

Ether or Alkene?

Controlling the Dehydration of Alcohols



Alcohol Dehydration with Acid

Heating an alcohol in the presence of a protic acid triggers dehydration. However, the outcome is rarely singular. The reaction faces a critical crossroad depending strictly on the reaction conditions.

General Reaction (Two Possibilities)



Option A:
Substitution to form an
Ether (R-O-R)

Option B:
Elimination to form an
Alkene (C=C)

Protic Acid Catalyst Required (e.g., H₂SO₄, H₃PO₄)

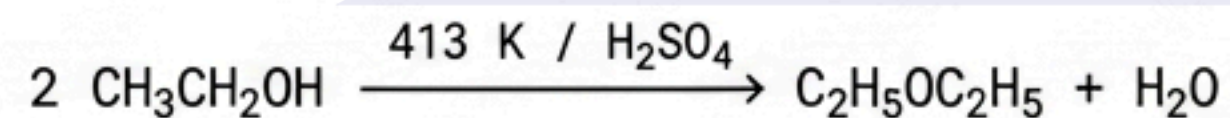
The Temperature Shortcut

The fate of the reaction hinges entirely on temperature. Lower heat favors substitution (Ether); higher heat forces elimination (Alkene).

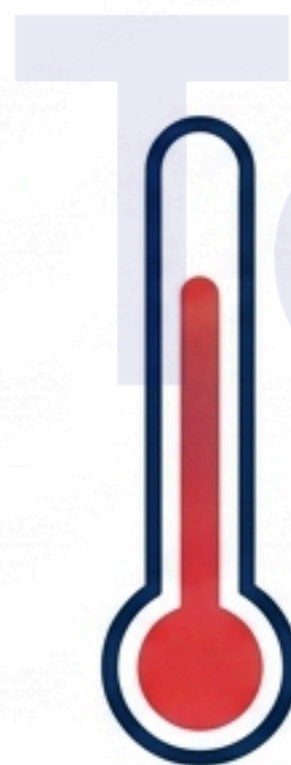
413 K (140 C)

Pathway: Nucleophilic Substitution (SN2)

Product: Ethoxyethane (Ether)



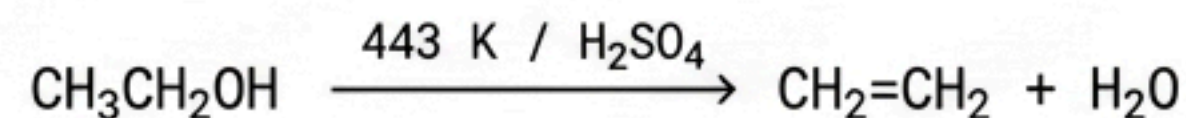
Desired Ether Pathway



443 K (170 C)

Pathway: Elimination

Product: Ethene (Alkene)



Competing Alkene Pathway



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$$E=mc^2$$



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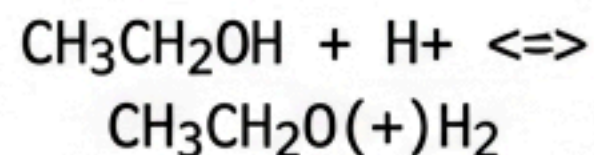


The S_N2 Mechanism

Ether formation is a nucleophilic bimolecular reaction. It involves the attack of an unprotonated alcohol on a protonated alcohol.

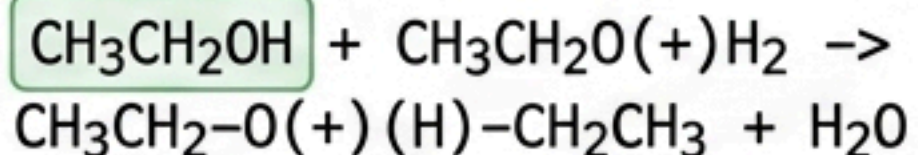
1 Protonation

Acid catalyst donates a proton, creating a good leaving group (H₂O).



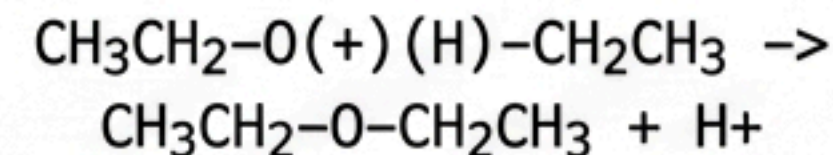
2 Nucleophilic Attack

A second alcohol molecule attacks, displacing water.



3 Deprotonation

The intermediate loses a proton to regenerate the acid catalyst.



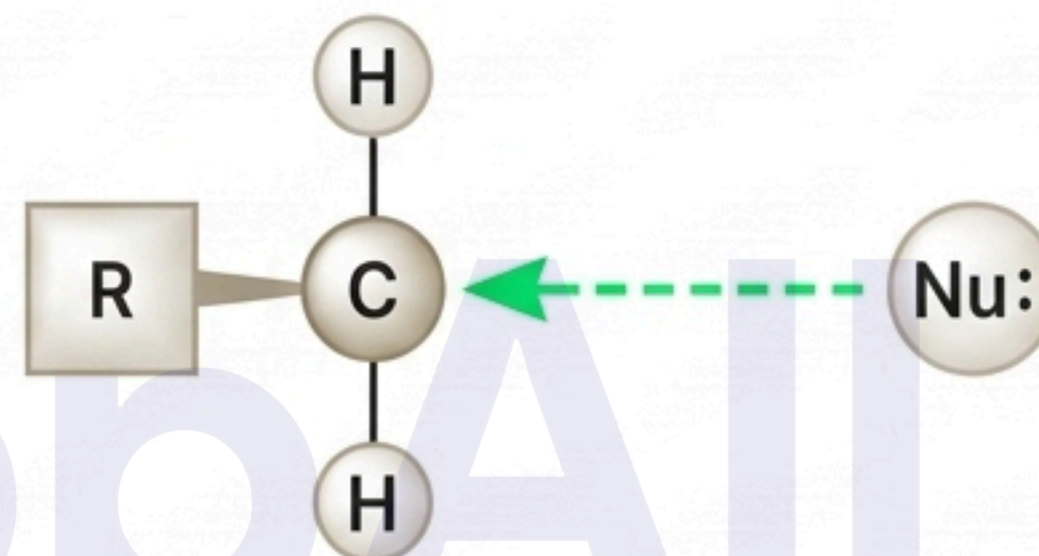
Primary Alcohols Preferred

For this dehydration method to yield an ether, the alkyl group must be primary and unhindered.

Why Primary?

The S_N2 mechanism requires the nucleophile (the second alcohol molecule) to physically reach and attack the carbon atom. Primary alcohols leave this attack angle wide open.

The Unhindered Path



- Target carbon is exposed.
- Bimolecular substitution (S_N2) proceeds smoothly.
- Optimal condition for ether synthesis.

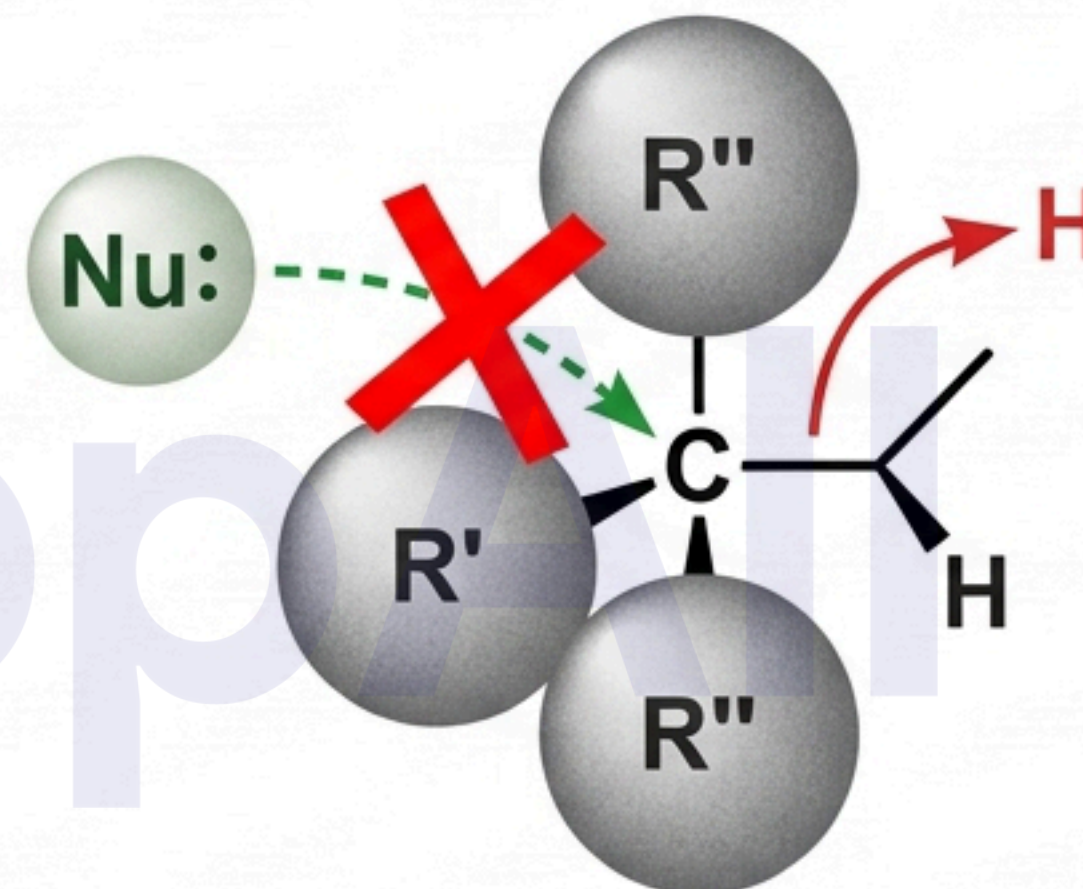
The Secondary & Tertiary Trap

Dehydration of secondary and tertiary alcohols to give corresponding ethers is highly unsuccessful.

Elimination Dominates

Alkoxides are strong bases. With bulky secondary or tertiary alkyl groups, steric hindrance physically blocks the S_N2 nucleophilic attack. Elimination heavily competes with and overpowers substitution.

The Result



Alkenes are exclusively formed.

Rule: Do not use for Sec/Tert Alcohols

Preparation by Dehydration: The Cheat Sheet



The successful synthesis of ethers via acid dehydration requires strict adherence to two main variables.

Variable	Ether Pathway (SN2)	Alkene Pathway (Elimination)
Temperature	Low (413 K / 140 C)	High (443 K / 170 C)
Substrate Type	Primary Alcohols Only	Secondary & Tertiary Alcohols
Reagent/Catalyst	H2SO4 or H3PO4	H2SO4 or H3PO4
Primary Action	Nucleophilic substitution	Proton elimination

Key Takeaway: To make an ether, keep the temperature strictly at 413 K and exclusively use unhindered, primary alcohols.



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