Physical Properties of Carboxylic Acids

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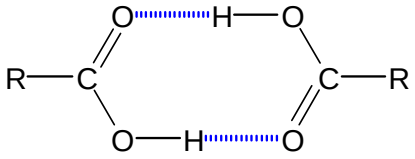
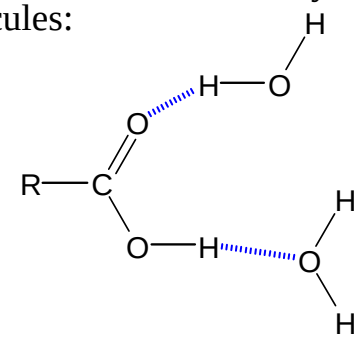
Physical Properties of Carboxylic Acids

- Carboxylic acids hydrogen bond to themselves to form a **dimer**:



- Carboxylic acids also form hydrogen bonds to water molecules:



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Physical Properties of Carboxylic Acids

- Since carboxylic acids can form more than one set of hydrogen bonds, their boiling points are usually higher than those of other molecules of the same molecular weight (MW).
- Low-MW carboxylic acids are generally liquids at room temp. (often, they are somewhat oily); higher-MW carboxylic acids are generally waxy solids.
- Carboxylic acids with 12 to 20 carbon atoms are often referred to as **fatty acids**, since they are found in the triglycerides in fats and oils (more later).
- Short-chain carboxylic acids are also generally more soluble in water than compounds of similar MW, since they can hydrogen bond to more than one water molecule.

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Physical Properties of Carboxylic Acids

- As the number of carbons in a carboxylic acid series becomes greater, the boiling point increases and the solubility in water decreases.
- Many carboxylic acids that are liquids at room temperature have characteristically sharp or unpleasant odors.
  - Ethanoic acid/acetic acid is the main ingredient in vinegar.
  - Butanoic acid is partially responsible for the odor of locker rooms and unwashed socks.
  - Hexanoic acid is responsible for the odor of Limburger cheese.
- Like most acids, carboxylic acids tend to have a sour taste (e.g., vinegar, citric acid, etc.)

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Table 5.2 Physical properties of some carboxylic acids

Common Name	Structural Formula	BP (°C)	MP (°C)	Solubility (g/100 mL H_2O)
Formic acid	H—CO_2H	101	8	Infinite
Acetic acid	CH_3—CO_2H	118	17	Infinite
Propionic acid	CH_3CH_2—CO_2H	141	-21	Infinite
Butyric acid	$CH_3(CH_2)_2$—CO_2H	164	-5	Infinite
Valeric acid	$CH_3(CH_2)_3$—CO_2H	186	-34	5
Caproic acid	$CH_3(CH_2)_4$—CO_2H	205	-3	1
Caprylic acid	$CH_3(CH_2)_6$—CO_2H	239	17	Insoluble
Capric acid	$CH_3(CH_2)_8$—CO_2H	270	32	Insoluble
Lauric acid	$CH_3(CH_2)_{10}$—CO_2H	299	44	Insoluble
Myristic acid	$CH_3(CH_2)_{12}$—CO_2H	Dec.	58	Insoluble
Palmitic acid	$CH_3(CH_2)_{14}$—CO_2H	Dec.	63	Insoluble
Stearic acid	$CH_3(CH_2)_{16}$—CO_2H	Dec.	71	Insoluble

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Boiling Points of Various Functional Groups

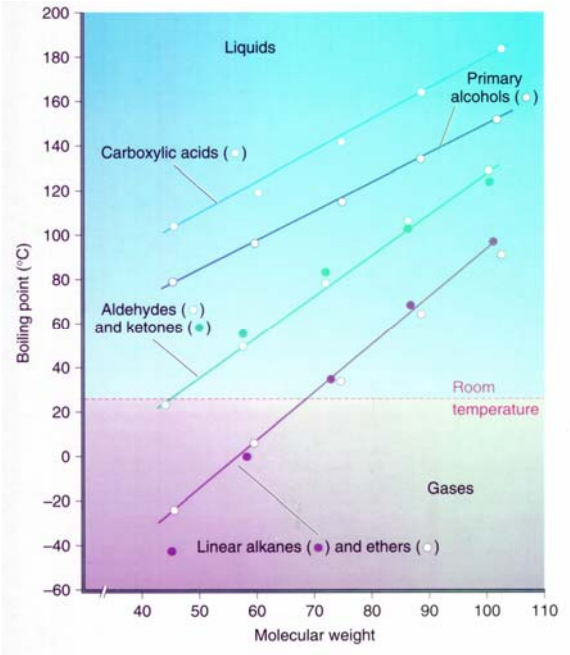

Figure 5.4
The boiling points of carboxylic acids compared to 1° alcohols, aldehydes and ketones, ethers and alkanes.

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Comparing Physical Properties

Boiling Point:

↑
- Carboxylic acid
- Alcohols
- Aldehydes/Ketones
- Ethers
- Alkanes

Water Solubility:

↑
- Carboxylic acid
- Alcohols
- Aldehydes/Ketones
- Ethers
- Alkanes

Name	Molecular weight	Boiling point	Solubility in water
Pentane	72 g/mol	35°C	Insoluble
Diethyl ether	74 g/mol	35°C	Insoluble
Butanal	72 g/mol	76°C	7.1 g / 100 mL H_2O
1-Butanol	74 g/mol	118°C	9.1 g / 100 mL H_2O
Propanoic acid	74 g/mol	141°C	Infinite

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Examples: Predicting Physical Properties

- Arrange the following compounds in order of increasing boiling point. (All of the compounds have about the same molecular weight.)
  - 1-pentanol
  - hexane
  - butanoic acid
  - pentanal
- Which member of each of the following pairs of compounds would you expect to have a higher solubility in water?
  - 2-butanone *or* propanoic acid
  - hexanoic acid *or* ethanoic acid

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