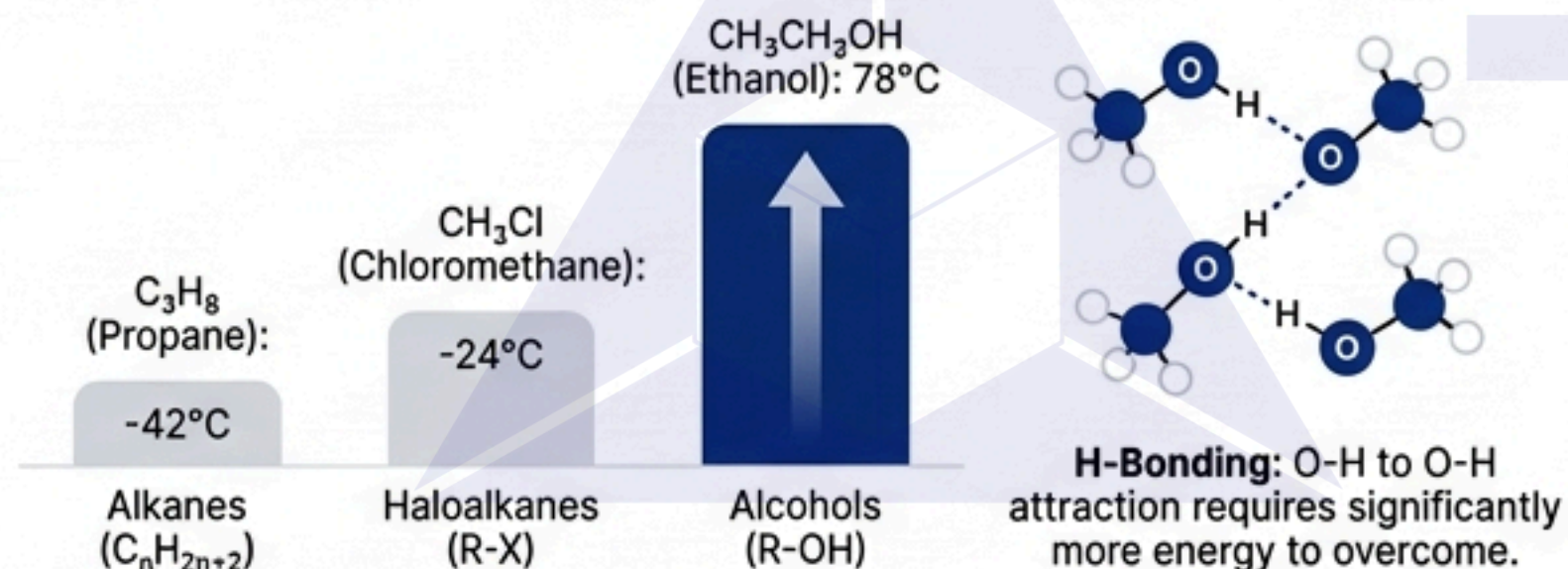


Physical Properties of Alcohols and Phenols

Understanding boiling points, solubility, and the molecular forces that drive them.

BOILING POINTS: THE HYDROGEN BOND ADVANTAGE

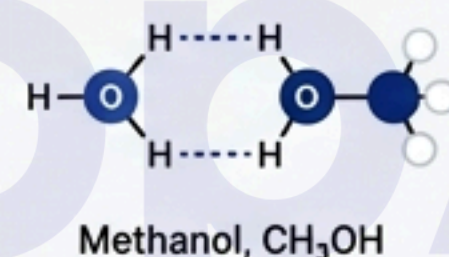
Strong Intermolecular Forces



SOLUBILITY: LIKE DISSOLVES LIKE

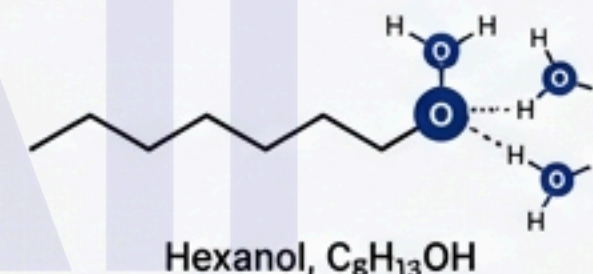
Water Miscibility & Hydrocarbon Chains

MISCIBLE IN WATER



Small alcohols (C₁-C₃) are completely miscible. The polar -OH group forms strong H-bonds with water.

DECREASING SOLUBILITY



As the hydrophobic alkyl chain grows (C₄+), solubility decreases. The non-polar part hinders H-bonding with water.

⚠️ DIAGNOSTIC TRAP: MOLECULAR WEIGHT MISCONCEPTION

While boiling point increases with molecular weight within a homologous series, the dominant factor comparing alcohols to similar-sized hydrocarbons is the presence of hydrogen bonding, not just mass.

Propane (MW 44) vs. Ethanol (MW 46): Ethanol's BP is drastically higher due to H-bonding.



SUMMARY TAKEAWAY: THE -OH GROUP EFFECT

The physical properties of alcohols and phenols are governed by the polar hydroxyl (-OH) group, which enables strong hydrogen bonding. This results in significantly higher boiling points compared to similar-sized hydrocarbons and high water solubility for lower molecular weight alcohols.

Phenols: Less soluble than lower alcohols due to the bulky aromatic ring, but still more soluble than corresponding aromatic hydrocarbons.

Slide slide

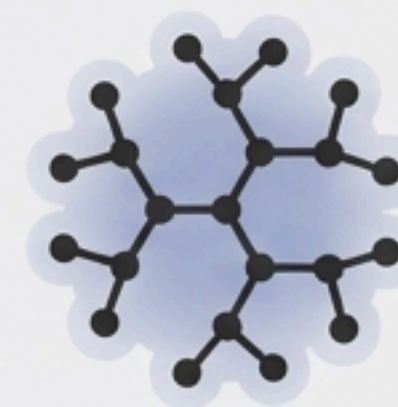
Intermolecular Hydrogen Bonding

The strong attraction between the polarized -OH groups of neighboring alcohol or phenol molecules. This is the primary driver of anomalously high boiling points.



van der Waals Forces

Weaker, surface-area-dependent forces. These increase with carbon chain length and decrease with structural branching.



The Molecular Interface: Boiling Point Determinants



**BP rises with
carbon count.**

Increased surface area amplifies van der Waals forces.



**BP falls with
branching.**

Molecules become spherical, reducing surface area and weakening van der Waals forces.



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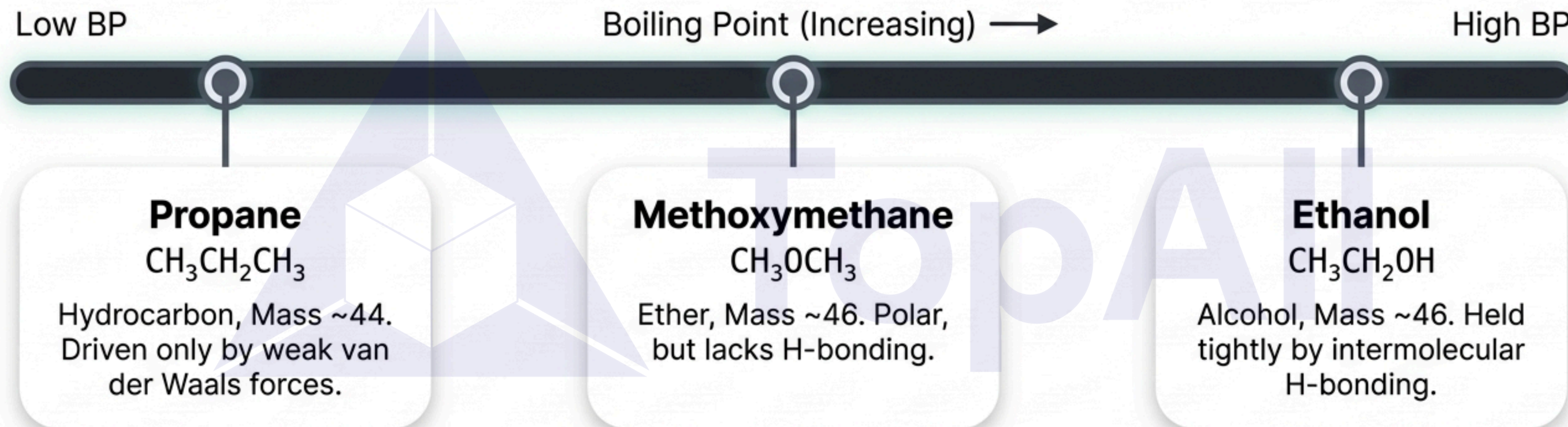
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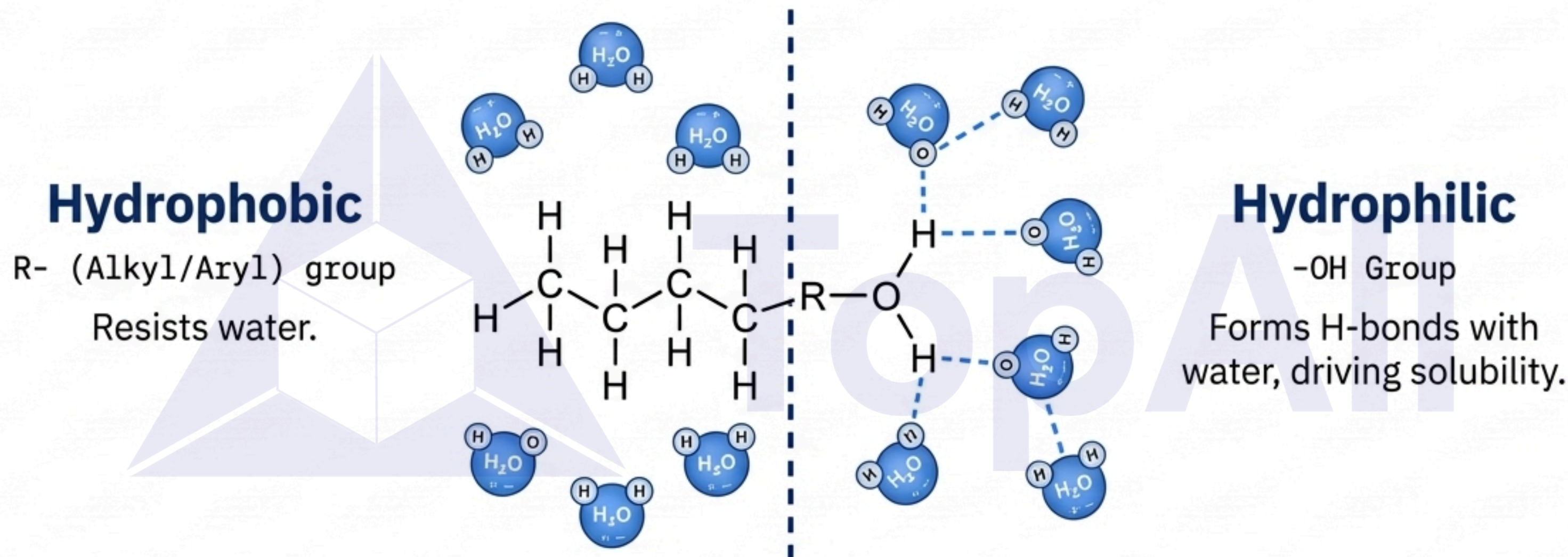


Boiling Point & Intermolecular Forces: Mass Constant, Type of Force Varies



By holding molecular mass constant, we prove that the type of intermolecular force strictly dictates the physical state.

The Molecular Interface: Alcohol Solubility and Structure



Solubility falls as the size of the hydrophobic alkyl/aryl group rises.
 Lower mass alcohols remain miscible in water in all proportions.

Which correctly ranks the boiling points of compounds with comparable mass?



Ethanol > Propane > Methoxymethane



Ethanol > Methoxymethane > Propane

Watch for this common comparison.

It is easy to assume ethers behave exactly like non-polar hydrocarbons due to their lack of H-bonding. However, ethers possess a net dipole moment. Therefore, their boiling point sits strictly INTERMEDIATE between a non-polar hydrocarbon and an H-bonded alcohol of comparable mass.

Key Takeaways

- Alcohols and phenols have anomalously high boiling points compared to hydrocarbons, ethers, or haloalkanes of similar mass entirely due to intermolecular H-bonding.
- Solubility in water is driven by H-bonding, but decreases as the hydrophobic alkyl/aryl chain grows larger. Conversely, boiling points rise with total carbon count but fall with structural branching.



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