Chemistry | Organic Chemistry

Tests for Carboxylic Group

General Aim

Identification of carboxylic acid through the chemical detection of carboxylic groups.

Method

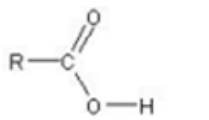
Detection of the presence of carboxylic groups in carboxylic acids using special chemical tests.

Learning Objectives (ILOs)

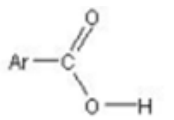
- Define and determine aliphatic and aromatic carboxylic acids theoretically through their chemical structure.
- Classify carboxylic acids into aliphatic and aromatic.
- Compare between carboxylic acids and other organic compounds in terms of chemical structures, properties and reactions.
- Identify carboxylic acids experimentally.
- Select the appropriate reagents to differentiate between carboxylic acids and other organic compounds.

Theoretical Background/Context

- A carboxylic acid is an organic compound that possesses at least one carboxylic group (- COOH). The general formula for aliphatic carboxylic acid class is R – COOH, where the R is the rest of the molecule e.g. acetic acid. On the other hand, aromatic carboxylic acids have the general formula Ar – COOH, where Ar contains at least one aromatic ring as in aromatic carboxylic acids. Carboxylic acids are highly acidic compounds as they are deprotonated easily forming carboxylate anions.



Aliphatic Cyclic Alcohol



Aliphatic Acyclic Alcohol

- Carboxylic acids are also classified according to the number of carboxylic acids in their structure into mono, di and tricarboxylic acids.
- There are various classes of organic compounds of different functions that belong to carboxylic acids. These include fatty acids, amino acids, keto acids, etc.

First: Preparation of Carboxylic Acids

- Carboxylic acids can be synthesized on the lab scale through different chemical synthesis procedures such as oxidation of primary alcohols and aldehydes using strong oxidizing agents such as potassium dichromate and potassium permanganate. They can be prepared also from esters and amides through acid or base catalyzed hydrolysis processes. They can also be prepared from olefins through an ozonolysis process using potassium permanganate or potassium dichromate.
- In addition, carboxylic acids can be prepared on an industrial scale through hydrolysis of triglycerides obtained from plants and animals. Vinegar which is diluted acetic acid can be obtained through fermentation of ethanol, etc.

Theoretical Background/Context (Cont')

Second: General Properties of Carboxylic Acids

- Carboxylic acids, the most commonly known organic acids, are considered as Bronsted-Lowery acids owing to their ability to donate protons.
- Carboxylic acids have strong odor and their corresponding esters are characterized by possessing pleasant odors making them useful to be used in fragrance.
- Carboxylic acids are weak acids as they can dissociate only into H3O+ and R – COO- in aqueous medium. After deprotonation of carboxylic acids, the carboxylate anions gain high stability due to resonance, where the negative charge is delocalized on the two oxygen atoms.

Third: Occurrence of carboxylic Acids in Nature

Many carboxylic acids and their corresponding esters, especially esters of fatty acids are abundant in nature. For instance, esters of fatty acids are main components of lipids inside cells. Also, polyamides of many amniocarboxylic acids are the main components of proteins structures.

Forth: Uses of Carboxylic Acids

- Many carboxylic acids as well as their derivatives are widely used in various applications including pharmaceutical, industrial, food, etc.
- For instance, many carboxylic acids are used in polymers manufacturing such as adipic acid, maleic acid, terephthalic acid, etc.
- In addition, some carboxylic acids have been used in food industries either as preservatives or flavoring agents such as citric acid, propionic acids, acetic acid, etc.
- Ethelenediaminetetraacetic acid, commonly known as EDTA, has been used as a chelating agent in industry as well as in analytical purposes.
- Other fatty acids as well as their salts have been used in soaps and coatings industries.
- Acetic acid is used in vinegar preparation, as well as in cleansing products, antiseptics and detergents.

Principle of Work

- In this experiment, carboxylic acids, mainly acetic acid, are tested through detecting their carboxylate group using chemical tests. In addition, these tests can be used to differentiate between carboxylic acids and other organic classes. This is done through using specific reagents.

Sodium Bicarbonate Test: In this test, sodium bicarbonate is added to a sample containing acetic acid. The sodium bicarbonate reacts with the acetic acid producing sodium acetate, water and carbon dioxide gas. Carbon dioxide is detected as gas bubbles. The chemical reaction of the test is illustrated below.

$$CH3COOH + NaHCO3 \rightarrow CH3COONa + CO2 \uparrow$$