Asian Journal of Chemistry Vol. 14, No. 1 (2002), 367–370

Characterisation of Plastic Clay and Prophyllite Used as Adsorbents for the Removal of Pollutants

KALPNA RAI*, MONA JAISWAL and A. MAHESHWARI
Department of Applied Chemistry
Government Engineering College, Jabalpur-482 011, India

Studies were made in search of non-conventional cheap adsorbents to use them for waste water treatment. Clay minerals, namely plastic clay and prophyllite, were characterised with IR, XRD and standard methods of chemical analysis. These have been tried for the removal of phenol, *o*-nitrophenol, *p*-nitrophenol, *o*-cresol, *m*-cresol, *p*-cresol, oxalate, Cr(VI), PO_4^{3-} through batch adsorption and the results confirmed these to be good adsorbents.

Key words: Plastic clay, pyrophyllite, adsorbents, removal of pollutants, X-ray diffractogram, IR spectra.

INTRODUCTION

Phenols and heavy metal pollutants present in industrial wastewater cause direct toxicity, both to human and other living beings, due to their presence beyond specified limits[1]. The main object of the present study is to adopt an appropriate method and to develop suitable techniques either to prevent the heavy metal pollution or to reduce it to very low levels. The most commonly used methodologies for the treatment of pollutants bearing waste waters include solvent extraction, physical adsorption, chemical oxidation and aerobic and anaerobic biological degradation[2]. Adsorption has been shown to be very effective in treating wastewaters that contain moderate pollutants[2].

Removal of pollutants from wastewaters by adsorption on activated carbon and synthetic resins has been studied by a number of researchers[3,4]. High cost of activated carbon and synthetic resins in India has prompted search for cheaper substituents. Fly ash, China clay, saw dust, bentonite, lignite, peat coal, rice husk, plastic clay, pyrophyllite[5,6] are some of the low cost adsorbents which have proved to be effective in wastewater treatment.

The rate and extent of removal of pollutants by adsorption are mainly influenced by the nature of the adsorbents and adsorbate. Therefore, in order to have a better insight into the mechanism of the process involved, it is essential to characterise the adsorbent. An attempt has therefore been made to characterise the clay on the basis of chemical composition, XRD and IR analysis. Experiments for the removal efficiency or adsorption capacity of plastic clay and pyrophyllite have also been carried out.

EXPERIMENTAL

Batch experiments were carried out by shaking 2 g of adsorbent with 50 mL of aqueous solution of adsorbate of desired concentration and pH for 2 h in a temperature controlled shaking water bath. The initial pH of the solution was adjusted with 0.1 N NaOH and HCl. The remaining concentration of adsorbate after adsorption was determined by suitable methods.

Plastic clay and pyrophyllite used as adsorbents were obtained from Shiv minerals, Damoh Road, Jabalpur. This was sieved through standard test sieves into different particle sizes and dried for 2 h at 110°C in an electric oven and stored in a desiccator for use.

The chemical and proximate analysis of the adsorbents used was carried out as per standard methods[7]. The X-ray diffractograms were obtained on X-ray diffractometer model PW1710 using CuK_a radiations and Ni filter of $\lambda = 1.54060$. Diffraction patterns were measured at 2θ with a current of 20 mA at 30 kV. The IR of these adsorbents was recorded in KBr and nujol mull using Perkin-Elmer spectrophotometer Model-817, in the range of 4000–500 cm^{-1}.

RESULTS AND DISCUSSION

The results of chemical analysis of the adsorbents, plastic clay and pyrophyllite (Table-1) show that they have mainly the oxides of silica and alumina whereas iron, magnesium, calcium oxides are present in small amount. The main constituents of plastic clay, a pure form of hydrated aluminium silicate, are silica (60.24%), alumina (25.07%) and trace amounts of the oxides of iron, magnesium and calcium. The main constituents of pyrophyllite are silica (71.15%), alumina (9.32%) and trace amounts of iron, magnesium and calcium oxides. The results are in conformity with those reported earlier[8]. It is thus expected that pollutants will be mostly removed by these main constituents of adsorbents. The percentage of adsorption of pollutants on these adsorbents is reported in Table-2.

TABLE-1
CHEMICAL COMPOSITION OF PLASTIC CLAY AND PYROPHYLLITE

Adsorbent	Particle size (μm)	Chemical composition (% by weight)					
		LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Plastic clay	75	11.20	60.24	25.07	1.46	0.58	0.39
	150	16.70	53.34	23.04	1.26	0.56	0.37
	425	22.92	53.05	20.40	1.20	0.51	0.31
Pyrophyllite	75	15.87	71.15	9.32	0.59	0.15	0.12
	150	23.31	62.04	5.21	0.26	0.10	0.08
	425	27.45	56.25	2.85	0.12	0.05	0.02

LOI: Loss on ignition.

TABLE 2
REMOVAL OF PHENOL AND HEAVY METALS BY PLASTIC CLAY AND PYROPHYLLITE

Pollutants	Plastic clay (%)	Pyrophyllite
Phenol	51.00	44.02
o-Nitrophenol	61.72	54.10
p-Nitrophenol	73.75	65.34
m-Nitrophenol	63.04	59.45
o-Cresol	44.70	34.04
m-Cresol	47.00	39.25
p-Cresol	57.00	50.62
Oxalate	79.41	60.00
Cr(VI)	64.72	32.00
PO_4^{3-}	70.00	80.94

IR studies of these adsorbents help in detection of the presence of different constituents in the form of their minerals. In the IR spectra of plastic clay, the bands at 1000. 792 and 540 cm^{-1} indicating the presence of quartz[9]. A band at 3452 and 1635 in the spectrum of plastic clay suggested the possibility of water of hydration in the adsorbent. The adsorption bands at 3695, 3622, 1037, 1008, 914, 750 and 540 cm^{-1} are attributed to the presence of kaolinite[9]. Bands at 468 and 426 cm^{-1} are attributed to the presence of illite[9] and hematite[9]. Similar universal peaks were reported by earlier workers in other adsorbents.[10, 11]

The important IR bands of pyrophyllite are at 771, 692, 518 and 445 cm^{-1}, showing the presence of quartz. The vibrations observed at 3440, 1018 and 414 cm^{-1} indicate the possibility of the presence of hematite. However, most of the bands at 3624, 1018, 771 and 692 cm^{-1} are attributed to the presence of kaolinite. The presence of bands at 3440, 1622, 1018 and 771 cm^{-1} indicates the possibility of illite. The bands at 3043 and 3008 cm^{-1} indicate the occurrence of natrochalcite[9]. The bands at 3913 and 3141 cm^{-1}show the presence of aluminite.

The interlayer hydrogen bonding in these adsorbents is assigned by a characteristic band in the range of 3624–3620 cm^{-1}.

XRD is used to determine the mineralogical composition of adsorbents. The 'd' values of plastic clay shows the presence of kaolinite, quartz[12], hematite, illite and trace amounts of muscovite and gibbsite. The 'd' value of pyrophyllite also shows the presence of kaolinite, quartz, hematite. illite and small amounts of calcite, natrochalcite.

Conclusion

The chemical analysis, IR and XRD show that plastic clay and pyrophyllite are mainly constituted of alumina and silica containing minerals. Adsorption studies proved these to be effective adsorbents for wastewater treatment. Further studies are required in the field of effluent treatment with these adsorbents.

REFERENCES

1. M. Kumaresan and P. Riyazuddin, *Res. J. Chem. and Environment*, **3**, 59 (1999).
2. M.M. Swamy, I.D. Mall, B. Prasad and I.M. Mishra, *Indian J. Environment Hlth.*, **40**, 67 (1998).
3. K. Claus and S.M. Smith, Chem. Engg. Sci., **40**, 1041 (1985).
4. O.C. David and Xi Zhenpeng, *AlchE Journal*, **40**, 360 (1994).
5. K.K. Pandey, G. Prasad and V.N. Singh, *J. Chem. Tech. and Biotechnol.*, **34A**, 367 (1984).
6. M. Jaiswal and A. Maheshwari, *Ultra Science*, **12**, 238 (2000).
7. Indian Standard Methods of Chemical Analysis of Fire Clay and Silica Refractory Materials, IS: 1527 (1960).
8. R.B. Ladoo and W.M. Myeas, Nonmetallic Minerals, 2nd Edn. (1951).
9. Atlas of Infrared Spectroscopy of Clay Minerals and Their Admixtures, Elsevier Sci. Pub. Co., N.Y. (1976).
10. S. Jasienko and B. Karabon, *Chem. Abstr.*, **62**, 2637a (1965).
11. B.D. Saksena, K.C. Agrawal and G.S. Jauhri, *Trans. Faraday Soc.*, **59**, 276 (1963)
12. R.T. Vanderbilt, Pyrophyllite, New York, p. 24 (1943).

(*Received*: 31 August 2001; *Accepted*: 27 October 2001) AJC-2504