13.Membrane electrolyzer

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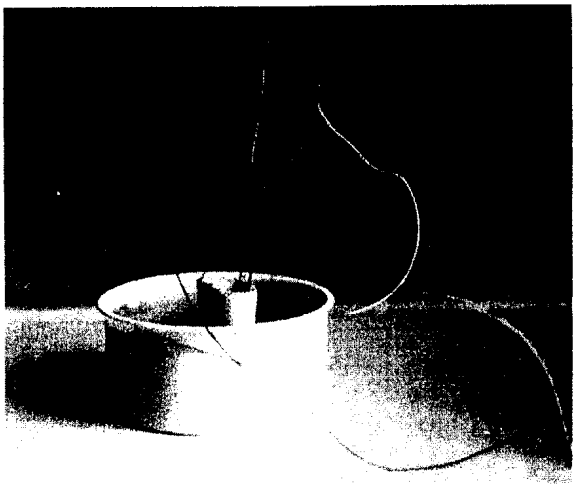
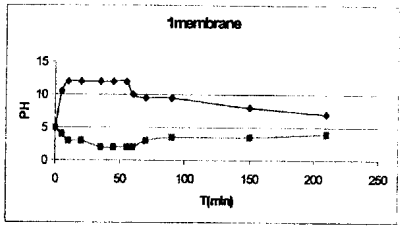
To investigate how a difference of PH-value depends on the pore size of the membrane we have made experiment. It consists in following.

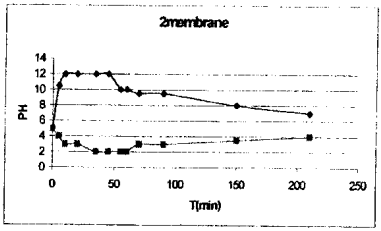


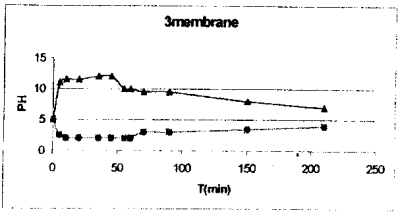
We took a test tube with electrolyte. Electrolyte is sodium sulfate .We placed two inert electrodes (lead and stainless steal) in test tube. There is membrane between them, which has cylinder shape. Membrane is stick by dichlorethane glue to acrylic plastic. Both of them are inert

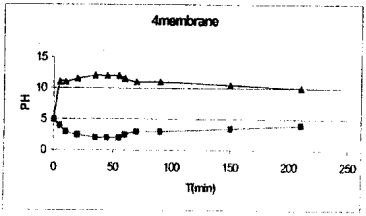
The current flows to system throw rectifier. During given period of time we measure PH-value in anodic and cathodic parts of system. PH-value we measure by litmus paper. We have some membranes with different pore size. Then we take PH-value and compare them. You can see the graphs on which there is dependence PH-value on the time of electrolyze by given diameter of membrane's pore.

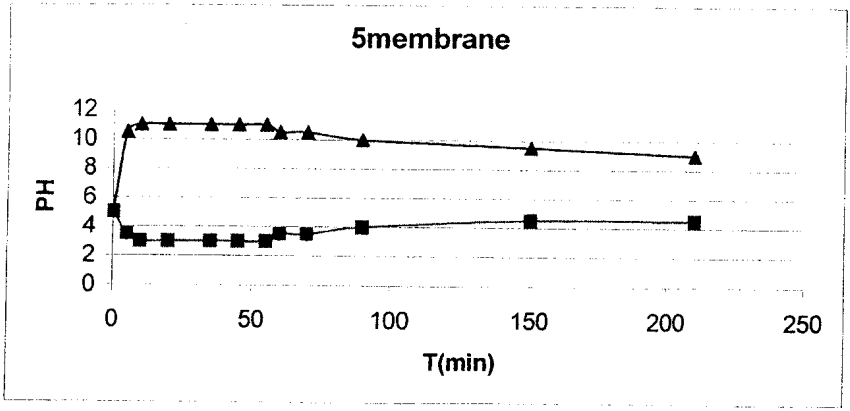
Graphs


1membrane
PH
T(min)


2membrane
PH
T(min)


3membrane
PH
T(min)


4membrane
PH
T(min)


5membrane
PH
T(min)

Now let us consider what we have during electrolyses and why we have difference of PH-value in anode cathode.

$$Na_2SO_4 + 4H_2O \rightarrow 2H_2 \uparrow + O_2 \uparrow + 2NaOH + H_2SO_4$$

$$NaOH \rightarrow Na^+ + OH^-$$

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

So we get liberation of oxygen and hydrogen. We can observe this phenomenon visually.

Visual

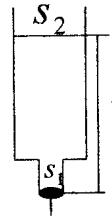
$Na^+ \quad OH^-$	$Na^+ \quad OH^-$
$2H^+ \quad SO_4^{2-}$	$2H^+ \quad SO_4^{2-}$

Also we have ions of sodium, hydrogen and

Ions OH^- and H^+ pass throw membrane to anode and cathode and ions of Na^+ and SO_4^{2-} transfer the charge. So the difference of PH-value is made by OH^- and H^+ ions.

To calculate pore size we have made the second experiment. It consists in following.

We have bottle at one side of which membrane stick. In the bottle we have the same level of electrolyte. And we calculated the hydrostatic pressure and velocity of electrolyte's leak. Then by this quantities we can calculated the coefficient of leak K.



Membrane

$$K = \frac{vl\eta}{pS_1\tau}$$

$$p = gh\rho$$

$h = const$

$$v = \sqrt{\frac{2gh}{1 - \frac{s_1}{s_2}}}$$

v – velocity of water

l – thickness of membrane

η – viscosity of water

p – hydrostatic pressure

S_1 – area of membrane

τ – time

h – height of water

s_2 – area of bottle

The following expression is for the pore diameter calculation.

$$D = 0{,}003\beta\sqrt{k/g}$$

β – coefficient of twisting, g – bulk porosity, k – coefficient of leak

It is very difficult to calculate coefficient of pore twisting, but we know that it varies from 1 to 2.So to reduce the error, we took the coefficient of twisting equal to1.5.

$$\beta \in (1;2)$$

We can calculate bulk porosity by formula

$$g = 1 - \frac{d_{ap}}{d_t}$$

$$d_t = \frac{p_d}{p_d - p_w}$$

$$d_{ap} = \frac{mg}{Vg\rho}$$

d_{ap} -apparent specific gravity

d_t - true specific gravity

V -volume of membrane

p_d -mass of membrane in dry state

p_w -mass of membrane in wet state

All membranes were scaled at the exact electric weight. By this way we can calculate diameters of pore.

You can see diameters of pore by given membranes.

Diameters

$D_1 = 167 \cdot 10^{-6}(m)$ $D_2 = 152 \cdot 10^{-6}(m)$

$D_3 = 115 \cdot 10^{-6}(m)$ $D_4 = 8.1 \cdot 10^{-6}(m)$

$D_5 = 328 \cdot 10^{-6}(m)$

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References

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