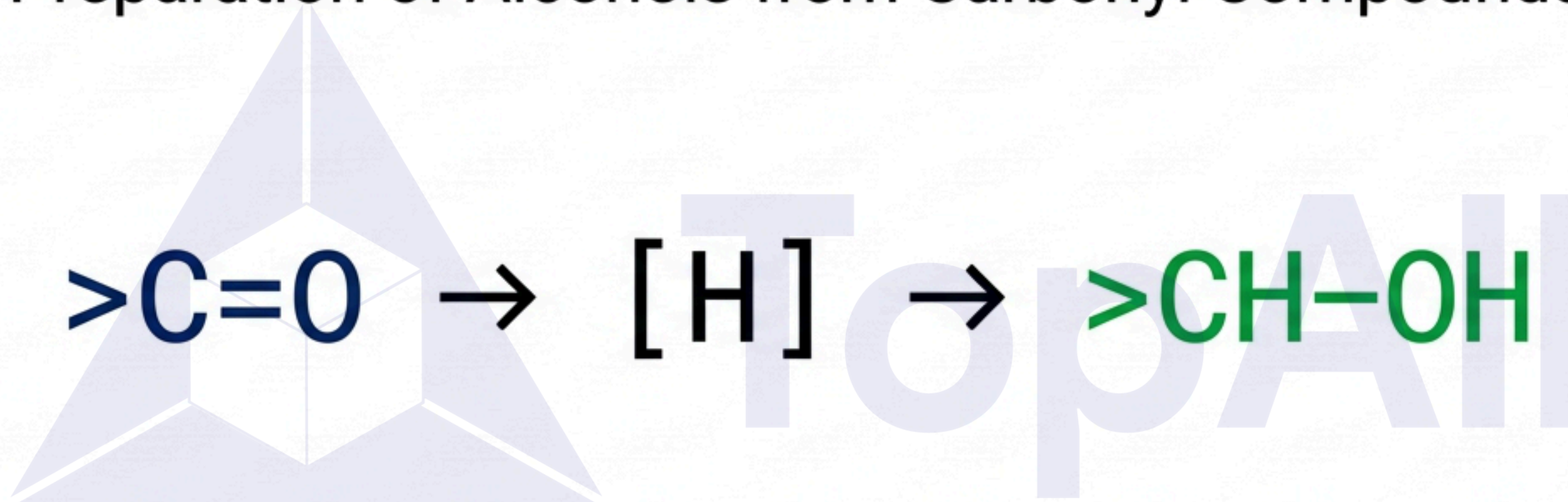


# Reduce C=O to C–OH

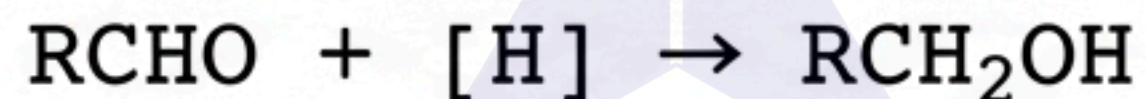
Preparation of Alcohols from Carbonyl Compounds



The Universal Reduction: Adding hydrogen across the carbonyl double bond.

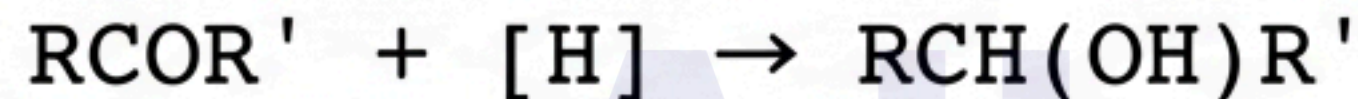
# The Foundation: Substrate Dictates Product

## Aldehydes



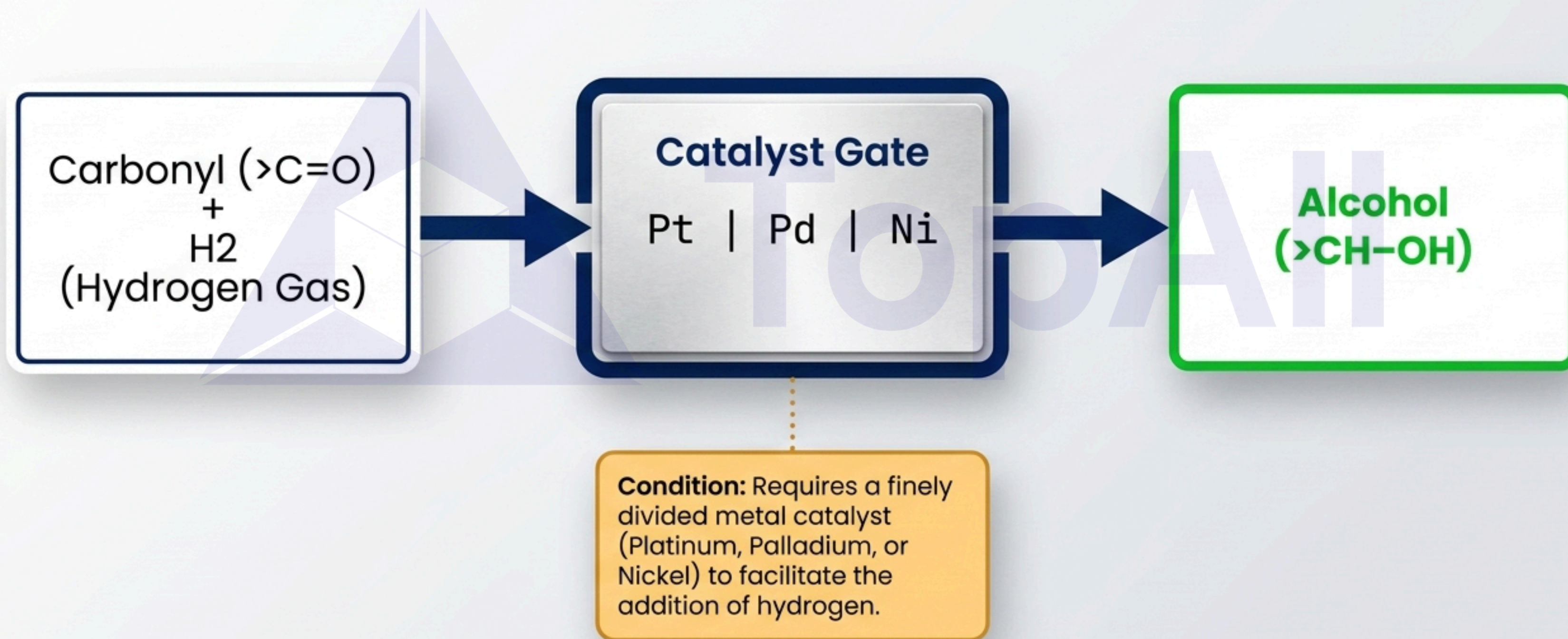
**Primary (1°) Alcohol**

## Ketones



**Secondary (2°) Alcohol**

# Tool 1: Catalytic Hydrogenation





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$$E=mc^2$$



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# Tool 2: Complex Metal Hydrides



## Standard Reduction

Excellent Yields

Effectively reduces Aldehydes  $\rightarrow$  1° Alcohols  
and Ketones  $\rightarrow$  2° Alcohols.

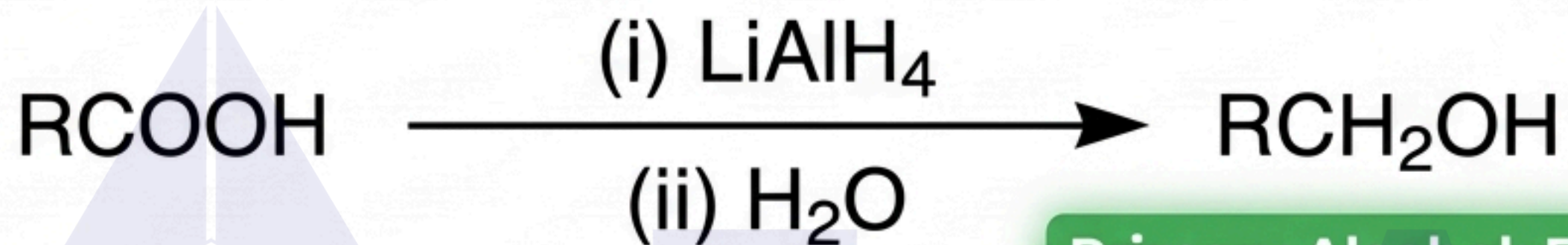


## Stronger Reducing Agent

Capable of reducing standard carbonyls, but  
vital for more stubborn substrates.

**Advantage:** Both reagents yield the corresponding alcohols without requiring high-pressure hydrogen gas or heavy metal surfaces.

# The Heavyweight: Carboxylic Acids



Primary Alcohol: Excellent Yield

## Industrial Constraint

LiAlH<sub>4</sub> is a highly expensive reagent. It is strictly used for preparing special chemicals only, making this direct route unsuitable for commercial mass-production.

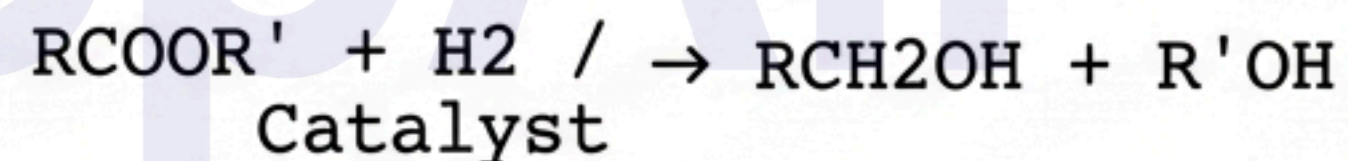
# The Industrial Hack: Acids via Esters

## Step 1



Convert the stubborn acid into a more easily reduced ester.

## Step 2



Use cheap, readily available catalytic hydrogenation.

**Commercial Viability:** By converting the acid to an ester first, industry utilizes affordable catalytic hydrogenation instead of expensive  $\text{LiAlH}_4$ .

# The Product Decision Chart

| Starting Material                     | Ideal Reagent                                                     | Alcohol Produced |
|---------------------------------------|-------------------------------------------------------------------|------------------|
| Aldehyde ( $\text{RCHO}$ )            | $\text{H}_2/\text{Cat}$ OR $\text{NaBH}_4$<br>OR $\text{LiAlH}_4$ | 1° Alcohol       |
| Ketone ( $\text{RCOR}'$ )             | $\text{H}_2/\text{Cat}$ OR $\text{NaBH}_4$<br>OR $\text{LiAlH}_4$ | 2° Alcohol       |
| Carboxylic Acid<br>( $\text{RCOOH}$ ) | $\text{LiAlH}_4$<br>(Lab Scale Only)                              | 1° Alcohol       |
| Ester<br>( $\text{RCOOR}'$ )          | $\text{H}_2/\text{Cat}$<br>(Industrial Scale)                     | 1° + 1° Alcohols |



# You've Learned the Theory.

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