(81)　　　　　　　　　　　　　　:　　　　,　　　　　,　　　　　,　　　　　　,　　　　　　,　　　-
　　　　　　　　　　　,　　　　　,　　　　,　　　,　　　　,　　　,　　,　　,　　,
　　　　　　　　　,　　,　　　　,　　,　　　　,　　　,　　　　,　　　,　　　,
　　　　　　　　　,　　,　　　,　　,　　　　,　　　,　　　　,　　　,　　　,
　　　　　　　　,　　　,　　　,　　　,　　　,　　　,　　　,　　,　　　,
　　　　　　　,　　,　　　,　　,　　　　,　　　,　　　,　　,　　,
　　　　　　　　,　　　,　　　　,　　　,　　　,　　　,　　　,　　,　　　,
　　　　　　　,　　,　　,　　,　　,　　　,　　　,　　,　　　,　　　,
　　　　　　　　　,　　,　　,　　　,　　　,　　　,　　,　　,　　,
　　　　　　　,
　　　　　　　AP ARIPO　 :　　　,　　　,　　　,　　　,　　　　,　　　,　　　　,　　,
　　　　　　　,　　　,
　　　　　　　EA　　　　　　:　　　　,　　　　　,　　　　,　　　　,　　　　　,　　　,
　　　　　　　,　　　,　　　　　,
　　　　　　　EP　　　　:　　　,　　,　　　,　　,　　　,　　　,　　　,　　,　　　,
　　　　　　　,　　,　　　,　　,　　　,　　,　　,　　,　　　　,
　　　　　　　OA OAPI　　:　　　　　,　　,　　　　,　　,　　　　,　　,　　,
　　　　　　　,　　,　　,　　,　　,　　,　　,　　,　　　,

(30)　　　　　　　　　10024576.5　　　　　　　2000　05　19　　　　　　(DE)

(71)
　　　　　　　　　　,　　　　　　70199,　　　　　　　　　　72.

(72)　　　　　　　　,
　　　　　　　,　　　　　73760,　　　　　11
　　　　　　,
　　　　　　　,　　　　　70569,　　　　　　54
　　　　　　,
　　　　　　　,　　　　69469,　　　　　　　11

(74)

:

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(54)

, (1) , Q

, , , (2) (3) , R 2 , a) R

(4A), (4B), (4C), (4D), (4E), (4F), (4G) / (4H) , b)

R (5A) / (5B) / R

(5C) / (5D) , c) R (6) (bridge) ,

R , R_1, R_2, R_3, R_4, R_5, M, X, Y, Z m .

,

- Q- R (1)

,

Q , , ,

(2) (3) ,

R 2 .

, .

(1) . , (poly
pyrene) (polyarylene), (polystyrene) (polyvinylpyridine),
(polyphenylenevinylene) ,
, , Radel( ) R (polysulfone), PEK
. , (polybenzimidazole), , (
polyazulene), (polycarbazole), (polyindophenine) (polypyrrole),
, (polyazole) .

.

.

, (polyelectrolyte membrane fuel cell) (PEM)

(proton conductor)   .   (membrane electrode assembly) (MEA)   ,

(tolerance)   ,   .

,   ,   ,   (lower upper flow limit) ,   ,   ,
.

DE 196 22 337, WO 99/02755,   WO 99/02756
. DE 196 22 337   (sulfinate)   ,   (   )
(ionomer)   .   (network)
.   ,   ,
,   .   ,
,   .

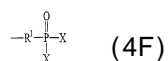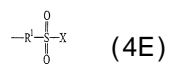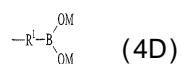WO 99/02756   WO 99/02755   (   )
.   ,
/   /
.   ,   ( )   60   90   .   ,
,   /   .
80   .

,   .
25   100   ,   ,   ,
.

,   ,   ,   (swell ing property)   .   90   100%   .

80   ,   100   .

.

1   .
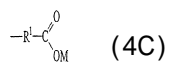1   .
,
.

a)   R   (4A), (4B), (4C), (4D), (4E), (4F), (4G)   /   (4H)

$$-R^1-\overset{O}{\underset{O}{\overset{\|}{S}}}-OM \qquad (4A)$$

$$-R^1-\overset{O}{\underset{OM}{\overset{\|}{P}}}-OM \qquad (4B)$$

$$-R^1-C\overset{O}{\underset{OM}{\diagup}} \qquad (4C)$$

$$-R^1-B\overset{OM}{\underset{OM}{\diagdown}} \qquad (4D)$$

$$-R^1-\overset{O}{\underset{O}{\overset{\|}{S}}}-X \qquad (4E)$$

$$-R^1-\overset{O}{\underset{X}{\overset{\|}{P}}}-X \qquad (4F)$$

$$-R^1-C\overset{O}{\underset{X}{\diagup}} \qquad (4G)$$

$$-R^1-B\overset{X}{\underset{X}{\diagdown}} \qquad (4H)$$

,

R^1 1   40   ,
,

M   ,   ,   Li$^+$, Na$^+$, K$^+$, Rb$^+$, Cs$^+$,   ,
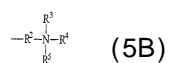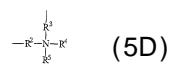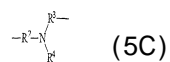
X   ,

b)   R   (5A)   /   (5B)   ,

$$-R^2-\overset{R^3}{\underset{R^4}{\diagup}} \qquad (5A)$$

$$-R^2-\overset{R^3}{\underset{R^5}{\overset{\|}{N}}}-R^4 \qquad (5B)$$

R^2, R^3, R^4 R^5 1   40   ,

, R^2, R^3, R^4

/   R   (5C)   /   (5D)   ,

   (5C)
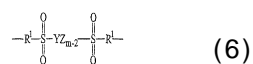
   (5D)

c)   R   (6)   (bridge)   ,

          (6)

R   ,

Y   1   40   ,

,

Z   ,   ,

    (7)

,   H, C, O, N, S, P,   , 20 g/   ,

m   2   ,

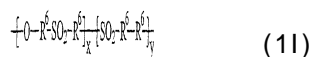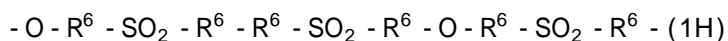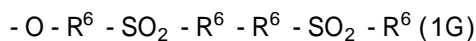(1)   ,

,   ,   ,

.

,   .   ,

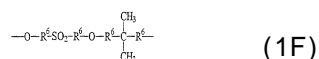(doped polymer membrane)   ,   25   100

,

,   ,

10   100   ,   80   ,

,   ,

80   ,   ,

.

, . ,

. ,

. , " " 1.0 CD Rompp Ch

enie Lexikon(Stuttgart/New York: Georg Thieme Verlag, 1995) , .

(1) , (1A), (1B), (1C), (1D), (1E), (1F), (1G),

(1H), (1I), (1J), (1K), (1L), (1M), (1N), (1O), (1P), (1Q), (1R), (1S) / (1T)

.

- O- R^6 - (1A)

- S- R^6 - (1B)

- O- R^6 - SO_2 - R^6 - (1C)

- O- R^6 - SO_2 - R^6 - O- R^6 - (1D)

- O- R^6 - SO_2 - R^6 - O- R^6 - R^6 - (1E)

$$-O-R^6-SO_2-R^6-O-R^6-\overset{CH_3}{\underset{CH_3}{C}}-R^6-$$ (1F)

- O- R^6 - SO_2 - R^6 - R^6 - SO_2 - R^6 (1G)

- O- R^6 - SO_2 - R^6 - R^6 - SO_2 - R^6 - O- R^6 - SO_2 - R^6 - (1H)

$$\left[O-R^6-SO_2-R^6\right]_x\left[SO_2-R^6-R^6\right]_y$$ (1I)

$0 <$ x, y $< 100\%$

- O- R^6 - CO- R^6 - (1J)

- O- R^6 - CO- R^6 - CO- R^6 - (1K)

- O- R^6 - CO- R^6 - O- R^6 - CO- R^6 - CO- R^6 (1L)

- O- R^6 - O- R^6 - CO- R^6 - (1M)

- O- R^6 - O- R^6 - CO- R^6 - CO- R^6 - (1N)

$$\left[R-NH-R-NH\right]_y\left[R-N=\langle\rangle=N\right]_{100\%-y}$$ (1O)

0 < y < 100%

- R^6 - (1P)

- R^6 - CH= CH- (1Q)

- CHR^7 - CH$_2$ - (1R)

 (1S)

 (1T)
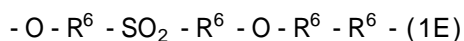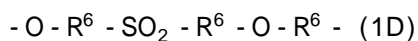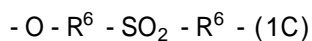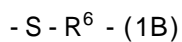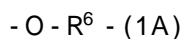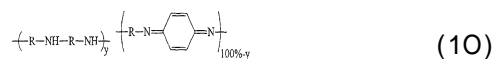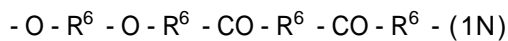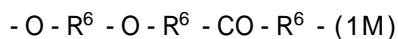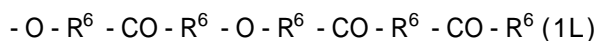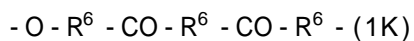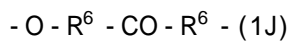
R^6 1,2-   , 1,3-   , 1,4-   , 4,4'-   ,
        2   , C$_{10}$ 2   , C$_{14}$ 2   /   2   (pyrene)
. C$_{10}$, C$_{14}$.   /
        ,   R^6 -,   -,   -   .

    R^7, R^8,   R^9 1   , 2   3   ,
            U   ,   ,   , 1   20   ,
                                                              ,   .

                                            (1)   (homopolymer)
        (copolymer)   ,   Victrex(   ) 720 P   Astrel(   )   .
                                          ,   ,   ,   ,   ,   ,
        ,   ,   ,   ,   ,   ,   ,   ,
              :

    (1A- 1)

              :

    (1B- 1)

        :

Victrex(   ) 200 P

(1C- 1)

Victrex(　　　) 720 P

(1I- 1)

n > 0

Radel(　　)

(1G- 1)

Radel(　　) R

(1E- 1)

Victrex(　　) HTA

(1H- 1)

Astrel(　　　)

(1I- 2)

n < 0

Udel(　　)

(1F- 1)

:

PEK

(1J- 1)
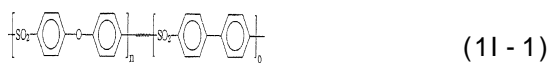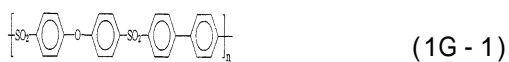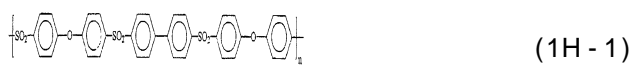
PEKK
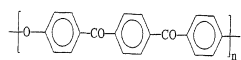
(1K- 1)

PEKEKK
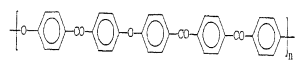
(1L- 1)

PEEK
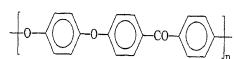
(1M- 1)

PEEKK

(1N- 1)

:

　(1P- 1)

:

　(1P- 2)

:

(1S- 1)

:

　(1P- 3)

:

(1Q- 1)

:

(1O- 1)

:

(1P- 4)

:

(1P- 5)

:

(1P- 6)

:

(1P- 7)

:

(1R- 1)

(1R- 2)
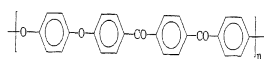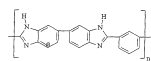
(1R- 3)
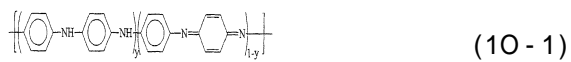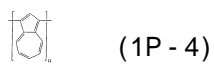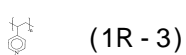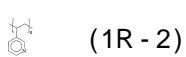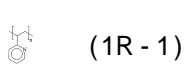
(1A- 1), (1B- 1), (1C- 1), (1I- 1), (1G- 1), (1E- 1), (1H- 1), (1I- 2), (1F- 1), (1J- 1), (1K- 1), (1L- 1), (1M- 1) / (1N- 1) .

, n .

(1) 10 , 100 .

(1A), (1B), (1C), (1D), (1E), (1F), (1G), (1H), (1I), (1J), (1K), (1L), (1M), (1N), (1O), (1P), (1Q), (1R), (1S) / (1T) 10 , 100 .

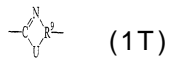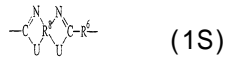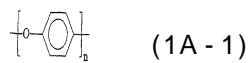, 25,000 g/mol , 50,000 g/mol , 100,000 g/mol .

. ,

, (1A), (1B), (1C), (1D), (1E), (1F), (1G), (1H), (1I), (1J), (1K), (1L), (1M), (1N), (1O), (1P), (1Q), (1R), (1S) / (1T) .

, R (4A), (4B), (4C), (4D), (4E), (4F), (4G) / (4H), (4A), (4B), (4C) / (4D), (4A), (4B) / (4C), (4A):

(4A)

(4B)

(4C)

(4D)

(4E)

(4F)

(4G)

$-R^1-B\begin{smallmatrix}X\\X\end{smallmatrix}$ (4H)

.
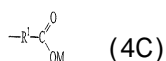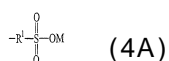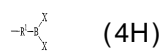
R^1 1   40   ,

.

, R^1 .

M   ,   ,   Li$^+$, Na$^+$, K$^+$, Rb$^+$, Cs$^+$,   ,
Li$^+$,   .

X   .

, , R (5A) / (5B), (5A)
/

$-R^2-\begin{smallmatrix}R^3\\R^4\end{smallmatrix}$ (5A)

$-R^2-\begin{smallmatrix}R^3\\|\\R^4\end{smallmatrix}-R^5$ (5B)

R (5C) / (5D), (5C) .

$-R^2-N\begin{smallmatrix}R^3-\\R^4\end{smallmatrix}$ (5C)

$-R^2-\begin{smallmatrix}|\\N\\|\end{smallmatrix}-R^5$ (5D)

,   R^2, R^3, R^4 R^5 1   40   ,
,   R^2, R^3,   R^4
.

R   (5A- 1)   /   (5A- 2)   ,   .

$\begin{smallmatrix}O\\||\end{smallmatrix}_{R^{10}}$ (5A- 1)

$\begin{smallmatrix}OM\\|\end{smallmatrix}_{R^{11}}^{R^{19}}$ (5A- 2)

R^{10} ,   ,
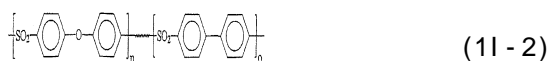
,   . R^{11} ,   ,   ,
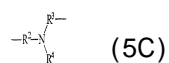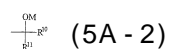
,   R^{10} , R^{10} R^{11}

.

R^{10} ,

(5A- 1)   ,   .   , R^{10} R^{11}

,   (5A- 2)   .

,   R   (6)   ,

$-R^1-\overset{O}{\underset{O}{S}}-YZ_{m-2}-\overset{O}{\underset{O}{S}}-R^1-$ (6)

R   , Y   1   40   ,

, 1   6

.

Z   ,   ,
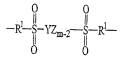
$-\overset{O}{\underset{O}{S}}-R^1-$ (7)

H, C, O, N, S, P   20 g/mol   ,

m   2   ,   2   .

.   ,

(doping agent)   (proton conductivity)

.   (dopant)   .

,   .   ,

,   .   ,

,   (Cr, Mo, V, W   )

(As, I, P, Se, Si, Te   )

.   12-   (12- molybdatophosphoric acid)   12-

(12- tungstophosphoric acid)   .

(H_3PO_4) .

(degree of doping)   ,   .

,   .   ,   .

, 3   15   ,   6   12   .

.   ,   ,

0.5 - 96   ,   1 - 72   ,   100   ,

,

.

，   .

0.5 meq/g   1.9 meq/g   .

25   100   ,   50   ,   20

.

.   ，

，   ，   .   ，   80   ，

100   ，   120   ，   10   90 ，   20

80   .   50   100 ，

，   90   100%   .

.   ，

，a) , b)   d)

(7)   , d)   (6)   ，

$-\overset{\overset{O}{\|}}{\underset{}{R}}-S-OM$ (6)

YLm (7)

L   ，   F, Cl, Br, I,   ，n   2   ，   2 .

(1)   . ，   .

，   R   (5A)   ，

(5C)   ，   (7)   (8)   /   (9)   .

$-\overset{\overset{R^3}{|}}{\underset{\overset{|}{R^4}}{R^2}}-N-YZ_{m-z}-\overset{\overset{O}{\|}}{\underset{\overset{\|}{O}}{S}}-R^1-$ (8)

$-\overset{\overset{|}{R^2}}{\underset{\overset{|}{R^4}}{R^3}}-N-YZ_{m-z}-\overset{\overset{O}{\|}}{\underset{}{S}}-R^1-$ (9)

(5A)   /   (5C)

.

，
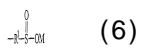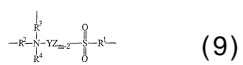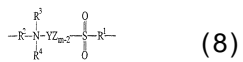
1)   a)   ，

2)   b)   ，

3)   d)   .

,

1)   a)   b)   ,

2)   d)   .

,

1)   a)   d)   ,

2)   b)

.

, 1)   a)   ,

2)   b)   d)   ,

.

, a), b)   d)

.

(1)

.   ,   (1A), (1B), (1C), (1D), (1E), (1F), (1G), (1H), (1I), (1J), (1K), (1
L), (1M), (1N), (1O), (1P), (1Q), (1R), (1S)   /   (1T)   .

(1A), (1B), (1C), (1D), (1E), (1F), (1G), (1H), (1I), (1J), (1K), (1L), (1M), (1N), (1O), (1P),
(1Q), (1R), (1S)   /   (1T)   10   ,   100   .

,   25,000 g/mol,
50,000 g/mol,   100,000 g/mol   .

a), b)   /   d)   .   (1)
(aprotic solvent),   (THF)   ,
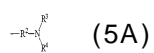, n-   ,   .

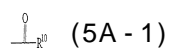,   ,   ,

L-   (10) (   )

,   /   ,
/   .

SO$_3$,   SO$_2$.

,

.

,   ,   4,833,219   (J. Kerres, W. C
ui, S. Reichle,   ), "   -   -   (
) PSU Udel(   )" J. Polym. Sci.:   A: Polym. Chem. 34, 2421- 2438 (1996), WO 00/09588 A
1   (   ).

0.1   3   (group)   ,
              0.2   2.2   .
a)   0.2   0.8   .   ,   0.8   2.2   b)
                                                    .   ,   0.8   1.3   d)
              .

                        ,   ,   N,N-   , N,N-   , N
-              ,   (sulfolane)   ,
                                    .

a)   (substrate),   ,

b)   , 25   /   1000 mbar
              ,   .

              ,   ,
a)   1   ,

b)   ,   1
              .

                                                                    . 25
      ,   100   .
                        ,   ,   2   ,   ,
          ,   .

          ,   ,   (pervaporation),   (, perstraction),   ,   (nanofil
tration),   (electrodialysis)   (diffusion dialysis)
                        .

          ,   ,
                        .   .

              (IEC)   ,   . 1mg
      50ml   NaCl   .   , H$^+$,
                        .   24   .   ,
                  ,   0.1-   NaOH   .
IEC   .

IEC(meq/g) = { NaOH   (meq/g) * NaOH   (ml) * NaOH   (factor)} /   (g)

              (R^{SP})   (0.25cm^2)   (Plexiglas unit)
              (IM6   , Zahner elektrik)   .   ,
              0   .   . 0.5N HCl   ,
                  Nafion 117   , Nafion 117/   /Nafion 117
                  .   ,   ,
          ,   Nafion 117   . Nafion
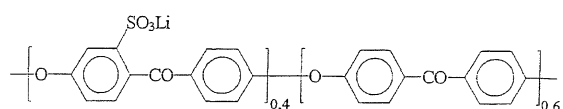   .   ,   25   .

, $(= m^{SWOLLEN})$.

$(= m^{dry})$.

$Q = (m^{SWOLLEN} - m^{dry})/m^{dry}$

a)

a- 1) PSU Udel( )

PSU P 1800 (Amoco)

a- 2) PEK- SO_3Li:

PEK;

:

1.8 meq SO_3H/g PEK- SO_3H 100g   10   %   LiOH   100 0ml   24   .   Li   PEK- SO_3Li ,   , 100   48   .   0.4 SO_3Li {   (IEC) = 1.8 meq SO_3H/g)   .
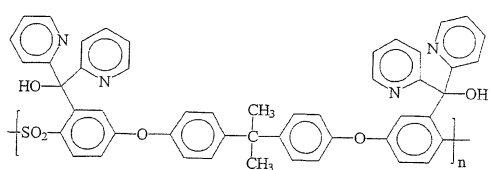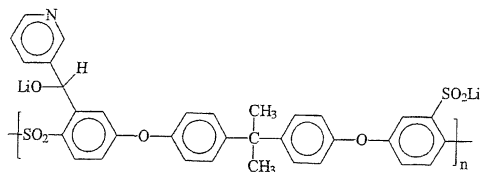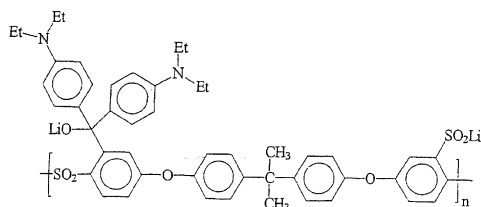
a- 3) PSU- SO_2Li:

PSU Udel( )
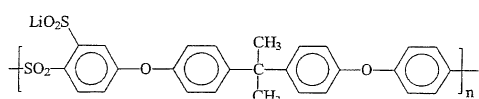
4,833,219 (J. Kerres, W. Cui, S. Reichle,), J. Po lym. Sci.: A: Polym. Chem. 34, 2421- 2438 (1996) " - - ( ) PSU Udel( ) " , IEC = 1.95 meq SO_2Li/g .

a- 4) PSU- DPK

2,2'-   PSU Udel   (WO 00/09588 A1   ),   2,2'-
.

a- 5) PSU- P3- SO$_2$Li, PSU- EBD- SO$_2$Li

PSU- P3- SO$_2$Li

PSU- EBD- SO$_2$Li

PSU Udel(   )   THF   - 75   .
2.5M   n-   (n- BuLi)   .   10M   n- B
uLi   .   (batch)   ,   - 3-   4,4'-   (N,N-
)   .   - 20   . SO$_2$,
- 75   SO$_2$.

, 10ml   /   ,
,   ,   .   80
. ^{1}H- NMR   .

[1]PSU- P3- SO

	(BATCH)		
PSU- P3- SO$_2$Li	10ml 10M BuLi1000ml THF22.1g PSU Udel( )5.35g - 3- SO$_2$		0.8 - 3- 1.2 SO$_2$Li
PSU- EBD- SO$_2$Li	10ml 10M BuLi1000ml THF22.1g PSU Udel( )16.22g 4,4'- - (N,N-) SO$_2$		0.4 4,4'- (N,N-) 1.6 SO$_2$Li

b)

PEK- SO$_3$Li, PSU- P3- SO$_2$Li, PSU- EBD- SO$_2$Li, PSU- DPK / PSU- SO$_2$Li 2 NMP
. , 1,4- (1,4- diiodobutan
e) . (doctor blade) . 60
1 , 1 90 , 120
. (waterbath) . 90
10% HCl . 60 .

c)

2 3 . (IEC^{theo})
. 3 ,
, 90 .

[2]

		( )	IEC^{exp} (meq/g)	IEC^{theo} (meq/g)	R^{sp} ( )
1(wz054)	0.77g PSU- EBP2.0g PEK- SO$_3$Li0.6g 1,4-	64	1.03	1.09	6.87
2(wz051)	0.77g PSU- Pe2.0g PEK- SO$_3$Li0.48g 1,4-	87	0.81	0.88	3.62
3(wz40)	3g PEK- SO$_3$Li0.3g PSUSO$_2$Li0.3g PSU- DPK0.205ml 1,4-	113	1.43	1.4	13.4
4(wz40R)	1g PEK- SO$_3$Li0.3g PSUSO$_2$Li0.3g PSU- DPK0.205ml 1,4-	52	0.86	0.89	35.96
1(wz43)	3g PEK- SO$_3$Li0.3g PSU- DPK	126	1.52	1.52	7.8
2(wz43R)	1g PEK- SO$_3$Li0.5g PSU- DPK	56	0.92	0.79	24.5
3	PEK- SO$_3$H	82	1.63	1.8	7.13

IEC^{exp} :

R^{sp} :

[3]

	(%)			
	25	40	60	90
1(wz054)	40.79	46.05	46.05	59.21
2(wz051)	38.46	44.61	44.61	61.54
3(wz40)	42	42.48	58.41	151.33
4(wz40R)	22.9	27.1	29.2	35.9
1(wz43)	95.9	110.4	161.09	224.43
2(wz43R)	29	33.77	34.2	48.05
3PEK- SO$_3$H	107.32	122	129.27	139.02

, 25 100 , , ,
, , , ,
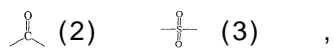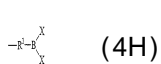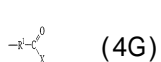(swelling property) , ,
.

(57)

　　　1.

- Q- R (1)

　　　　　,

Q 　　　　, 　, ,

 (2) 　　 (3) 　,

　　　R 　　　　　　　　　　2 　　　, 　　　　　　　　　　　　　,

a) 　　　　R 　　　　　　(4A), (4B), (4C), (4D), (4E), (4F), (4G) 　/ 　(4H)

 (4A)

 (4B)

 (4C)

 (4D)

 (4E)

 (4F)

 (4G)

 (4H)

,

R^1 1   40   ,

,

M   ,   ,   Li$^+$, Na$^+$, K$^+$, Rb$^+$, Cs$^+$,   ,

X   ,

b)   R   (5A)   /   (5B)   ,

$-R^2-\overset{R^6}{\underset{R^4}{\vee}}$ (5A)

$-R^2-\overset{R^3}{\underset{R^5}{N}}-R^4$ (5B)

R^2, R^3, R^4 R^5 1   40   ,
,   R^2, R^3,   R^4
/   R   (5C)   /   (5D)
,

$-R^2-\overset{R^3-}{\underset{R^4}{N}}$ (5C)

$-R^2-\overset{R^3}{\underset{R^5}{N}}-R^4$ (5D)

c)   R   (6)   (bridge)   ,

$-R^1-\overset{O}{\underset{O}{S}}-YZ_{m-2}-\overset{O}{\underset{O}{S}}-R^1-$ (6)

R   ,

Y   1   40   ,

,

Z

$-\overset{O}{\underset{O}{S}}-R^1-$ (7)
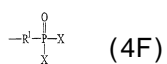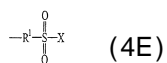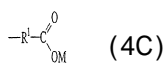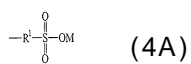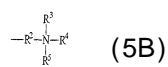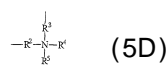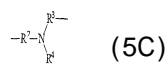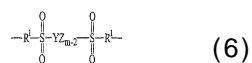
,   H, C, O, N, S, P,   , 20 g/   ,

m 2   ,

                    .

      2.

  1   ,   (1)   (1A), (1B), (1C), (1D), (1E), (1F), (1G), (1H),
(1I), (1J), (1K), (1L), (1M), (1N), (1O), (1P), (1Q), (1R), (1S)   /   (1T)   ,

- O- R^6- (1A)

- S- R^6- (1B)

- O- R^6- SO$_2$- R^6- (1C)

- O- R^6- SO$_2$- R^6- O- R^6- (1D)

- O- R^6- SO$_2$- R^6- O- R^6- R^6- (1E)

$$-O-R^6SO_2-R^6-O-R^6-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-R^6-\quad (1F)$$

- O- R^6- SO$_2$- R^6- R^6- SO$_2$- R^6 (1G)

- O- R^6- SO$_2$- R^6- R^6- SO$_2$- R^6- O- R^6- SO$_2$- R^6- (1H)

$$\left(O-R^6SO_2-R^6\right)_x\left(SO_2-R^6-R^6\right)_y \quad (1I)$$

$0 < x, y < 100\%$

- O- R^6- CO- R^6- (1J)

- O- R^6- CO- R^6- CO- R^6- (1K)

- O- R^6- CO- R^6- O- R^6- CO- R^6- CO- R^6 (1L)

- O- R^6- O- R^6- CO- R^6- (1M)

- O- R^6- O- R^6- CO- R^6- CO- R^6- (1N)

$$\left(R-NH-R-NH\right)_y\left(R-N=\bigcirc=N\right)_{100\%-y} \quad (1O)$$

$0 < y < 100\%$

- R^6 - （1P)

- R^6 - CH= CH- （1Q)

- CHR^7 - CH$_2$ - （1R)

    （1S)

    (1T)

R^6 1,2-   , 1,3-   , 1,4-   , 4,4'-   ,
          2   , C$_{10}$ 2   , C$_{14}$ 2   /   2   (pyrene)

,

R^7, R^8,   R^9 1 , 2   3   ,

U   ,   , 1   2
0   ,   ,
          ,

                    .

3.

1   2   ,   ,   .

4.

1   3   ,   25   100
          ,   .

5.

1   4   ,   90   100%
          ,   .

6.

1   5   ,   0.5 meq/g   1.
9 meq/g   ,   .

7.

1   6   ,

a), b)   d)   (7)
          ,

a)   b)   1   ,

d)   (6)   ,

$-\overset{O}{\underset{}{N}}-\overset{}{\underset{}{S}}-OM$ (6)

YLm (7)

L   , n   2   ,   .

8.

7   ,

1)   a)   ,

2)   b)   ,

3)   d)   ,   .

9.

7   ,

1)   a)   b)   ,

2)   d)   ,   .

10.

7   ,

1)   a)   d)   ,

2)   b)   ,   .

11.

7   ,

1)   a)   ,

2)   b)   d)   ,   .

12.

7   ,   a), b)   d)   ,
          .

13.

7   12   ,

,   ,   N,N-   , N,N-
, N-   ,   (sulfolane)   ,
,   .

14.

13   ,

a)   (substrate)   ,

b)   , 25   /   1000 mbar
,   .

15.

7   14   ,

a)   1   ,

b)   ,

1   ,   .

16.

7   15   ,

,   ,   .

17.

1   6   ,

,   2   ,   ,   ,
,   .

18.

1   6   ,

,   ,   (pervaporation),   (, perstraction),   ,
(nanofiltration),   (electrodialysis)   (diffusion dialysis)   ,
.