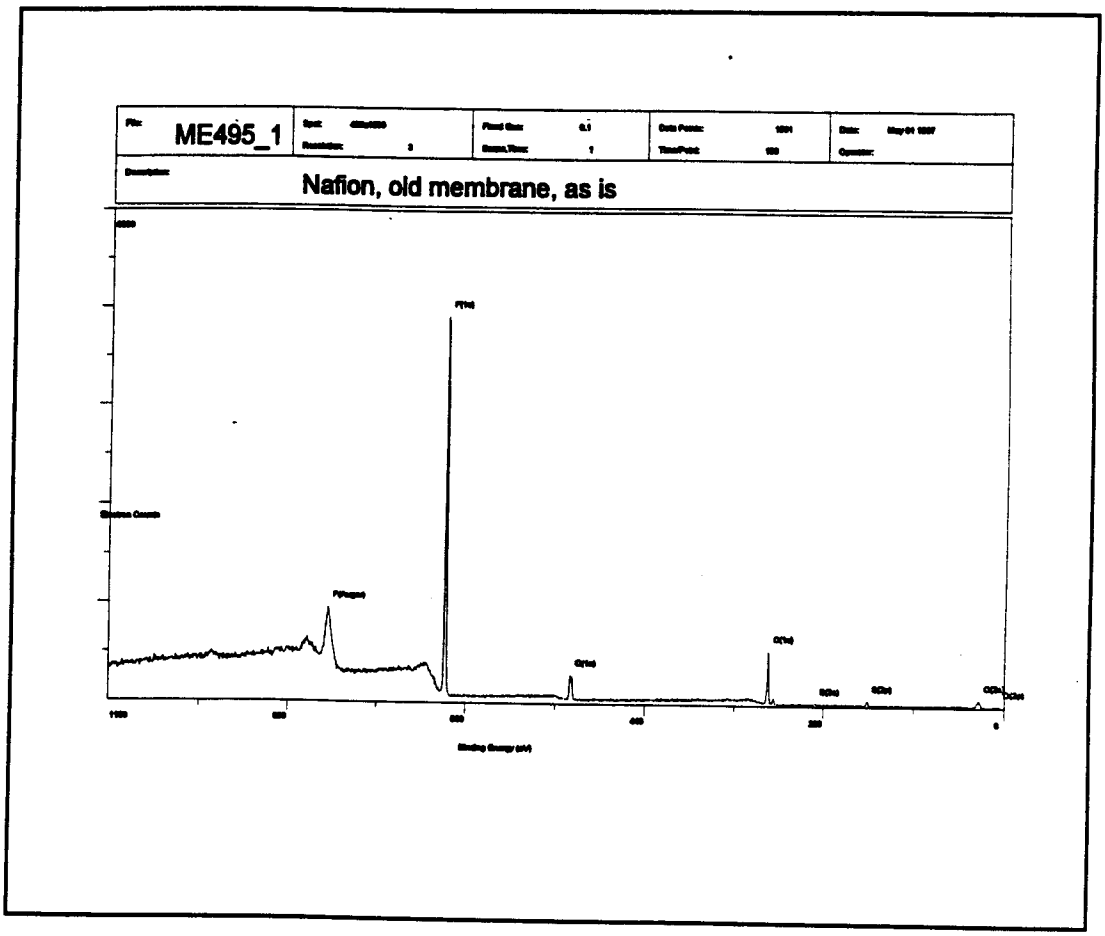
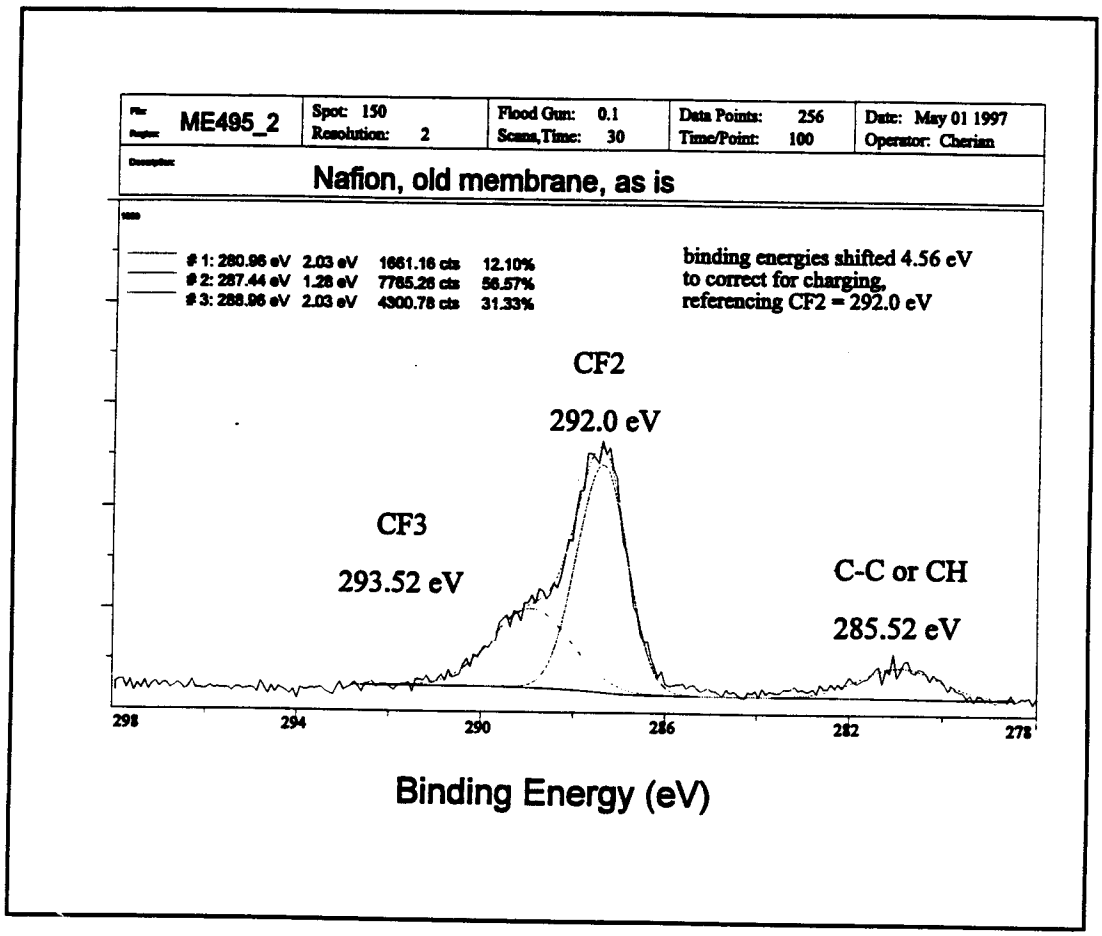
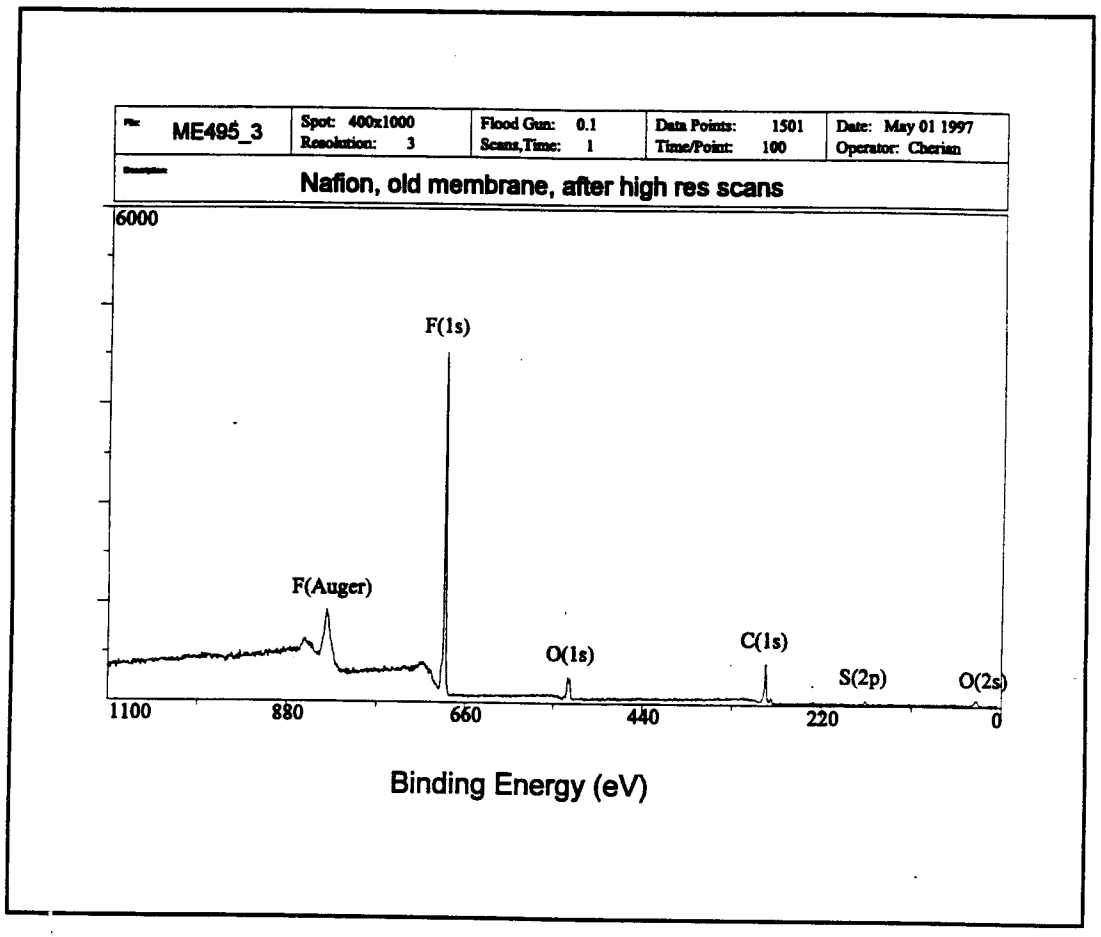


Surface Composition Table Summary
File name: ME495_1.MRS
Description: Nafion, old membrane, as is
Operator: Jesse T. Cherian
Date: Thu May 1 07:56 1997

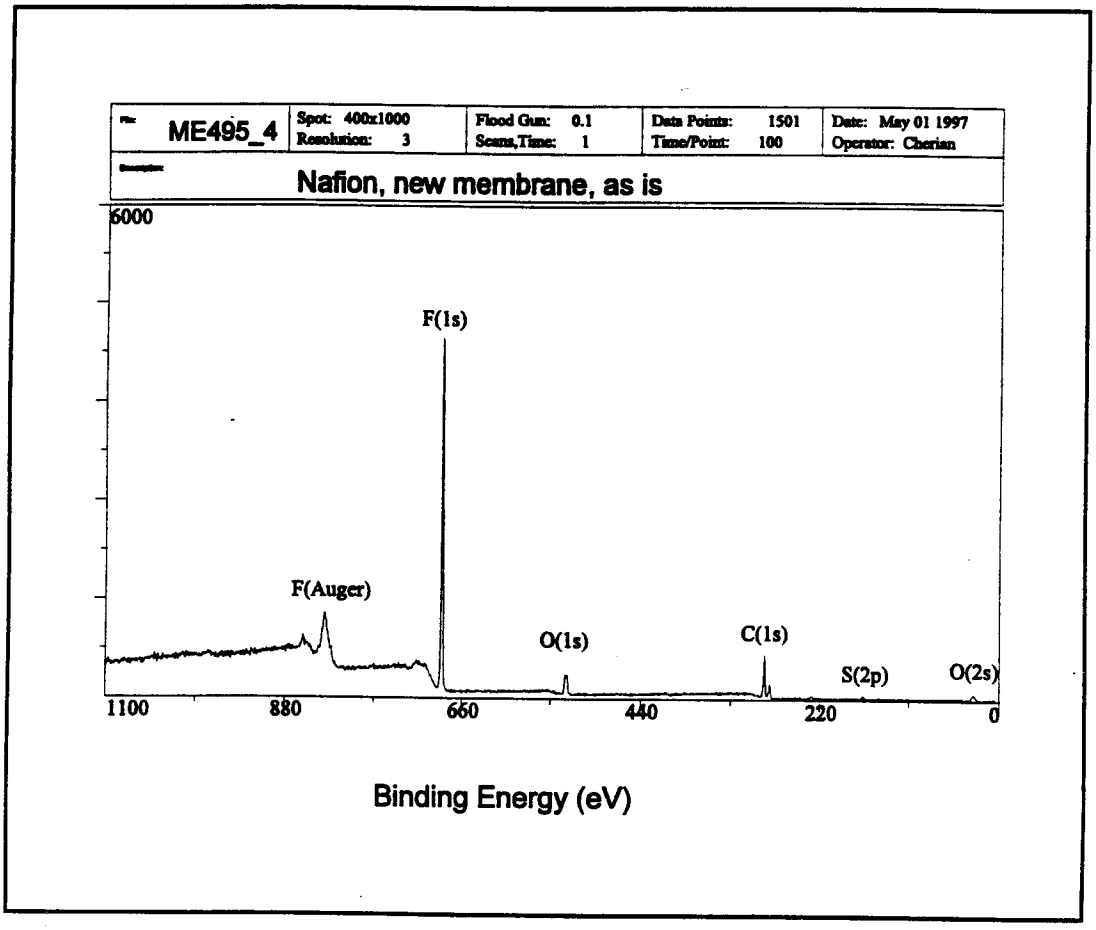
Element	Binding Energy	atom %
F (1s)	682.0	61.53
O (1s)	528.3	8.77
C (1s)	284.6	27.87
S (2p)	162.5	1.83


ME495_2
Spot: 150
Resolution: 2
Flood Gun: 0.1
Scans,Time: 30
Data Points: 256
Time/Point: 100
Date: May 01 1997
Operator: Cherian
Nafion, old membrane, as is
1: 280.96 eV 2.03 eV 1661.16 cts 12.10%
2: 287.44 eV 1.28 eV 7765.26 cts 56.57%
3: 288.96 eV 2.03 eV 4300.78 cts 31.33%
binding energies shifted 4.56 eV
to correct for charging,
referencing CF2 = 292.0 eV
CF2
292.0 eV
CF3
293.52 eV
C-C or CH
285.52 eV
298
294
290
286
282
278
Binding Energy (eV)



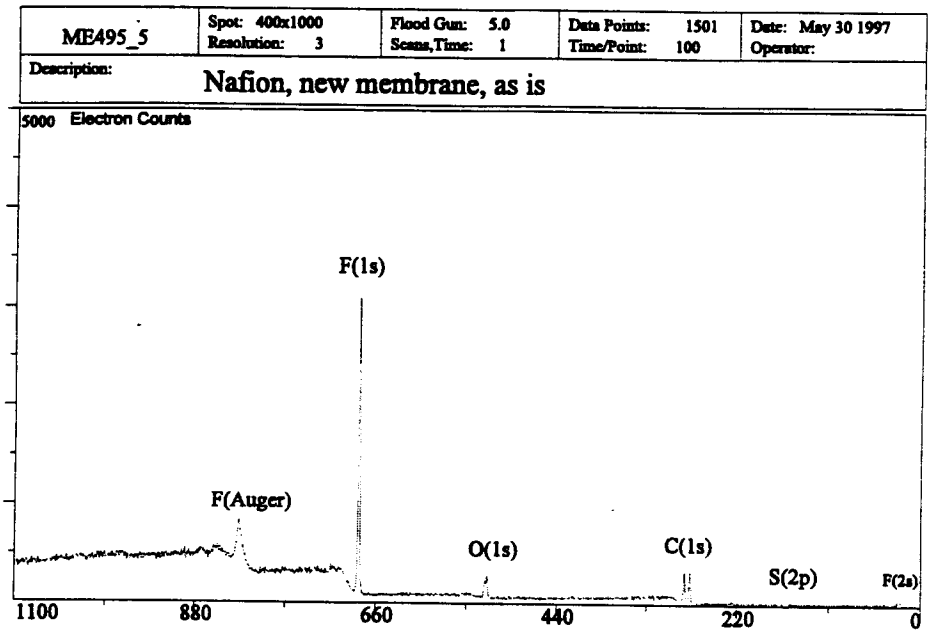
Surface Composition Table Summary
File name: ME495_3.MRS
Description: Nafion, old membrane, after high res scans
Operator: Jesse T. Cherian
Date: Thu May 1 09:57 1997

Element	Binding Energy	atom %
F (1s)	682.0	61.39
O (1s)	528.2	9.38
C (1s)	284.6	27.79
S (2p)	162.5	1.45



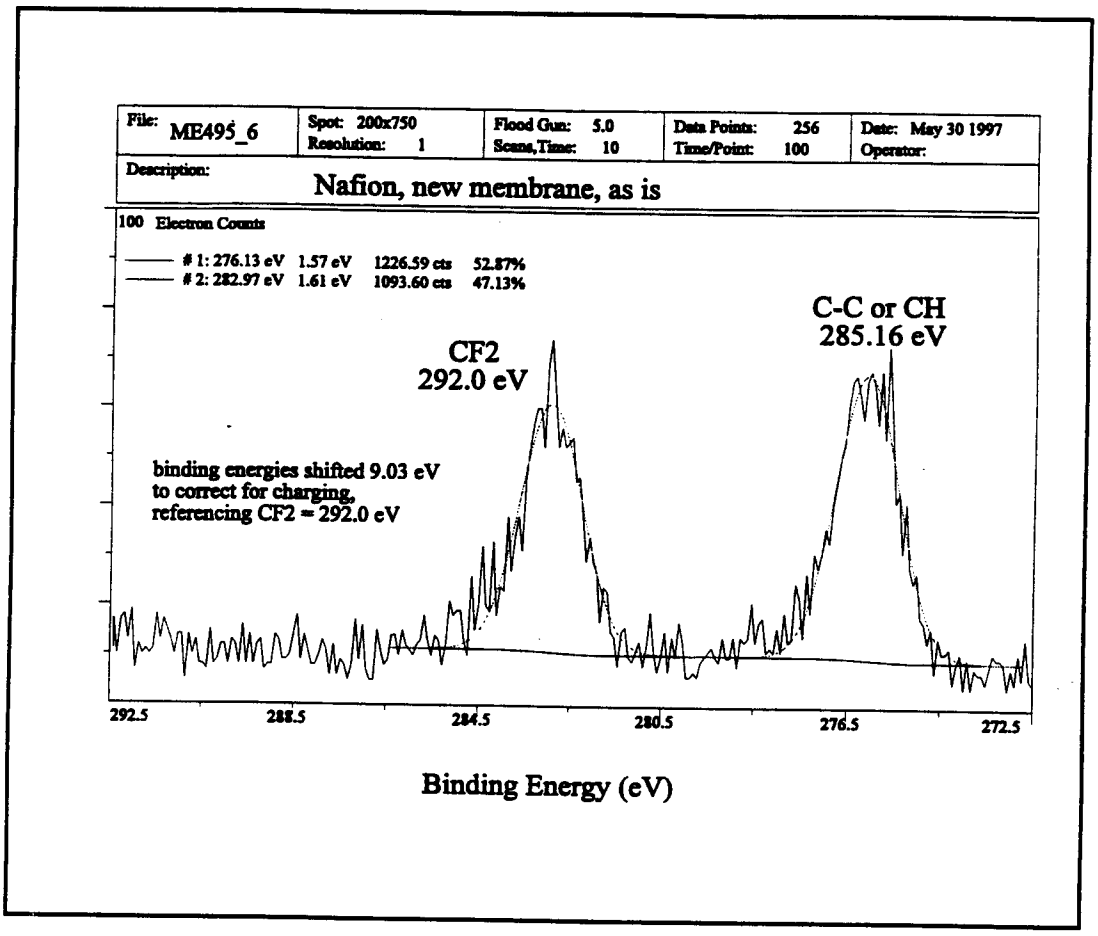
Surface Composition Table Summary
File name: ME495_4.MRS
Description: Nafion, new membrane, as is
Operator: Jesse T. Cherian
Date: Thu May 1 10:09 1997

Element	Binding Energy	atom %
F (1s)	682.0	59.64
O (1s)	526.4	8.44
C (1s)	284.6	30.59
S (2p)	162.3	1.33

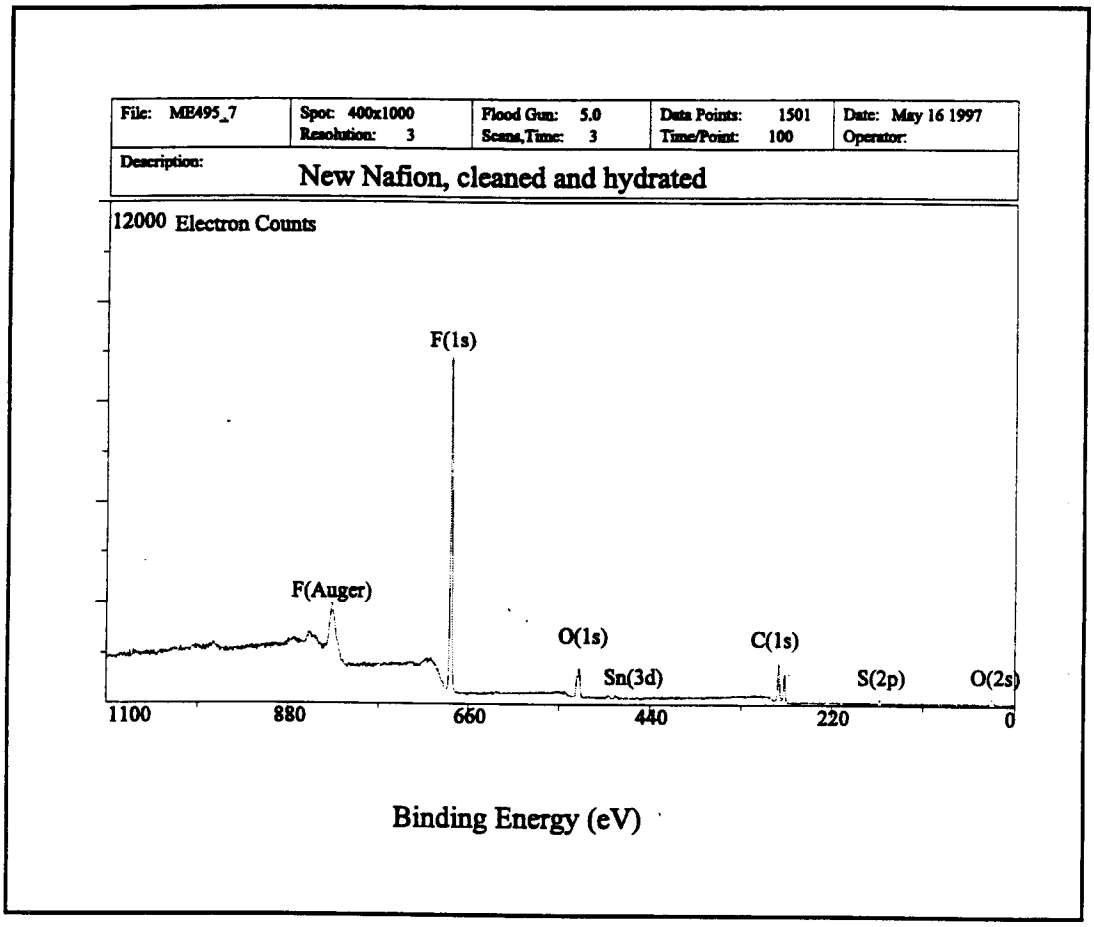


Surface Composition Table Summary
File name: ME495_5.MRS
Description: Nafion, new membrane, as is, 30 days later
Operator: Jesse T. Cherian
Date: Fri May 30 07:19 1997

Element	Binding Energy	atom %
F (1s)	688.9	52.24
O (1s)	532.8	9.22
C (1s)	284.6	37.38
S (2p)	168.6	1.16



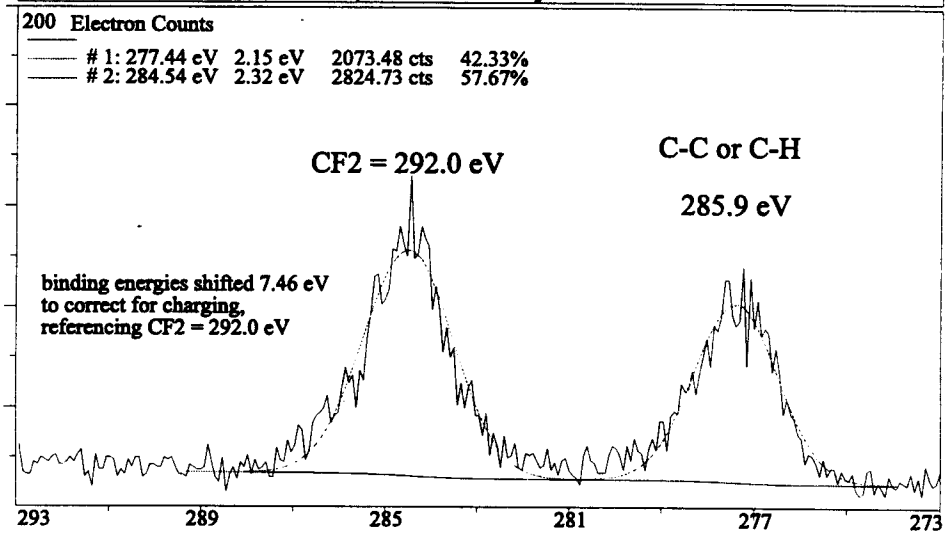
File name: ME495_6.MRS
Description: Nafion, new membrane, as is, 30 days later
Operator: Jesse T. Cherian
Date: Fri May 30 07:19 1997

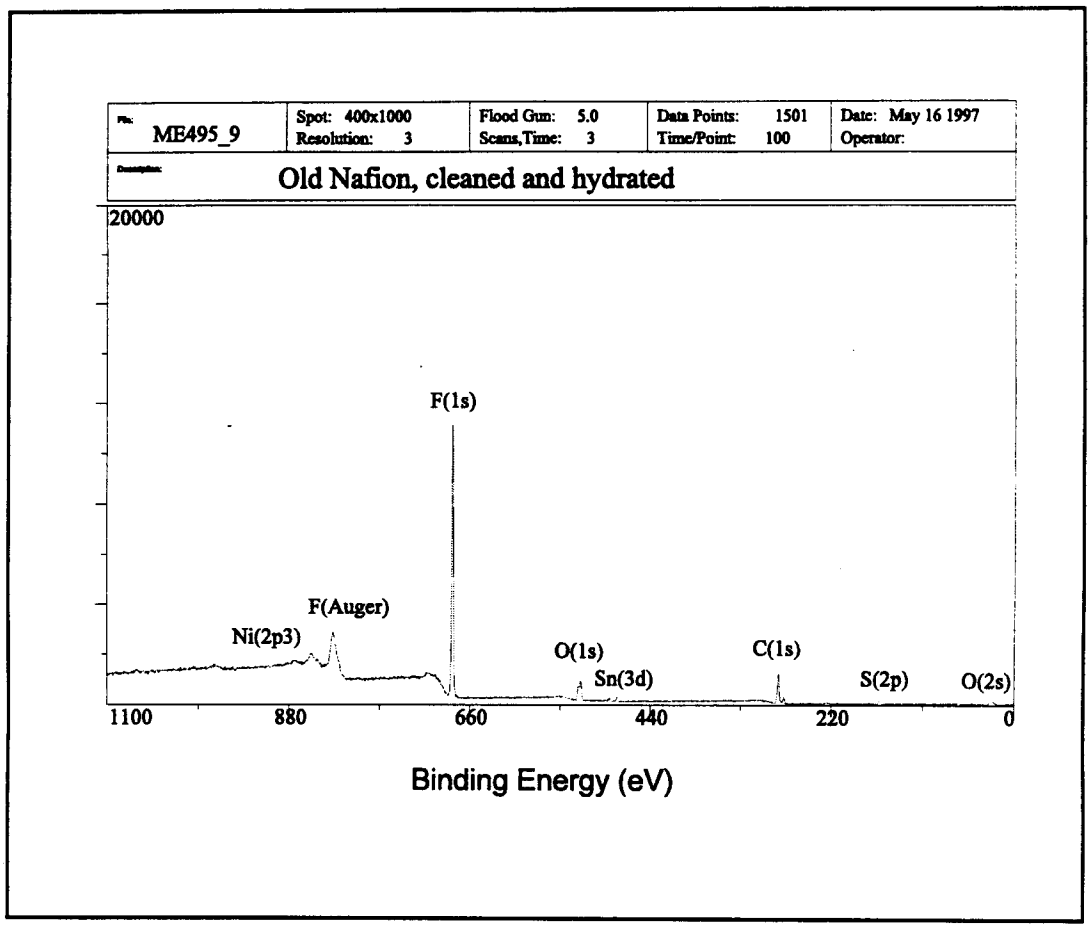


Surface Composition Table Summary
File name: ME495_7.MRS
Description: New Nafion, cleaned and hydrated
Operator: Jesse T. Cherian
Date: Fri May 16 11:09 1997

Element	Binding Energy	atom %
F (1s)	682.0	54.09
O (1s)	525.8	10.37
C (1s)	284.6	34.07
S (2p)	162.2	1.33
Sn (3d)	482.4	0.15

ME495_8	Spot: 400x1000 Resolution: 1	Flood Gun: 5.0 Scans, Time: 10	Operator: Cherian	Date: 05.16.1997
Description: New Nafion, cleaned and hydrated				

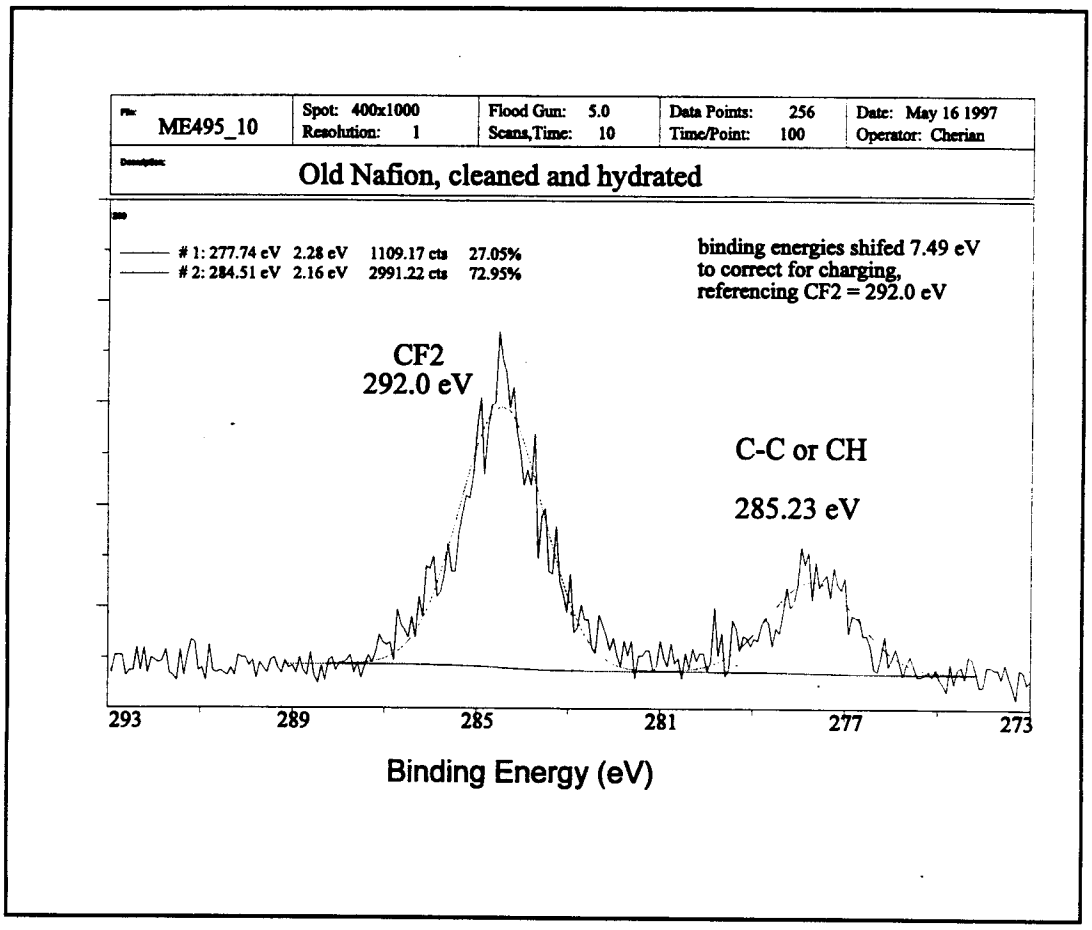


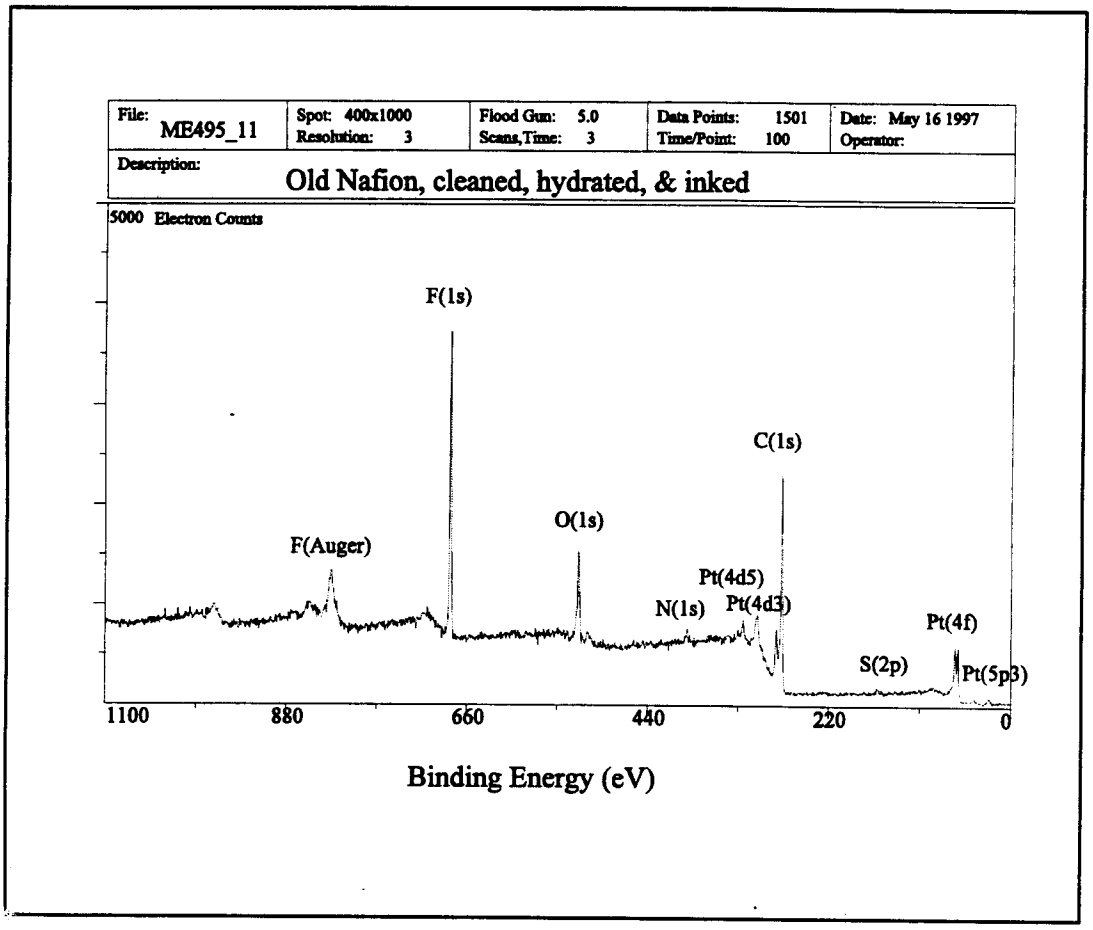


Surface Composition Table Summary
File name: ME495_9.MRS
Description: Old Nafion, cleaned and hydrated
Operator: Jesse T. Cherian
Date: Fri May 16 08:04 1997

Element	Binding Energy	atom %
F (1s)	682.0	61.07
O (1s)	525.7	10.27
C (1s)	284.6	27.45
Sn (3d)	481.6	0.16
Ni (2p3)	854.1	1.05

Note: The Ni peak is due to the nickel charging screen


ME495_10
Spot: 400x1000
Resolution: 1
Flood Gun: 5.0
Scans,Time: 10
Data Points: 256
Time/Point: 100
Date: May 16 1997
Operator: Cherian
Old Nafion, cleaned and hydrated
1: 277.74 eV 2.28 eV 1109.17 cts 27.05%
2: 284.51 eV 2.16 eV 2991.22 cts 72.95%
binding energies shifed 7.49 eV
to correct for charging,
referencing CF2 = 292.0 eV
CF2
292.0 eV
C-C or CH
285.23 eV
293
289
285
281
277
273
Binding Energy (eV)



Surface Composition Table Summary

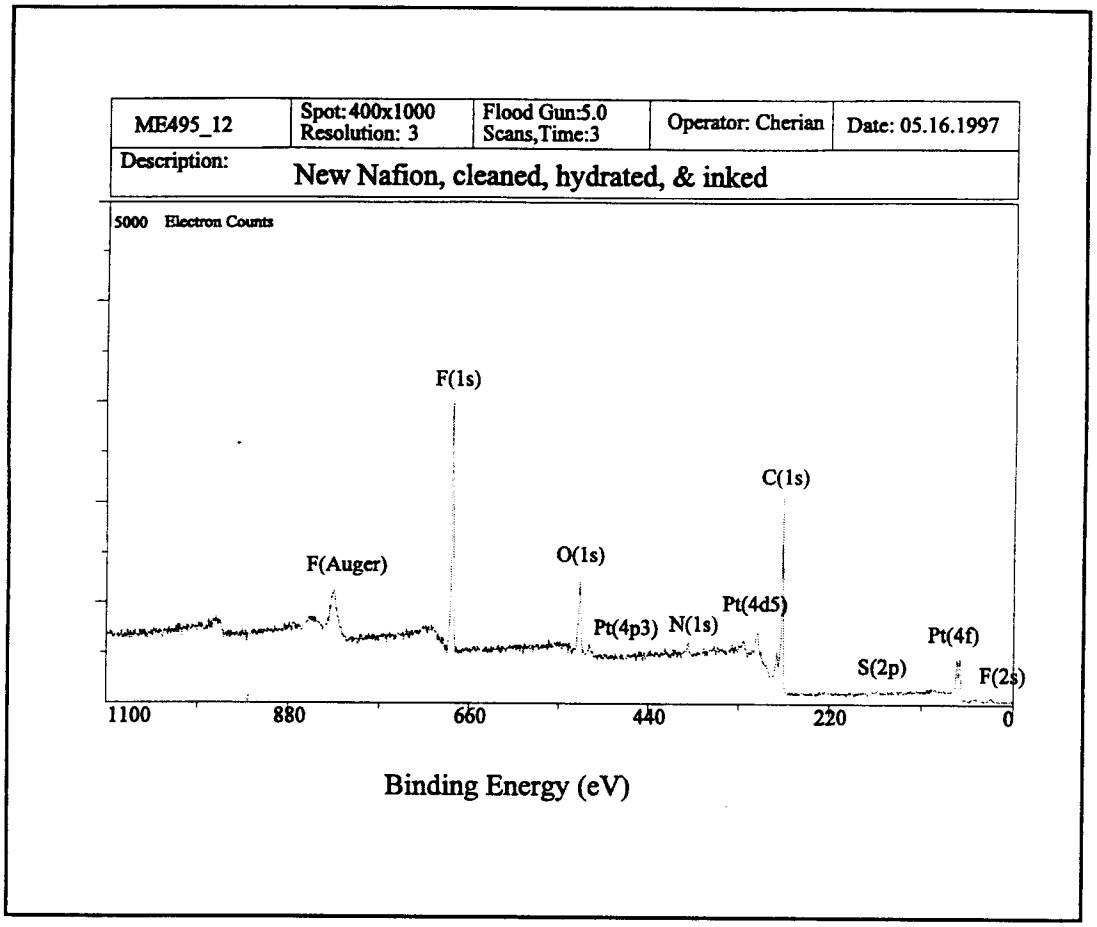
File name: ME495_11.MRS

Description: Old Nafion, cleaned, hydrated, & inked

Operator: Jesse T. Cherian

Date: Fri May 16 13:38 1997

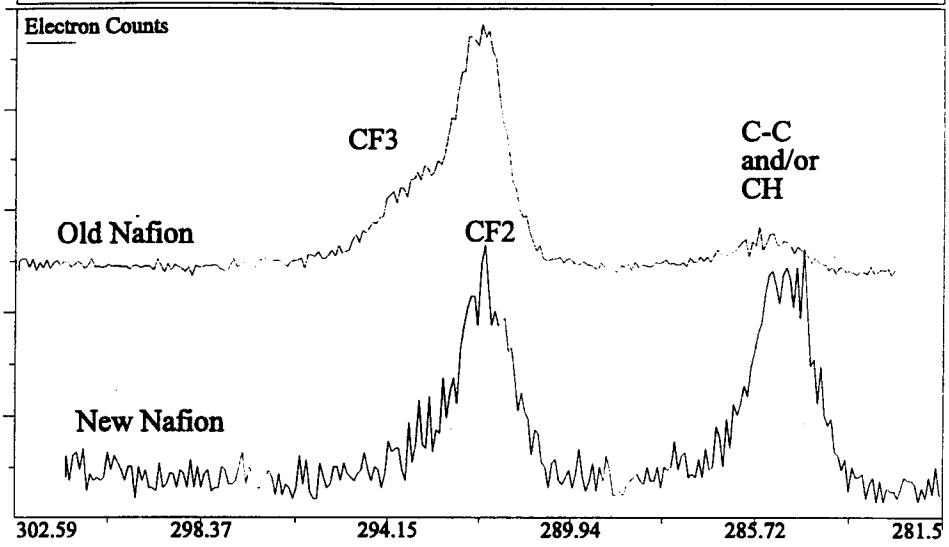
Element	Binding Energy	atom %
F (1s)	689.0	21.01
O (1s)	532.6	12.37
C (1s)	284.6	63.19
S (2p)	169.3	1.31
Pt (4f)	71.4	1.53
N (1s)	400.4	0.59



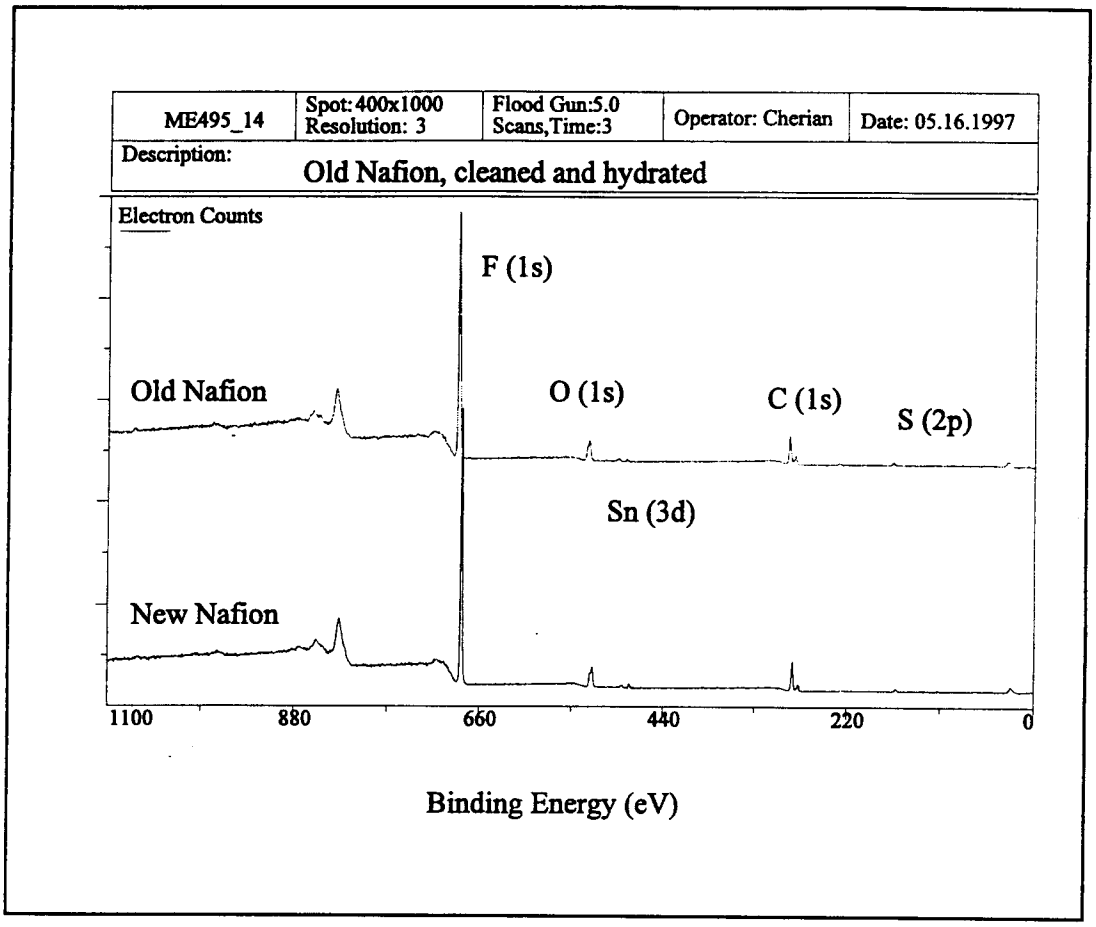
Surface Composition Table Summary
New Nafion, cleaned, hydrated, & inked

Element	Binding Energy	atom %	% by mass
F (1s)	689.1	22.66	22.66
O (1s)	532.6	11.25	10.83
N (1s)	399.7	2.41	2.03
C (1s)	284.6	61.22	44.21
Pt (4f)	71.6	1.25	14.67
S (2p)	169.2	1.22	2.35

ME495_13	Spot: 200x750 Resolution: 1	Flood Gun:5.0 Scans,Time:10	Operator: Cherian	Date: 05.30.96
Description:	Nafion: Comparison of New & Old Membrane			



Binding Energy (eV)

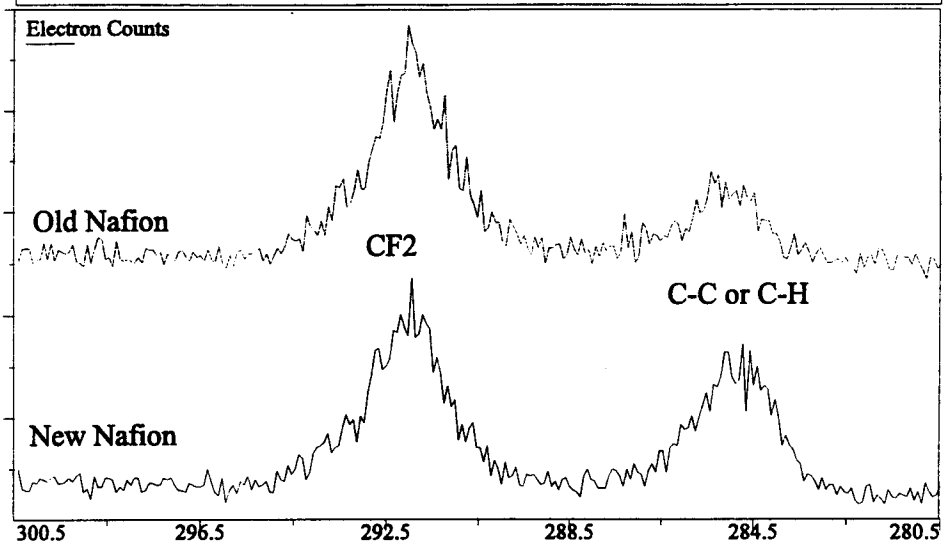


Surface Composition Table Summary

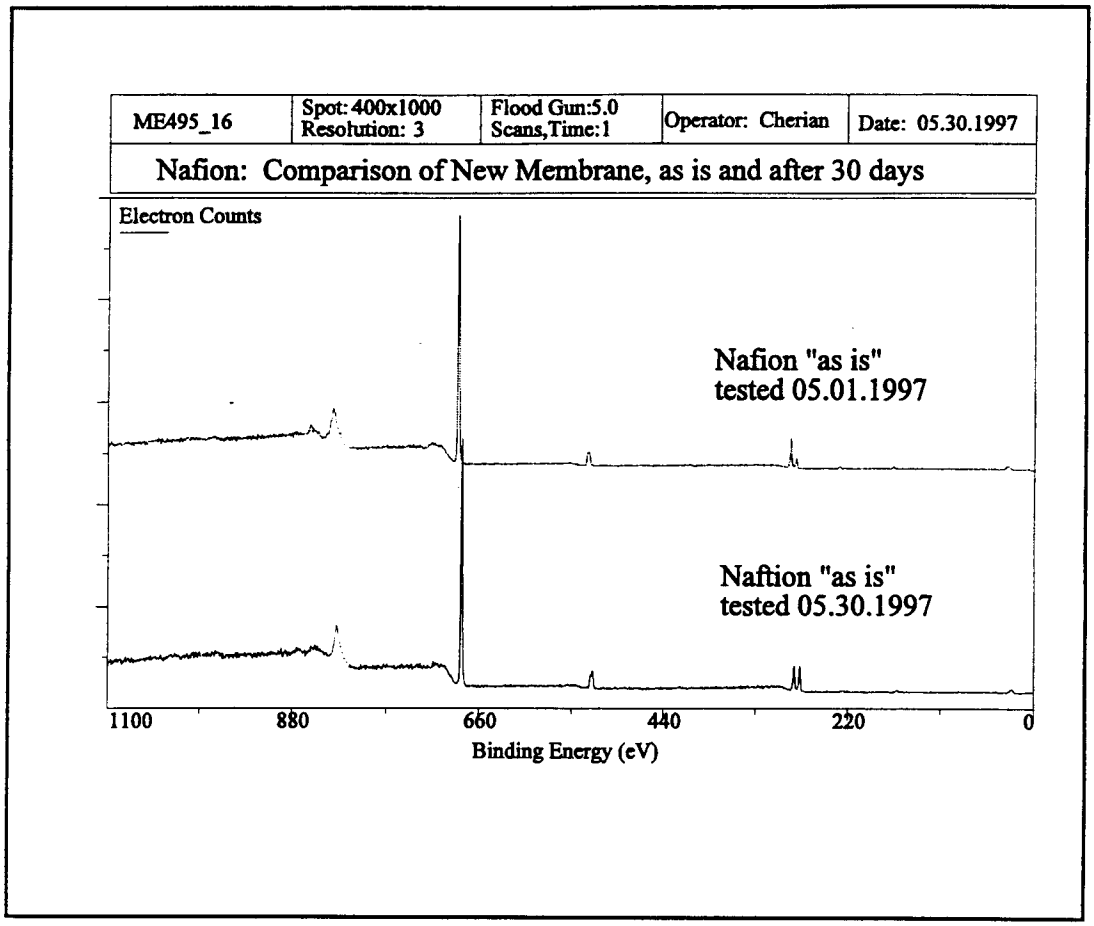
Element	Binding Energy	OLD atom %	NEW atom %
F (1s)	682.0	60.80	59.84
O (1s)	526.4	10.22	9.96
Sn (3d)	491.9	0.16	0.18
C (1s)	284.6	27.33	28.63
S (2p)	162.3	1.49	1.39

ME495_15	Spot: 400x1000 Resolution: 1	Flood Gun: 5.0 Scans,Time: 10	Operator: Cherian	Date: 05.16.1997

Nafion: Comparison of New & Old Membrane, cleaned and hydrated



Binding Energy (eV)



Surface Composition Table Summary

Element	Binding Energy	May 1 atom %	May 30 atom %
F (1s)	682.0	59.64	52.24
O (1s)	526.4	8.44	9.22
C (1s)	284.6	30.59	37.38
S (2p)	162.3	1.33	1.16

APPENDIX C: Fuel Cell Membrane Fabrication Procedure

The procedure followed during the course of our research is basically a reproduction of the procedure outlined in the paper by Mahlon, Valerio, and Gottesfeld; "Low Platinum Loading Electrodes for Polymer Electrolyte Fuel Cells Fabricated Using Thermoplastic Ionomers" Electrochimica Acta, Volume 40, 1995, pp 355 - 363. To add clarity, it is given below.

Preliminary results using this procedure were very encouraging. However, reproduction of these results has been problematic. The attached plot details our initial findings.

Preparation:

Nafion Membrane

Materials:

- Nafion 117 membrane (MW = 1100, 7 mil thickness)
- 3% aqueous peroxide solution
- 1 M sodium chloride solution

Procedure:

- Cut to fit the test apparatus, taking into account the fact that the Nafion will swell when hydrated
- Boil in a 3% by weight aqueous peroxide solution for 1 hour
    - performed to clean the membrane and saturate it with water
- Boil in approximately 1 M aqueous sodium chloride solution for 1 hour
    - performed to ensure complete conversion to the sodium form

Catalyst Ink

Materials:

- Nafion solution from Aldrich, 5% solublized Nafion by weight
- Platinum catalyst
    - 10% platinum by weight on carbon black Vulcan XC 72-R, the Electrosysthesis Company
- Tetrabutylammonium Hydroxide solution (TBOH), 1 M from Aldrich
- Glycerol, from Aldrich
- Isopropanol

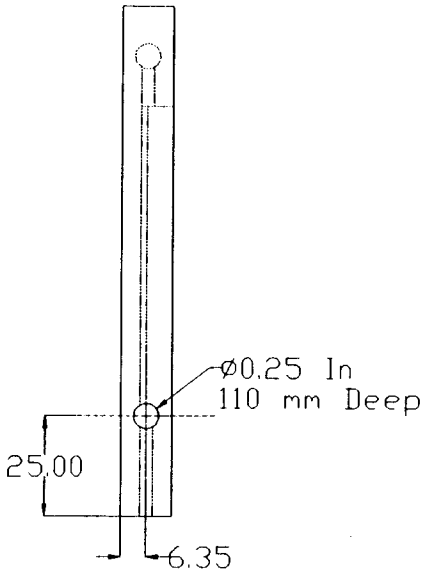
Procedure:

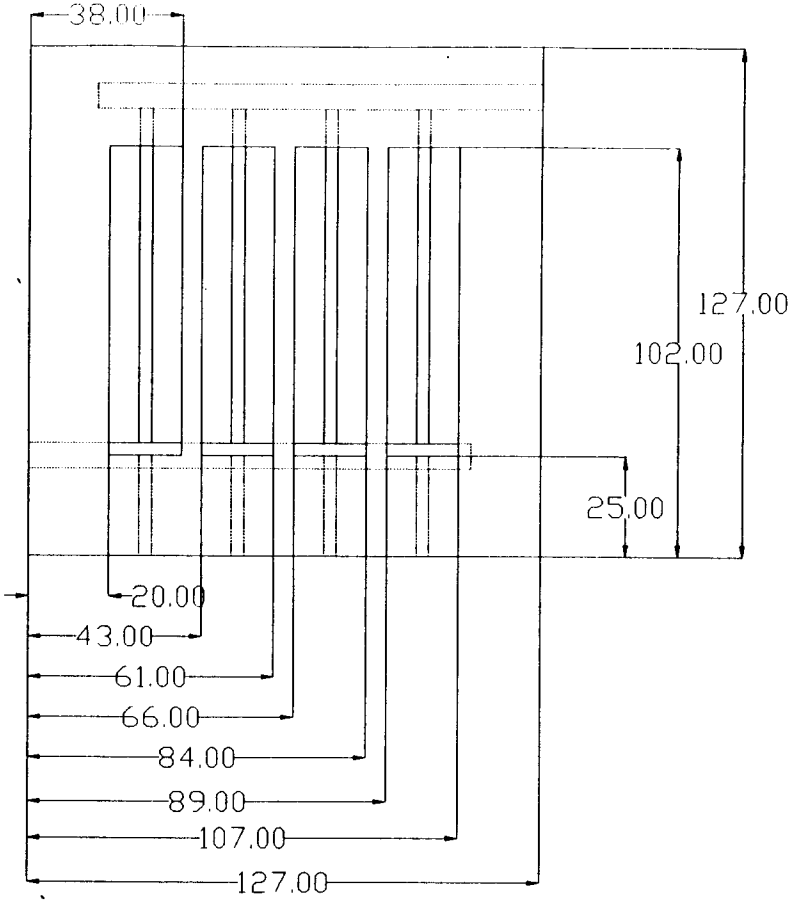
- Combine Nafion solution and platinum catalyst material (1:3 Nafion to platinum ratio by mass) in a small flask
- Add isopropanol and glycerol until desired consistency is achieved
- Sonicate a minimum of 2 hours (longer is preferable)

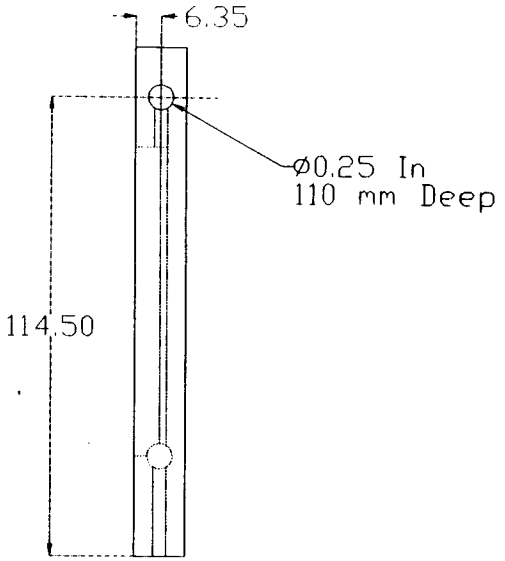
Table 1: Membrane Weights

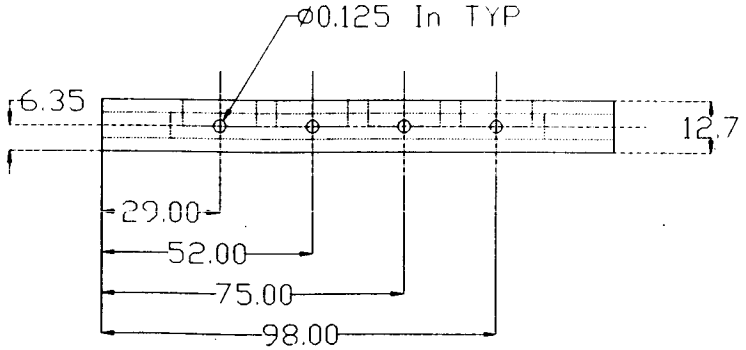
TYPE	Before cleaning & hydration	After cleaning & hydration	After application of platinum ink
OLD	5.785g	8.638g	6.309g
OLD	0.982g	1.649g	
NEW	6.405g	9.403g	7.483g
NEW	1.043g	1.643g	

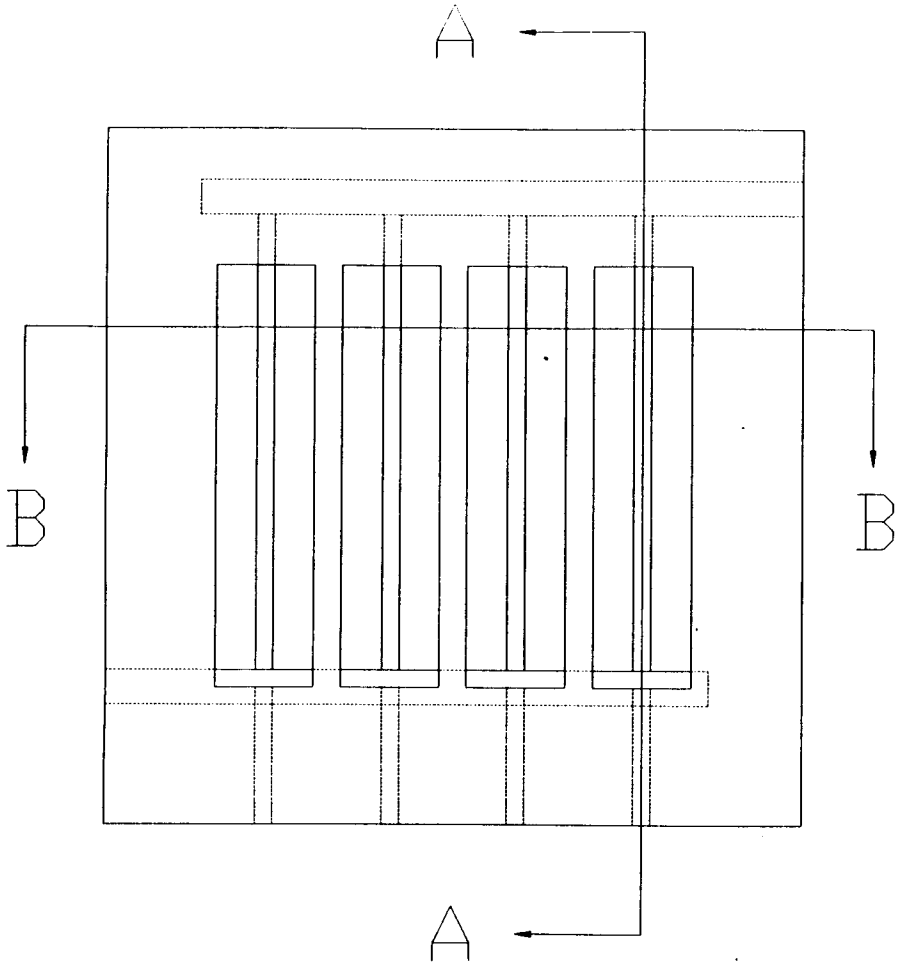
Appendix D: Engineering Drawings of Final Prototype

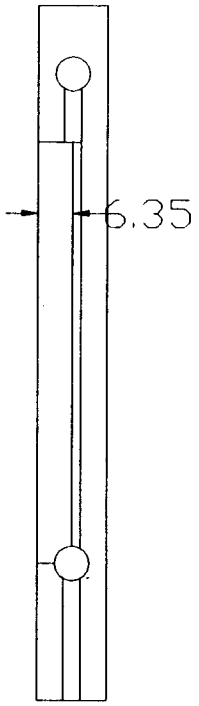

ø0.25 In
110 mm Deep
25.00
6.35


38.00
127.00
102.00
25.00
20.00
43.00
61.00
66.00
84.00
89.00
107.00
127.00

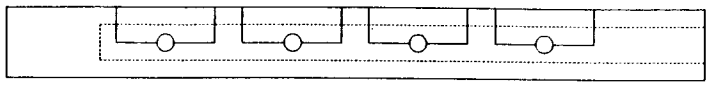

6.35
ø0.25 In
110 mm Deep
114.50


ø0.125 In TYP
6.35
12.7
29.00
52.00
75.00
98.00





Section A-A



Section B-B