

Physico-chemical properties and TGA studies of Montmorillonite

[Ashok Kumar Jha]

Abstract- *Montmorillonite is a specific mineral name of the smectite group widely distributed in several states of India. Jharkhand montmorillonites collected from different places have been studied for physico-chemical properties and TGA. Montmorillonite deposits of economic importance occur only in tertiary formations. Jharkhand montmorillonites have got more industrial application due to its good swelling power, adsorption capacity and ion exchange capacity. The exchangeable cations are Ca^{2+} , Mg^{2+} , Na^+ and K^+ . cation exchange capacities are calculated in (meq/100g) for different cations. Clay minerals have a layered structure based on sheets with 6-membered rings of silica tetrahedra. The composition of minerals are SiO_2 , Al_2O_3 , Na_2O , K_2O , Fe_2O_3 and traces of MnO showing colours grey, black and brown. Montmorillonite unit gives blue stain test with benzidine solution. The ratio of SiO_2 and Al_2O_3 varies from one sample to another. The TGA experiments show a loss of mass about 18.9% indicating the loss of molecular water and dehydroxylation.*

Keywords:

Monmorillonite, Smectite, Cation exchange capacity, TGA

I. Introduction

There are two kinds of clay deposits containing montmorillonite as a main constituent mineral: one is called bentonite and the other acid clay [1,2]. Bentonite deposits have been formed due to alteration from rhyolitic ash in a marine Environment and hydrothermal alteration from rhyolite tuff. The constituent minerals of bentonites are SiO_2 , Al_2O_3 ,

Fe_2O_3 , MgO , CaO , Na_2O , K_2O and traces of TiO_2 and MnO . Though the detailed investigation of properties of bentonite minerals from different places in India has been done, the bentonites of different grades and colours of Rajmahal Hills have attracted the attention of researchers to study the physico-chemical properties of the Rajmahal bentonites. The stain test, swelling power, loss on ignition and TGA studies have been done. Bentonites of Jharkhand, Rajula, Akli and Hati singh ki Dhani samples are typical montmorillonite whereas jaipur and Kerauli samples are predominantly illitic [3,4,5]. The importance of Jharkhand Rajmahal bentonites is growing due to its various industrial uses e.g decolorization of oil, manufacture of catalyst, preparation of oil drilling muds, in agriculture [6,7]. Utility in water treatment due to cation exchange capacity and adsorption capacity have also been exploited. Rajmahal Hill bentonites can also be used for defluoridation, removal of arsenic from aqueous medium. Generally the percentage of Al_2O_3 content in Rajmahal bentonites varies from 19.02 to 34.01% and percentage of SiO_2 is almost around 51%. The SiO_2 and Al_2O_3 ratio varies from 1.5 to 3.00 in Rajmahal bentonites. Alkali and alkaline earth metal oxides have been recognized as important constituents of these bentonites.

The development of cation exchange capacity attracted industries to start ion exchange methods for water softening, treatment of waste water, sea water treatment soap industry and pharmaceutical industries. Rajmahal Hill bentonites can be exploited for removal of toxic metals from aqueous medium. [8,9,10].

Dr Ashok Kumar Jha thanks UGC, Eastern regional office for providing financial assistance in the research project.

II. Results and discussion

The stain tests were performed with the bentonite samples using benzidine in ethanol. Eleven out of twelve samples gave blue colour with benzidine solution suggesting the presence of montmorillonite. The swelling power is an important property of clay mineral. The calculated swelling power of the minerals have been shown in Table I. It has been found that Rajmahal bentonites have poor swelling power than Rajasthan bentonites. The bentonite samples of Rajmahal Hills have gel volume never more than seven and less than three. Loss on ignition has been found to vary from 4.20 to 12.64. These data are comparable with data reported in TableII from literature.

From Table III it is clear that CEC of bentonites varies from 35.86 to 101.45 meq per 100g measured by K_2CO_3 method. Rajmahal bentonites have exchangeable cations like Na,K.Mg, and Ca, confirmed by testing for these cations in the solution extract.

Substitution within the lattice structure of trivalent Al for quadrivalent Si in the tetrahedral sheet and Mg for trivalent Al in the octahedral sheet result in unbalanced charges.

During TGA studies, Fig.I, Fig.II and Fig.III show that bentonites presented a total loss of mass of 18.809%, 18.929% and 19.21% respectively between 373K and 1073K. Fig.IV show a total loss of mass of 14.49%. The first loss due to hygroscopicity and the second loss due to the removal of water composition from the bentonites

Experimental

Physico-chemical properties of bentonite minerals were done following the methods (Mishra 2008). Stain test is done by saturated solution of benzidine in ethanol. Cation exchange capacity has

been determined by K_2CO_3 standard solution.

TABLE I

Properties of Rajmahal Hill Bentonite.	Sample Code	Stain Test	Swelling Power	Gel volume	% loss on ignition
	RHB ₁	+	2.20	5	6.79
	RHB ₂	+	2.00	5	6.48
	RHB ₃	+	1.80	3	8.38
	RHB ₄	+	2.30	7	10.49
	RHB ₅	-	1.60	3	12.59
	RHB ₆	+	2.50	4	10.05
	RHB ₇	+	2.00	5	-----
	RHB ₈	+	3.00	5	7.85
	RHB ₉	+	2.11	7	4.60
	RHB ₁₀	+	2.53	5	4.20
	RHB ₁₁	+	5.02	5	5.33
	RHB ₁₂	+	6.88	6	11.25

RHB stands for Rajmahal Hill bentonites.

TABLE II

Comparative literature values of properties of Rajmahal bentonites	Name of place	Swelling power	Gel volume	% loss on ignition
	Harwecha	3.0	4.0	-
	Hathi singh ki Dhani	7.0	13.0	10.61
	Akli-Giral	2.0	2.5	8.02
	Bisala	6.0	15.0	-
	Mahwar	3.0	5.0	-
	Rajula	-	-	7.62

TABLE III

Cation exchange capacity of Rajmahal Hill bentonites	Sample Code	Cation exchange capacity (milli equivalent /100gm) K_2CO_3 method
	RHB ₁	81.85
	RHB ₂	101.45
	RHB ₃	85.83
	RHB ₄	57.99
	RHB ₅	53.02
	RHB ₆	96.65
	RHB ₇	35.86
	RHB ₈	67.00
	RHB ₉	93.12

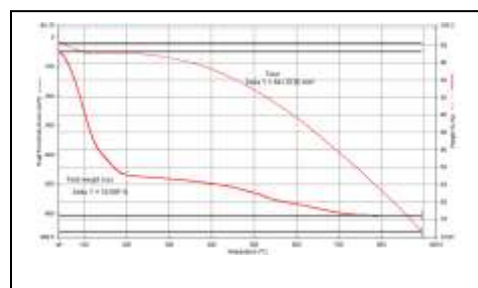


Figure I. TGA curves of RHB3

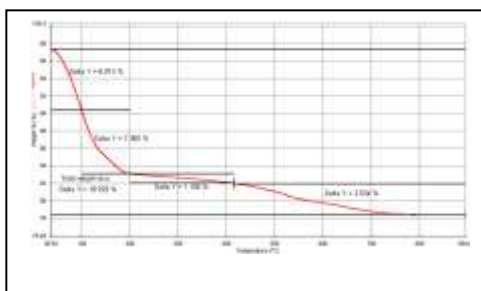


Figure II. TGA curves of RHB2

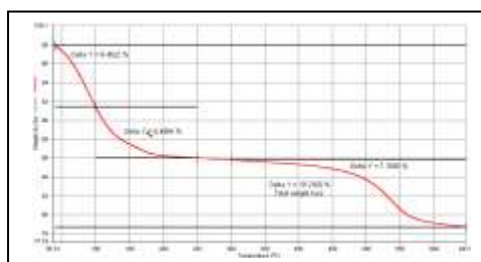


Figure III. TGA curves of RHB7

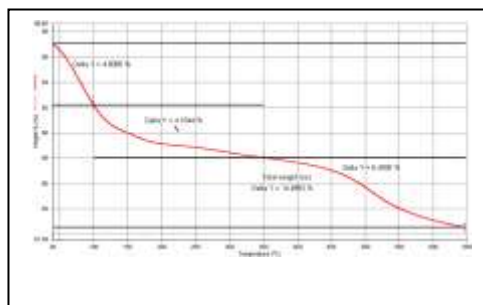


Figure IV. TGA curves of RHB8

Environment and pollution ,vol 8, No 4, 93-96,2011.

- [5] Ashok Kr. Jha, Ph.D thesis, Studies on water purification using aquatic plants and Bentonite minerals of Rajmahal Hills of Jharkhand, S.K.M Univ. Dumka, Jharkhand,2011.
- [6] R. Kunel, Elements of ion exchange, Reinhold publishing corporation New York, 1964.
- [7] J. Choudary, Ph.D thesis, T.M.Bhag. Univ. Bhagalpur,Bihar,1985.
- [8] F.Ayari, E.Srasra and M.Trabelsi, Characterization of bentonite clays and their use as adsorbent, Desalination185,391-397, 2005.
- [9] H.Zaitan and D.Bianchi, A comparative study of the adsorption and desorption of o-xylene onto bentonite clay and alumina, Journal of hazardous materials,153,852-859,2008.
- [10] Z.Yermiyahu, I.Lapides and S. Yariv, Thermo-XRD analysis of congo-red by montmorillonite saturated with different cations, J.Them. Anal calorim,69,317-332,2002.

References

- [1] D.Jha, B.K.Mishra,S.S.Mishra and A.K.Jha, Bentonite clays minerals of Rajmahal Hills, J. Haematol and Ecotoxical 5(1), 1-7,2010.
- [2] A.K.Jha and B.Mishra, Removal of fluoride by bentonite minerals of Rajmahal Hills, J Indian Chem. Soc. Vol 89,519-521, 2012.
- [3] M.V.Kok, Thermogravimetry of selected bentonites , Energy sources ,24(10),899-907,2002.
- [4] Ashok Kr. Jha, Arun Kr.Jha, Arun Kr. Mishra, Vineeta Kumari and B.Mishra, Asian Journal of water,



Dr. Ashok Kumar Jha is a renowned scientist working in the field of water pollution. He has published 20 papers in referred National and International journals, edited two books and authored one book. He has the pride of organizing eight National seminars sponsored by UGC, CSIR and NABARD. He has completed two research projects sponsored by UGC and delivered many invited lectures in National seminars.