CLIL - Complexometric titration

Complexometric titration (sometimes chelatometry) is a form of volumetric analysis in which the formation of a colored complex is used to indicate the endpoint of a titration. Complexometric titrations are particularly useful for the determination of a mixture of different metal ions in solution. An indicator capable of producing an unambiguous color change is usually used to detect the endpoint of the titration. In theory, any complexation reaction can be used as a volumetric technique provided that:

1. the reaction reaches equilibrium rapidly after each portion of titrant is added.
2. interfering situations do not arise. For instance, the stepwise formation of several different complexes of the metal ion with the titrant, resulting in the presence of more than one complex in solution during the titration process.
3. a complexometric indicator capable of locating equivalence point with fair accuracy is available.

In practice, the use of EDTA as a titrant is well established. EDTA, ethylenediaminetetraacetic acid, has four carboxyl groups and two amine groups that can act as electron pair donors, or Lewis bases. The ability of EDTA to potentially donate its six lone pairs of electrons for the formation of coordinate covalent bonds to metal cations makes EDTA a hexadentate ligand. However, in practice EDTA is usually only partially ionized, and thus forms fewer than six coordinate covalent bonds with metal cations. Disodium EDTA is commonly used to standardize aqueous solutions of transition metal cations. Disodium EDTA (often written as Na_2H_2Y) only forms four coordinate covalent bonds to metal cations at pH values $\leq$ 12. In this pH range, the amine groups remain protonated and thus unable to donate electrons to the formation of coordinate covalent bonds. Note that the shorthand form $\mathbf{Na_{4-x}H_xY}$ can be used to represent any species of EDTA, with x designating the number of acidic protons bonded to the EDTA molecule. EDTA forms an octahedral complex with most 2+ metal cations, M^{2+}, in aqueous solution. The main reason that EDTA is used so extensively in the standardization of metal cation solutions is that the formation constant for most metal cation-EDTA complexes is very high, meaning that the equilibrium for the reaction:

$$M^{2+} + H_4Y \rightarrow MH_2Y + 2H^+$$

lies far to the right. Carrying out the reaction in a basic buffer solution removes H^+ as it is formed, which also favors the formation of the EDTA-metal cation complex reaction product. For most purposes it can be considered that the formation of the metal cationEDTA complex goes to completion, and this is chiefly why EDTA is used in titrations / standardizations of this type. Indicators To carry out metal cation titrations using EDTA, it is almost always necessary to use a complexometric indicator to determine when the endpoint has been reached. Common indicators are organic dyes such as Fast Sulphon Black, Eriochrome Black T. Color change shows that the indicator has been displaced (usually by EDTA) from the metal cations in solution when the endpoint has been reached. Thus, the free indicator (rather than the metal complex) serves as the endpoint indicator.

Adapted from: webstor.srmist.edu.in

TEACHING AIMS:

- Understanding the meaning of complexometric titration;
- Understanding the complexometric reactions;
- Understanding the base principles about titration with EDTA;
- Understanding the differences between the several methods of complexometric titration.

EXERCISE

1 Answer the following questions:

1) Describe the base concept on complexometric titration.
2) Describe the reactions for complexometric Titration.
3) Describe the complexometric Titration with EDTA;
4) Describe the complexometric Titration indicators.