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Kinetics and Mechanism of the Adsorption of Lead (II) Ions on Aluminium (III) Oxide Powder

Vivekanand Choudhary and Shri Niwash Singh*
Department of Chemistry, H. D. Jain College, V K S University, Ara, Bihar, India
*Corresponding author: snsingh1214@gmail.com

Abstract: Adsorption is adhesion of a chemical species on the surface of adsorbents particles. In general adsorption can be defined as accumulation or, depletion of solute molecules at an interface. Lead is one of the most toxic heavy metals, is attracting wide attention of environmentalists due to its acute and chronic toxic effects in animal and human health. Alumina is one of the most widely used ceramics due to its high specific surface area, very good thermal stability and amphoteric properties. A R grade lead nitrate ($Pb(NO_3)_2$) (99.0% purity) and alumina (Al_2O_3) (99.9% purity) were used as adsorbate and adsorbent respectively for study. The present study was carried out to evaluate feasibility of aluminium (III) oxide powder for the removal of Pb(II) ions from aqueous solution through batch adsorption process. The effects of adsorbent dose, contact, time, concentration, temperature and pH value of the adsorbate were studied. The percentage amount adsorbed increases with increase in dilution and pH value. On the other hand decreases with the rise of temperature. The percentage amount adsorbed is optimum for 0.1 mole l^{-1} concentration, 298K temperature and pH value of 8.5. The decrease of adsorption with increase in temperature indicates the process of adsorption is physical in nature. The present research work describes the kinetics and mechanism of the adsorption process in details.

Keywords: Aluminium (III) oxide, Pb(II) ions.

I. Introduction

Adsorption is a surface phenomina in which a gas or liquid molecule attach to a solid surfaces. Adsorption finds its use in the removal of dissolved substances from waste water with selective choice of the adsorbent and adsorbate [1-15]. The conventional methods for the removal of heavy metal ions from waste waters include precipitation ion exchange chromatography etc. [16-18]. Alumina is used in paint, abrasive, catalysis, filler etc. Alumina is a material of hip replacement. Alumina is use as adsorbent in past several decades for the removal of several heavy metal ions. Lead in natural environment arise from both natural and anthropogenic sources and is detrimental to human health and all leaving things. All lead compounds are considered cumulative poisons. Recently increasing interest has been focused on removing Pb(II) ions from drinking water due to its supreme toxicity to our health. Lead is used in a varieties of products including cosmetics, paints, solders, pipes and gasoline. The scope of the present study is to generate the technical data on batch adsorption of Pb(II) ions by varying experimental parameters. The present study were carried out on aluminium (III) oxide powder to evaluate its capacity for removal of Pb(II) ions from solutions.

II. Materials and Method

Materials: AR grade lead nitrate of assay 99.0% purity manufactured by Fisher Chemicals, Chennai were used for preparing synthetic solutions of a heavy metal ions in the required concentration. Alumina (99.9% purity) manufactured by Loba Chemic pvt, Ltd, Mumbai was used as adsorbent for study. Alumina was activated by heating at 773K for 12 hour before being used as adsorbent.

Batch adsorption experiment: A definite volume of Pb(II) ions solutions with a known initial concentration was stirred with 0.01g of activated alumina for the stipulated time at a fixed temperature in a mechanical shaker. The unabsorbed heavy metal ions which remained in solution were filtered and the amount of heavy metal ions were estimated after attainment of equilibrium. By use of spectrophoto meter same experiments were repeated under identical condition.

III. Results and Discussion

Table I: Effect of Adsorbent Dose on the Removal of Pb(II) Ions on the Aluminium (III) Oxide Powder. Temperature: 298K, Concentration: 0.1 ML^{-1}, pH=8.5

Time(min)	*Percentage Amount Adsorbed*			
	Adsorbent Dose=0.5g	*1.0g*	*1.5g*	*2.0g*
0	0	0	0	0
10	3.8	4.1	4.9	5.1
20	8.7	9.7	10.8	11.3
30	20.1	16.8	19.6	21.6
40	30.9	31.5	33.2	35.6
60	43.1	47.1	49.5	55.5
90	43.9	47.1	49.3	55.5
120	43.1	47.3	49.4	55.7

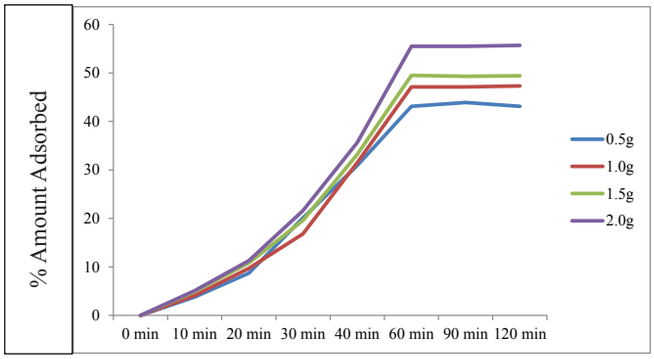

Fig. 1: Effect of Adsorbent Dose on the Removal of Pb(II) Ions on Aluminium (III) Oxide Powder

Table II: Effect of Concentration on the Removal of Pb(II) Ions on the Aluminium (III) Oxide Powder. Temperature: 298K, pH: 8.5, Adsorbent Dose: 2.0g

Time (min)	*Conc= 0.4mL^{-1}*	*0.06mL^{-1}*	*0.08mL^{-1}*	*0.10 mL^{-1}*
0	0	0	0	0
10	5.2	5.1	4.8	4.2
20	10.7	9.6	8.8	7.7
30	21.9	18.8	17.6	15.9
40	32.6	29.6	27.7	25.2
60	56.1	51.7	48.3	41.7
90	56.6	51.8	48.5	41.8
120	56.3	51.3	48.4	42.1

Table III: Effect of Temperature on the Removal of Pb(II) Ions on the Aluminium (III) Oxide Powder. Adsorbent Dose: 2.0g, pH: 8.5, Concentration: 0.1 ML^{-1}

Time(min)	*Percentage Amount Adsorbed*			
	Temperature 313K	*308K*	*303K*	*298K*
0	0	0	0	0
10	25.2	25.5	25.7	26.9
20	43.8	46.8	47.2	48.3
30	45.6	47.4	51.3	53.7
40	49.8	51.4	54.2	57.7
60	50.6	52.6	55.4	61.2
90	52.1	52.8	55.5	61.4
120	52.2	52.8	55.8	61.3

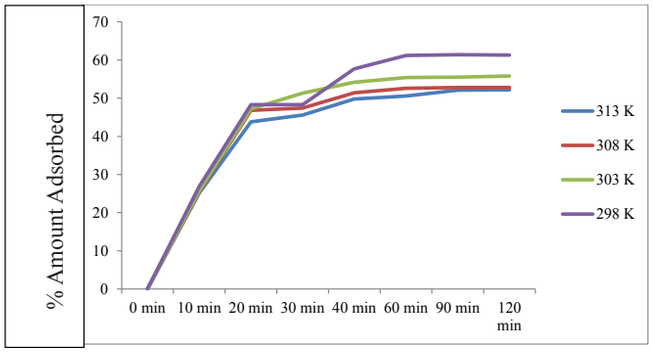

Fig. 2: Influence of Temperature on the Adsorption of Pb(II) Ions on Aluminium (III) Oxide Powder

Table IV: Effect of pH on the Removal of Pb(II) Ions on the Aluminium (III) Oxide Powder. Adsorbent Dose =2.0g Temperature: 298K, Concentration: 0.1 ML^{-1}

Time(min)	*Percentage Amount Adsorbed*			
	pH 3.5	*pH 4.5*	*pH 7.5*	*pH 8.5*
0	0	0	0	0
10	4.4	4.6	4.5	4.9
20	9.8	11.4	15.1	20.4
30	15.7	20.1	27.2	39.6
40	30.9	35.6	46.1	54.2
60	45.1	51.6	63.8	65.2
90	45.2	51.6	63.3	71.2
120	45.1	51.7	64.1	71.3

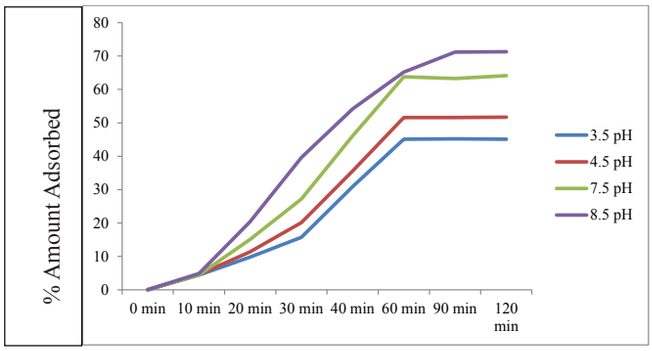

Fig. 3: Influence of pH on the Adsorption of Pb(II) Ions on Aliuminium (III) Oxide Powder

IV. Discussion

The time variation of amount of Pb(II) ions adsorbed on aluminum (III) oxide powder as function of adsorbent dose is presented in Table I. It can be seen from this table that the amount of Pb(II) ions adsorbed is maximum for 0.2g adsorbent and increases with the increase dose of adsorbent. Maximum adsorption at 0.20g of adsorbent may be due to large surface area of the adsorbent at higher adsorbent dose. However, the time require to reach the equilibrium is 60 minutes. The time variation of Pb(II) ions adsorbed on aluminum (III) Oxide powder at 298K was studied at varying amount of concentration of adsorbate at pH 8.5. The results obtained are reported in Table II. It is clear from this table that the percentage amount of Pb(II) ions adsorbed increases with increase of dilution from 42.18-56.34 at 0.04 $molL^{-1}$ -0.1 $molL^{-1}$. This may be due to comparatively higher amount of adsorbate for equal quantity of adsorbent sites [19-20]. The influence of temperature on the amount adsorbed in the temperature range 298K-313K have been carried out and results are presented in Table III. As can be seen from this table that the higher percentage of amount adsorbed is obtained at lower temperature. This may be due to high surface activity of the adsorbent [21]. At higher temperature similar results are were also reported by for" Cr(II) and Ni(II) adsorption on aluminium (III) oxide as adsorbent by Sheeba Thavamain and Rajkumar and Candmium (II) ions by mixed adsorbents of alumina by Latif *et al.* The effect of pH value on the adsorption of Pb(II) ions on aluminium (III) oxide adsorbent was also studied pH value range of 3.5-8.5 and the results are shown in Table IV. It is evident from the Table IV that the percentage amount adsorbed is maximum at pH 8.5 and minimum at 3.5 under similar condition. As pH increases surface may be come negatively charge as a result of which more amount of Pb(II) ions may be adsorbed [22].

V. Conclusion

1. Adsorption method is most suitable technique for the removal and recovery of heavy metal ions from waste waters.
2. Aluminum (III) oxide powder is potential adsorbent for the removal of Pb(II) ions.
3. Percentage amount adsorbed is optimum 0.1$molL^{-1}$ concentration, temperature 298K, adsorbent dose of 2.0g and pH value 8.5.

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