FIG. 1

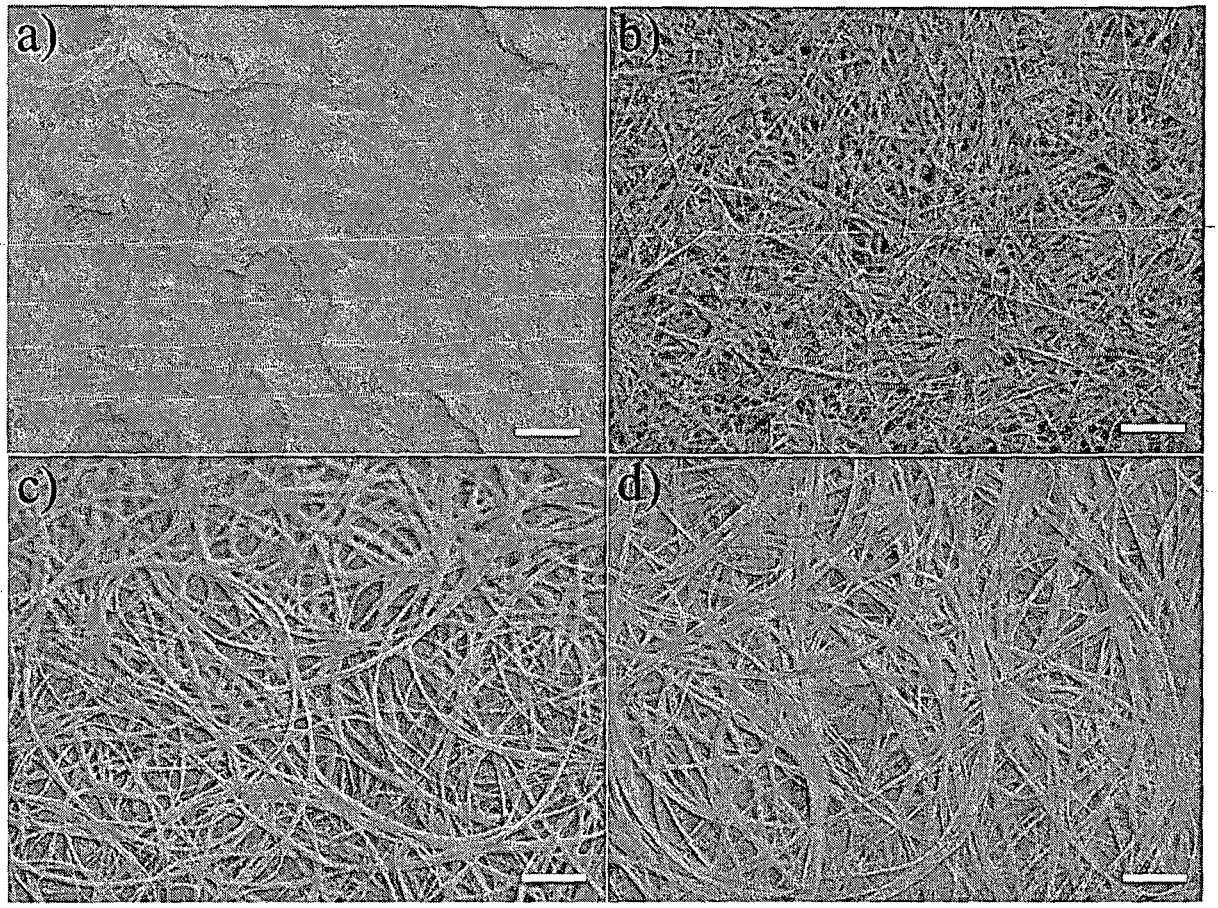

FIG. 2

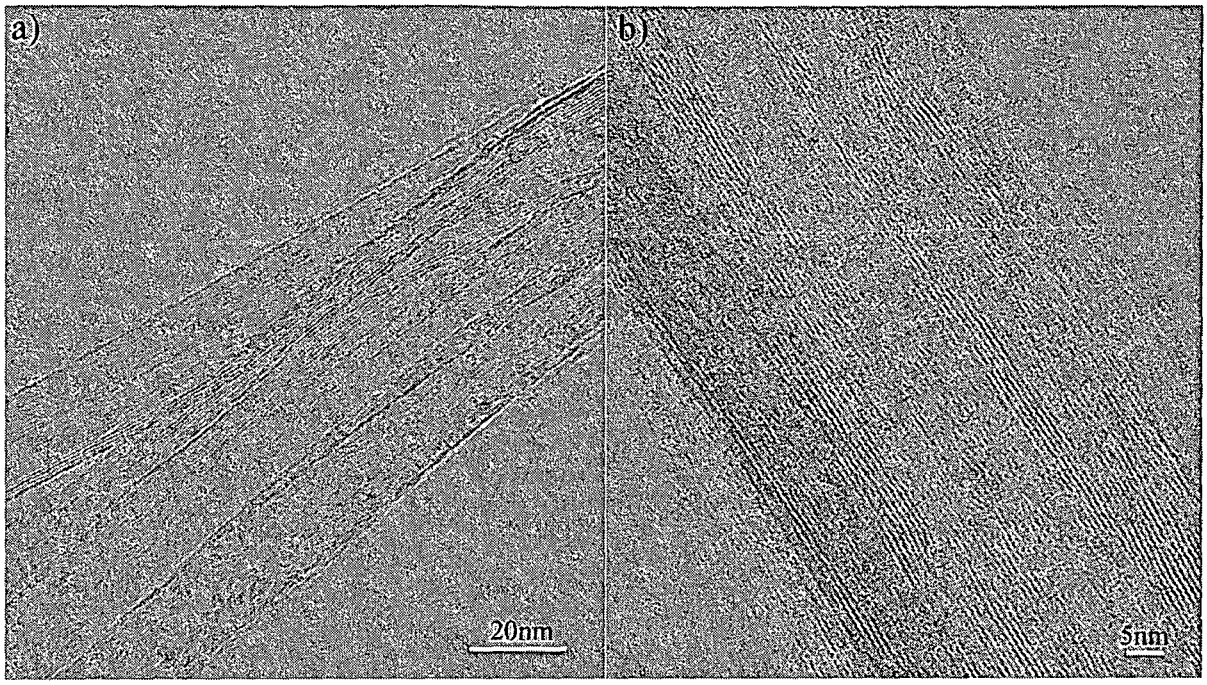

FIG. 3

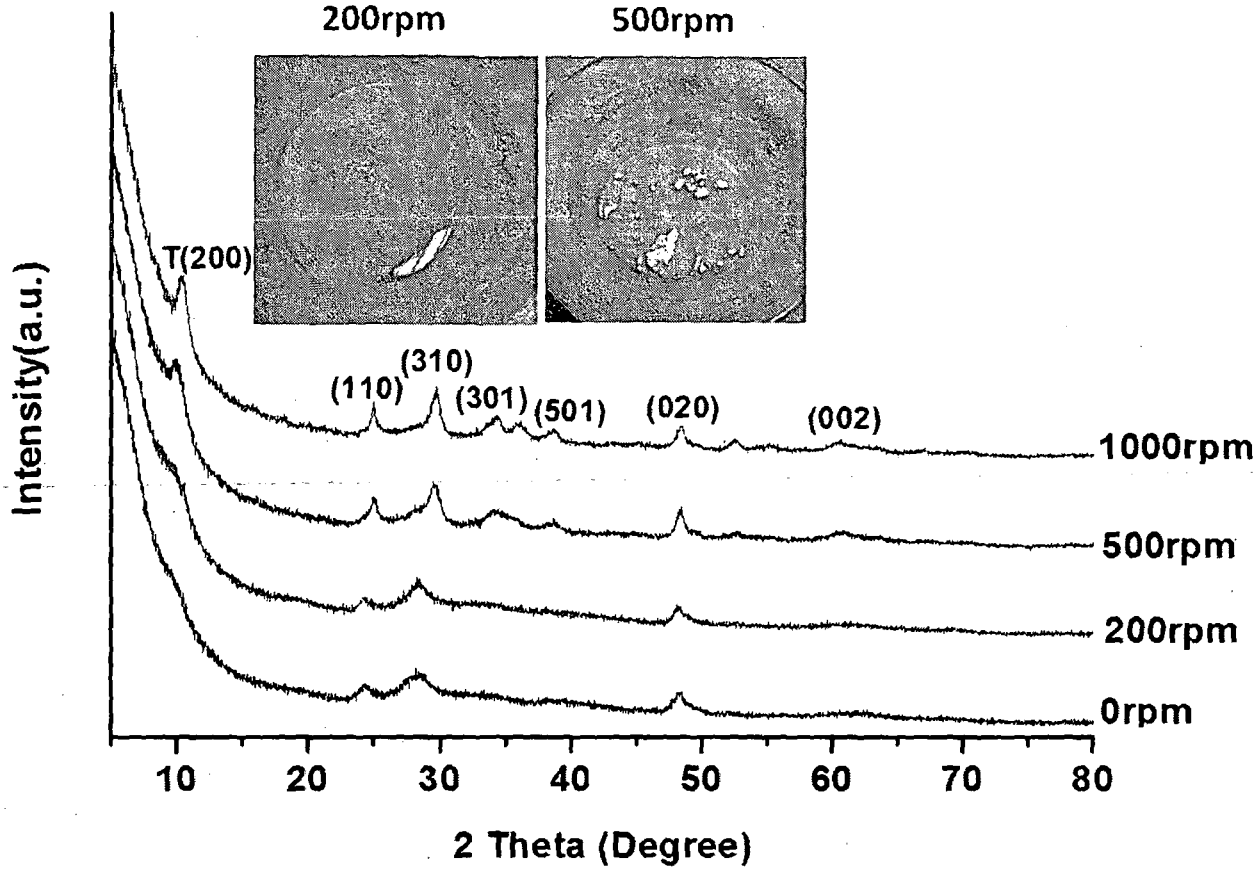
200rpm
500rpm
T(200)
(110)
(310)
(301)
(501)
(020)
(002)
1000rpm
500rpm
200rpm
0rpm
Intensity(a.u.)
10
20
30
40
50
60
70
80
2 Theta (Degree)

FIG. 4

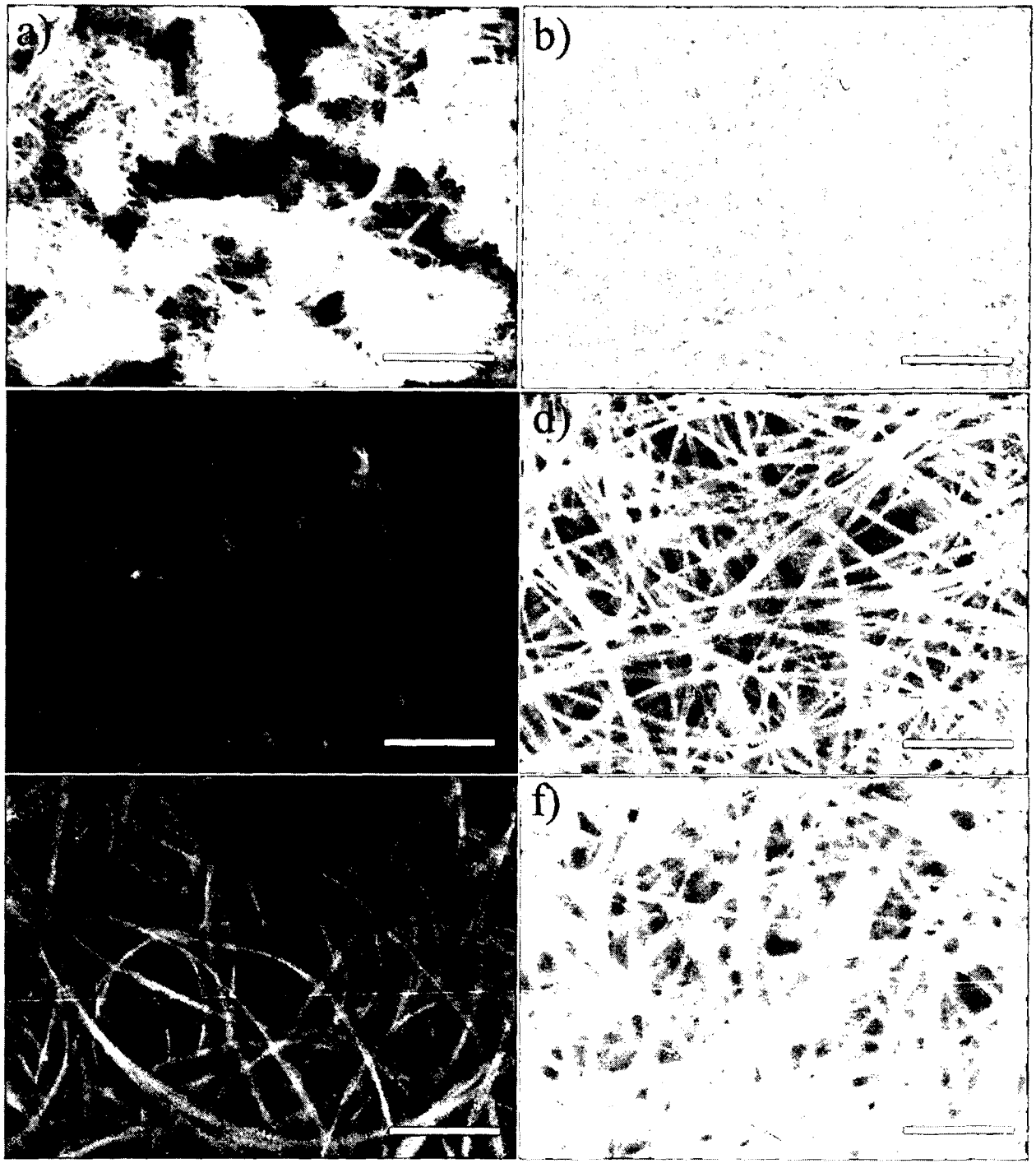

FIG. 5

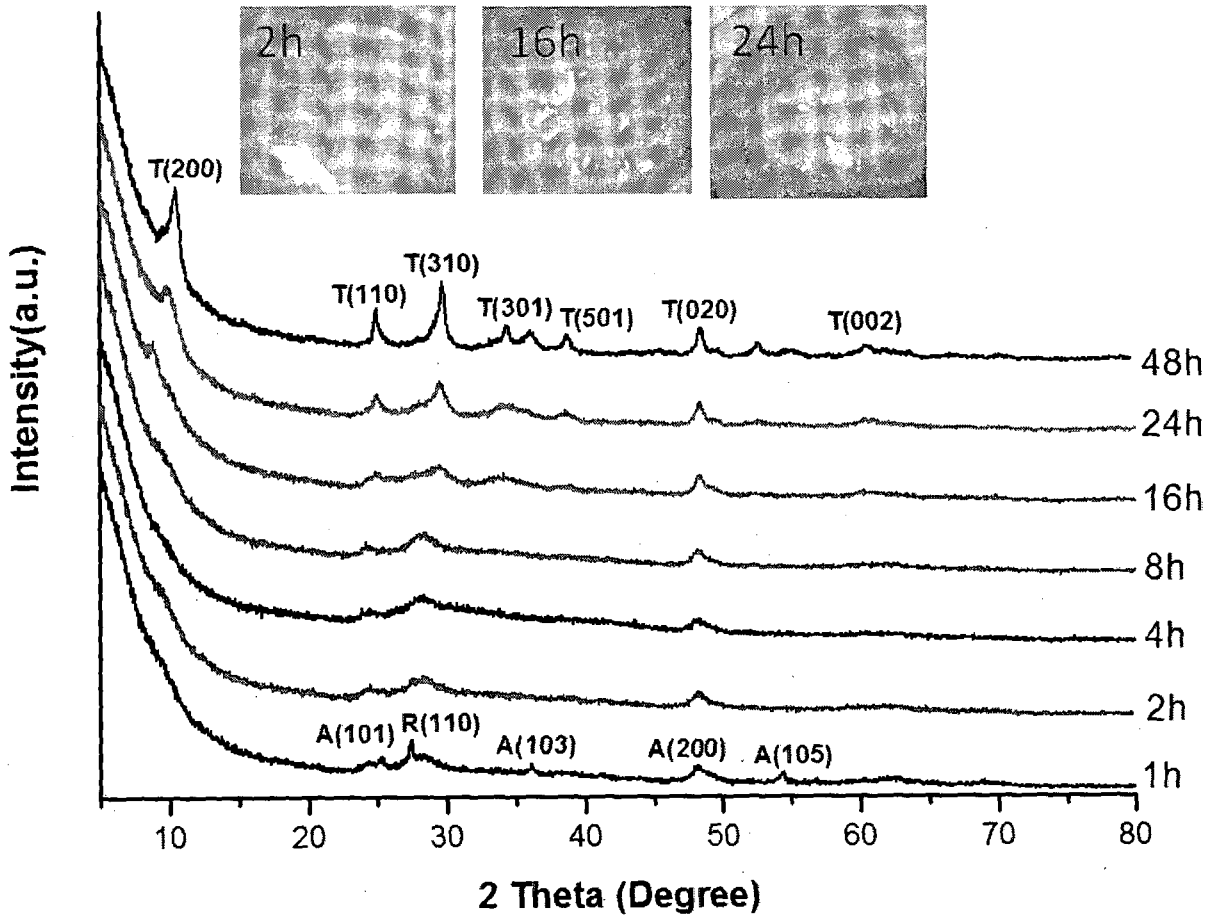
2h
16h
24h
T(200)
T(110)
T(310)
T(301)
T(501)
T(020)
T(002)
A(101)
R(110)
A(103)
A(200)
A(105)
48h
24h
16h
8h
4h
2h
1h
Intensity(a.u.)
10
20
30
40
50
60
70
80
2 Theta (Degree)

FIG. 6

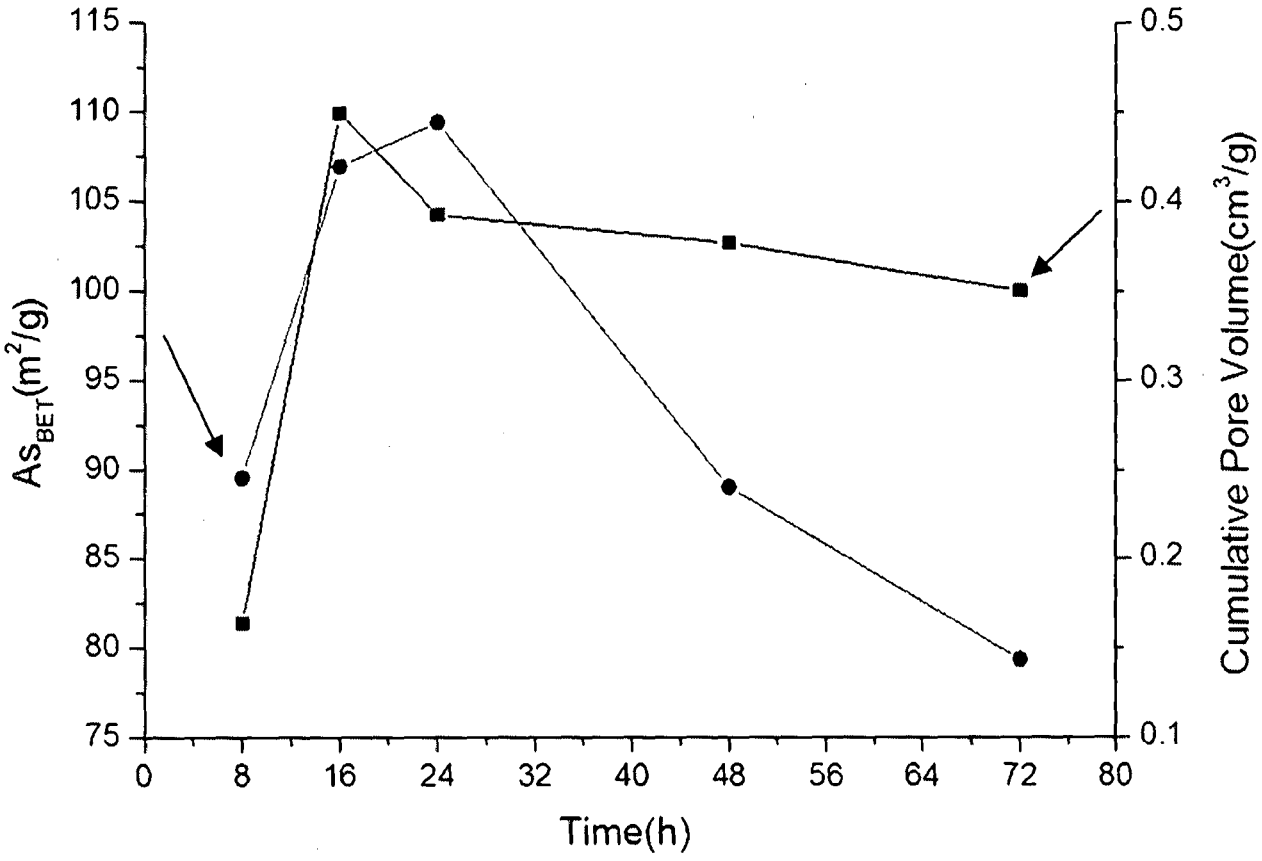
115
110
105
100
95
90
85
80
75
0.5
0.4
0.3
0.2
0.1
0
8
16
24
32
40
48
56
64
72
80
Time(h)
As$_{BET}$(m^2/g)
Cumulative Pore Volume(cm^3/g)

FIG. 7

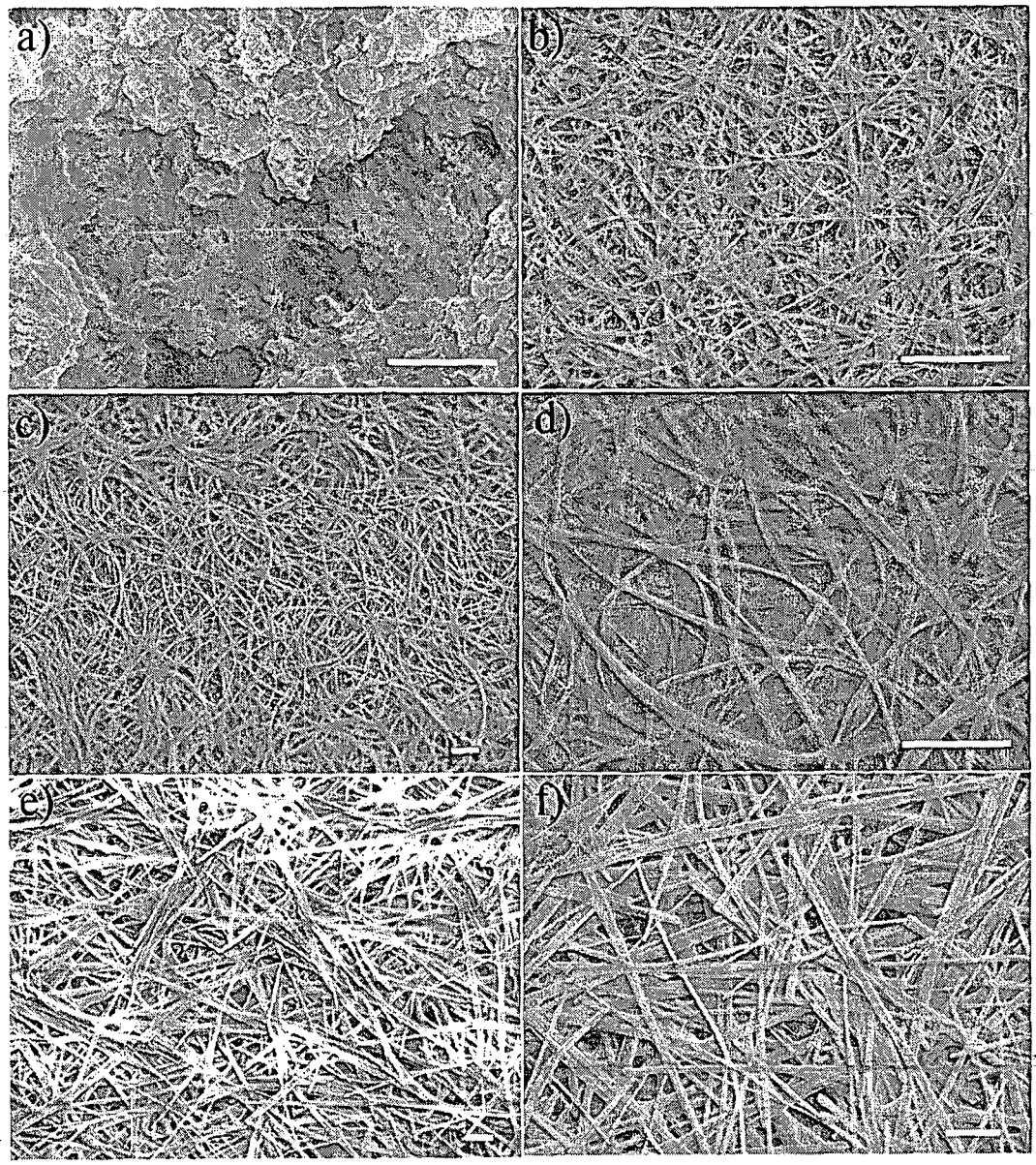

FIG. 8

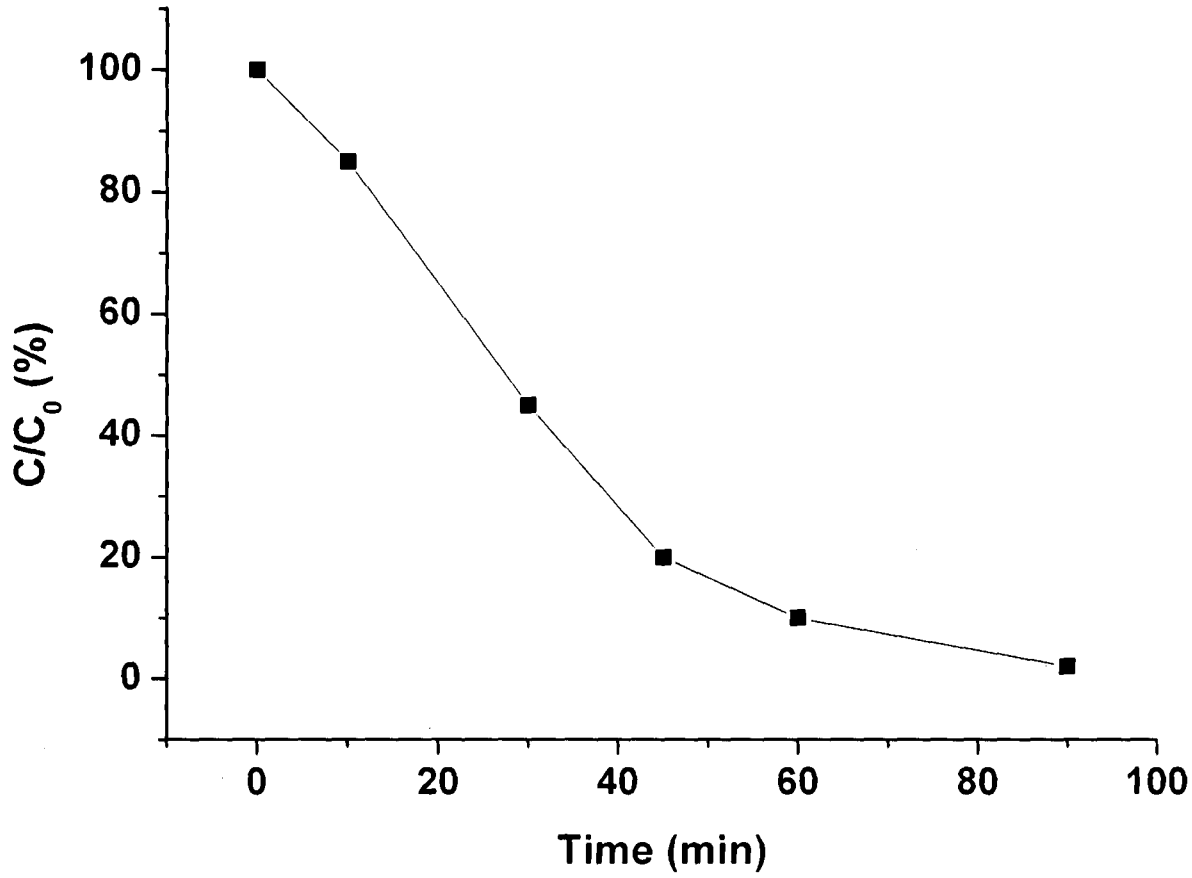

FIG. 9

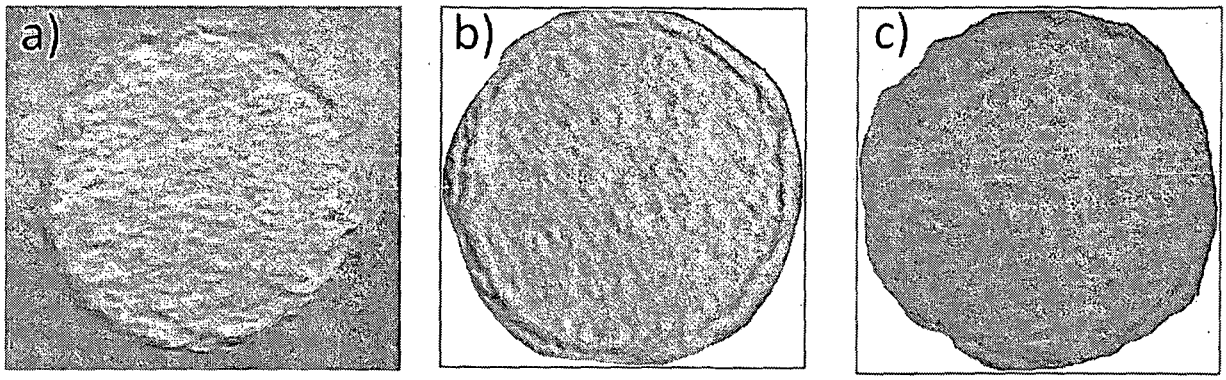

FIG. 10

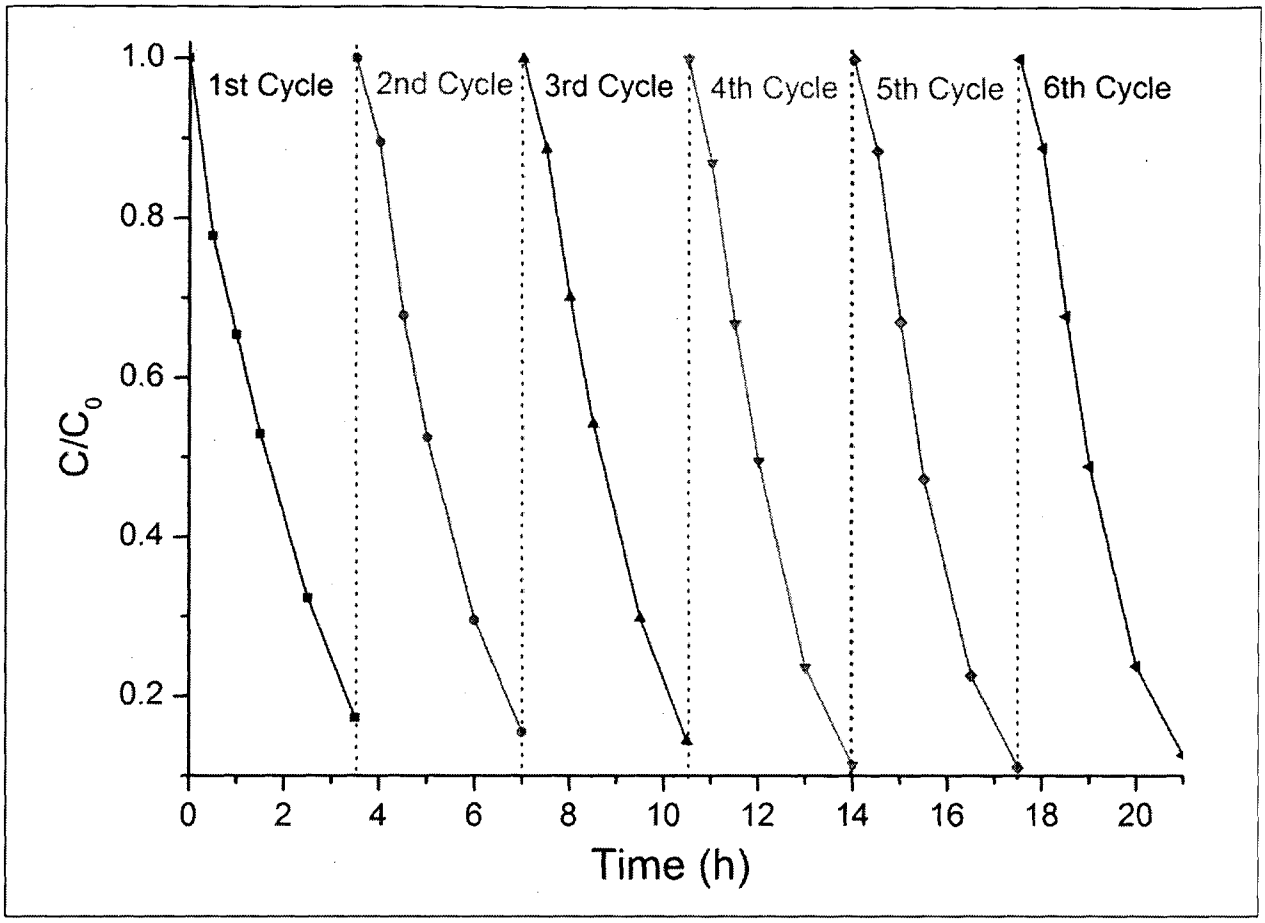
1st Cycle
2nd Cycle
3rd Cycle
4th Cycle
5th Cycle
6th Cycle
C/C0
Time (h)
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
16
18
20

FIG. 11

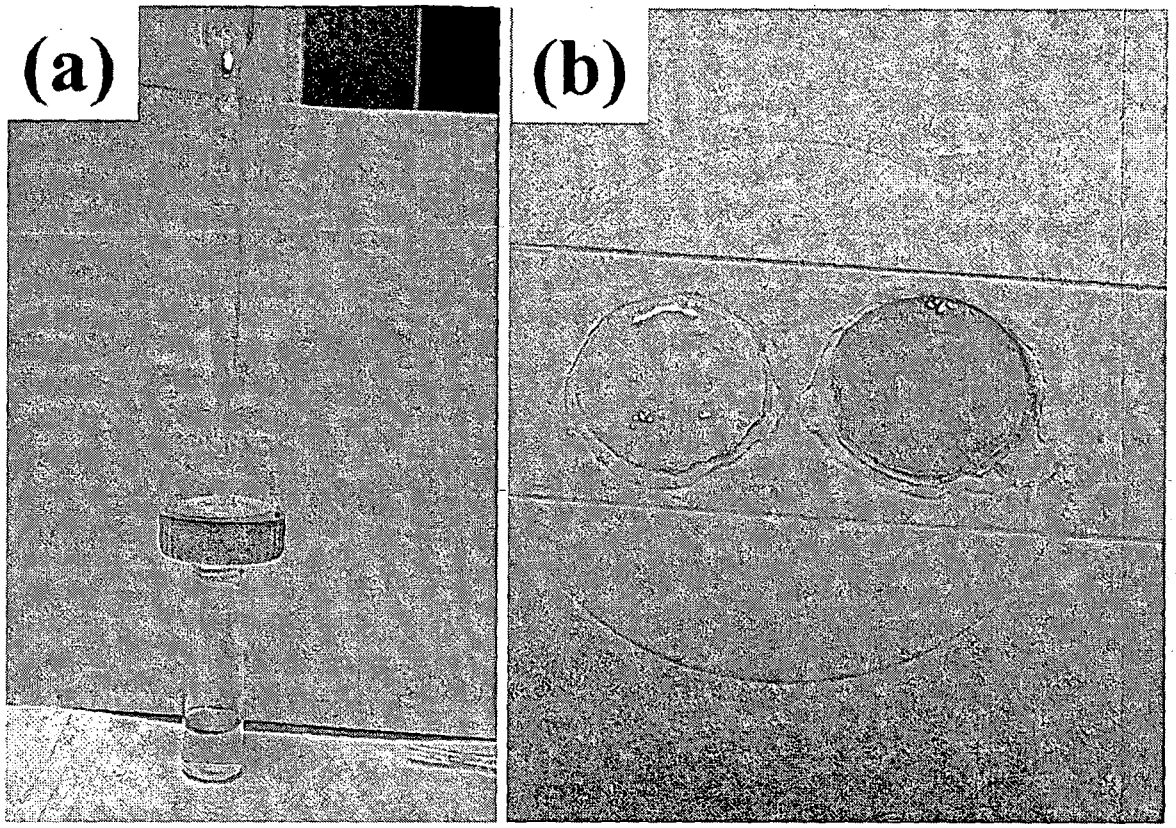

FIG. 12

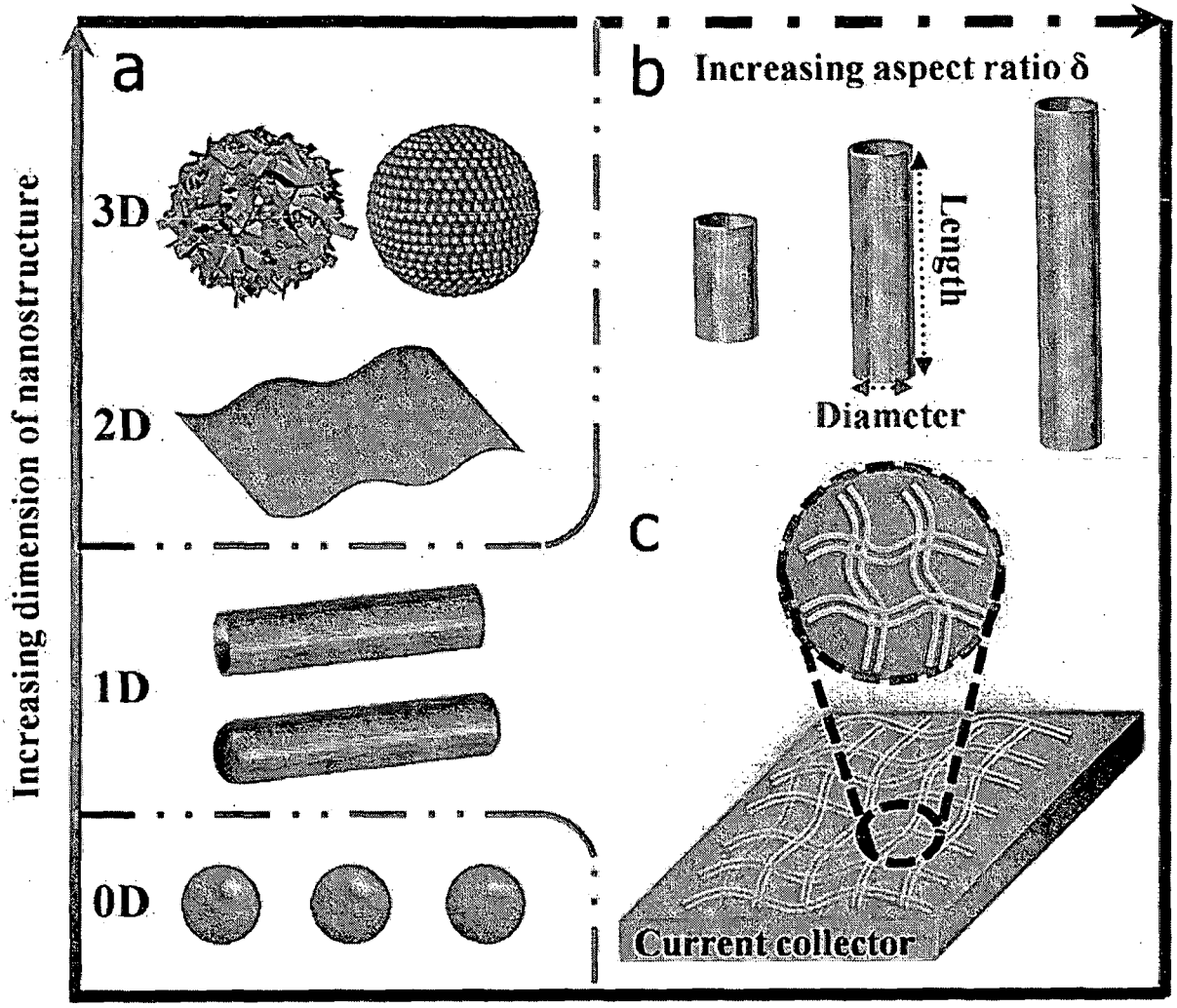
a
b
Increasing aspect ratio δ
3D
2D
1D
0D
Length
Diameter
c
Current collector
Increasing dimension of nanostructure

FIG. 13

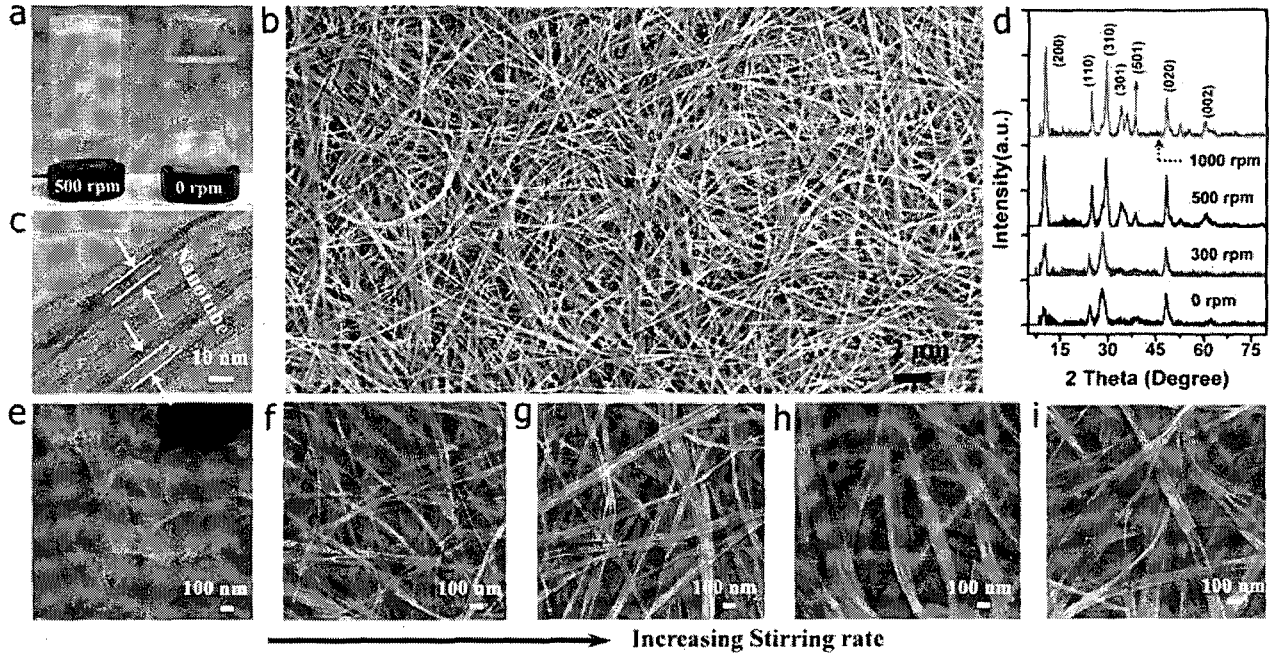
a
500 rpm
0 rpm
b
c
10 nm
d
(200)
(110)
(310)
(301)
(501)
(020)
(002)
1000 rpm
500 rpm
300 rpm
0 rpm
Intensity(a.u.)
15 30 45 60 75
2 Theta (Degree)
e
f
g
h
i
100 nm
Increasing Stirring rate

FIG. 14

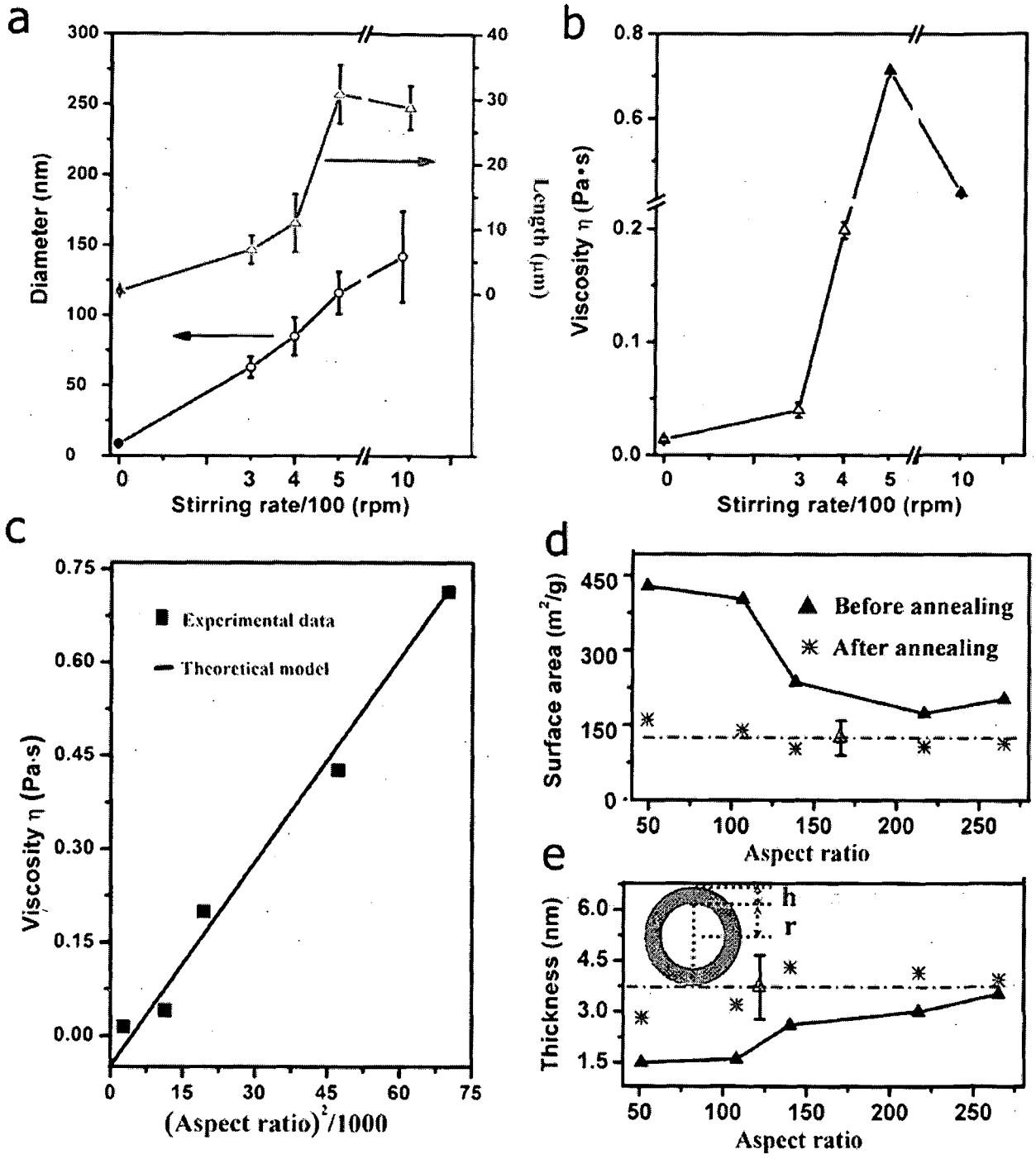
a
Diameter (nm)
Length (μm)
Stirring rate/100 (rpm)
b
Viscosity η (Pa•s)
Stirring rate/100 (rpm)
c
Experimental data
Theoretical model
Viscosity η (Pa·s)
(Aspect ratio)²/1000
d
Before annealing
After annealing
Surface area (m²/g)
Aspect ratio
e
h
r
Thickness (nm)
Aspect ratio

FIG. 15

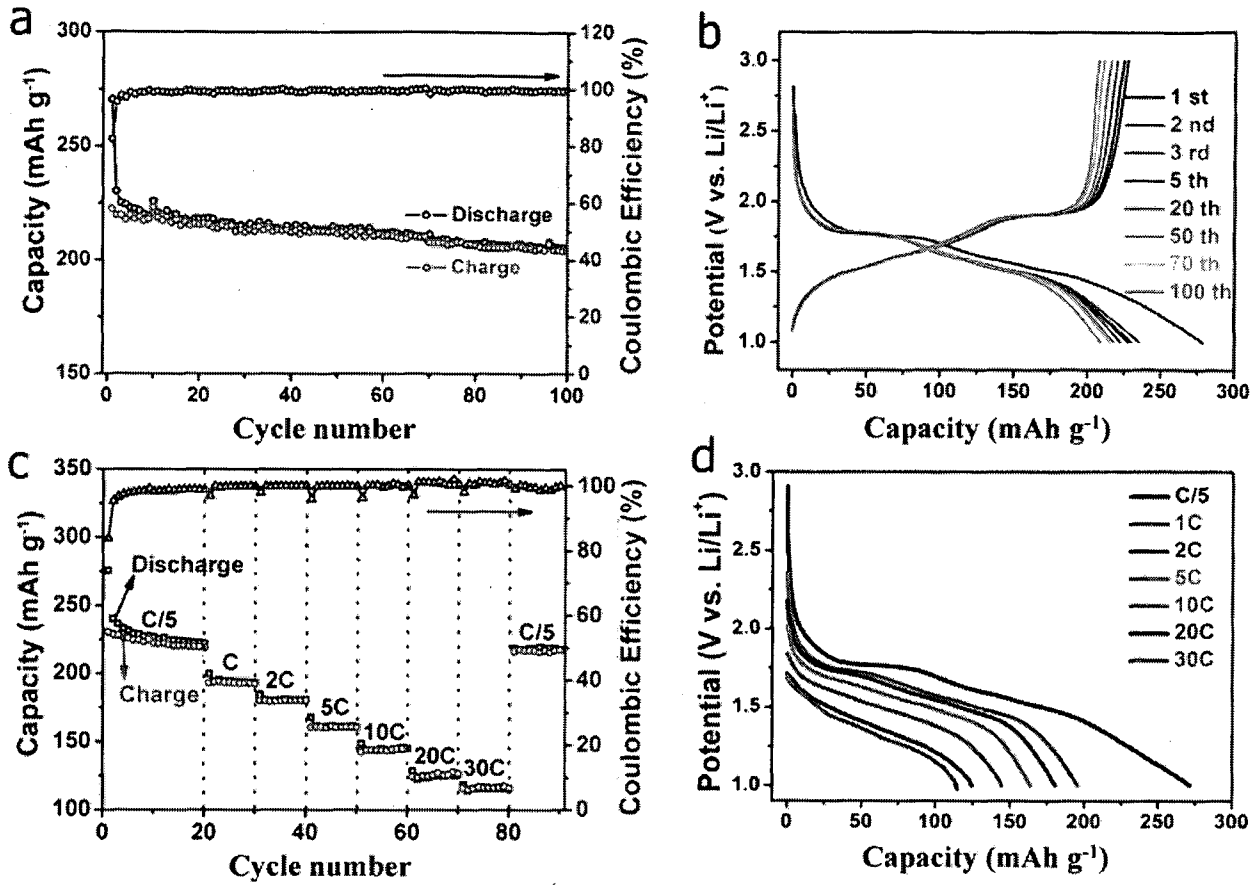
a
Capacity (mAh g-1)
Coulombic Efficiency (%)
Cycle number
Discharge
Charge
b
Potential (V vs. Li/Li+)
Capacity (mAh g-1)
1 st
2 nd
3 rd
5 th
20 th
50 th
70 th
100 th
c
Capacity (mAh g-1)
Coulombic Efficiency (%)
Cycle number
Discharge
Charge
C/5
C
2C
5C
10C
20C
30C
C/5
d
Potential (V vs. Li/Li+)
Capacity (mAh g-1)
C/5
1C
2C
5C
10C
20C
30C

FIG. 16

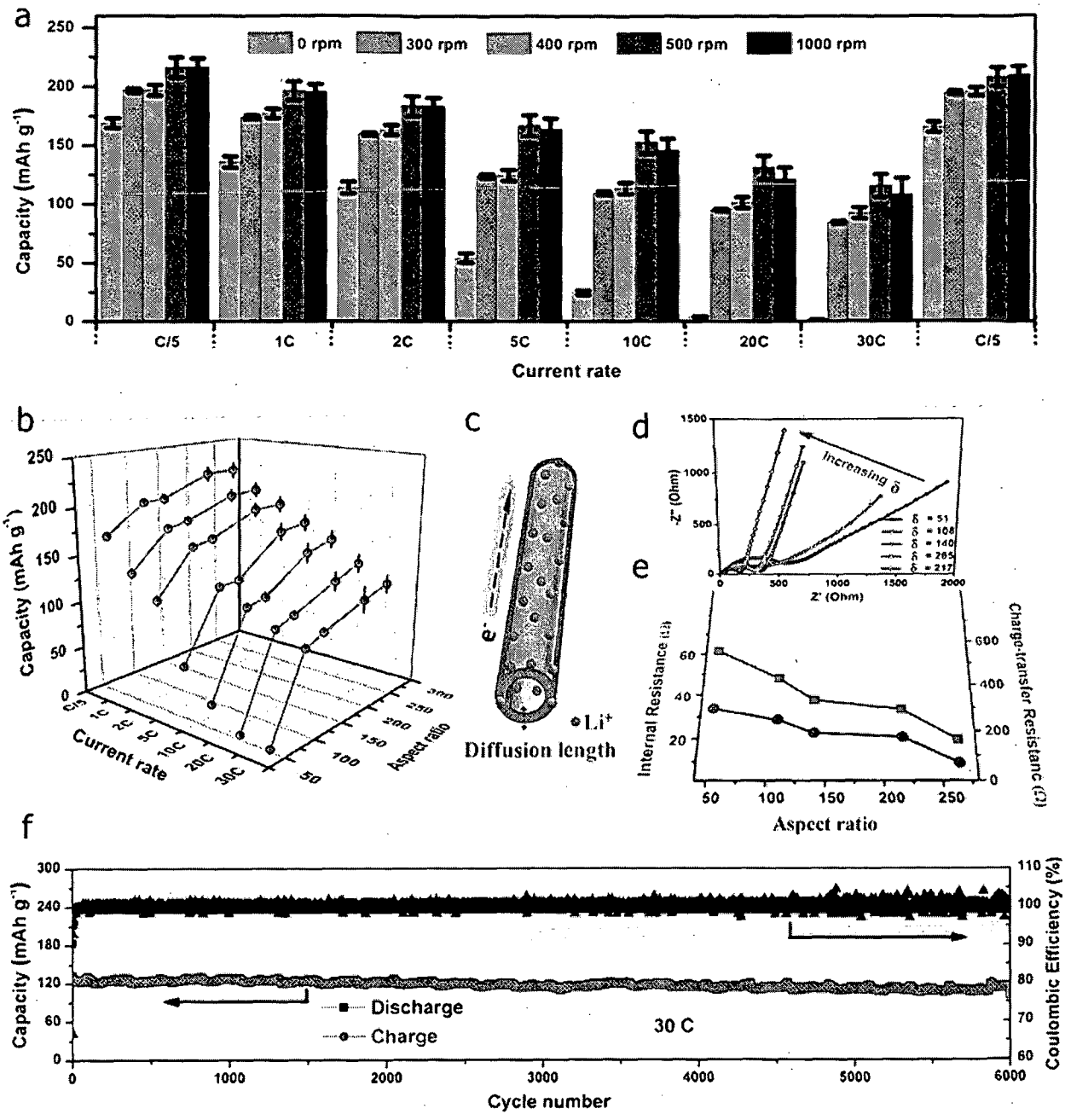
a
0 rpm
300 rpm
400 rpm
500 rpm
1000 rpm
Capacity (mAh g-1)
C/5
1C
2C
5C
10C
20C
30C
C/5
Current rate
b
Capacity (mAh g-1)
Current rate
Aspect ratio
c
e-
Li+
Diffusion length
d
-Z'' (Ohm)
Z' (Ohm)
Increasing δ
δ = 51
δ = 108
δ = 140
δ = 265
δ = 217
e
Internal Resistance (Ω)
Charge-transfer Resistance (Ω)
Aspect ratio
f
Capacity (mAh g-1)
Coulombic Efficiency (%)
Discharge
Charge
30 C
Cycle number

FIG. 17

Table 1. Comparison of the electrochemical performance of representative anatase TiO_2 electrode materials at high rates.

Electrode materials	Specific capacity (mAh/g)	Discharge rate (C)	Electrode composition*	Ref.
Pure TiO_2 electrode with additive				
Mesoporous anatase TiO_2	~ 123[Δ]	9 C[*]	7:1.5:1.5	
Ultrathin TiO_2 nanosheets	95	20 C	7:2:1	
TiO_2 nanofibers	77[Δ]	20 C	7:2:1	
TiO_2 nanosheets	88[Δ]	30 C	7:2:1	
Black TiO_2 nanoparticles	~ 153[Δ]	30 C	8.5:0.75:0.75	
TiO_2-composite electrode with additive				
Carbon nanotube–TiO_2	110	20 C	NA[♦]	
Mesoporous TiO_2–RuO_2	125	20 C[*]	3:1:1	
TiO_2 nanoparticle–Graphene	96	30 C	NA	
TiO_2 nanodots–Graphene	100[Δ]	30 C	8:1:1	
Additive-free TiO_2 electrode				
TiO_2 nanowire arrays	84	3 C	/	
TiO_2 nanofibers	60	5 C	/	
Vertical TiO_2 nanotubes	130	10 C	/	
Micropatterned TiO_2	~ 60	20 C	/	
High aspect ratio TiO_2 NTs	161	10 C	/	This work
	133	30 C	/	

*: Electrode composition is listed using the mass ratio of active material: conductive carbon: binder;

[*]: Discharging rate is unified as 1 C = 168 mAh g^{-1};

[Δ]: Capacity is recalculated based on the total weight of the electrode, including the active material, conductive carbon, and binder;

[♦]: NA means not available.

FIG. 18

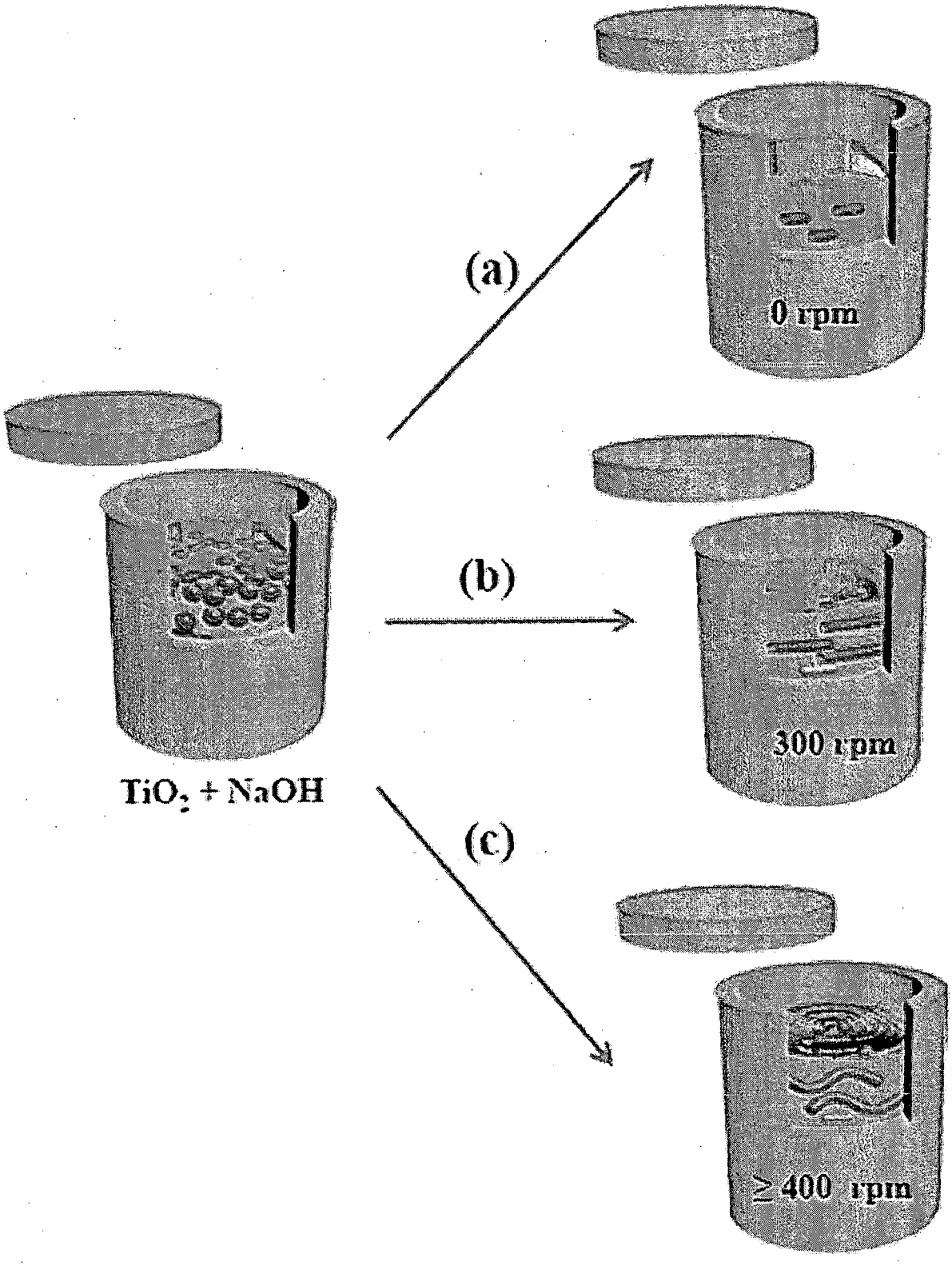

FIG. 19

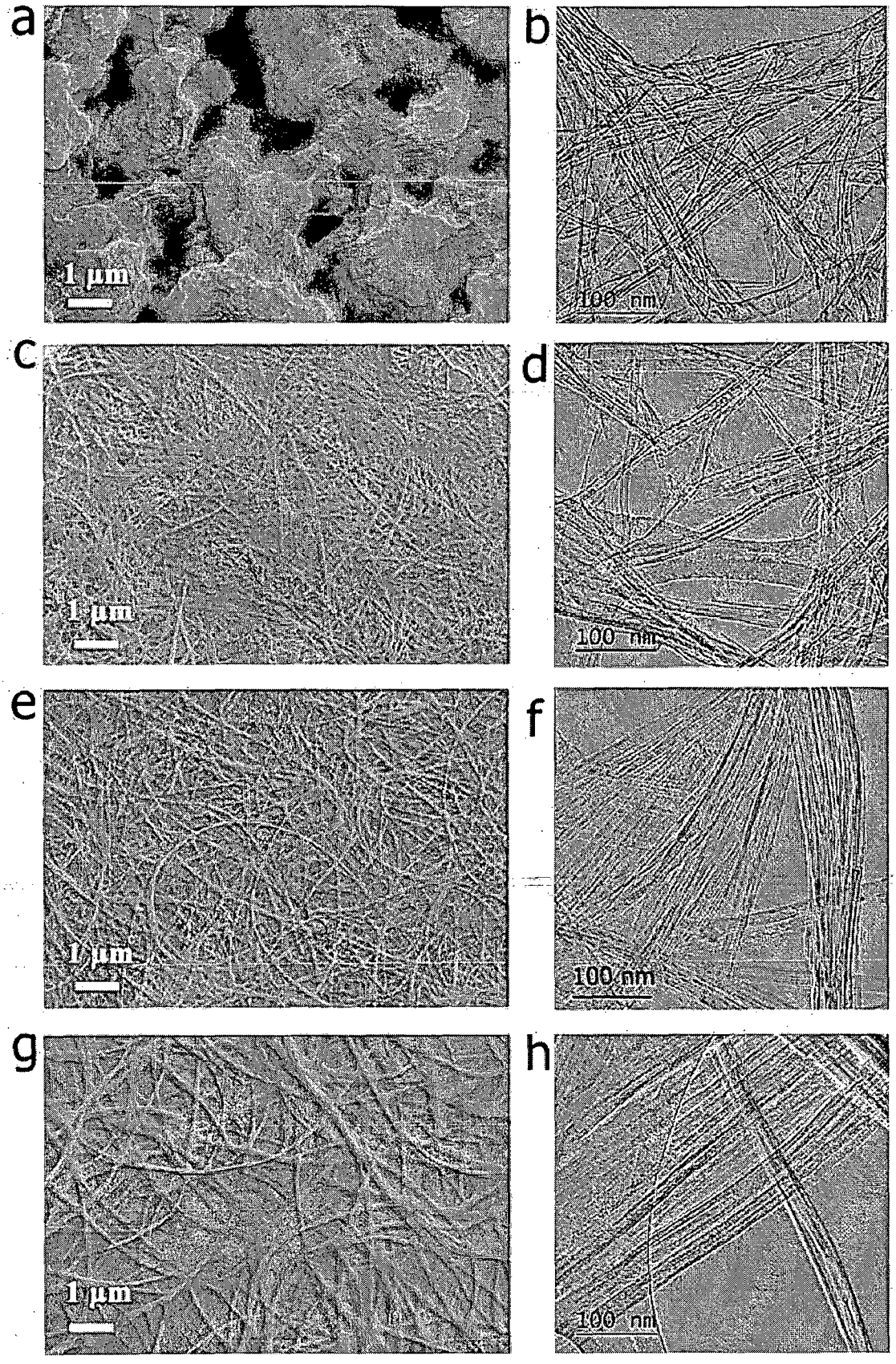

FIG. 20

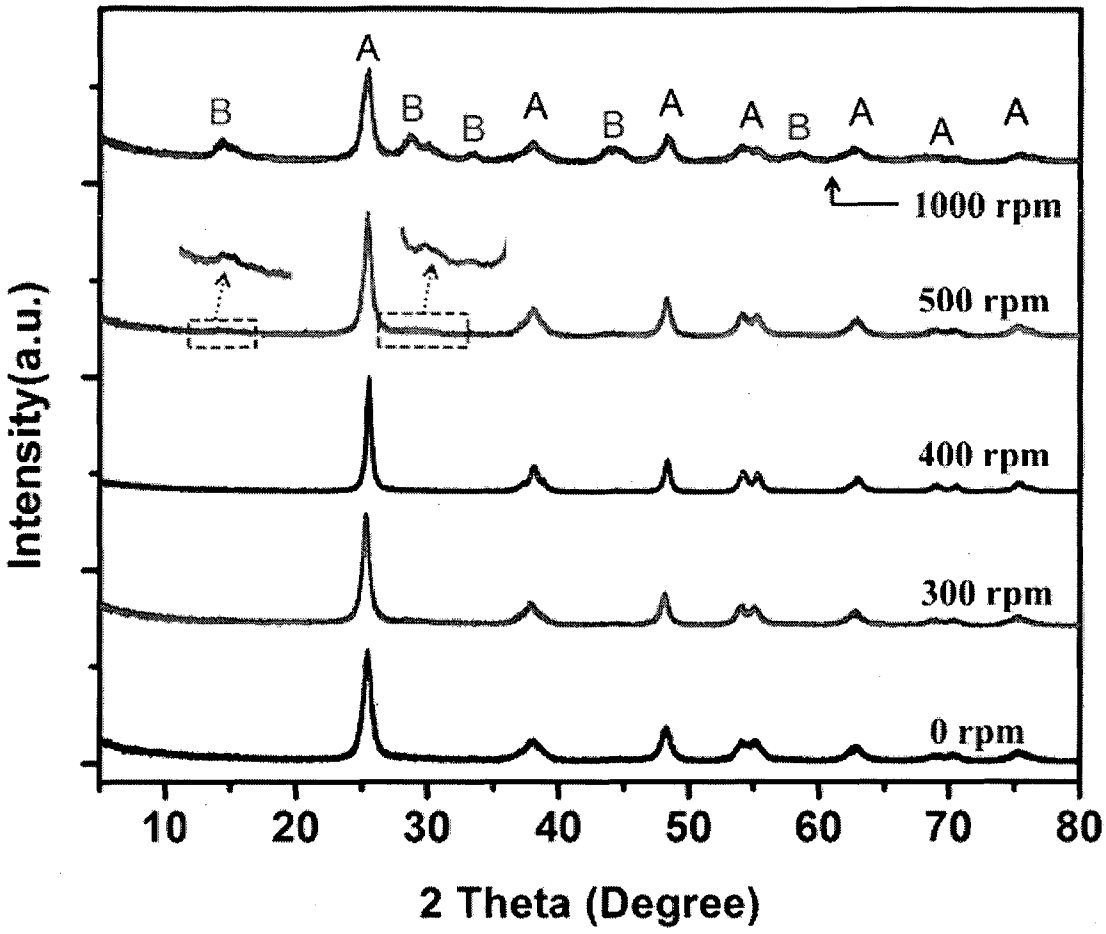
A
B
B
B
A
B
A
A
B
A
A
A
1000 rpm
500 rpm
400 rpm
300 rpm
0 rpm
Intensity(a.u.)
10
20
30
40
50
60
70
80
2 Theta (Degree)

FIG. 21

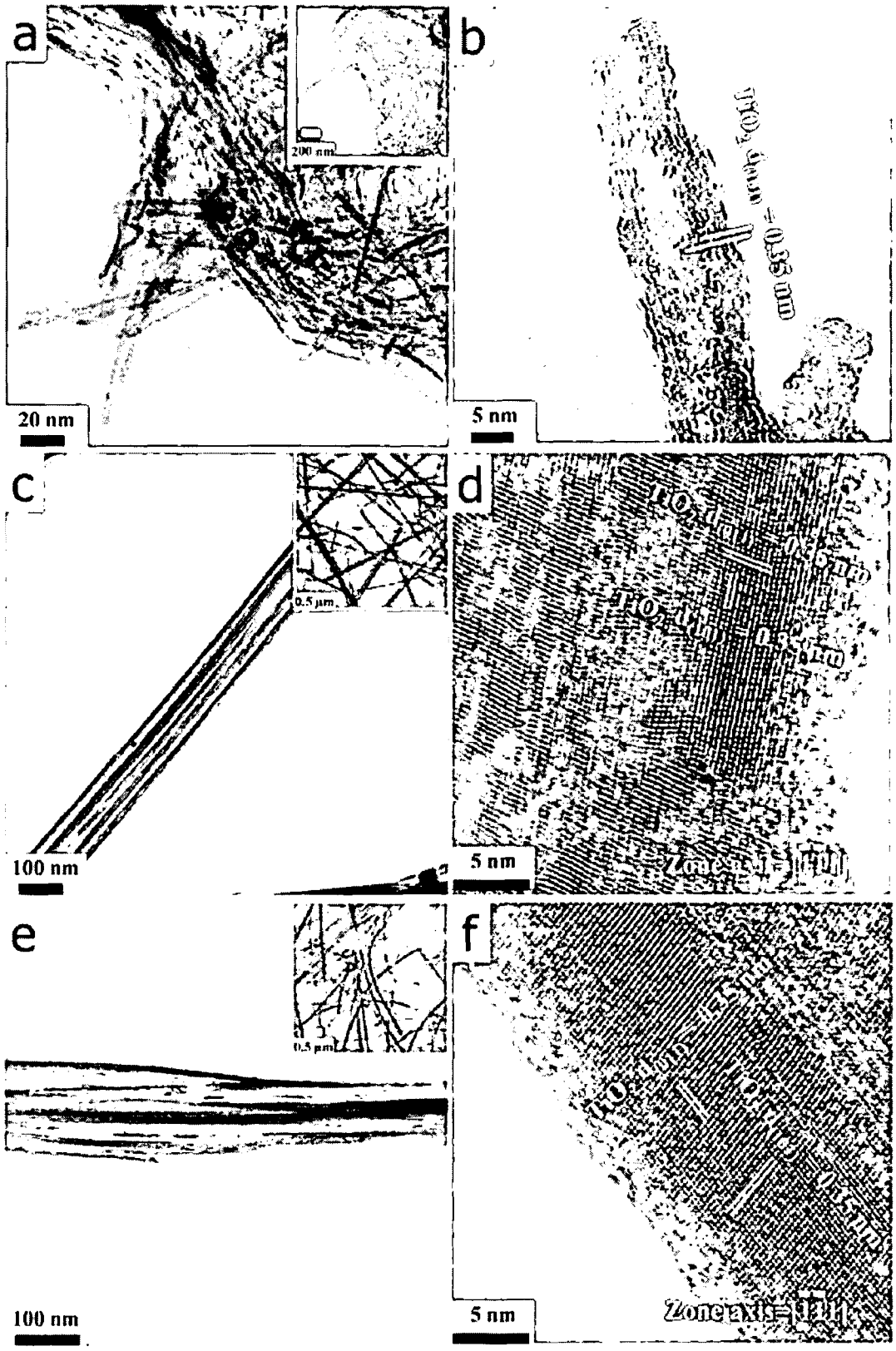

FIG. 22

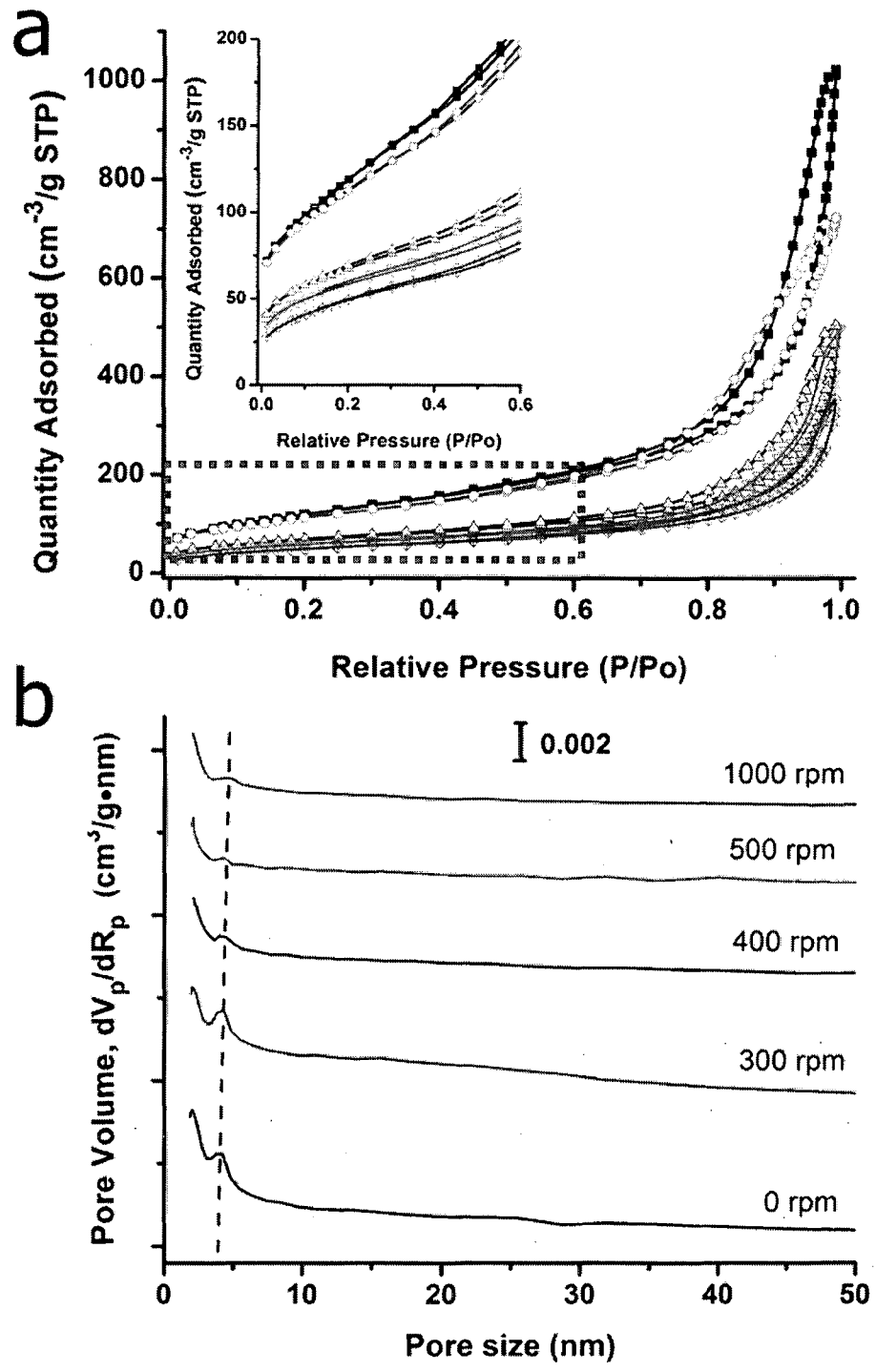
a
Quantity Adsorbed (cm-3/g STP)
Relative Pressure (P/Po)
Quantity Adsorbed (cm-3/g STP)
Relative Pressure (P/Po)
b
Pore Volume, dVp/dRp (cm3/g•nm)
0.002
1000 rpm
500 rpm
400 rpm
300 rpm
0 rpm
Pore size (nm)

FIG. 23

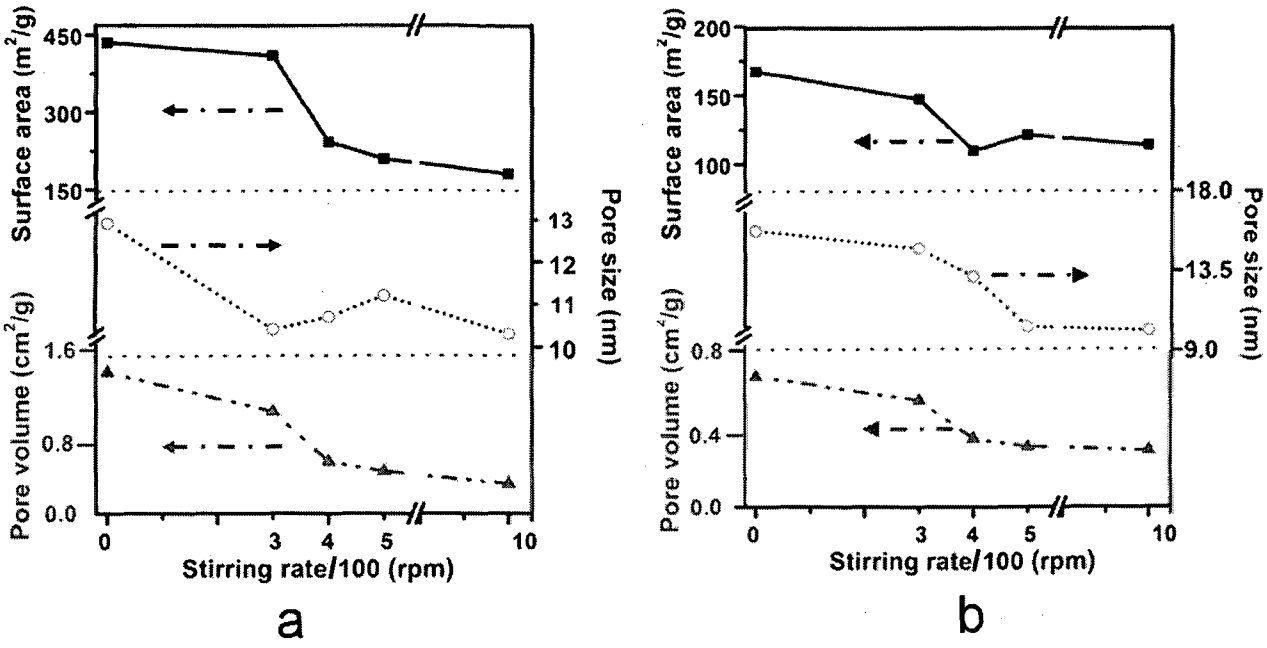
Surface area (m^2/g)
Pore volume (cm^3/g)
Pore size (nm)
Stirring rate/100 (rpm)
a
b

FIG. 24

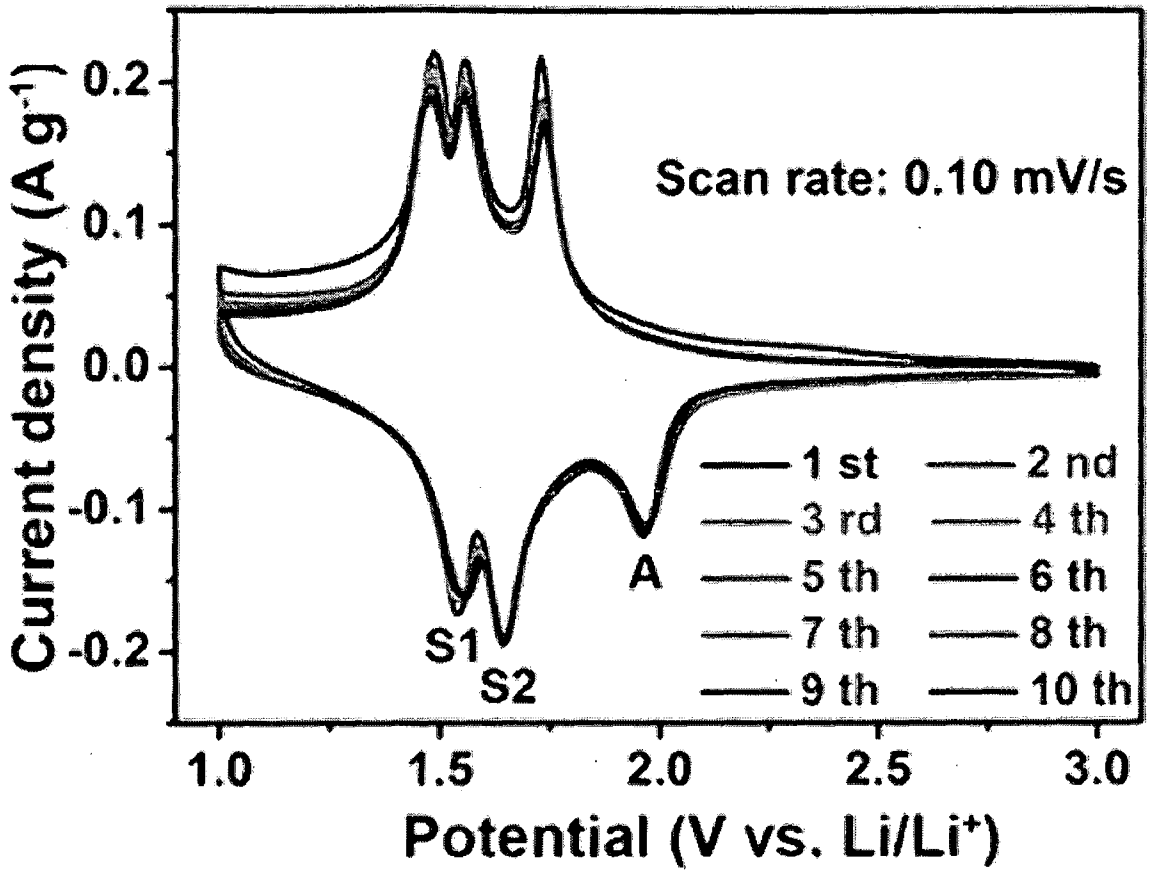
Current density (A g-1)
0.2
0.1
0.0
-0.1
-0.2
Scan rate: 0.10 mV/s
1 st
2 nd
3 rd
4 th
5 th
6 th
7 th
8 th
9 th
10 th
A
S1
S2
1.0
1.5
2.0
2.5
3.0
Potential (V vs. Li/Li+)

FIG. 25

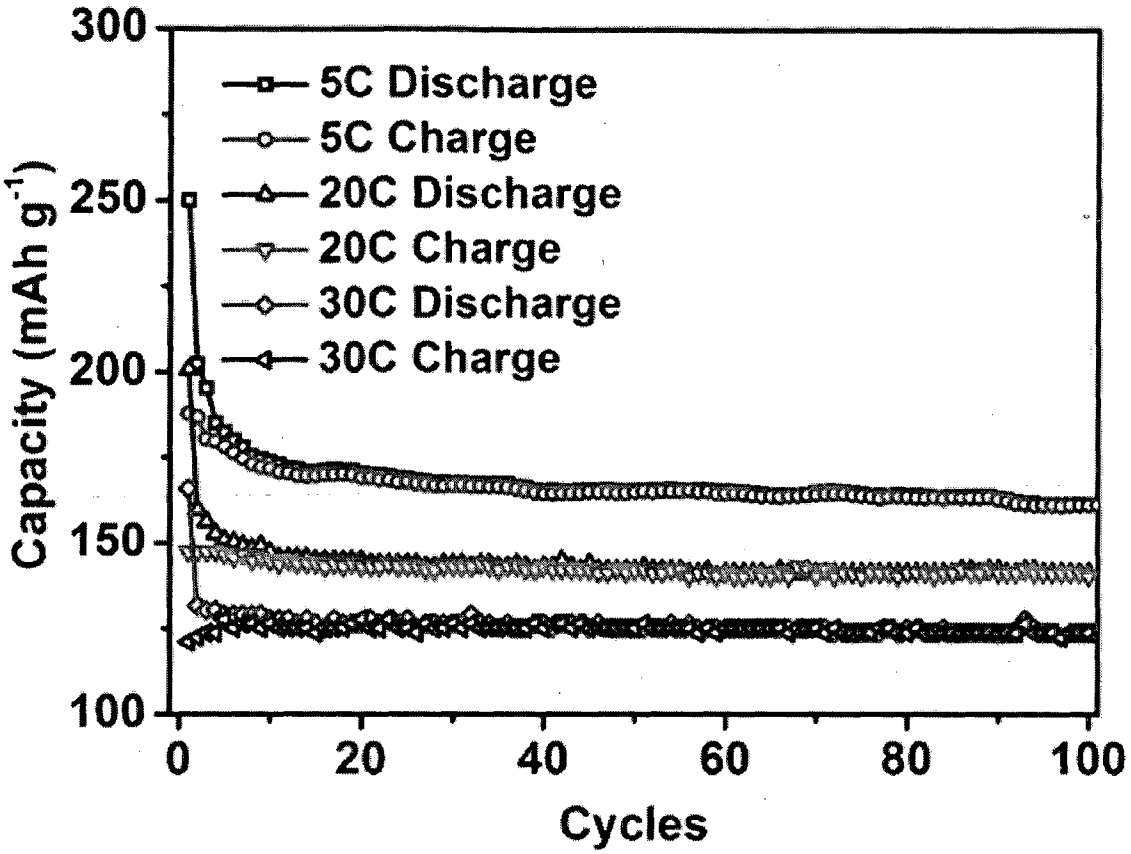
5C Discharge
5C Charge
20C Discharge
20C Charge
30C Discharge
30C Charge
Capacity (mAh g-1)
300
250
200
150
100
0
20
40
60
80
100
Cycles

FIG. 26

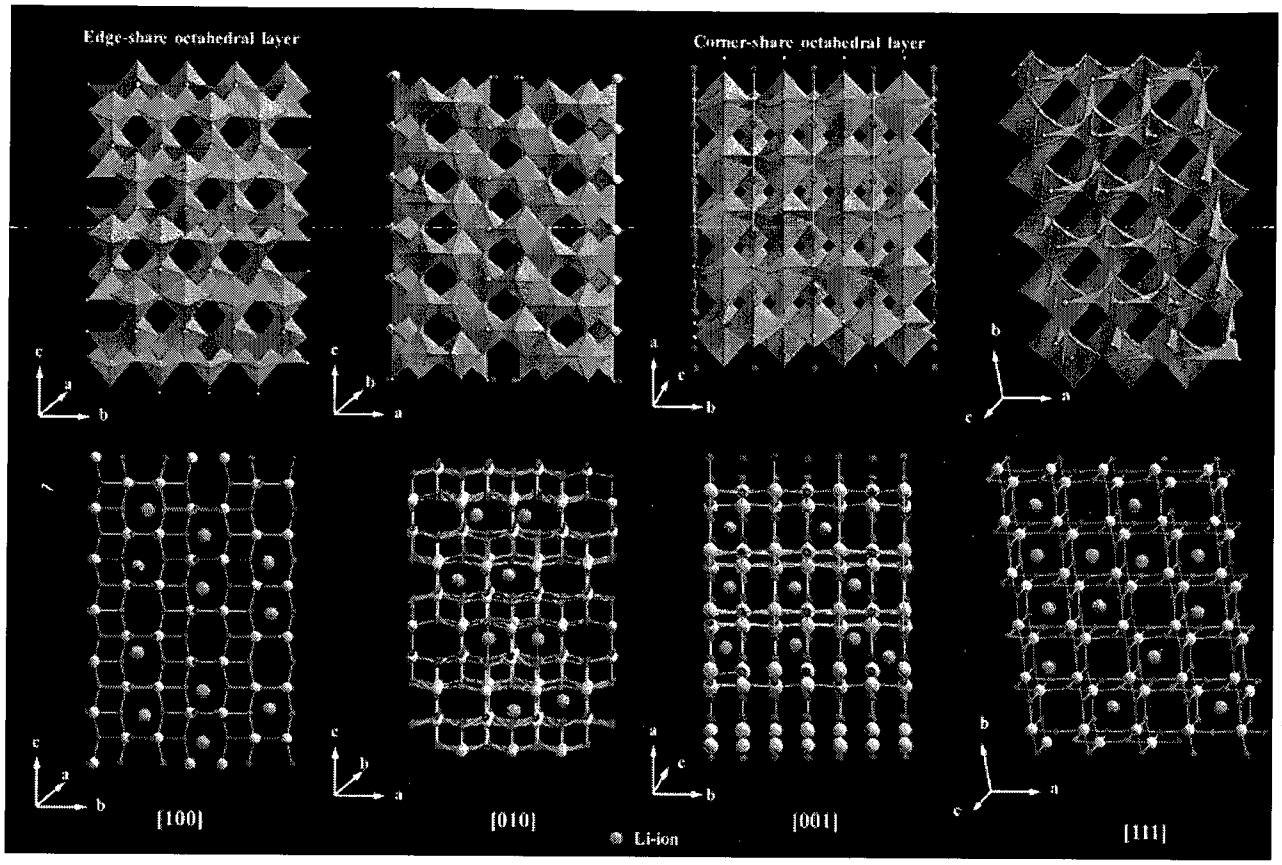
Edge-share octahedral layer
Corner-share octahedral layer
[100]
[010]
[001]
[111]
Li-ion

FIG. 27

Table S1. The relationship of the stirring rate with viscosity of the solution, length and diameter of the titanate nanotube.

Stirring speed (rpm)	Viscosity H (Pa.s)	Length (μm)	Diameter (nm)	Aspect ratio $\tilde{\delta}$	$\tilde{\delta}^2/1000$
0	0.014 ± 0.002	0.45 ± 0.18	8.7 ± 1.5	51	2.7
300	0.040 ± 0.006	6.8 ± 2.2	63 ± 15	108	11.4
400	0.199 ± 0.007	11.9 ± 4.4	85 ± 27	140	19.4
500	0.713 ± 0.001	30.7 ± 4.5	116 ± 30	265	70.0
1000	0.426 ± 0.003	28.7 ± 3.4	132 ± 65	217	47.2

FIG. 28

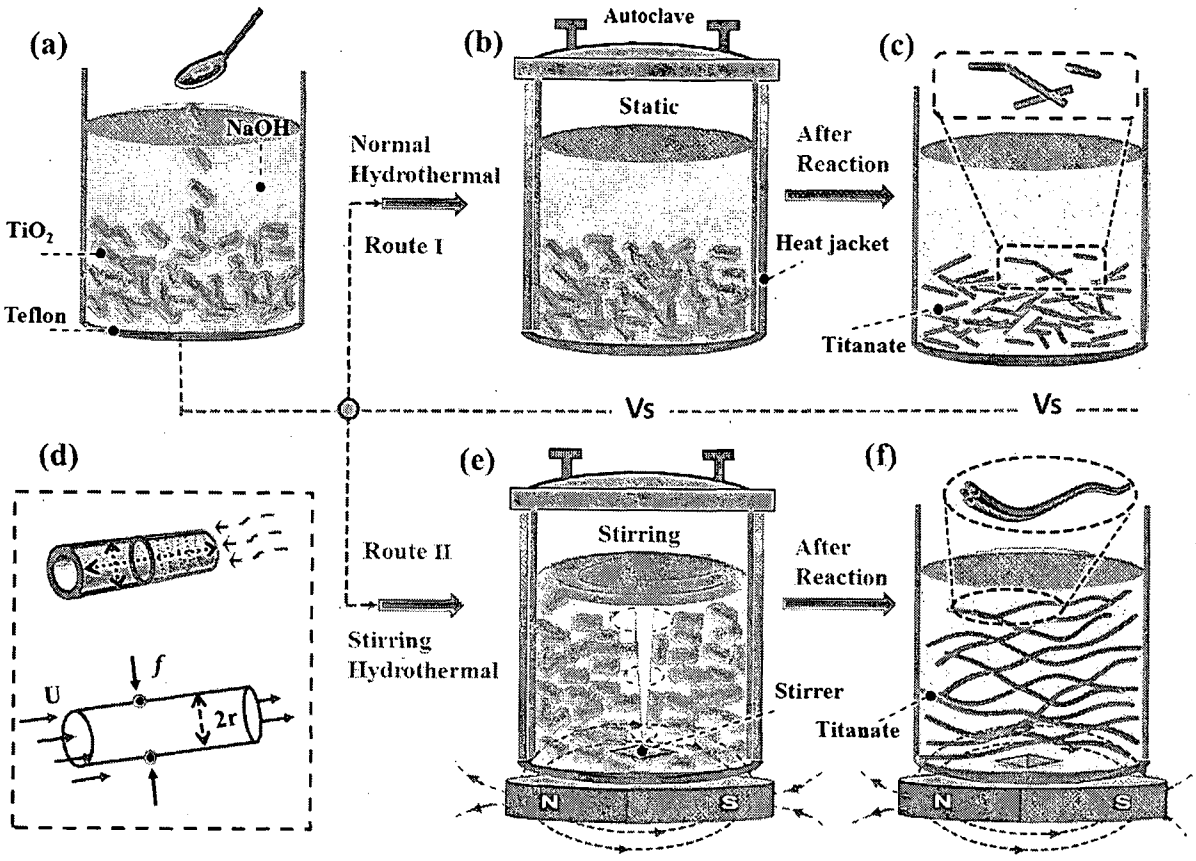
(a)
NaOH
TiO_2
Teflon
Normal
Hydrothermal
Route I
(b)
Autoclave
Static
Heat jacket
After
Reaction
(c)
Titanate
Vs
Vs
(d)
U
f
2r
Route II
Stirring
Hydrothermal
(e)
Stirring
Stirrer
N
S
After
Reaction
(f)
Titanate
N
S

FIG. 29

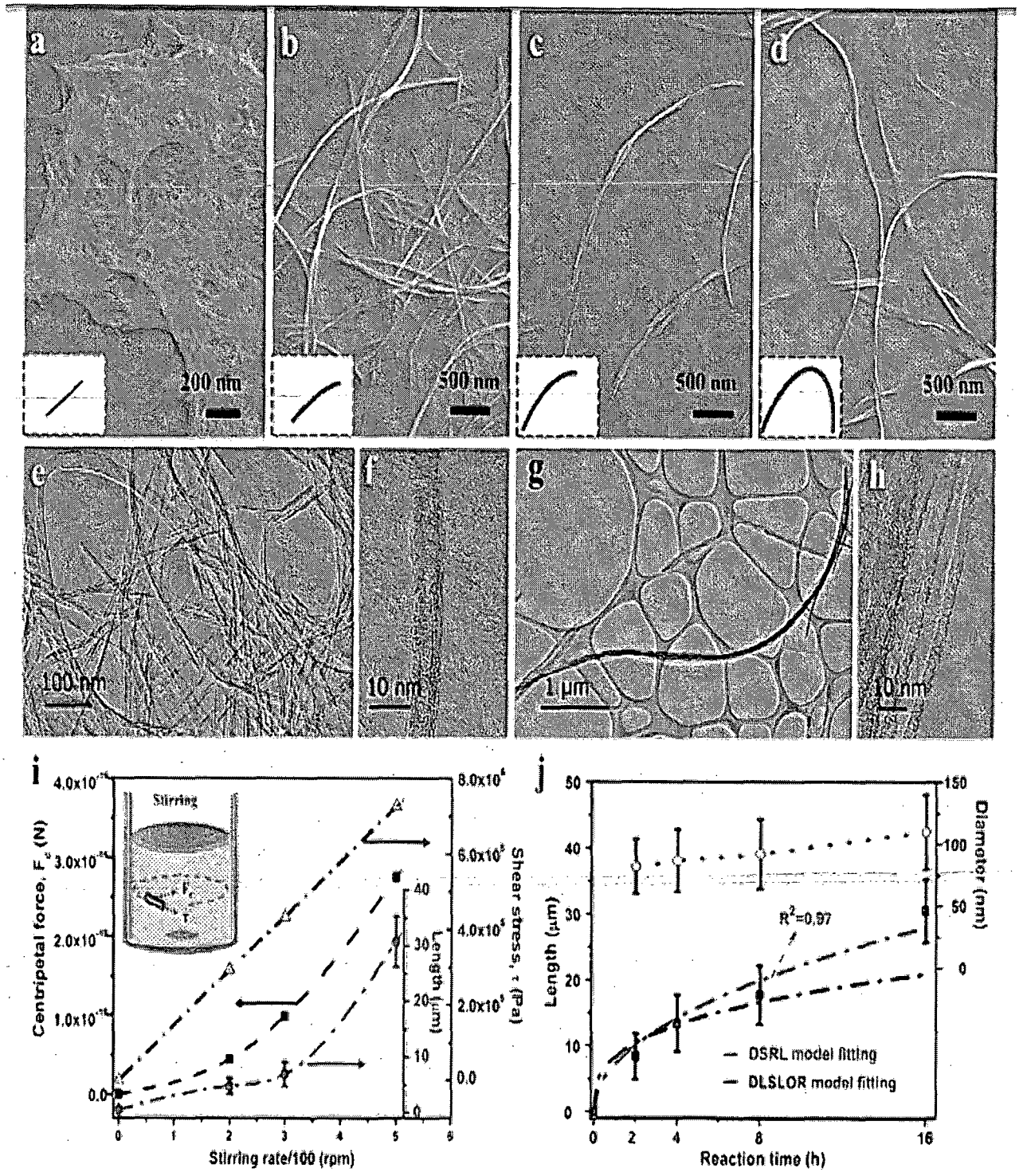
a
200 nm
b
500 nm
c
500 nm
d
500 nm
e
100 nm
f
10 nm
g
1 μm
h
10 nm
i
Stirring
Centripetal force, F_c (N)
Shear stress, τ (Pa)
Length (μm)
Stirring rate/100 (rpm)
j
Length (μm)
Diameter (nm)
R^2=0.97
DSRL model fitting
DLSLOR model fitting
Reaction time (h)

FIG. 30

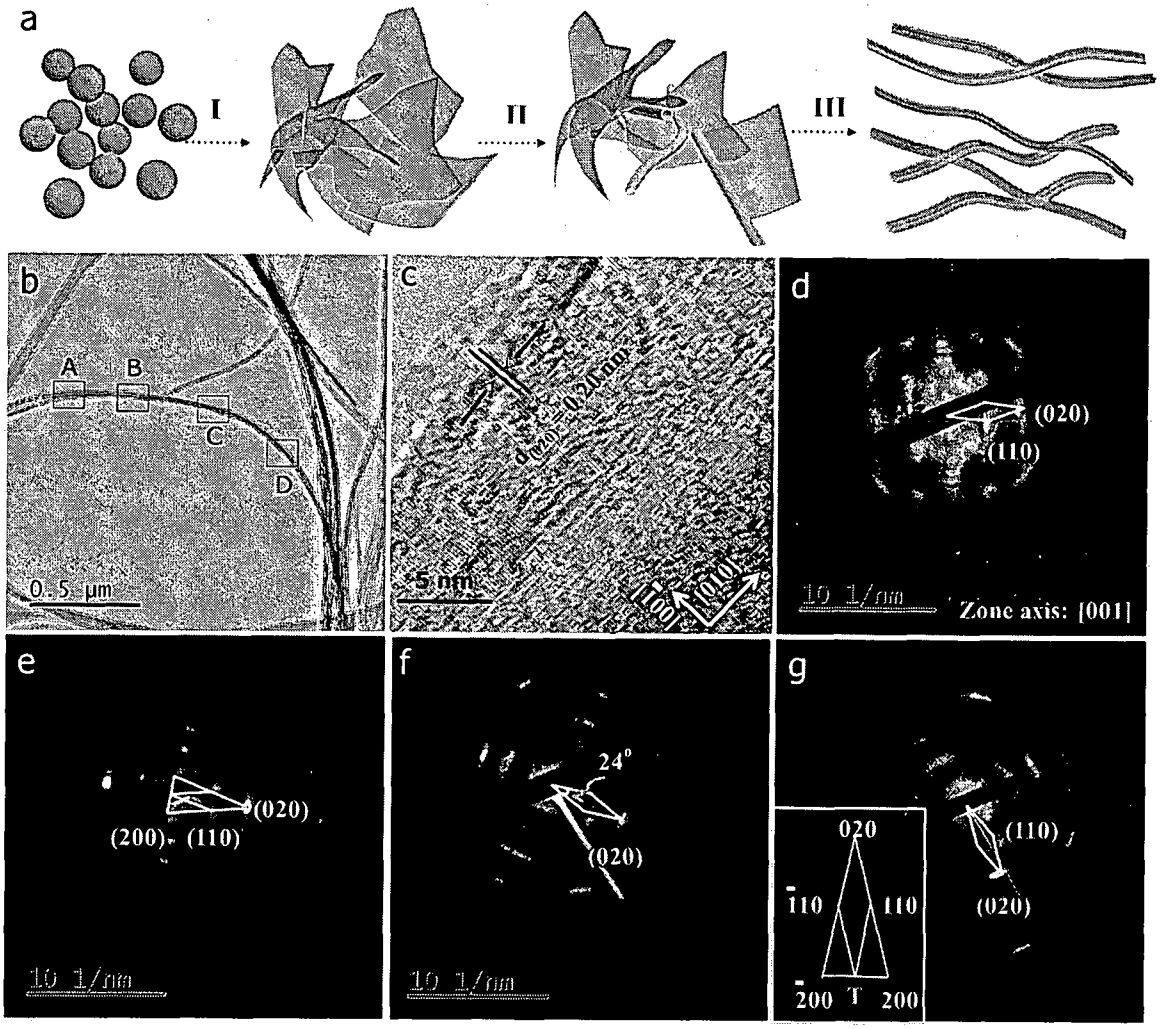
a
I
II
III
b
A
B
C
D
0.5 μm
c
0.240 nm
5 nm
d
(020)
(110)
10 1/nm
Zone axis: [001]
e
(020)
(200)
(110)
10 1/nm
f
24°
(020)
10 1/nm
g
020
110
110
200
T
200
(110)
(020)

FIG. 31

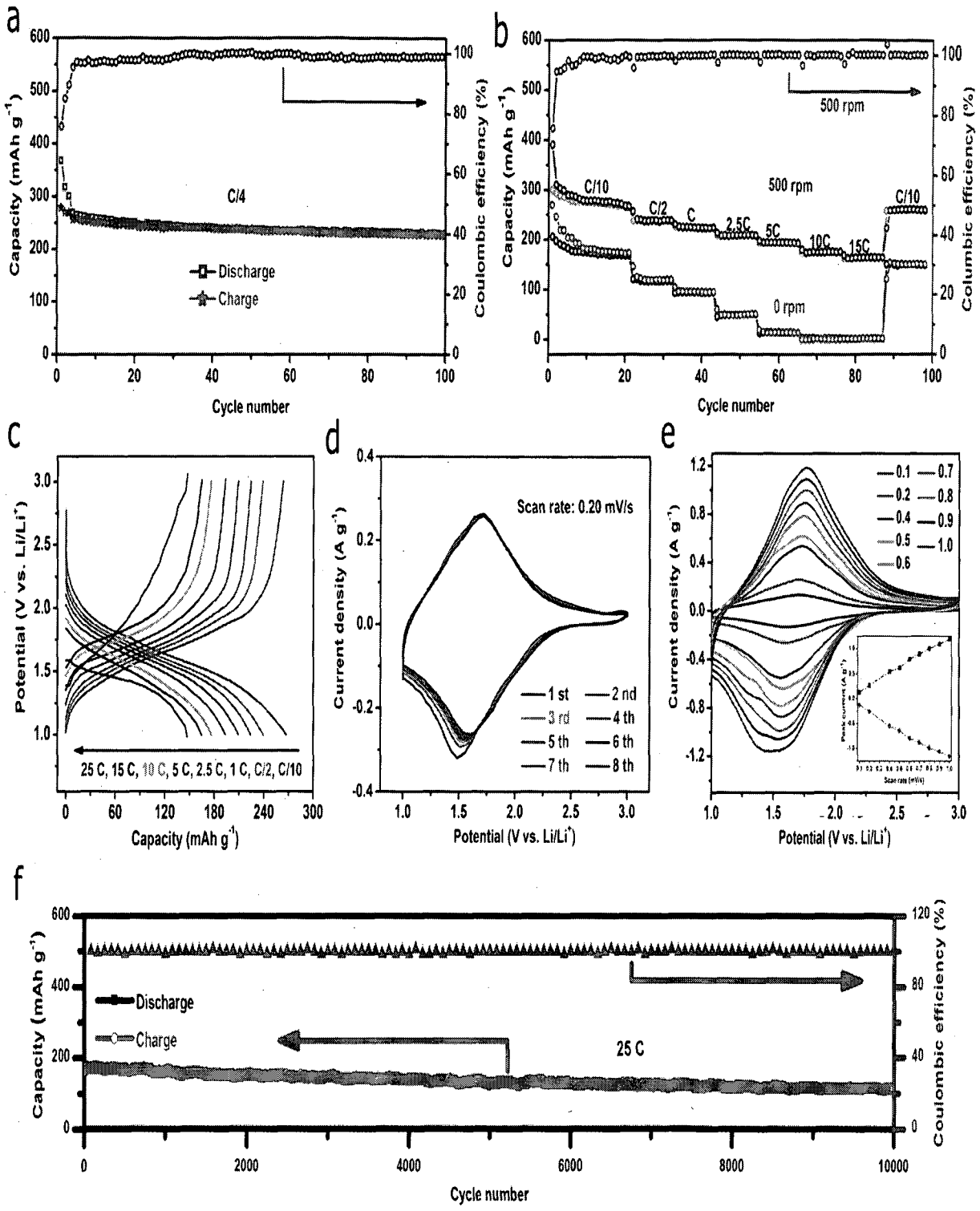
a
Capacity (mAh g-1)
Coulombic efficiency (%)
Cycle number
C/4
Discharge
Charge
b
Capacity (mAh g-1)
Coulombic efficiency (%)
Cycle number
500 rpm
C/10
C/2
C
2.5C
5C
10C
15C
C/10
0 rpm
c
Potential (V vs. Li/Li+)
Capacity (mAh g-1)
25 C, 15 C, 10 C, 5 C, 2.5 C, 1 C, C/2, C/10
d
Current density (A g-1)
Potential (V vs. Li/Li+)
Scan rate: 0.20 mV/s
1 st
2 nd
3 rd
4 th
5 th
6 th
7 th
8 th
e
Current density (A g-1)
Potential (V vs. Li/Li+)
0.1
0.2
0.4
0.5
0.6
0.7
0.8
0.9
1.0
f
Capacity (mAh g-1)
Coulombic efficiency (%)
Cycle number
Discharge
Charge
25 C

FIG. 32

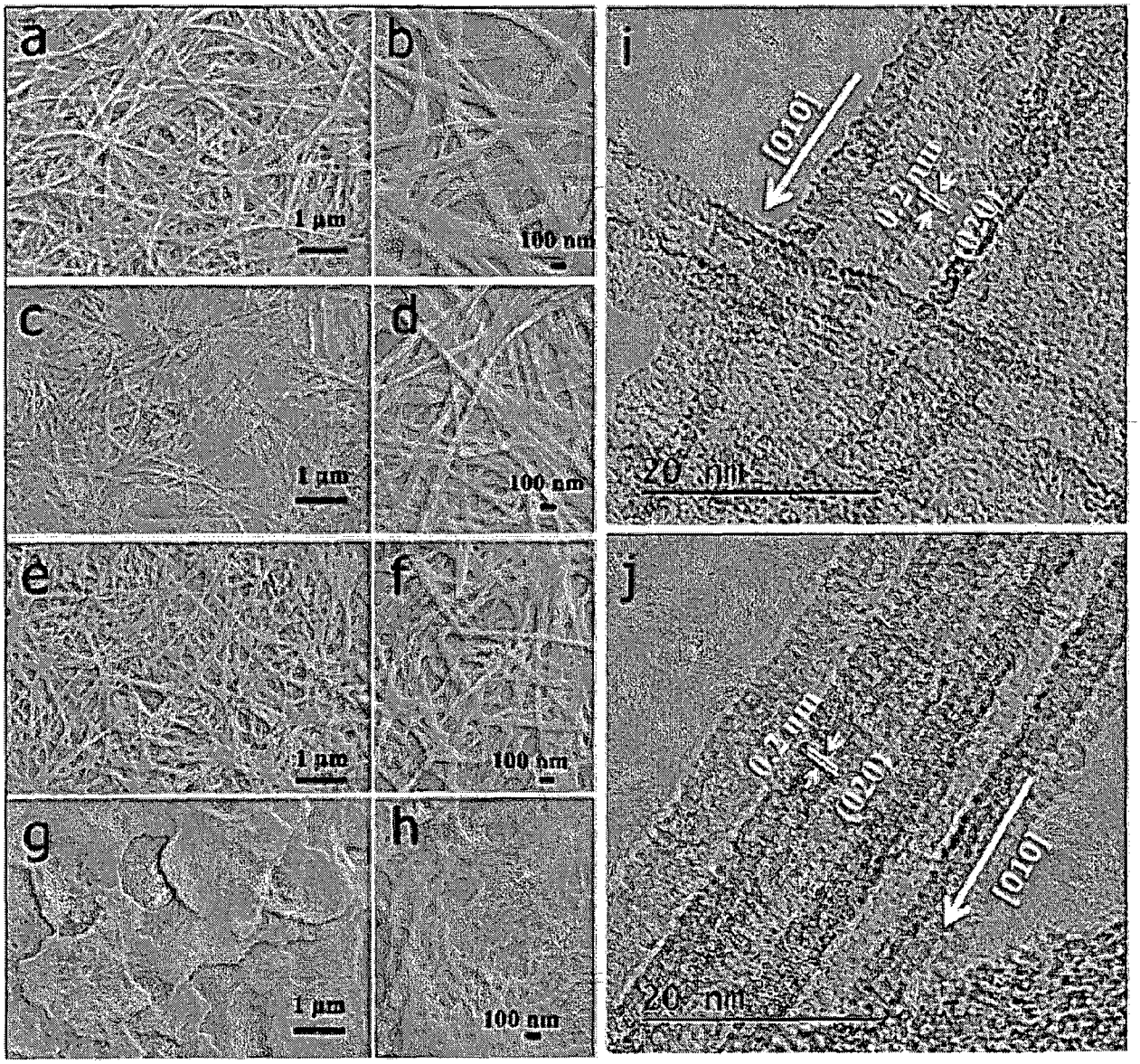
a
1 μm
b
100 nm
c
1 μm
d
100 nm
e
1 μm
f
100 nm
g
1 μm
h
100 nm
i
[0101]
0.2 nm
(0 2 0)
20 nm
j
0.2 nm
(0 2 0)
[0101]
20 nm

FIG. 33

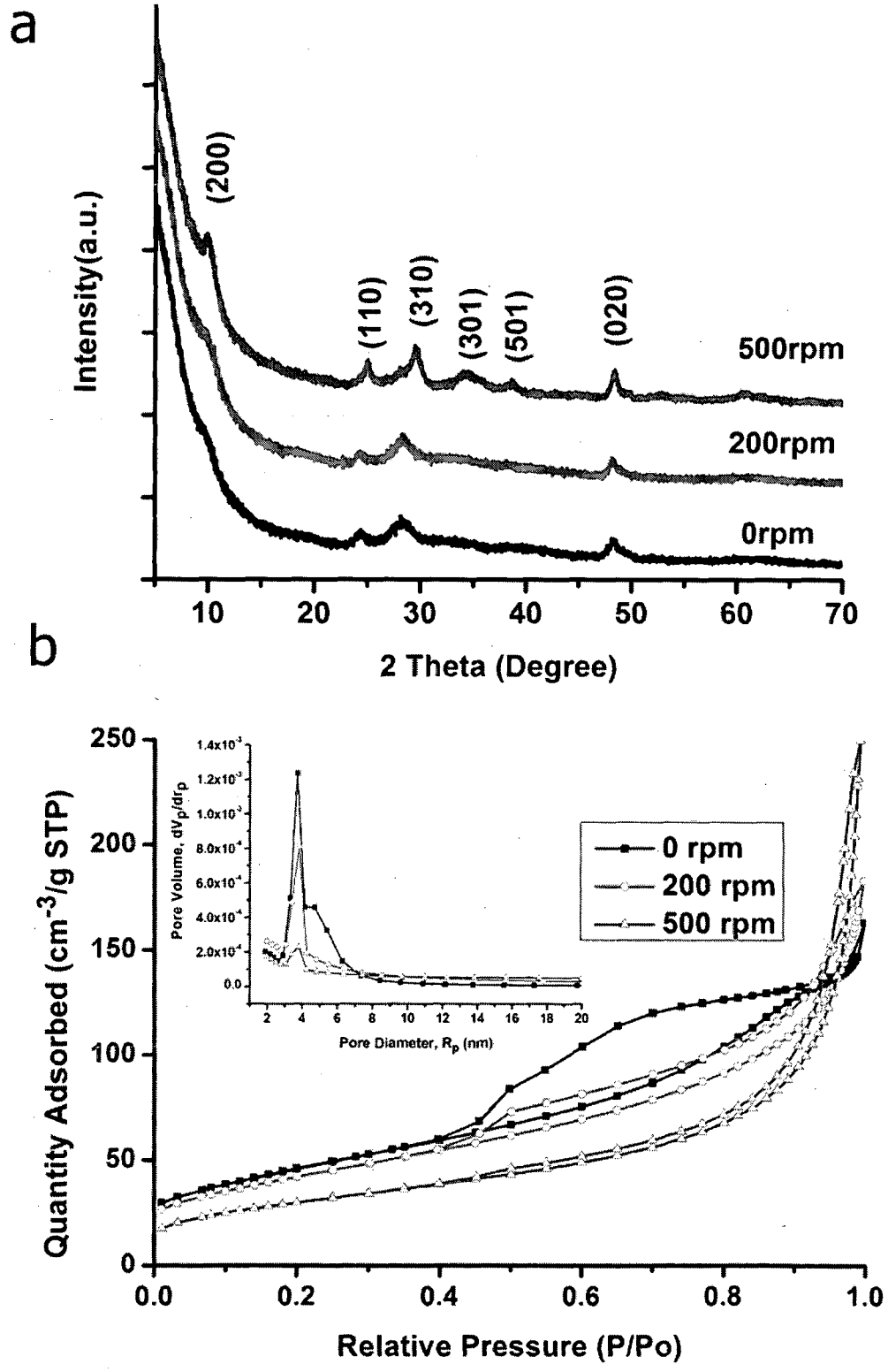
a
Intensity(a.u.)
(200)
(110)
(310)
(301)
(501)
(020)
500rpm
200rpm
0rpm
10
20
30
40
50
60
70
2 Theta (Degree)
b
Quantity Adsorbed (cm-3/g STP)
250
200
150
100
50
0
0.0
0.2
0.4
0.6
0.8
1.0
Relative Pressure (P/Po)
0 rpm
200 rpm
500 rpm
Pore Volume, dVp/drp
Pore Diameter, Rp (nm)

FIG. 34

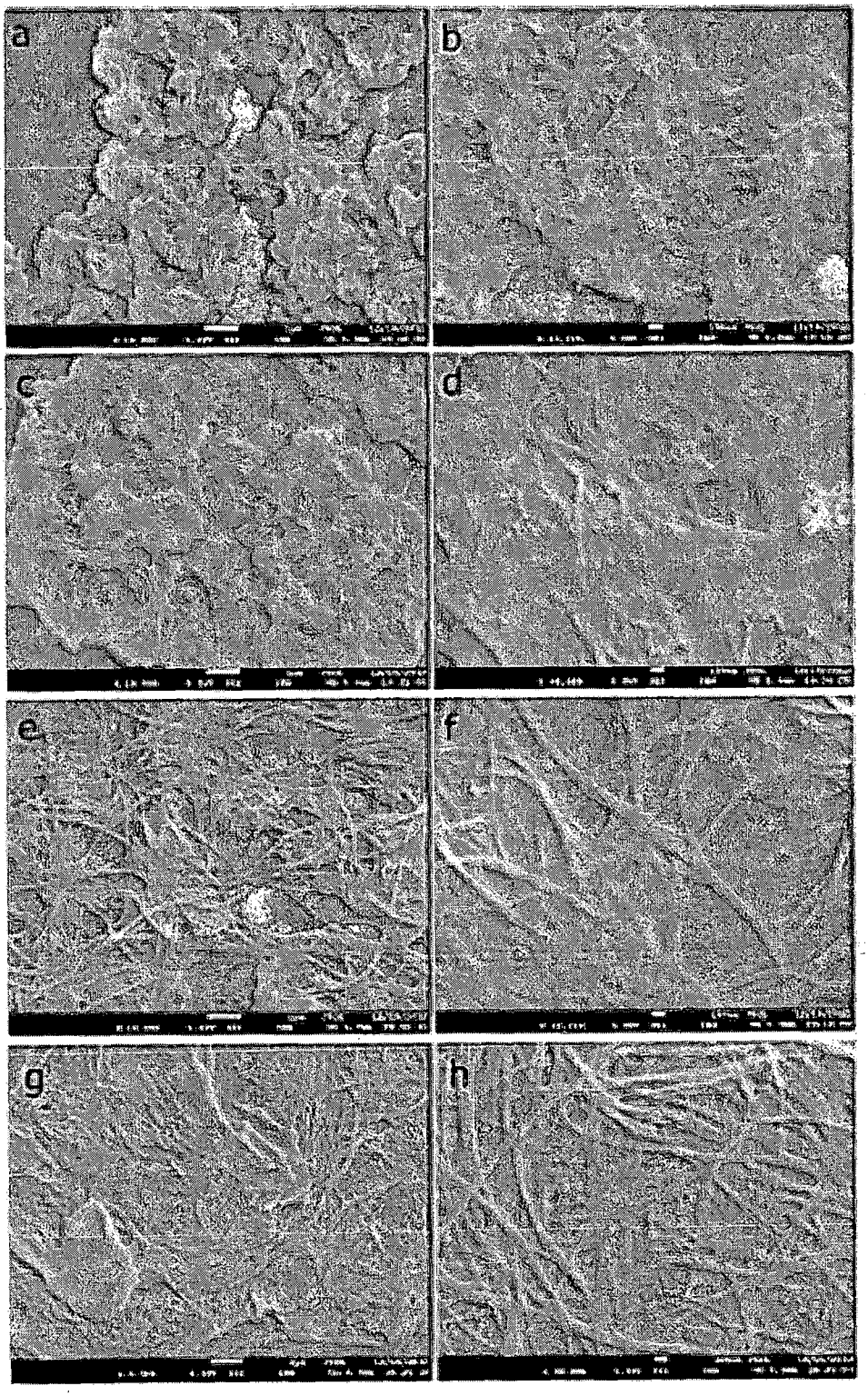

FIG. 35

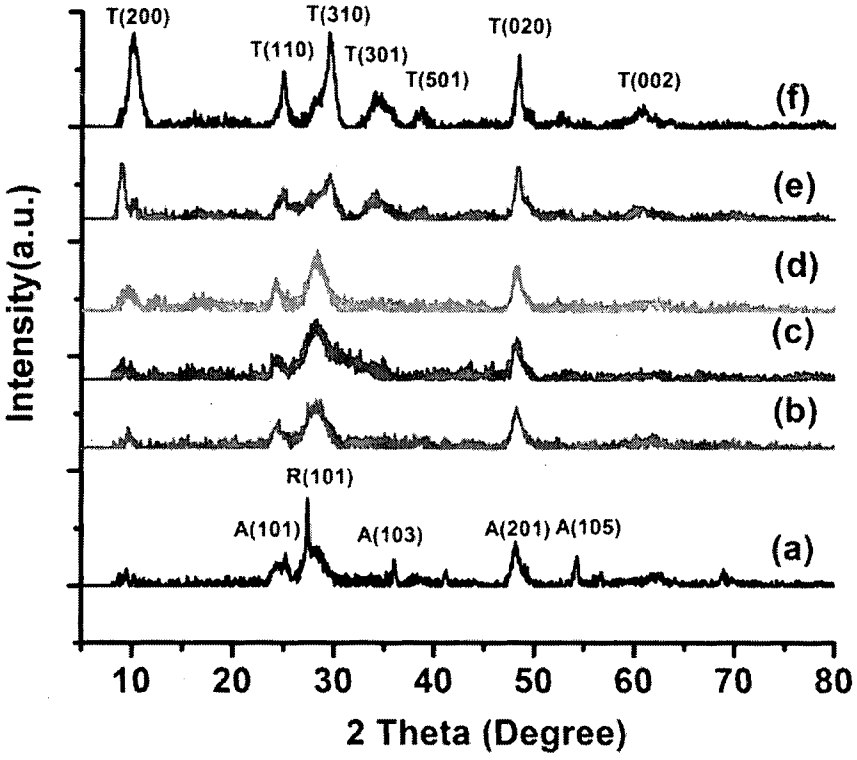
T(200)
T(110)
T(310)
T(301)
T(501)
T(020)
T(002)
(f)
(e)
(d)
(c)
(b)
R(101)
A(101)
A(103)
A(201)
A(105)
(a)
Intensity(a.u.)
10
20
30
40
50
60
70
80
2 Theta (Degree)

FIG. 36

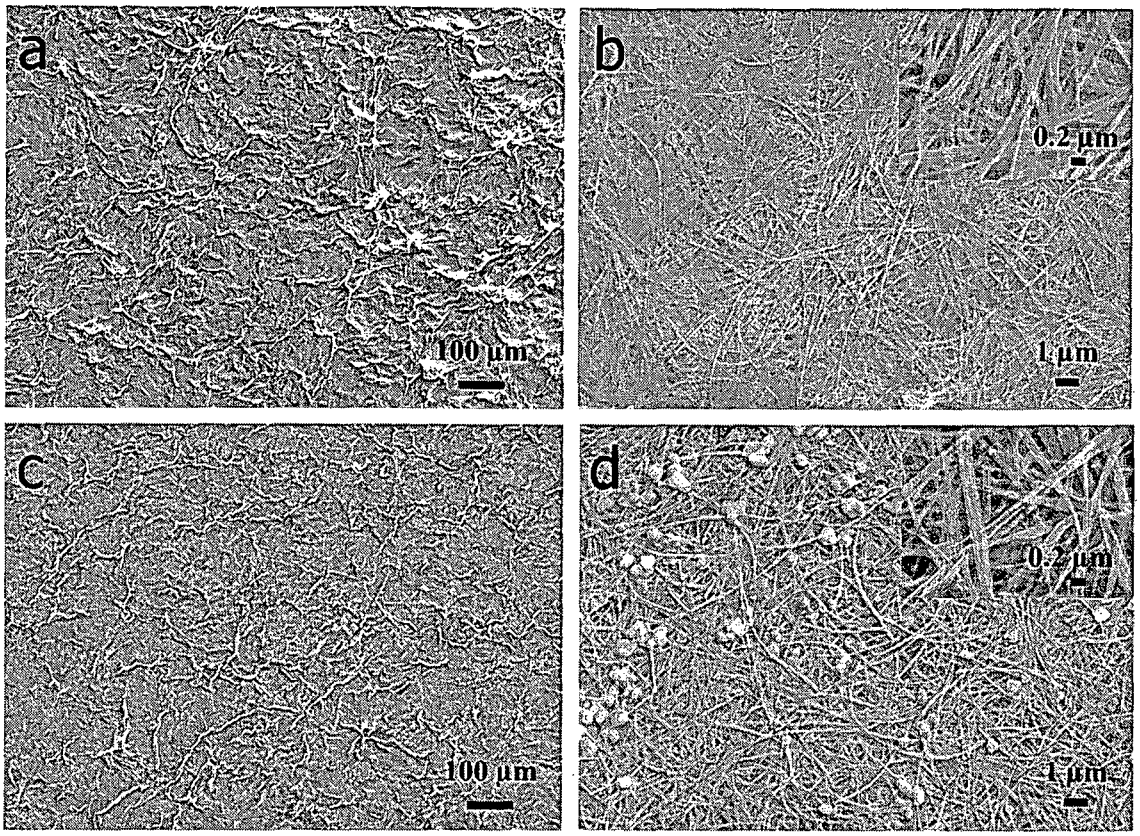

FIG. 37

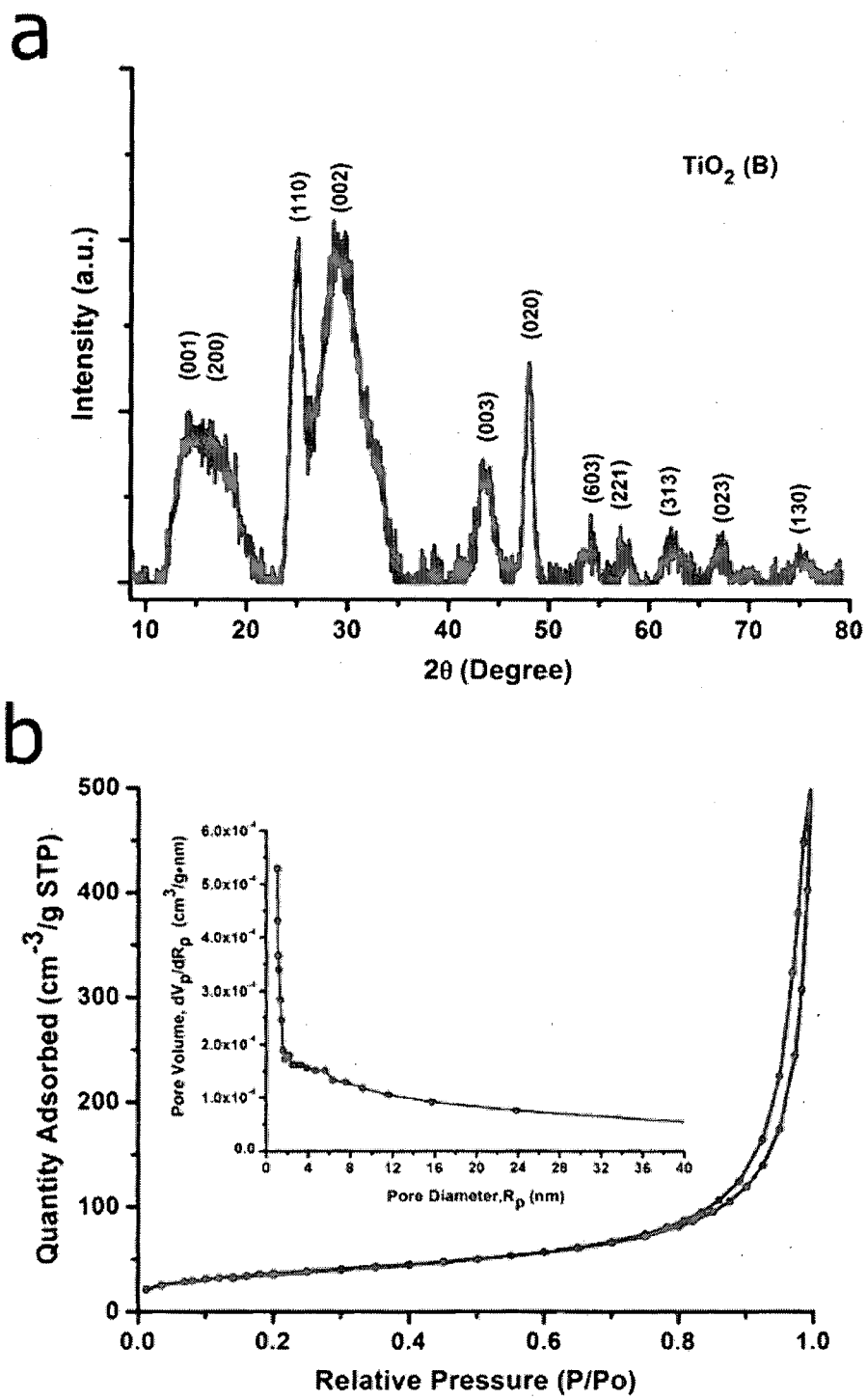
a
TiO2 (B)
Intensity (a.u.)
(001)
(200)
(110)
(002)
(003)
(020)
(603)
(221)
(313)
(023)
(130)
10
20
30
40
50
60
70
80
2θ (Degree)
b
Quantity Adsorbed (cm-3/g STP)
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
Relative Pressure (P/Po)
Pore Volume, dVp/dRp (cm3/g•nm)
6.0x10-4
5.0x10-4
4.0x10-4
3.0x10-4
2.0x10-4
1.0x10-4
0.0
0
4
8
12
16
20
24
28
32
36
40
Pore Diameter,Rp (nm)

FIG. 38

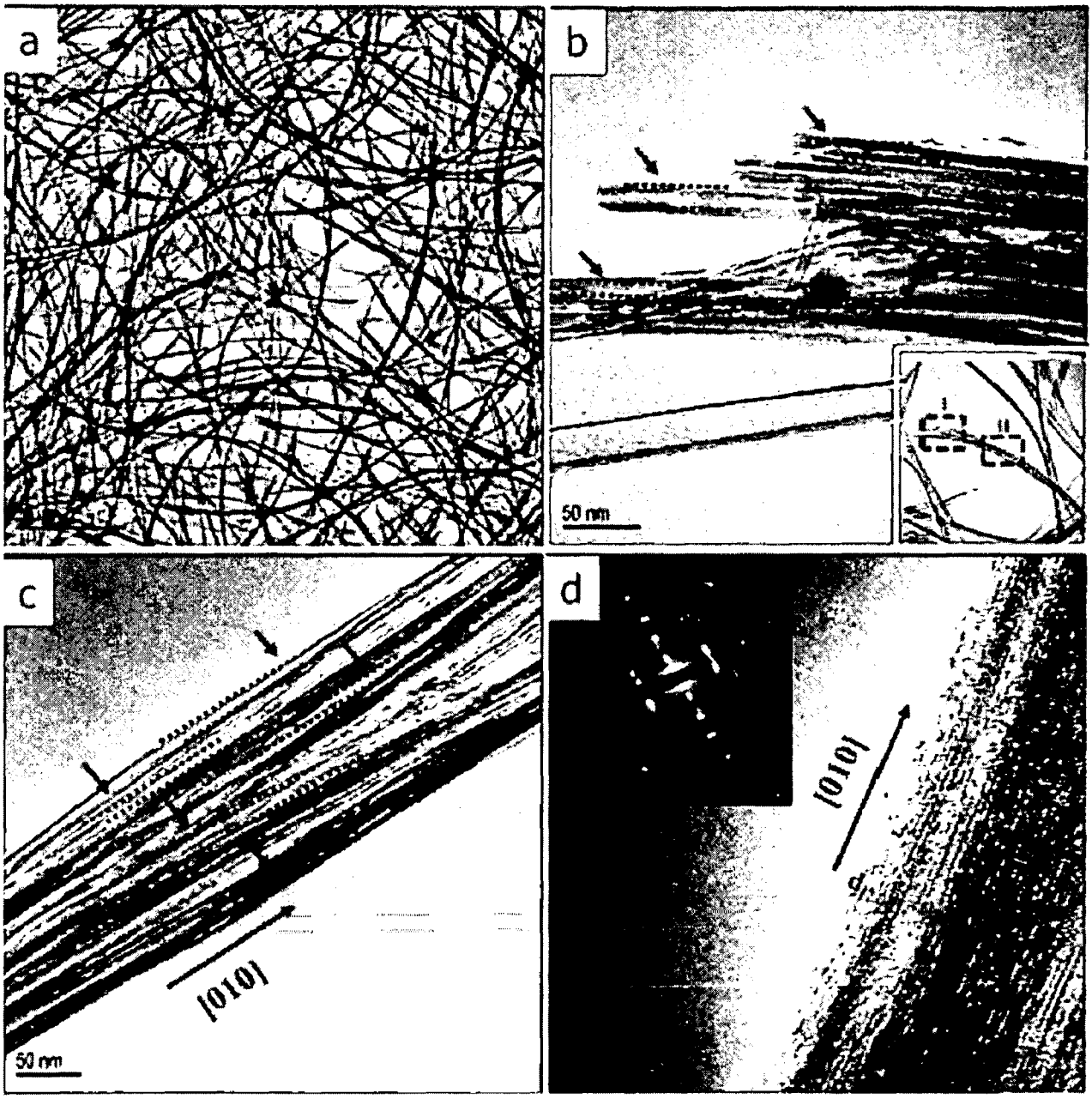

FIG. 39

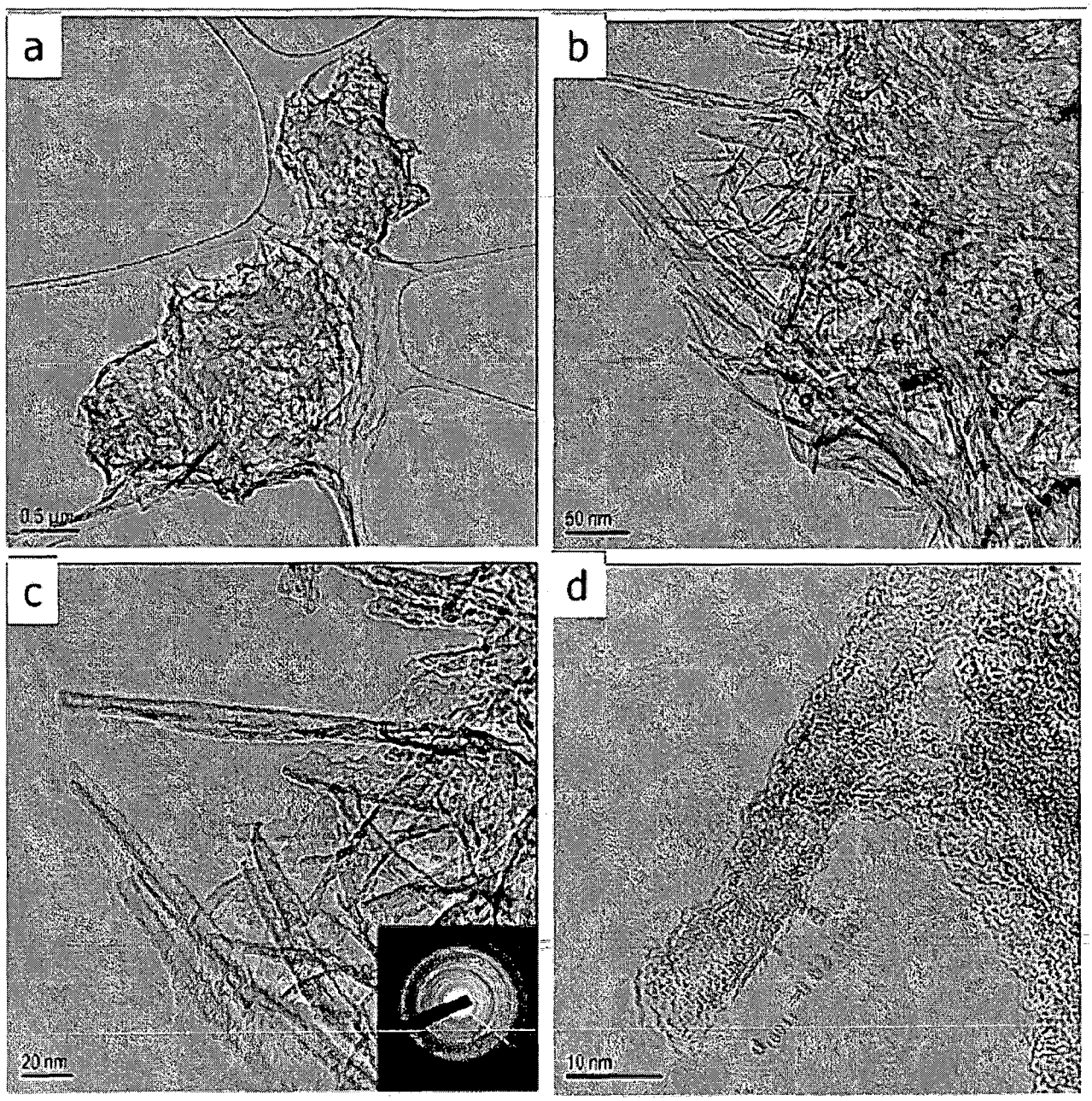

FIG. 40

