PRODUCTION AND APPLICATION OF CATION / ANION EXCHANGE MEMBRANES OF HIGH PERFORMANCE

Zhili Xu* Chunhong Tan Xiangmin Yang
Department of Chemistry
East China University of Science and Technology
200237 Shanghai, P.R.China

ABSTRACT

A third affiliated factory of our university has been established for the production in batches of cation/anion exchange membranes of high performance, trade marks of which are HF-1 and HF-2. Membrane products have been applied in various fields (including industries and research institutions) with great success.

INTRODUCTION

Homogeneous cation/anion exchange membranes are the main part of electrolyzers and electrodialyzers, but their successful application depends upon the quality of ion exchange membranes.

Ion exchange membranes of high performance can be produced by different ways, among them the radiation grafting and crosslinking of perfluorinated films has been proved to be an effective method for this purpose.

We have carried out radiation induced grafting of various monomers into Teflon FEP films to obtain different sorts of homogeneous cation and anion exchange membranes, which exhibit good electrochemical properties, excellent thermo- and corrosion resistance, high mechanical strength, and long service life. So they have found a wide range of application.

In order to improve the uniform distribution of grafted chains through membrane substrate of large dimension, Prof. Xu Zhili had designed and worked out special devices for irradiation and reactions.

EXPERIMENTAL

1. Materials:

Teflon FEP films, commercially available.

Styrene, commercially available, distilled before use.

Divinylbenzene, commercially available, inhibitor was extracted by 2N NaOH aq. sol. before use.

Chlorosulfonic acid and concentrated sulfuric acid, (c.p.).

Chloromethyl methyl ether, commercially available.

Trimethyl amine, commercially available.

2. Apparatus:
   Van de Graaff electron accelerator, 2 Mev; 150 microampere.
   Co-60 Radiation source, 3 x 10^{14} Bq.

RESULTS AND DISCUSSION

1. The Uniformity of Irradiated Teflon FEP Films
   Dimension of irradiated Teflon FEP films – 400 x 800 mm.
   Samples (20 x 40 mm) were cut off randomly through the whole area. Then, the percentage graft of samples after reaction was detected as shown in Tab. 1.

2. The Stability of Grafting Process
   Samples were cut off from the irradiated films , and their corresponding percentage graft was detected after certain pre-set reaction time. The typical grafting curve is shown in Figure 1. All points were plotted on a curve with 1.0 % standard deviation.

Tab. 1. Uniformity of irradiated substrates

No.	Relative G(%)
51	102.0
52	100.3
53	100.1
54	98.7
55	98.3
G = (100 ± 0.7) %	

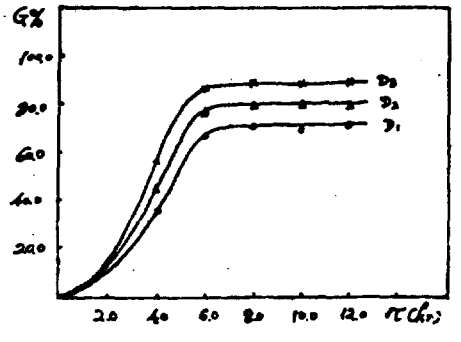

Fig. 1. Percentage graft vs. reaction time

3. Major Characteristics of Ion-exchange Membranes

Major characteristics of ion-exchange membranes, made from Teflon FEP films by means of radiation induced grafting, are listed in Table 2.

Tab. 2. Major characteristics of ion-exchange membranes

Ion-exchange capacity (meq/g)	0.8-1.5
Selectivity (0.1NKCL/0.2NKCL)	> 96%
Specific resistance (ohm*cm)	100-200
Tensile strength (Kg/CM^2)	140-180
Bursting strength (Kg/CM^2)	5-7

4. Results of Accelerated (Enhanced)Oxidation Test

Accelerated (enhanced)oxidation test of produced ion-exchange membranes was carried out at room temperature in a solution, containing 10% H_2O_2 + 0.05M NaOH +1.85x10-4 g-ion of Fe/L.

Experimental results are compared with some published data as shown in Table 3.

Tab. 3. Comparative data of accelerated oxidation tests

Trade mark	Substrate	Monomer	Time for doubled resistance (H)
МПФС-26	P(VF+HFP)	St	0.025
МРФ-26	ibid	TFS	1.8
МРФ-4МБ	P(TFE+HFP)	TFS	2.0
[HF]	ibid	St+DVB	>> 4.0

5. Results of Extra-corrosion Test

Extra-corrosion test of produced ion-exchange membranes was conducted at ambient temperature in a mixture of 16N HNO_3 + 23N HF (2:1 by volume) and the experimental results are listed in Table 4.

$IEC / (IEC)_0$ – Remaining portion of ion exchange capacity

L / L_0 – Remaining portion of specific conductivity

Tab. 4. Experimental results of extra-corrosion test

Time(H)	$IEC/(IEC)_0$ (%)		L/L_0 (%)	
	cation	anion	cation	anion
48	100	100	100	100
480	100	94	100	98
3600	68	61	93	85

6. Examples of Membrane Application

Ion exchange membranes of [HF] series have been successfully applied at various factories and research institutions. Some interesting examples are described as follows.

(1) Regeneration of Chromine-plating Solution

Waste chromine-plating solution, concentration of which may reach as high as 250-300 g/L [CrO_3], containing impurity exceeded 12 g/L of Fe, Cu and Ni, was treated with [HF-1] cation exchange membranes by means of electrolytical separation. Regenerated plating solution can be adopted as fresh one.

(2) Direct Preparation of Pure Magnesium Hydroxide

Direct preparation of pure magnesium hydroxide via electrolysis of magnesium chloride using single cation exchange membrane electrolyzer. Current efficiency exceeded 95% and purity of $Mg(OH)_2$ is close to 99% .

(3) Electrochemical Synthesis of p-Aminophenol from Nitrobenzene

Ion exchange membranes of [HF] series are operated in such a corrosive and contaminating medium with noticeable service time.

(4) Electrodialytical Desalination of Mixed Amino-acids

When desalting percentage varies from 90% to 95%,the current efficiency and recovery of amino acids consists of 90% and 80% respectively.