108 Pharmaceutical Analysis

Methodology: In a particular instance when an 'excess of $[I^-]$ ' is carefully incorporated into a solution an oxidizing agent under investigation, then—'iodine (I_2) gets liberated quantitatively in an amount just equivalent to the actual oxidizing agent precisely present.

Alternatively, the said 'liberated I_2 ' may, therefore, be titrated with a reducing agent; and hence, the result shall be almost identical just like the oxidizing agent being titrated directly.

However, in both these instances sodium thiosulphate is employed as the 'titrating agent.'

The specific analysis of an **oxidizing agent** carried out in this fashion is commonly termed as an **iodometry** or an **iodometric method**.

Examples:

1. Determination of Dichromate: The qualitative determination of dichromate $[Cr_2O_7^{2-}]$ ion may be accomplished as per the following ionic reaction.

$$Cr_{2}O_{7}^{2-} + 6I^{-} + 14H^{+} \longrightarrow 2Cr^{3+} + 3I_{2} + 7H_{2}O \qquad \dots(i)$$
[In Large Excess]
$$I_{2} + 2S_{2}O_{3}^{2} \longrightarrow 2I^{-} + S_{4}O_{6}^{2-} \qquad \dots(ii)$$
(a)
(b)

In Eqn. (*ii*) each dichromate $[Cr_2O_7^{2-}]$ ion happen to generate three molecules of iodine $[I_2]$, which eventually interacts with six equivalents $[6S_2O_3^{2-}]$ of thiosulphate ion. In other words, the millimoles (mm) dichromate $[Cr_2O_7^{2-}]$ are found to be equivalent to 1/6th mm of thiosulphate $[S_2O_3^{2-}]$ actually consumed in the titration. [In Eqn. (*iii*): (*a*) = thiosulphate ion ; and (*b*) = tetrathionate ion].

2. Determination of Iodate $[IO_3^-]$: The iodate $[IO_3^-]$ ion may also be determined quantitatively by the iodometric method, as expressed under:

$$IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$$
 ...(*iii*)

In Eqn. (*iv*), each iodate ion $[IO_3^-]$ gives rise to the formation of three moles of iodine $[3I_2]$, that subsequently reacts with $6S_2O_3^{2-}$ (thiosulphate ion); and ultimately the millimoles the IO_3^- are duly accomplished ion $[S_2O_3^{2-}]$ adequately employed in the titration by 1/6th the quantum.

3.13.2 Permanganate Titrations

Potassium permanganate [KMnO₄] has been employed extensively and intensively as one of the most versatile, reliable, and valuable oxidizing agents in the domain of **redox titrimetry** since more than a century. It acts as a **self-indicator** for the detection of equivalence point, and serves as a very strong oxidizing agent [$E^\circ = 1.51$ V]. In fact, the freshly prepared KMnO₄ solution is fairly stable provided adequate necessary precautions are taken duly in its preparation.

Autocatalytic Decomposition of KMnO₄ Solution

It has been duly observed that a freshly prepared KMnO_4 solution invariably possesses small quantum of 'reducing impurities' inherently present in the solution that reduce a small amount of the permanganate $[\text{MnO}_4^-]$ ion. Importantly, in a 'neutral solution' the prevailing reduction product of the corresponding permanganate $[\text{MnO}_2]$ is manganese dioxide $[\text{MnO}_2]$; whereas, in an 'acidic environment' the resulting reduction product is manganese metallic ion $[\text{MnO}_2^+]$. It has been established

Salient Features of Colloidal Particles

The various salient features of the colloidal particles are as stated under:

- 1. Due to the inherent small size of the **colloidal particles** a significant fraction of their respective atoms or ions or molecules are found to be strategically located in the **'boundary layer'** between:
 - (a) particle and air (surface), and/or
 - (b) particle and liquid or solid (interface).
- 2. Ions that are critically present in the surface of a NaCl-crystal and water molecules very much within the surface of a 'natural rain drop' are duly exposed to obvious unbalanced forces of attraction; and the remaining materials are adequately surrounded by identical ions or molecules located on all the sides, having predominantly the so called 'balanced force fields'. Interestingly, at this stage the skilful incorporation of a surface free energy component right into total free energy of the colloidal particles, that eventually turns out to be definitely more vital and important because the particles do become distinctly smaller in size *viz*, larger segments of their respective ions, atoms or molecules are duly positioned in either their surface or interfacial zone.

Conclusively, the overall solubility of the vapour pressure of extremely **tiny liquid droplets** and extremely fine **solid particles** are invariably observed to be relatively **'bigger'** in comparison to the corresponding values of **large drops** or **coarse particles** of the same substances respectively.

5.6 COPRECIPITATION AND FACTORS AFFECTING COPRECIPITATION

It has been duly proved and established that the **precipitation** obtained in the course of an analysis also take along with them various impurities that are found to be usually quite soluble by themselves.

Example: Sulphuric acid $[H_2 SO_4]$ on being incorporated gradually to a specific solution comprising of a mixture of **barium chloride** [**BaCl₂**] and **ferric chloride** [**FeCl₃**], one may commonly expect only **barium sulphate** [**BaSO₄**] to be duly precipitated. However, this is not the exact realistic status of the situation *i.e.*, the other salt **ferric sulphate** [**Fe**₂ (**SO**)₃]* is water-soluble. In actual practice, however, this salt is also precipitated partially. Therefore, one may distinctly observe that when the ensuing precipitate is duly filtered/washed/ignited, the resulting precipitate is not absolutely white in appearance (*i.e.*, the original colour of BaSO₄) but would look more or less brownish on account of **ferric oxide** [**Fe**₂(SO₄)₃] upon ignition, as given below:

$$\begin{array}{cccc} \operatorname{Fe}_2(\operatorname{SO}_4)_3 & \longrightarrow & \operatorname{Fe}_2\operatorname{O}_3 & + & \operatorname{3SO}_3\uparrow \\ \\ \operatorname{Ferric \ sulphate} & & \operatorname{Ferric \ oxide} & & \operatorname{Sulphur \ trioxide} \\ & & (\operatorname{Red}) & (\operatorname{Escapes}) \end{array}$$

Thus, coprecipitation may be defined as 'the precipitation of any extraneous substances, that are not usually precipitated under the given conditions by the precipitant used'.

Coprecipitation Vs Chemical (ordinary) Precipitation: Coprecipitation is easily distinguished from the chemical (ordinary) precipitation of the 'sparingly soluble impurities' along with the major component, when their solubility products $[K_{sp}]$ are adequately exceeded upon the careful incorporation of the precipitant.

^{*} Ferric sulphate may be generated almost simultaneously.

- 10. Write a **detailed account** on:
 - (a) Thermal Degradations,
 - (b) Thermogravimetric Analyses (TGA)
- 11. Discuss the Pharmaceutical Applications of Gravimetric Analysis in the Assay of drugs:
 - (a) Papaverine Hydrochloride Tablets
 - (b) Amodiaquine Hydrochloride
- 12. Applications of Gravimetric Techniques in the quantitative determination of:
 - (*i*) Sulphate Ion $[SO_4^{2-}]$ as Barium Sulphate
 - (ii) Aluminium Ion [Al^{3+,}]- as Aluminium Oxide
 - (iii) Calcium Ion [Ca²⁺] as Calcium Oxalate
 - (iv) Magnesium Ion [Mg²⁺] as Magnesium Pyrophosphate

Discuss the above with reactions and salient features.