

Organic Chemistry | Reaction Mechanisms

Best Lab Route to Ethers

Mastering the Williamson Synthesis

The Fundamental Equation

The Nucleophile

Sodium Alkoxide



Acts as both a strong nucleophile and a strong base.



The Electrophile

Alkyl Halide



The substrate targeted for attack.



The Product

Ether + Salt

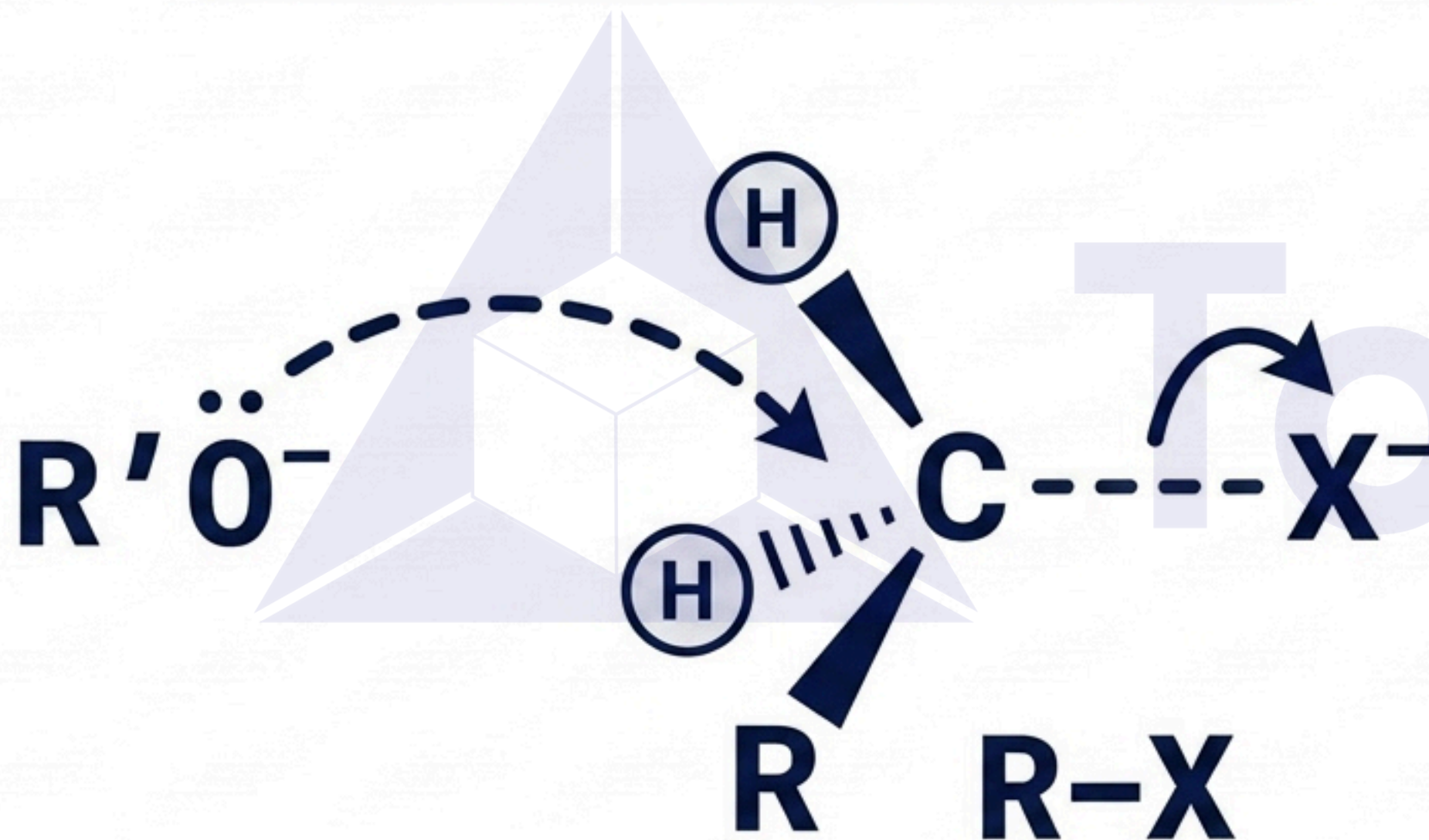


Can be a symmetrical or unsymmetrical ether.



Driven by SN2 Attack

Bimolecular Nucleophilic Substitution (SN2)



Backside Attack

Alkoxide ion attacks the carbon from the opposite side of the carbon-halogen bond.

Concerted Mechanism

Bond formation and bond breakage occur in a single, simultaneous step.

Leaving Group

The halide ion (X^-) acts as the leaving group, completing the substitution.

The Exam Rule: Substrate Choice is Everything

Primary (1°)

Primary Halide

Reaction Pathway:
Pure SN2

Ether formed cleanly
in high yield.

Works Best!

Secondary (2°)

Secondary Halide

Reaction Pathway:
SN2 competes with E2
(Elimination)

A messy mixture of
ether and alkene.

Mixed Products

Tertiary (3°)

Tertiary Halide

Reaction Pathway:
100% Elimination (E2)

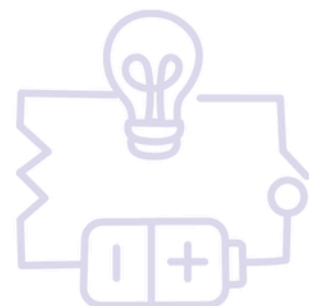
Exclusively Alkene.
No ether is formed.

Alkene Trap!



**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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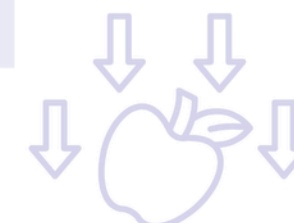
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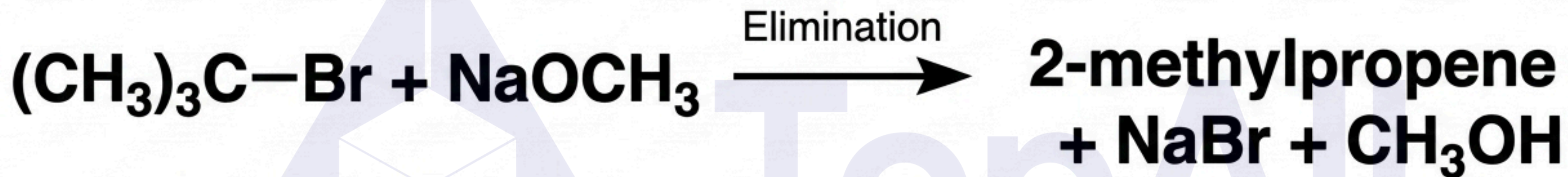
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Why Tertiary Halides Fail

Alkoxides are not just nucleophiles; they are strong bases.



The Alkene Trap

Steric hindrance on a tertiary halide entirely blocks the $\text{S}_{\text{N}}2$ backside attack. This forces the strong base to steal a proton instead, resulting in an **elimination** reaction.

Building Unsymmetrical Ethers

Goal: Synthesize t-butyl ethyl ether

The Wrong Way



Strategy:

Reacting a tertiary halide + primary alkoxide.

Equation:

t-butyl bromide + sodium ethoxide

Result:

Alkene formation (Elimination).

The Right Way



Strategy:

Reacting a primary halide + tertiary alkoxide.

Equation:

ethyl bromide + sodium t-butoxide

Result:

High yield of t-butyl ethyl ether (S_N2).

Always put the bulky group on the alkoxide. Keep the halide primary.

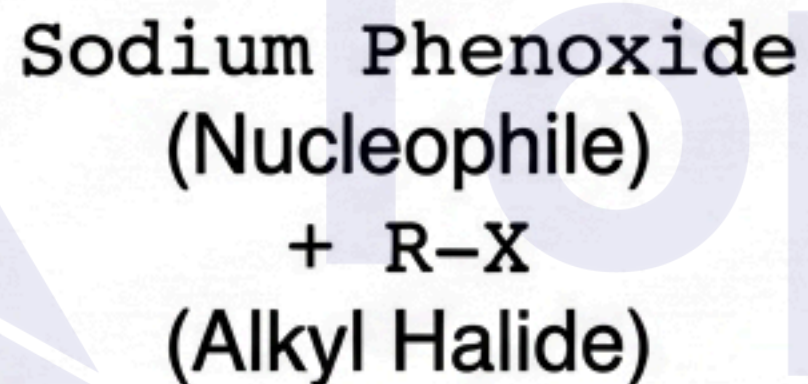
Synthesizing Aromatic Ethers

The Williamson approach extends perfectly to aromatic rings by utilizing a phenoxide intermediate.

Step 1



Step 2



Step 3



Industrial Application

This exact synthetic route is the primary laboratory method used to synthesize Anisole (methoxybenzene).

The Chemist's Summary



Primary Halides = Ethers

The less hindered the alkyl halide, the cleaner the S_N2 attack and the better the ether yield.

Tertiary Halides = Alkenes

Never use bulky tertiary halides. Steric hindrance blocks substitution, forcing complete elimination.

Bulky Alkoxides are Safe

Need a branched ether? Make the alkoxide bulky, not the halide. Alkoxides don't suffer the same steric penalties during attack.

Aromatic Compatible

Phenol easily converts to a phenoxide ion, making it a perfect nucleophile for synthesizing alkyl aryl ethers.



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