RESITIVITY OF MATERIALS USED IN CHLORINE ELECTROLYSER IN LABORATORY

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Abstract

Chlorine electrolyser for laboratory purposes is not available as industrial equipment. Therefore, a chlorine electrolyser was assembled from commonly available materials and containers. This is the reason why the materials used in the electrolyser have to be monitored. The functionality and safety of materials and electrolysis process were observed. The influence of chlorine electrolysis process on materials and containers during and after electrolysis is the subject of this paper.

Key words

electrolyser, chlorine, material resistivity, electrode

Introduction

Chlorine electrolyser operating in HEZ laboratory is determined for water disinfection and observation of the whole process from chlorine production to water disinfection. The effectiveness of process and products quality was observed as significant parameters. The device was powered by renewable power source - a photovoltaic board.

Chlorine electrolyser

Electrolyser complies with the following required parameters;

- simple operation and exchange of electrodes and components;
- the electrolyser body must be made of material with resistivity to influence of electrolyte and electrolysis products;
- the electrolyser body is transparent for visibility of process in progress;
- cheap, safe and simple exchangeable diaphragm;
- electrodes must be resistant to influence of electrolyte and electrolysis products, inactive electrodes must be resistant during long time in electrolyser;
- simple separating and exhausting of produced gases with possibility of storage or usage;
- simple fill up and fill out of electrolyte.

On the basis of the abovementioned parameters, the laboratory chlorine electrolyser was constructed with the following parameters:

- the electrolyser body was made of glass, the common reaction vessel with glass cover (volume 3 liters) was used, in the cover, there are NZ 29/32 and NZ 14/19standardised ground joints;
- the gasket between the cover and the electrolyser body is made of rubber 5 mm thick;
- the teflon release valve is in the bottom of electrolyser's body;
- the tight connector of cover and body of electrolyser is achieved by stainless steel collet;
- the sintered glass cartridge with matching size is used as diaphragm;
- the separation of gases produced during electrolysis is achieved by a plexiglass board which is fixed to the electrolyser cover by a silicone sealant, the hole for isolated copper wire for cathode is in the board;
- the gas exhaust from electrolyser is fitted with two-way valves, then gases are drained off by rubber hoses;
- both electrodes are made of carbon, but the combination of steel and carbon electrode was used too;
- electricity is supplied to the electrolyser through a rubber plug by using two solid copper wires, the ends of the wires are insulated cca 1 cm , the insulated ends of wire are then connected to the electrode;
- metal electrodes are connected to the wire by screws;
- carbon electrodes are connected to the wire with screw-driving application (thread is made in the electrode material, and a copper bar with 2.5mm thread is screwed in electrode), the connection of copper bar and copper wire is made by soldering;
- electrolyte is the saturated salt solution;
- the electricity supplied to the electrolyser is: 4.0 V direct current voltage, the current is min. 1.5 A [4].

The glass cover and body

The glass cover and body of electrolyser are exposed to all chemicals in electrolyser. The glass was chosen for extraordinary resistance from most chemicals. No negative impact of chemicals to the electrolyser glass material was observed to present day. Glass is not corroded by sodium hydroxide either.

Fig. 1 *Glass body of electrolyser evinces no signs of destruction [photo: R. Kuracina]*

Cover gasket of electrolyser

The cover gasket is made of rubber. The gasket is exposed to electrolyte and sodium hydroxide. No negative impact of chemicals to gasket has been observed to present day. The gasket is resistant to influence of sodium hydroxide and to the pressure inside the electrolyser.

Fig. 2 *The cover gasket of electrolyser is without visible damage [Photo: R. Kuracina]*

Teflon valve

Teflon valve for the electrolyte release can be damaged only due to the influence of electrolyte and the products of electrolysis dissolved in electrolyte. No negative impact of chemicals to valve material has been observed to present day.

Iron electrodes

Iron electrodes suffer during the operation of laboratory electrolyser. Normally, the electrode is connected to the negative pole of power supply. Hydrogen is formed on the surface of this electrode [1]. Mainly, this electrode type is suitable for continuous electrolyser. Therefore, corrosion of the electrode material is due to the influence of electrolyte. The corrosion of iron electrode in the sodium hydroxide and salt solution results information. Figure 3 shows the result of the long-term influence of electrolyte on iron electrode.

Fig. 3 *The result of long-term influence of electrolyte on iron electrode (left)*
[Photo: R. Kuracina]

Polarity reversal of the power supply is another problem associated with iron electrodes. In this case, the cathode is connected to the positive pole of power supply. If the polarity is of feeding the electrolyser is reversed, the adverse reactions occurs [1]. These reactions caused a rapid and effective destruction of electrode. In the first stage, the reaction of developed chlorine with the surface of the iron electrode material occur [2].

$$2\ Fe + 3\ Cl_2 = 2\ FeCl_3, \quad (1)$$
$$Fe + Cl_2 = FeCl_2\ . \quad (2)$$

In the next stage, iron chloride reacts with sodium hydroxide formed during electrolysis [2]. The iron hydroxides precipitates formed during this reaction then clog the pores of diaphragm. This process degraded the diaphragm. The cleaning of diaphragm was both time and chemicals-consuming.

$$FeCl_3 + 3\ NaOH = 3\ NaCl + Fe(OH)_3\ . \quad (3)$$

The result of chlorine influence on iron electrode is shown in Figure 4. Figure 5 show iron oxides in diaphragm.

Fig. 4 *Damage of iron electrode used as anode [Photo: R. Kuracina]*

Fig. 5 *Iron oxides in diaphragm [Photo: R. Kuracina]*

After polarity reversal, only carbon electrodes (anode and cathode) are used. These electrodes offer excellent resistance to electrolyte and gaseous products of electrolysis. Some wear of the electrodes was observed only at high voltage supplied to the electrolyser.

Rubber plugs

No negative impact of chemicals to rubber plugs has been observed to present day. The regular status check of stoppers is recommended.

Plexiglas (PMMA)

Plexiglas plate separates hydrogen from chlorine. Chlorine is the main aggressive chemical in electrolyser. No negative impact of chlorine to plexiglass plate was observed. [3] Therefore, the plexiglass surface does not need any inspection. However, the silicone sealant needs inspection regularly. The silicone sealant reacts with chlorine. This may cause the improper function of sealant, e.g. chlorine leakage to hydrogen etc.

***Fig. 6** Silicone sealant partly degraded by chlorine (originally transparent)*
[Photo: R. Kuracina]

Wires

Wires for power supply are made of copper. Copper in electrolyser is corroded which is due to the influence of gaseous chlorine, high humidity and salinity. Electrolyte reacts with salt solution and humidity. The copper hydroxide formation in small amount was observed. However, chlorine reacts with copper in larger amounts (this may cause secession of electrode from wire) [2]:

$$Cu + Cl_2 = CuCl_2 \qquad (4)$$

This reaction may cause damage to electrode or electrolyser. Copper salts may influence the speed, quality and efficiency of electrolysis.

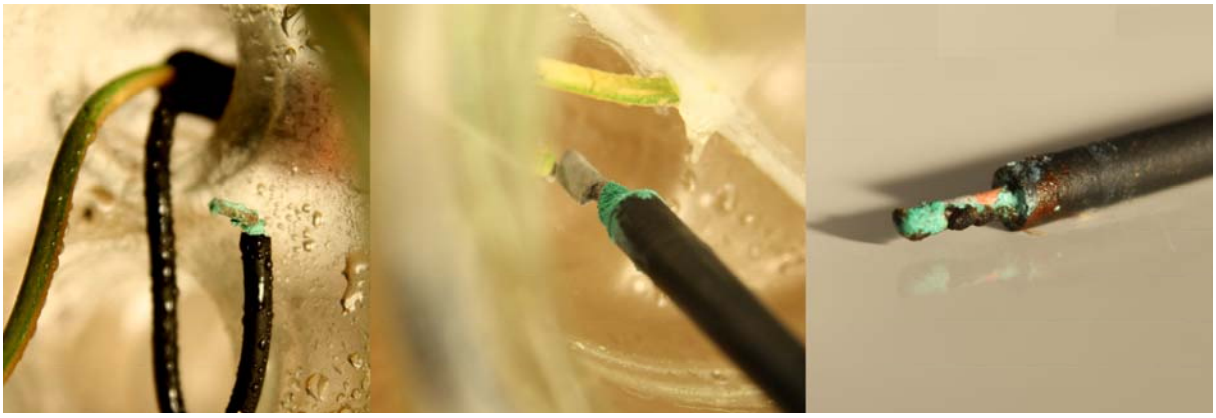

***Fig. 7** Influence of inside environment of electrolyser to anode wire (left), to wire and copper bar in cathode (middle) and to copper bar in anode (right, anode was seceded)*
[Photo: R. Kuracina]

Diaphragm

Diaphragm is a sintered glass cartridge. Sintered glass contains small particles of glass, mutually combined. These small particles are more reactive than conventional glass [5]. In the electrolyser, the increasing concentration of sodium hydroxide reacts in long time with the glass particles in diaphragm. This process may cause lower efficiency of the electrons transportation. The result of this is lower efficiency of electrolysis or electrolysis abort. The diaphragm surface after 6 months in electrolyte is shown in Figure 8.

Fig. 7 *Detail of the diaphragm surface after 6 months in electrolyser [photo: R. Kuracina]*

Conclusion

The salt solution or products of electrolysis in chlorine electrolyser are aggressive chemicals. Therefore, the materials and technical solutions must be resistant to the influence of all chemicals in electrolyser. On the basis of experience with the operation of electrolyser we can state that it is possible to achieve safe operation of electrolyser without any problems.

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