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REACTIVITY OF CARBOXYLIC ACIDS AND CARBOXYLIC ACID DERIVATIVES AND ITS MAJOR APPLICATIONS: A STUDY

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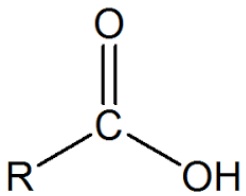
Abstract

This article focussed on reactivity of carboxylic acids and carboxylic acid derivatives and its applications.The functional groups are experiencing nucleophilic acyl substitutions are called carboxylic acid subsidiaries: these incorporate carboxylic acids themselves, carboxylates (deprotonated carboxylic acids), amides, esters, thioesters, and acyl phosphates. The carboxylic acid derivatives can be recognized from aldehydes and ketones by the nearness of a group containing an electronegative heteroatom - generally oxygen, nitrogen, or sulfur – reinforced legitimately to the carbonyl carbon. It can think about a carboxylic acid subordinate as having different sides. One side is the carbonyl group and the appended alkyl group: this is called an acyl group (in the particular situation where R is a methyl group, the term acetyl group is utilized).

1. OVERVIEW

The reactivity fingerprint mark of a carboxylic acid is characterized in any case by the high acidity of its OH group and, in the second, by the electro-philicity of its carbonyl carbon. The overall acidity of the alpha hydrogen's to a carbonyl group is totally covered in carboxylic acids by the a lot higher acidity of the OH group. Carboxylic acids have a place with a class of natural mixes in which a carbon (C) iota is attached to an oxygen (O) particle by a twofold bond and to a hydroxyl group (−OH) by a solitary bond. A fourth bond interfaces the carbon iota to a hydrocarbon group (R). The carboxyl (COOH) group is named after the carbonyl group (C=O) and hydroxyl group.



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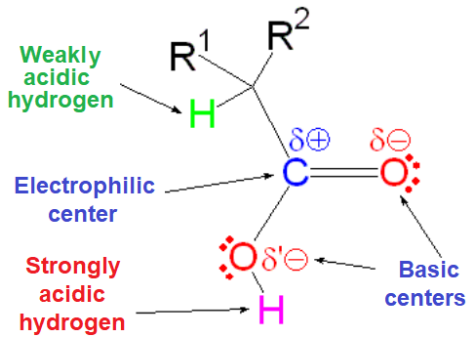
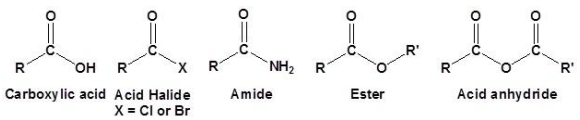
In general, carboxylic acids undergo a nucleophile substitution reaction where the nucleophile (-OH) is substituted by another nucleophile (Nu). The carbonyl group (C=O) gets polarized (i.e. there is a charge separation), since oxygen is more electronegative than carbon and pulls the electron density towards itself. As a result, the carbon atom develops a partial positive charge (δ+) and the oxygen atom develops a partial negative charge (δ-). In some cases, in the vicinity of a strong electrophile, the partially negatively charged carbonyl oxygen (δ-) can act as a nucleophile and attack the electrophile (as you will notice in the example of acid chloride synthesis, discussed later in this tutorial).



The high acidity of the carboxyl group strongly interferes with any reaction carried out in basic medium. The base is instantly neutralized by the carboxyl group and the reaction won't proceed. Therefore, the nucleophilic attack to the carbonyl carbon of a carboxylic acid can only be performed in acidic medium. The mechanism of the nucleophilic attack to a carboxylic acid or an acid derivative is known as addition-elimination reaction because it is made of these two steps.

2. RELATIVE REACTIVITY'S OF CARBOXYLIC ACIDS AND CARBOXYLIC ACID DERIVATIVES

Carboxylic acid derivatives are a group of functional groups whose chemistry is closely related. The main difference is the presence of an electronegative substituent that can act as a leaving group during nucleophile substitution reactions. Although there are many types of carboxylic acid derivatives known we will be focusing on just four: Acid halides, Acid anhydrides, Esters, and Amides[1-2].



General reactions

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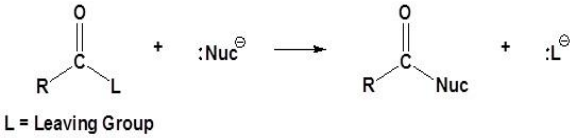
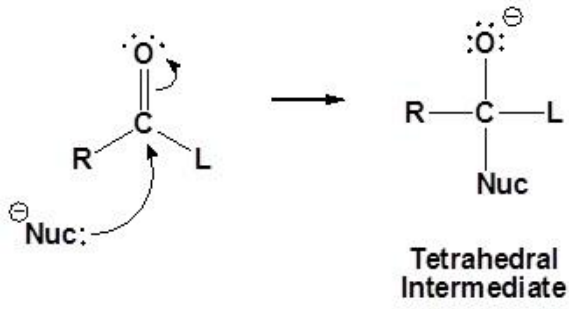
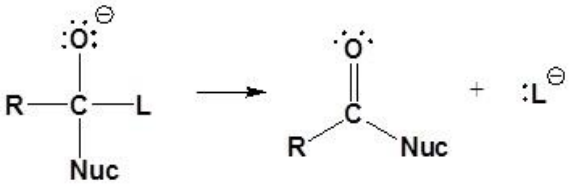


General mechanism

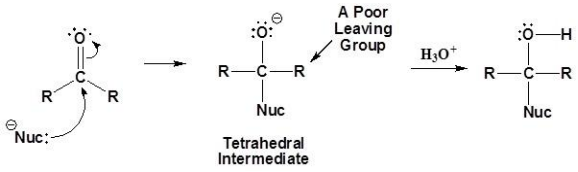
1) Nucleophilic attack on the carbon



2) Leaving group is removed



Although aldehydes and ketones also contain a carbonyl their chemistry is distinctly different because they do not contain a suitable leaving group. Once the tetrahedral intermediate is formed aldehydes and ketones cannot reform the carbonyl. Because of this aldehydes and ketones typically undergo nucleophilic additions and not substitutions.



The relative reactivity of carboxylic acid derivatives toward nucleophile substitutions is related to the electronegative leaving group's ability to activate the carbonyl. The more electronegative leaving groups withdrawn electron density from the carbonyl, thereby, increasing its electrophilicity.

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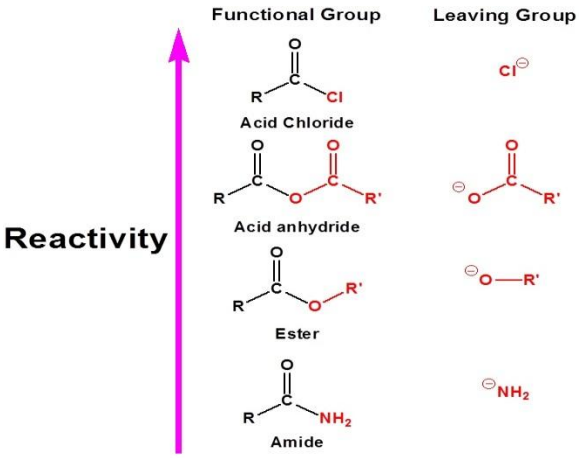
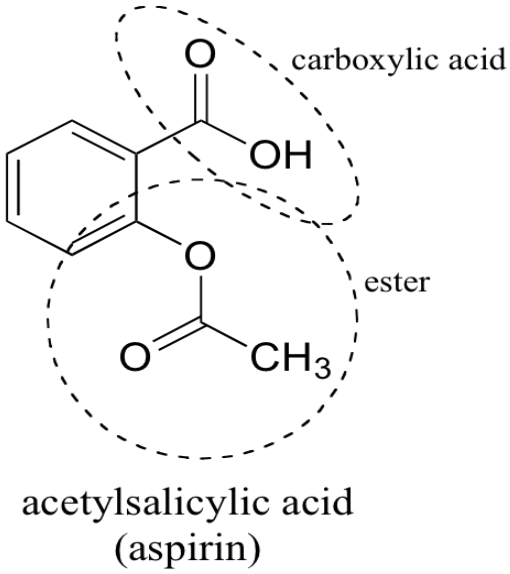


Aspirin Functions group

When etodolac is administered with aspirin, its protein binding is reduced, although the clearance of free etodolac is not altered. The clinical significance of this interaction is not known; however, as with other NSAIDs, concomitant administration of etodolac and aspirin is not generally recommended because of the potential of increased adverse effects[2].



acetylsalicylic acid
(aspirin)

We can see- carboxylic acid and ester groups are present. We can also see a benzene ring on the left side

Cyclosporine, Digoxin, Methotrexate

Etodolac, like other NSAIDs, through effects on renal prostaglandins, may cause changes in the elimination of these drugs leading to elevated serum levels of cyclosporine, digoxrin, methotrexate, and increase toxicity. Nephrotoxicity associated with cyclosporine may also be enhanced[3-6].

3. APPLICATIONS OF CARBOXYLIC ACIDS IN ORGANIC SYNTHESIS

Carboxylic acids are compounds with excellent chemical and physical properties, the most particular characteristics of this type of organic compounds, is their high solubility in polar solvents, as water, or alcohols, methanol, ethanol, etc. Chemical structure contains a carbonyl function (-C=O) and an hydroxyl group (OH), these groups interact easily with polar compounds, forming bridges of H, obtaining high boiling points. The carbonyl group (C=O) is considered a one of the most functional groups involved in many important reactions. The carboxylic acids are the most important functional group that present C=O[4].

This type of organic compounds can be obtained by different routes, some carboxylic acids, such as citric acid, lactic acid or fumaric acid are produced from by fermentation, most of these type of carboxylic acids are applied in the food industry. Historically, some carboxylic acids were produced by sugar fermentation. Synthetics route, there are different synthesis reactions such as reactions of oxidation from alcohols in the presence of strong oxidants such as KMnO4, oxidation of aromatic compounds among other routes[5].

For example, citric acid is a carboxylic acid, can be obtained by different routes, synthetic, enzymatic and naturally occurring, is considered harmless and cheap, used in the food industry, because is non-toxic, has a thermal stability to the 175°C. They showed, that the presence of citric acid, is important in the dispersion of the Ni particles when are incorporate in porous materials, thus inhibiting the agglomeration[6].

Derivatives of carboxylic acid, as alkyl halides, esters, and amides, present different and important application in diverse areas. In the case of esters, these are obtained from the reaction between carboxylic acids and alcohols in presence of an acid catalyst usually H2SO4 with heat, this type of reaction is known as esterification. In the case of the amides, it is obtained in the presence of an amine, may be primary and secondary, with a carboxylic acid, in this reaction also can be used a catalyst and heat to accelerate the reaction. Due to their chemical and physical characteristics, this type of organic compounds presents innumerable applications in the different areas, such as medicine, pharmacy, organometallic, polymer, nanotechnology, food, among others. Exist different reports, where study carboxylic acid, in the area organic synthesis, the use of a carboxylic acid, salicylic acid type "aspirin-like", molecule obtained through a novel

approach, where the phenol reaction to nitrooxy-acyl, this molecule present pharmaceutical properties.

4. USE OF CARBOXYLIC ACIDS

Organic synthesis

The use of carboxylic acids in organic synthesis is a very wide area and the chemical transformations of this group to another have made it a very versatile functional group. These chemical transformations have seen improvement when they carry out through Green chemistry processes.

One of the methods to aim for energy efficiency (one of the principles of Green Chemistry) is to make reactions under microwave irradiation. The first report by this methodology was an esterification reaction with carboxylic acids and alcohols obtaining high yields in a short reaction time. In addition to the esterification, the amidation reaction by a transformation of the carboxylic acids is also important because of the new covalent bond formed. This bond is of great importance because it can be found in a wide variety of molecules both in natural products and in small molecules with pharmacological activity.

Nanotechnology

One of the most important applications today of the carboxylic acids is the surface modification of the nanoparticles, this because during the synthesis of the nanoparticles by any methodology these tend to agglomerate due to the van der Waals forces and the absence of repulsive forces. In addition, oxidation at the surface of the nanoparticles causes instability which leads to aggregation. One of the strategies to avoid this problem is to protect the colloidal particles with a passivating or stabilizing agent, which associates with the surface of the nanoparticles to keep them suspended, and therefore to prevent their aggregation.

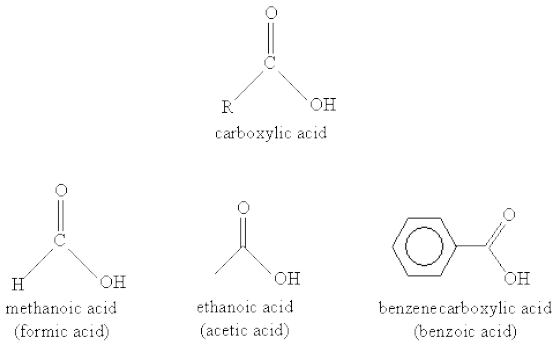
Polymer

The carboxylic acids present applications in the obtaining of polymers, acting as monomers, additives, initiators, catalysts, dopants, etc. Currently, an area of great interest is the production of acidic polymers, with different applications, for example in electronic area required that present characteristics such as electron donors, high solubility in aqueous solvents, etc. As additive the carboxylic acids have been studied. In 2017, it was reported the study of a series of linear carboxylic acids whit different chain lengths of 6 trans-2-hexanoic acid carbon atoms (CA-6), trans-2-decanoic acid (CA-10), 9-tetradecanoic acid (CA-14), used as halogen-free additives-solvent, considered a sustainable and viable process useful for the production of polymeric films

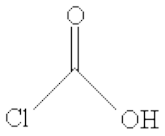
whit optical properties, whit potential application in solar cells. The conclusion of the study showed that increasing the length of the carboxylic acid chain changes the topology of the polymeric film.

5. CONCLUSION

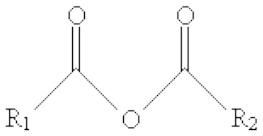
In this research, researcher will briefly introduce carboxylic acids and some of their derivative compounds, beginning with the nomenclature followed by some representative reactions involving these chemicals. As with some of the compounds, carboxylic acids combine multiple functional groups (carbonyl and hydroxyl groups in the case of a generic carboxylic acid). A carboxylic acid has the general form shown below, where R is a substituent alkyl group. The functional group attached to the R alkyl group is called a carboxyl group. Several example carboxylic acids and their names (systematic and common) follow.



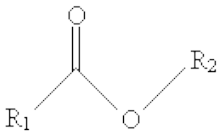
A number of similar molecules are considered derivatives of carboxylic acids. These compounds involve substitution of the hydroxyl group with another group, such as a chlorine atom. These derivatives are all linked by their combination of an acyl group with an electronegative element in the substituent group. The basic carboxylic acid derivatives we will consider are acyl chlorides, esters, and acid anhydrides. The general structure of each compound is shown below, where R1 and R2 are alkyl groups.



acyl chloride



acid anhydride



ester

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In nanotechnology, the carboxyl acid, present in different applications, the use of organic carboxylic acids: tartaric acid, maleic acid, and malic acid, assisted the surface modification of multiple wall carbon nanotubes (MWCNTs) by ultrasonic radiation, with applications in the production of polymer nanomaterials.

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