3)_2-O^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-C(CH_3)_2-OH$

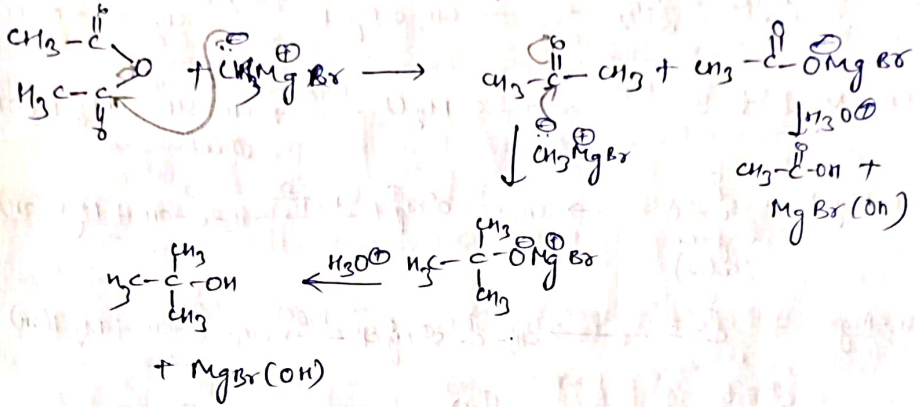
(k) $CH_3-MgCl + H-C\equiv N \longrightarrow CH_3-CH=N^-Mg^+Cl \xrightarrow{H_3O^+} CH_3-CH=NH + Mg(OH)Cl$
$CH_3CHO + NH_3 + Mg(OH)Cl$

(l) $CH_3-MgCl + CH_3-C\equiv N \longrightarrow CH_3-C(CH_3)=N^-Mg^+Cl \xrightarrow{H_2O^+} CH_3-C(=O)-CH_3 + NH_3 + Mg(OH)Cl$

(m) $CH_3-MgCl + R-C(=O)-Cl \longrightarrow CH_3-C(R)(H)-O^-Mg^+Cl \longrightarrow$  $+ MgCl_2$
$\downarrow CH_3-MgCl$

$H_3C-C(R)(CH_3)-OH \xleftarrow{H_2O} H_3C-C(R)(CH_3)-O^-Mg^+Cl$

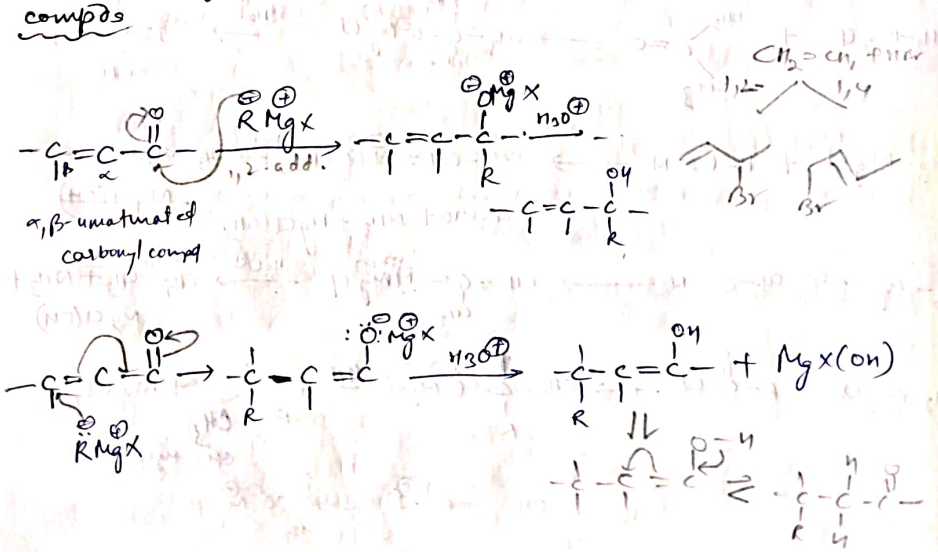
Rxn of Grignard Reagent with acid anhydride



* Miscellaneous

- $2RMgX + HgCl_2 \longrightarrow R_2Hg + 2MgX$
- $2RMgX + CdCl_2 \longrightarrow R_2Cd + 2MgX$
- $3RMgX + BCl_3 \longrightarrow R_3B + 3MgX$
- $4RMgX + SiCl_4 \longrightarrow R_4Si + 4MgX$
- $4RMgX + SnCl_4 \longrightarrow R_4Sn + 4MgX$
- $4RMgX + 2PbCl_2 \longrightarrow R_4Pb + 4MgX_2 + Pb$

Rxn of Grignard Reagent with α-β-unsaturated carbonyl compds



Grignard Reagent reacts with α,β-unsaturated carbonyl compds to give 1,2 and 1,4-addition prdt. The orientation of addition is controlled by steric factor. In most cases α,β-unsaturated ketones, both the prdts are formed. The extent of 1,4-addition can be ↑ed by carrying out the rxn in ⊖nce of $CH_3(CuI)$, $CH(CH_3COO)_2$ cuprous chloride or cupric Acetate. 1,4-addition is also known as conjugate Addition and occures by Free Radical Mechanism.

Limitations of Grignard Synthesis

- Since Grignard Reagent is highly sensitive to moisture, oxygen, CO_2, carrying out a rxn of Grignard Reagent is very difficult.
- Generally, branching of the carbon chain near the functional grp restricts the attack of Grignard Reagent. For example: CH_3MgBr fails to react with ditertiarybutyl ketones. Similarly, Grignard Reagents having larger alkyl grp are less reactive.
- Grignard reagent cannot be prepared from alkyl halide containing other reactive functional grp such as -OH, -SH, $-NH_2$, $-SO_2$, -CHO, -COOH, -CN etc.
- Compds which are capable of enolization decompose Grignard Reagent.

② Organolithium Comp

Organolithium comps like alkyllithium can be prepared by the rxn betⁿ alkyl halide or aryl halide with Li-metal in dry ether or THF.

$$R\text{-}X + 2Li \xrightarrow[\text{ether}]{\text{dry}} R\text{-}Li + LiX$$

The alkyl halides can be 1°, 2° or 3°. However, reactivity of alkyl halides ↑es in the order —

Alkyl Chloride < Alkyl Bromide < Alkyl Iodide.

Alkyl Fluorides are relatively unreactive comps like vinyl halides or aryl halides.

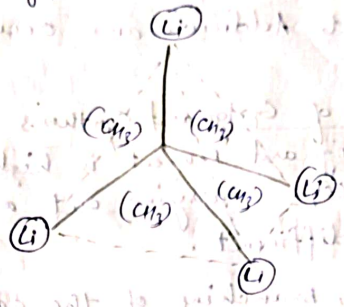
$$R\text{-}\overset{\text{Most}}{I} + Li \rightarrow R^{\ominus} + LiI$$

$$\downarrow H_2O$$

$$RH + LiI.$$

Structure of Alkyl Lithium

Methyl Lithium is known to exist in tetrameric form $(CH_3Li)_4$. With the help of X-ray diffraction studies, it has been established that in this tetrameric organometallic, Lithium metals occupy the corners of a tetrahedron and the methyl grps are centered over the facial planes as shown.



Reaction of Alkyl Lithium

As in Grignard Reagent, Organolithium compds contain a polar covalent bond, C–Li. Because of the greater electropositivity of Lithium, the C–Li bond is more ionic then C–Mg bond and thus organolithium compds are more reactive than Grignard Reagent.

1) Synthesis of hydrocarbons

Alkyl Lithiums react with compds having active H atoms, such as carboxylic acids, alcohols, water and 1° and 2° amines liberating the hydrocarbon in quantitative yield.

$$R\text{–}Li + H\text{–}Z \longrightarrow R\text{–}H + Li^{\oplus}Z^{\ominus}$$

$Z = O\text{–}\overset{O}{\overset{\|}{C}}\text{–}R$

$= -O\text{–}R$

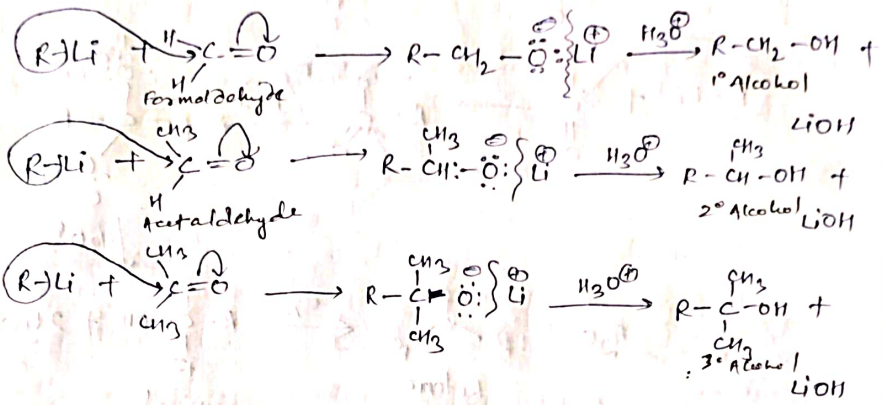
$= -OH$

$= -NH\text{–}R$

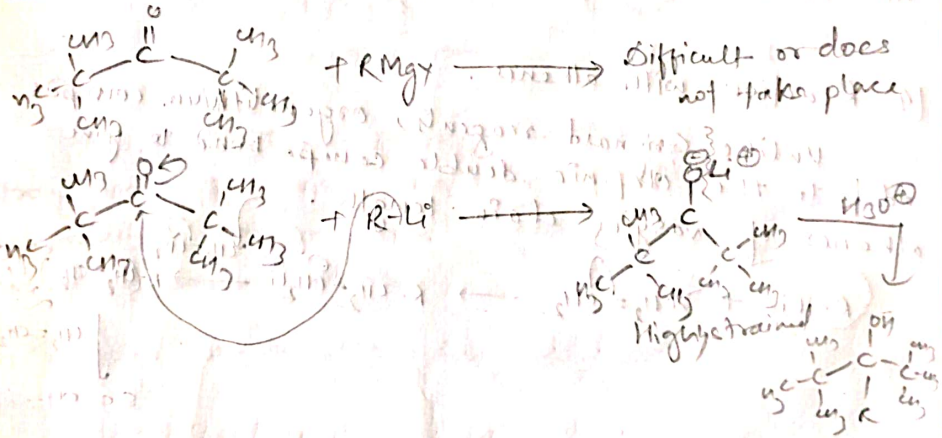
$= -N(R)\text{–}R$

(2) Synthesis of 1°, 2° and 3° alcohol

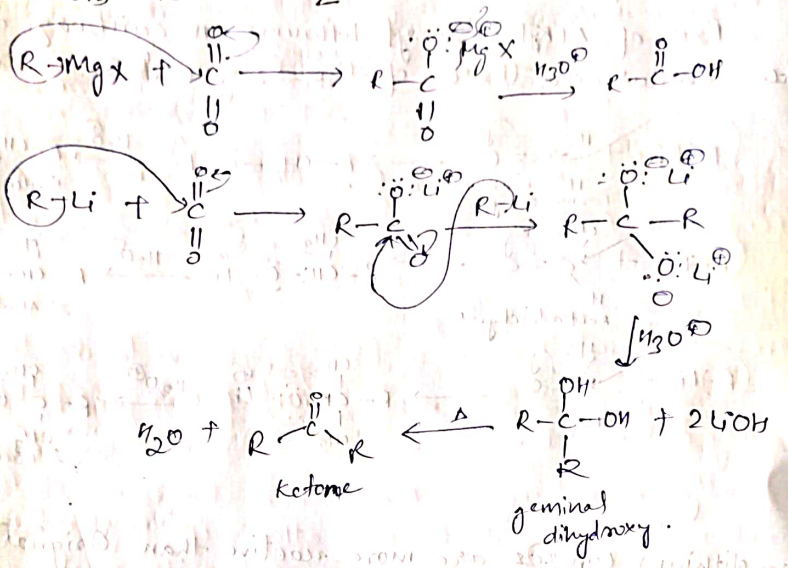
Rxn of Alkyl or aryl lithiums on carbonyl compds are similar to those of the Grignard Reagents



Organolithium compds are more reactive than Grignard Reagents and therefore more difficult to handle. Hence, Grignard Reagents are preferable for simple additions to carbonyl compds. However, organolithiums have an advantage of over grignard reagent. Grignard reagents failed to give 3° alcohols when treated with highly hindered Ketones while alkyl lithiums can easily react and form the corresponding 3° alcohols.



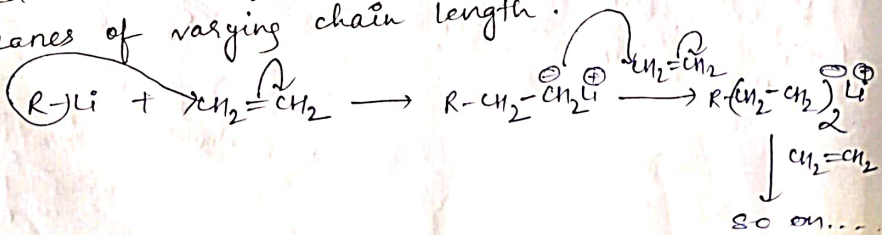
(3) Reactions with $-CO_2$.



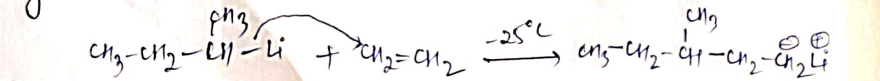
The basic difference bet^n the rxn of Grignard reagent with $RMgX$ and $R-Li$ is that, while $R-MgX$ reacts with one molecule of $-CO_2$ to produce to carboxylic acids, $R-Li$, bcoz of its higher reactivity, two molecules of it reacts with $-CO_2$ to produce a ketone via an unstable gem. dihydroxy compd.

(4) Reaction with alkenes.

Unlike Grignard reagents, organolithium compds add to the olefinic double compd bond to give alkanes of varying chain length.

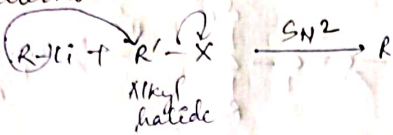


2° and 3° alkyl lithiums react efficiently with ethene to give monomeric prdts at low temp^r.

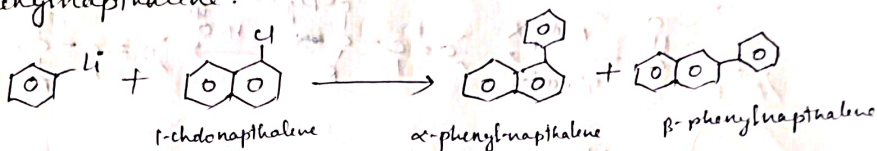


(5) Nucleophilic displacement

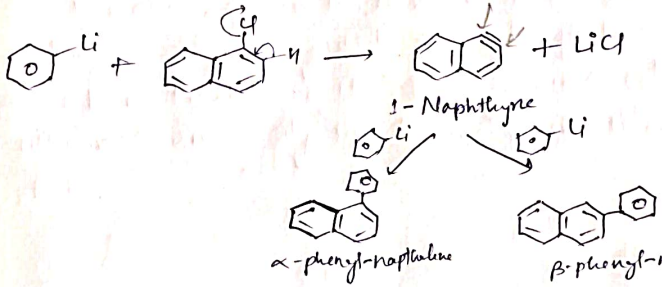
Alkyl lithium compds can be used in substitution reaction similar to S_N2 type during reaction with haloalkanes.



Phenyl lithium on treatment with 1-chloro-napthaline gives a prdt containing both α-phenyl napthaline & β-phenylnapthaline.

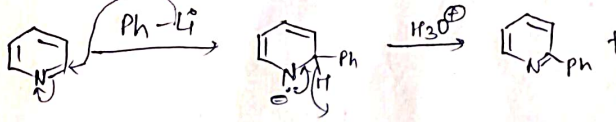


Formation of isomeric phenylnapthalenes can be explained on the basis of following mechanisms

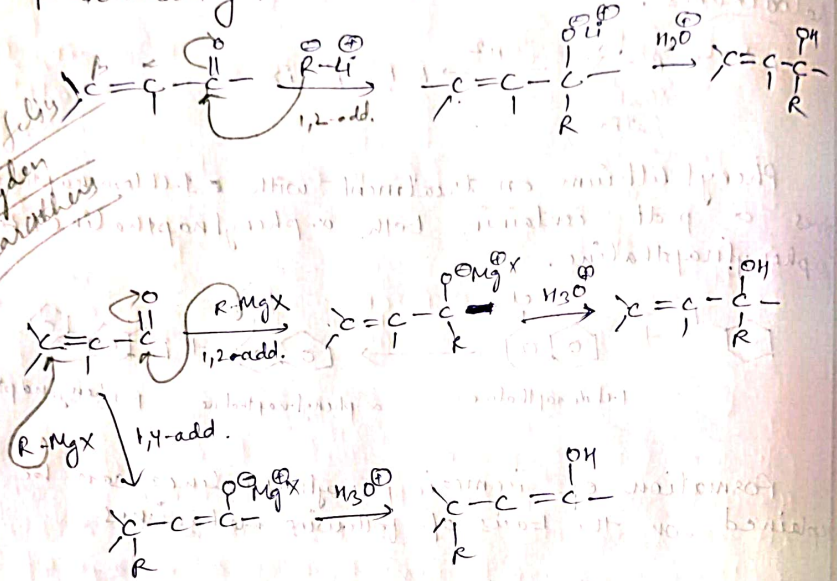


Here, phenyllithium plays a dual role, it acts as a strong base to remove the ortho-H generating the corresponding naphthyne and it also acts as a $Nu^{\ominus}$ to form the isomeric compds.

(6) Pyridine reacts with phenyl lithium to form 2-phenylpyridine



(7) Alkyllithiums react with α,β-unsaturated carbonyl compds to give the 1,2-addition prdt predominantly.



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Organo copper compound

Two types of organo copper compounds are of synthetic importance.

1) Alkyl copper, RCu
2) Lithium dialkyl cuprate, R_2CuLi (Less reactive & weak reagent)

The organocuprates, Lithium dialkyl cuprite react more repeatidly and usually gives higher yield then alkyl copper compound. The organocuprates are more reactive then Grignard Reagent and organo Lithium compound.

For Example:- To prepare an alkene from alkyl halides, Lithium dialkyl cuprates are mostly used.

$$R-MgX + R'-X \longrightarrow \text{slow or No } rx^n$$

$$R-Li + R'-X \longrightarrow \text{slow or no } Rx^n$$

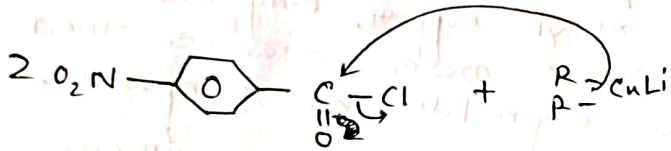
$$R_2CuLi + R'-X \longrightarrow R-R' + RCuLi$$

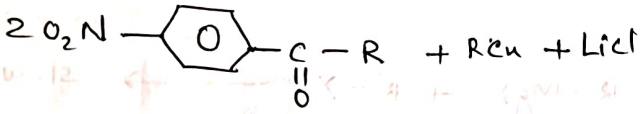
Higher alkane

Less affinity of organomagnesium and organoLithium compound is due to the Less tendency towards soft & - hard interaction.

organocopper compounds are highly selective towards the different functional gp and these selectively is a major factor in determining their usefulness.

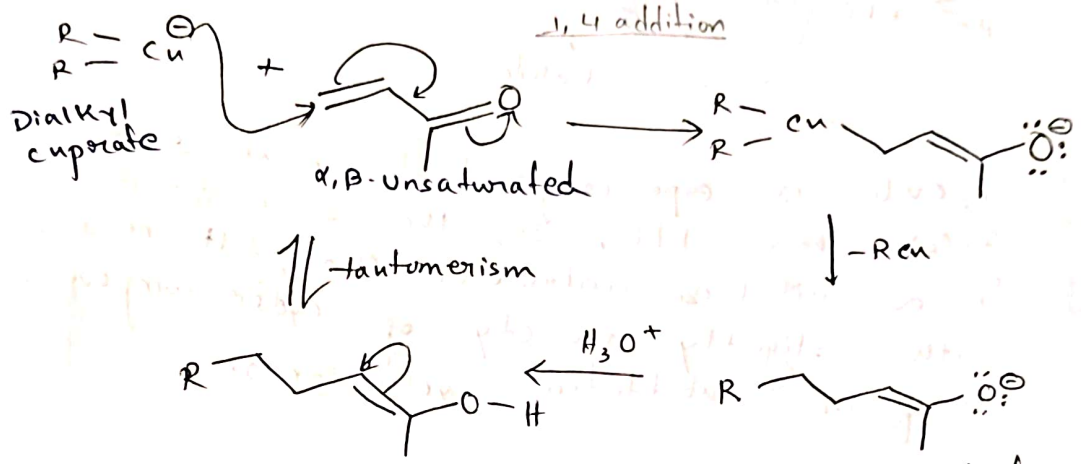
Lithium dialkyl cuprates do not react with many functional gp which Grignard Reagent and organo Lithium do react. These are $-NO_2$, $-CN$, $-COOR$ etc. Thus, presence of one of these functional gp in the acid chloride does not interfer with the synthesis of a Ketone.



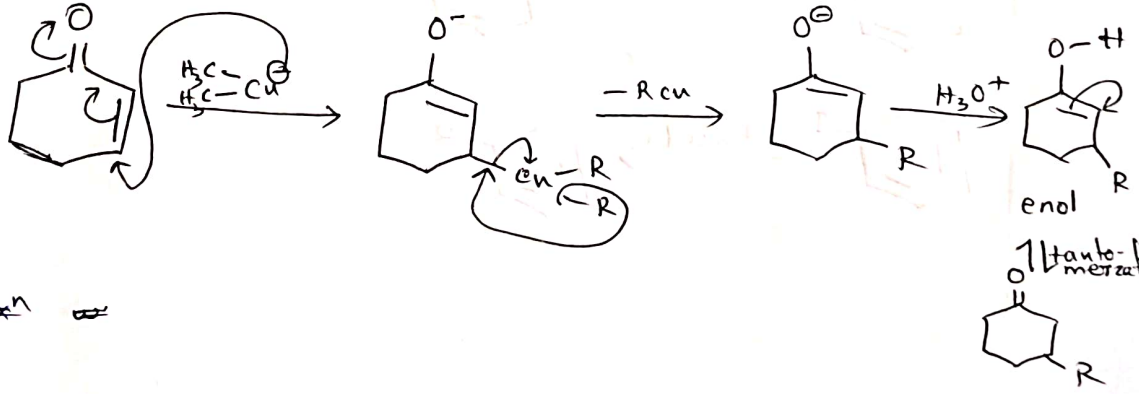


~~Dialkyl Lithium~~ ~~cuprate with unsaturated~~

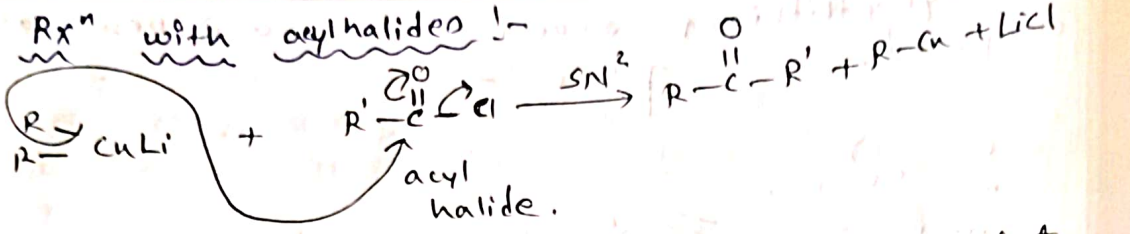
* Dialkylcuprate Lithium reacts with α, β-unsaturated compound as follows :-



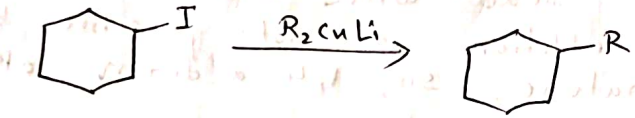
Dialkyl cuprate react with α, β-unsaturated compound, 1, 2 addition is not possible bcoz of the bulky nature, so, 1, 4 addition taken place. elimination of R-cu.

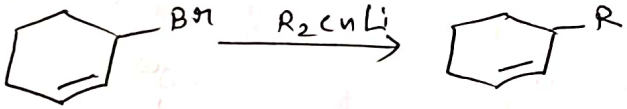


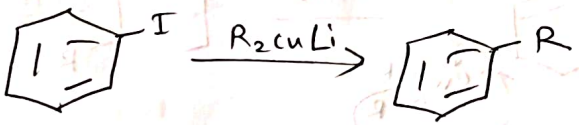
Rxn with acylhalides :-



R_2CuLi is comparatively most stable that can be kept in a suitable container. Also, it reacts with slightly variety of cyclic compounds to form substituted cycloalkanes.







10/10/25

Organo zinc compounds:-

Electronegativity difference betⁿ C and Zn is very less, so, such organo-metallic compound can be prepare by trans metallation Rxⁿ.

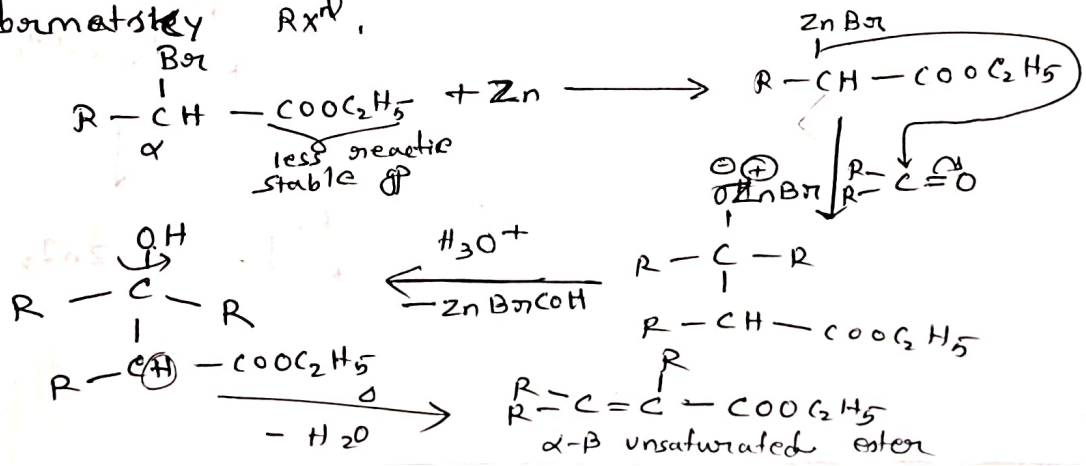
For Eg:-

$$2RLi + ZnCl_2 \longrightarrow R_2Zn + 2LiCl$$

But, R_2Zn is unstable and expossive in nature and is easily attack by H_2O, HCl or C_2H_5OH. on the other hand, Zn being a divalent metal like Mg is expected to form Grignard types compounds. But such organo zinc compound easily undergo disproportion Rxⁿ.

$$2RZnX \longrightarrow R_2Zn + ZnX_2$$

* However, when an electron withdrawing gp like COOR, is present in the attacked carbon of C-Zn bond, the stability of the resulting organo zinc compound. This type of organozinc compound is formed as intermediate in Reformatsky Rxⁿ.

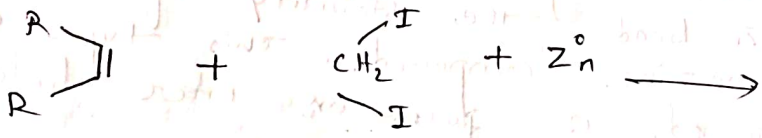


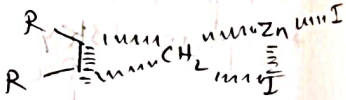
Since, organozinc compound are much more reactive other Grignard Reagent ($RMgX$) or alkyl Lithium or RLi. They chemo selectively attack the keto carbonyl gp not the ester gp. The organozinc compounds also do not attack $C{\equiv}C$ CN or CO_2

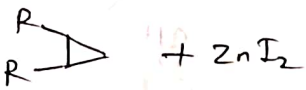
② Simmon-Smith Reaction cyclopropanation alkene

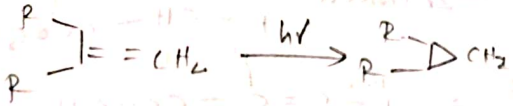
The $C=C$ of alkene is converted to cyclopropane ring. by treated with methylene Iodide. In the presence of metallic zinc.

In this reaction, A transient organozinc compound is formed.









Thiol

16/09/25

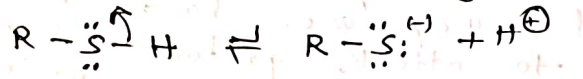
thio – S – SH

preparation of thiol & chemical rxn of thiol — Google classroom

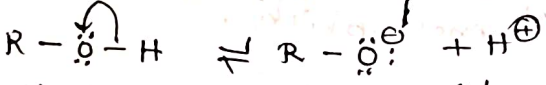
Acidic property of thiols.

R–SH ← more acidic

R–OH Acid is stronger if its cB is stable.



Thiol cB Thiolate ion



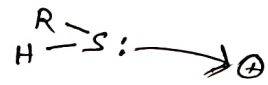
Alcohol Alkoxide

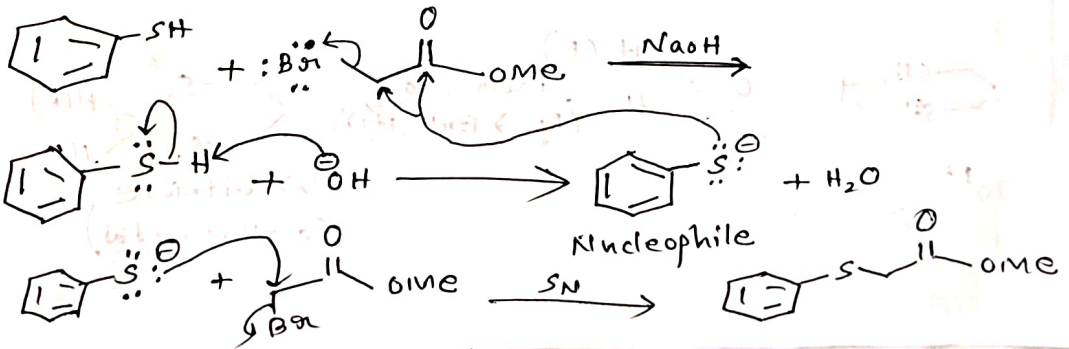
Nucleophilicity of Thiols:-

↑ behaviour as a nucleophile

$\ddot{N}u^{\ominus}$

R–SH

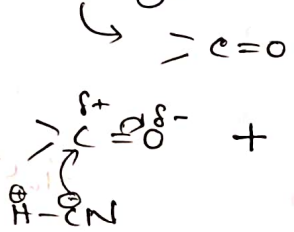




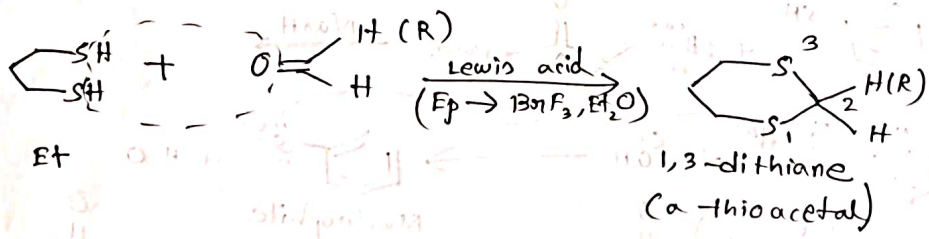
consider, the above Rxn, Here, Thiolate ion prefers to attack at the saturated carbon, and not the carbonyl carbon. There is because sulfur nucleophiles are soft.

Smaller oxyanions have high charge density and low Energy fills orbital - they are hard nucleophiles and prefer to attack proton and the carbonyl group. Larger, Less basic thiolates anion have high Energy filled orbital and are soft nucleophile.

Umpolung Reversal of polarity :-



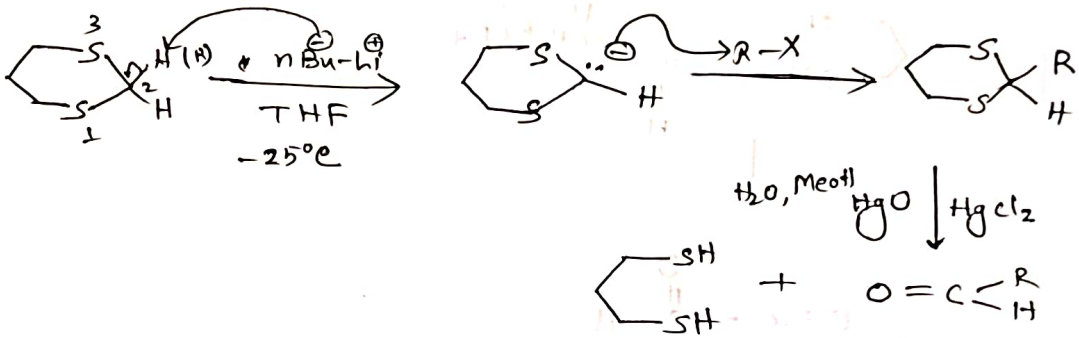
Nucleophilic addn Rxn :-



Here, the H atom in C_2 is relatively acidic because of adjucent as atom.

The anions derived from the dithianes react with alkyl halide to it the corresponding alkylated dithianes.

There treatment with $HgCl_2$ / HgO Regenerates aldehyde or ketone



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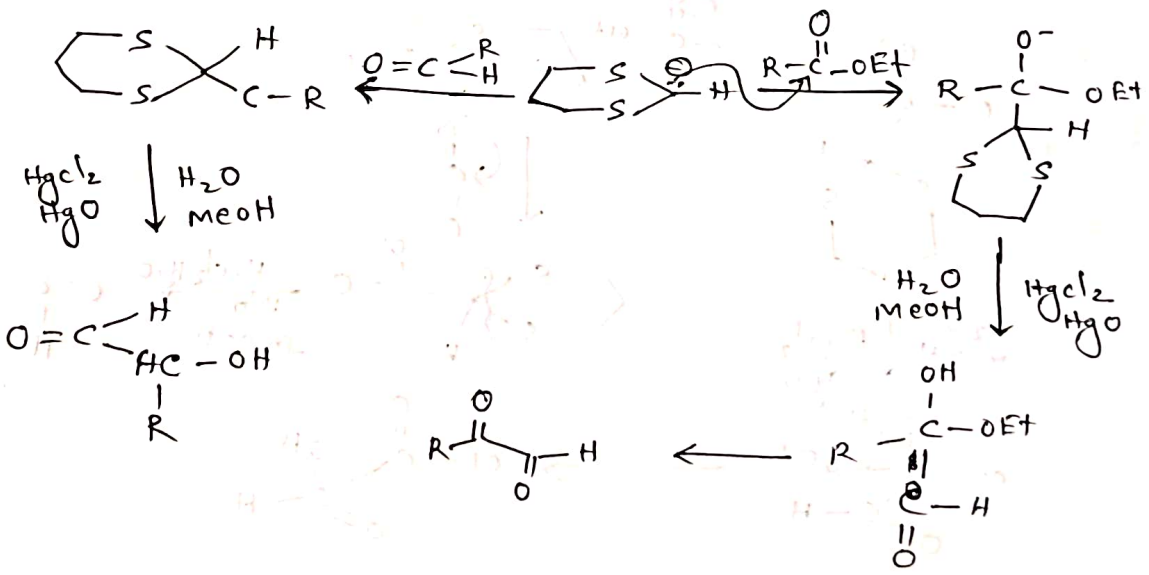

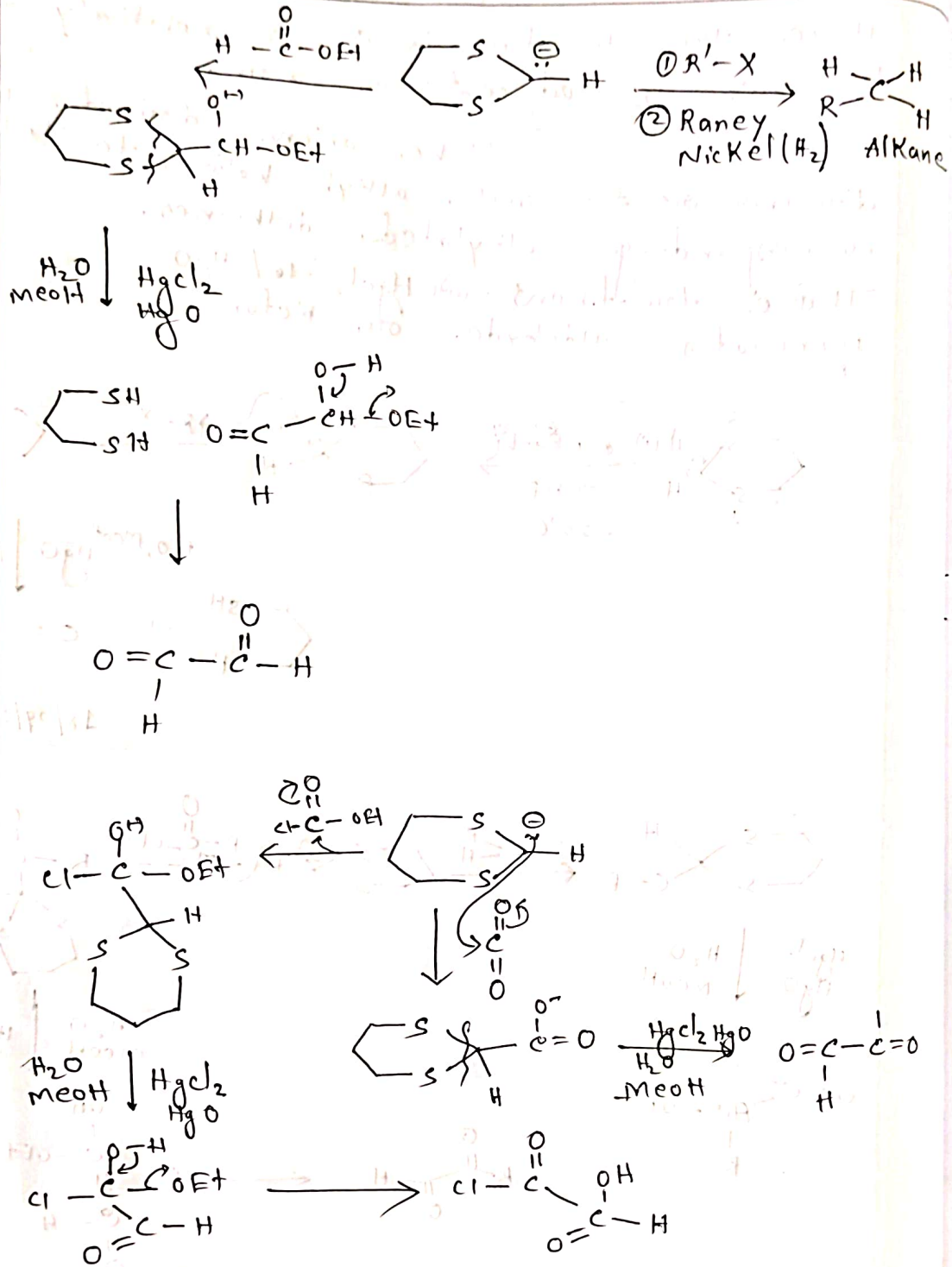
H – C(=O) – OEt
CH – OEt
① R' – X
② Raney Nickel (H2)
Alkane
H2O
MeOH
HgCl2
HgO
SH
SH
O=C – CH – OEt
H
O=C – C(=O) – H
Cl – C – OEt
Cl – CH2 – C(=O)
HgCl2 HgO
H2O
MeOH
Cl – C – OEt
O=C – H
Cl – C(=O)
OH
O=C – H

Use of dithiane umpolung to prepare complex natural product :-