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Turbidometric Study of Precipitate Formation in Inorganic Reactions

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Abstract: The paper describes turbidometeric study of precipitate formation of $BaSO_4$, Colloidal Sulphur and $SrSO_4$. The variation of turbidity with time is noted down and first order rate constants were determined. It was found that the precipitation reaction follows first order reaction, though the mechanism is studied previously by conventional methods, we used turbidometric method for determination of formation of precipitations.
Key Words: Sodium Thiosulphate, Hydrochloric Acid, Strontium Chloride and Sulphuric Acid and potassium chloride, Turbidometer and Precipitation reaction.

Introduction

The equilibrium between a solid ion, salt and its solutions in water was generated by the solubility product expression. Many ion which form insoluble salts can be determined by titration[1], if a suitable method and/or indicator is available. There is Nephelometry, Conductometry, Potentiometry[3], Chromatographic technique[4] are used to monitor precipitation reaction. The precipitation reaction becomes complicated if an additional reaction such as hydrolysis, condensation takes place simultaneously.

Experimental

The chemicals used for the present investigations were of S.D.Fine Chemicals Ltd and used without further purification. Double distilled water was used as solvent.

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A (CL 52D) Elico make nephelometer was calibrated using farmazine solution. Effect of variation of concentration, effect of radiation and effect of temperature was studied. A known amount of $Na_2S_2O_3$ was mixed with known concentration of HCl and the appearance of turbidity was followed using nephelometer. Similarly known quantity of strontium chloride was equilibrated with sulphuric acid solution and the reaction was followed nephelometrically.

Results and Discussion

Part-I Reaction between sodium thiosulphate and HCl.

For the present study, we have taken a definite amount of solid sodium thiosulphate, which is treated with hydrochloric acid solution. The solution becomes turbid, due to the formation of sulphure particles. The reaction takes sufficient times; therefore it can be successfully studied by using nephelometry.

$$Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + SO_2 + H_2O + S\ (ppt)$$

In the present investigation, we monitored the turbidity obtained due to product formation. Although reaction order is different, we maintained pseudo first order conditions. So the different order reactions exhibit different functional forms for the time dependence of reactant concentrations.[5]

It was observed that NTU reading increases very fast up to 3 to 4 min and then gradually decreases. The curve becomes more parabolic as the amount of sodium thiosulphate increases. At lower concentration of sodium thiosulphate a gradual increase in turbidity with time is observed. When 100 mg of sodium thiosulphate was dissolved in HCl. A smooth curve was observed keeping the higher concentration of HCl, the pseudo first order.

Rate constants were determined (Table 1). It is observed that the increasing the concentration of $Na_2S_2O_3$ the rate constant increases but decreasing the concentration HCl increases the rate constant. The data suggests that when the concentration of HCl and $Na_2S_2O_3$ are in the same range 10^{-2} M. rate constant is maximum.

Fig 1 Variation pf NTU with time for HCl and $Na_2S_2O_3$

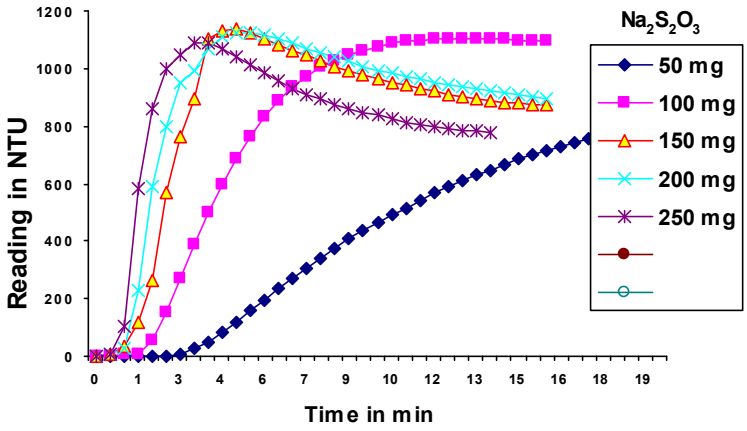


Table No.1 Variation of rate constant (k Sec-1) with $[Na_2S_2O_3]$

[HCl] (M)	$[Na_2S_2O_3]$ 1.343 x 10^{-2}M k Sec^{-1}	$[Na_2S_2O_3]$ 2.686 x 10^{-2}M k Sec^{-1}	$[Na_2S_2O_3]$ 4.029 x 10^{-2}M k Sec^{-1}
0.1	2.3 x 10^{-3}	2.9 x 10^{-3}	14.5 x 10^{-3}
0.05	4.6 x 10^{-3}	6.2 x 10^{-3}	7.5 x 10^{-3}
0.025	6.3 x 10^{-3}	9.9 x 10^{-3}	31.5 x 10^{-3}

To check the effect of added salt on precipitation, we added KCl, The result reveals that at [HCl] = 0.1 M and $[Na_2S_2O_3]$ = 2 x 686 x 10^{-2} M increase in rate constant with increasing KCl is observed but at higher $[Na_2S_2O_3]$ rate constants does not show any particular variations whereas at lower concentration of $[Na_2S_2O_3]$, some degree of variation is observed. This might be due to the excess chloride ions present in the solution (Table No. 2)

Table No. 2 Effect of Salt [KCl] On Rate Constant (k sec-1).

[KCl] (M)	[HCl] = 0.1M $[Na_2S_2O_3]$ 1.343 x 10^{-2}M	[HCl] = 0.1M $[Na_2S_2O_3]$ 2.686 x 10^{-2}M	[HCl] = 0.1M $[Na_2S_2O_3]$ 4.029 x 10^{-2}M
0.0	2.3 x 10^{-3}	2.9 x 10^{-3}	1.45 x 10^{-3}
0.1	2.2 x 10^{-3}	4.3 x 10^{-3}	1.1 x 10^{-3}
0.2	8 x 10^{-3}	5.2 x 10^{-3}	1.12 x 10^{-3}
0.3	8.9 x 10^{-3}	8.4 x 10^{-3}	0.85 x 10^{-3}

The Mechanism of precipitation reaction between sodium thiosulphate and HCl is given as

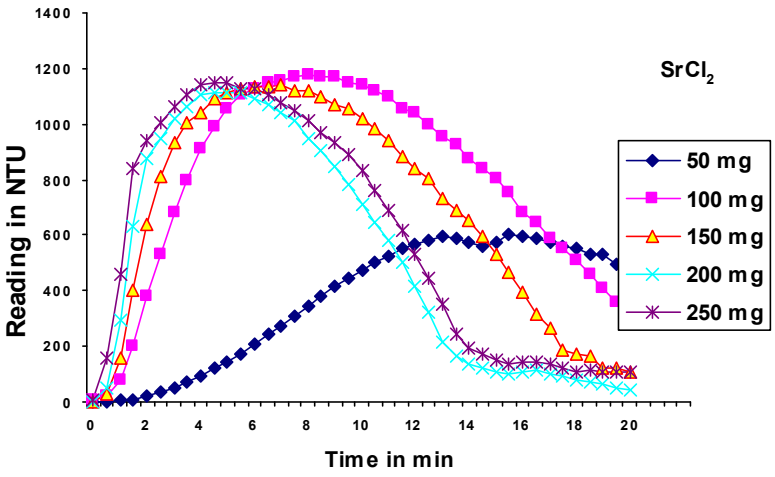
$$S_2O_3^{2-} + H^+ \longrightarrow HS_2O_3^-$$

$$HS_2O_3^- + H^+ \longrightarrow SO_2 + S\ (ppt).\ + H_2O$$

Part-II Reaction between Strontium Chloride and H_2SO_4.

In the second set of experiments strontium chloride was allowed to mix with suphuric acid and the turbidity is measured using Nephelometer (Fig.2)

Fig 2 Variation of NTU reading with time ($SrCl_2$ vs H_2SO_4)



The first order rate constants were calculated and are represented in table 3.

Table No.3 Variation of Rate Constant (k Sec-1) With $[H_2SO_4]$

$[H_2SO_4]$ (M)	$[SrCl_2]$ 2.1028×10^{-2}M	$[SrCl_2]$ 4.2056×10^{-2}M	$[SrCl_2]$ 6.3085×10^{-2}M
0.1	9.5×10^{-3}	12.3×10^{-3}	24.4×10^{-3}
0.05	7.5×10^{-3}	12.8×10^{-3}	14.0×10^{-3}
0.025	5.6×10^{-3}	8.9×10^{-3}	10.1×10^{-3}

The rate constant value increases with the increase in concentration of $[H_2SO_4]$ and $[SrCl_2]$. When KCl is added to the solution, regular variation is not observed. (Table-4)

Table No 4. Effect of salt [KCl] on rate constant (k Sec-1)

[KCl] (M)	$[H_2SO_4] = 0.1$M $[SrCl_2]$ 4.2056×10^{-2}M	$[H_2SO_4] = 0.1$M $[SrCl_2]$ 6.3084×10^{-2}M	$[H_2SO_4] = 0.1$M $[SrCl_2]$ 8.4111×10^{-2}M
0.0	12.3×10^{-3}	24.4×10^{-3}	20.2×10^{-3}
0.1	1.22×10^{-2}	9.1×10^{-3}	3.2×10^{-3}
0.2	8.2×10^{-3}	11.1×10^{-3}	10.1×10^{-3}
0.3	8.21×10^{-3}	7.1×10^{-3}	3.15×10^{-2}

But the rate constant values in presence of KCl were suppressed, indicating the adverse effect of KCl on the precipitate formation of $SrSO_4$.
It is possible that $SrCl_2$ gets dissociated into the solution

$$SrCl_2 \rightleftharpoons 2\,Sr^{2+} + 2\,Cl^-.$$

H_2SO_4 is a strong acid, it also dissociate to complete

$$H_2SO_4 + H2O \rightleftharpoons H_3O^+ + HSO_4^-$$

$$HSO_4^- + H2O \rightleftharpoons SO_4^{2-} + H_3O^+.$$

$$SrCl_2 + SO_4^{2-} \longrightarrow Sr(OH)Cl + H_3O^+$$

$$Sr(OH)Cl + H_2O \longrightarrow Sr(OH)_2 + H_3O^+$$

$$Sr(OH)_2 + SO_4^{2-} \longrightarrow SrSO_4 + 2OH^-$$

$$2\,H_3O^+ + 2OH^- \longrightarrow H_2O.$$

The rate constant increases with increase in concentration of H_2SO_4. The rate varies concentration of H_2SO_4 as well as with concentration of $SrCl_2$.

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