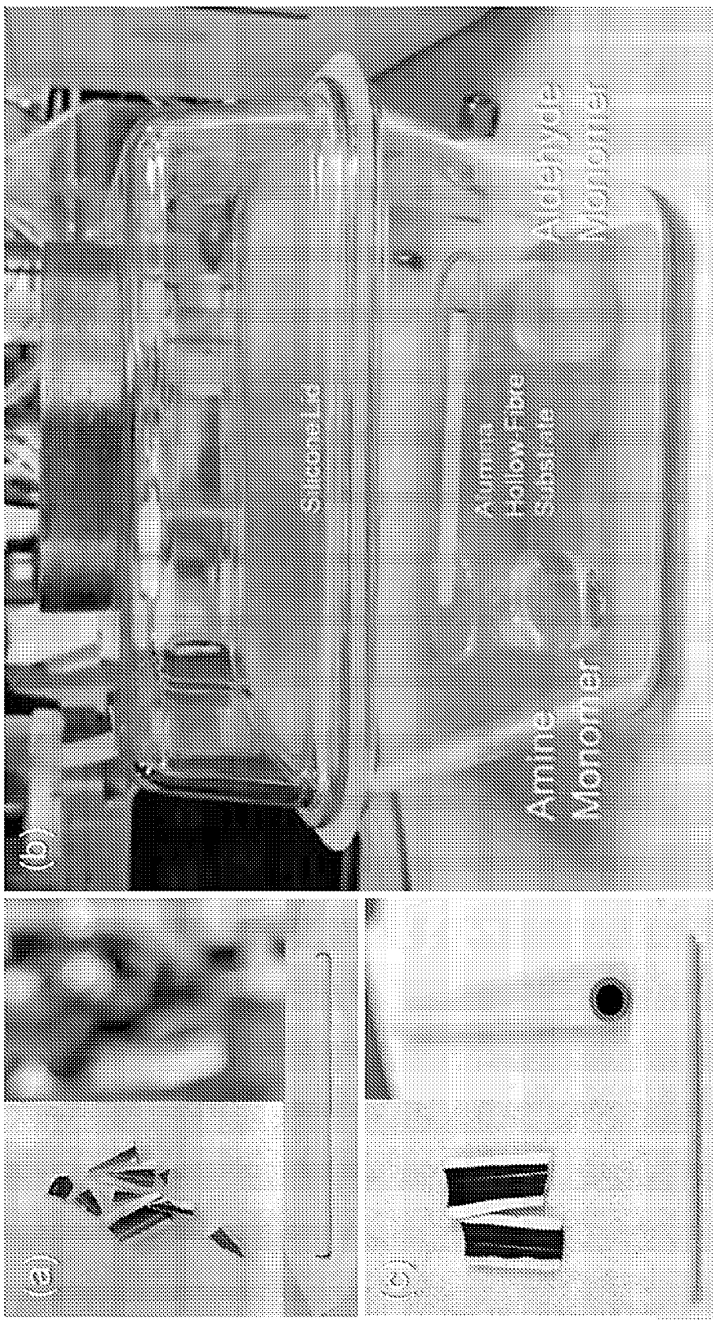

Silicon Lid
Anode
Hollow Fiber
Substrate
Aldehyde
Monomer
Amine
Monomer

FIG. 1

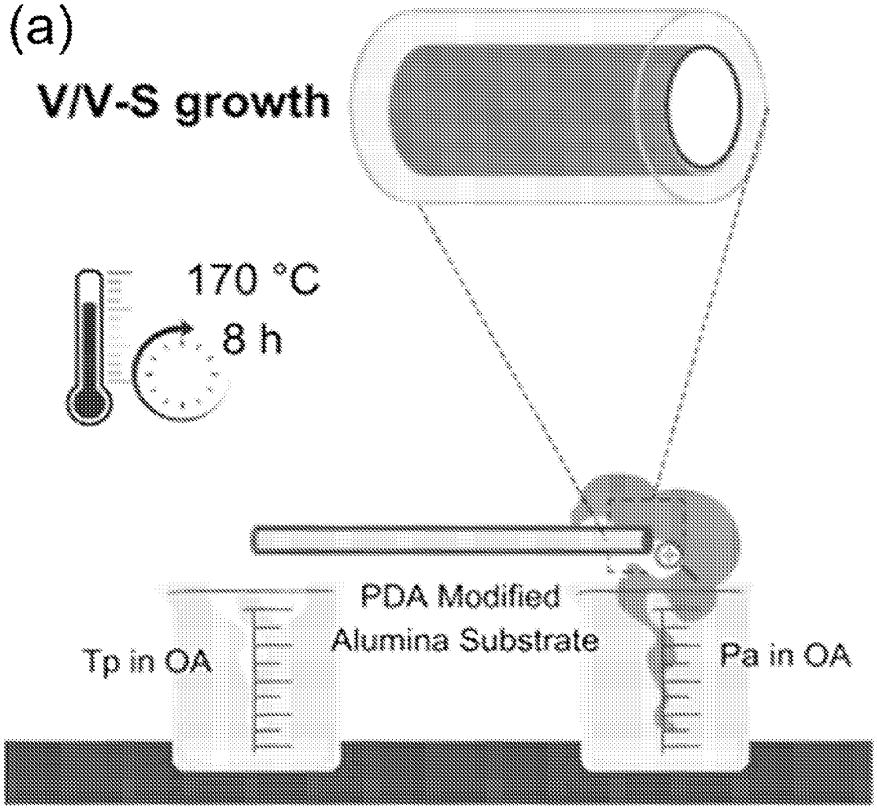

(a)
V/V-S growth
170 °C
8 h
PDA Modified
Alumina Substrate
Tp in OA
Pa in OA

FIG. 2a

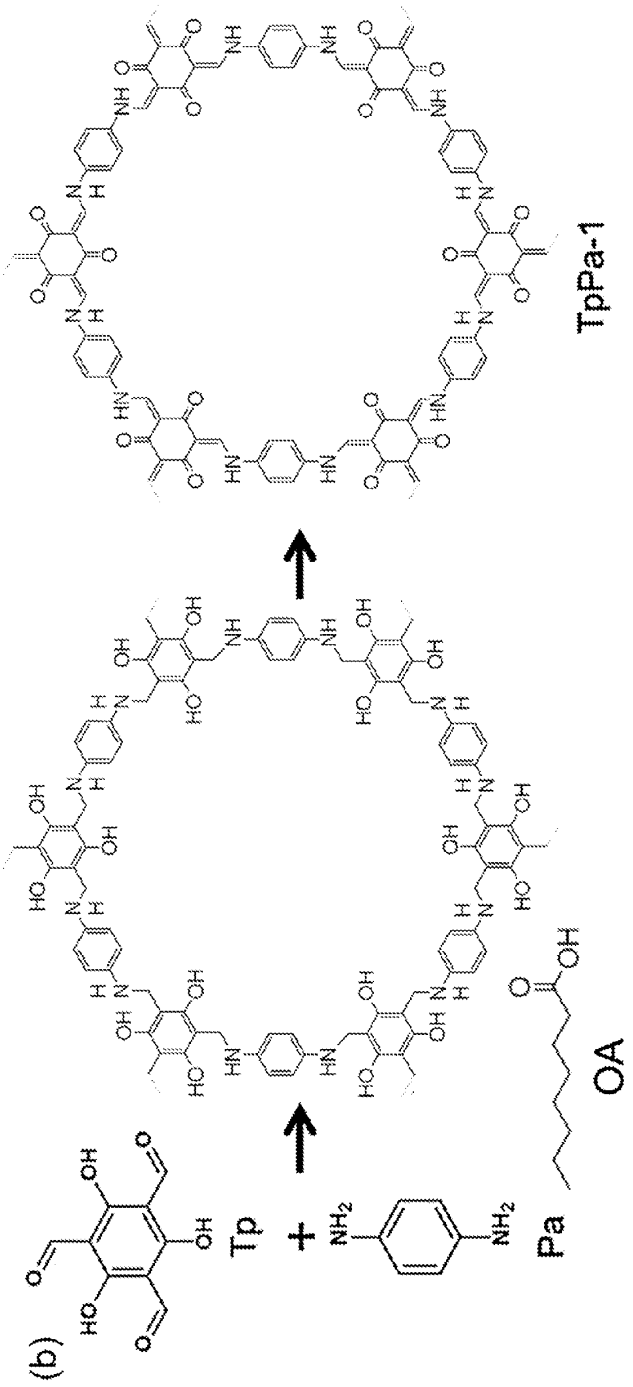


FIG. 2b

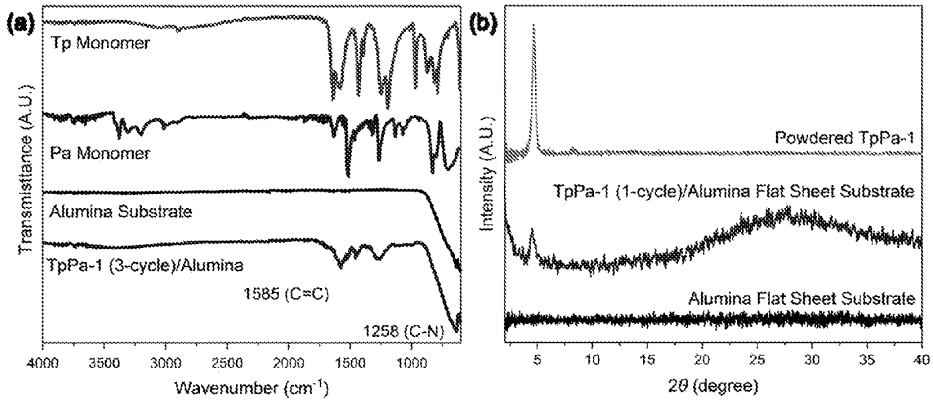

(a)
Tp Monomer
Pa Monomer
Alumina Substrate
TpPa-1 (3-cycle)/Alumina
1585 (C=C)
1258 (C-N)
Transmittance (A.U.)
4000 3500 3000 2500 2000 1500 1000
Wavenumber (cm-1)
(b)
Powdered TpPa-1
TpPa-1 (1-cycle)/Alumina Flat Sheet Substrate
Alumina Flat Sheet Substrate
Intensity (A.U.)
5 10 15 20 25 30 35 40
2θ (degree)

FIG. 3

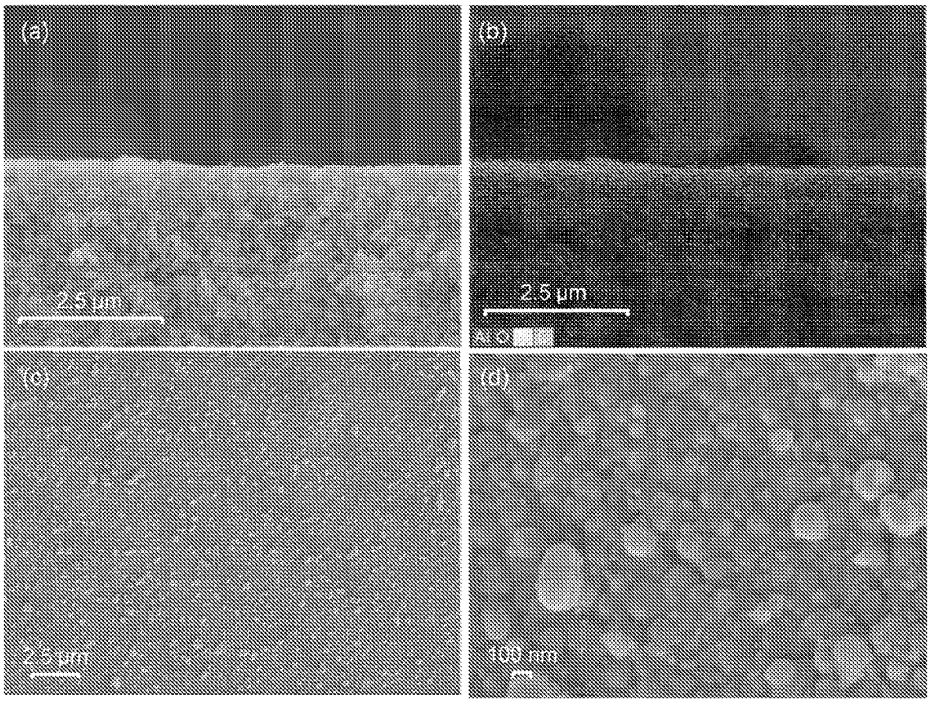

(a)
2.5 μm
(b)
2.5 μm
Al
C
(c)
2.5 μm
(d)
100 nm

FIG. 4

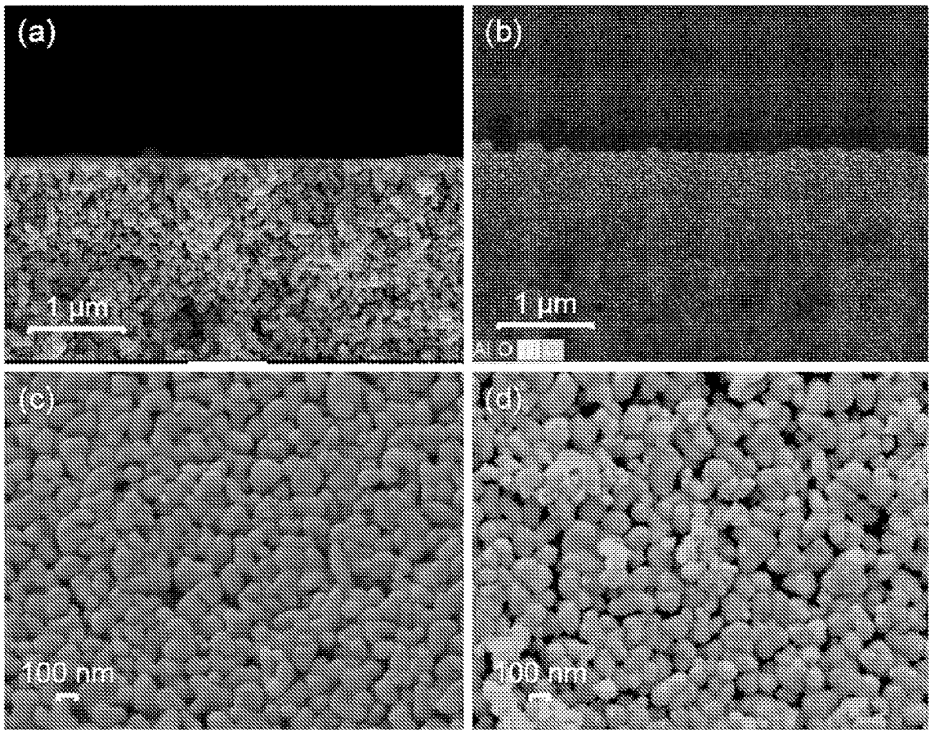


FIG. 5

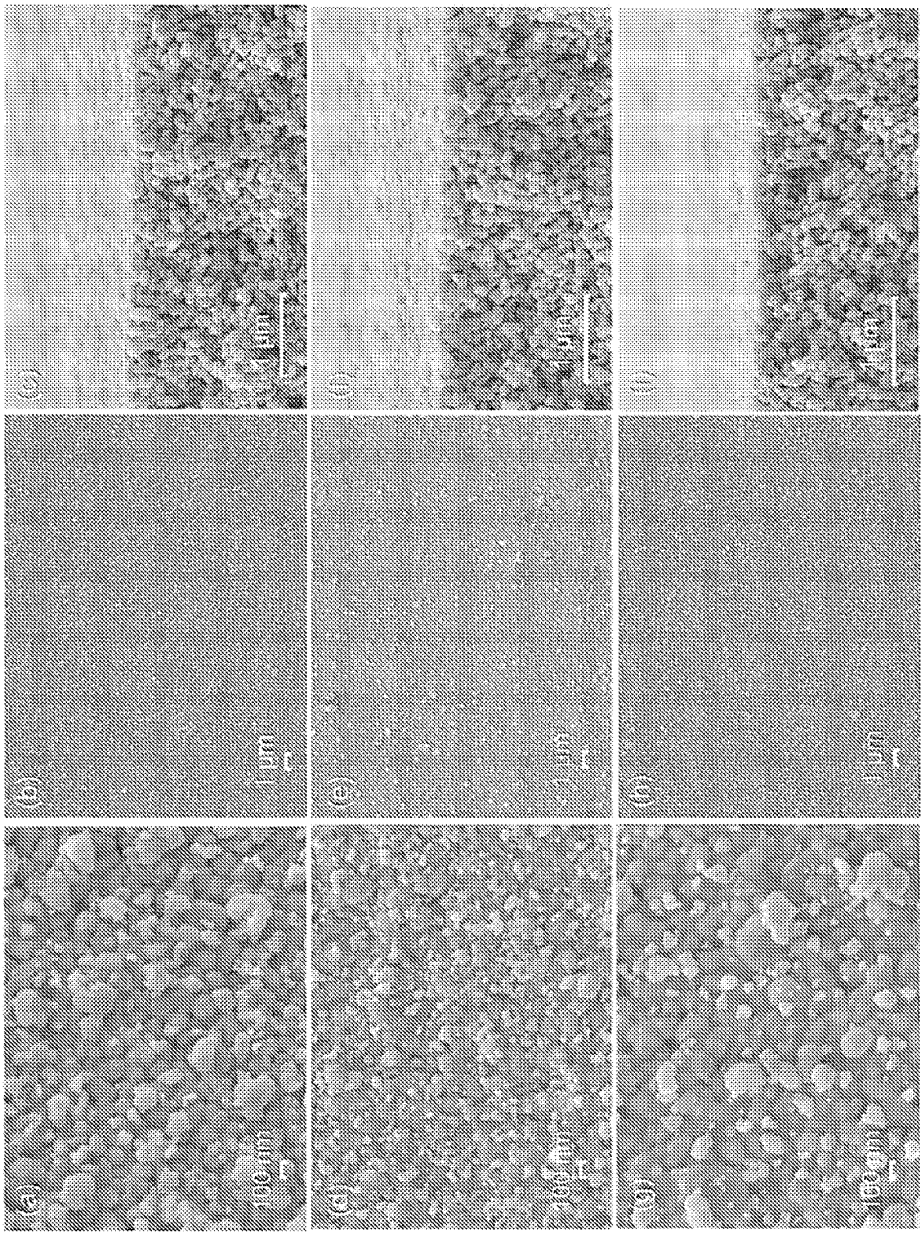

(a)
100 μm
(b)
100 μm
(c)
100 μm
(d)
100 μm
(e)
100 μm
(f)
100 μm
(g)
100 μm
(h)
100 μm
(i)
100 μm

FIG. 6

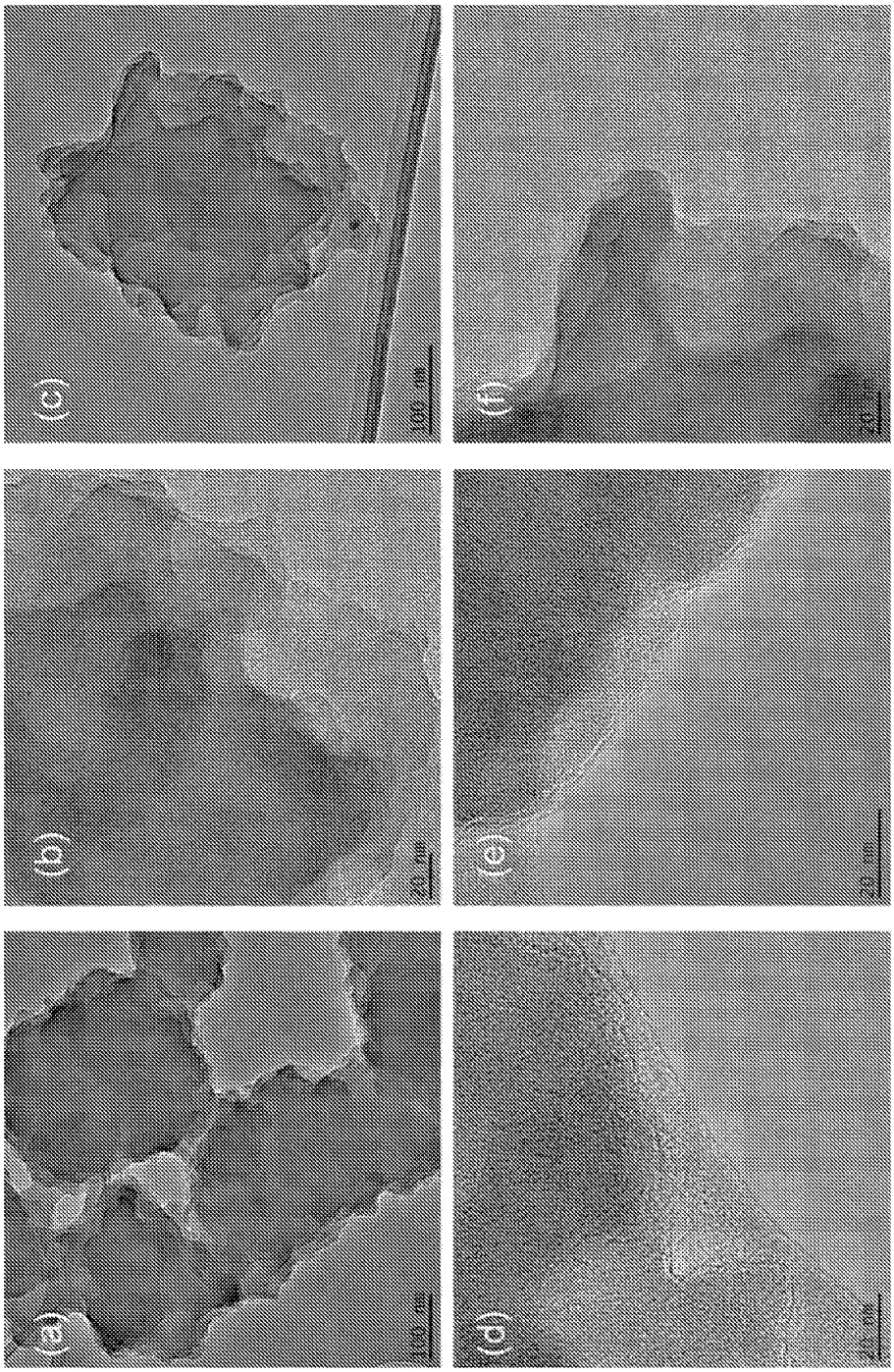


FIG. 7

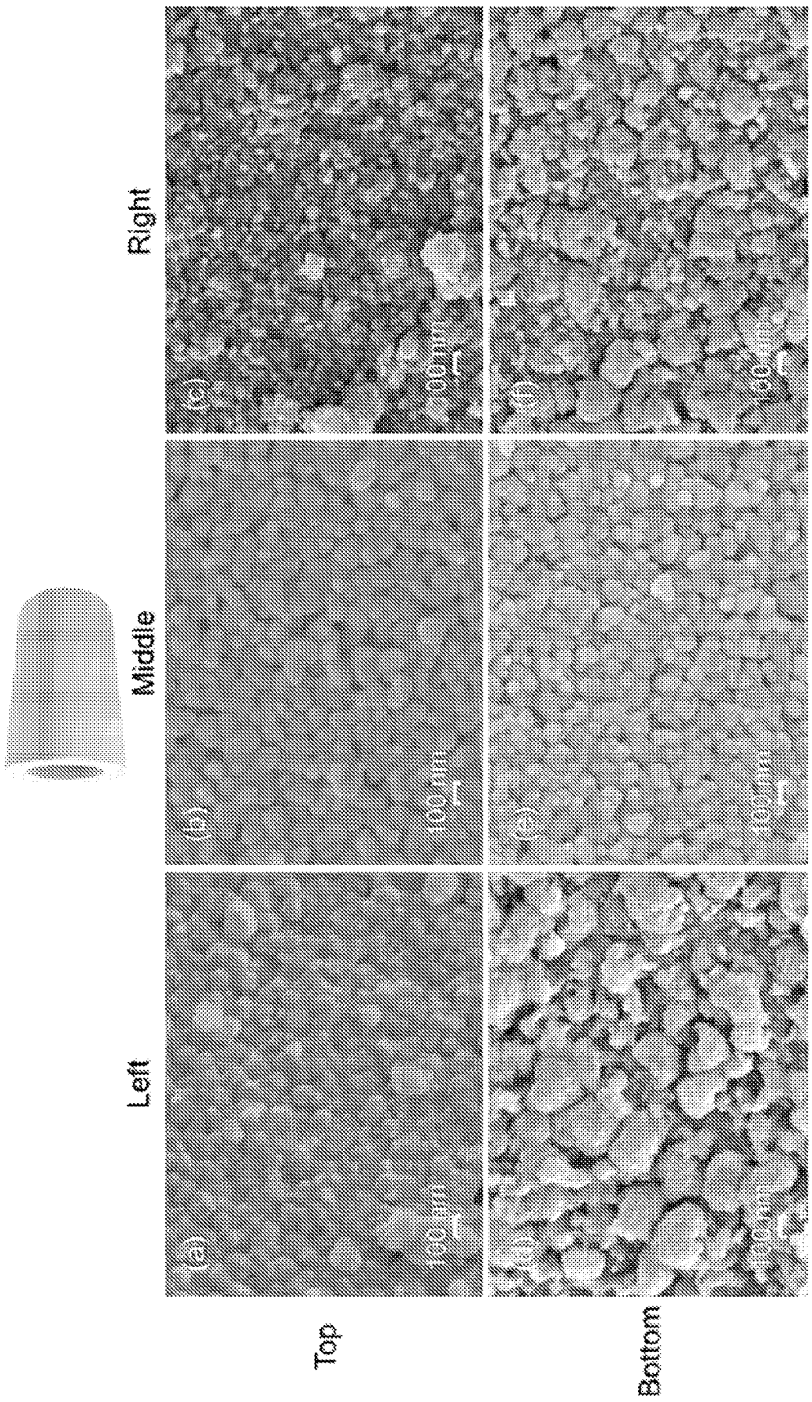


FIG. 8

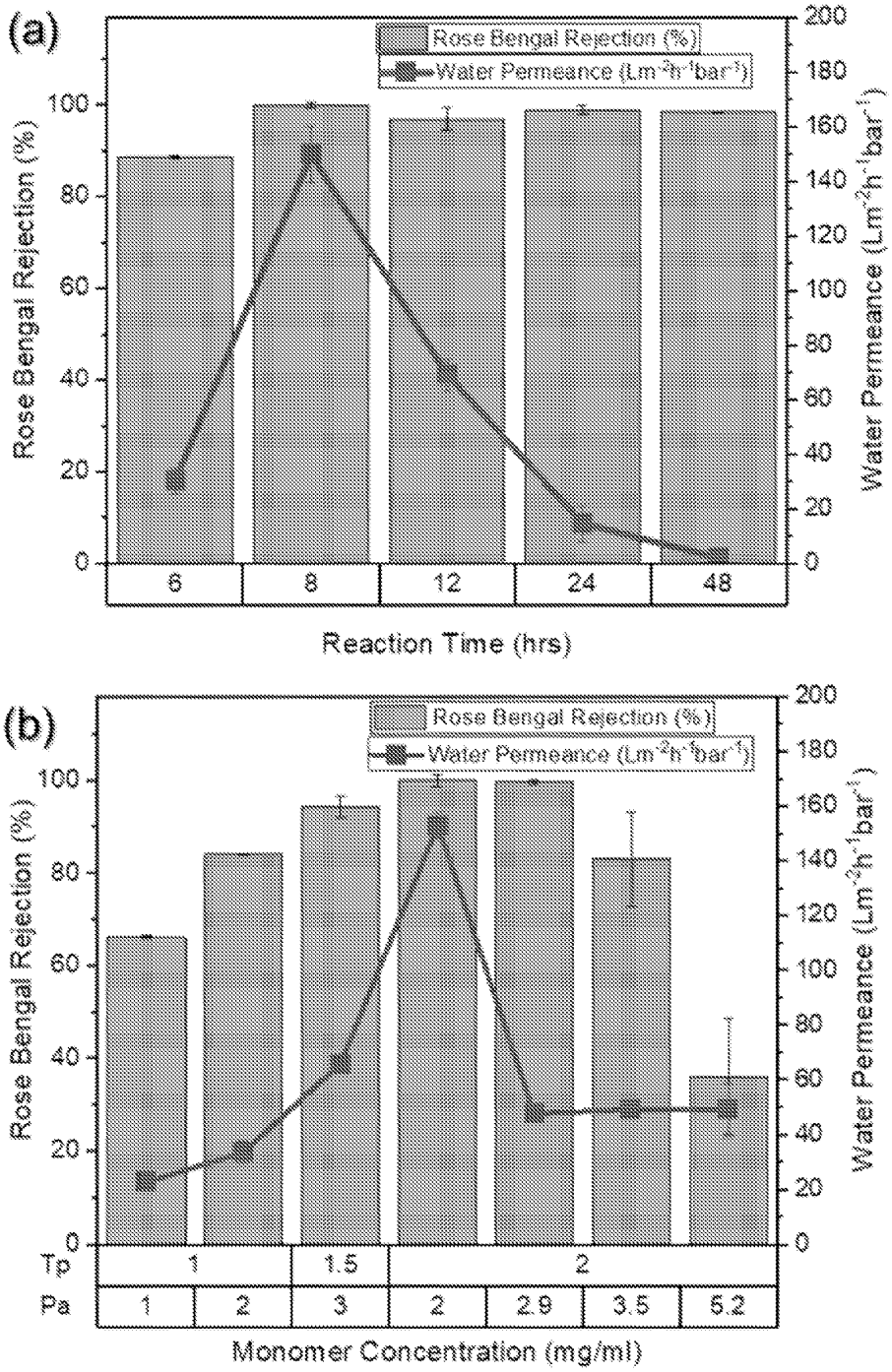

(a)
Rose Bengal Rejection (%)
Water Permeance (Lm-2h-1bar-1)
Rose Bengal Rejection (%)
Water Permeance (Lm-2h-1bar-1)
0
20
40
60
80
100
0
20
40
60
80
100
120
140
160
180
200
6
8
12
24
48
Reaction Time (hrs)
(b)
Rose Bengal Rejection (%)
Water Permeance (Lm-2h-1bar-1)
Rose Bengal Rejection (%)
Water Permeance (Lm-2h-1bar-1)
0
20
40
60
80
100
0
20
40
60
80
100
120
140
160
180
200
Tp
1
1.5
2
Pa
1
2
3
2
2.9
3.5
5.2
Monomer Concentration (mg/ml)

FIG. 9

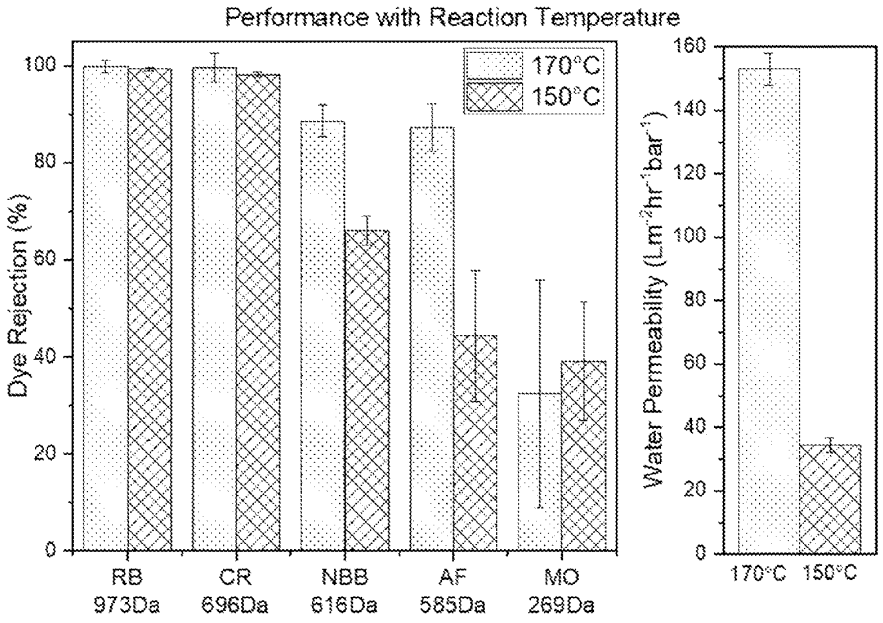

Performance with Reaction Temperature
Dye Rejection (%)
170°C
150°C
RB
973Da
CR
696Da
NBB
616Da
AF
585Da
MO
269Da
Water Permeability (Lm-2hr-1bar-1)
170°C
150°C

FIG. 10

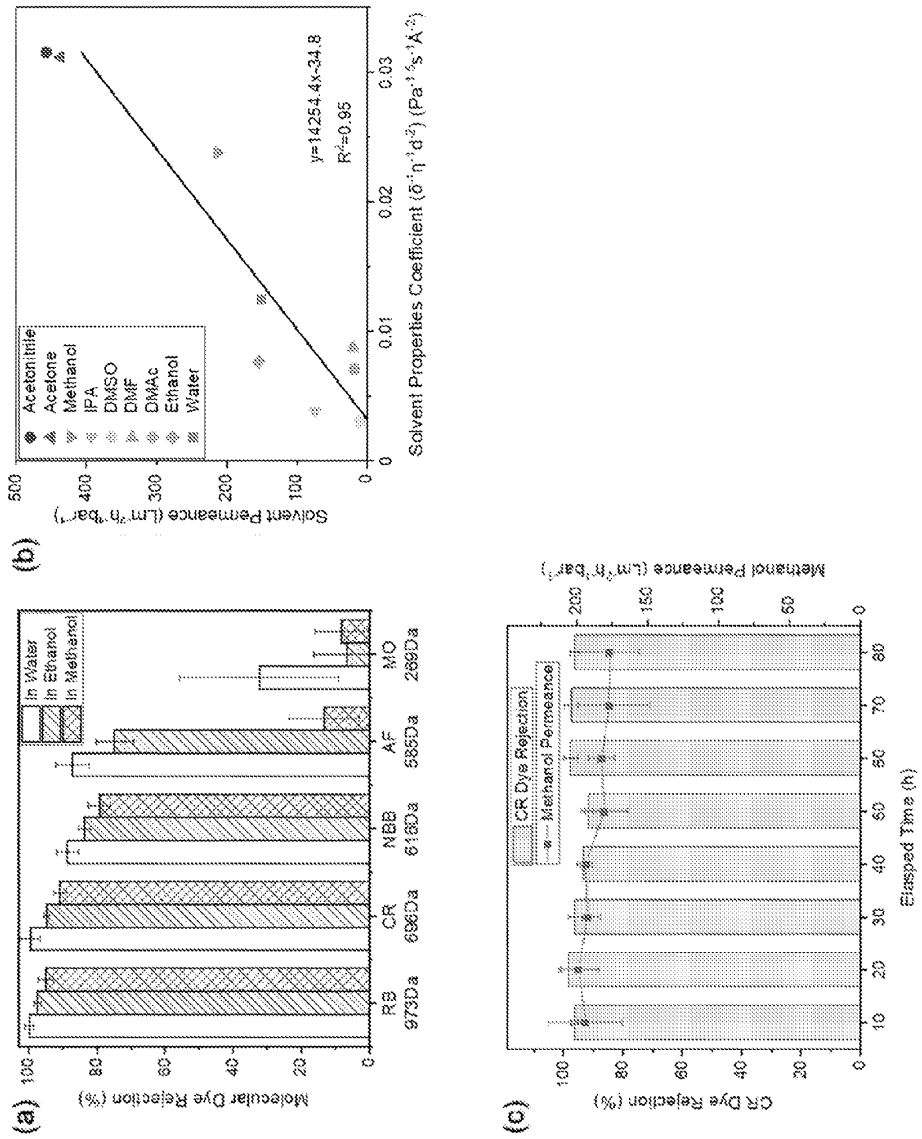

(a)
Molecular Dye Rejection (%)
In Water
In Ethanol
In Methanol
RB
979Da
CR
696Da
NBB
618Da
AF
585Da
MO
269Da
(b)
Solvent Permeance (Lm⁻²h⁻¹bar⁻¹)
Solvent Properties Coefficient (δ⁻¹η⁻¹d⁻²) (Pa⁻¹s⁻¹Å⁻²)
y=14254.4x-34.8
R²=0.95
Acetonitrile
Acetone
Methanol
IPA
DMSO
DMF
DMAc
Ethanol
Water
(c)
CR Dye Rejection (%)
Methanol Permeance (Lm⁻²h⁻¹bar⁻¹)
Elasped Time (h)
CR Dye Rejection
Methanol Permeance

FIG. 11

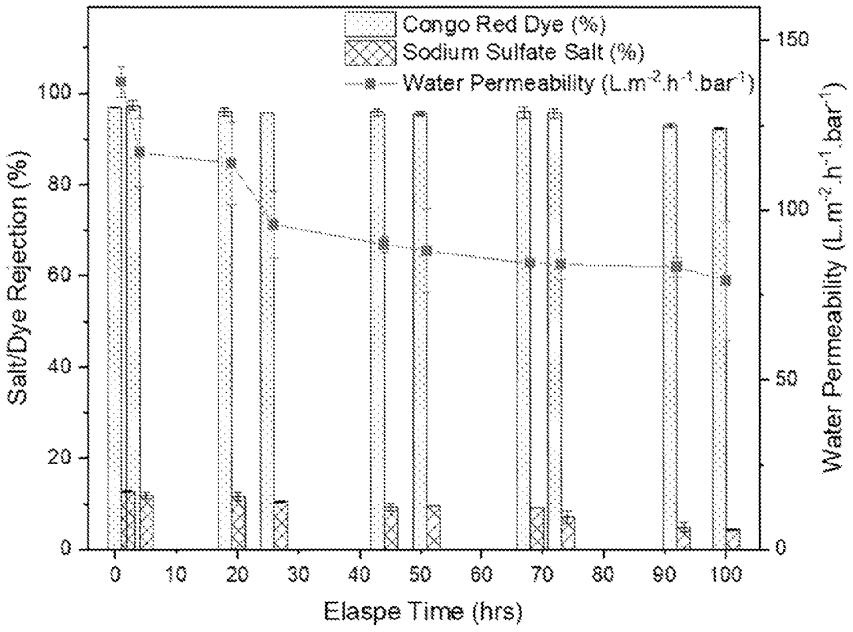

Congo Red Dye (%)
Sodium Sulfate Salt (%)
Water Permeability (L.m-2.h-1.bar-1)
Salt/Dye Rejection (%)
Water Permeability (L.m-2.h-1.bar-1)
Elaspe Time (hrs)
0
20
40
60
80
100
0
50
100
150
0
10
20
30
40
50
60
70
80
90
100

FIG. 12

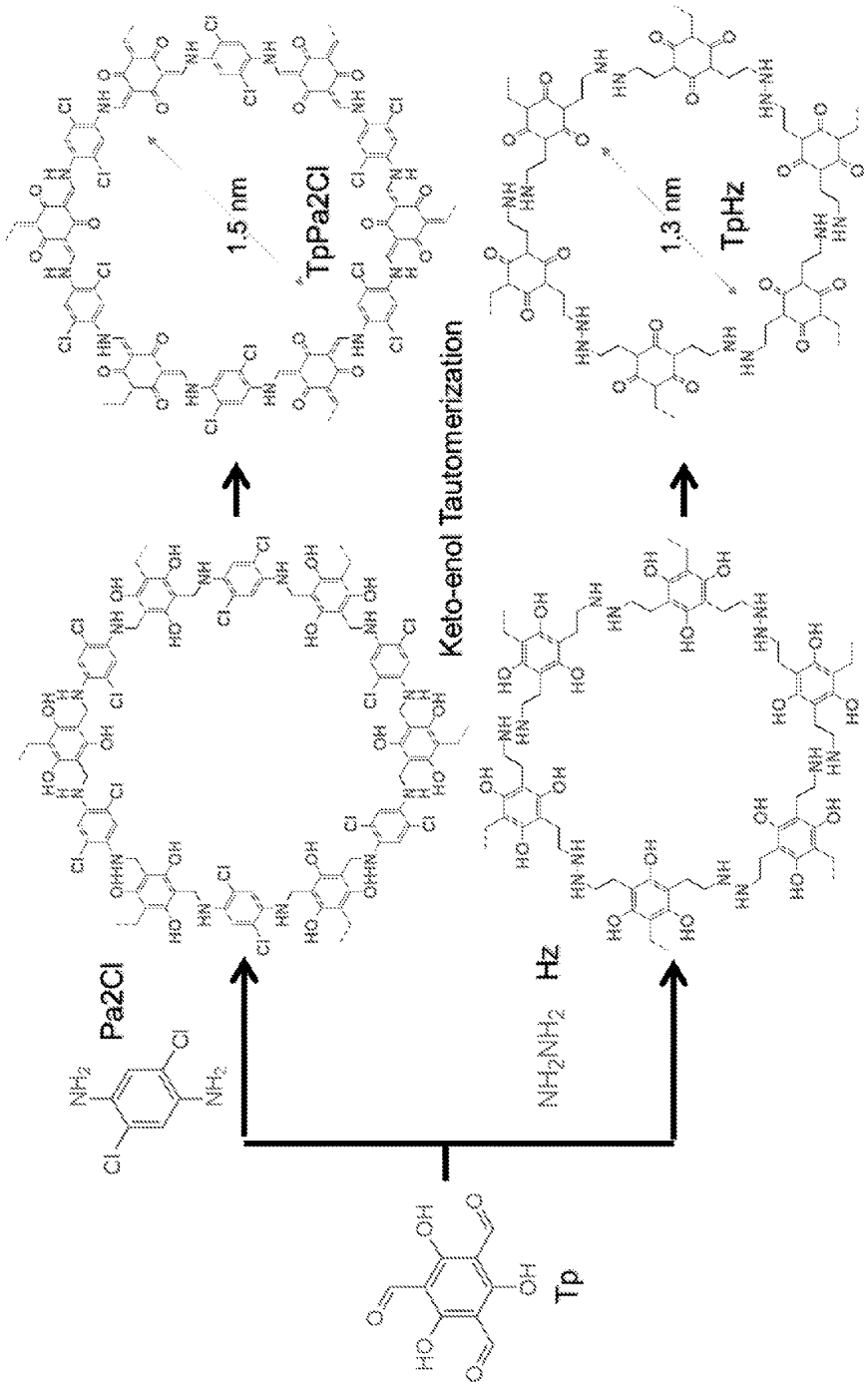

1.5 nm
TpPa2Cl
1.3 nm
TpHz
Keto-enol Tautomerization
Pa2Cl
Hz
NH_2NH_2
Tp

FIG. 13

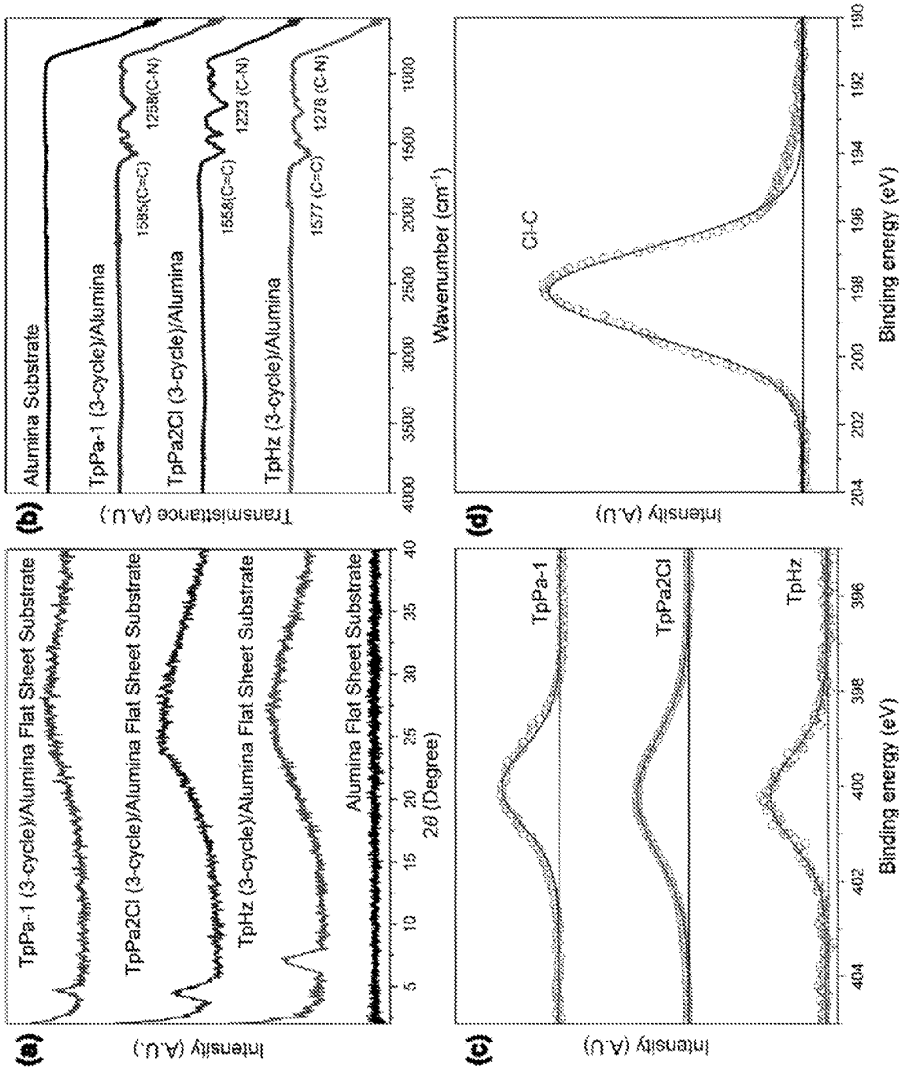

(a)
TpPa-1 (3-cycle)/Alumina Flat Sheet Substrate
TpPa2Cl (3-cycle)/Alumina Flat Sheet Substrate
TpHz (3-cycle)/Alumina Flat Sheet Substrate
Alumina Flat Sheet Substrate
Intensity (A.U.)
2θ (Degree)
(b)
Alumina Substrate
TpPa-1 (3-cycle)/Alumina
TpPa2Cl (3-cycle)/Alumina
TpHz (3-cycle)/Alumina
1585(C=C)
1258(C-N)
1554(C=C)
1223 (C-N)
1577 (C=C)
1278 (C-N)
Transmistance (A.U.)
Wavenumber (cm-1)
(c)
TpPa-1
TpPa2Cl
TpHz
Intensity (A.U)
Binding energy (eV)
(d)
C1-C
Intensity (A.U)
Binding energy (eV)

FIG. 14

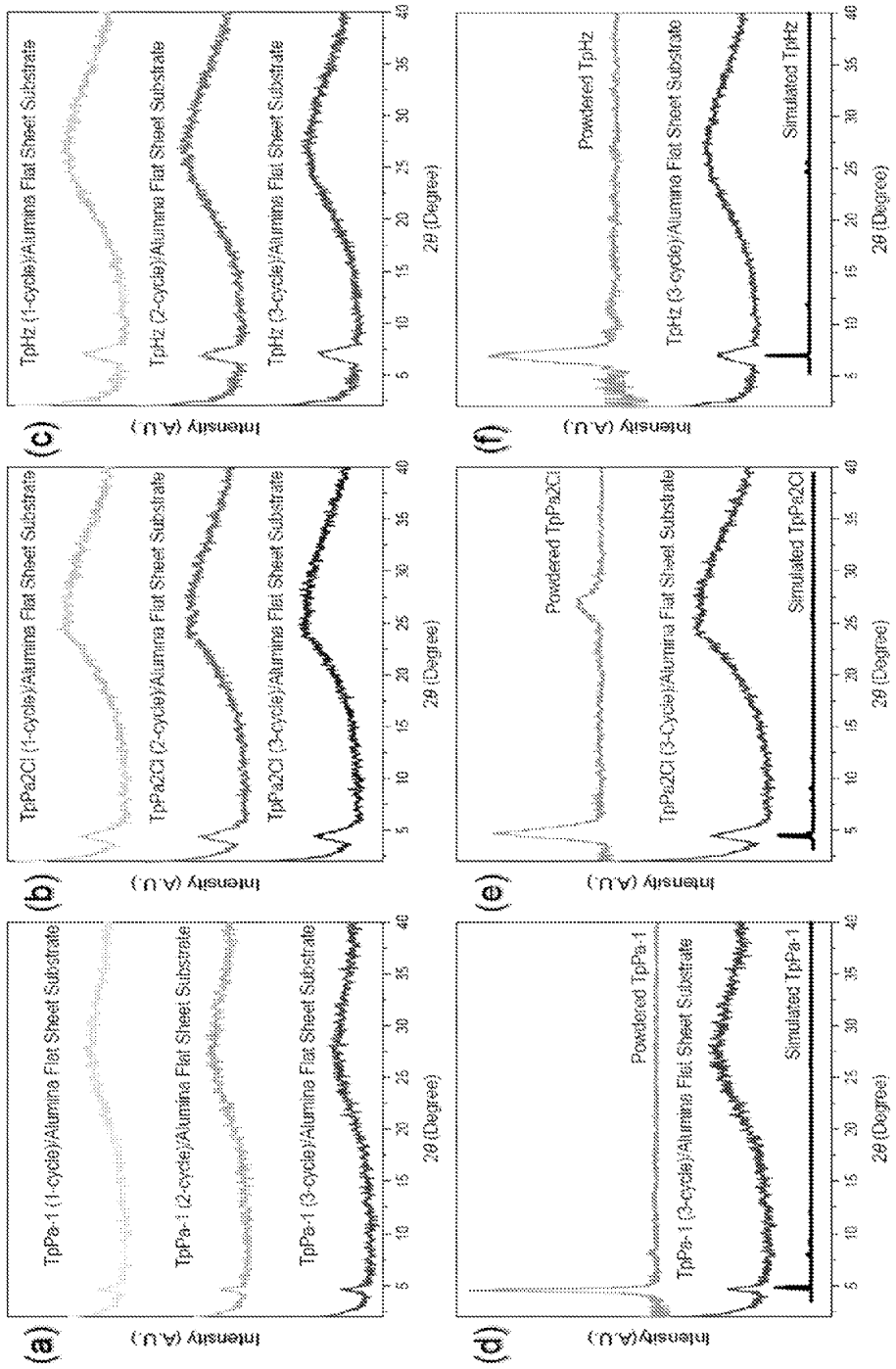

(a)
TpPa-1 (1-cycle)/Alumina Flat Sheet Substrate
TpPa-1 (2-cycle)/Alumina Flat Sheet Substrate
TpPa-1 (3-cycle)/Alumina Flat Sheet Substrate
Intensity (A.U.)
2θ (Degree)
(b)
TpPa2Cl (1-cycle)/Alumina Flat Sheet Substrate
TpPa2Cl (2-cycle)/Alumina Flat Sheet Substrate
TpPa2Cl (3-cycle)/Alumina Flat Sheet Substrate
Intensity (A.U.)
2θ (Degree)
(c)
TpHz (1-cycle)/Alumina Flat Sheet Substrate
TpHz (2-cycle)/Alumina Flat Sheet Substrate
TpHz (3-cycle)/Alumina Flat Sheet Substrate
Intensity (A.U.)
2θ (Degree)
(d)
Powdered TpPa-1
TpPa-1 (3-cycle)/Alumina Flat Sheet Substrate
Simulated TpPa-1
Intensity(A.U.)
2θ (Degree)
(e)
Powdered TpPa2Cl
TpPa2Cl (3-Cycle)/Alumina Flat Sheet Substrate
Simulated TpPa2Cl
Intensity (A.U.)
2θ (Degree)
(f)
Powdered TpHz
TpHz (3-cycle)/Alumina Flat Sheet Substrate
Simulated TpHz
Intensity (A.U.)
2θ (Degree)

FIG. 15

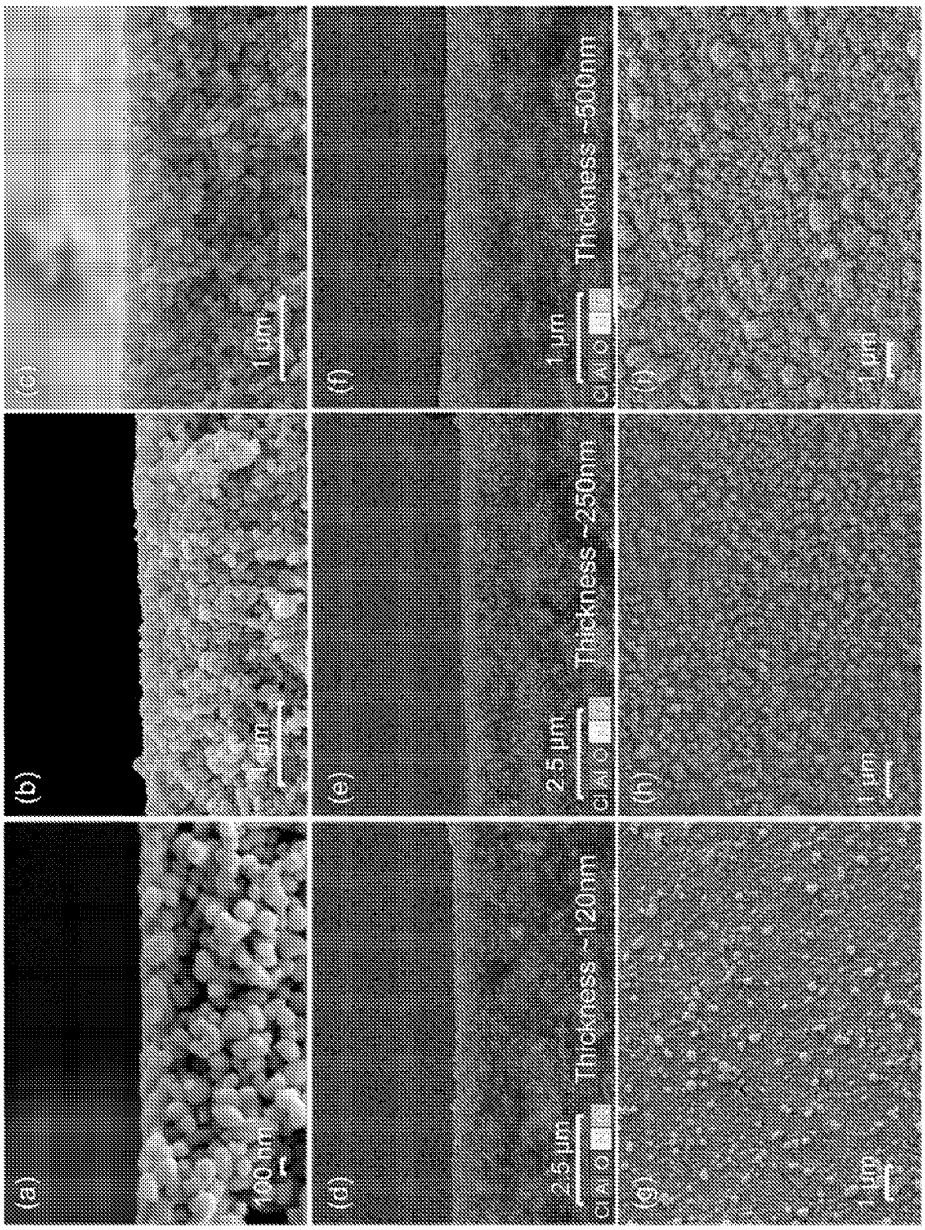

(a)
100 nm
(b)
1 µm
(c)
1 µm
(d)
2.5 µm
CMO
Thickness ~120nm
(e)
2.5 µm
CMO
Thickness ~250nm
(f)
1 µm
CMO
Thickness ~500nm
(g)
1 µm
(h)
1 µm
(i)
1 µm

FIG. 16

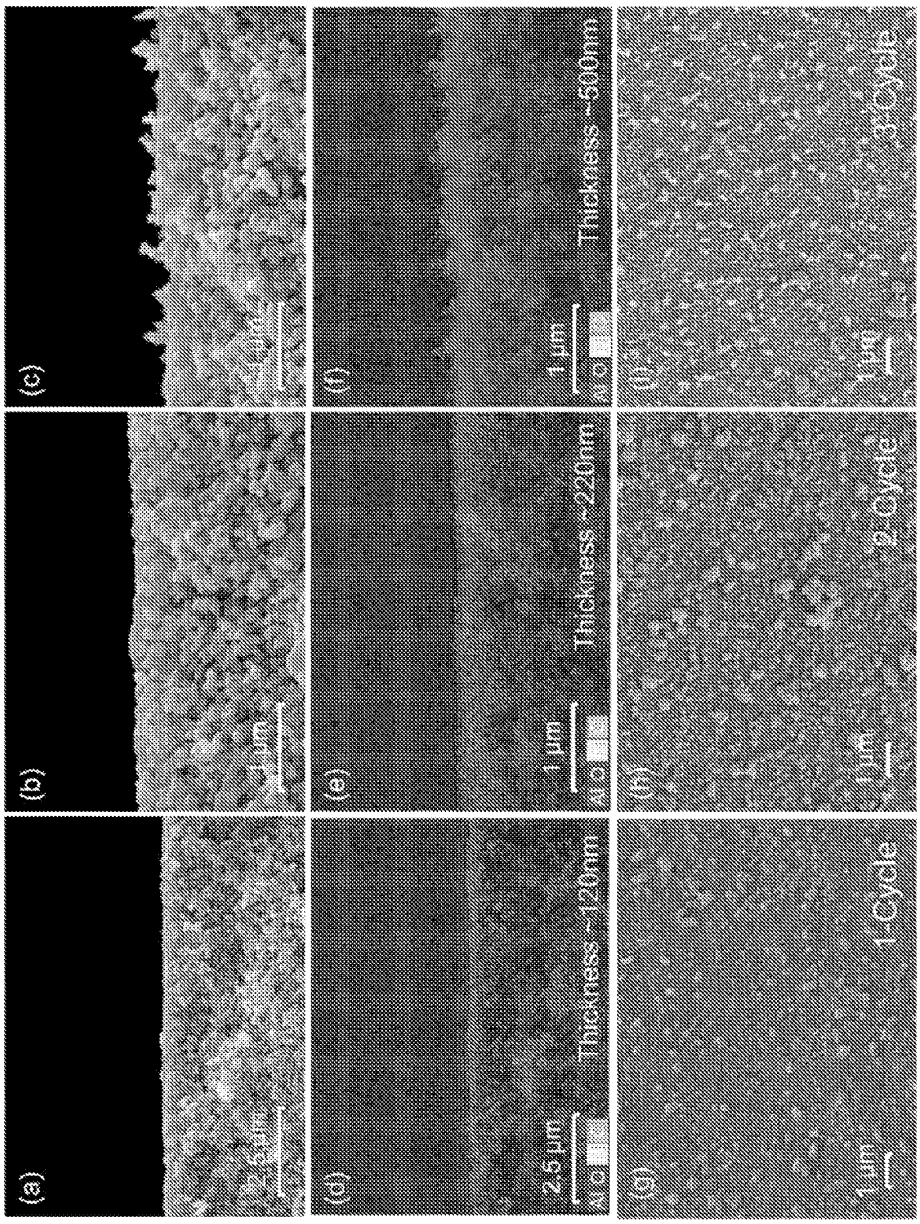

(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
Thickness ~120nm
Thickness ~220nm
Thickness ~680nm
Al
O
1-Cycle
2-Cycle
3-Cycle
2.5 μm
1 μm
1 μm
1 μm
1 μm
1 μm
1 μm
1 μm
1 μm

FIG. 17

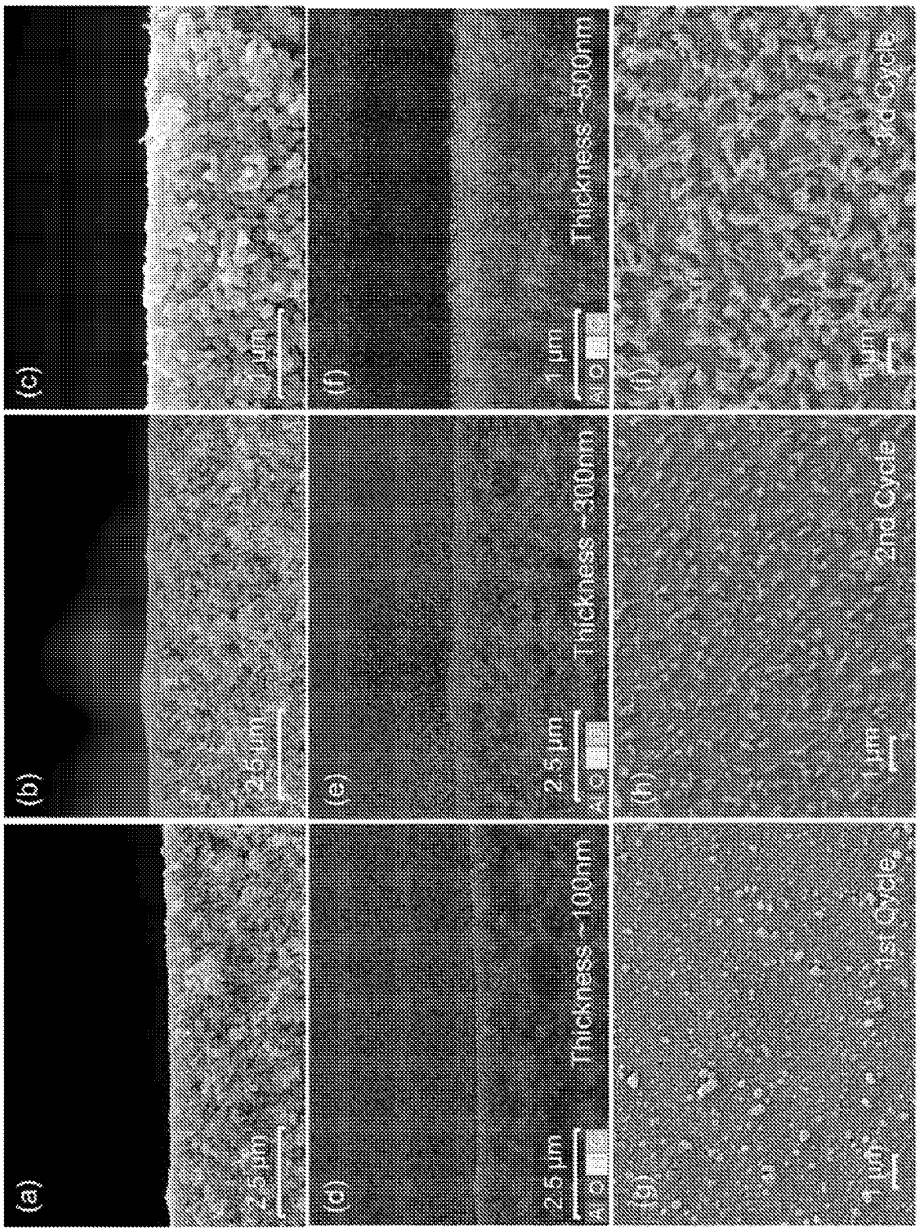

(a)
2.5 μm
(b)
2.5 μm
(c)
1 μm
(d)
Thickness ~100nm
2.5 μm
(e)
Thickness ~300nm
2.5 μm
(f)
Thickness ~500nm
1 μm
(g)
1st Cycle
1 μm
(h)
2nd Cycle
1 μm
(i)
3rd Cycle
1 μm

FIG. 18

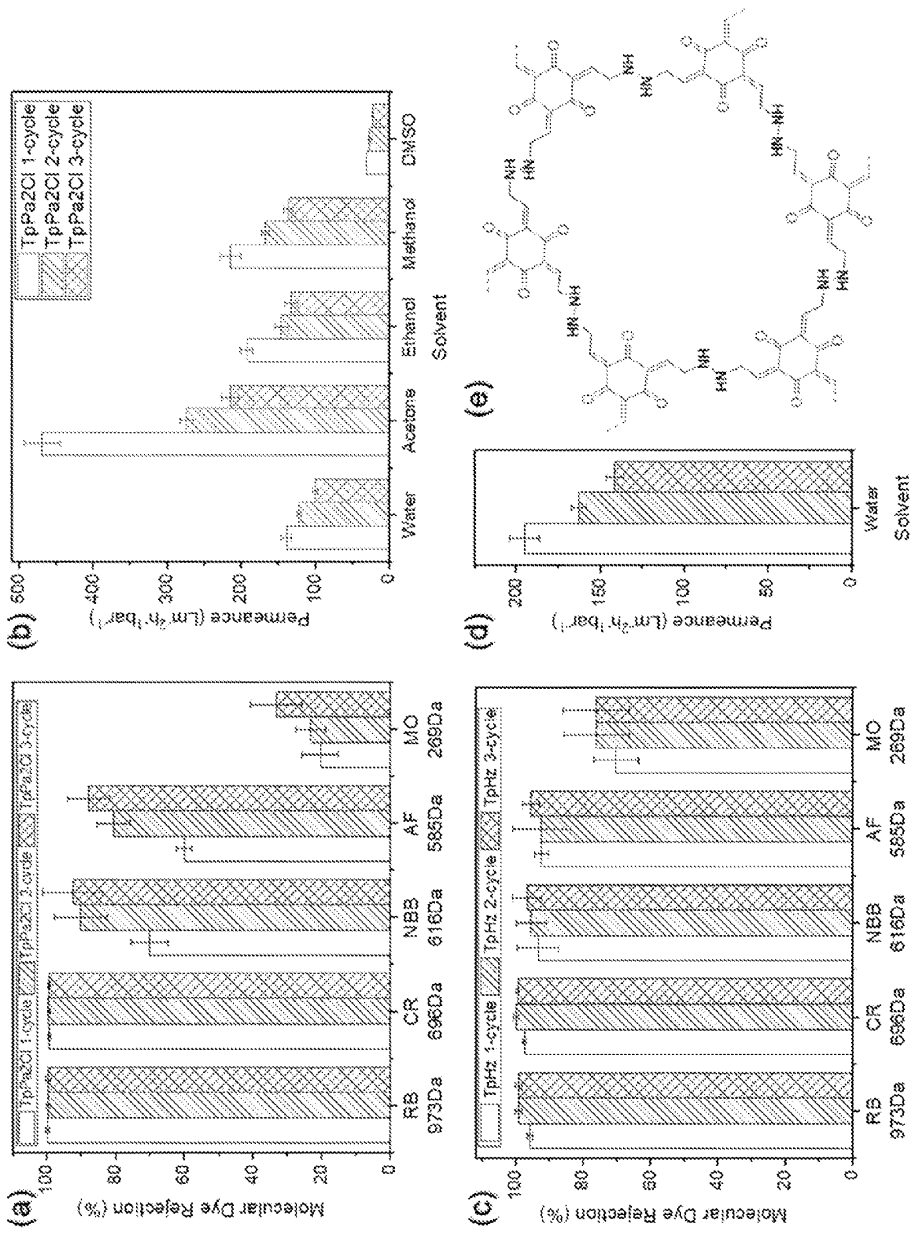

(a)
Molecular Dye Rejection (%)
TpPa2Cl 1-cycle
TpPa2Cl 2-cycle
TpPa2Cl 3-cycle
RB 973Da
CR 696Da
NBB 616Da
AF 585Da
MO 269Da
(b)
Permeance (L.m⁻².h⁻¹.bar⁻¹)
Water
Acetone
Ethanol
Methanol
DMSO
Solvent
(c)
Molecular Dye Rejection (%)
TpHz 1-cycle
TpHz 2-cycle
TpHz 3-cycle
RB 973Da
CR 696Da
NBB 616Da
AF 585Da
MO 269Da
(d)
Permeance (L.m⁻².h⁻¹.bar⁻¹)
Water
Solvent
(e)

FIG. 19

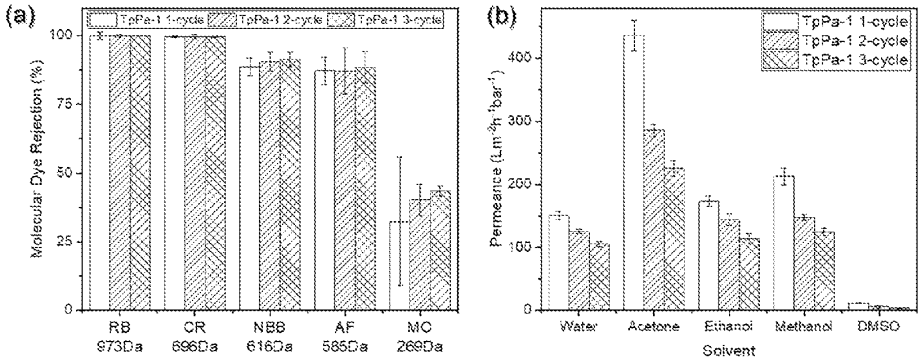
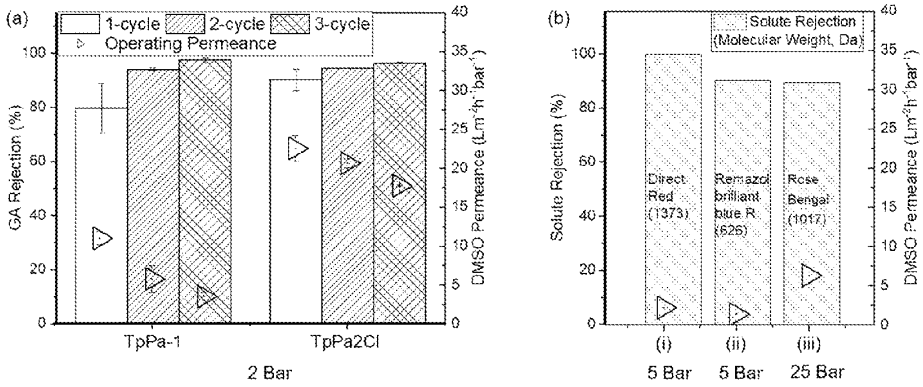


FIG. 20



(i) J. Aburabie *et al.*, *React. Funct. Polym.* **2015**, *86*, 225–232
(ii) D. Y. Xing *et al.*, *Green Chem.* **2014**, *16*, 1383–1392
(iii) Y. Li *et al.*, *Ind. Eng. Chem. Res.* **2019**, *58*, 6712–6720

FIG. 21

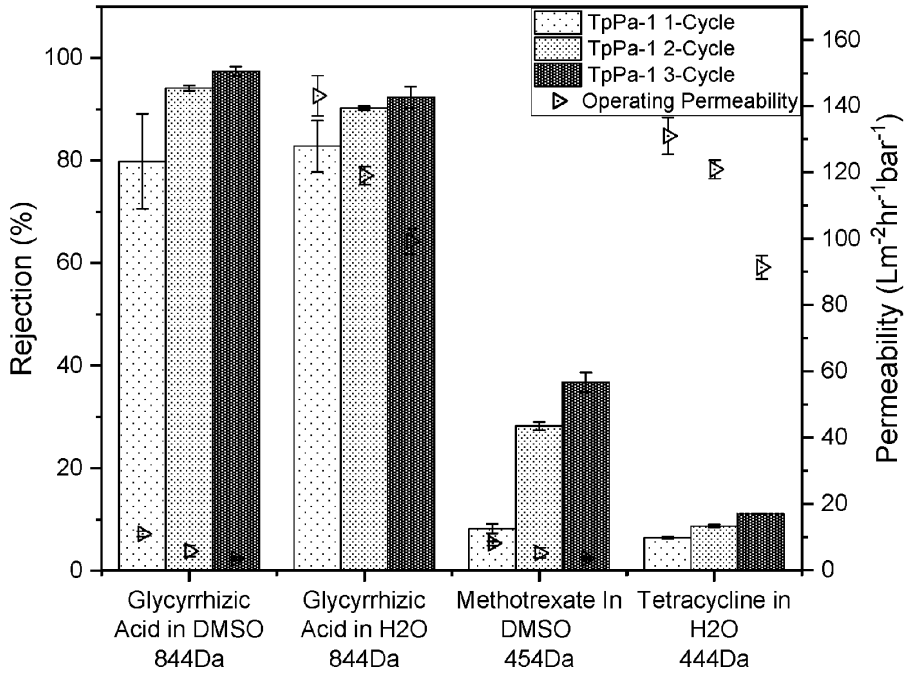

TpPa-1 1-Cycle
TpPa-1 2-Cycle
TpPa-1 3-Cycle
Operating Permeability
Rejection (%)
Permeability (Lm-2hr-1bar-1)
0
20
40
60
80
100
120
140
160
Glycyrrhizic Acid in DMSO 844Da
Glycyrrhizic Acid in H2O 844Da
Methotrexate In DMSO 454Da
Tetracycline in H2O 444Da

FIG. 22

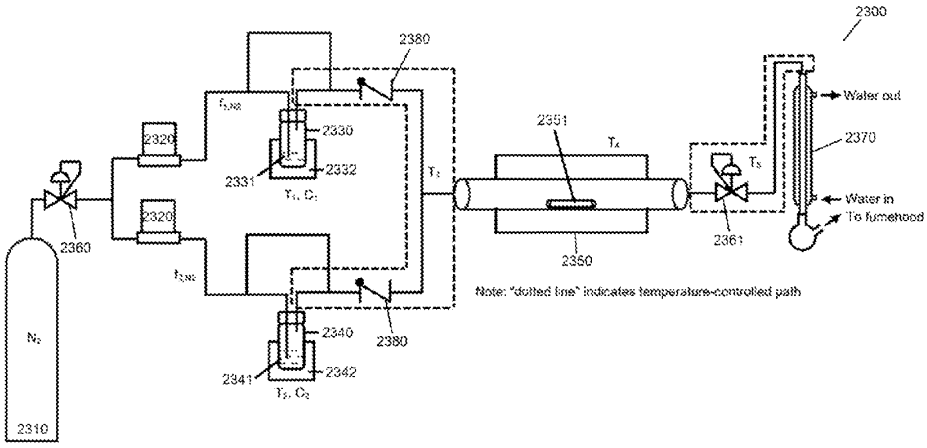

2300
2380
2330
2331
2332
2320
2320
2360
2310
2340
2341
2342
2380
2351
2350
2370
2361
Water out
Water in
To fumehood
Note: "dotted line" indicates temperature-controlled path

FIG. 23

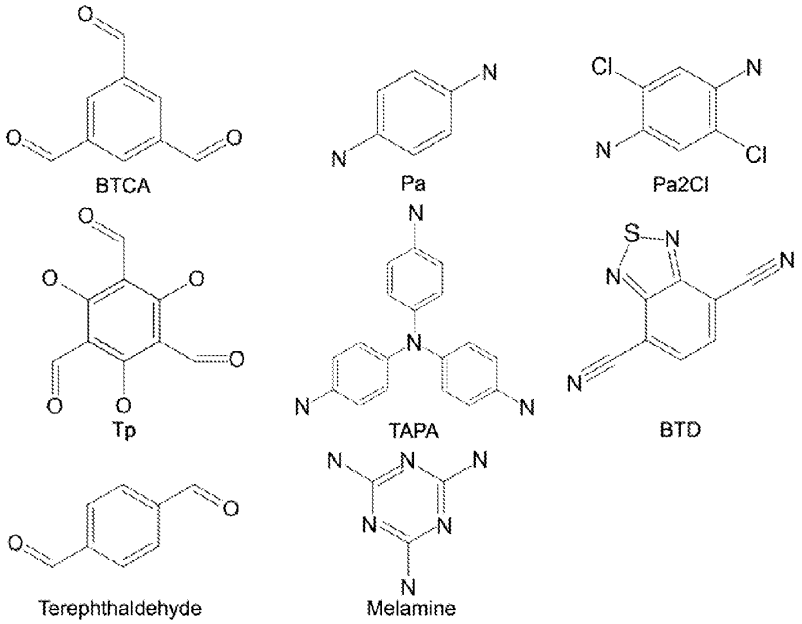

BTCA
Pa
Pa2Cl
Tp
TAPA
BTD
Terephthaldehyde
Melamine

FIG. 24

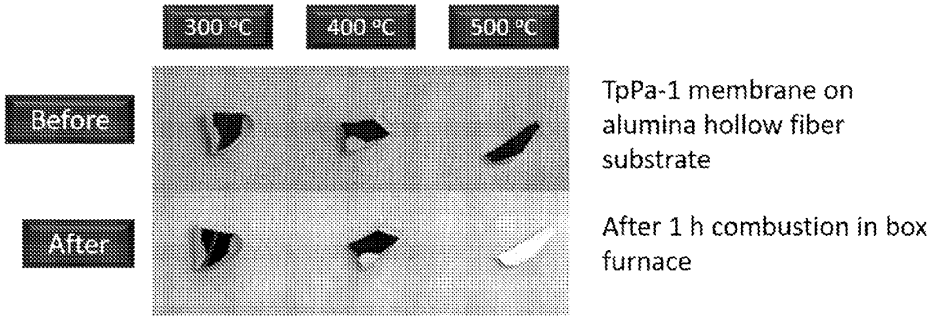

300 °C
400 °C
500 °C
Before
After
TpPa-1 membrane on alumina hollow fiber substrate
After 1 h combustion in box furnace

FIG. 25

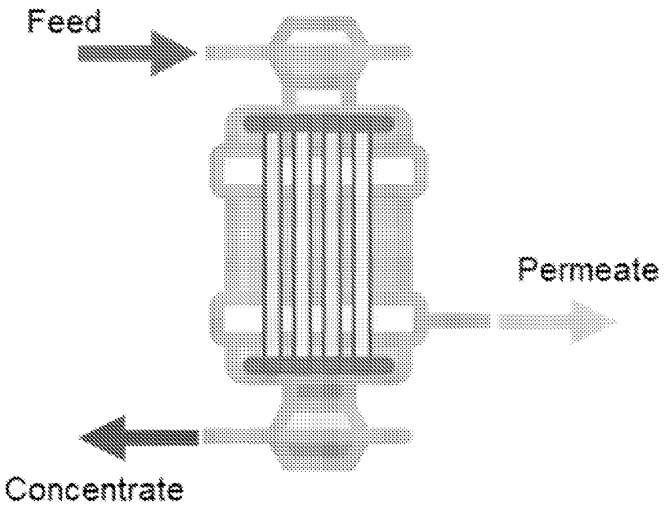

Feed
Permeate
Concentrate

FIG. 26

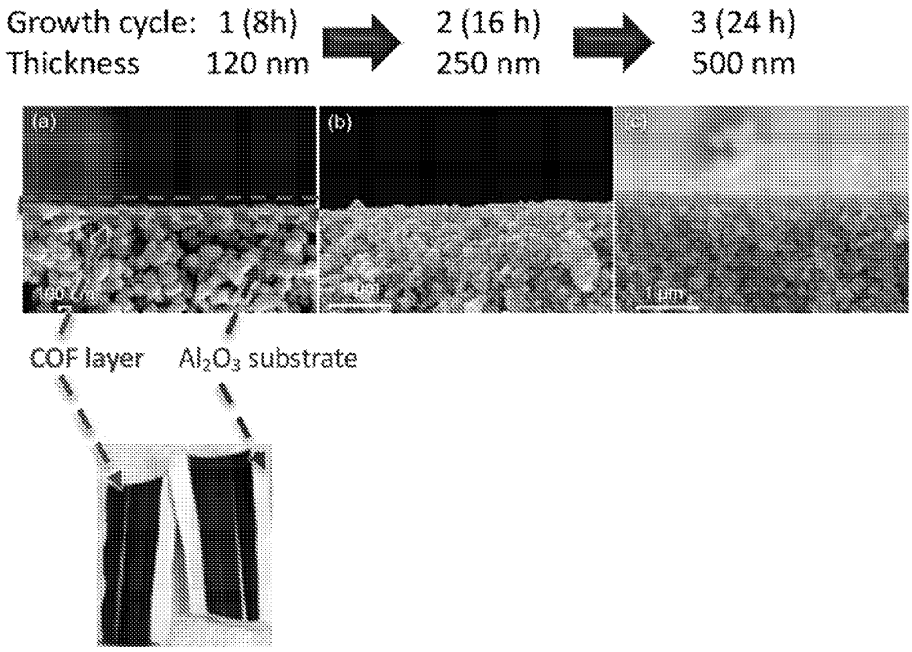

Growth cycle: 1 (8h) 2 (16 h) 3 (24 h)
Thickness 120 nm 250 nm 500 nm
(a)
(b)
(c)
1 μm
COF layer
Al_2O_3 substrate

FIG. 27