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Demineralisation or Ion exchange method

Demineralization or Deionisation can be carried out using ion exchange resins (IER). IE resins are insoluble, cross-linked long chain organic polymers with micro- porous structure. The functional groups attached to the polymeric chain have the tendency to exchange the (hardness causing) ions. Acidic functional groups such as carboxyl (-COOH), sulphonic acid (-SO3H) have the capacity to exchange cations whereas basic functional groups such as amines (-NH2), hydroxyl (-OH) have the capacity to exchange anions. Ion exchange resins are generally synthesized such as styrene-divinyl benzene copolymers

The copolymer has the structure of alternate styrene and divinyl benzene units with the aromatic rings bearing the substituents of acidic / basic functional groups such as sulphonic acid, carboxylic acid, (substituted) amines etc

Process: It is the process of removal of any mineral (cation or anion) from the water sample. Water sample is first passed through a column called cation exchanger, which is packed with cation exchange resins. This causes the removal of cations by ion exchange process, but renders the water sample acidic. The cation exchange resins are synthesized by the carboxylation or sulphonation of styrene-divinyl benzene copolymers. The structure of these resins is given below

Cation exchange resin is generally represented as RH_2; the ion exchange process is represented as

$$RH_2 + CaCl_2 \rightarrow RCa + 2HCl$$

$$RH_2 + MgSO_4 \rightarrow RMg + 2\,H_2SO_4$$

The acidic water coming out of the cation exchanger is then fed to a column called anion

exchanger, which is packed with anion exchange resins. This causes the removal of anions by ion exchange process and also neutralizes the acidity of the water sample, explained as follows.

The anion exchange resins are synthesized by the Hydroxylation or amination of styrene-divinyl benzene copolymers. Anion exchange resin is generally represented as $R(OH)_2$; the ion exchange process is represented as

$$R(OH)_2 + H_2SO^{2}{}_4{}^{-}{}_{-} \rightarrow RSO_4 + 2H_2O$$

The ultimate reaction taking place on passing the water sample through the cation and anion exchanger systems is

$$H^+ + OH^- \rightarrow H_2O$$

Regeneration

When the cation exchange resin is exhausted, it can be regenerated by passing a solution of dil HCl or dil H_2SO4.

$$RCa + 2HCl \rightarrow RH_2 + CaCl_2$$

$$RNa + HCl \rightarrow RH + NaCl$$

Similarly, when the anion exchange resin is exhausted, it can be regenerated by passing a solution of dil NaOH.

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$$R' \quad Cl_2 \quad + \quad 2NaOH \quad \rightarrow \quad R'(OH)_2 \quad + \quad 2NaCl$$