Chapter 16: Carbonyl Compounds I

Learning Objectives:

1. Recognize the general structures of carboxylic acids, acyl halides, acid anhydrides, esters, amides, and nitriles, and be able to assign names to simple members of these compound families.
2. Identify and be able to write the general mechanism for nucleophilic acyl substitution, and be able to judge the relative reactivities of carbonyl compounds in this reaction.
3. Identify and be able to write the mechanisms for nucleophilic substitutions of acyl halides, and esters.
4. Identify and be able to write the mechanism for the acid-catalyzed hydrolysis of an ester and of a nitrile.
5. Identify and be able to write the mechanism for the hydroxide-promoted hydrolysis of an ester.
6. Identify and be able to write the mechanisms for the acid-catalyzed and the hydroxide-promoted hydrolysis of amides.
7. Identify and be able to write the mechanism for the Fischer esterification of a carboxylic acid
8. Be able to describe the structures of fats, oils, and soaps, and be able to explain how detergents and surfactants work.
9. Be able to describe how to use chemical reagents for the desired transformation among acid derivatives.

Sections:

16.1 Nomenclature of Carboxylic Acids and Carboxylic Acid Derivatives
16.2 Structures of Carboxylic Acids and Carboxylic Acid Derivatives
16.3 Physical Properties of Carbonyl Compounds
16.4 Naturally Occurring Carboxylic Acids and Carboxylic Acids Derivatives#
16.5 How Class I Carbonyl Compounds React*
16.6 Relative Reactivities of Carboxylic Acids and Carboxylic Acid Derivatives*
16.7 General Mechanism for Nucleophilic Acyl Substitution Reactions*
16.8 Reactions of Acyl Halides
16.9 Reactions of Acid Anhydrides
16.10 Reactions of Esters
16.11 Acid-Catalyzed Ester Hydrolysis and Transesterification*
16.12 Hydroxide –Ion Promoted Ester Hydrolysis*
16.13 Soaps, Detergents, and Micelles
16.14 Reactions of Carboxylic Acids
16.15 Reactions of Amides
16.16 Acid-Catalyzed Hydrolysis of Amides*
16.17 Hydrolysis of Amides Is Catalyzed by Acids
16.18 Hydrolysis of an Imide: A Way to Synthesize Primary Amines
16.19 Hydrolysis of Nitrile*
16.20 Designing a Synthesis V: The Synthesis of Cyclic Compounds
16.21 How Chemists Activate Carboxylic Acids*
16.22 How Cell Activate Carboxylic Acids#
16.23 Dicarboxylic Acids and Their Derivatives

* Sections that will be focused

[#] Sections that will be skipped

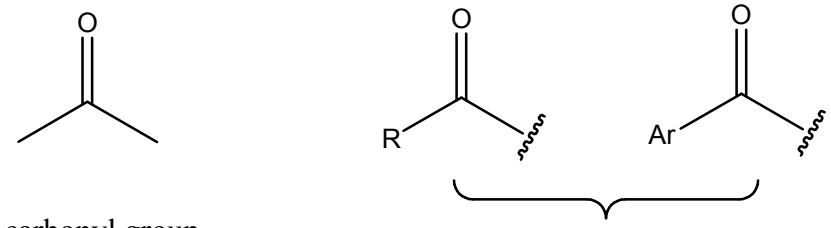
Recommended additional problems

16.45 – 16.87

Class Note

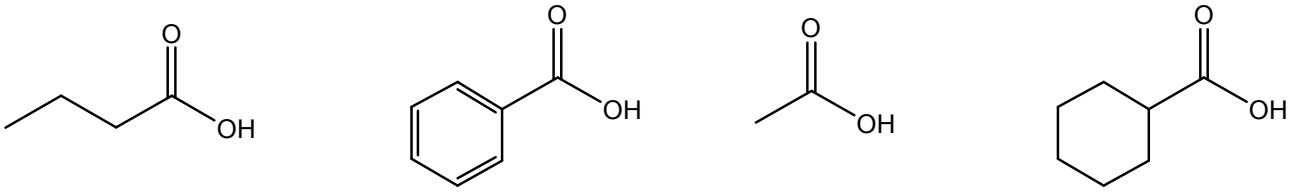
16.1 Nomenclature of Carboxylic Acids and Carboxylic Acid Derivatives

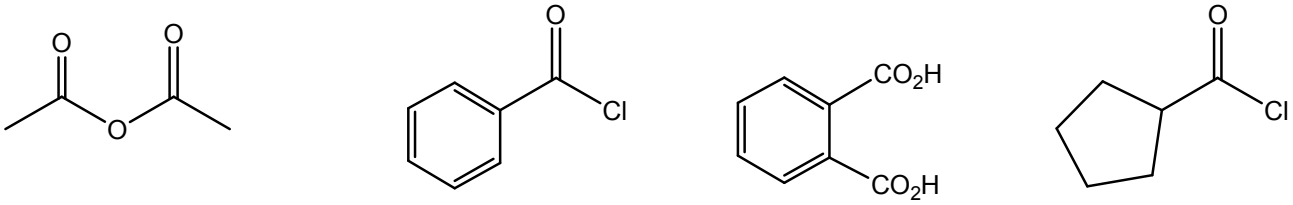
R: alkyl group Ar: aryl group

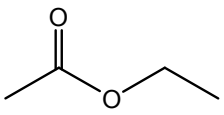
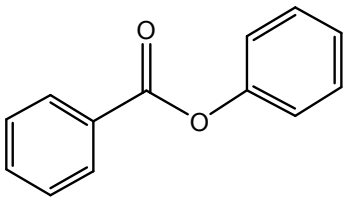
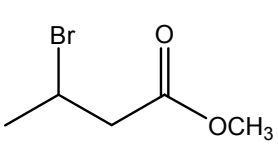
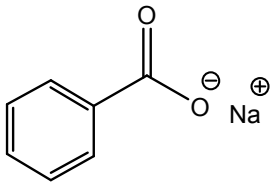
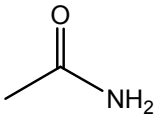
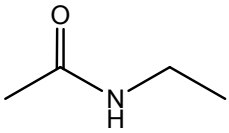
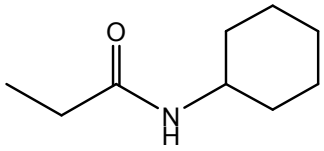
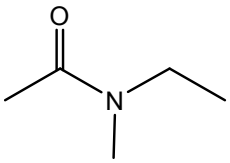


carbonyl group

acyl group





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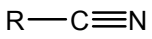
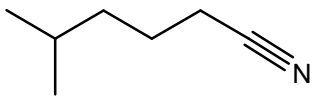



16.2 Structures of Carboxylic Acids and Carboxylic Acid Derivatives

16.3 Physical Properties of Carbonyl Compounds

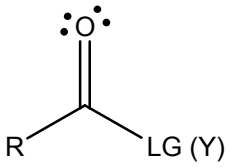
16.5 How Class I Carbonyl Compounds React*, 16.6 Relative Reactivities of Carboxylic Acids and Carboxylic Acid Derivatives* and 16.7 General Mechanism for Nucleophilic Acyl Substitution Reactions*

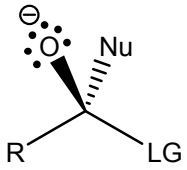
A. General mechanism

(i) Nucleophile (nucleophilicity) and leaving group

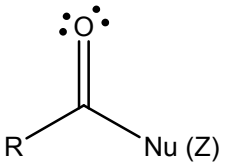
(ii) Nucleophilicity, basicity, and *p*Ka

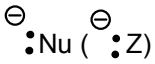
(iii) Nucleophilic acyl substitution reaction (an addition-elimination reaction)

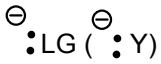




tetrahedral
intermediate

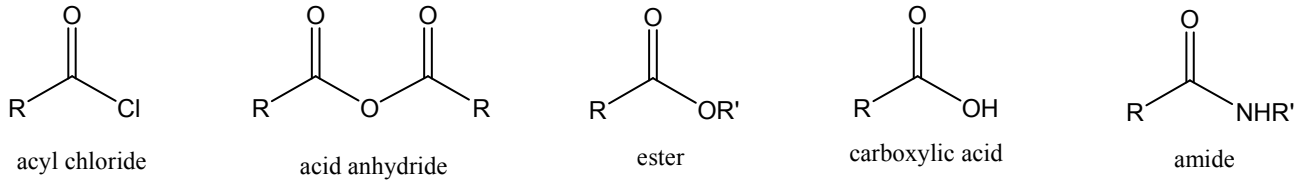






(iv) Molecular orbital view of nucleophilic acyl substitution reaction

B. Relative reactivities of carboxylic acid derivatives



(i) Inductive effect vs. resonance effect

(ii) Nucleophilicity, basicity, and *p*Ka

16.8 Reactions of Acyl Halides

A. Reactions

B. Why two equivalents of amine are needed for the formation of amide?

16.9 Reactions of Acid Anhydrides

16.10 Reactions of Esters

16.11 Acid-Catalyzed Ester Hydrolysis and Transesterification*

16.12 Hydroxide –Ion Promoted Ester Hydrolysis*

A. Comparison of hydrolysis of ester in acidic and basic conditions

B. Mechanistic studies using isotope

16.13 Soaps, Detergents, and Micelles

16.14 Reactions of Carboxylic Acids

A. Fisher esterification

B. Other reactions

16.15 Reactions of Amides, 16.16 Acid-Catalyzed Hydrolysis of Amides* and 16.17 Hydrolysis of Amides Is Catalyzed by Acids

16.18 Hydrolysis of an Imide: A Way to Synthesize Primary Amines

A. Gabriel synthesis

16.19 Hydrolysis of Nitrile*

16.20 Designing a Synthesis V: The Synthesis of Cyclic Compounds

16.21 How Chemists Activate Carboxylic Acids*

A. Use of $SOCl_2$, PCl_3, PBr_3

B. Use of P_2O_5

16.23 Dicarboxylic Acids and Their Derivatives