Objectives

After completing this section, you should be able to

1. write an equation for the oxidation of an aldehyde using
   b. Tollens reagent.
2. explain the difference in structure which makes aldehydes susceptible to oxidation and ketones difficult to oxidize.
3. identify the carboxylic acid produced when a given aldehyde is oxidized.
4. identify the aldehyde, the oxidizing agent, or both, needed to prepare a given carboxylic acid.

Key Terms

Make certain that you can define, and use in context, the key term below.

- Tollens reagent

Study Notes

An important difference between aldehydes and ketones is the ease with which the latter can be oxidized. Tollen’s reagent is a classical organic laboratory technique to test for the presence of an aldehyde. The reagent consists of silver(I) ions dissolved in dilute ammonia. When the aldehyde is oxidized, the silver(I) ions are reduced to silver metal. When the reaction is carried out in a test-tube, the metallic silver is deposited on the walls of the tube, giving it a mirrorlike appearance. This characteristic accounts for the term “silver mirror test” which is applied when this reaction is used to distinguish between aldehydes and ketones—the latter, of course, do not react.

This page looks at ways of distinguishing between aldehydes and ketones using oxidizing agents such as acidified potassium dichromate(VI) solution, Tollens' reagent, Fehling's solution and Benedict's solution.

Why do aldehydes and ketones behave differently?

You will remember that the difference between an aldehyde and a ketone is the presence of a hydrogen atom attached to the carbon-oxygen double bond in the aldehyde. Ketones don't have that hydrogen.
Oxidation of Aldehydes

The presence of that hydrogen atom makes aldehydes very easy to oxidize. Or, put another way, they are strong reducing agents. The most common reagent for this conversion is \( \text{CrO}_3 \) in aqueous acid. This reaction generally gives good yields at room temperature.

Unfortunately, the acid condition for the previous reaction can cause unwanted side reaction. If this problem occurs it can be rectified by using a solution of sliver oxide, \( \text{Ag}_2\text{O} \), in aqueous ammonia, also called Tollens' reagent.

Because ketones do not have that particular hydrogen atom, they are resistant to oxidation, and only very strong oxidizing agents like potassium manganate(VII) solution (potassium permanganate solution) oxidize ketones. However, they do it in a destructive way, breaking carbon-carbon bonds and forming two carboxylic acids.

Contributors

- Dr. Dietmar Kennepohl FCIC (Professor of Chemistry, Athabasca University)
- Prof. Steven Farmer (Sonoma State University)
- Jim Clark (Chemguide.co.uk)