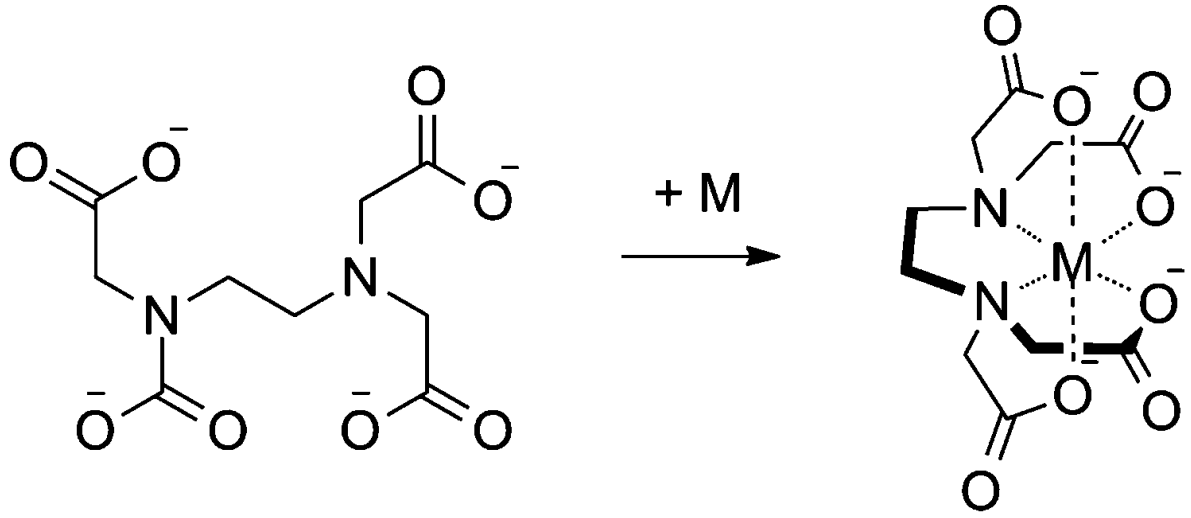
Estimation of Hardness of Water

Advantages of EDTA method

This method is preferable because of

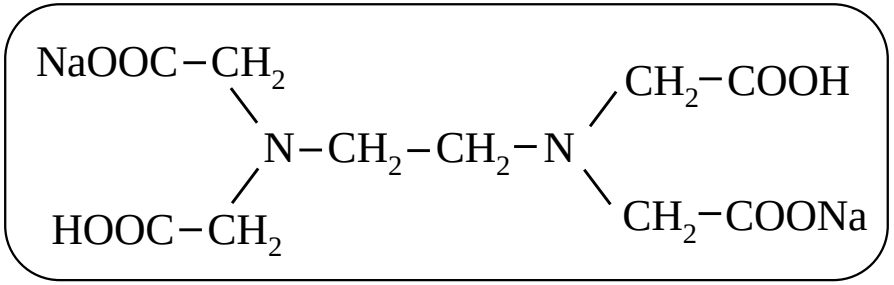
1) Greater accuracy
2) Convenience
3) More rapid procedure



EDTA method

- Ethylene diamine tetra acetic acid disodium salt (EDTA disodium salt) is used as a strong complexing agent with Ca^{2+} and Mg^{2+} in hard water.

- The structure of EDTA disodium salt is:



- Initially, Ca^{2+} and Mg^{2+} are treated with Eriochrome black T (EBT) indicator using ammonia buffer (to maintain pH between 9-10) to get an unstable complex of Ca^{2+} and Mg^{2+} formed with EBT.

$$Ca^{2+}/Mg^{2+} + EBT \xrightarrow{\text{pH 9-10}} Ca^{2+}/Mg^{2+} - EBT$$

(unstable complex – wine red)

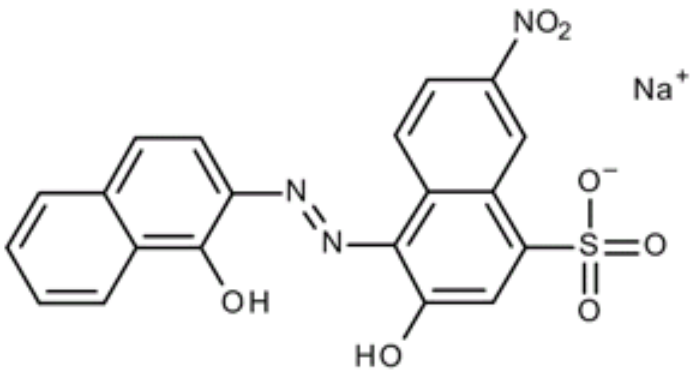
Estimation Water Hardness

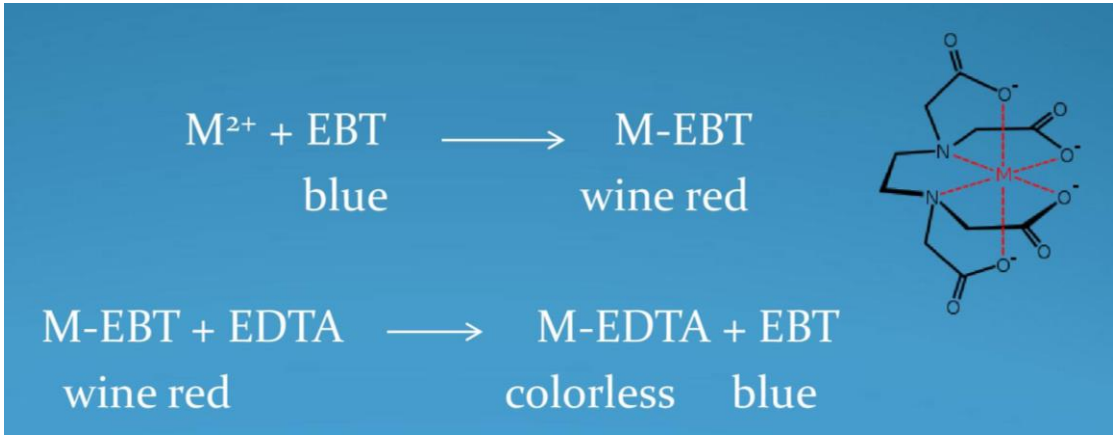
On addition of EDTA, EBT gets replaced by EDTA since EDTA forms a stronger complex with the metal ions.

This is indicated by the formation of a ***steel blue*** coloured complex.

Ca^{2+}/Mg^{2+} — EBT + EDTA $\xrightarrow{\text{pH 9-10}}$ Ca^{2+}/Mg^{2+} — EDTA + EBT

(Stable complex - Steel blue)





Experimental Procedure

1) Standardization of EDTA

- First EDTA Solution is standardized using standard hard water (1 mg/mL of $CaCO_3$ equivalents is prepared as standard hard water).
- For this, first known aliquot of Standard hard water is taken and 10-15 mL of ammonia buffer is added to bring the pH between 9-10.
- Then a few drops of EBT solution is added to form the unstable complex giving **wine red** colour.
- This solution is titrated with the EDTA solution till the solution turns to **steel blue** indicating the formation of stable EDTA-Metal ion complex.
- This volume of EDTA is noted as V_1.

Experimental Procedure

2) Estimation of Total Hardness

- The above procedure is repeated with sample hard water of unknown hardness.
- Volume of EDTA is noted as V_2.

3) Estimation of Permanent Hardness

- Then sample hard water of 250 mL is taken and evaporated to a volume of 50mL when the temporary hard salts settle down.
- The solution is filtered and washed thoroughly and made up again to 250mL.
- From this solution, 50 mL is pipetted out and titrated in similar manner as done with standard hard water.
- Volume of EDTA is noted as V_3.

Experiment

1. Preparation of EDTA solution (0.01 M)
   i.e. dissolve 3.72 g of sodium salt of EDTA crystals in 1 litre of distilled water

2. Preparation of standard Hard Water
   a. dissolve 1.0 g of pure, dry $CaCO_3$ in small quantity of conc. HCl and evaporate the solution to dryness
   b. Dissolve the residue in distilled water (1 litre)

1ml of this solution contains 1 mg of $CaCO_3$ equ. hardness

3. Preparation of buffer solution
   Add 67.5 g of NH_4Cl to 570 ml of conc. Ammonia soln. and dilute with distilled water to 1 litre

4. Preparation of indicator
   Dissolve 0.5 g of EB-T in 100 ml alcohol

5. Standardization of EDTA solution

Burette - EDTA solution (0.01 M)

Conical Flask - 50 ml of std. hard water + 10-15 ml of ammonia buffer + few drops of EB-T indicator

Volume of EDTA consumed = V_1 ml

a) Standardization of EDTA:

V_1 mL of EDTA is consumed by 50 mL of std. hard water

$$V_1 \text{ mL of EDTA} = 50 \text{ mg of } CaCO_3$$

$$1 \text{ mL of EDTA} = \left(\frac{50}{V_1}\right) \text{ mg of } CaCO_3$$

6. Estimation of total Hardness

Conical Flask - 50 ml of sample hard water + 10-15 ml of ammonia buffer + few drops of EB-T indicator

b) Total hardness:

Volume of EDTA consumed = V_2 ml

$$1 \text{ mL of EDTA} = \left(\frac{50}{V_1}\right) \text{mg of } CaCO_3$$

$$\text{So, } V_2 \text{ mL of EDTA} = \left(\frac{50}{V_1}\right) \mathbf{x\ V_2} \text{ mg of } CaCO_3$$

$$\text{Therefore, 1000 mL of sample hard water} = \left(\frac{50}{V_1}\right) \text{x} \left(\frac{V_2}{50}\right) \mathbf{x\ 1000} \text{ mg/L}$$

$$\text{i.e. Total hardness of sample hard water} = \left(\frac{V_2}{V_1}\right) \mathbf{x\ 1000} \text{ mg of } CaCO_3 \text{ (ppm.)}$$

7. Estimation of permanent hardness

Sample water is boiled and filtered

Conical Flask – **50 mL of boiled & filtered sample hard water** + **10-15 mL of ammonia buffer** + **Few drops of EB-T Indicator**

c) Permanent hardness:

Volume of EDTA consumed = V_3 mL

$$1 \text{ mL of EDTA} = \left(\frac{50}{V_1}\right) \text{mg of } CaCO_3$$

$$\text{So, } V_3 \text{ mL of EDTA} = \left(\frac{50}{V_1}\right) \mathbf{x\ V_3} \text{ mg of } CaCO_3$$

$$\text{Therefore, 1000mL of sample hard water} = \left(\frac{50}{V_1}\right) \text{x} \left(\frac{V_3}{50}\right) \mathbf{x\ 1000} \text{ mg/L}$$

$$\text{i.e. Permanent hardness of sample hard water} = \left(\frac{V_3}{V_1}\right) \mathbf{x\ 1000} \text{ mg of } CaCO_3 \text{ (ppm.)}$$

Temporary hardness calculation

Temporary hardness:

Temporary hardness = Total hardness – permanent hardness

$$= \left(\frac{V_2}{V_1} \times 1000\right) - \left(\frac{V_3}{V_1} \times 1000\right)$$

$$= \left(\frac{V_2 - V_3}{V_1} \times 1000\right)$$