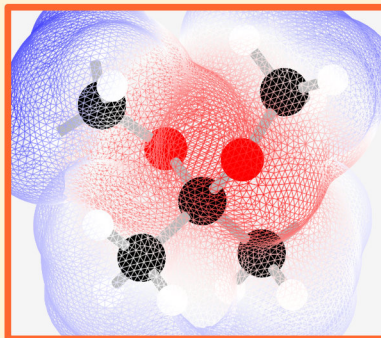


# HIGHLIGHTS

- Acetal formation.
- Reversibility & driving the reaction to completion.
- Imine formation.
- Enamine formation.
- Examples.



Nucleophilic attack on the carbonyl group can occur with loss of the original carbonyl oxygen in a **condensation reaction**. The key step is the formation of a **good leaving group** by protonating the hydroxyl group of the tetrahedral intermediate. The reaction is reversible, and water must be removed to drive it forward. **Hydrolysis**, the addition of water to the compound, transforms the products back into the original C=O bond.

When the nucleophile is an **alcohol**, the reaction gives a hemiacetal then an **acetal**. If the nucleophile is a **primary amine** the product is an **imine**, the nitrogen equivalent of the carbonyl. If it is a **secondary amine**, then the product will be an **enamine**.

Mechanisms involving a leaving group on a tetrahedral intermediate are important. It is key to these condensation reactions and will be important in the next reaction of the carbonyl group, substitution reactions of carboxylic acids and their derivatives.

## CHEMISTRY CLASSICS

### ADDITION TO THE CARBONYL GROUP

#### CONDENSATION REACTIONS - ACETALS, IMINES, & ENAMINES

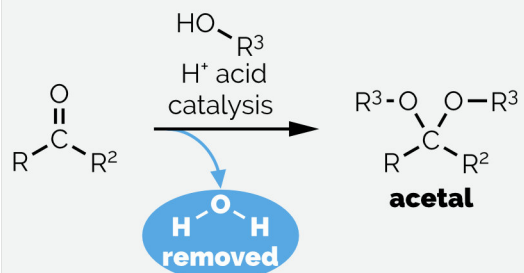


© gjr for makingmolecules.com  
This handout is shared under a  
Creative Commons Attribution-  
NonCommercial-ShareAlike  
BY-NC-ND-SA 4.0 licence.



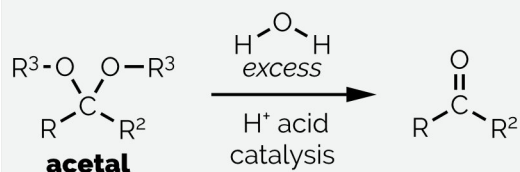
# Condensation reactions of C=O bond

## 1. Acetal formation



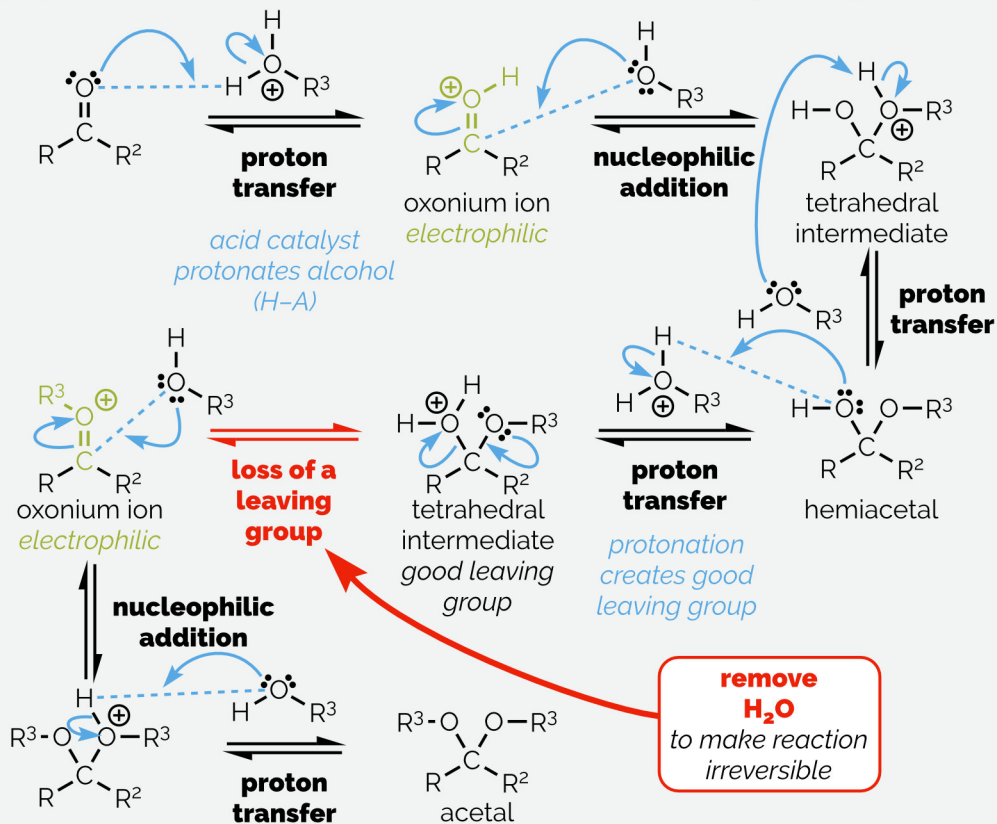
Remove water with Dean-Stark apparatus or a dehydrating agent.

## 2. Acetal hydrolysis

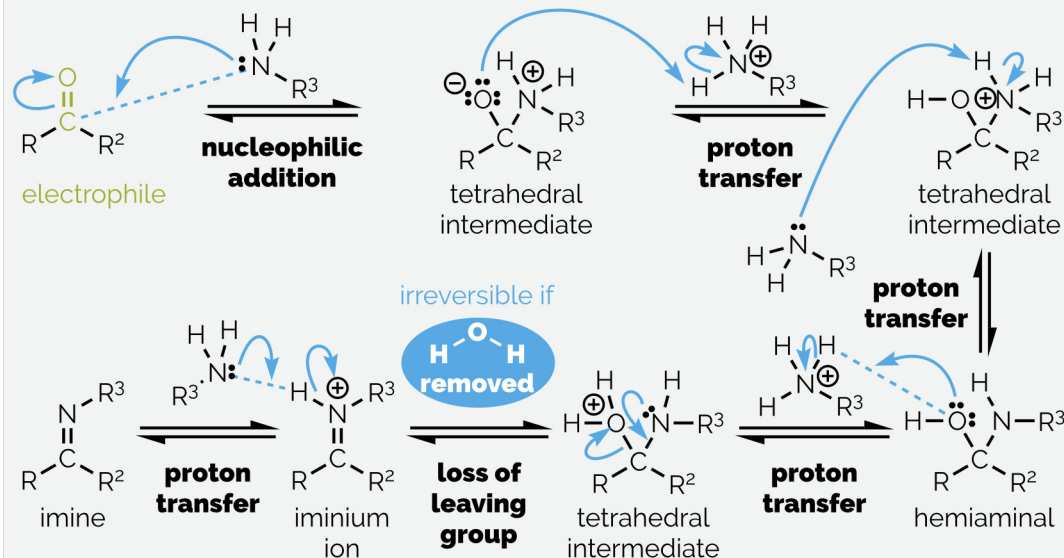
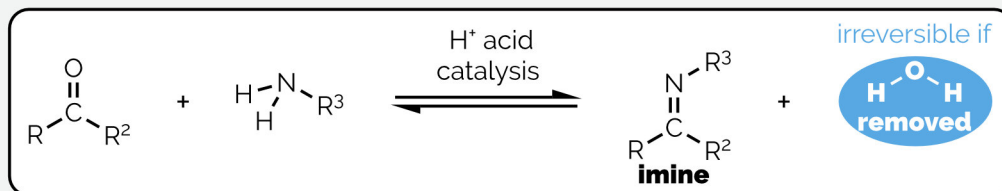


The reversibility of the reaction makes acetals a useful **protecting group**.

## 3. Mechanism of acetal formation & hydrolysis

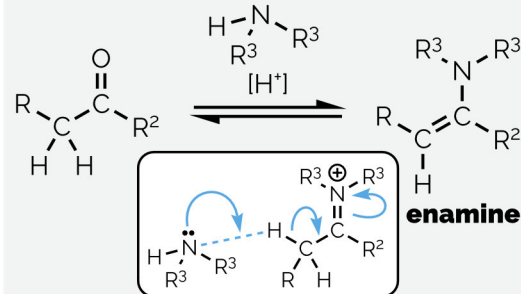


## 4. Imine formation - nucleophile is primary amine



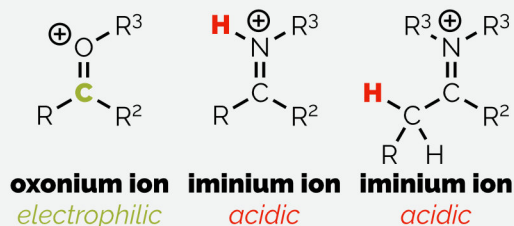
First addition & proton transfer steps reversed as amine more basic than carbonyl.

## 5. Enamine formation



Secondary amine gives **enamine** if there is an  $\alpha$ -proton or an **iminium ion** if not.

## 6. Differences



**Acetal** formed as oxonium electrophilic.  
**Imine** formed as iminium ion acidic.  
**Enamine** formed as  $\alpha$ -position acidic.