Exercise 1

Recovery of Biocomponents

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Extraction of residual elements from biomass

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1. **Requirements:**
   - **a.** Calculation and re-calculation of concentrations.
   - **b.** Ion exchange resins, ion exchange.
   - **c.** Principle of ion exchange process.

2. **Introduction:**

Ion exchangers, or as they are often called ionites, are solid, insoluble polyelectrolytes characterized by the ability to exchange ions attached to their functional groups to ions located in the external solution.

Polymers with ion-exchange functional groups are divided into two groups:

a) **Cat-ion exchange resins**, possessing groups revealing characteristics of an anion: -SO_3H, -PO_3H, -COOH
b) **An-ion exchange resins**, possessing groups revealing characteristics of a cation: -NR_2H, -N^+R_3

This means that the polymer in which the functional groups are capable of binding anions is called anion exchange resin (e.g., a polymer with amino groups), and the polymer in which the functional groups are capable of binding cations is called a cation exchange resin (a polymer with carboxyl or sulphonic groups).

During the ion exchange, a cation exchange resin, initially in the acid form, passes into the corresponding salt according to the reaction:

$$2R\text{-}SO_3^-H^+ + Cu^{2+} + SO_4^{2-} \rightarrow [R\text{-}SO_3^-]_2Cu^{2+} + 2H^+ + SO_4^{2-}$$

A cation exchange resin, which is transformed into a salt form, can be completely regenerated using acid, and an anion exchange resin can be regenerated with a hydroxide. The ion exchange process is an equilibrium process, and the phenomena occurring during the exchange take place at the interface between the solid and the water phase.

Ion exchange processes are used in water treatment processes, such as: preparation of drinking water, water desalination, as well as the recovery of resources from various media.

3. Manual:

The aim of the exercise is to separate ions of copper(II) using strong-acidic cation exchange resin with sulphonic functional groups. To do so it is necessary to:

a. Prepare 1L $CuSO_4 \cdot 5H_2O$ (4 gL^{-1}) solution

b. Measure the value of ΔE using colorimeter.

c. Wash the bead of cation exchange resins (placed in a column) with water and 1M HCl. Using a tap, adjust flow rate.

d. Measure the height and diameter of the resin bead before concentration of copper. Thickness of the walls of glass ion exchange column is 2 mm. Measure the resin bead again after concentration of Cu(II) and after regeneration as well.

e. Introduce into the column solution prepared in point a.

f. Collect the passed solution in 25 mL portions. Measure change of a colour by determining value of ΔE using colorimeter.

g. The resin becomes fully saturated when to colour of solution collected at the bottom of the column matches the feed solution (ΔE of column effluent is equal to this, measured in point b). After reaching thereof, wash the resin with water.

h. Regenerate the resin using 1M HCl. Measure value of ΔE for the collected solution.

i. Wash the resin with water

4. Report:

a. estimate the volume of solution that could be treated with the anion exchange resin's bed.
b. determine the effectiveness of Cu concentration on the column.
c. propose an anion exchange reaction leading to the regeneration of the resin's bed.