Electrolytic production of sodium hypochlorite for bleaching

R. Palanisamy, V. Rengarajan, G. Sozhen and K. C. Narasimham

ABSTRACT

Calcium hypochlorite is used at present for the bleaching of pulp in the paper industry However there is an increasing interest shown to switch over to sodium hypochlorite since it can be a single stage operation with sodium hypochlorite. Hence direct electrolytic oxidation of sodium chlorite to sodium hypochlorite has been attempted. In this paper the operating conditions of a 4x40 A bipolar cell and a 500 A monopolar cell are discussed. The results of the bleaching of various pulps from different paper industries are also reported.

Key Words : Sodium hypochlorite, Bipolar Cell, Bleaching of pulp.

Introduction

Sodium hypochlorite is extensively used for sterilising drinking water, chlorination of swimming pools apart from the bleaching of pulp in paper and textile industries [1]. At present there is an increasing interest shown by paper industries to switch over to sodium hypochlorite bleaching of pulp in the place of the conventional three stage bleaching involving calcium hypochlorite in the final stage. Though sodium hypochlorite can be prepared chemically by bubbling chlorine gas into dilute sodium hydroxide solution at room temperature, the raw materials, viz , alkali and chlorine which are produced by electrolysis, have to be transferred to the site involving expenditure for transportation. So an on-site production of sodium hypochlorite by the direct electrolytic oxidation of sodium chloride can be a solution to obviate these difficulties.

Both monopolar and bipolar cells can be made use of for the production of sodium hypochlorite [2, 3]. In addition, the emergence of catalytic type of metal anodes in the production of sodium hypochlorite has proved to be advantageous both from economic and energy conservation point of view [4, 5].

The present paper describes the use of both monopolar cell (500 A) fitted with electrocatalytically activated titanium anode and bipolar cell (4x40A) for the production of sodium hypochlorite. The results obtained in the use of sodium hypochlorite for bleaching of various pulps are also reported.

EXPERIMENTAL

MONOPOLAR CELL

Cell Assembly : A monopolar cell made of P. V. C. (60 (l) x 40 (b) x 50 cm (h)) fitted with six numbers of cylindrical titanium substrate insoluble anodes 7.5 (dia) x 35 cm (h) and six numbers of cylindrical perforated mild steel cathodes (9.5 (dia) x 35cm (h)) surrounding each anode with an inter electrode distance of 1 cm constitutes the cell assembly.

Electrolysis : 160 litres of brine solution containing 40 to 60 g. l^{-1} sodium chloride and 1 g. l^{-1} sodium dichromate was used as the electrolyte. Direct current of 500 A was supplied from a rectifier (0-18V, 1000A), Electrolysis was carried out for 8 hours and the solution estimated for hypochlorite.

BI-POLAR CELL

Cell Assembly : A bipolar cell having four compartments and a stack pack arrangement with explosion

(Central Electro Chemical Research Institute,
Scientist, Industrial Liaison & Extn , Unit
KARAIKUDI 623006 (T. N.)

bonded titanium mild steel electrodes [6, 7] (20 x 20 cm) as reported earlier [8] was employed. The end plates alone were given electrical connection from rectifier (0-300 A; 0-40V).

Electrolysis : The bipolar cell was operated by passing 40A so that the current rating for the four compartments could be 160A. 60 litres of brine (40 to 60 g. $l.^{-1}$) with the addition of 1 g. l^{-1} sodium dichromate was used as electrolyte. The electrolyte was circulated and after 8 hours the hypochlorite concentration was estimated.

ANALYSIS :

Chloride was estimated by Mohr's method [9] while iodometric method was followed to estimate the hypochlorite content [9].

Bleaching Experiments

Experiments were carried out by taking a known weight of pulp and adding a known quantity of freshly prepared sodium hypochlorite containing 1.5% of available chlorine. The contents were mixed thoroughly and allowed for two hours for completion of bleaching. Then the pulp was washed thoroughly and filtered using an extractor. This treatment is adopted in the place of the conventional three steps involved namely chlorination, alkali extraction and hypotreatment as shown in Fig. 1, which normally takes 4.5 hrs [10] Some of the experiments were done in two stages with a view to improve the brightness.

RESULTS AND DISCUSSIONS

Sodium hypochlorite preparation

The operating details of both monopolar and bipolar cells for the production of sodium hypochlorite are given in Table-I The production of sodium hypochlorite is carried out at an anode current density of 10 to 15 A dm^{-2}. The low current efficiency viz 52-55% for both cells can be attributed to the simultaneous discharge of OH ions leading to oxygen evolution at the anode since the low concentration of sodium chloride and alkaline pH can favour the discharge of OH^-. The formation of hypochlorite is favoured at lower temperatures as evidenced by earlier experiments.

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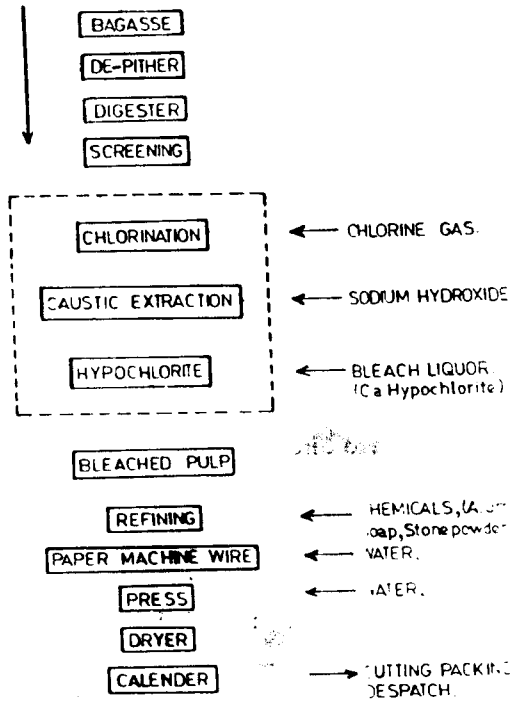

Fig 1

TABLE I

Operating conditions for the production of Sodium Hypochlorite

Details	Monopolar cell	Bipolar cell
Initial Concentration NaCl $g.l^{-1}$	40 — 50	40 — 50
Final Concentration NaCl $g.l^{-1}$	28 — 36	27 — 35
NaOCl $g.l^{-1}$	15.3	16.8
Available Chlorine %	1.5	1.6
Anode current density KA. m^{-2}	1.0	1.0
Cell Voltage (V)	3 4 — 3.6	14 — 15
Cell Temperature (K)	308 — 311	308 — 311
Current efficiency (%)	52	55
Energy consumption (kWh $kg.^{-1}$)	5.7	5.2

BLEACHING OF PULP WITH-SODIUM HYPOCHLORITE SOLUTION :

Electrolytically prepared sodium hypochlorite solution (15g/l of available chlorine) was used for the bleaching experiments of different pulps.

a. Bleaching of bagasse pulps :

The results of the experiments carried out for the bleaching of bagasse pulp using sodium hypochlorite solution are given in Table II. The brightness of more than 80% is achieved when larger quantity of sodium hypochlorite is taken for a single stage. However when the treatment is done in two stages the same b·ightness is achieved with lesser quantity of chlorine but with longer duration.

TABLE II

Bleaching of bagasse pulp with sodium hypochlorite solution.

Temperature 303-305k Initial brightness - 39%

Particulars	Experiments						
	1	2	3	4	5	6	7
I Stage							
Weight of pulp (dry basis) (Kg)	0 2	0.2	1.0	1 0	1.0	1.0	1.0
Sodium hypochlorite added as available chlorine (%)	0.8	1.2	5.6	8.4	4.2	5 6	2 0
Retention time (min)	120	90	120	120	120	120	120
Chlorine consumption (%)	—	—	5 2	7.8	—	—	—
Brightness (%)	70	72	78	82	—	—	—
II Stage							
Sodium hypochlorite added as available chlorine (%)	—	—	—	—	1 4	2 8	2 0
Retention time (min)	—	—	—	—	90	90	120
Chlorine Consumption (%)	—	—	—	—	4 5	6 9	3.5
Brightness (%)	—	—	—	—	80	82	79

b Bleaching of Hardwood pulp :

Table III shows the results of the experiments carried out for the bleaching of hardwood pulp with sodium hypochlorite solution. In this case the brightness obtained is around 70% while the chlorine consumption was around 5.7% when the two stages of bleaching are employed for hardwood, no improvement in brightness is observed over the single stage.

TABLE III

Bleaching of Hardwood pulp with sodium hypoclorite solution.

Temperature 303-305K Initital brightness : 35%

Particulars	Experiments				
	1	2	3	4	5
I Stage					
Weight of pulp (dry basis) (Kg)	0 2	0.2	0.2	0.2	0.2
Sodium hypochlorite added as available chlorine (%)	4 0	5 0	6.0	7.0	7.0
Retention time (min)	120	120	120	120	120
Chlorine consumption (%)	3.7	3.9	4.1	5.4	5.7
Brightness (%)	63	64 5	65.5	68	70
II Stage					
Sodium hypochlorite added as available chlorine (%)	2	—	—	—	—
Retention time (min)	120	120	—	—	—
Chlorine consumption (%)	1.8	1.5	—	—	—
Brightness (%)	69	6	—	—	—

c. Bleaching of Rice straw pulp :

Table IV shows the results of the experiments carried out for the bleaching of rice straw pulp with sodium hypochlorite solution. The brightness achieved is around 77% in a single stage. In the double stage bleaching no significant improvement in brightness is achieved.

TABLE IV

Bleaching of rice straw pulp with sodium hypochlorite solution.

Temperature 303-305k Initial brightness : 38%

Particulars	Experiments				
	1	2	3	4	5
I Stage					
Weight of pulp (dry basis) (Kg)	0.2	0.2	0.2	0.2	0 2
Sodium hypochlorite added as available chlorine (%)	4 0	5.0	6.0	7.0	7.0
Retention time (min)	120	120	120	120	120
Chlorine consumption (%)	3.5	4.0	4.25	4.40	4.5
Brightness (%)	74	74.5	75	76	77
II Stage					
Sodium hypochlorite added as available chlorine (%)	2	2	—	—	—
Retention time (min)	120	120	—	—	—
Chlorine consumption (%)	1.6	1.7	—	—	—
Brightness (%)	75.5	76.0	—	—	—

CONCLUSION :

Sodium hypochlorite solution is containing about 1.5% available chlorine prepared electrolyticall with a current efficiency of 52-55% and an energy consumption of 5.0 to 5 3 kWh kg^{-1}. When bagasse pulp is treated with this solution, a brightness of more than 80% is achieved in a single stage thereby avoiding the three stages as is presently employed in the conventional bleaching. For hardwood and rice straw pulps the brightness obtained are 70% and 77% respectively under similar conditions and two stage of bleaching has no significant effect in improving the brightness.

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