



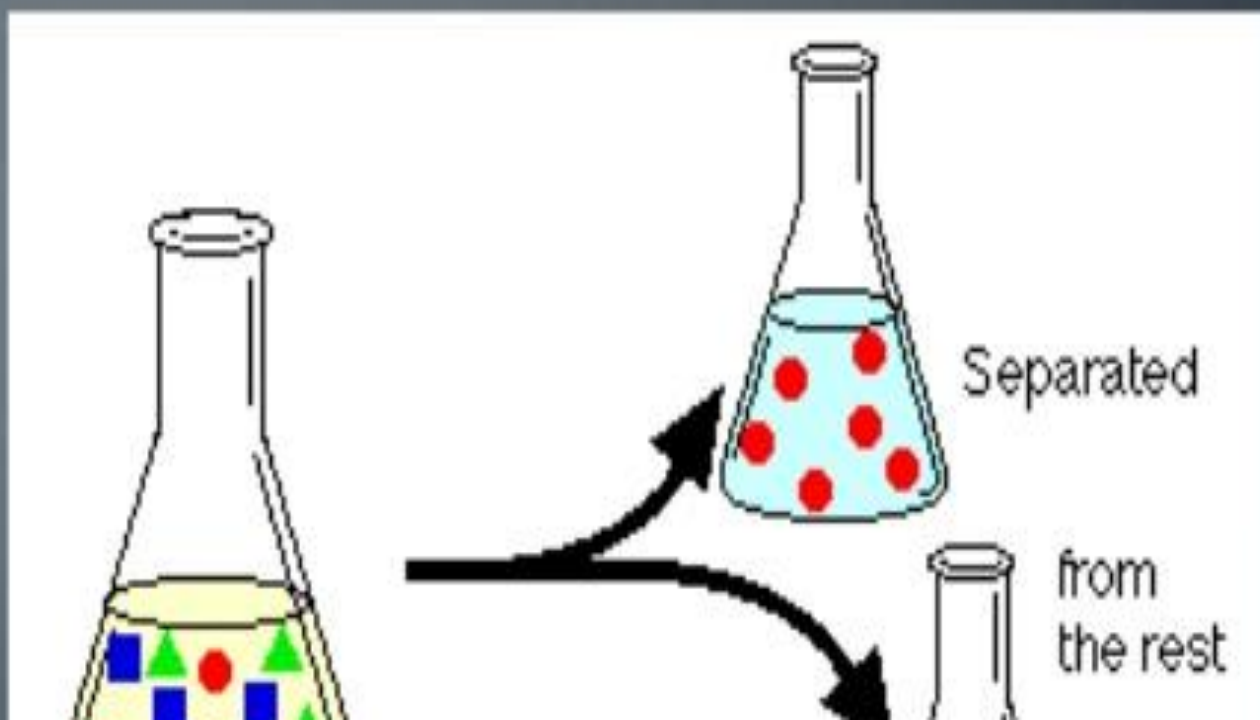
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Solvent extraction



Liquid-liquid extraction is a useful method to separate components (compounds) of a mixture.



- When shaken, with two immiscible solvents, the compound will distribute itself between the two solvents. Normally one solvent is **water** and the other solvent is a **water-immiscible organic solvent**.

Most organic compounds are more soluble in organic solvents, while some organic compounds are more soluble in water.

More

organic solvent

soluble compounds



← Ether →

← Water →

More

water-soluble

compounds



$$K = \frac{\text{concentration in solvent}_2}{\text{concentration in solvent}_1}$$

- This ratio is the **distribution coefficient, K_D or partition coefficient.**

(solvent1 and solvent2 are immiscible liquids)

Extraction efficiency

$$\frac{\text{mass}_{\text{organic phase}}}{\text{mass}_{\text{aqueous phase}}} = \frac{M_{\text{org}} V_{\text{org}}}{M_{\text{aq}} V_{\text{aq}}}$$

Fraction remaining in aqueous phase after one extraction:

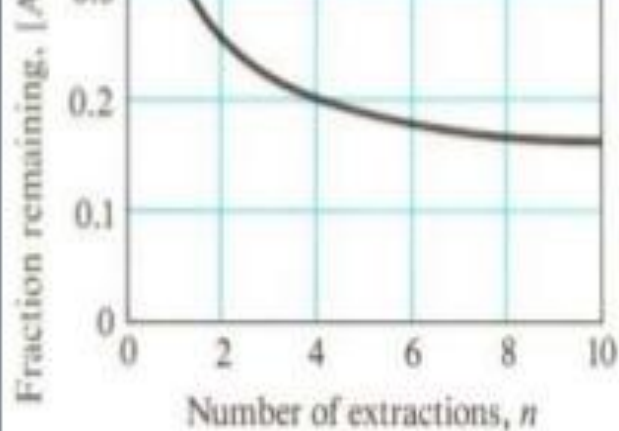
$$q = \frac{M_{\text{aq}} V_{\text{aq}}}{V_{\text{aq}}}$$

- After n extractions with V_{org} , the fraction remaining in the aqueous phase is:

$$q^n = \left(\frac{V_{aq}}{V_{aq} + KV_{org}} \right)^n$$

Extracting with the same amount of solvent but divided into several smaller fractions, is more efficient.

- Usually don't do more than three successive extraction



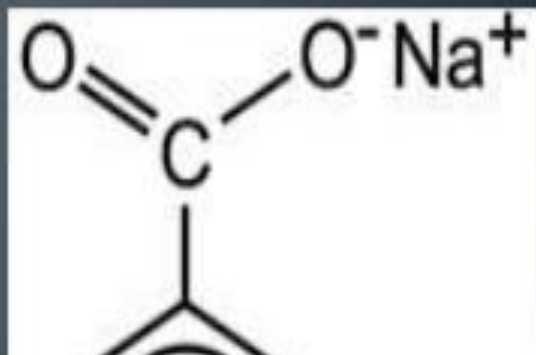
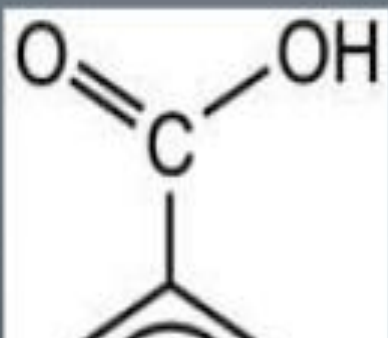
$$K = 2,$$

made water-soluble.

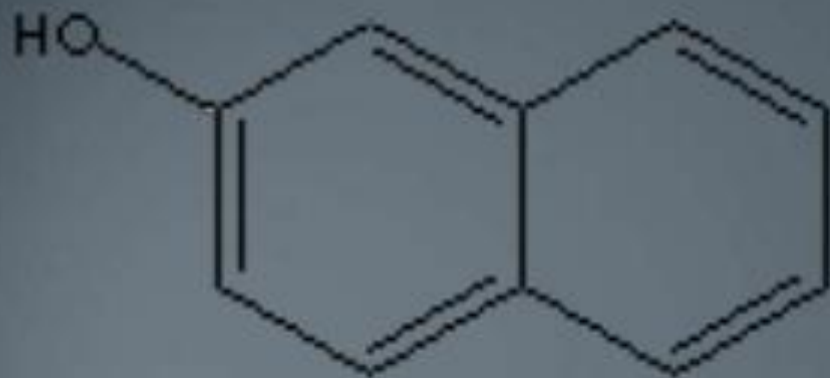
- Compounds belonging to the following solubility classes can be converted to their **water-soluble salt form**.
- **Organic Acids** and **Organic Bases**
- **Organic acids** include **carboxylic acids** (moderately weak organic acids) and **phenols** (weak organic acids).
- **Bases** include amines

concentration.

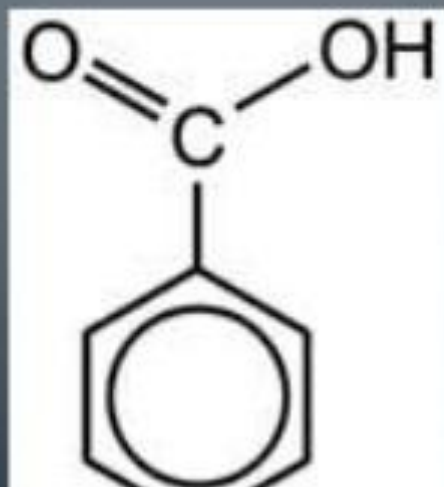
- K_D pertains to a single species
- Doesn't include products of side reactions
- Consider the distribution of benzoic acid between benzene and water



Separating species



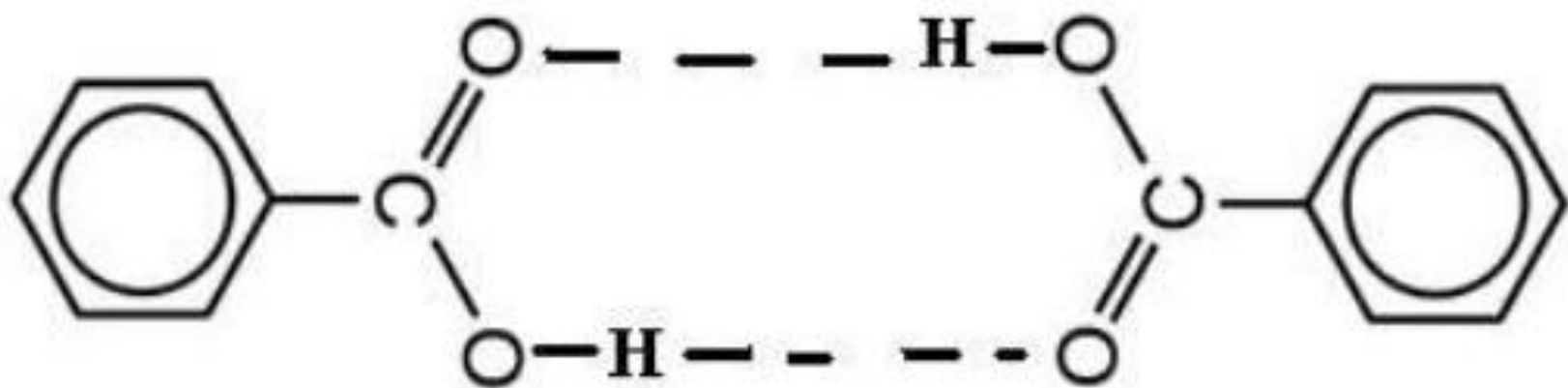
B-naphthol



Benzoic acid

- **pH < 2** Both non-ionic, both will transfer to benzene.
- **pH > 5** Benzoic acid is deprotonated and stays in water
- ↙-naphthol still transfers to benzene
- **pH 11** Both dissociate and both stay in water.

phase



Each species has own K_D

But we are interested in total amount extracted

$$D = \frac{\text{Total benzoic in organic phase}}{\text{Total benzoic in aqueous phase}}$$

$$D = \frac{[\text{HBz}]_{\text{org}} + 2[(\text{HBz})_2]_{\text{org}}}{[\text{HBz}]_{\text{aq}} + [\text{Bz}^-]_{\text{aq}}}$$

D is the Distribution ratio

$$[\text{Bz}^-] = K_a \frac{[\text{HBz}]}{[\text{H}^+]}, \quad K_D = \frac{[\text{HBz}]_{\text{org}}}{[\text{HBz}]_{\text{aq}}} \quad \text{and}$$

$$[(\text{HBz})_2] = K_f [\text{HBz}]^2$$

then

$$D = \frac{K_D (1 + 2K_f [\text{HBz}])}{1 + \frac{K_a}{[\text{H}^+]}}$$

dimerize – can simplify:

$$D = \frac{K_D}{1 + \frac{K_a}{[H^+]}}$$

Applications

- Separation – controlled by pH which controls ionization and complex formation
- Clean up before analysis
- Preconcentration: Extract from a large aqueous volume into a much smaller organic volume.

solvent extraction but their K_D s are not sufficiently different. So carry out a series of extractions:

START OF CYCLE



Counter current extraction

