BUBBLE PICK-UP STUDIES WITH ALUMINA

BY P. K. DESHPANDE AND G. N. BHAT
(*Department of Chemical Technology and Chemical Engineering,
Indian Institute of Science, Bangalore*)

Received November 4, 1954

Contact angle measurements have often proved valuable in flotation studies. All the same however, bubble pick-up technique has been gaining importance of late, in understanding flotation results, especially while dealing with materials that do not afford to provide the essential requirements needed for contact angle studies. Cooke and Digre[1] indicated attempts to correlate data from bubble pick-up studies and contact angle measurements. Sun and Troxell[2] have converted the quantitative data obtained from pick-up experiments into Bubble Pick-up " Indices " and " Coefficients ".

In this paper, results obtained from pick-up studies on alumina with oleic acid and sodium silicate have been presented, and attempts are made to interpret them in the light of present flotation theories.

APPARATUS, MATERIALS AND METHOD

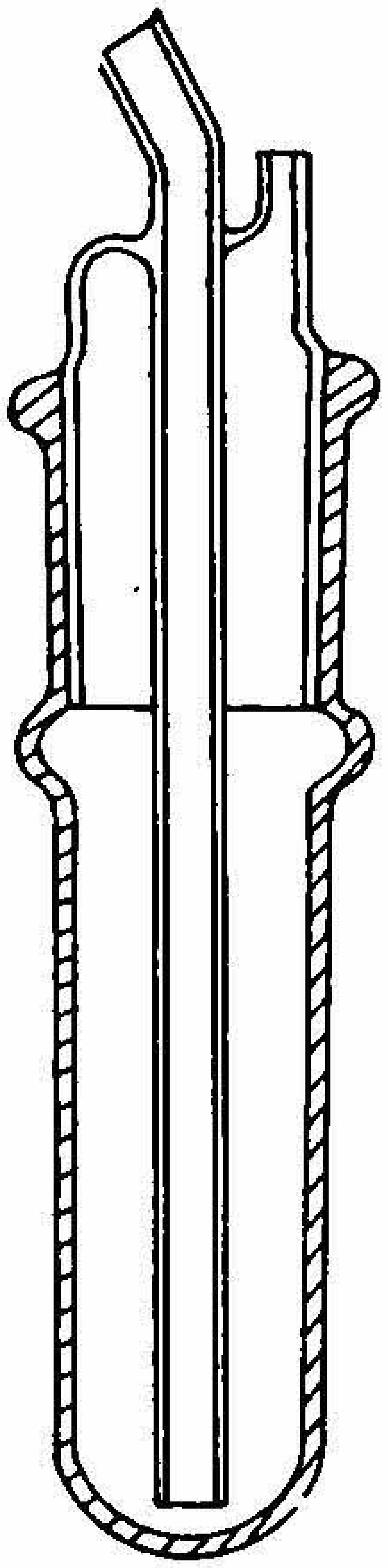
The bubble pick-up cell used in this investigation was the one proposed by Cooke[3] and the same has been shown in Fig. 1. The alumina was prepared by precipitating aluminium hydroxide from potassium aluminate by carbon dioxide, and calcining the dried hydroxide at 350–360° C. for 18 hours. Oleic acid used was of B.P. quality and the sodium silicate was the Denver product.

Every experiment was conducted by pipetting the required volumes of oleic acid, sodium silicate and buffer solutions into the cell (the original solution being in the non-pick-up range) and adding 0·5 gm. of alumina (– 40 + 60 mesh). After equilibrium conditions being attained, the sample was tested by pressing an air bubble against the powder, raising the bubble and visually noting the pick-up. Critical pick-up was determined by the technique of Last and Cook.[4]

RESULTS AND DISCUSSION

Results obtained in the present studies are given in Tables I to IV and in Figs. 2 and 3.

From the data of Table I it is obvious that the bulk concentration of oleic acid required for the critical bubble pick-up is less in all cases at pH of 7, thus indicating that oleic acid is easily adsorbed on alumina at this pH. This observation is in accordance with the fact that the much more surface-active acid is adsorbed from slightly acidic or neutral solutions to a greater degree, while the long-chain paraffin ions together with the electrostatically held positive "gegen" ions



THE CELL

Fig. 1

Table I

pH	3·35	4·74	5·81	6·94	8·60	9·50	10·70
Conc. of Sodium Silicate mgm./litre	Conc. of Oleic Acid in mgm./litre at Critical Pick-Up						
..	300	220	110	90	110	160	170
5	520	410	260	210	350	410	650
10	760	590	410	325	540	670	..
15	..	810	540	460	725	920	..
20	..	..	700	575	950	..	..
25	..	..	845	690	..	..	..

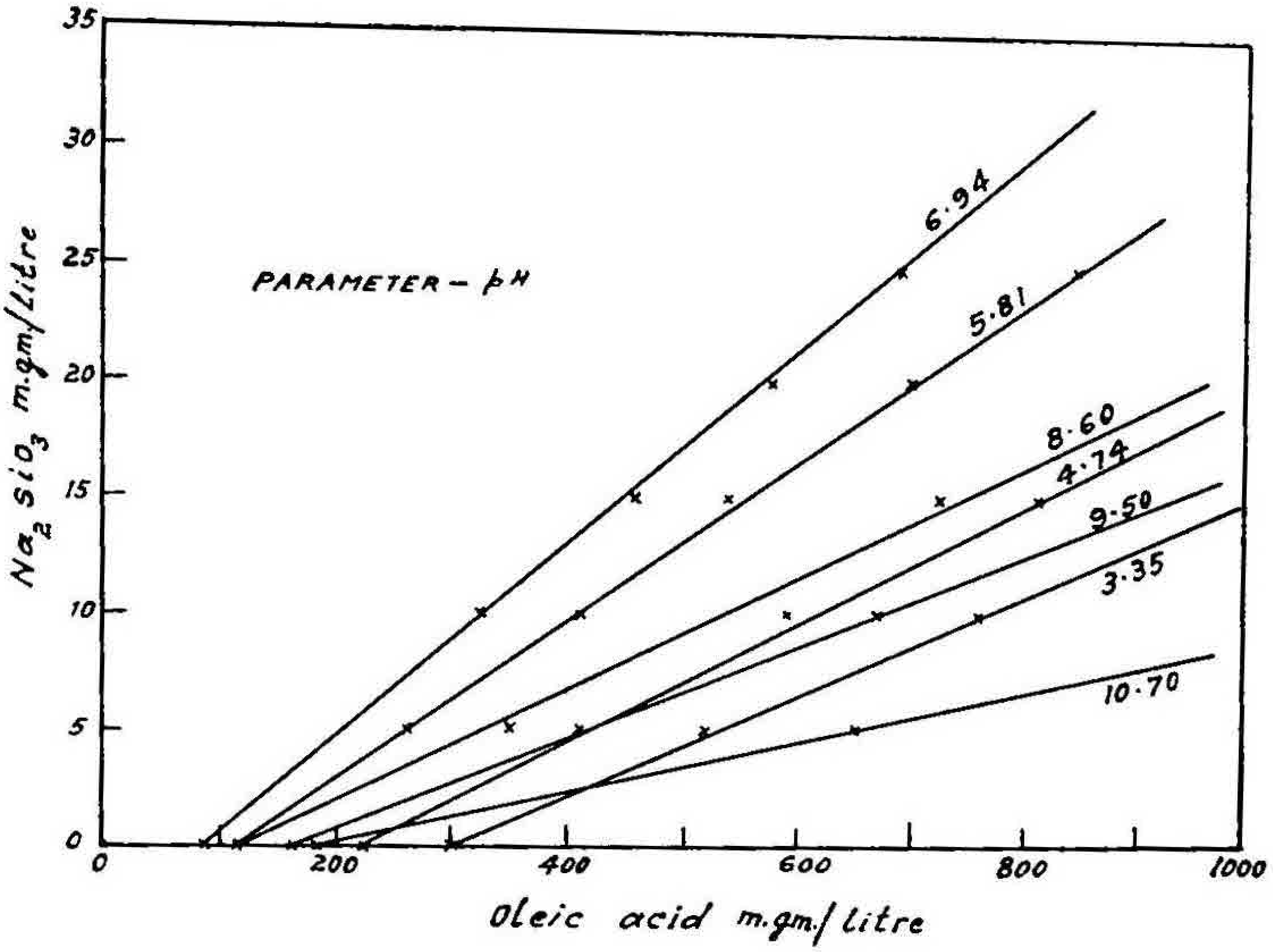


FIG 2

TABLE II

pH	3·35	4·74	5·81	6·94	8·60	9·50	10·70
Conc. of Oleic Acid mgm./litre	Conc. of Sodium Silicate in mgm./litre at Critical Pick-Up						
125	..	..	0·50	1·50	0·25	..	..
200	..	..	3·00	4·50	2·00	0·75	0·125
250	..	0·75	4·75	6·75	3·25	1·75	0·75
300	..	2·00	6·25	8·75	4·50	2·75	1·25
400	2·25	4·50	9·75	13·00	6·75	4·75	2·25
500	4·50	7·00	13·00	17·25	9·00	6·75	3·50

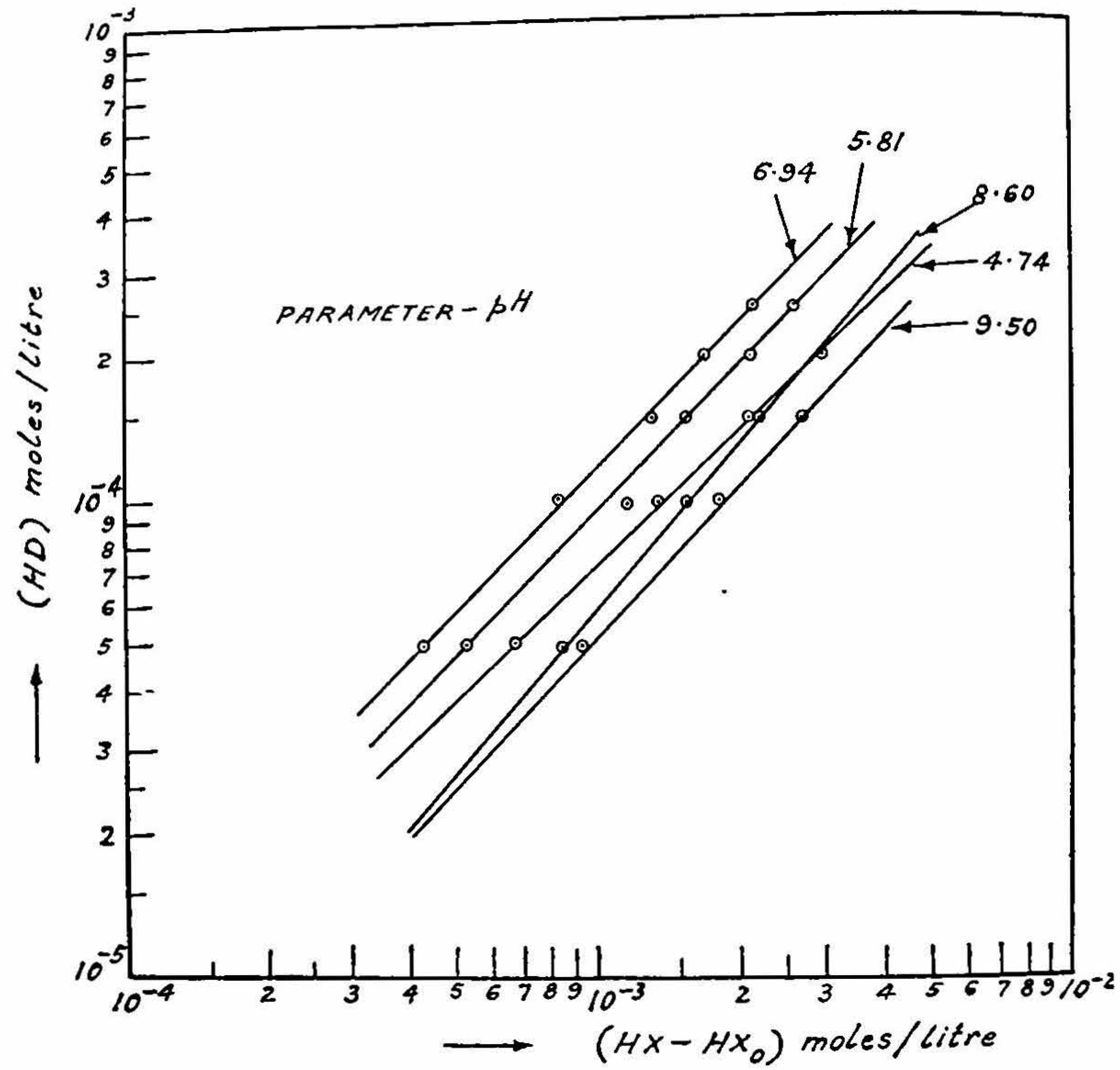


FIG. 3

are adsorbed from the strongly basic solutions as observed by Long, Nutting and Harkins.[5] Talmud and Lubman[6] have also noticed the pH of 7 to be optimum for the flotation of alumina by oleic acid. The present results are therefore, in conformity with the " Free-Acid " " Free-Base " adsorption theory of Cook and Nixon.[7]

From Table I it is also noticed that under critical pick-up conditions, the presence of sodium silicate in the solution requires a greater amount of oleic acid than during its absence, the amount being dependant on the concentration of sodium silicate.

The curves obtained by plotting the concentration of oleic acid *versus* the concentration of sodium silicate with pH as parameter, are straight lines (Fig. 2), similar to the representativn of flotation data by Last and Cook.[4] The curves log (HD) *versus* log $(HX-HX_0)$ also yield straight lines at a definite pH (where

TABLE III

pH	Conc. of Oleic Acid at Critical Pick-Up mgm./litre	Critical Pick-Up
6·60	80·00	No
6·60	100·00	Yes
6·60	120·00	Yes
6·60	140·00	Yes
6·60	160·00	Partial
6·60	180·00	Partial
6·60	200·00	No
6·60	220·00	No

TABLE IV

pH	HD mgm./litre	$(HX-HX_0)$ mgm./litre	HD moles/litre	$(HX-HX_0)$ moles/litre
3·35	5·0	(520−300)=220	$4{\cdot}903\times10^{-5}$	$7{\cdot}802\times10^{-4}$
3·35	10·0	(760−300)=460	$9{\cdot}804\times10^{-5}$	$1{\cdot}631\times10^{-3}$
4·74	5·0	(410−220)=190	$4{\cdot}903\times10^{-5}$	$6{\cdot}379\times10^{-4}$
4·74	10·0	(590−220)=370	$9{\cdot}804\times10^{-5}$	$1{\cdot}312\times10^{-3}$
4·74	15·0	(810−220)=590	$1{\cdot}471\times10^{-4}$	$2{\cdot}092\times10^{-3}$
5·81	5·0	(260−110)=150	$4{\cdot}903\times10^{-5}$	$5{\cdot}320\times10^{-4}$
5·81	10·0	(410−110)=300	$9{\cdot}804\times10^{-5}$	$1{\cdot}064\times10^{-3}$
5·81	15·0	(540−110)=430	$1{\cdot}471\times10^{-4}$	$1{\cdot}525\times10^{-3}$
5·81	20·0	(700−110)=590	$1{\cdot}961\times10^{-4}$	$2{\cdot}092\times10^{-3}$
5·81	25·0	(845−110)=735	$2{\cdot}451\times10^{-4}$	$2{\cdot}607\times10^{-3}$
6·94	5·0	(210− 90)=120	$4{\cdot}903\times10^{-5}$	$4{\cdot}256\times10^{-4}$
6·94	10·0	(325− 90)=235	$9{\cdot}804\times10^{-5}$	$8{\cdot}335\times10^{-4}$
6·94	15·0	(460− 90)=370	$1{\cdot}471\times10^{-4}$	$1{\cdot}312\times10^{-3}$
6·94	20·0	(575− 90)=485	$1{\cdot}961\times10^{-4}$	$1{\cdot}720\times10^{-3}$
6·94	25·0	(690− 90)=600	$2{\cdot}451\times10^{-4}$	$2{\cdot}128\times10^{-3}$
8·60	5·0	(350−110)=240	$4{\cdot}903\times10^{-5}$	$8{\cdot}511\times10^{-4}$
8·60	10·0	(540−110)=430	$9{\cdot}804\times10^{-5}$	$1{\cdot}525\times10^{-3}$
8·60	15·0	(725−110) 615	$1{\cdot}471\times10^{-4}$	$2{\cdot}181\times10^{-3}$
8·60	20·0	(950−110)=840	$1{\cdot}961\times10^{-4}$	$2{\cdot}966\times10^{-3}$
9·5	5·0	(410−160)=250	$4{\cdot}903\times10^{-5}$	$8{\cdot}865\times10^{-4}$
9·5	10·0	(670−160)=510	$9{\cdot}804\times10^{-5}$	$1{\cdot}809\times10^{-3}$
9·5	15·0	(920−160)=760	$1{\cdot}471\times10^{-4}$	$2{\cdot}696\times10^{-3}$
10·7	5·0	(650−170)=480	$4{\cdot}903\times10^{-5}$	$1{\cdot}702\times10^{-3}$

HD = Free-acid depressant concentration, HX = Free-acid collector concentration at HD and HX_0 = Free-acid collector concentration at HD = 0) (Fig. 3). Thus, validity of the proposed mechanism of Cook and Nixon[7] about the single-site adsorption involving both collector and depressant as free acids, seems well warranted in explaining the present experimental results.

Data given in Table III reveal that at any pH (in this case pH of 6·6) addition of collector in quantities larger than that required for critical pick-up gives partial or no pick-up condition. This situation clearly indicates the possibility of the formation of a partial or complete second layer of adsorbed collector molecules on alumina oriented the wrong way for attraction between the collector film and an air bubble.[8]

REFERENCES

1. Cooke, S. R. B. and Digre, M. .. *Trans. A.I.M.E.*, 1949, **184**, 229-305.
2. Sun, S. C. and Troxell, R. C. .. *Min. Engg.*, July 1953, 715.
3. Cooke, S. R. B. .. *Trans. A.I.M.E.*, 1949, **184**, 306.
4. Last, G. A. and Cook, M. A. .. *J. Phys. Chem.*, 1952, **56**, 637.
5. Long, F. A., Nutting, G. C. and Harkins, W. D. .. *J. Am. Chem. Soc.*, 1937, **59**, 2197.
6. Talmud, D. and Lubmen, N. M. .. *Kolloid Zeitchrift*, 1930, **50**, 159-62.
7. Cook, M. H. and Nixon, J. C. .. *J. Phys. Chem.*, 1950, **54**, 445.
8. Taggart, A. F. and Arbiter, N. .. *Trans. A.I.M.E.*, 1943, **153**, 500.

105-55 Printed at The Bangalore Press, Bangalore City, by C. Vasudeva Rao, Superintendent