The electrolysis on Hoffman's apparatus

1.INTRODUCTION

One of the simplest devices allowing electrolysis reaction is the Hofmann electrolyzer (Fig.1.). It was invented by German scholar August Wilhelm von of three glass cylinders that constitute the system of connected vessels.

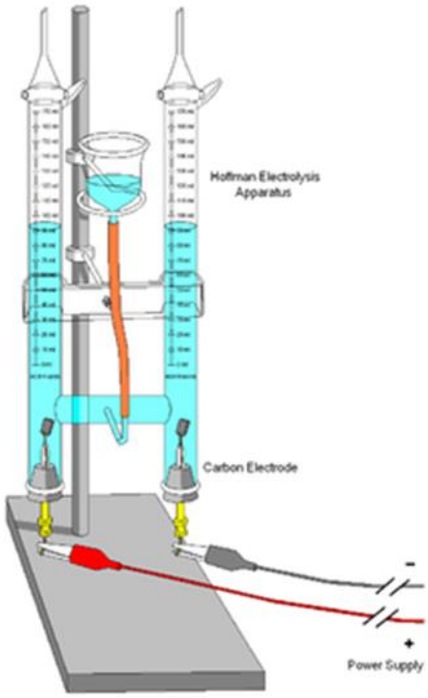

Fig.1. Hofmann apparatus

Middle cylinder it is open at the top (it is used for filling devices with electrolyte). These two cylinders have valves closing the outlet (by which it is discharged resulting gases - oxygen and hydrogen)and are connected to the electrodes.

When the process is run in an alkaline electrolyte, the electrochemical reactions occurring at the cathode and anode are given:

K(-) $4H_2O_{(l)} + 4e^- \rightarrow 2H_{2\,(g)} + 4OH^-$

A(+) $4OH^-_{(aq)} \rightarrow O_{2(g)} + 2\,H_2O_{(l)} + 4e$

Net reaction: $2\,H_2O_{(l)} \rightarrow O2 + 2H_{2\,(g)}$

In this way, hydrogen is obtained in one of the Hoffman's cylinders.

The laws describing the obtain of the element on the electrodes in the electrolysis process were described in 1833-34 by Michael Faraday. The first law of electrolysis he formulated says that the mass of elements that have been released on the electrode is proportional to the entire charge that has passed through the electrolyte. This expresses the formula:

$m=kQ$

k – electrochemical equivalent of hydrogen

$$(k = 1.1935 \cdot 10^{-5}\ \frac{g}{C})$$

2. LABORATORY EXERCISE

The purpose of this experience is **determining the performance of this device(Hofmann electrolyzer) by calculation electrolytic efficiency η_F and energy efficiency η_E for different electrolytes.**
After filling the cell with an electrolyte solution (5% NaOH solution and next 15% NaCl), a constant voltage is applied to the electrodes.

It should be observe and measure time of increasing the volume of hydrogen that it will cause change of the liquid level in the cathode cylinder by Δh .

Note the value of the current and process time.

3. CALCULATIONS

In order to calculate the **electrolytic efficiency η_F** of the electrolysis, one should compare the effective mass with the mass from I Faraday’s law (theoretical mass).

$$\eta_F = \frac{m_{H2,a}}{m_{H2,F}} \cdot 100\%$$

The effective hydrogen mass:

$$m_{H2,a} = \rho \cdot v,$$

ρ - hydrogen density (gas)

Theoretical mass of the resulting hydrogen from Faraday's law:

$$m_{H2,F} = k \cdot Q$$

which, after transformation, will take the form:

$$m_{H2,F} = k \cdot I \cdot t$$

k - electrochemical equivalent of hydrogen

$$\left(k = 1.1935 \cdot 10^{-5} \frac{g}{C} \right)$$

Energy efficiency η_E:

$$\eta_E = \frac{E_{H2,gen}}{E_{el}} \cdot 100\%$$

to calculate $E_{H2,gen}$ it’s needed heating value (Q_i) of hydrogen

$$Q_i = 12770 \frac{kJ}{nm^3} .$$

E =$VH_2 \cdot Q_i$

$E_{H2,gen}$ =$v_{H2} \cdot Q_i$ $E_{H2,gen}$ - hydrogen energy generated in the electrolysis process.

E_{el}=U·I·t

E_{el} – electric energy delivered to the Hoffmann apparatus.

Electrolyte	**I,mA**	**U,V**	**time, min**	**Δh, ml**
5% NaOH(sodium hydroxide)				
15%NaCl (sodium chloride)				