

Study of Electrochemical Properties In cation exchange membrane Used In The Fuel Cells

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Abstract—In recent years, with the problems of energy shortage and environment concerns, renewable and clean energy become more and more popular, one of the alternative sources of electric power is fuel cell. It is the clean energy, without any harmful emissions to the environment, and has high power density.

For example the ion exchange membranes can be used as core of a fuel cell that is another serious contender for replacing conventional internal combustion engine components. Among them, the membrane of Nafion®117 is a prime example of a cation exchange membrane. This membrane, also known as polymer electrolyte, is commonly used in various applications, particularly in fuel cells because of its good ion selectivity, chemical stability and excellent ionic conductivity. The Nafion 117 membrane may be used for the design of a fuel cell direct methanol to separate the anolyte and catholyte, the major issue is the distribution of methanol from the anode compartment to the cathode compartment. This results in a significant drop in the efficiency and performance of the fuel cell with methanol.

In our present work, and to justify their choice between the different other membranes, we have used the electrochemical technique known as voltammetry we chose to characterize both types of membranes: the Nafion® 117 membrane, which is a micellar membrane and CMX is a crosslinked membrane. This technique allows us to determine the ionic conductivity of these membranes by measuring their resistance. Indeed, after the application of an electric field using the electrodes platinized titanium, we record a transmembrane potential difference at the ends of the membrane, with silver chloride electrodes that we synthesized. The I-V curves obtained, allow us to see the effects of some parameters, namely the concentration of the electrolyte solution, the nature of against-ion and that of the co-ion. This study will lead to optimization of the current limit that must not be exceeded in the process of electro.

Keywords—Fuel cell; ;Nafion 117 ; voltammetry; current limit cation exchange membrane

I. INTRODUCTION

Fuel cells are discovered by Sir William Grove in 1839 systems. They now represent a major challenge in the development of low-impact renewable energy. Indeed, these

fuel cells can be operated with the oxidation-reduction of oxygen and a fuel, which may be hydrogen or any other product capable of being oxidized by hydrogen. In the case of hydrogen the reaction product is water. For other fuels, the reaction also releases carbon dioxide. But even in this case, the energy efficiency of fuel cells is well above that of a combustion engine with direct, they stay cleaner [1]. These stacks therefore have an obvious environmental benefit. The reduction of oxygen is made at the cathode while hydrogen is oxidized at the anode. Between the two compartments, you have an electrolyte that can be either a proton conductor or an anionic conductor. Different types of batteries are available according to the nature of the electrolyte (solid or liquid), operating temperature and the type of conduction.

The applications of such cells are numerous and are intensively studied as an energy source for embedded applications. Thus, the first prototype methanol fuel cell for mobile phone battery were presented in 2003[2]. We focused particularly fuel cells polymers (Polymer Exchange Membrane Fuel Cell - PEMFC). This type of battery can be seen as onboard power source for an electric car engine. The first specimens of these electric vehicles with fuel cells have emerged in 1994 with the Necar 1 model Mercedes-Benz.

Among the problems of hydrogen storage, which are currently still a real limitation to the growth of these cells hydrogens, the performance of these batteries still need to be improved.

In stacks of PEMFC, the electrolyte is a polymer membrane. To date, the membranes used fluorinated polymer backbone and sulfonate bearing functions (Nafion®, Aciplex®...). Sulfonate functions are very hydrophilic, they allow water to sting inside the hydrophobic fluorinated network.

II. EXPERIMENTAL PART

To study different physico-chemical parameters such as the current limit, the transmembrane ohmic resistance in the two regions and in

which the water dissociates we used the following electrochemical technique that is not other than voltammetry. In this technique, for voltammetry measurements, when a current passes through the cell, it follows, for each value of the intensity of current applied to the transmembrane potential difference measured by means of two electrodes of Ag / AgCl. These electrodes are positioned on either side of the membrane surface. This study is based on the curves of the drawn current density as a function of applied transmembrane potential difference measured.

The objective of this contribution practical to study the effect of the concentration and nature of the electrolyte on the curves (I-V) and the limiting current density.

II.1. Description of the experimental device :

The electrochemical cell used in this study consisted of two identical Plexiglas compartments volumes 70(ml). Are placed at the ends of the power cell electrodes which are platinized titanium. Between the two compartments of an opening 5(cm²) is reserved for the location of the membrane. in order to measure the transmembrane potential difference applied in the vicinity of the membrane to be investigated, an addition of two other electrodes is initiated. Latter are the reference electrodes Ag / AgCl which are made by electrolysis of two silver wire in HCl solution, under certain conditions in order to get a better pair. The membranes to be studied, an effective area of 5 (cm²) are placed in the circular opening between the two compartments. Then, they are filled with an electrolytic solution.



Figure.1 : Schematic symmetrical electrochemical cell made of Teflon , for voltammetric measurements

- (A) : Anode compartment;
- 1,2 : Working electrodes;
- (B) : Cathode compartment;
- 3,4 : Reference electrodes;

III. RESULTS AND DISCUSSION

III.1. Voltammetric characterization of the cation exchange membrane CMX :

In this study, we have characterized the cation exchange membrane CMX in the aqueous medium such as H₂SO₄. The results at different concentrations are shown in the following figure 2

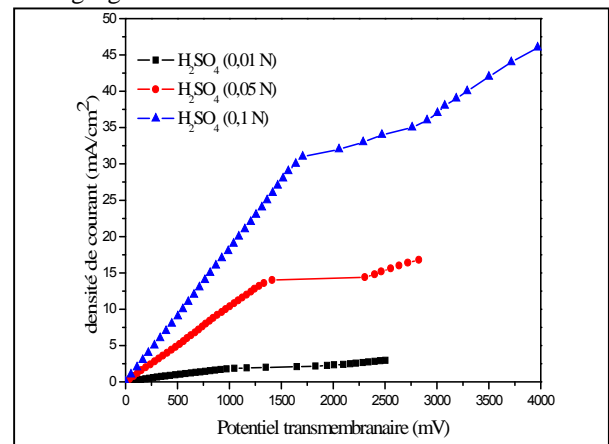


Figure 2 : Influence of the concentration of Sulfuric acid on the I-V curves

III.2. Voltammetric characterization of the cation exchange membrane Nafion 117:

In this study, we have characterized the cation exchange membrane Nafion 117 in different aqueous media such as H₂SO₄ and the CuSO₄. The results at different concentrations are shown in the following Figures 3-4-5:

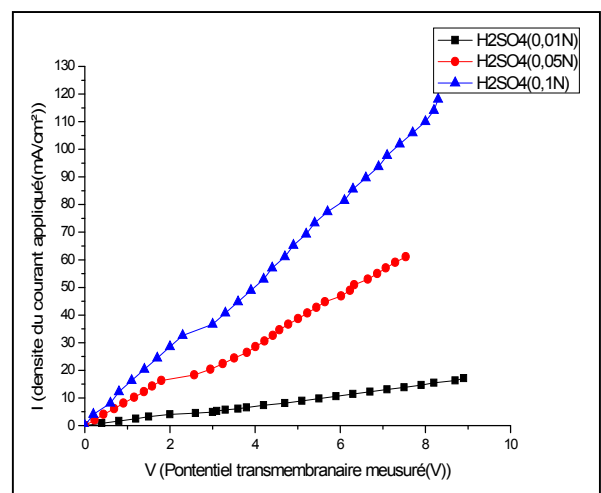


Figure.3 : Influence of the concentration of Sulfuric acid on the I-V curves.

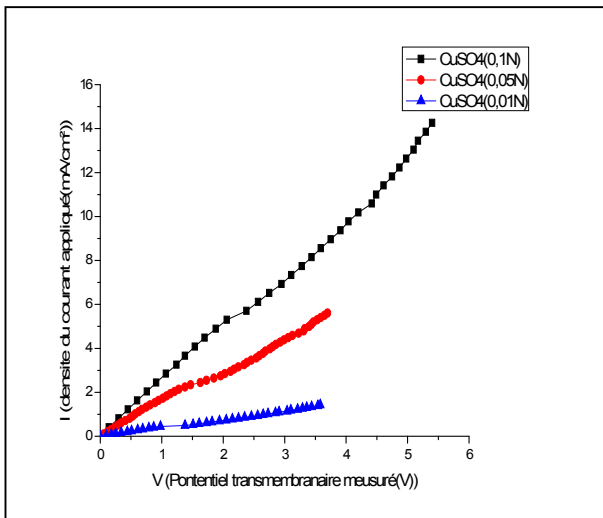


Figure.4 : Influence of the concentration of copper sulfate on the I-V curves.

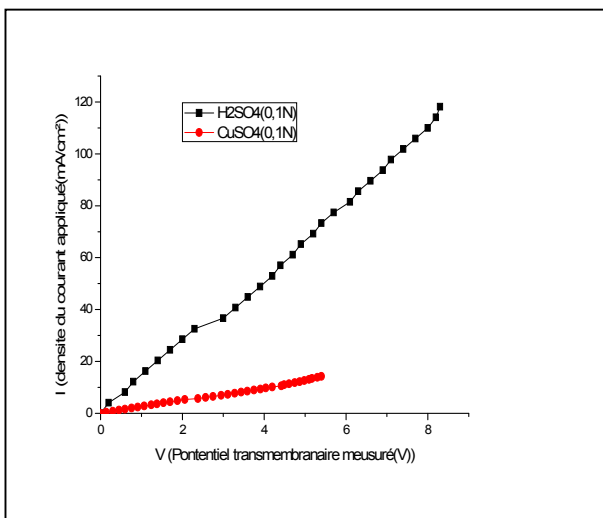


Figure.5 : Comparison between the proton and copper Sulphatemedium.

The IV curves of the two membrane Nafion®117 and in different media, consist of three characteristic regions:

- A first linear region which corresponds to the low current density. it represents the resistance ohmic of the system « Solution - Membrane - Solution ».

In this region, the ionic species H^+ driver for all electrolyte solutions used.

- A second region in the form of plate which corresponds to the limiting current density, due to the phenomenon of concentration polarization.
- A third linear region, corresponding to a further increase in the electric current: this is the region of super-critical current, which occurs in the dissociation of water.

In addition, we concluded that:

- The transmembrane resistance decreases with increasing concentration of the solution with which the membrane was characterized.
- The value of the limiting current density increases with increasing concentration of the solution with which the membrane was characterized.
- According to the fig. 5, the proton H^+ is much better transported compared to copper.

The system that the higher ohmic resistance is that which has the lowest value of the limiting current density I_{lim} .

This means that the limiting current density decreases with the increase of the ohmic resistance.

On the other hand, comparing Figs.2 and 3, we note that the transmembrane resistance of the Nafion membrane is small compared with that of the CMX. Therefore, it is preferable for the fuel cell, using the Nafion®117 instead of the CMX .

IV. CONCLUSION :

In order to better understand the properties of ion transport through the two cation exchange membranes CMX and Nafion®117, the voltammetric technique was undertaken during this work. Indeed, the curves of current – potential of these two membranes were studied confirming the existence of the three regions mentioned in the literature, that is the ohmic region, the plate corresponding to the current limit and the area showing the dissociation of water. Indeed, with the electrolytes used in this study (H_2SO_4 and $CuSO_4$) we have reached the following conclusions:

- The transmembrane resistance decreases with increasing concentration of the solution with which the membrane was characterized.
- The length of the plate decreases with increasing concentration of the electrolyte.
- The value of the limiting current density increases with increasing concentration of the electrolyte.
- The slope of the plate increases with the increasing concentration of the electrolyte.

- The proton H⁺ is considerably better compared transported copper.
- The distinction between the behavior of ions against namely the transmembrane resistance and limiting current density is more remarkable by increasing the concentration.

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