Parameter optimization of electrolytic process of obtaining sodium hypochlorite for disinfection of water

S Yu Bogoslovskii, N N Kuznetsov and V S Boldyrev
Department of Chemistry, Bauman Moscow State Technical University, Moscow, Russia

E-mail: b.su@bmstu.ru

Abstract.
Electrochlorination parameters were optimized in flowing and non-flowing modes for a cell with a volume of 1 l. At a current density of 0.1 A/cm² in the range of flow rates from 0.8 to 6.0 l/h with a temperature of the initial solution below 20 °C the outlet temperature is maintained close to the optimal 40 °C. The pH of the solution during electrolysis increases to 8.8 ÷ 9.4. There was studied a process in which a solution with a temperature of 7-8 °C and a concentration of sodium chloride of 25 and 35 g/l in non-flowing cell was used. The dependence of the concentration of active chlorine on the electrolysis time varies with the concentration of the initial solution of sodium chloride. In case of chloride concentration of 25 g/l virtually linear relationship makes it easy to choose the time of electrolysis with the aim of obtaining the needed concentration of the product.

Sodium hypochlorite belongs to a new generation of reagents used for water disinfection as alternative to gaseous chlorine, and can be applied either in the form of commodity (technical) hypochlorite (is a highly concentrated strong alkaline solution produced in chemical plants with a content of active chlorine 14%) or produced at the place of use in the required quantity by the electrolysis of sodium chloride. This method of obtaining hypochlorite directly into the sodium chloride solution with the help of electric current is called electrochlorination. Due to high concentration commodity hypochlorite (CH) decomposes faster than the one obtained directly on the spot in the cell (EH). This decomposition of hypochlorite into chlorate leads both to loss of product and the appearance of undesirable by-product in the water. The EH is made at the place of consumption as needed, thus reducing the storage period before use. CH has a high pH value (pH=12) to ensure stability of the product. Therefore, when introducing it in water with a high content of cations of calcium and magnesium there may form insoluble carbonates and hydroxides. It leads to the need for additional filtering of water prior to use. Finally, CH contains a potentially carcinogenic bromate, the concentration of which must not exceed 10 μg/l in the EU. EH with a low content of bromate can be obtained through the use of sodiumchloride with a low content of bromide. Therefore, the electrochlorination systems are increasingly used instead of technical hypochlorite batching operations.

Sea water can be used for process water instead of sodium chloride solution [1]. Chlorine is produced on the anode in the cell of the electrolyzer; water decomposes on the cathode with formation of hydrogen and hydroxyl ions. In the open reactor reagents freely
mix and react with the formation of the target product. At concentrations less than 1% sodium hypochlorite is classified as non-hazardous reagent, being at the same time effective disinfection, so it is advisable to choose electrochlorination parameters to generate a concentration from 0.2% to 0.8%. Besides, there present practically no chlorate at these concentrations of hypochlorite. In case of 14% TG 0.6% of active chlorine is converted to chlorate within the first days of storage at 22 °C [2], so during transportation and storage its ratio can be significantly increased.

Optimization of parameters of electrochlorination was carried out with the help of flow installation with a reactor volume equal to 1 liter, containing four titanium electrodes with oxide-ruthenium anodes, each with an area of 60 centimeters. The concentration of active chlorine was determined by iodometric method [3]. Oxide-ruthenium anode is known to work best of all at temperatures not below 18 °C. On the other hand, excessive heating of the electrolyte adversely affects the yield of sodium hypochlorite, therefore, the optimal temperature is 40-45 °C [4]. In case of flow through electrolytic cell the lower the flow rate the higher electrolyte temperature and its residence time in the reactor. Other conditions being equal, heating of the electrolyte also increases with decrease of concentration of sodium chloride. According to the data obtained in a wide range of flow rates from 0.8 to 6.0 l/h there occurs no excess of temperature if the initial solution does not exceed 20 °C.

The pH of the solutions during electrolysis increases to a value \( pH = 8.8 \pm 9.4 \) with the increase of time of electrolysis and the concentration of salt due to the reduction of water molecules. Conductivity of the solutions changes slightly in the range of 3 \%\% of the original. Consumption ensuring the achievement of active chlorine concentration of 0.2% at a current density of \( I = 9.1 \text{ A/cm}^2 \) is from 6 to 7.5 l/h depending on the concentration of chloride. The concentration of active chlorine of 0.4% is achieved at the flow rate 2.5 \( \pm \) 2.7 l/h.

We also studied the dependence of the temperature and concentration of sodium hypochlorite on the time of electrolysis in a non-flowing cell. In this experiment we simulated the use of sea water in winter as raw material. Initial temperature of sodium chloride solution was 7 to 8 °C (Fig. 1,2). The concentration of sodium chloride was 35 g/l and 25 g/l. It is seen that the temperature of the stagnant electrolyte in a cell increases almost linearly. The dependence of the concentration of hypochlorite on time in the case of more concentrated solution has a more pronounced deviation (Fig. 2). Each experiment was conducted three times. The obtained results show that by choosing the time of electrolysis, it is possible to obtain a product of needed concentration if we use sea water as raw material in winter time.
**Fig. 1.** The dependence of the temperature (left scale, circles) and concentration of active chlorine (right scale, cross) on time in a non-flowing cell for concentration of sodium chloride 25 g/l.

**Fig. 2.** The dependence of the temperature (left scale, circles) and concentration of active chlorine (right scale, cross) on time in a non-flowing cell for concentration of sodium chloride 35 g/l.
References
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