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INFLUENCE FACTORS IN THE ELECTROLYTIC PRODUCTION OF SODIUM HYPOCHLORITE

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Electrochemical production of sodium hypochlorite has advantages over chemical process. Experiments were carried out to study the effects of various factors in the production of sodium hypochlorite by electrolysis. The effect of current density and temperature on current efficiency is discussed. The effect of concentration of sodium chloride on the current efficiency, amount of chlorate formed, ratio of sodium hypochlorite and chloride and the energy consumption are also discussed.

Keywords: Sodium hypochlorite, current efficiency and energy consumption.

INTRODUCTION

Sodium hypochlorite is extensively used for sterilizing 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 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 only by electrolysis) have to be transformed to the site involving expenditure on 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 [4] in the production of sodium hypochlorite has proved to be advantageous both from economic and energy reduction point of view [5].

The present paper describes the influence of various parameters (viz. concentration of sodium chloride, temperature, current density) influence on the current efficiency for the production of sodium hypochlorite.

EXPERIMENTAL

A 2000 ml beaker was used as a cell fitted with a rectangular titanium substrate insoluble anode of size 15 x 5 cm and two numbers of perforated stainless steel cathodes (15 x 5 cm). The electrodes were clamped on a circular PVC cover. Screws made of PVC were provided between the anode and cathodes to avoid short circuit. 1.8 or 1.9 liter of brine solution containing 10 gm to 60 gm l^{-1} NaCl was used as electrolyte. Direct current of 10 A was supplied from a rectifier (0 - 50 A), electrolysis was carried out for 4 hours and the solution was estimated for hypochlorite, chloride and chlorate. The temperature of the experiments were controlled by water cooling arrangement. The experiment was repeated for a range of current densities (5 - 25 A.dm^{-2}) keeping the concentration of the NaCl at 50 gm l^{-1} and temperature as 308 K. Experiments were also carried out to study the effect of temperature in the range 303 to 333 K. For the production of sodium hypochlorite, keeping the current density at 10 A.dm^{-2} and concentration of NaCl at 50 gm l^{-1}.

RESULTS AND DISCUSSION

Table I shows the effect of current density on the current efficiency for the production of sodium hypochlorite. At the current density range of 5 - 10 A.dm^{-2} maximum current efficiency 56-57% is achieved. At higher current densities the current efficiency is decreased since, the increase in current density tends to increase the formation of chlorate in the cell [4] or oxygen evolution.

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TABLE I: The effect of current density and the temperature on current efficiency for the production of electrolytic sodium hypochlorite

Current density ($A.dm^{-2}$)	Current efficiency (%)
5	55
10	56
15	51
20	50
25	40
Temperature	
303	51
308	52
313	52
318	48
323	44
328	42
333	36

TABLE II: The effect of concentration on current efficiency for the production of sodium hypochlorite

Concn.of NaCl		Concn.	Concn.	Current	
Initial gpl	Final gpl	of ClO_3 gpl	of NaOCl gpl	efficiency %	E.C. $kwh.kg^{-1}$
10.1	2.9	6.1	11.1	40.2	13.1
21.5	9.9	6.5	12.3	42.3	11.2
31.6	17.5	8.8	15.3	52.1	6.2
40.9	29.2	5.8	15.4	59.0	4.9
50.3	36.8	6.0	16.9	58.5	4.8
60.7	47.3	7.2	13.9	50.1	5.4

The effect of temperature on the current efficiency for the production of sodium hypochlorite is given in Table I. It is clear from the table that at above 313 K the current efficiency decreases, which is attributed to the favourable condition for the formation of chlorates [5].

Table II shows the effect of electrolyte concentration over the current efficiency for the production of sodium hypochlorite. From the table it is clear that at 40-50 gpl of sodium chloride concentration the current efficiency is high (56.3-59%), with energy consumption corresponding to (4.8 kWh kg^{-1}). Higher concentration of NaCl can lead to the formation of chlorate. At very low concentrations the current efficiency is minimum due to water discharge leading to O_2 evolution. However

TABLE III: Duration on the current efficiency for the production of sodium hypochlorite

Duration (Hrs)	Concn.of NaCl (gpl)	Concn.of NaOCl (gpl)	Current efficiency (%)
1	46.18	5.58	80.34
2	41.49	10.79	77.68
3	39.16	12.65	60.71
4	36.82	15.64	56.30
5	32.64	15.91	45.44

surprisingly the rates of chlorate formation is also found to be 7.6 times higher than expected [6]. From Table III which describes the formation of NaCl with duration it is seen that the current efficiency decreases with duration for the production of sodium hypochlorite. This is attributed to the current efficiency for oxygen evolution, which is proportional to the hypochlorite concentration [7].

CONCLUSION

Maximum current efficiency for the production of sodium hypochlorite is achieved at a current density of 5-10 $A.dm^{-2}$, 313 K, between 5-10 $A.dm^{-2}$ and keeping the NaCl concentration between 40 and 50 $g.l^{-1}$. The current efficiency for the formation of NaOCl decreases with duration.

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