The Hong Kong Polytechnic University
Department of Civil and Environmental Engineering
Water and Waste Laboratories

Laboratory Worksheet C12 : **Functionality of Ion Exchange Groups**. by *WS LAM*

Objective : To determine the functionality groups of ion exchange resins.

Introduction

Ion exchange, as a process, is a natural phenomena, which occurs in soil, minerals, and tissues of both plants and animals. In each instance there are active sites, or groups of sites, which take part in ion exchange reactions. Historically, these natural phenomena has been utilized in various aspects without proper understanding of mechanism involved. It was in 1850 that Thompson and Way, agricultural chemists, recognized and described the process which has become know as Ion Exchange.

Ion exchange can be used for the removal of undesirable anions and cations from a wastewater. Cations are exchanged for hydrogen or sodium and anions for hydroxyl ions. Ion exchange resins consist of an organic or inorganic network structure with attached functional groups. Most ion exchange resins used in wastewater treatment are synthetic resins made by the polymerization of an organic compounds into a porous three-dimensional structure. The degree of crosslinking between organic chains determines the internal pore structure, with higher crosslink density giving smaller pore sizes. The functional ionic groups are usually introduced by reacting the polymeric matrix with a chemical compound containing the desired group. Exchange capacity is determined by the number of functional groups per unit mass of resin.

The key to the economical use of the ion exchange process is the fact that ion exchangers can be regenerated, and that in most applications they will operate without problems for many thousands of cycles. Treatment of wastewater by ion exchange involves a sequence of operating steps. The wastewater is passed through the resin until the available exchange sites are filled and the contaminant appears in the effluent which is defined as the breakthrough. At this point treatment is stopped and the bed is backwashed to remove dirt and to regrade the resin. The bed is then regenerated. After regeneration, the bed is rinsed with water to wash out residual regenerant. The bed is then ready for another treatment cycle.

In aqueous media, strong acid cation and strong base anion exchange resins are fully hydrated, and the ions associated with the active groups are always free to exchange with ions of like charge in the solution begin processed. The values at which ionization becomes effective (pK value) in weak acid cation and weak base anion exchangers are different. Strong acid cation and strong base anion exchange products, such as weak acid cation exchangers, are usually monofunctional. Weak base anion exchange products have been manufactured with several different and sometimes mixed diamines. As a result, these products are useful in some special applications. Knowledge of their capacity as function of pH is important for many of these special applications.

Apparatus and Materials

- NaCl solid.
- 0.1N NaOH solution
- 0.1N H_2SO_4 solution
- Ion Exchange Resins
- Magnetic stirrer
- pH meter

Procedure

Part A. Cation Exchange Groups

1. Prepare a 0.1N solution of NaCl by weighing out 5.844±0.001g of dry NaCl and transfer it to a clean 1L volumetric flask. Add distilled water to the mark and mix well.

2. Weigh out 2.00±0.001g of the cation exchanger and transfer it to a 400mL beaker.

3. Add 100mL of the 0.1N NaCl solution to the beaker containing the cation exchanger.

4. Stir the mixture gently using a magnetic stirrer.

5. With a pH meter, titrate the resin/water slurry by adding small portions of 0.1N NaOH via a 50mL burette.

6. After each addition of NaOH, allow sufficient time for the pH to stabilize.

7. Record the steady-state pH and the titration volume in mL after each addition.

8. Prepare a graph of pH against NaOH added.

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3. Add 100mL of the 0.1N NaCl solution to the beaker containing the cation exchanger.

4. Stir the mixture gently using a magnetic stirrer.

5. With a pH meter, titrate the resin/water slurry by adding small portions of 0.1N H_2SO_4 via a 50mL burette.

6. After each addition of H_2SO_4, allow sufficient time for the pH to stabilize.

7. Record the steady-state pH and the titration volume in mL after each addition.

8. Prepare a graph of pH against H_2SO_4 added.

Calculations

Using the graphs drawn from your observations, calculate the estimated capacity at each sharp change in pH as follows :

$$Capacity = \frac{Titration\ volume \times Normality\ of\ \ NaOH}{sample\ weight}$$

Identify the pK values from the graphs.

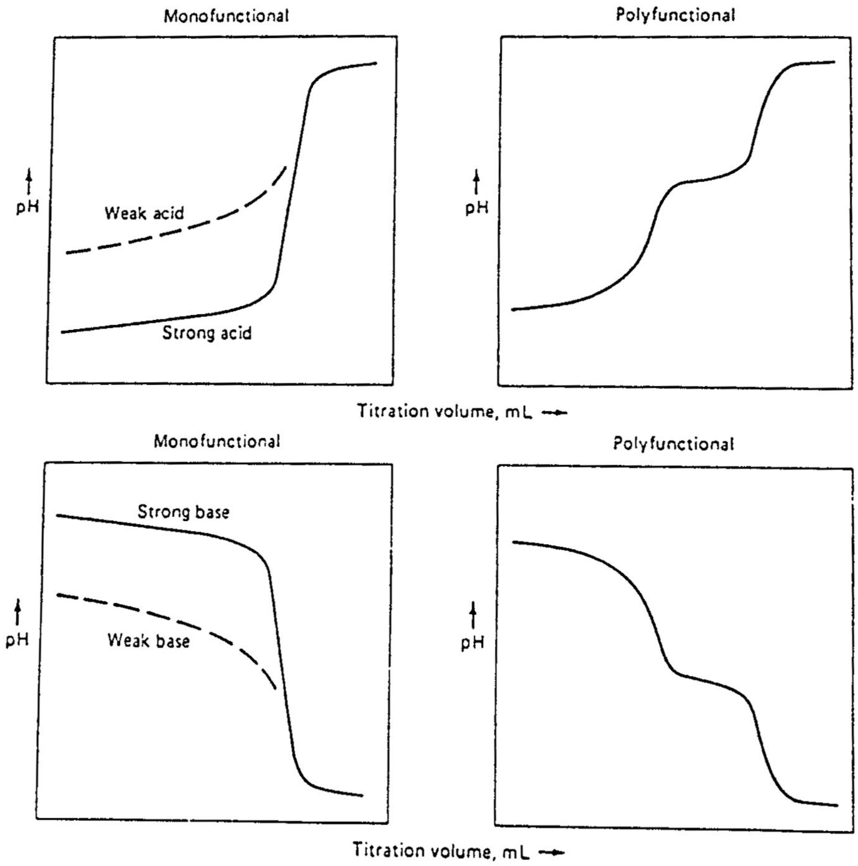

Fig. 1. Functionality of ion exchange groups.

Discussion

Soptive capacity of ion exchange resins can be estimated using the method in this laboratory test. The same parameter can also be determined by column test. Compare and contrast the two methods.

