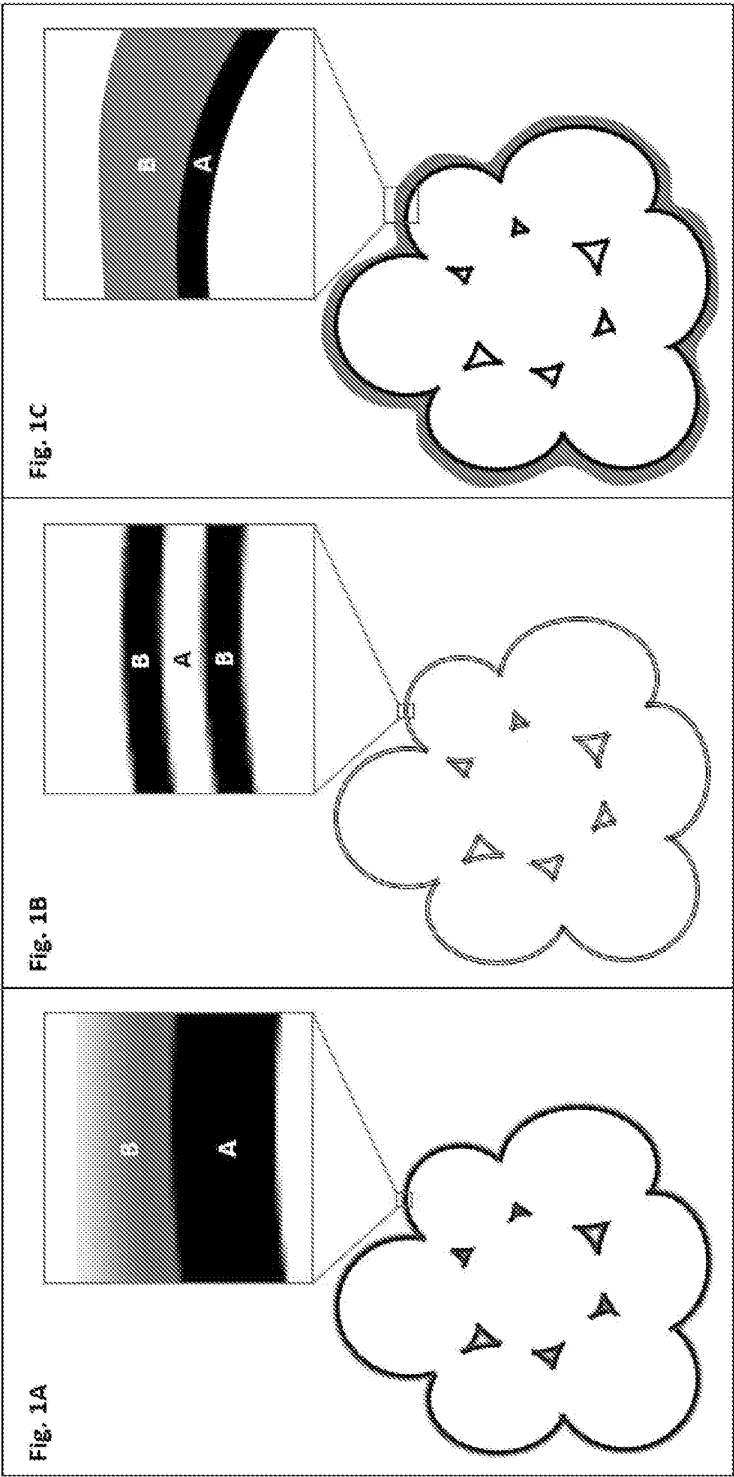




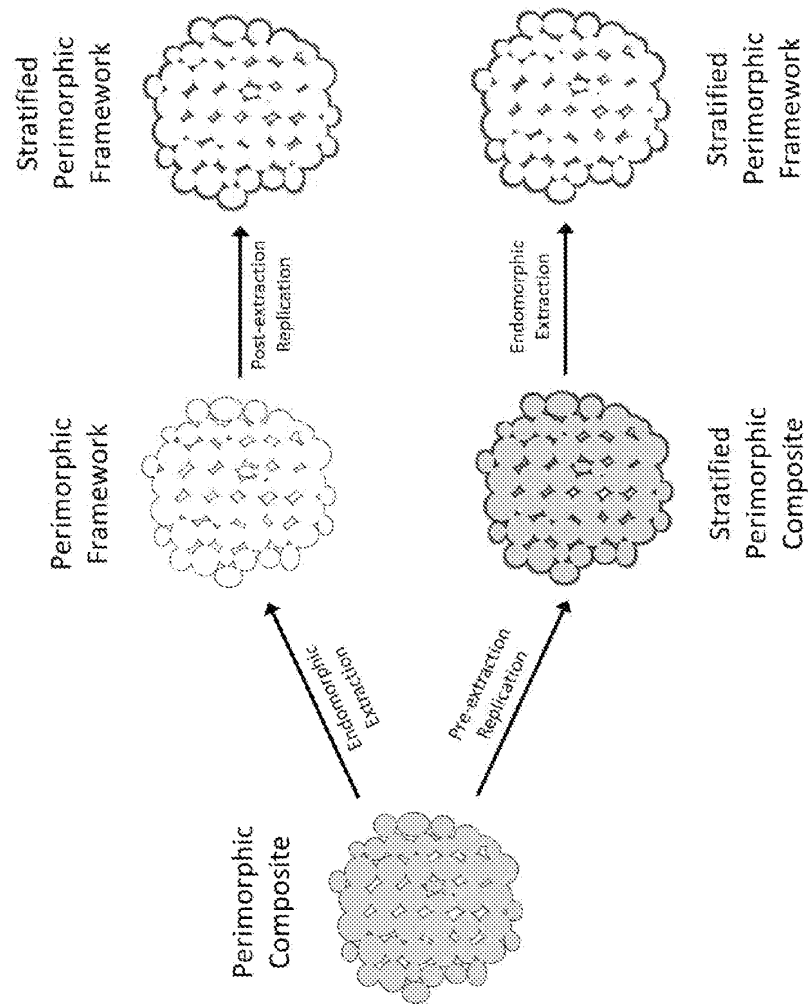
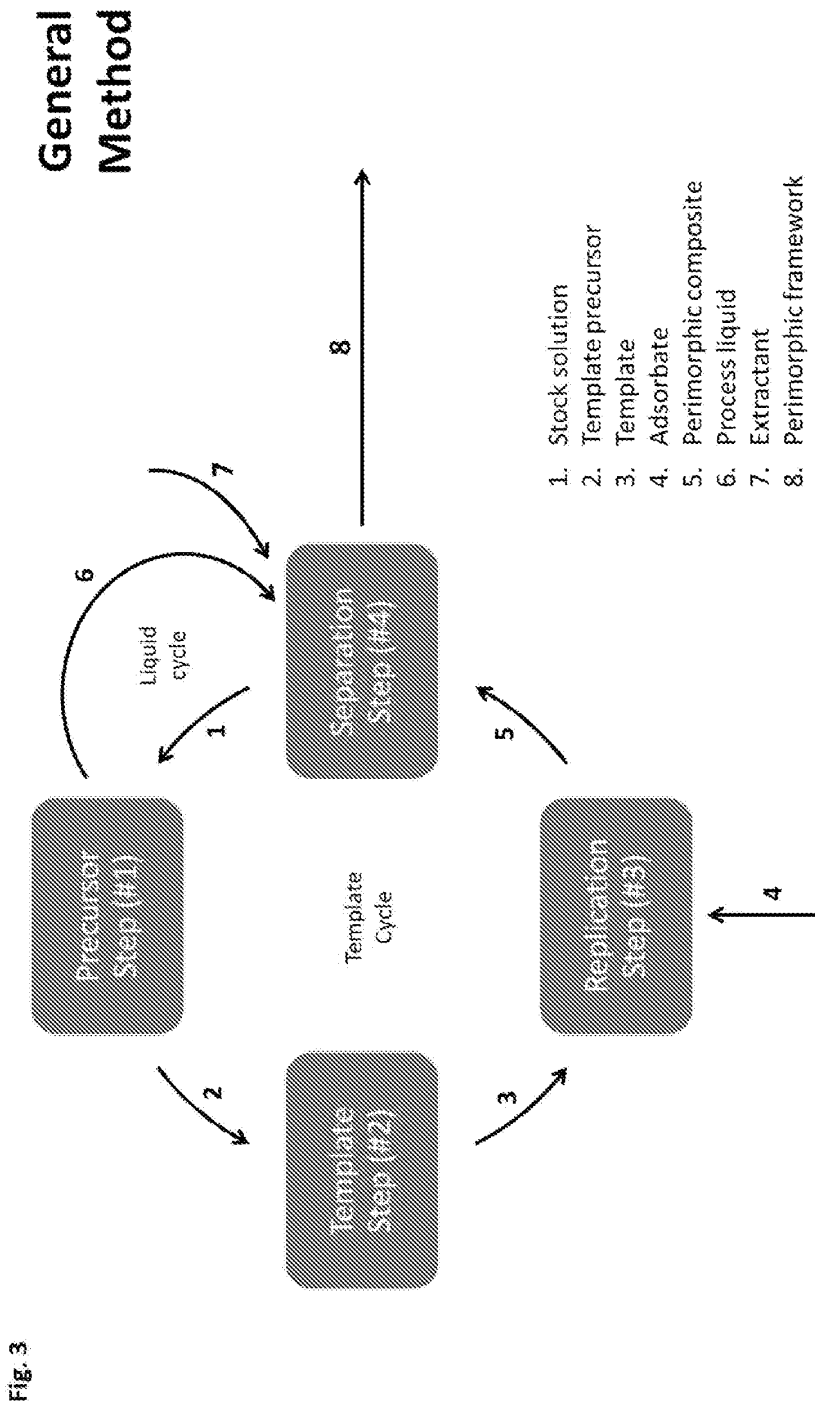
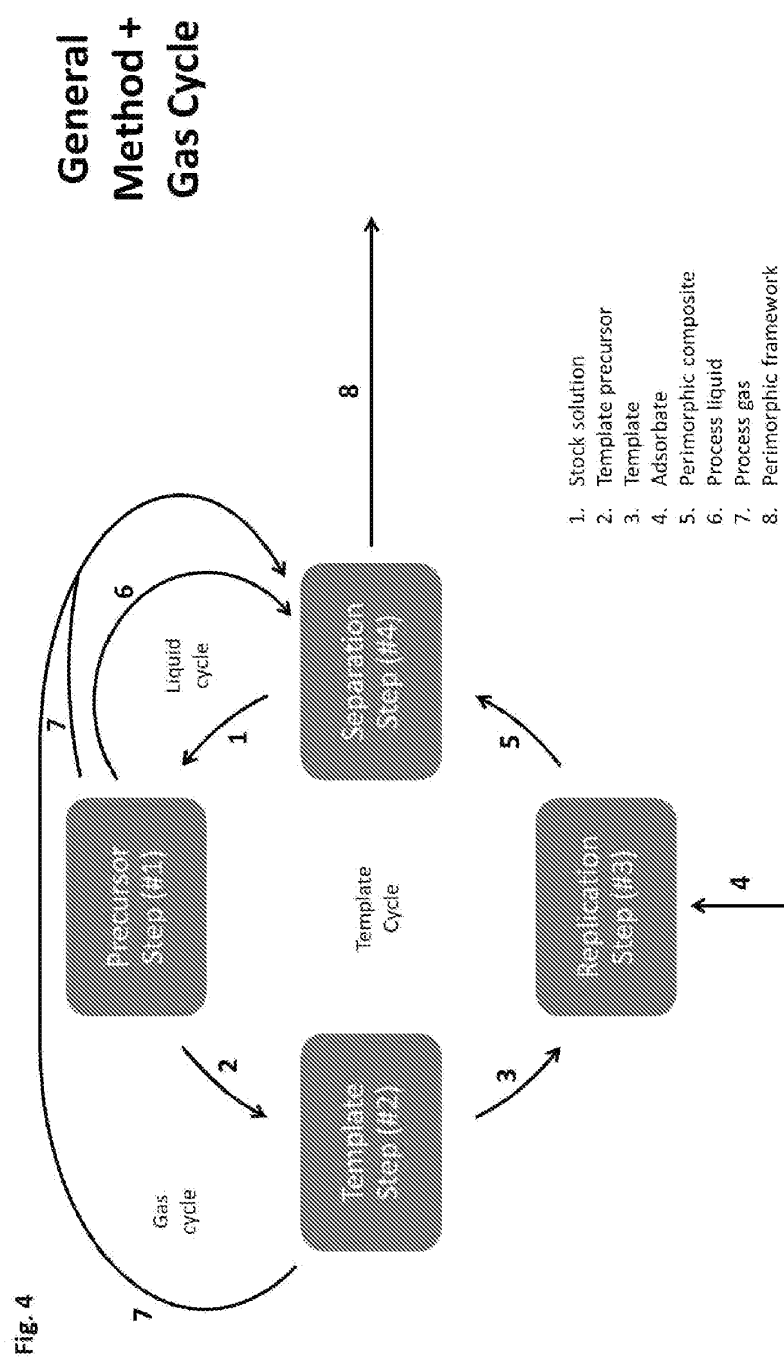


Fig. 2





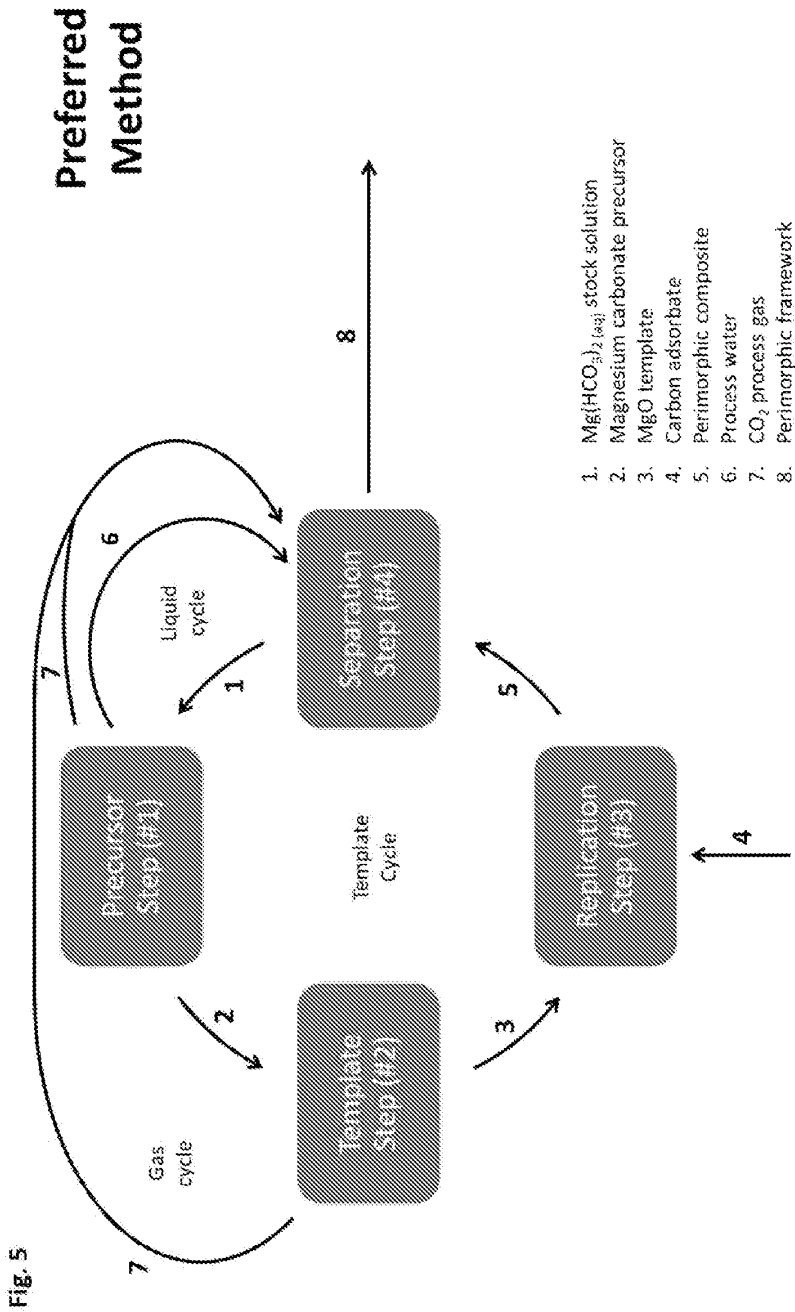
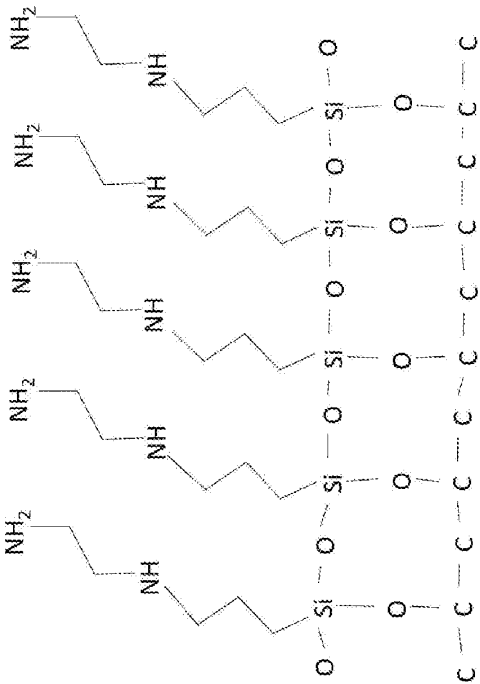
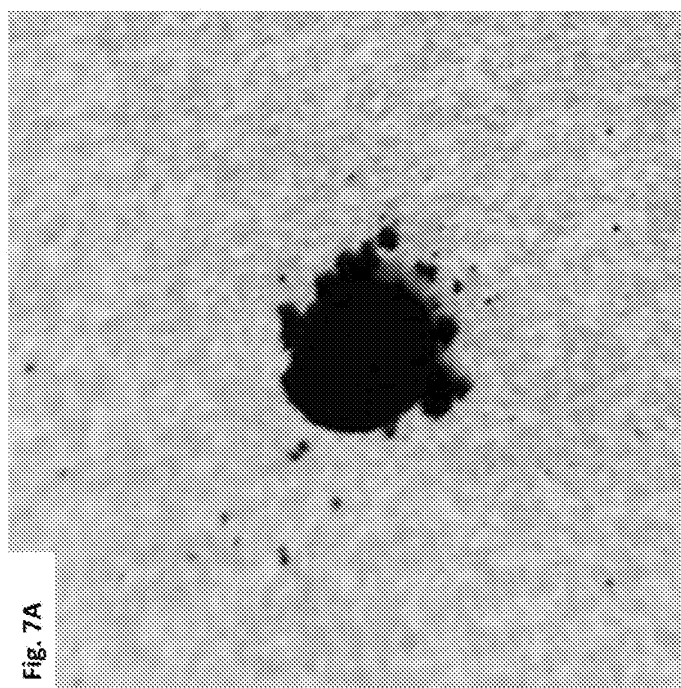
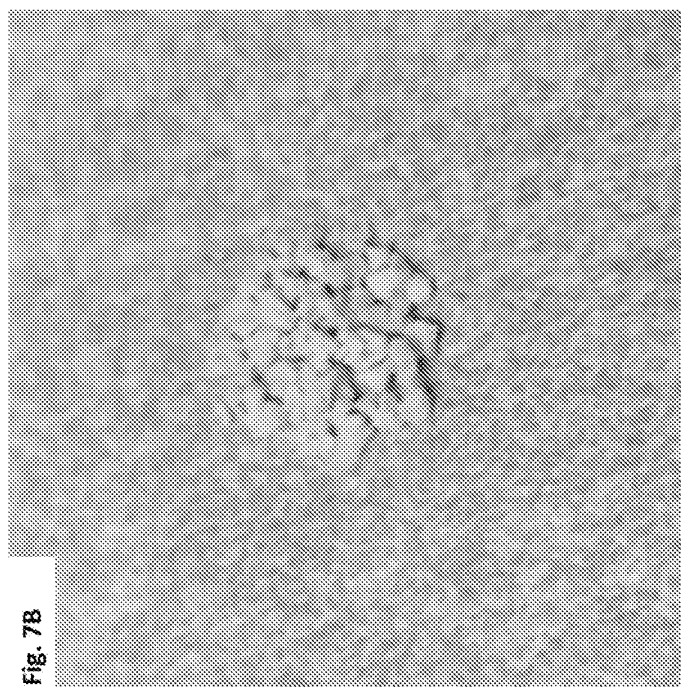
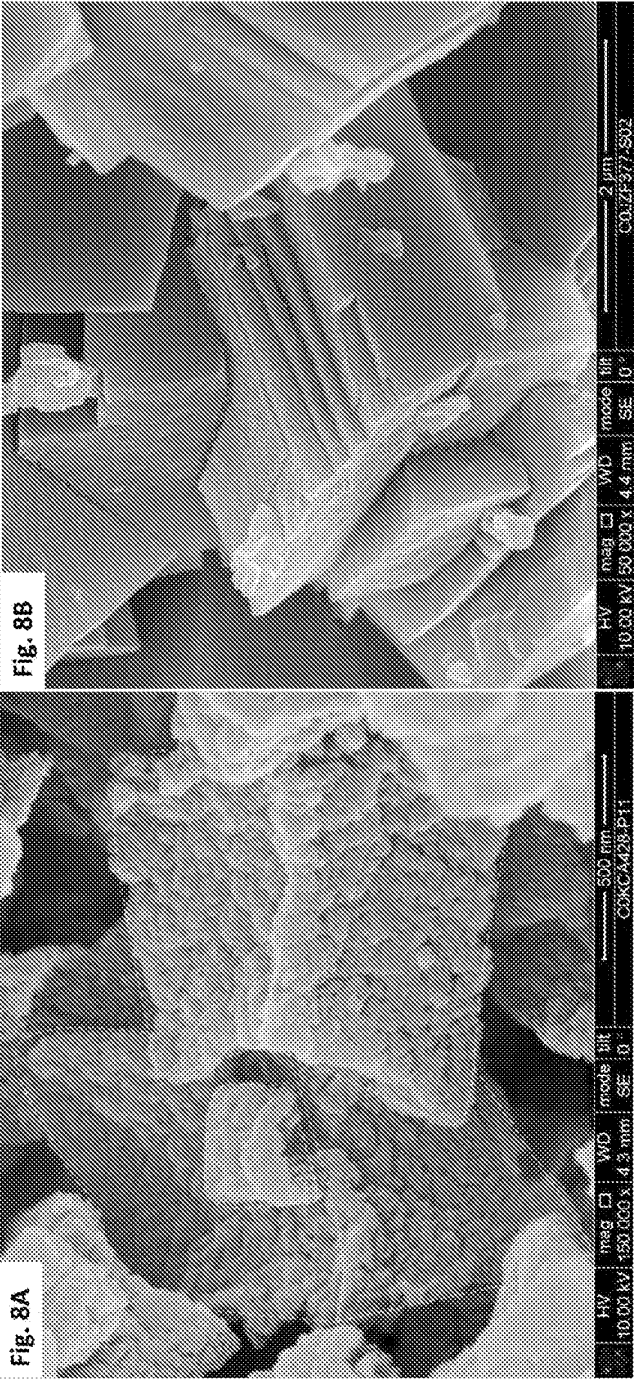


Fig. 6







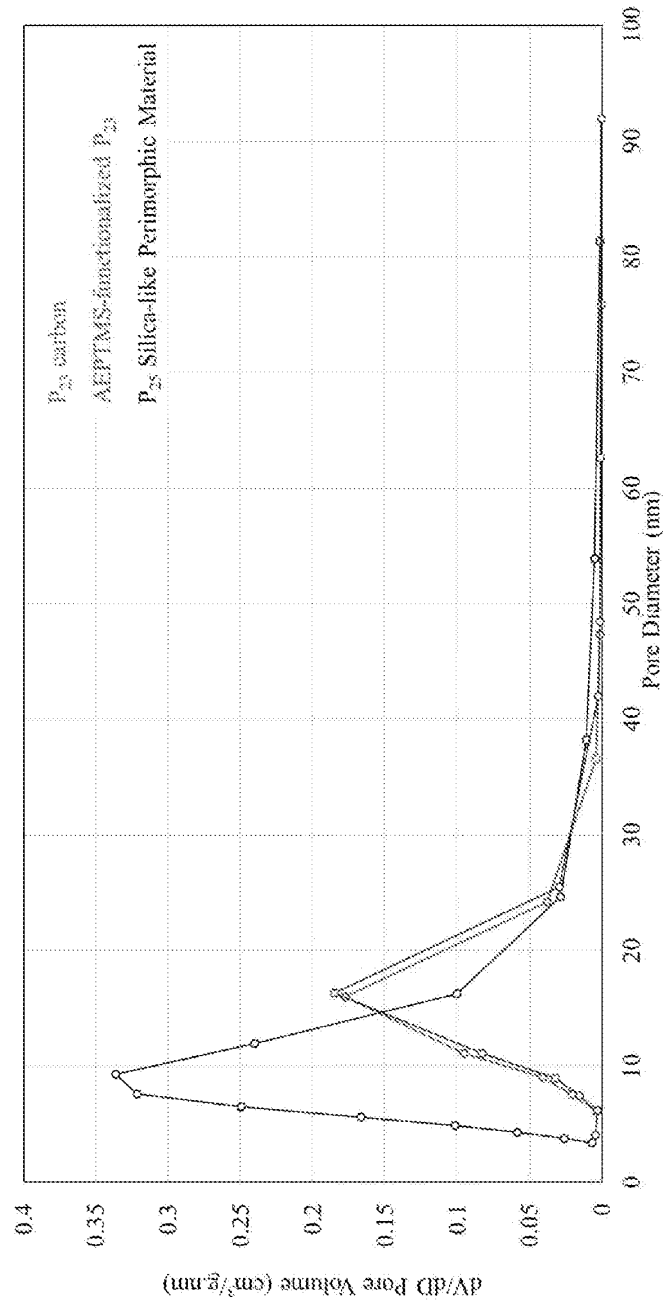


Fig. 9

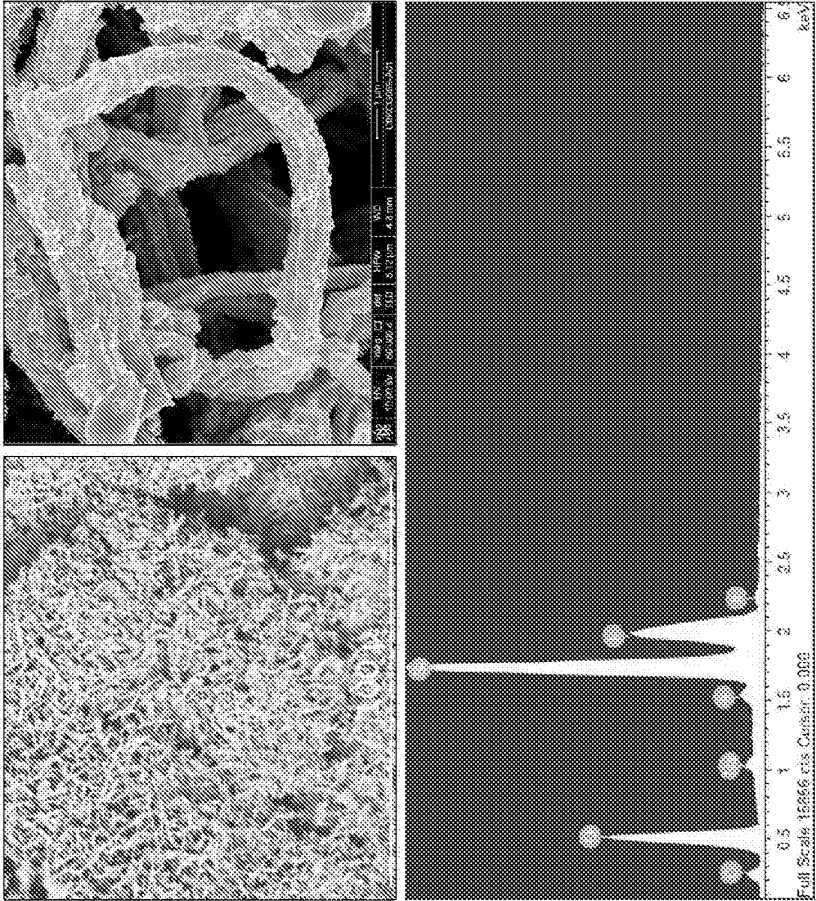


Fig. 10

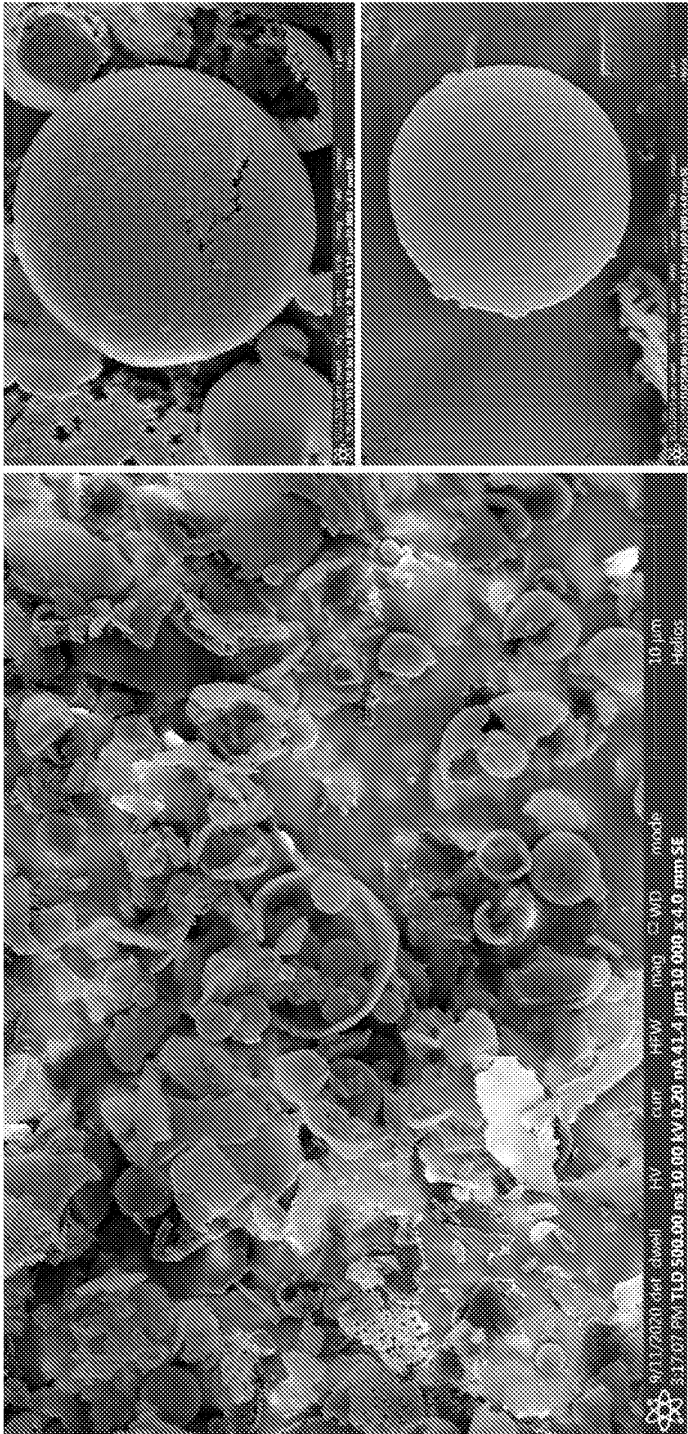
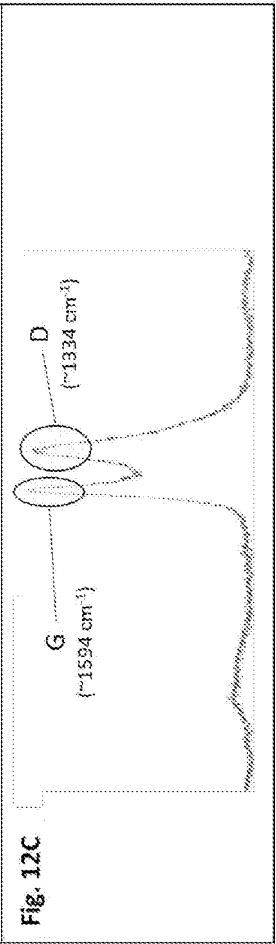
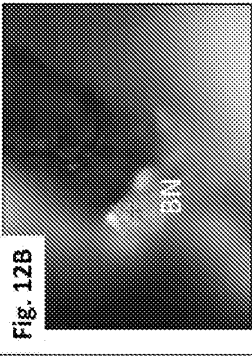
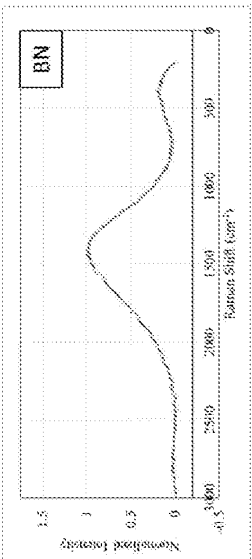
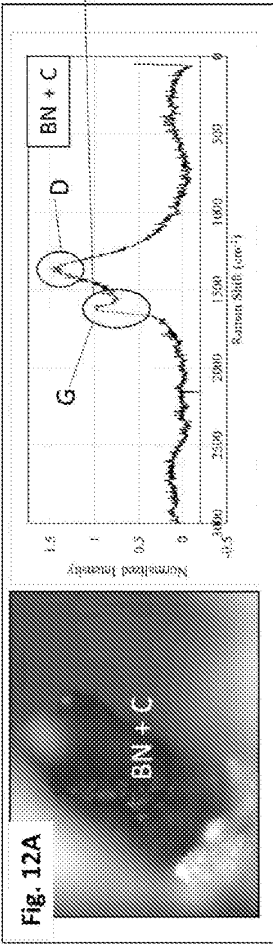
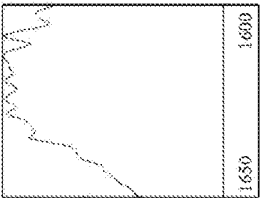
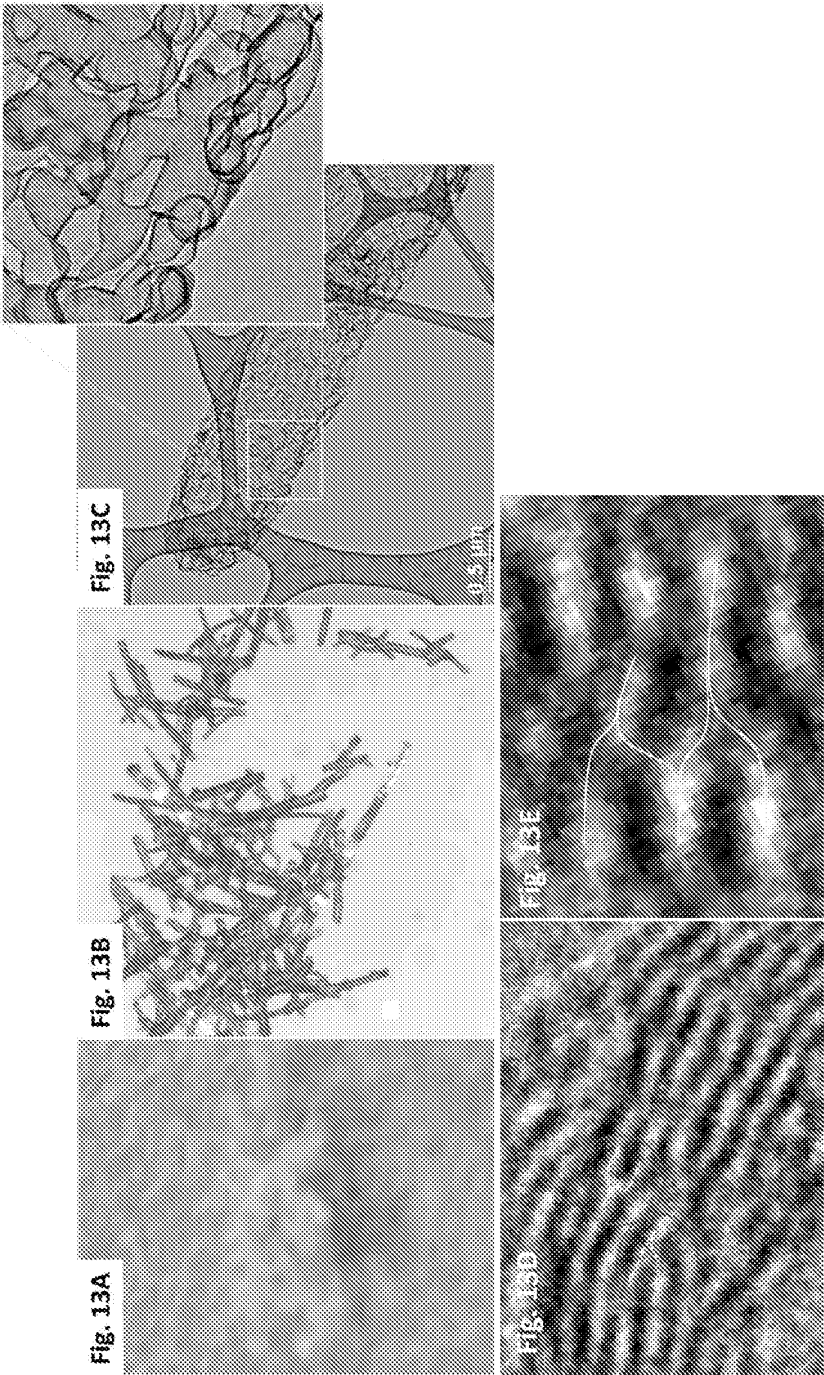
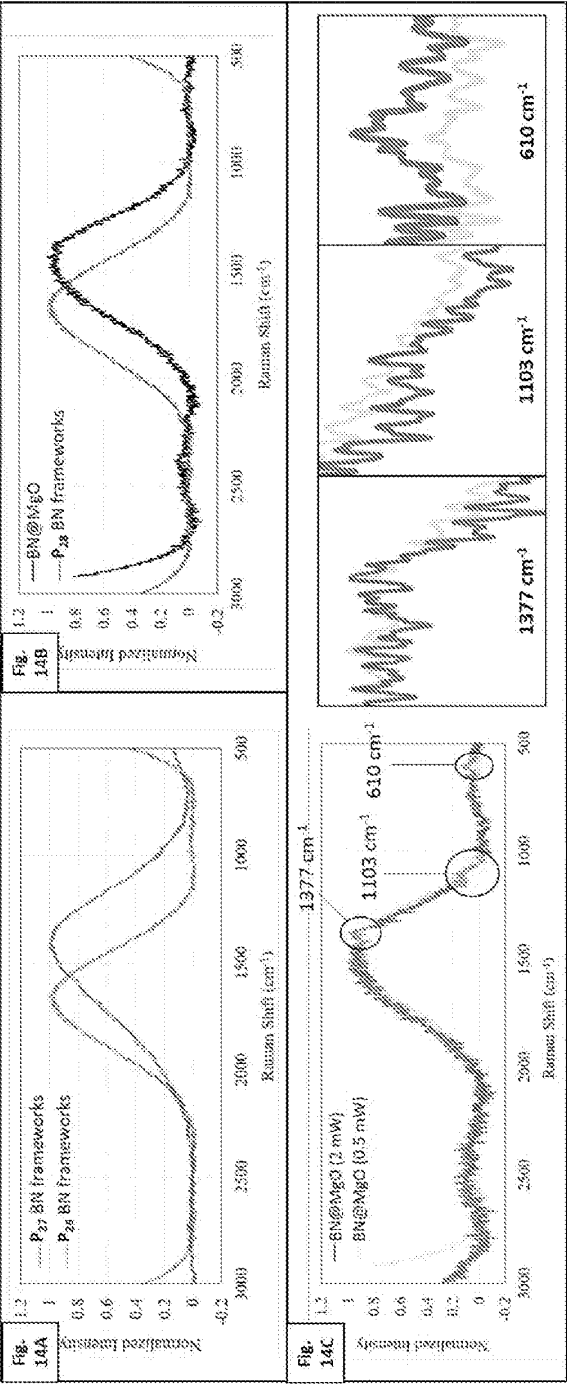
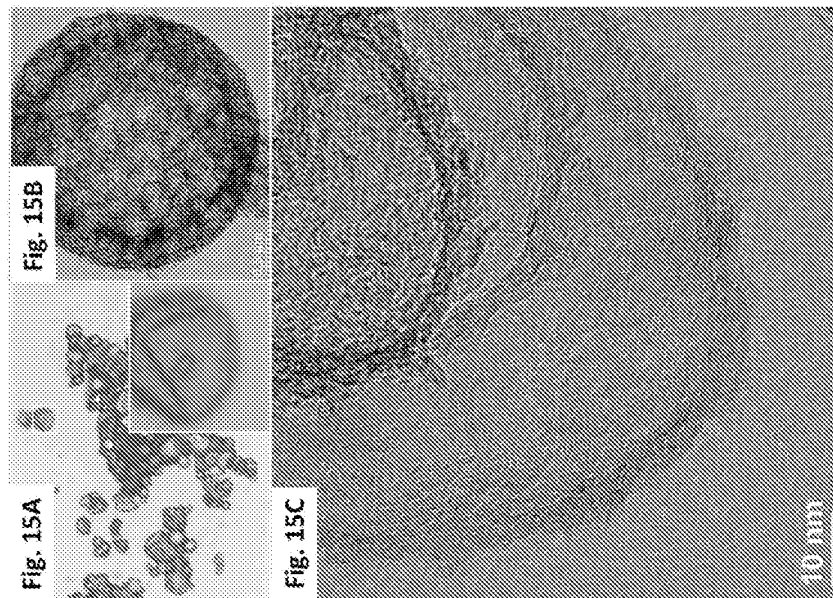


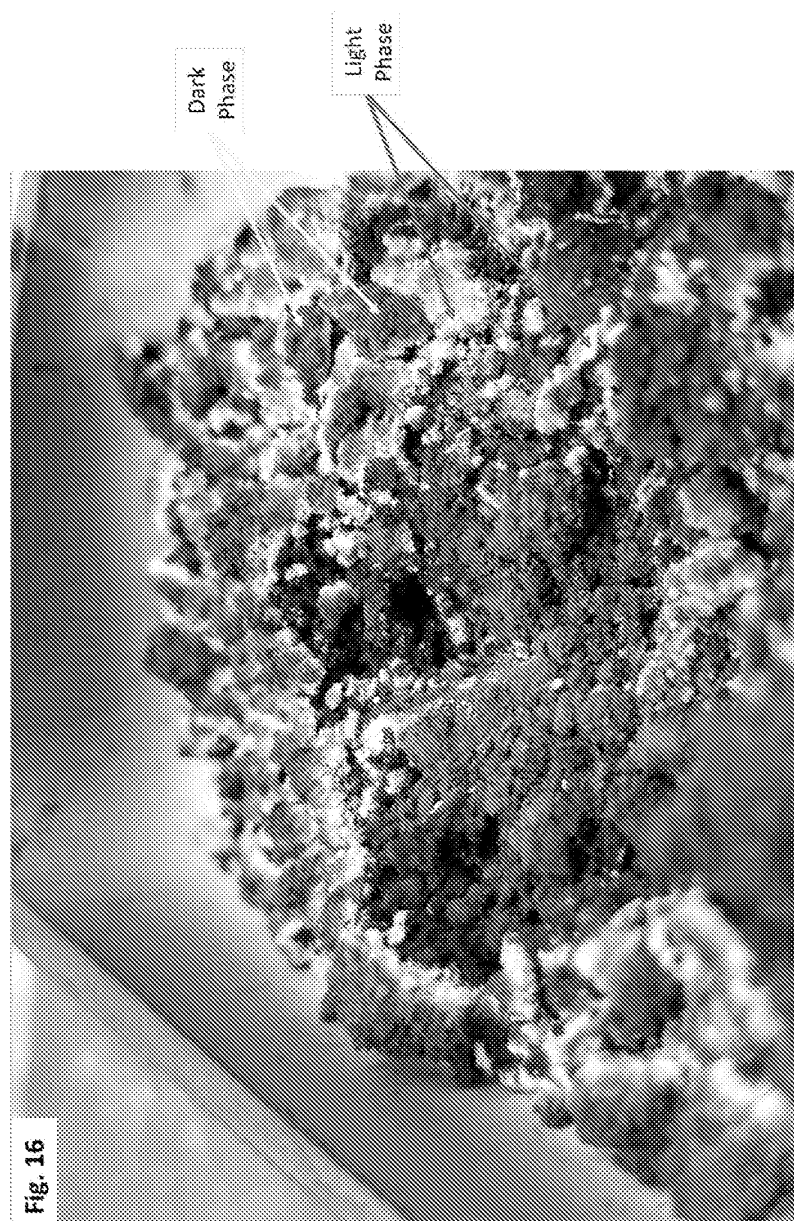
Fig. 11











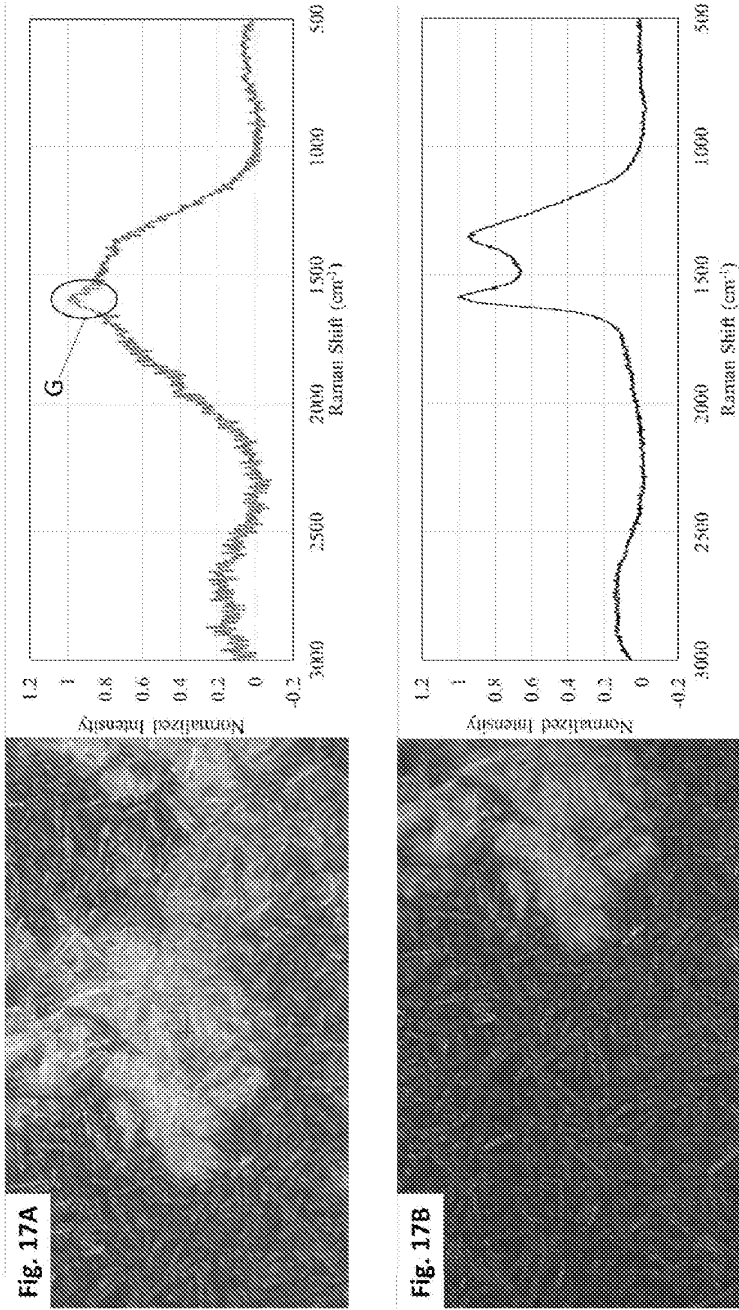


FIG. 18

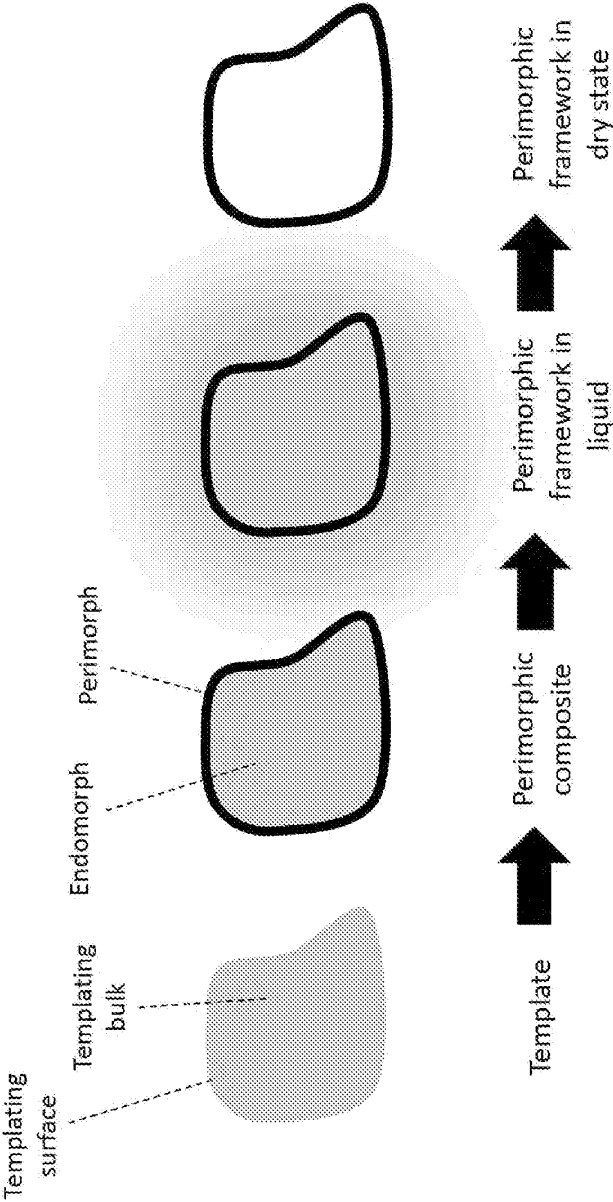
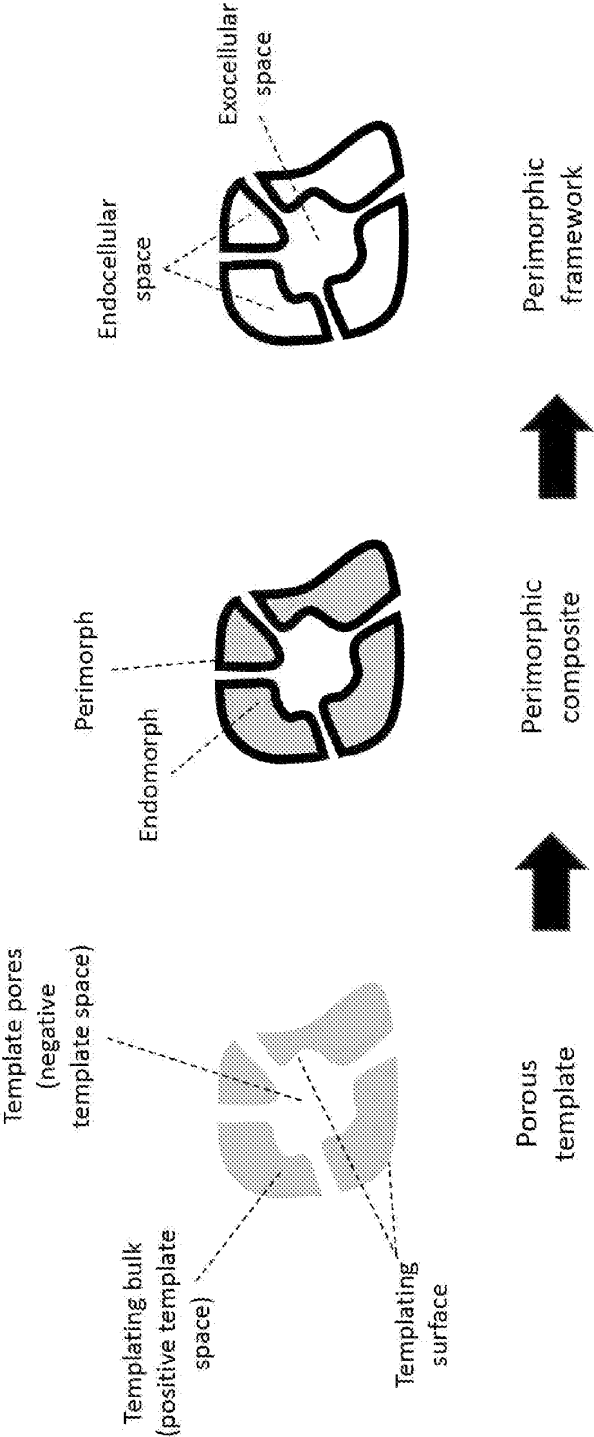


FIG. 19



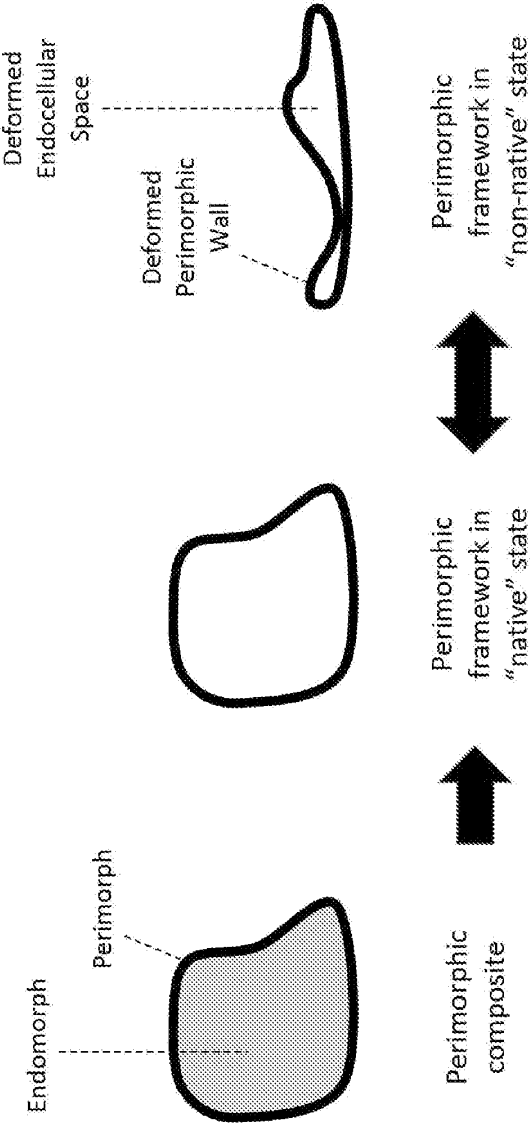
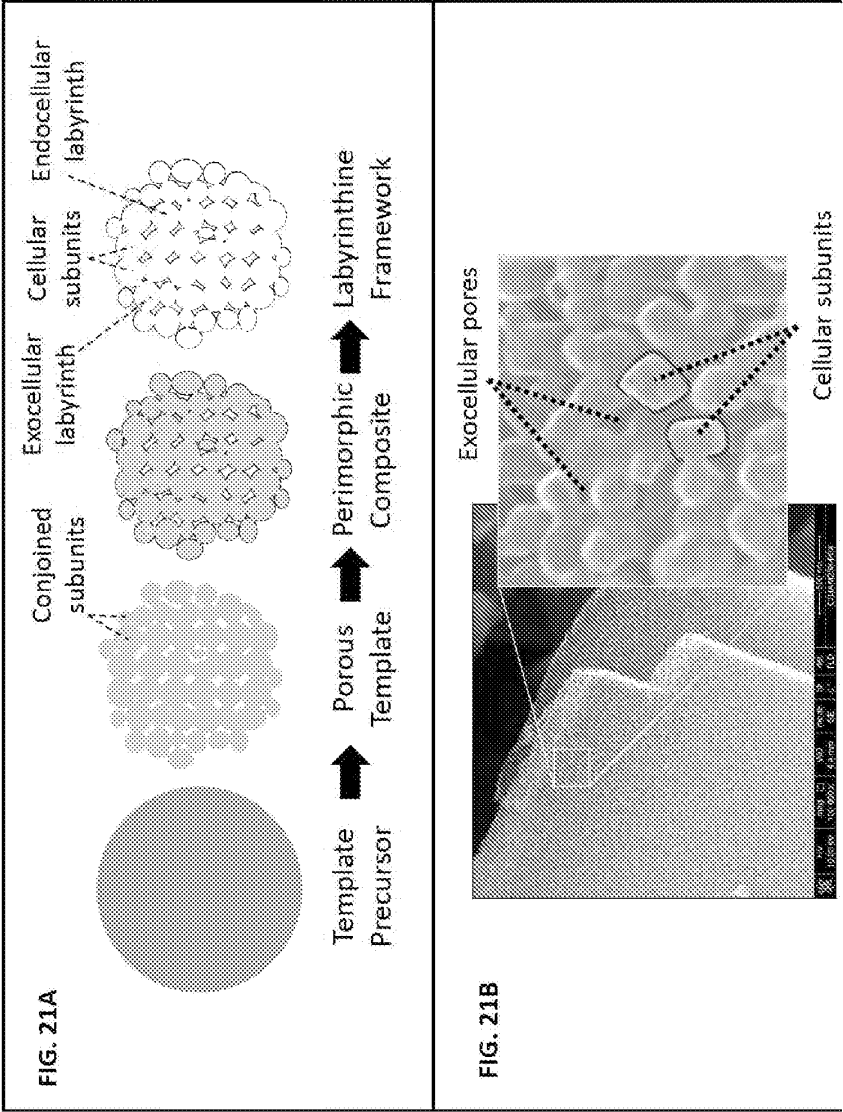


FIG. 20



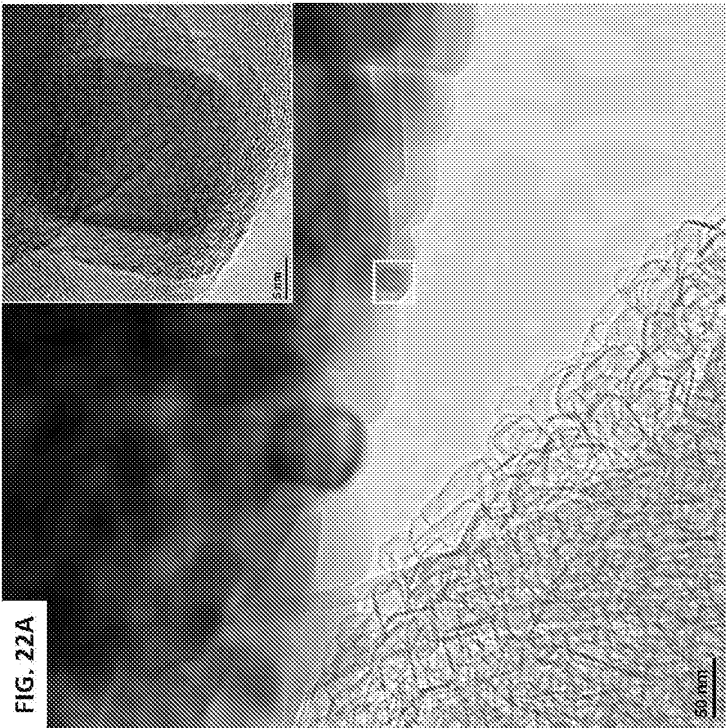
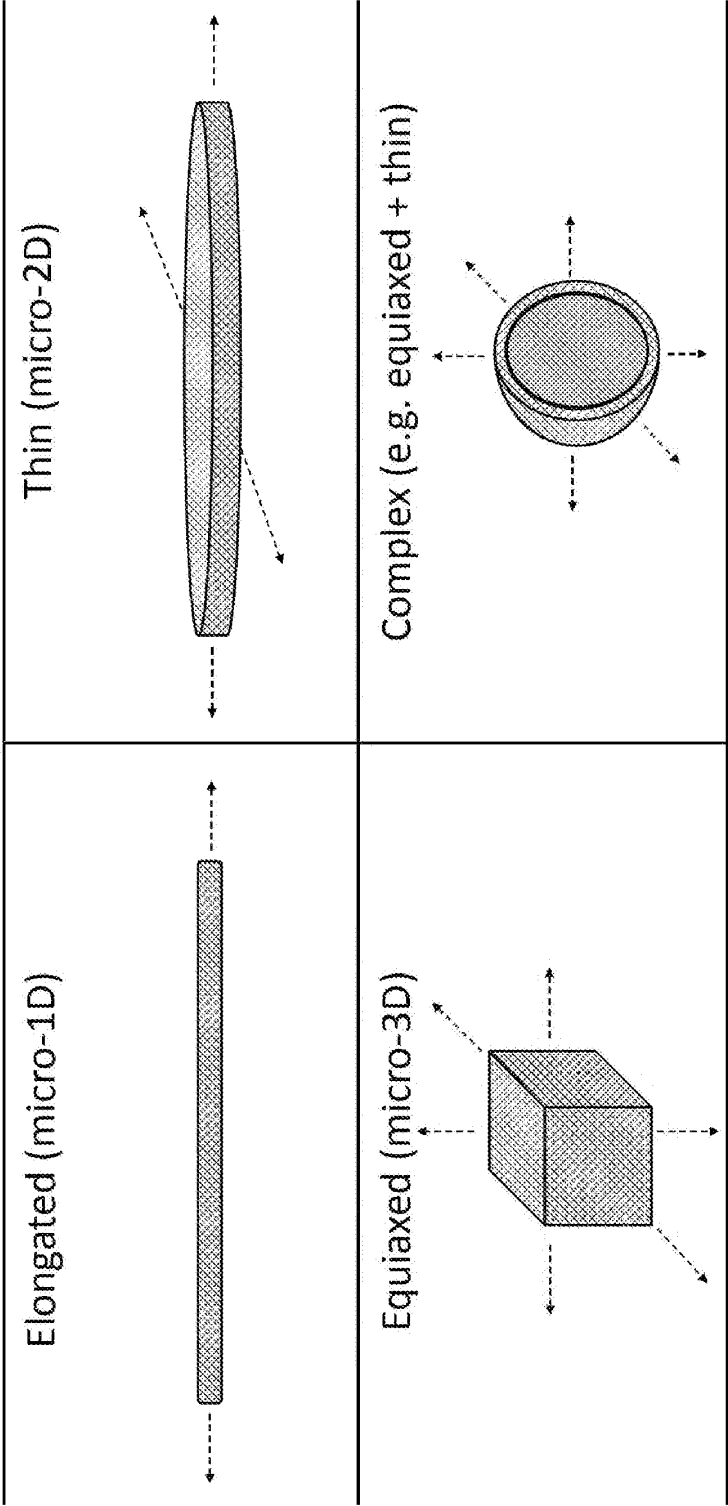
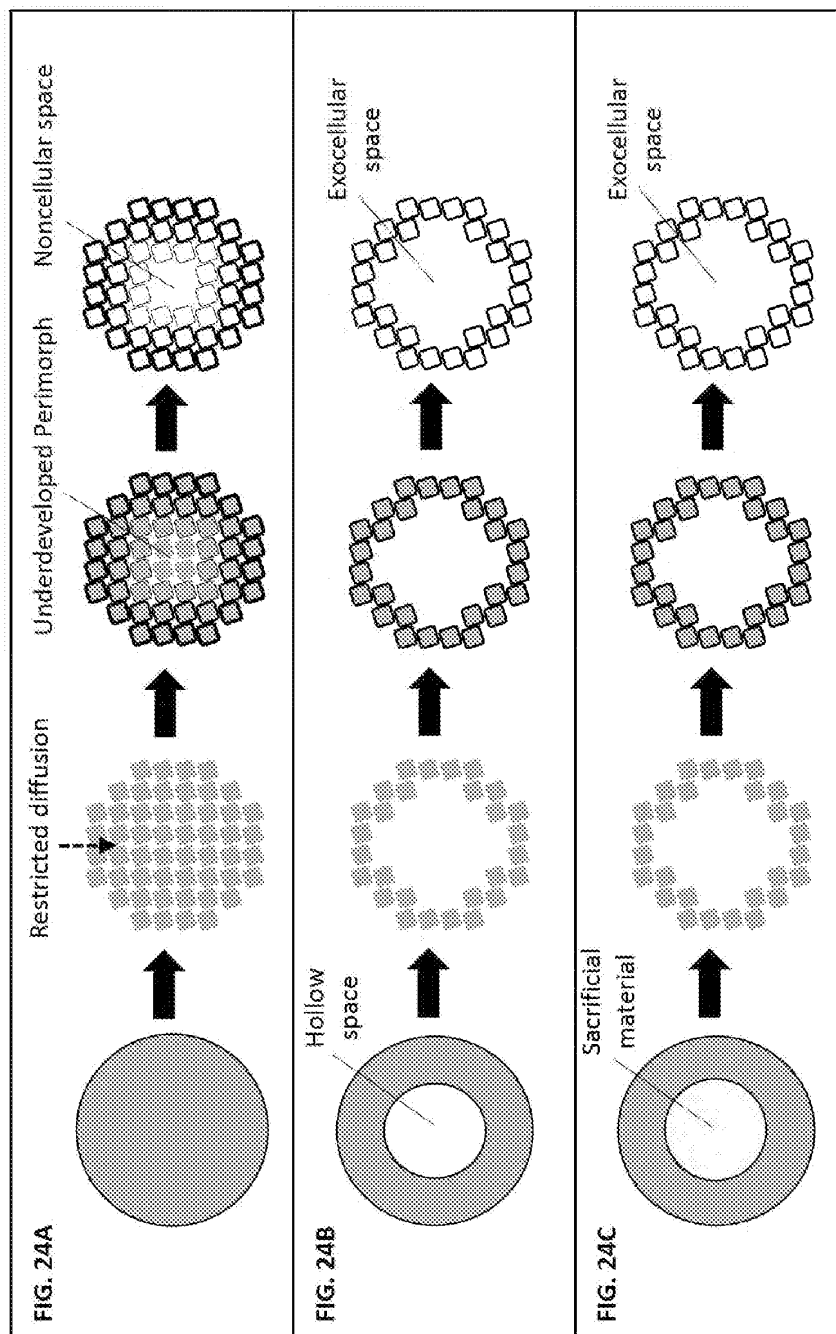


FIG. 5

FIG. 23





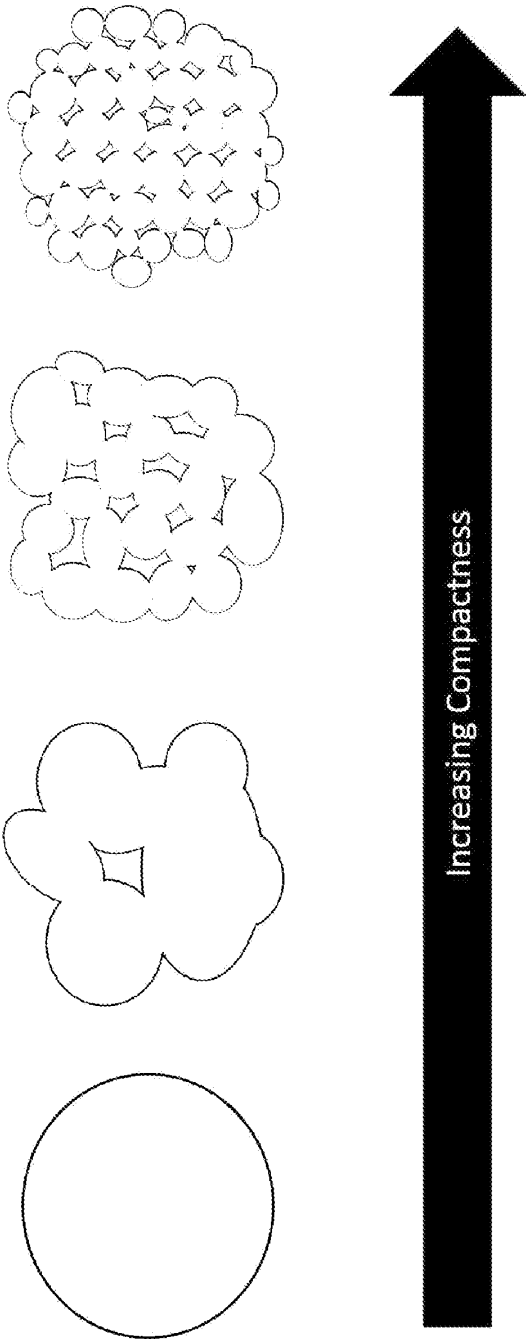


FIG. 25

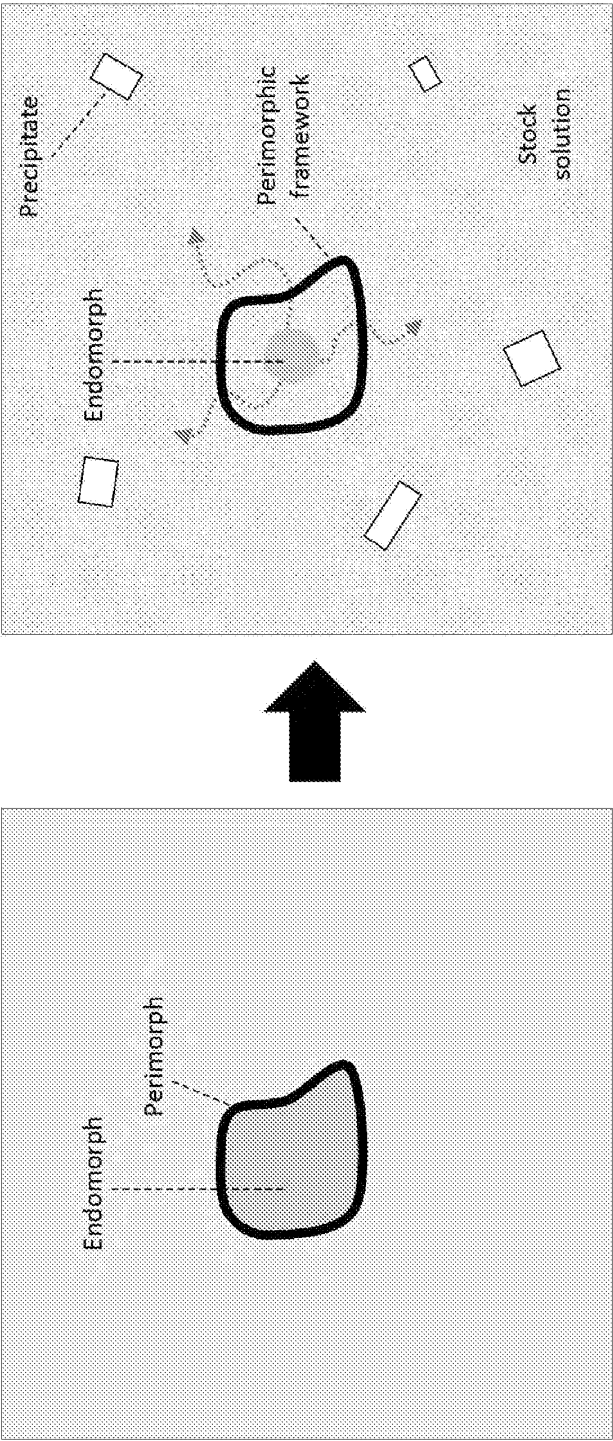
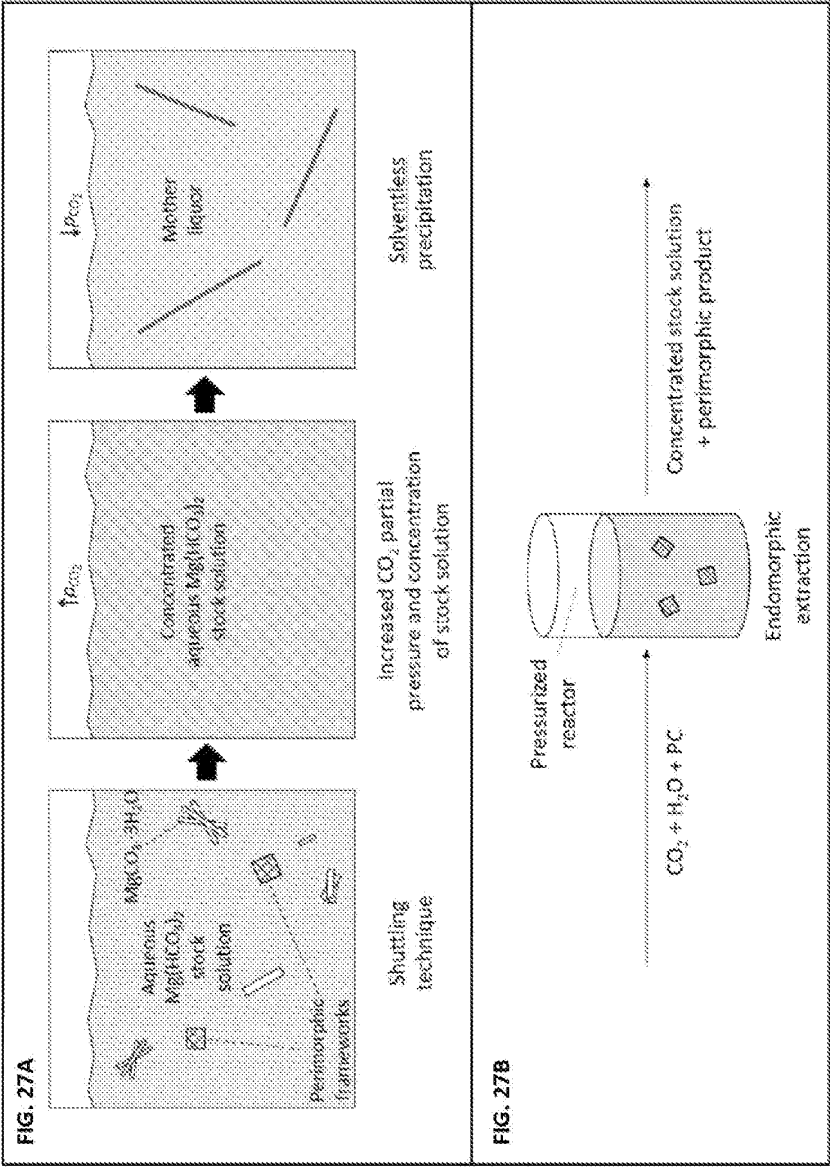


FIG. 26



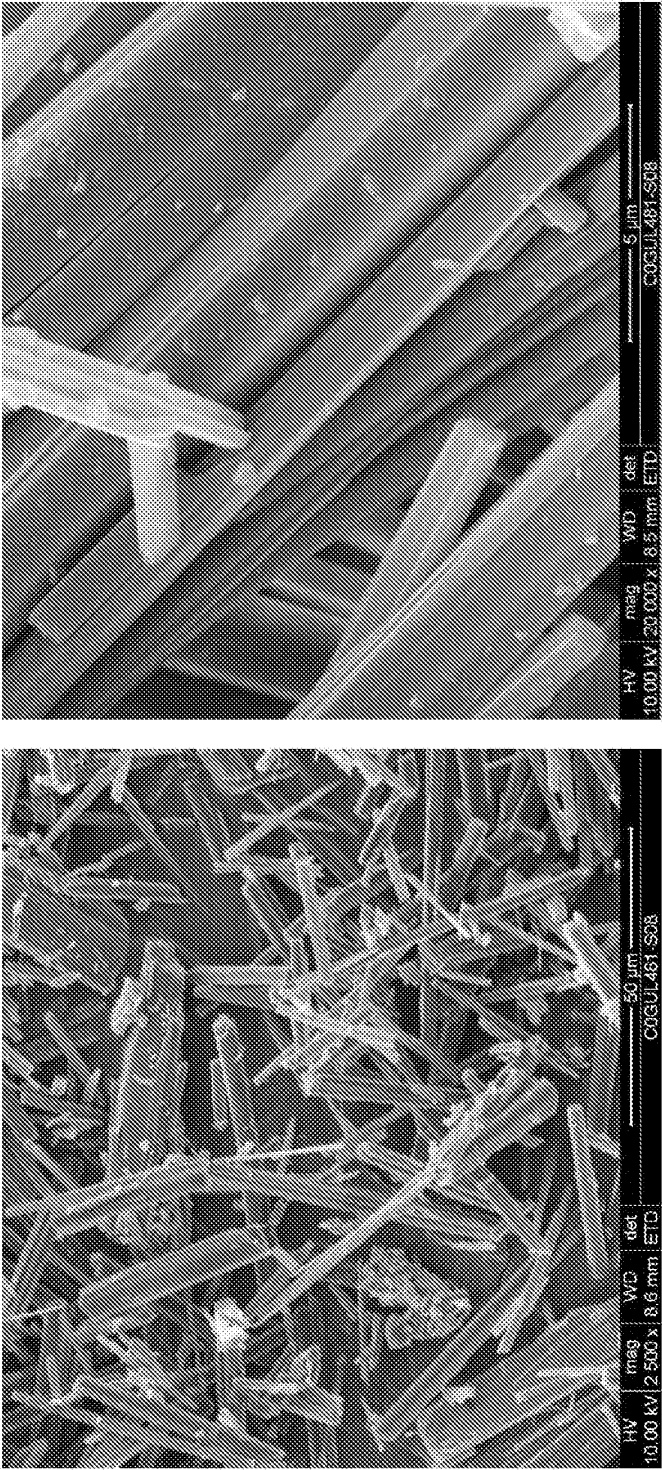


FIG. 28

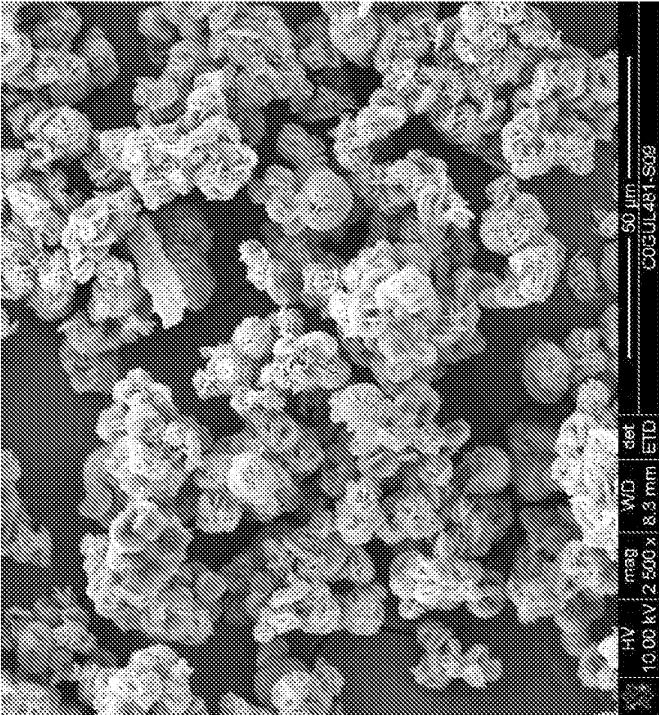
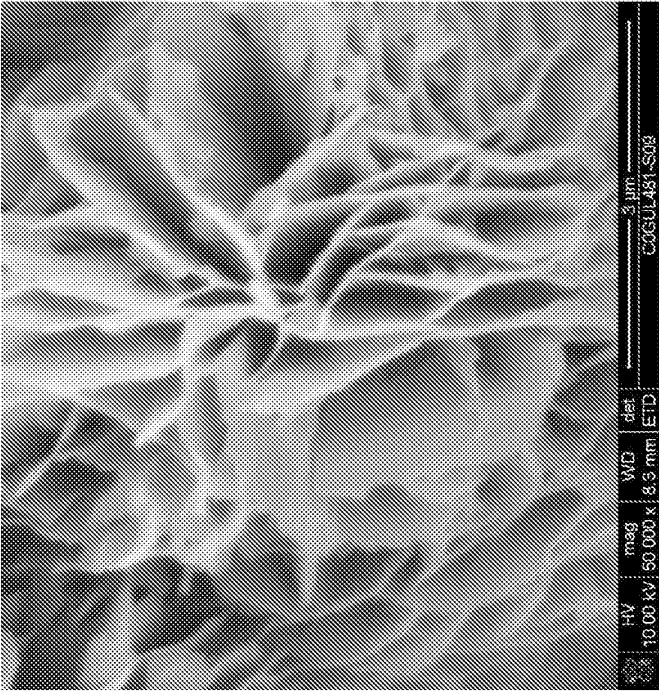


FIG. 29

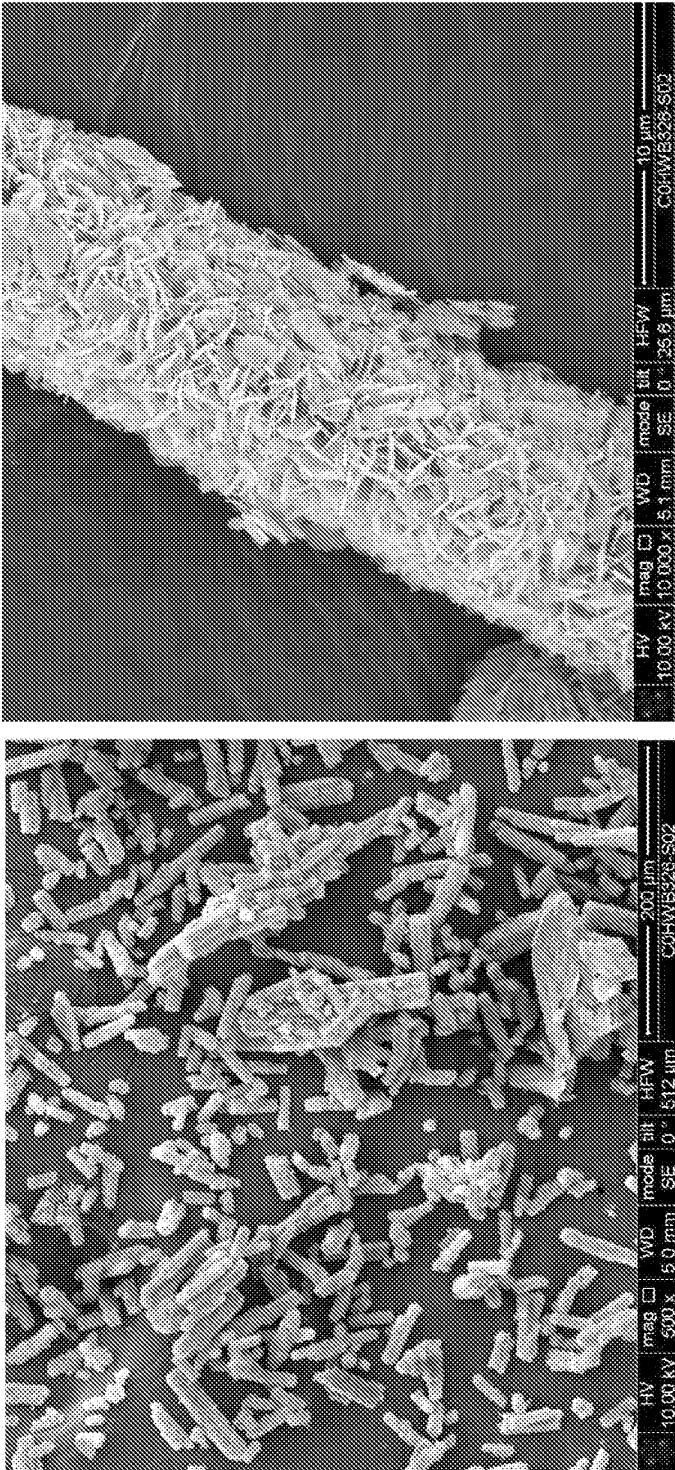


FIG. 30

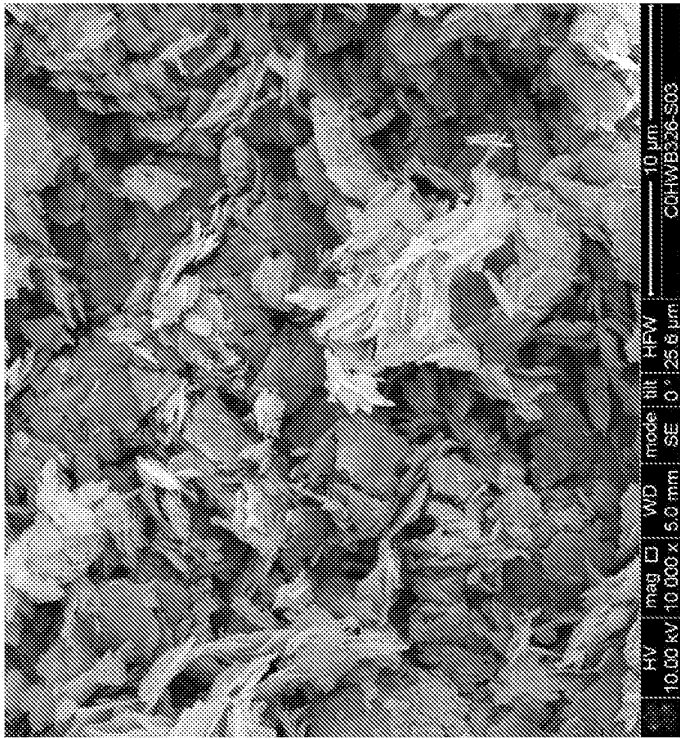


FIG. 31

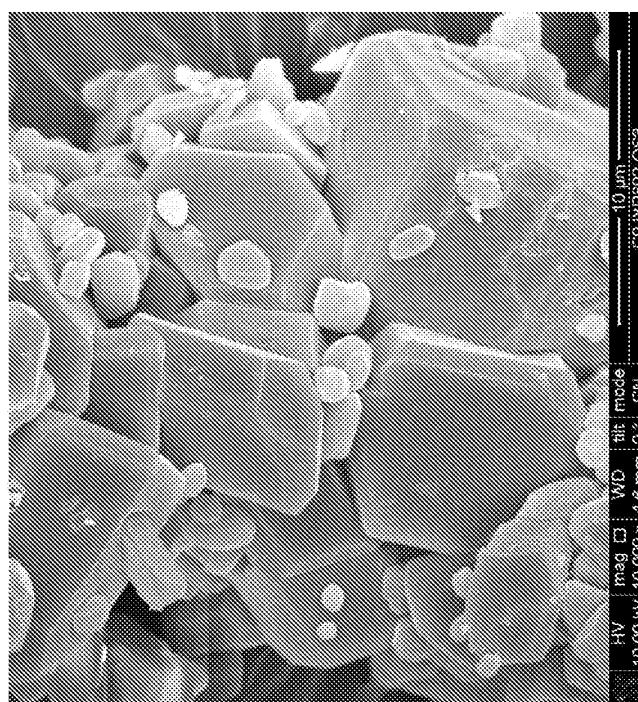


FIG. 32

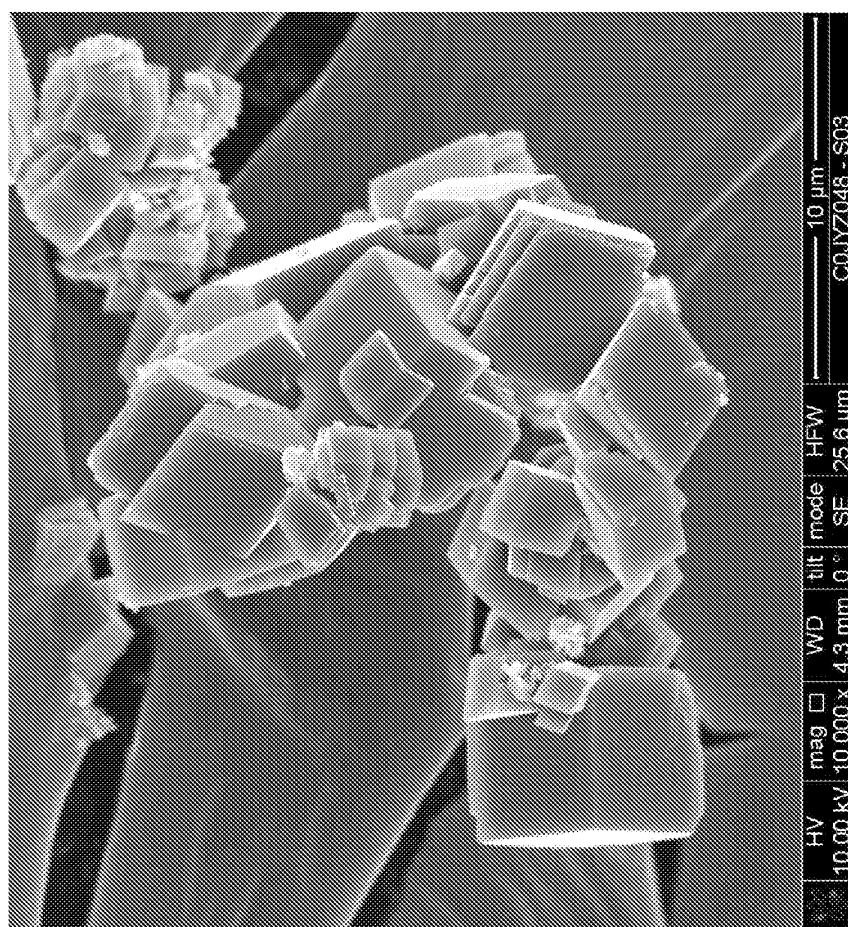


FIG. 33

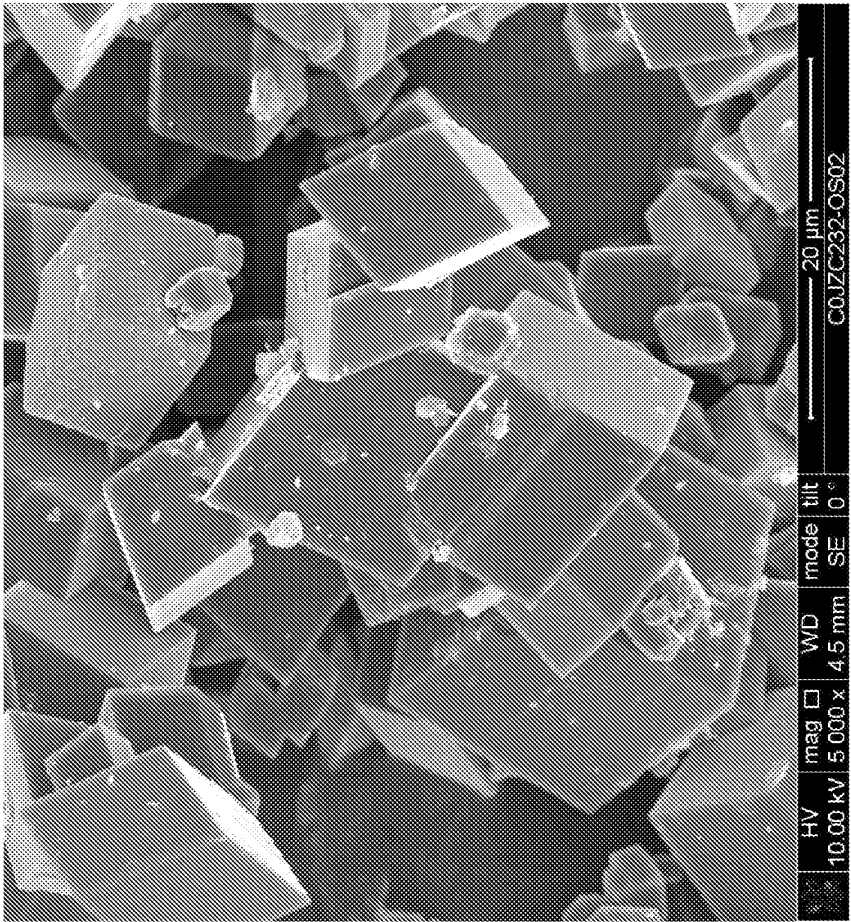


FIG. 34

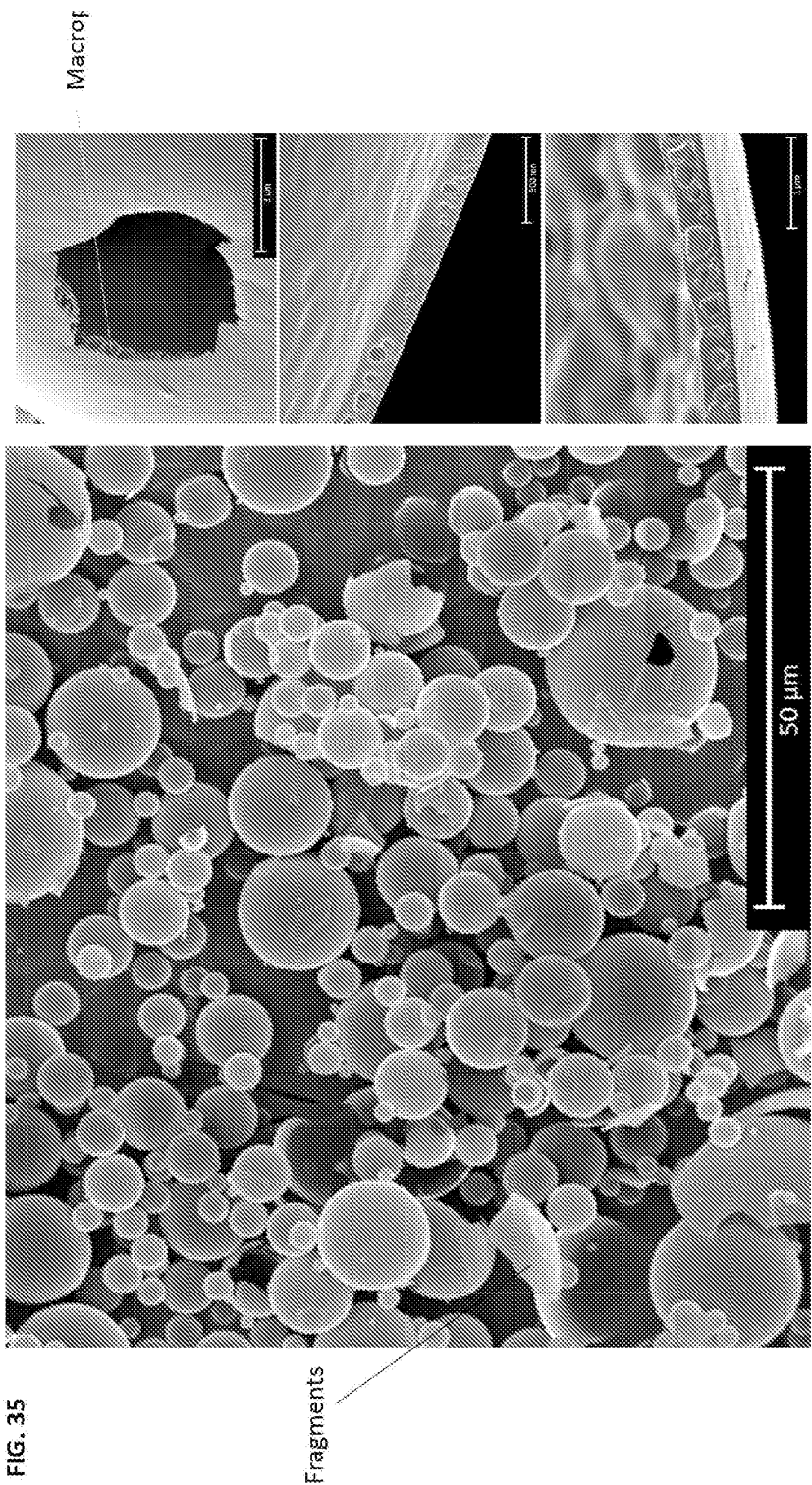
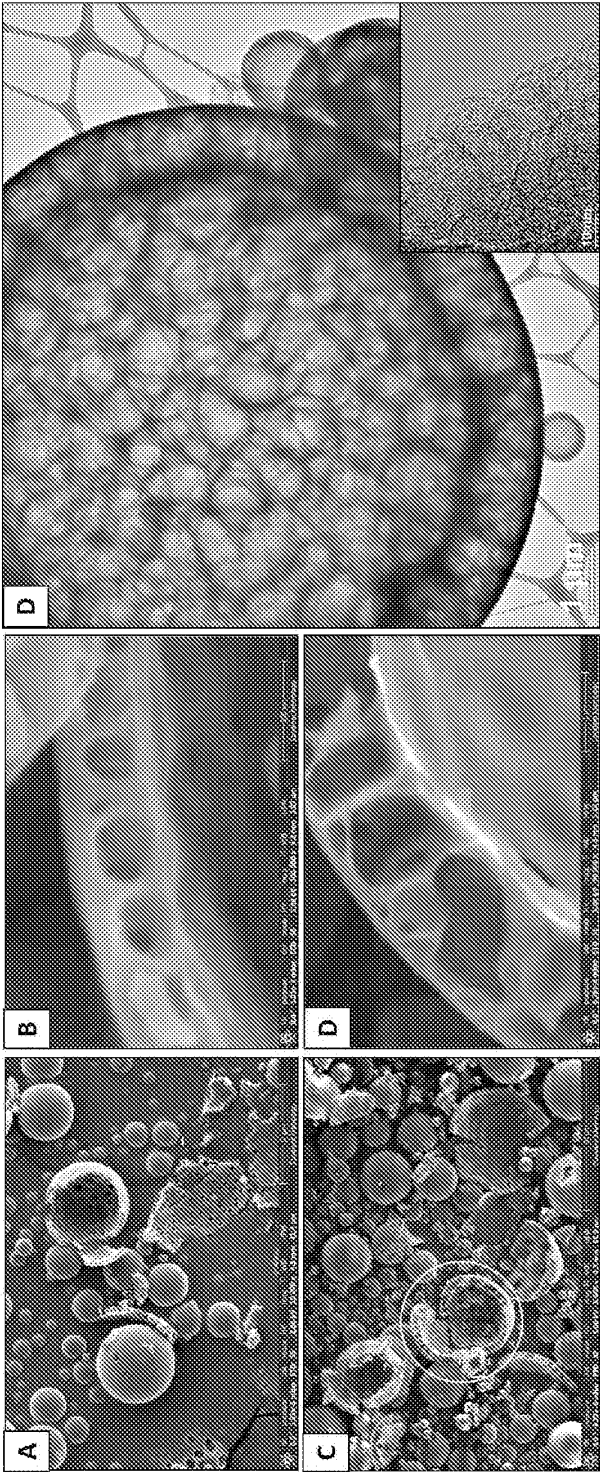
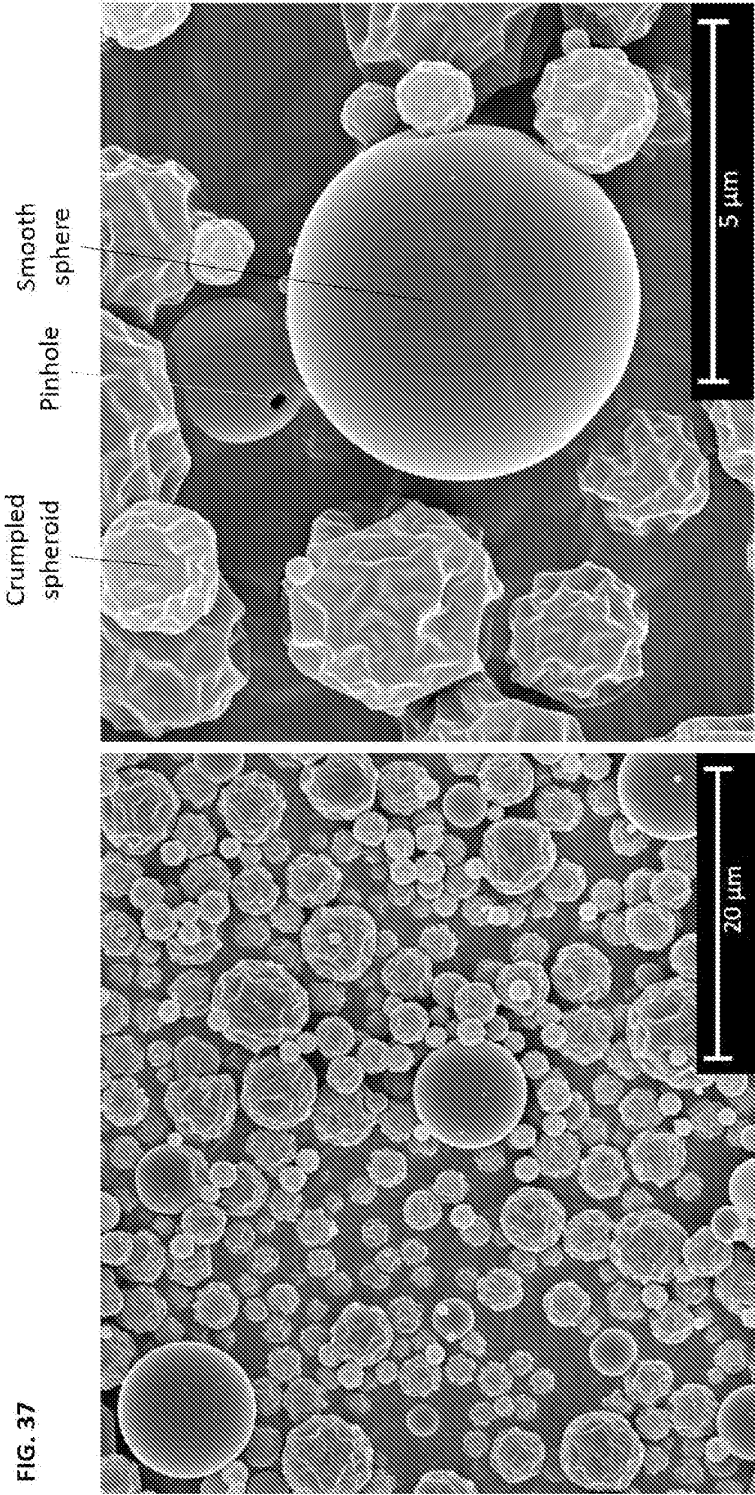


FIG. 36





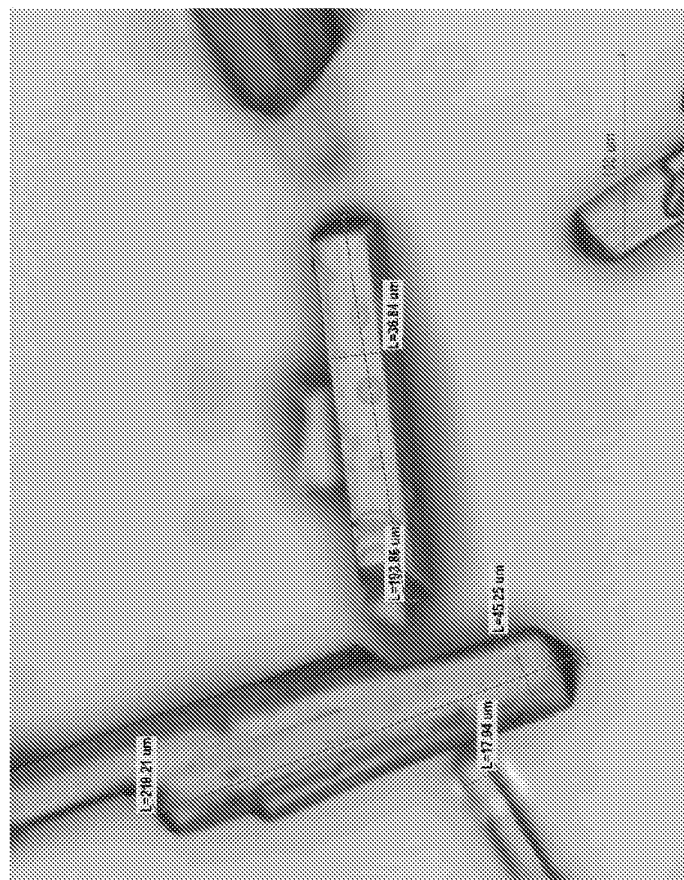
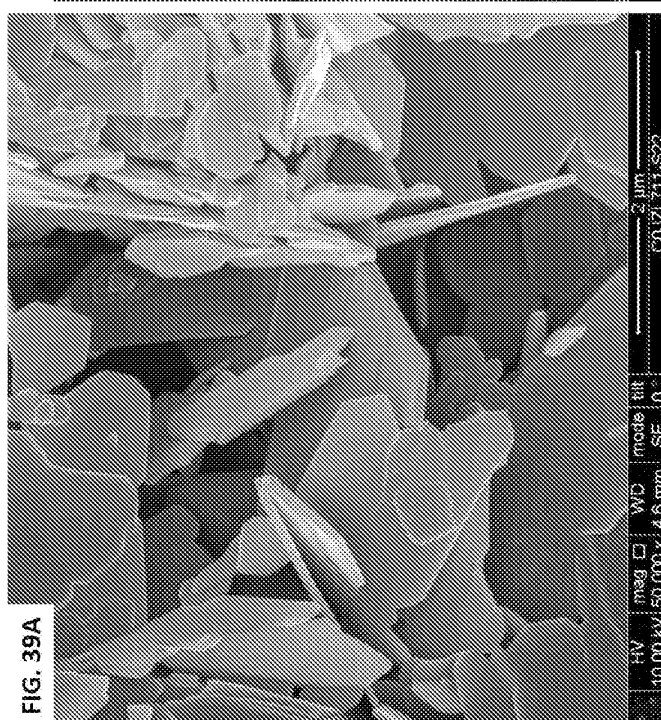
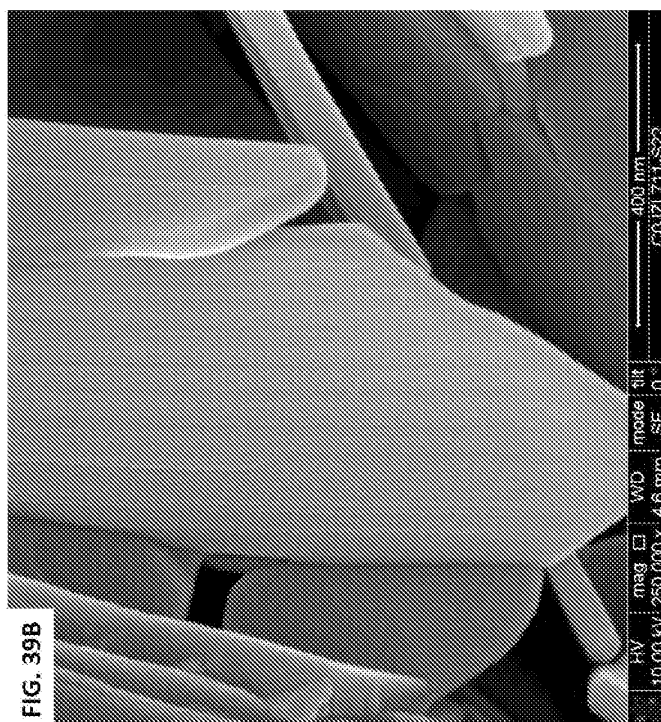
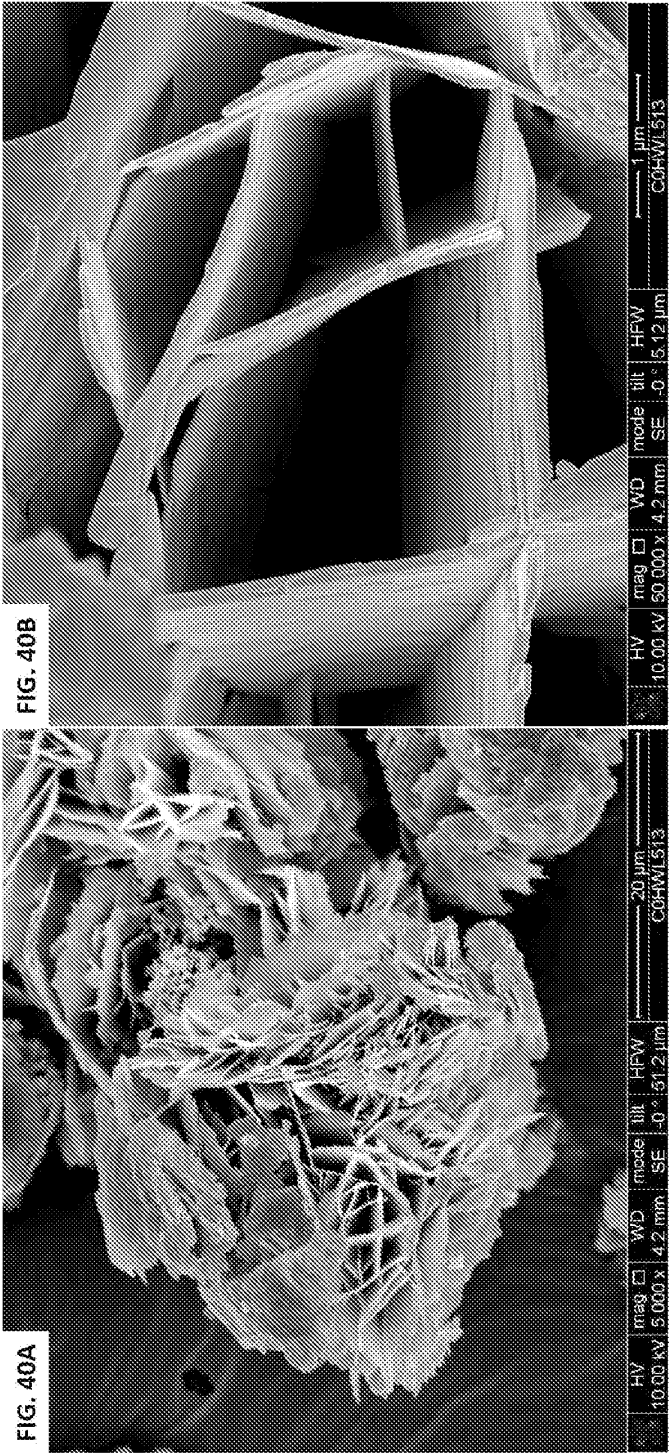
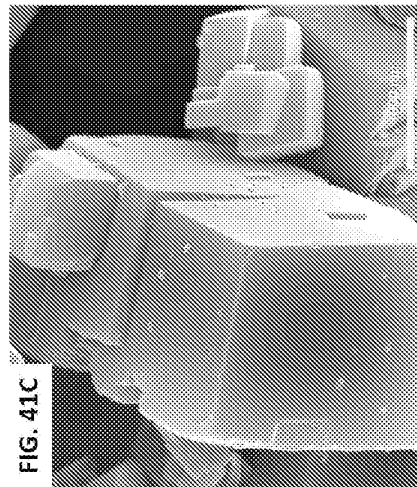


FIG. 38







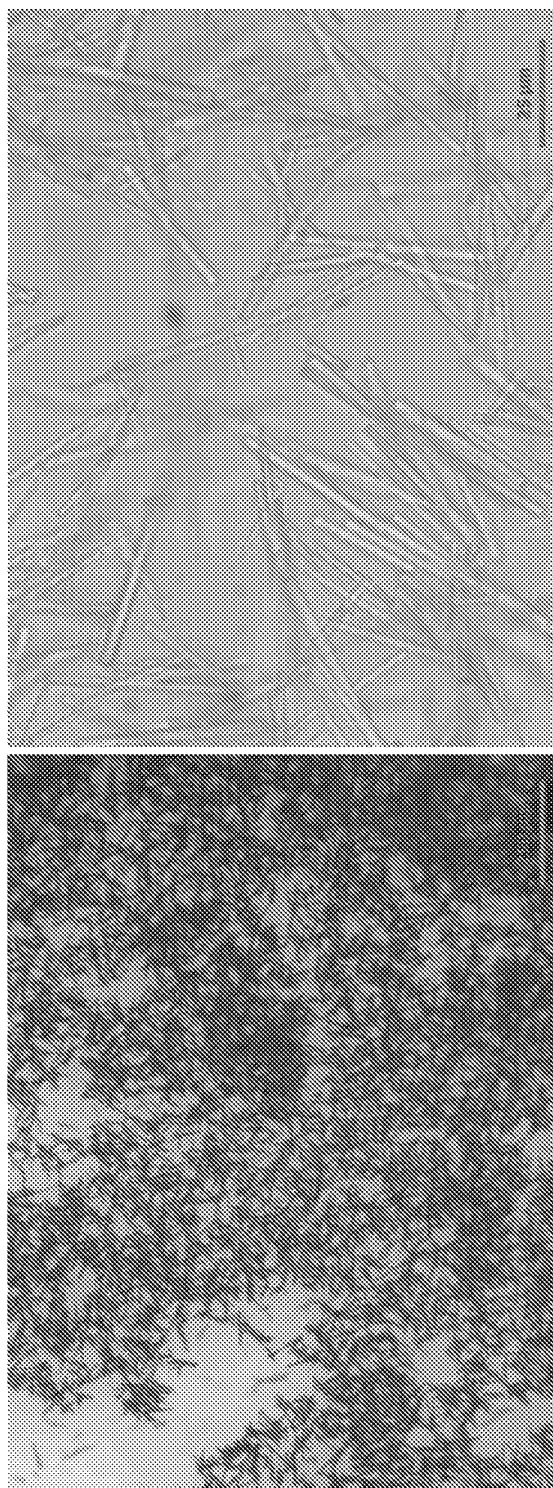


FIG. 42

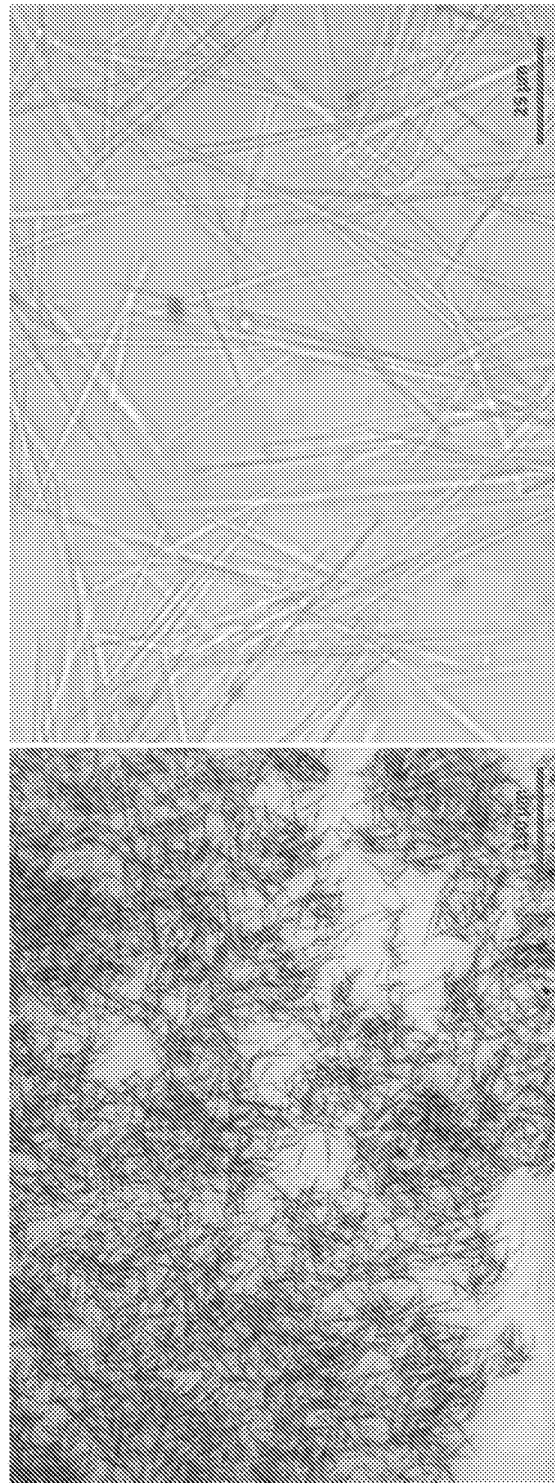
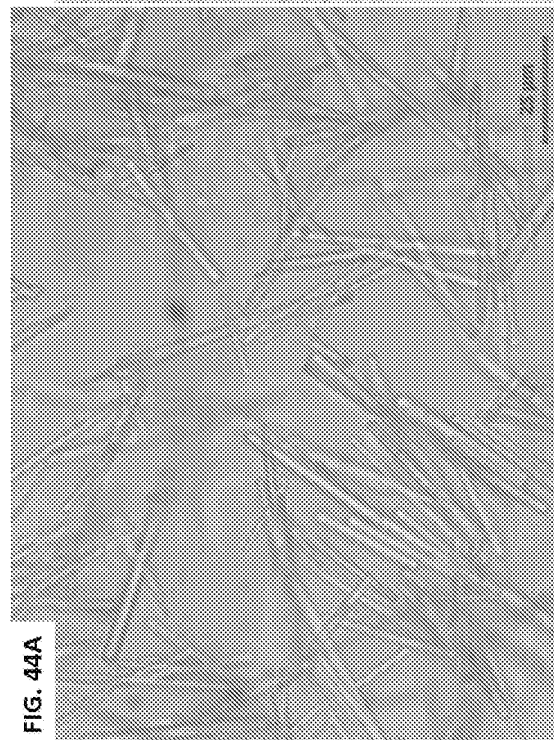
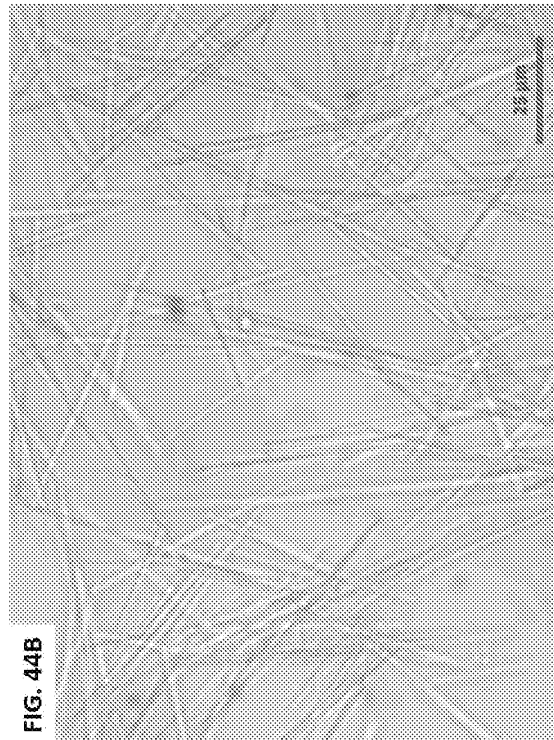


FIG. 43



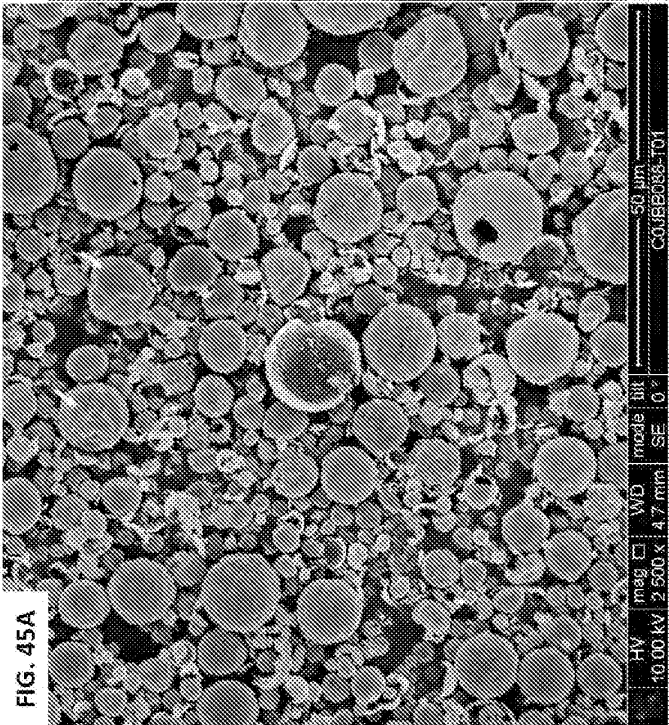
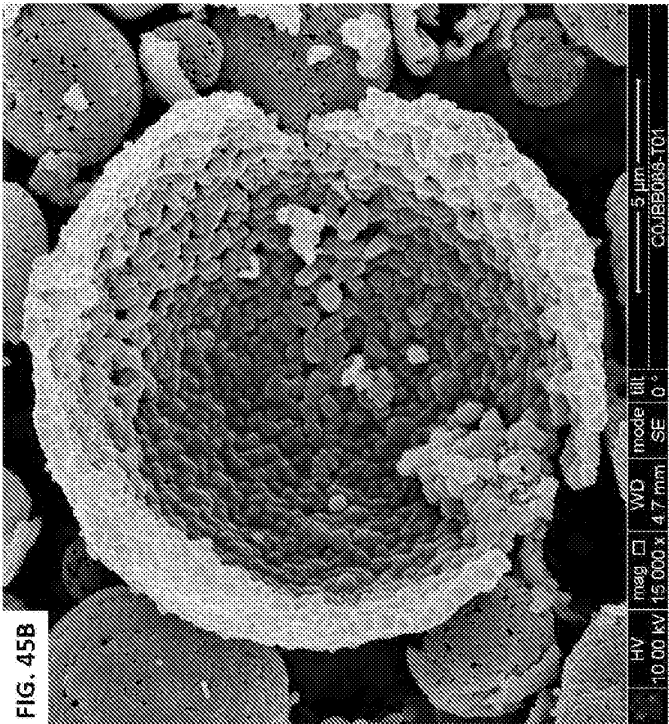


FIG. 46

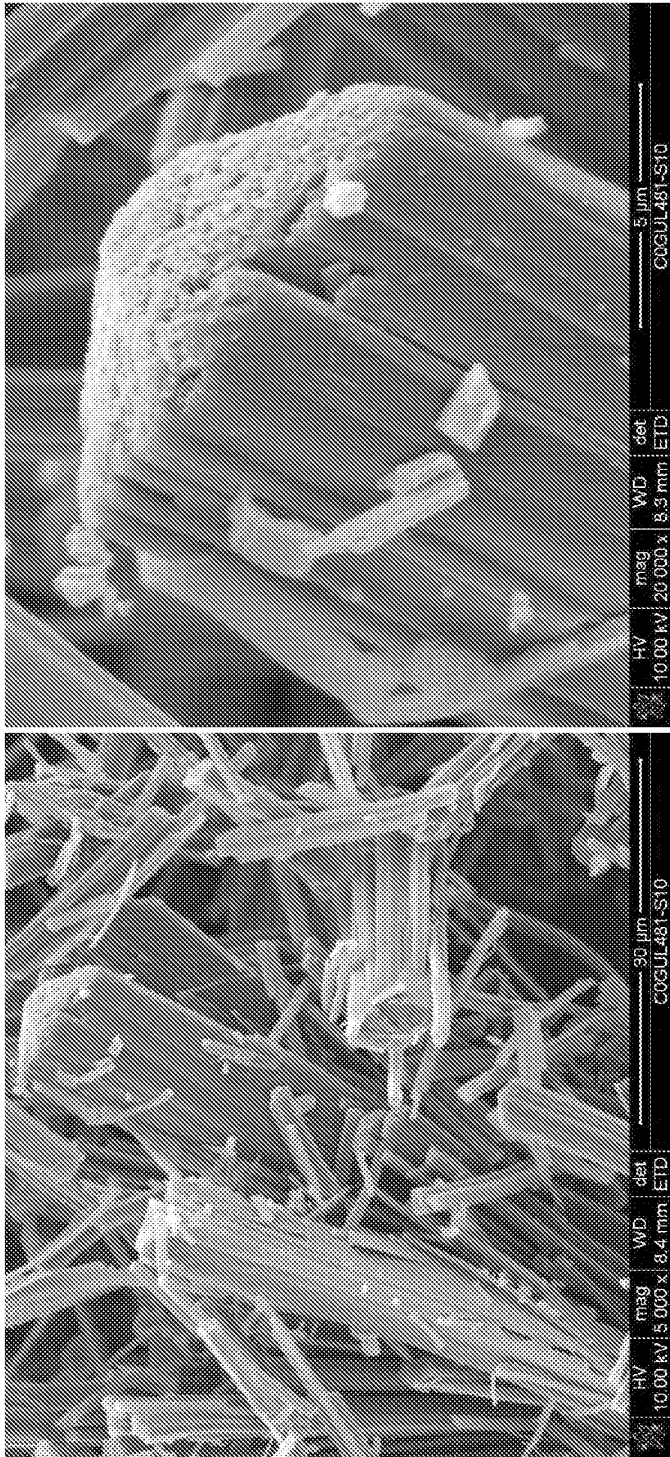
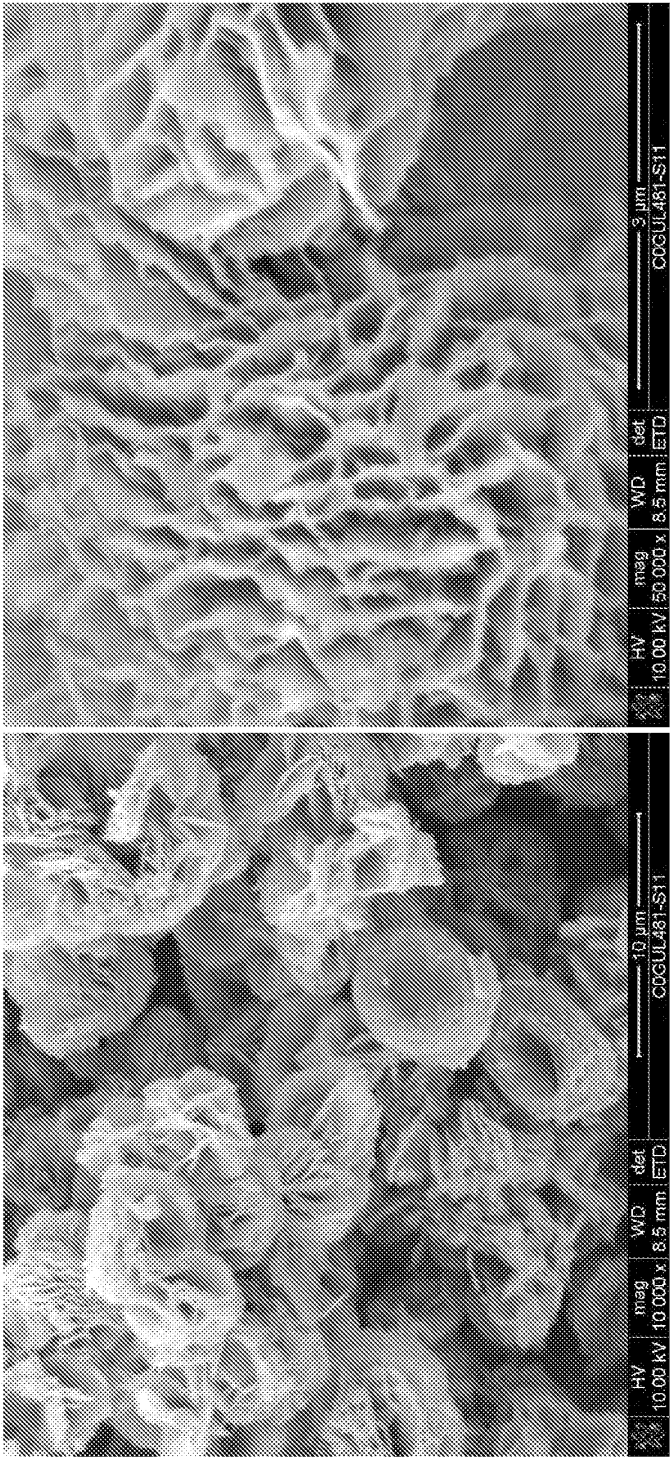


FIG. 47



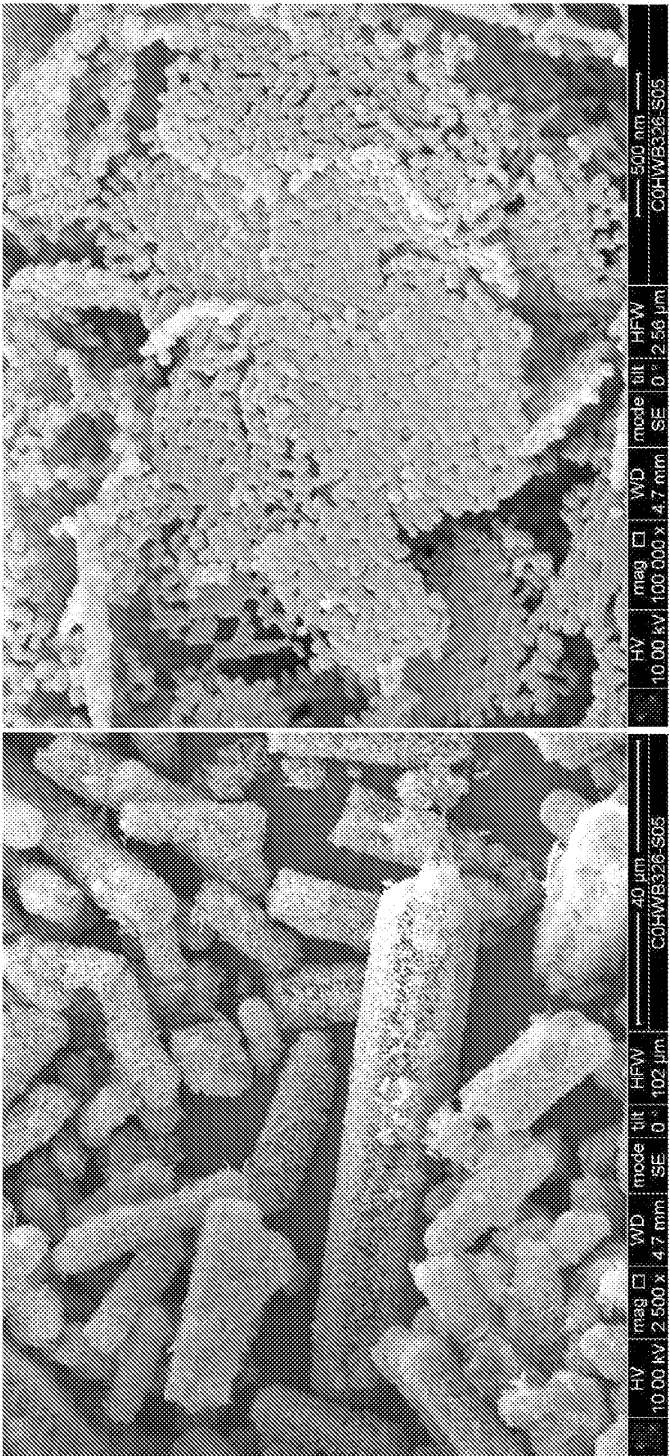


FIG. 48

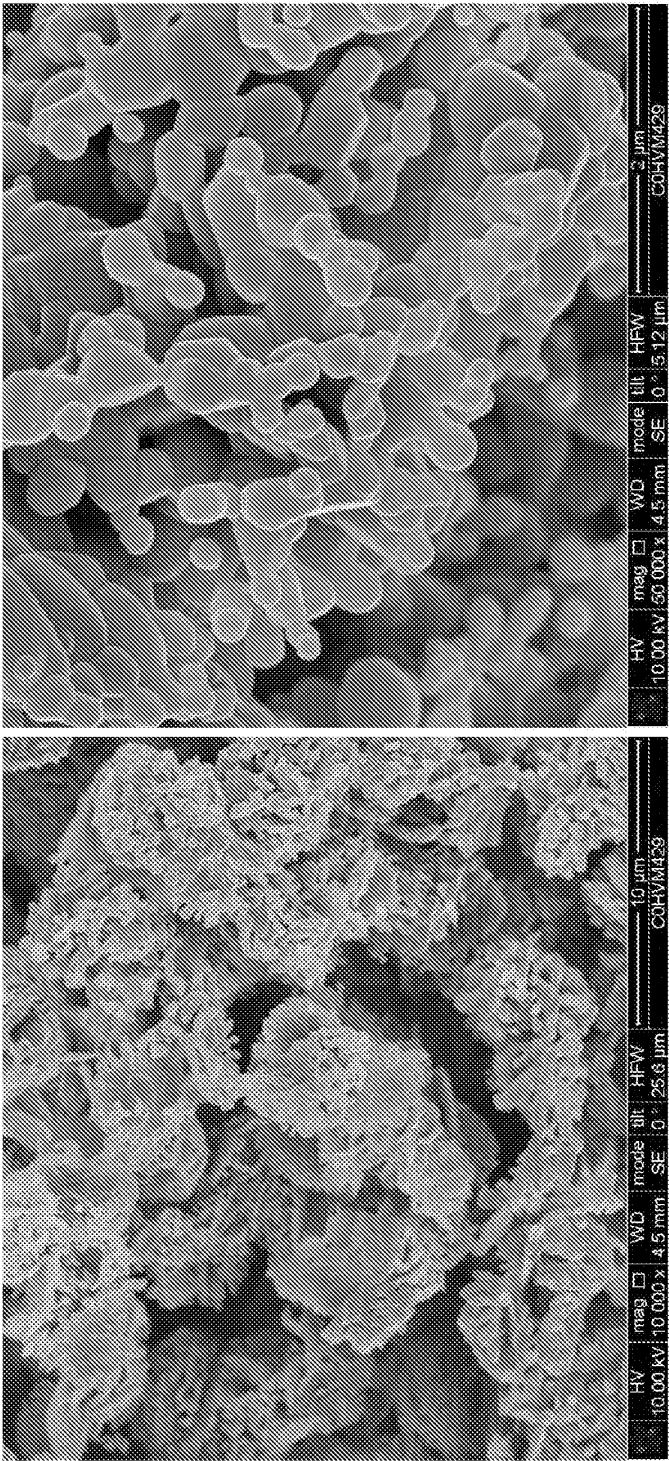


FIG. 49

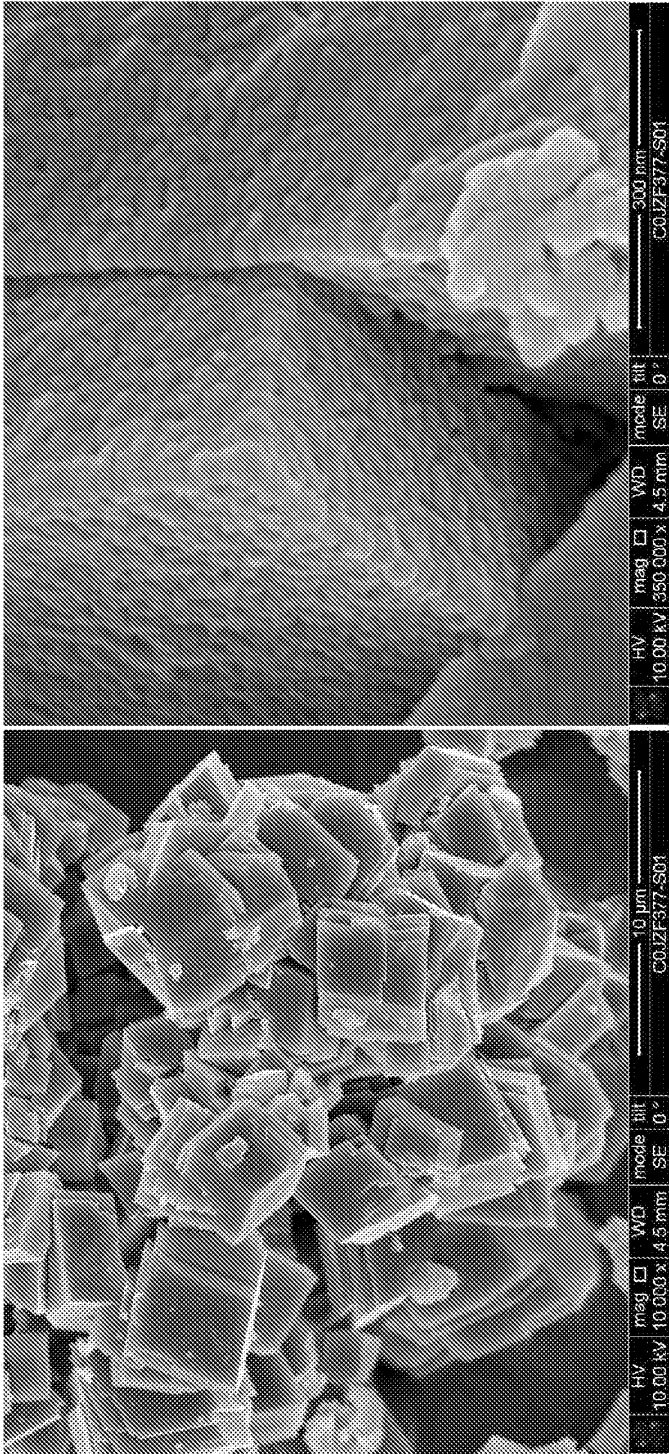


FIG. 50

FIG. 51

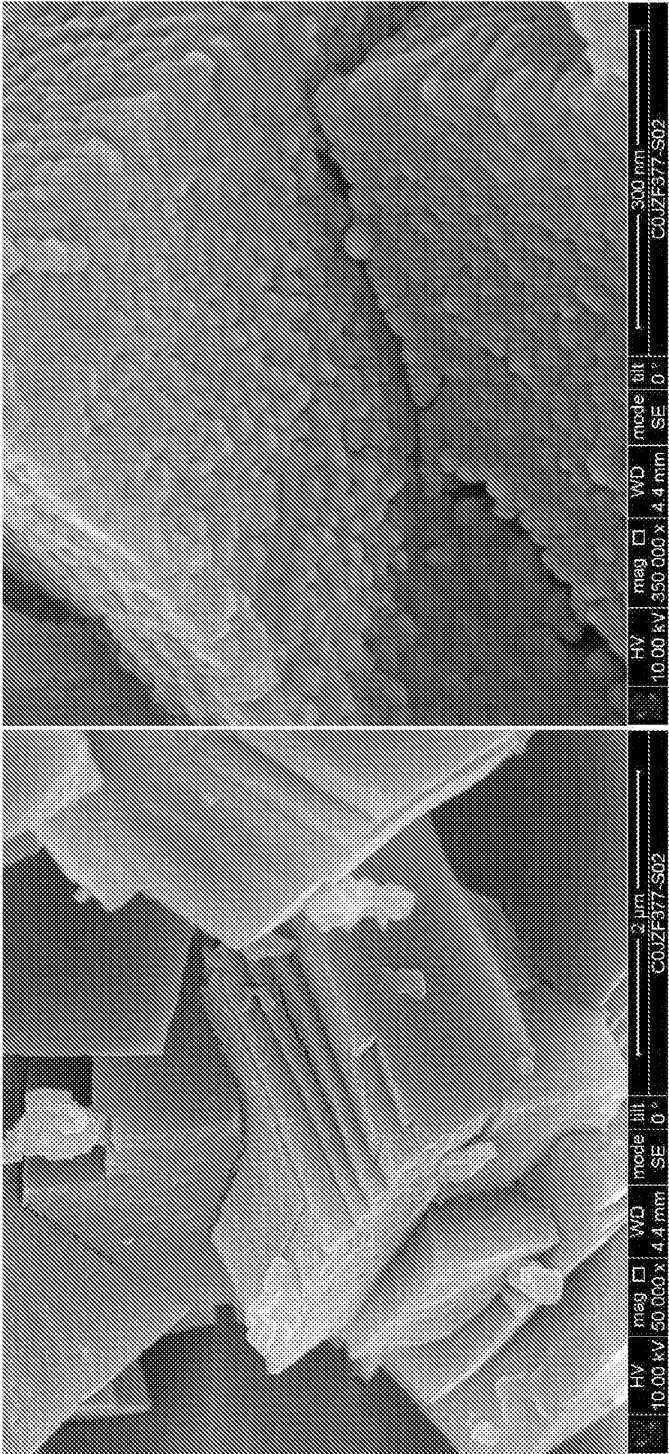


FIG. 52

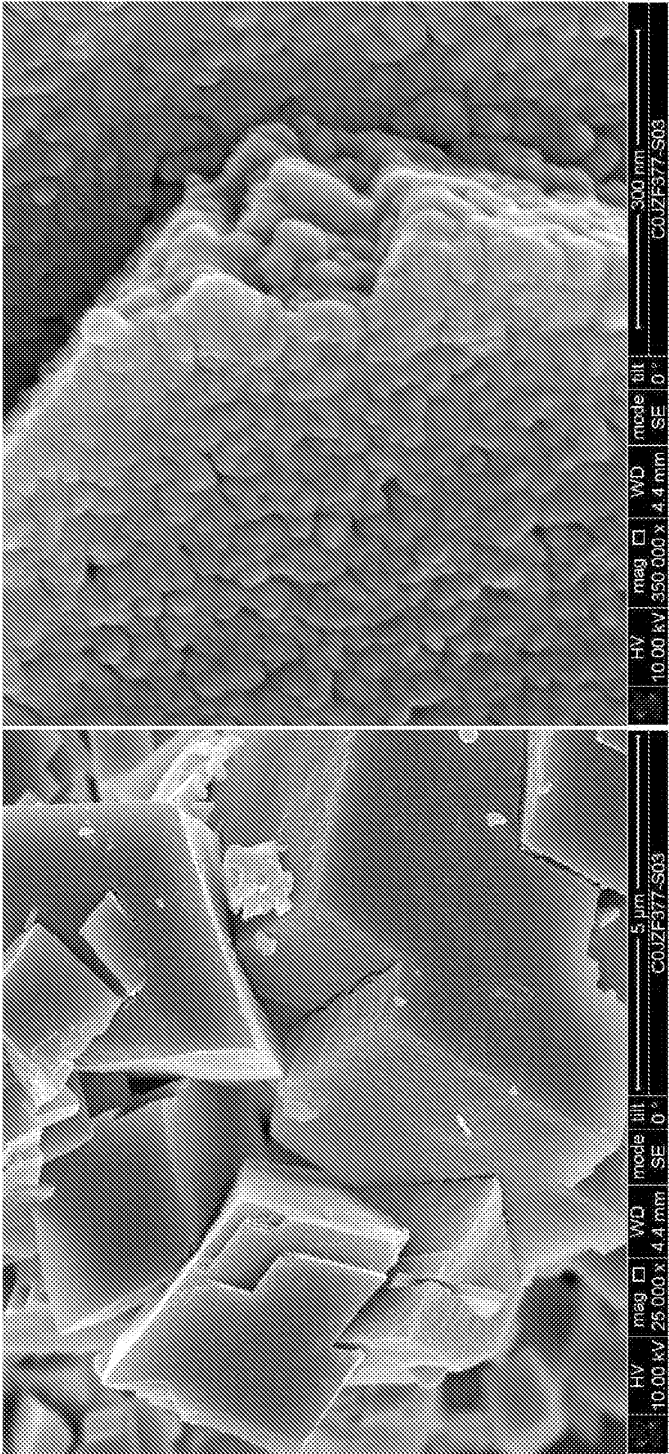
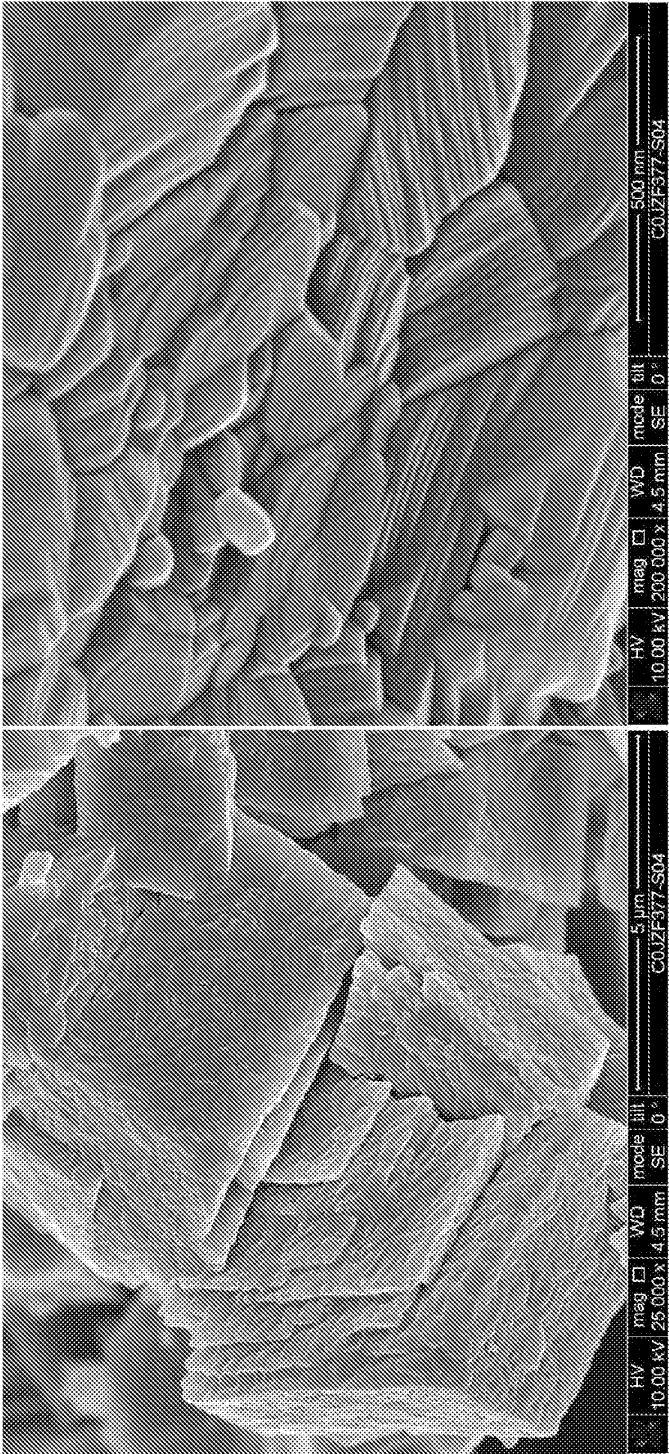
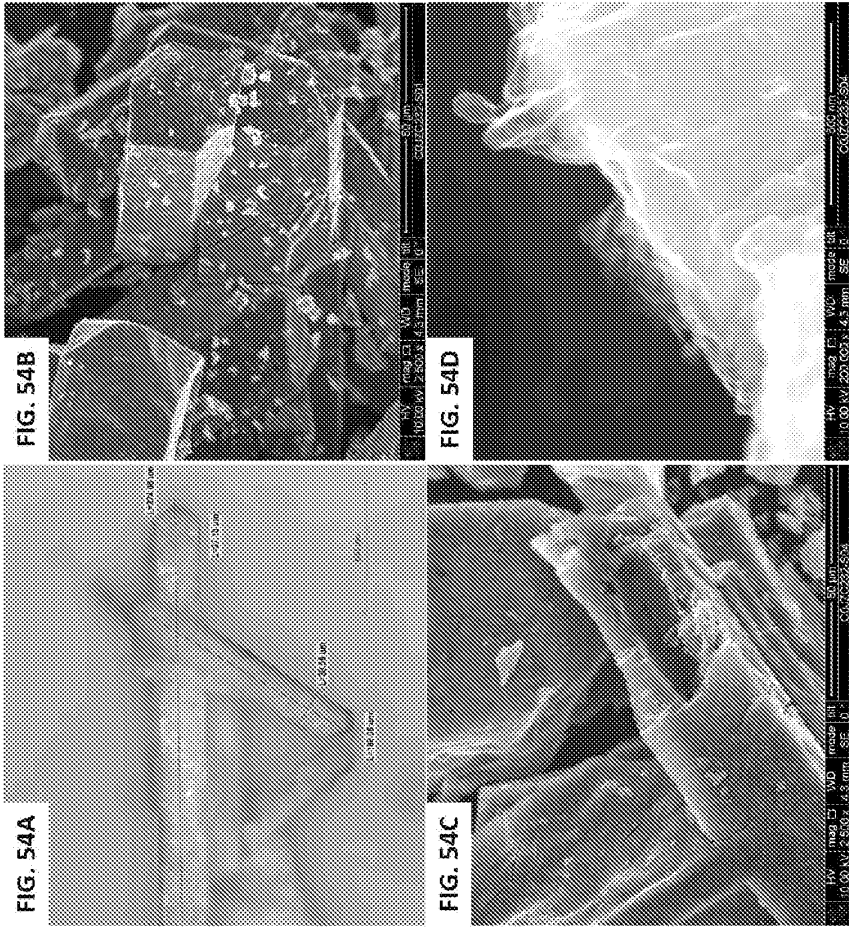
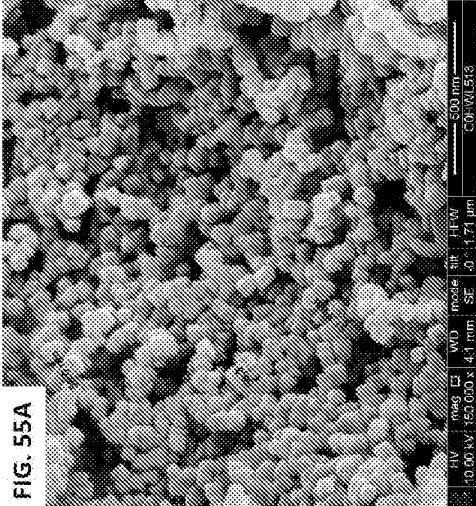
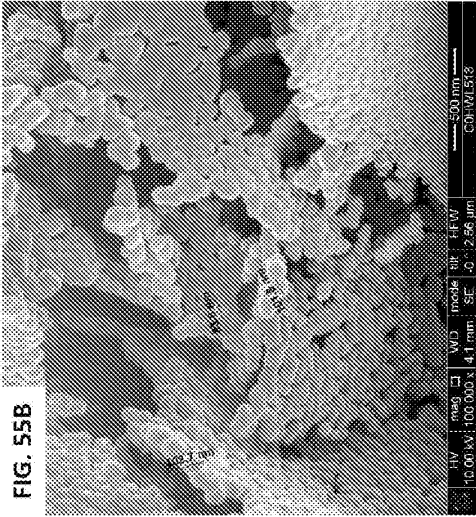
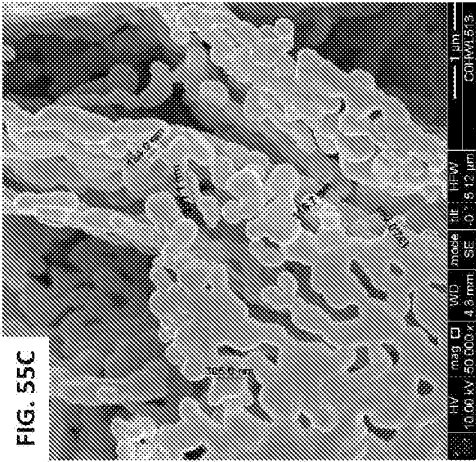


FIG. 53







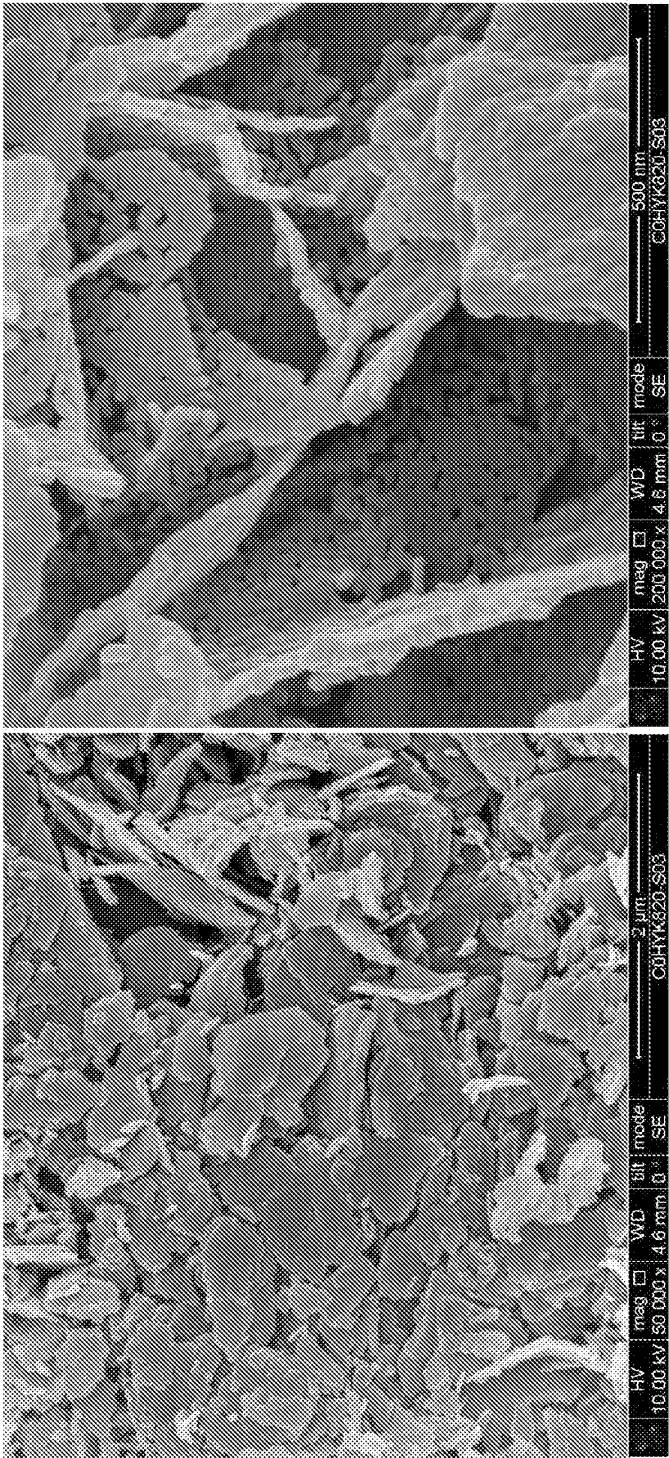
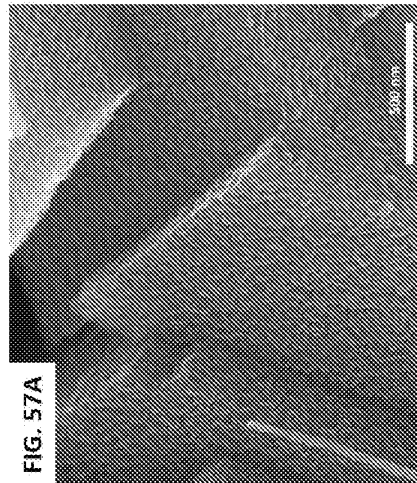
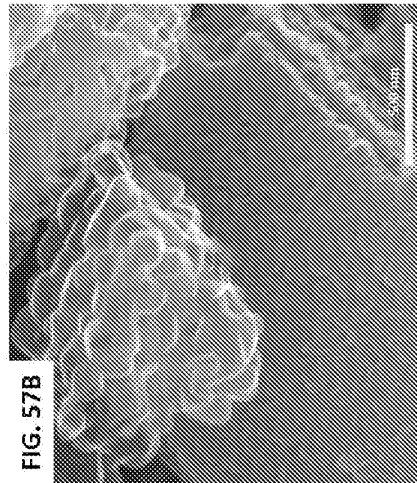
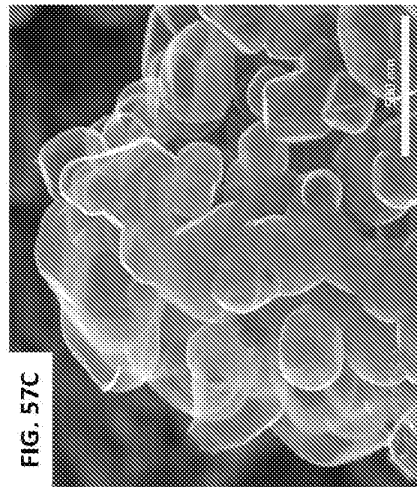
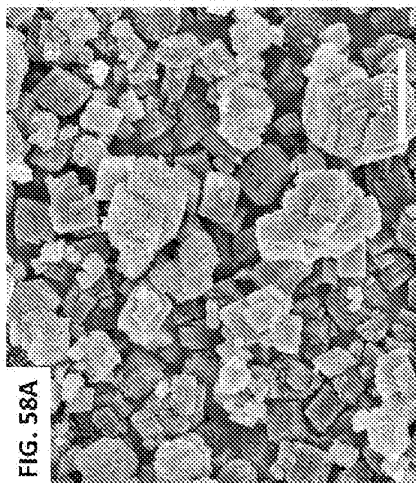
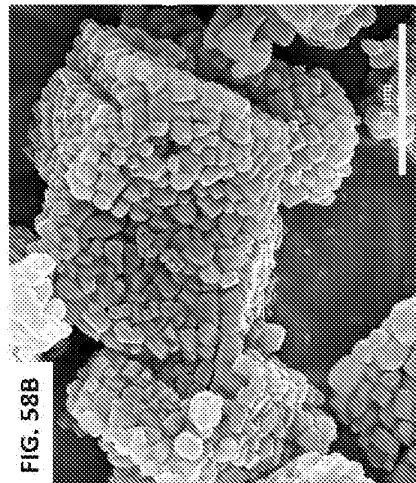
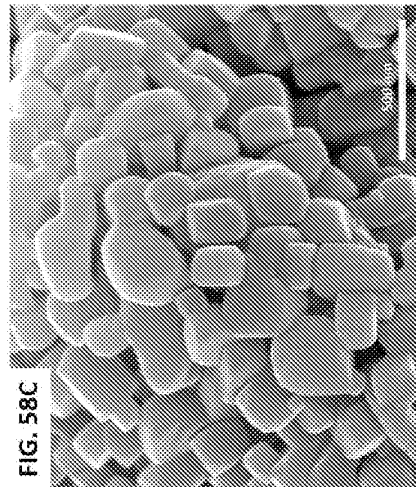


FIG. 56





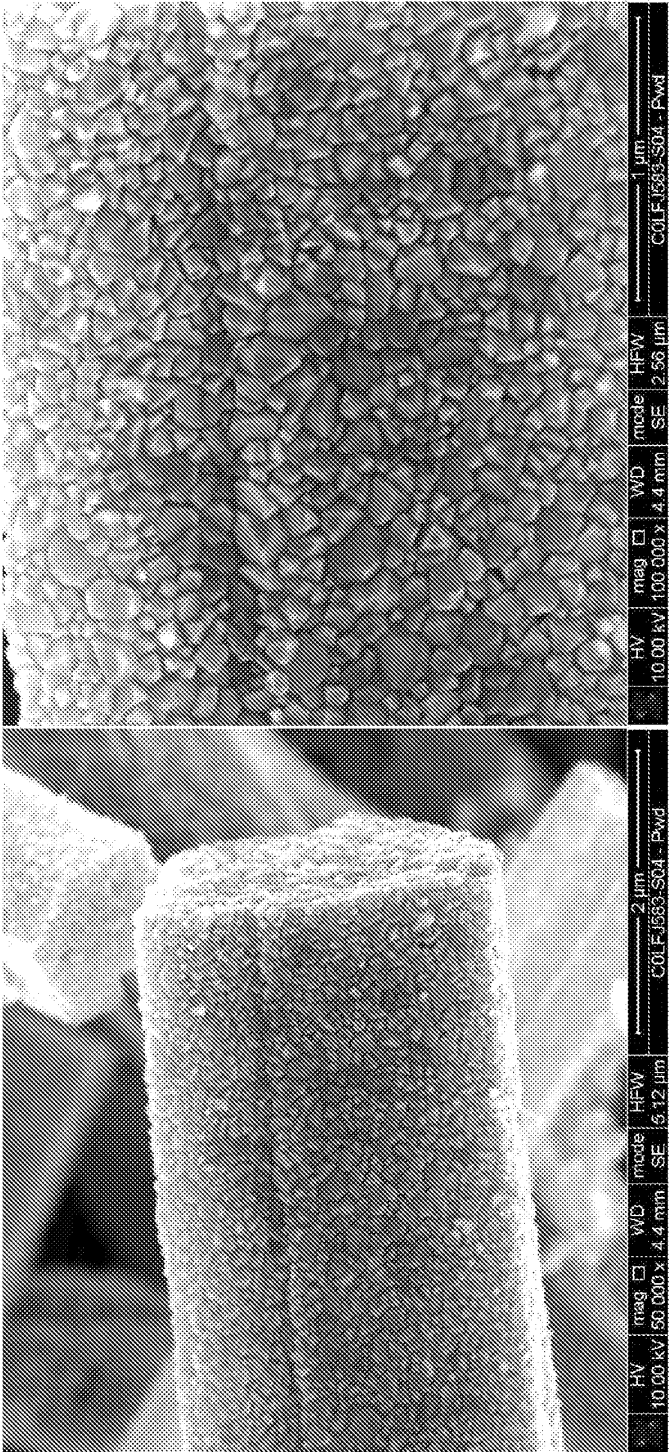
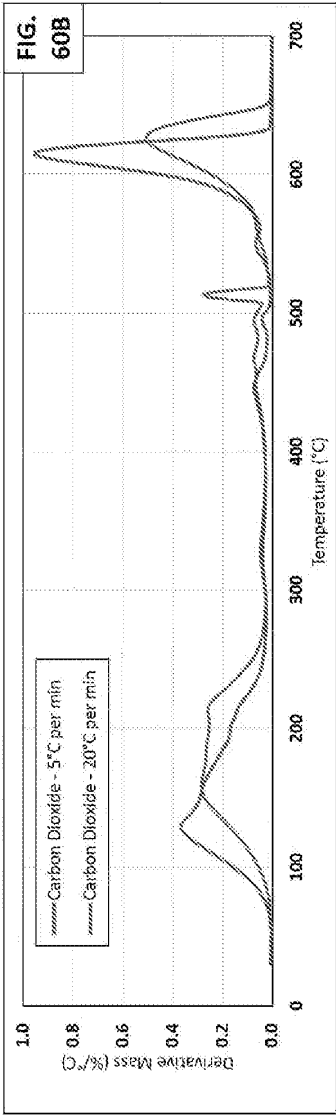
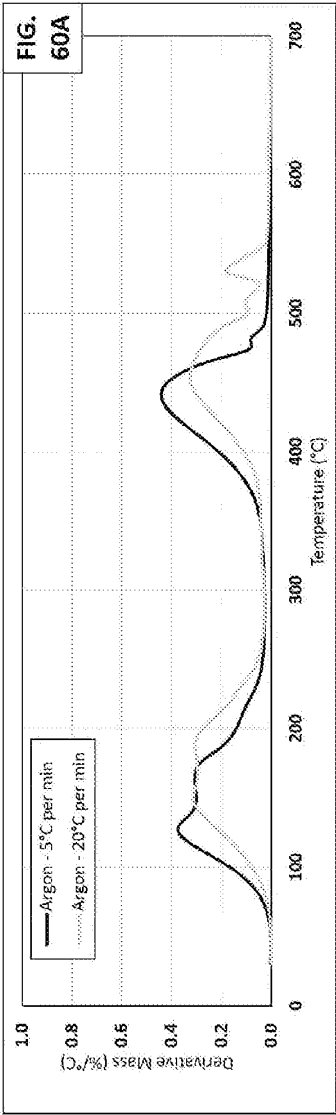
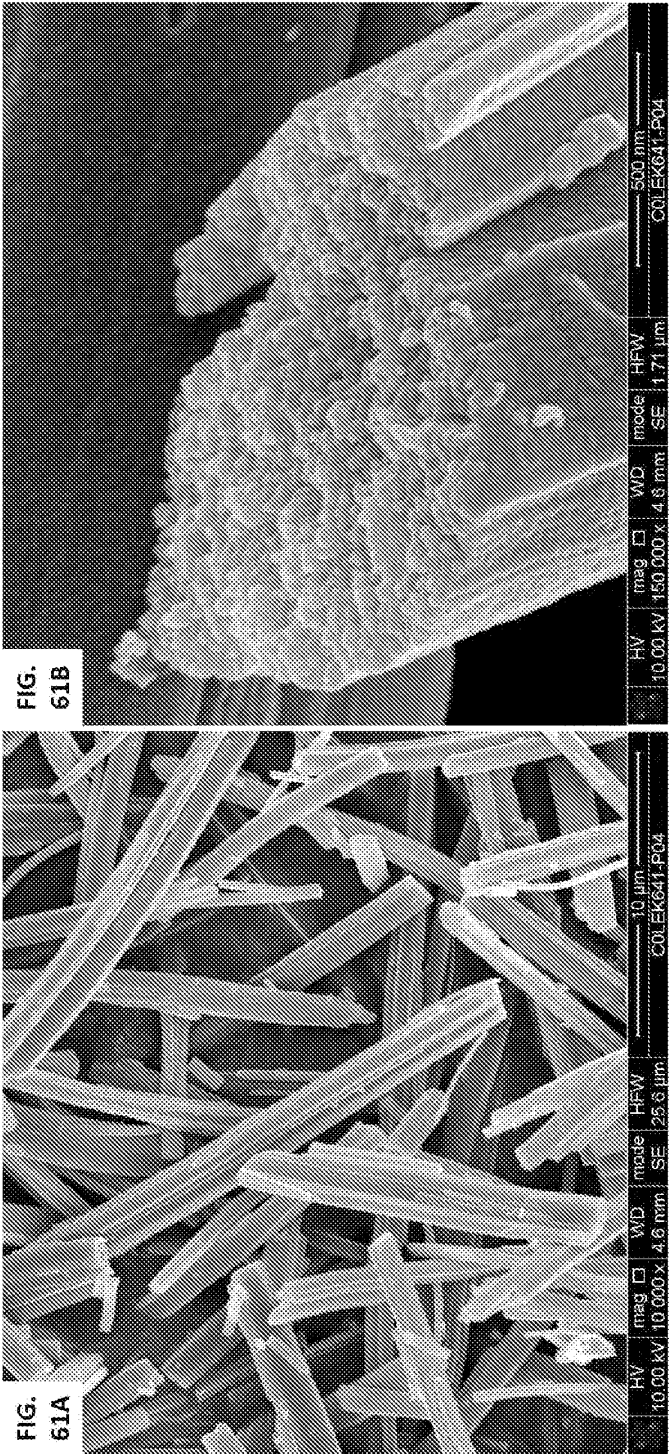
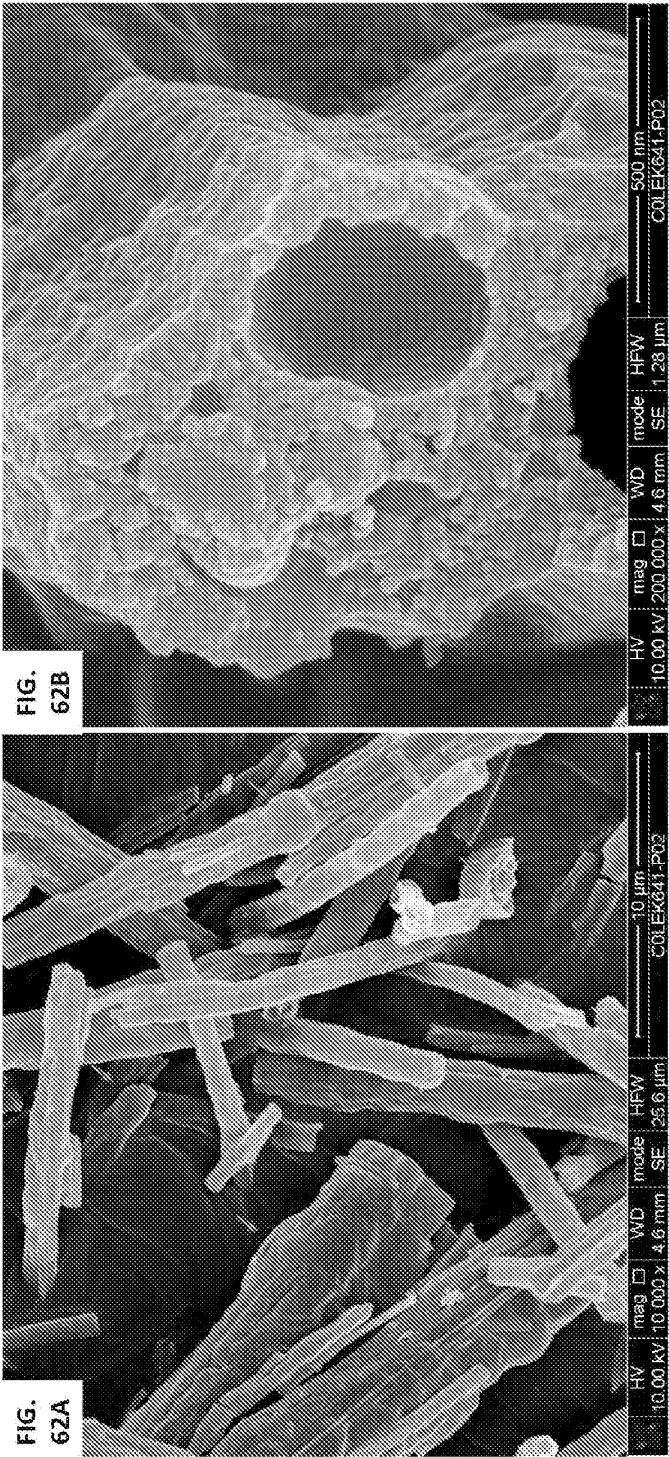
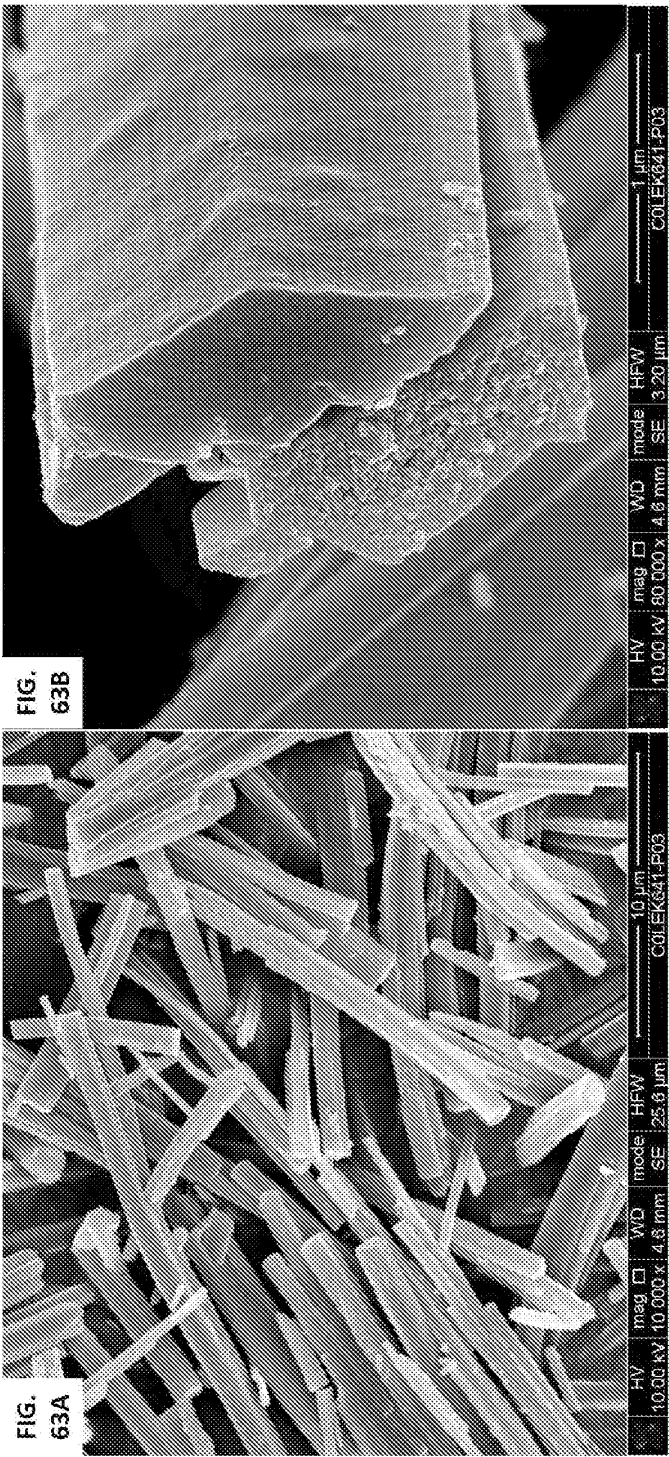


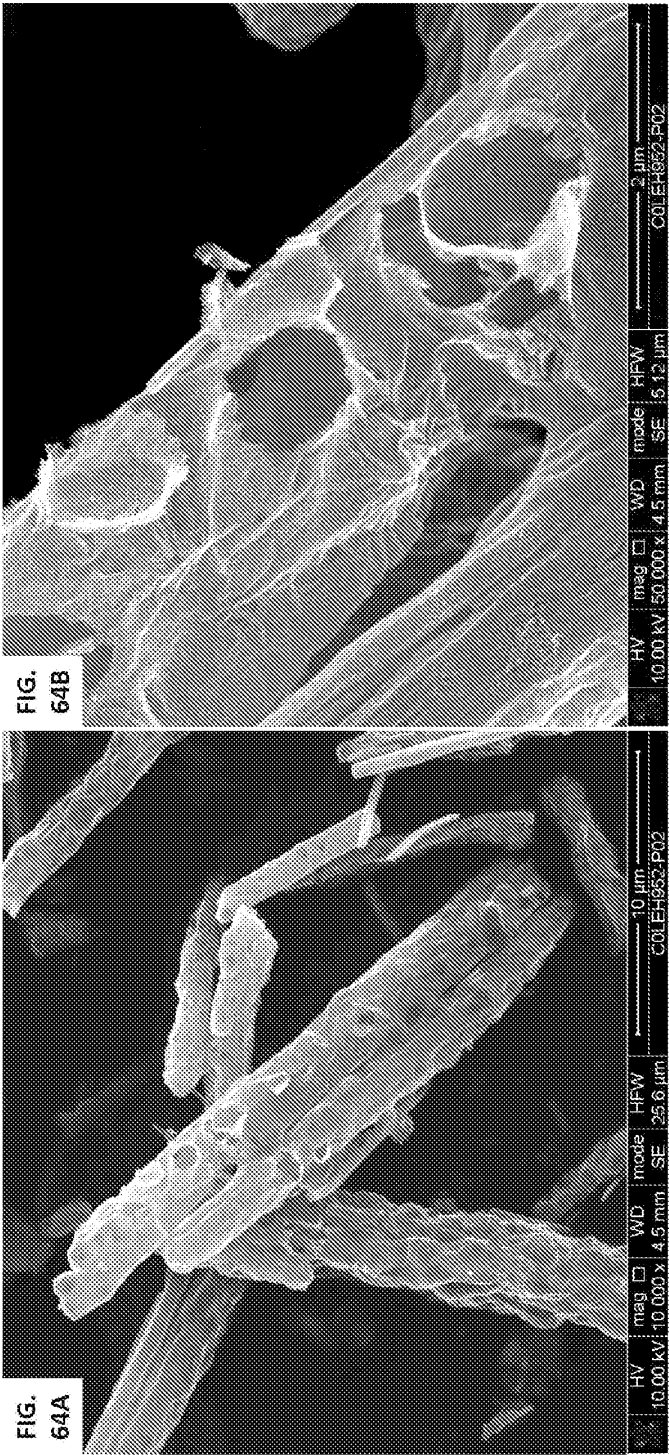
FIG. 59











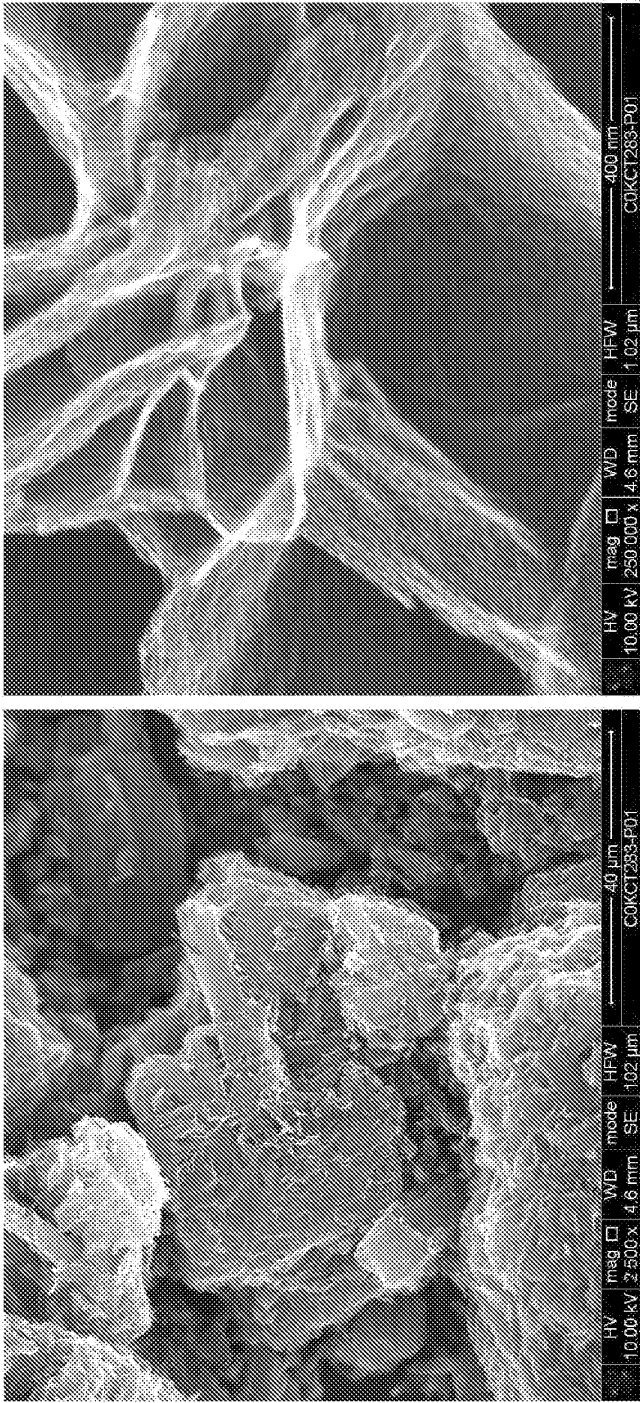
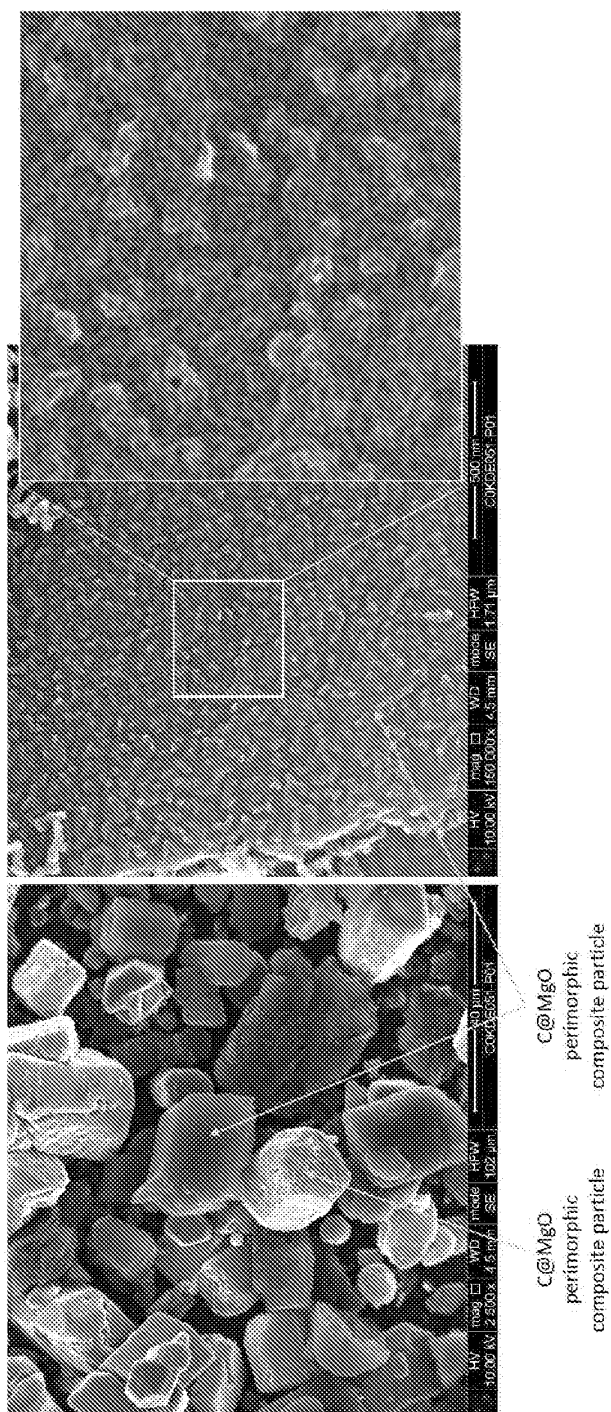
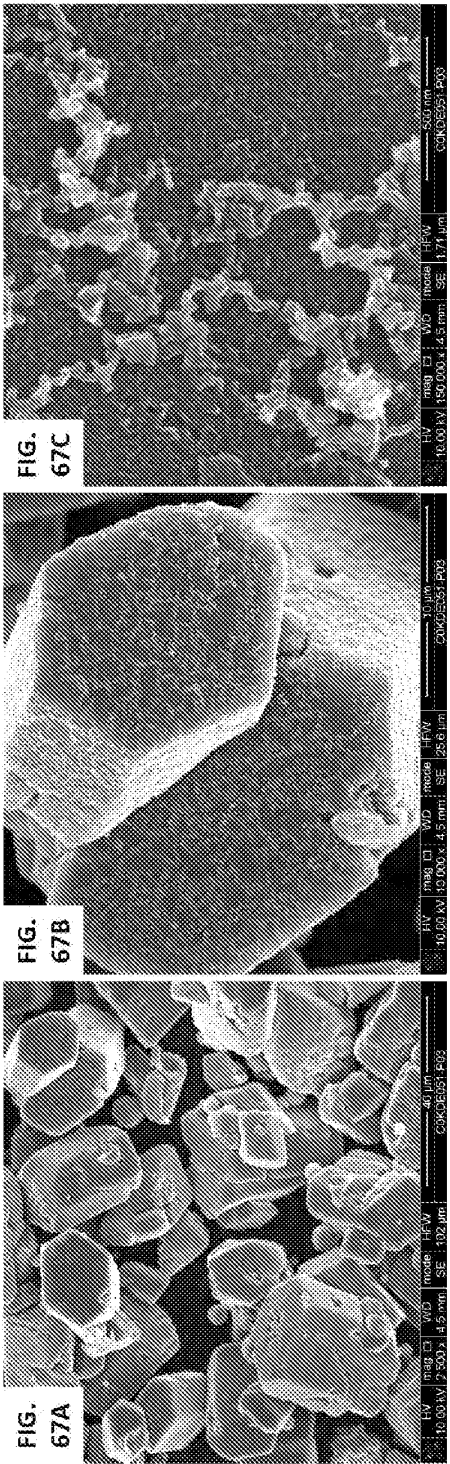


FIG. 65

FIG. 66





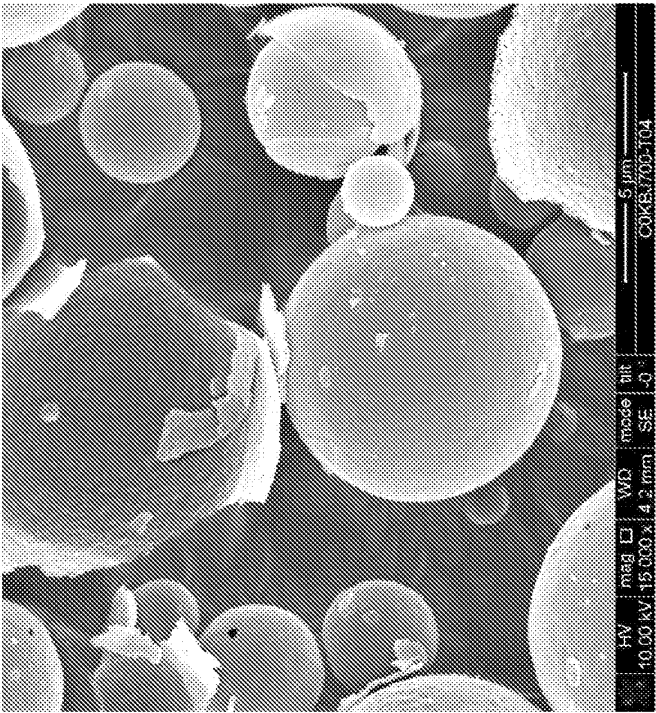
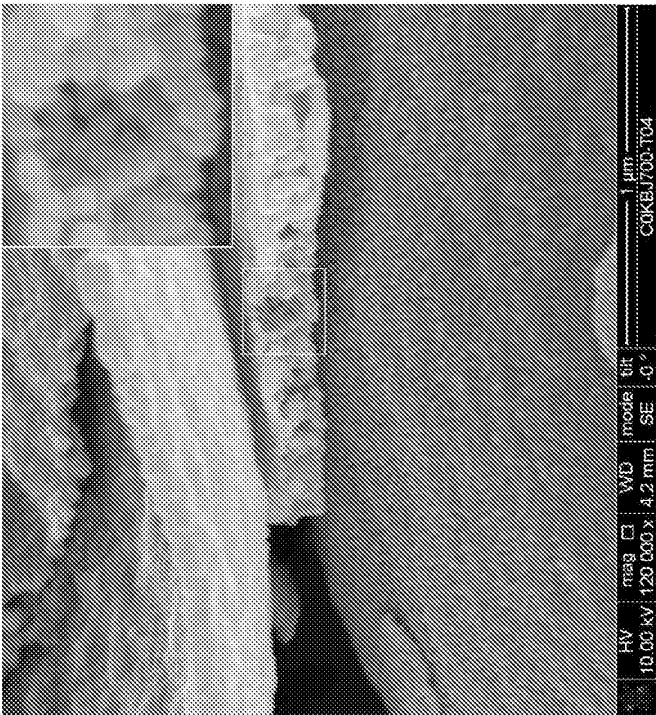
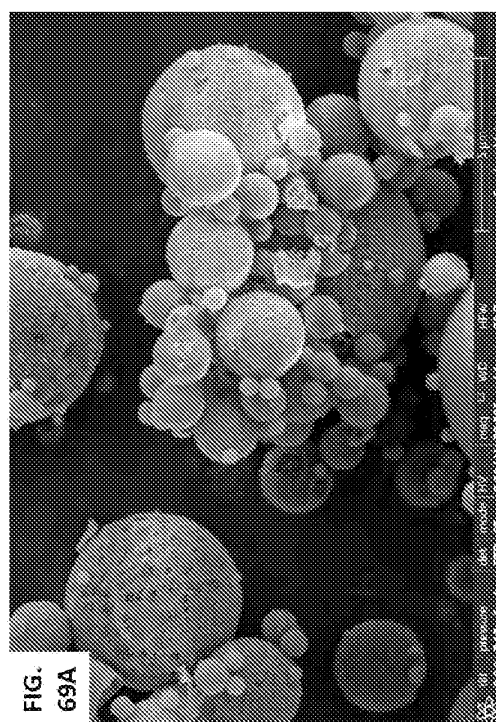
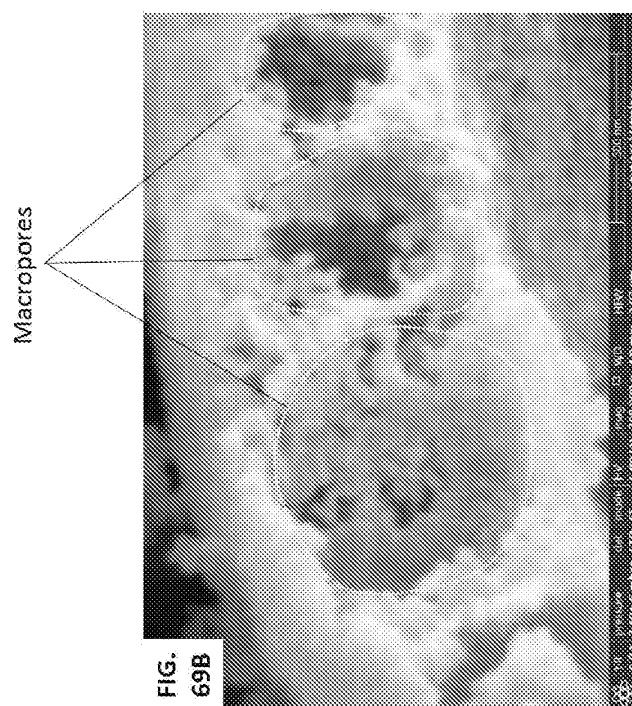


FIG. 68



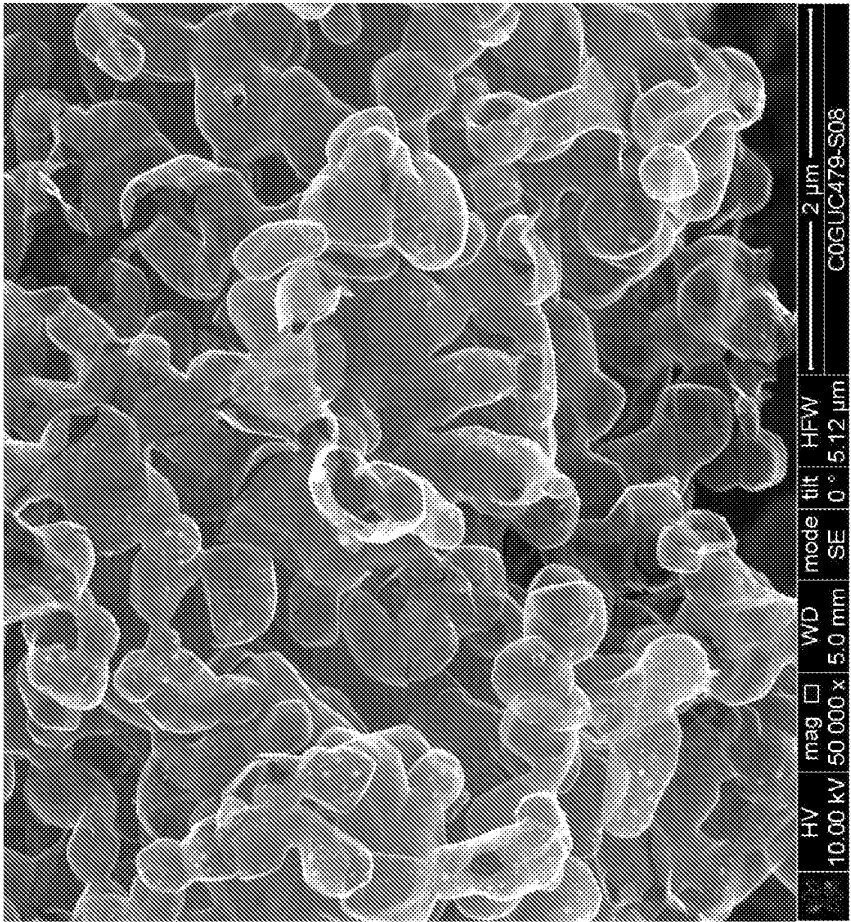


FIG. 70

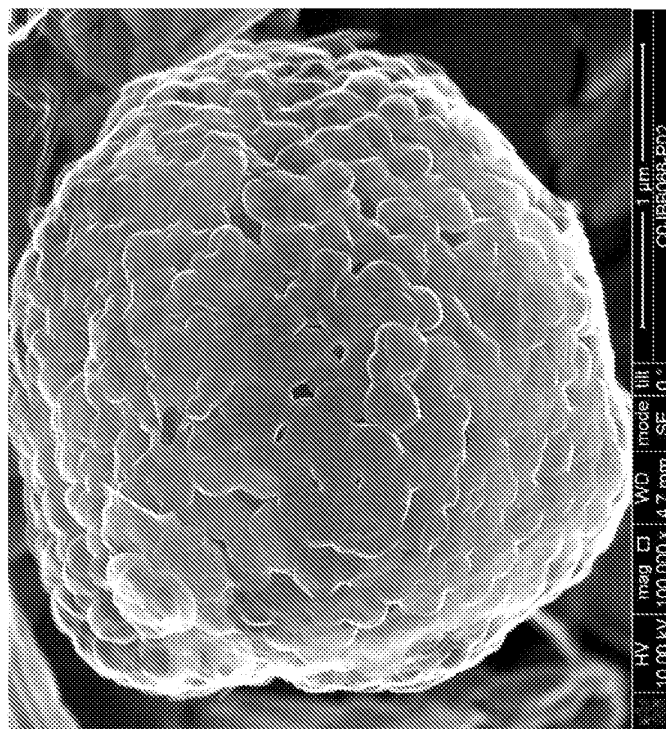
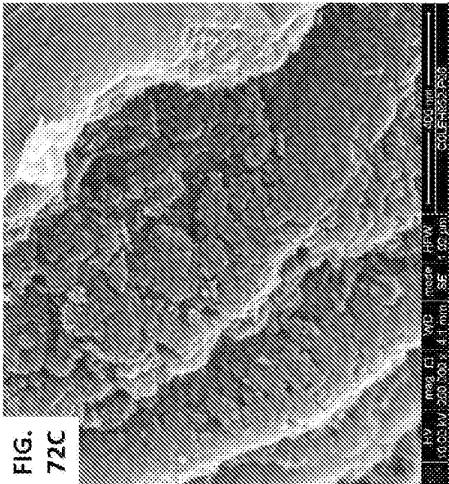
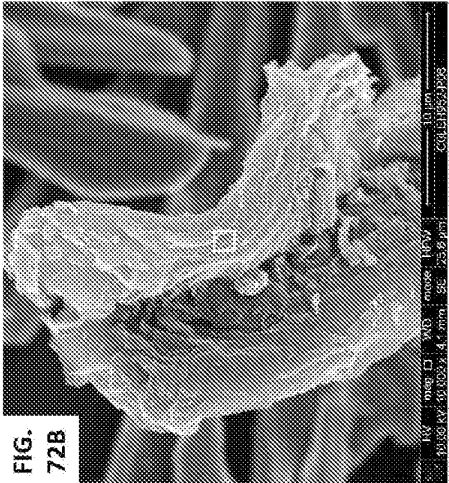
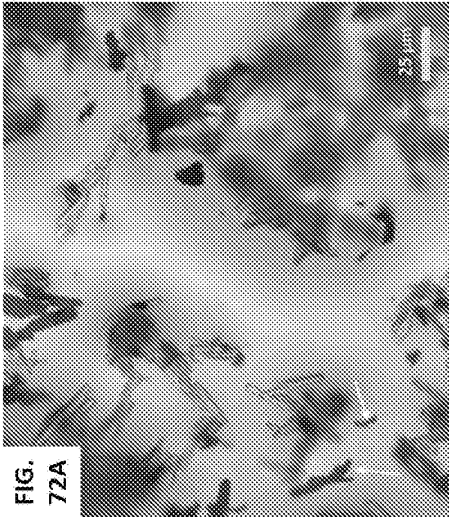
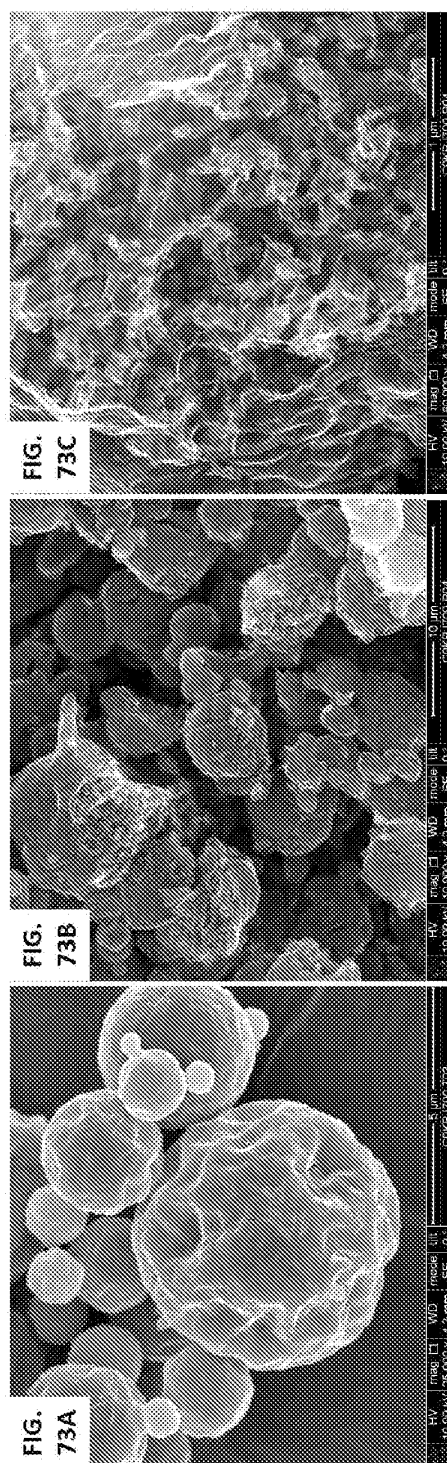


FIG. 72





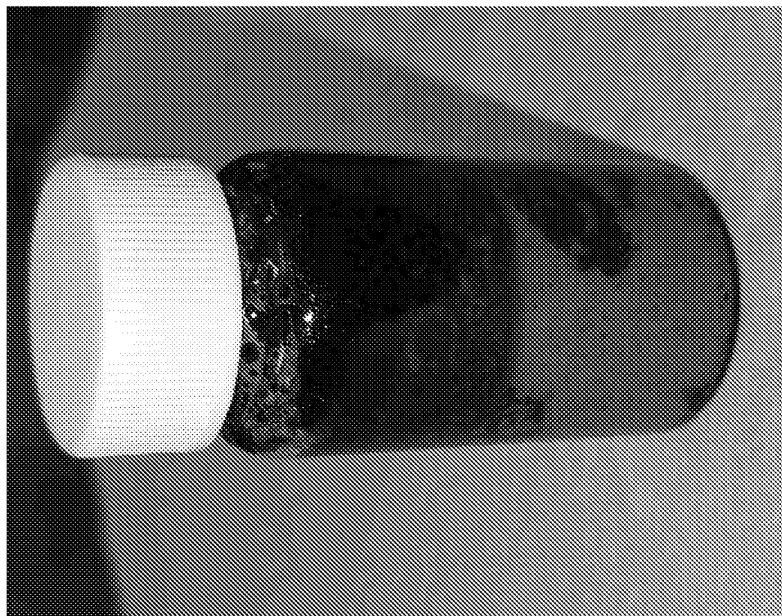
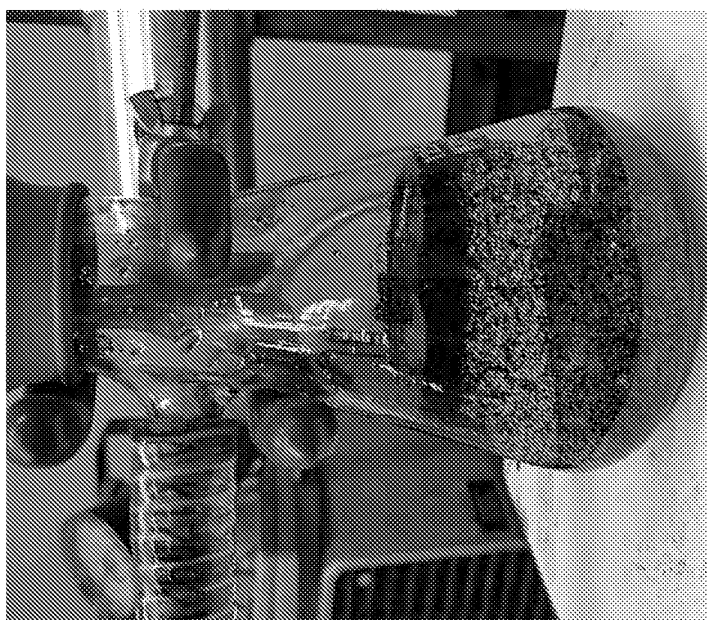


FIG. 74

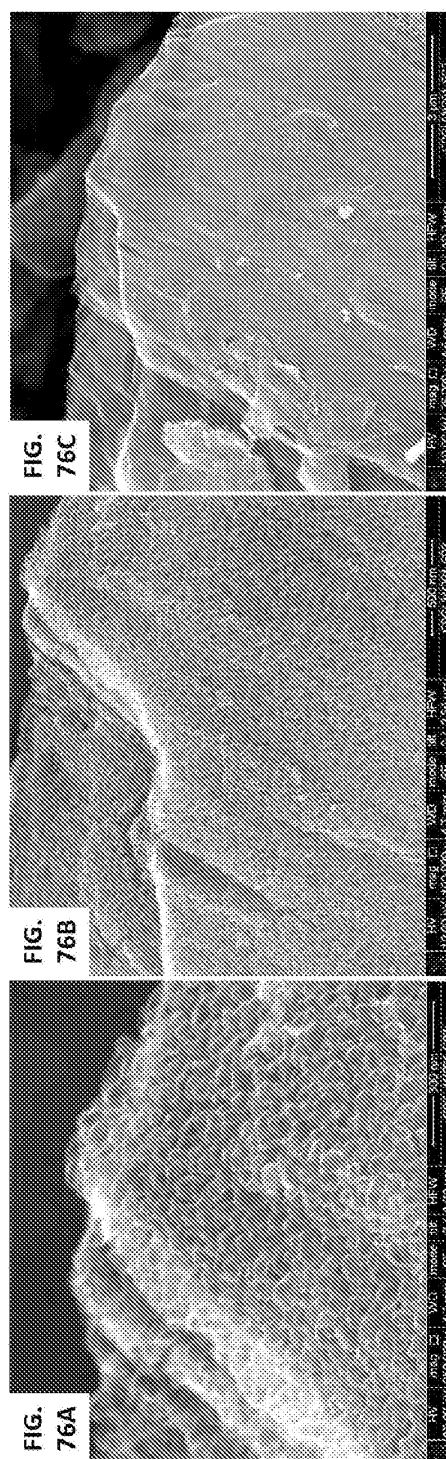


Flotation



Initial slurry

FIG. 75



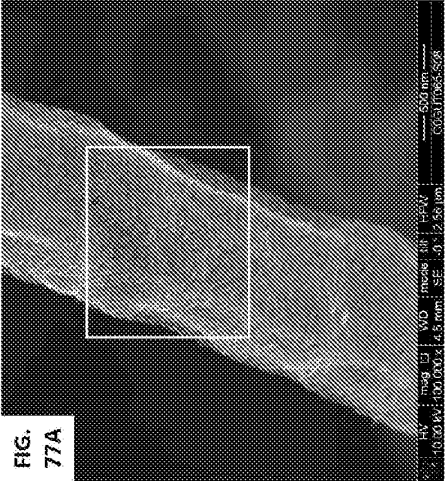
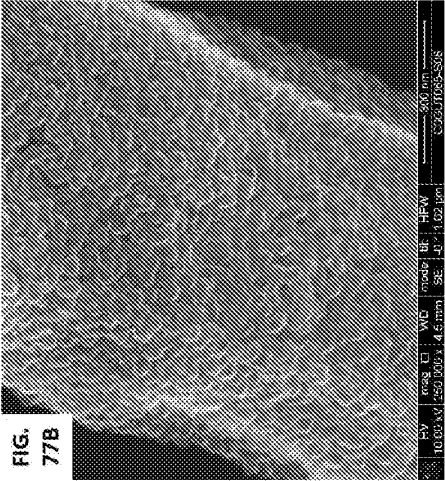
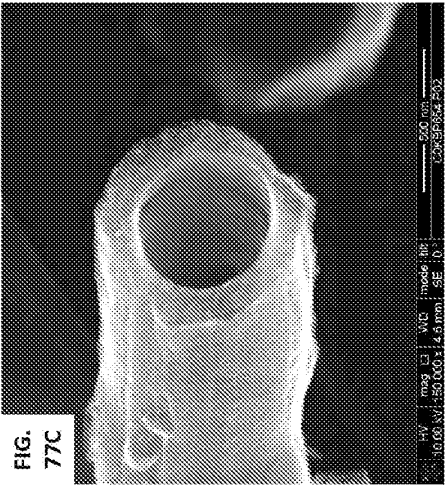
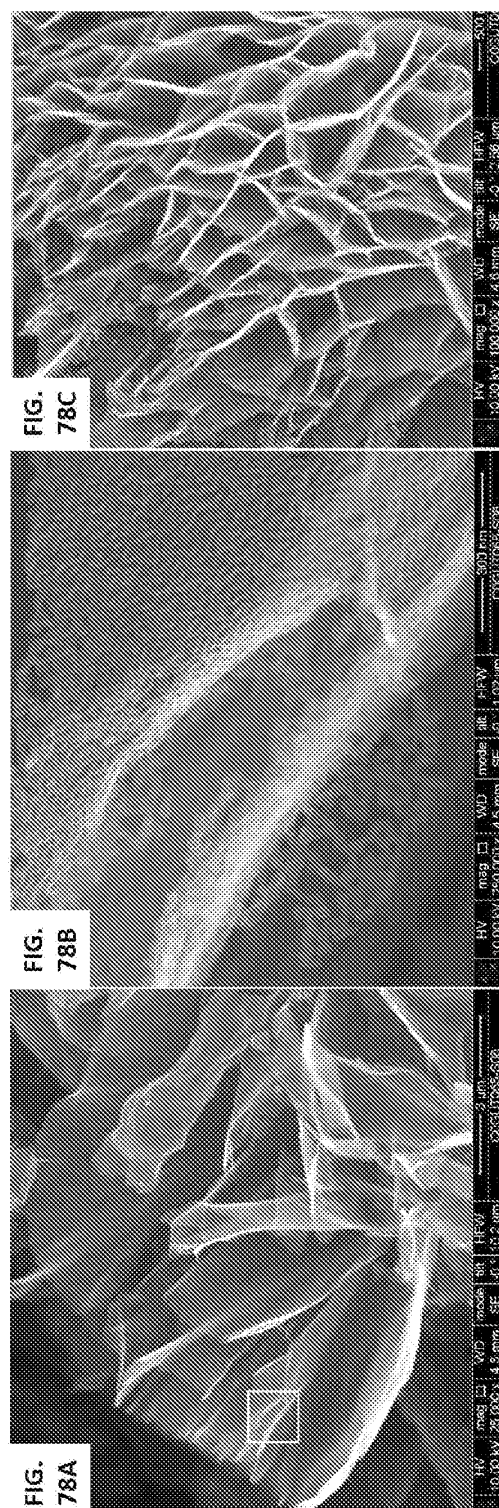


FIG. 64



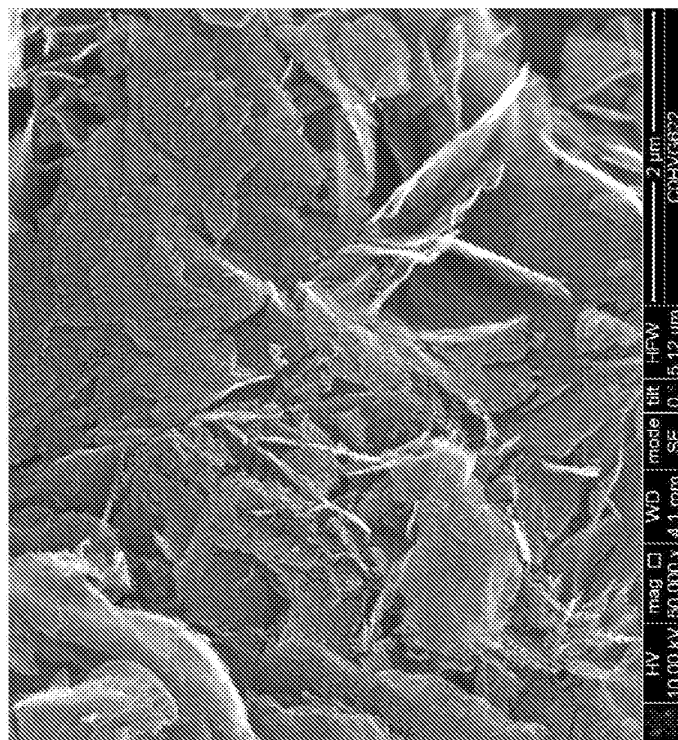


FIG. 79

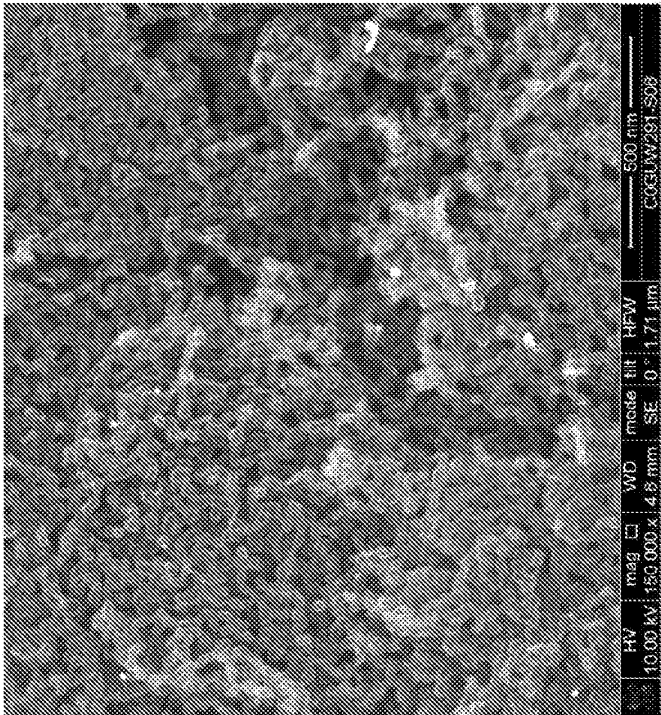


FIG. 80

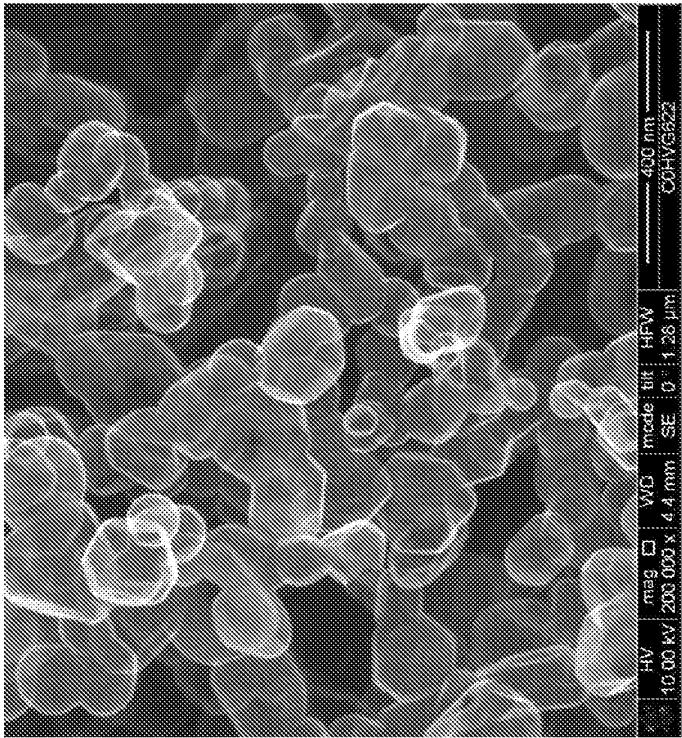


FIG. 81

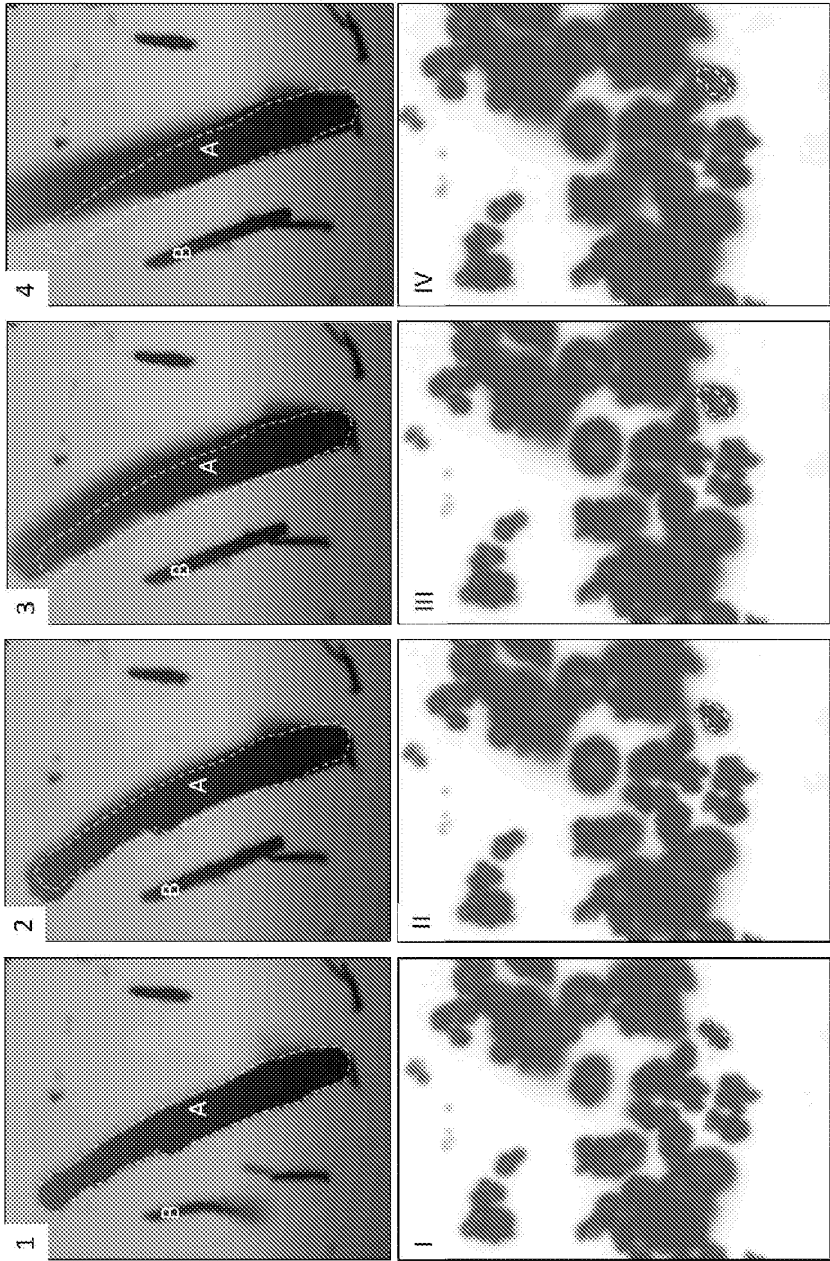
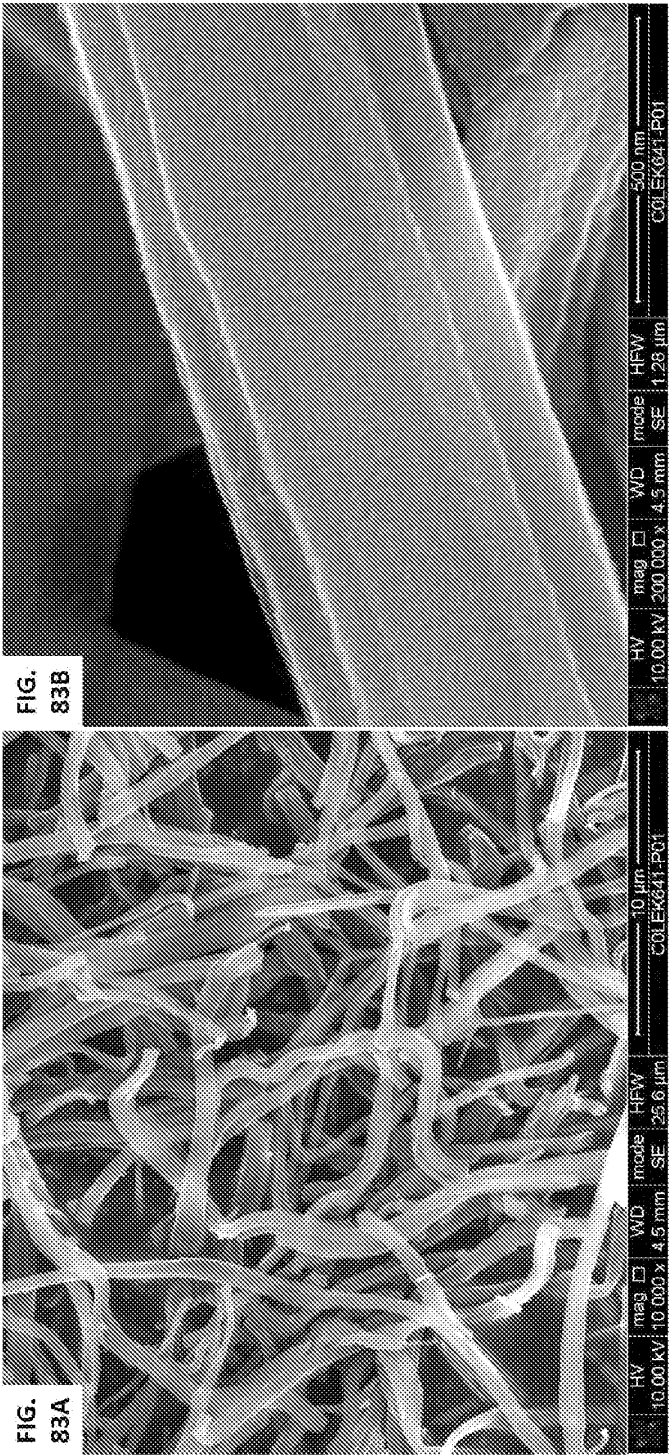


FIG. 82



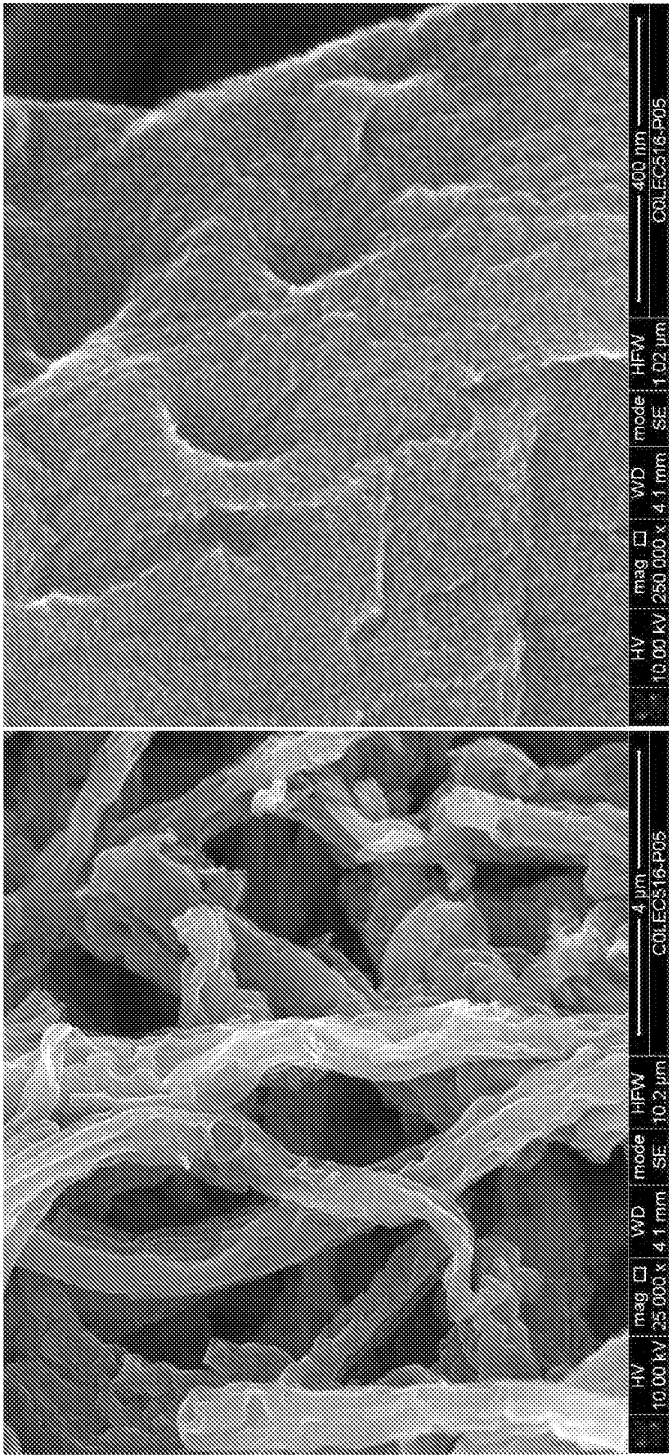
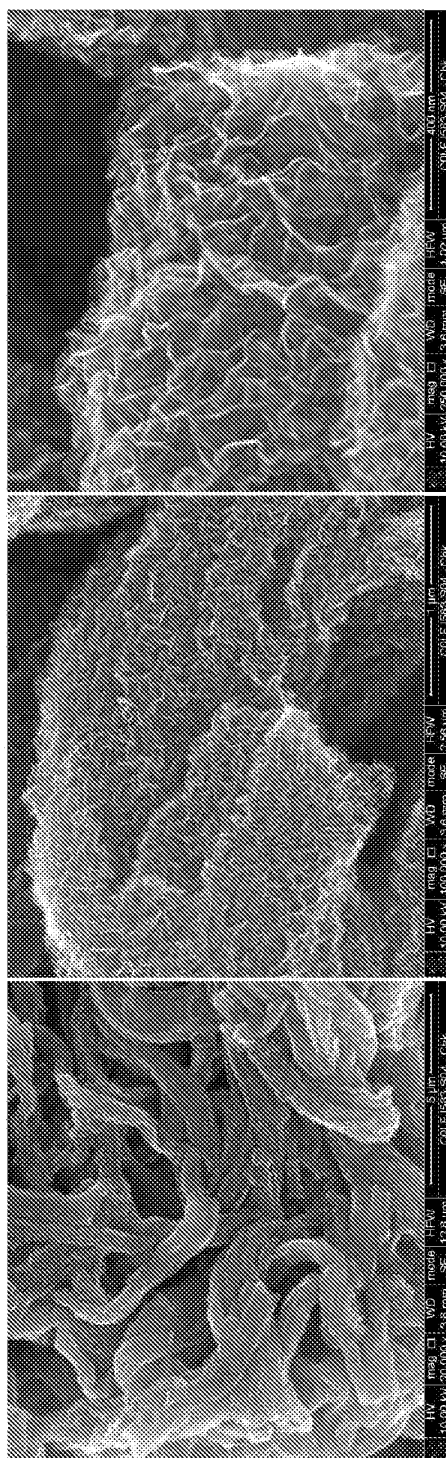


FIG. 85



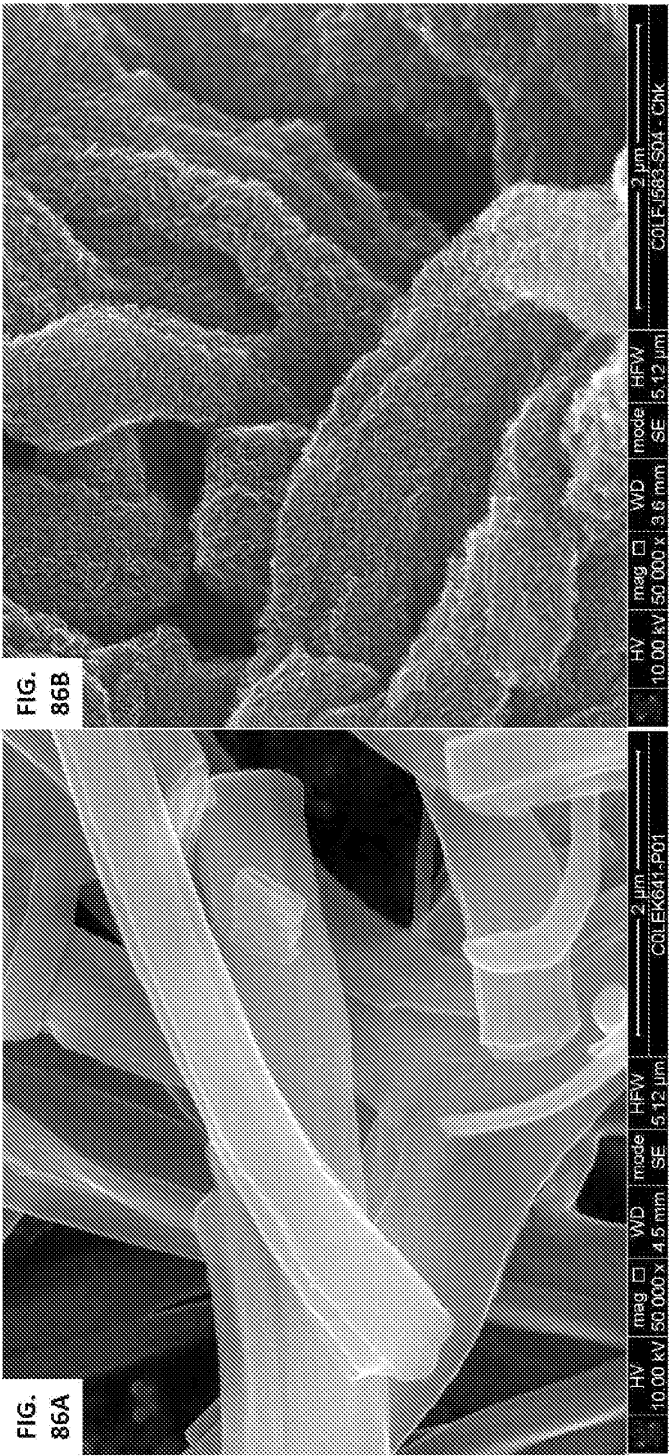
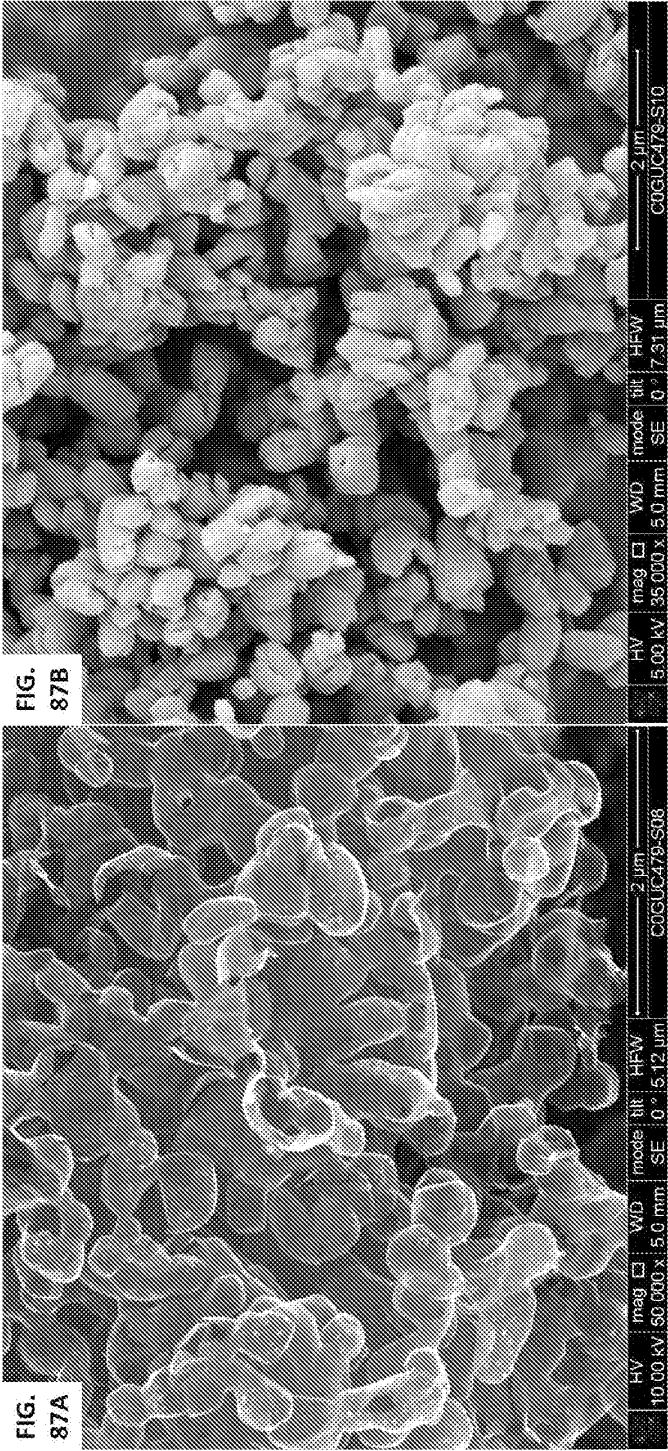


FIG. 87



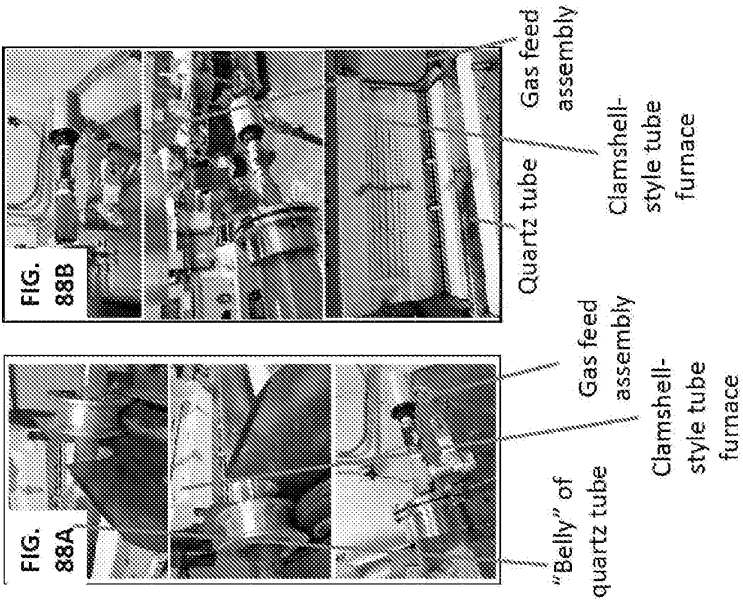
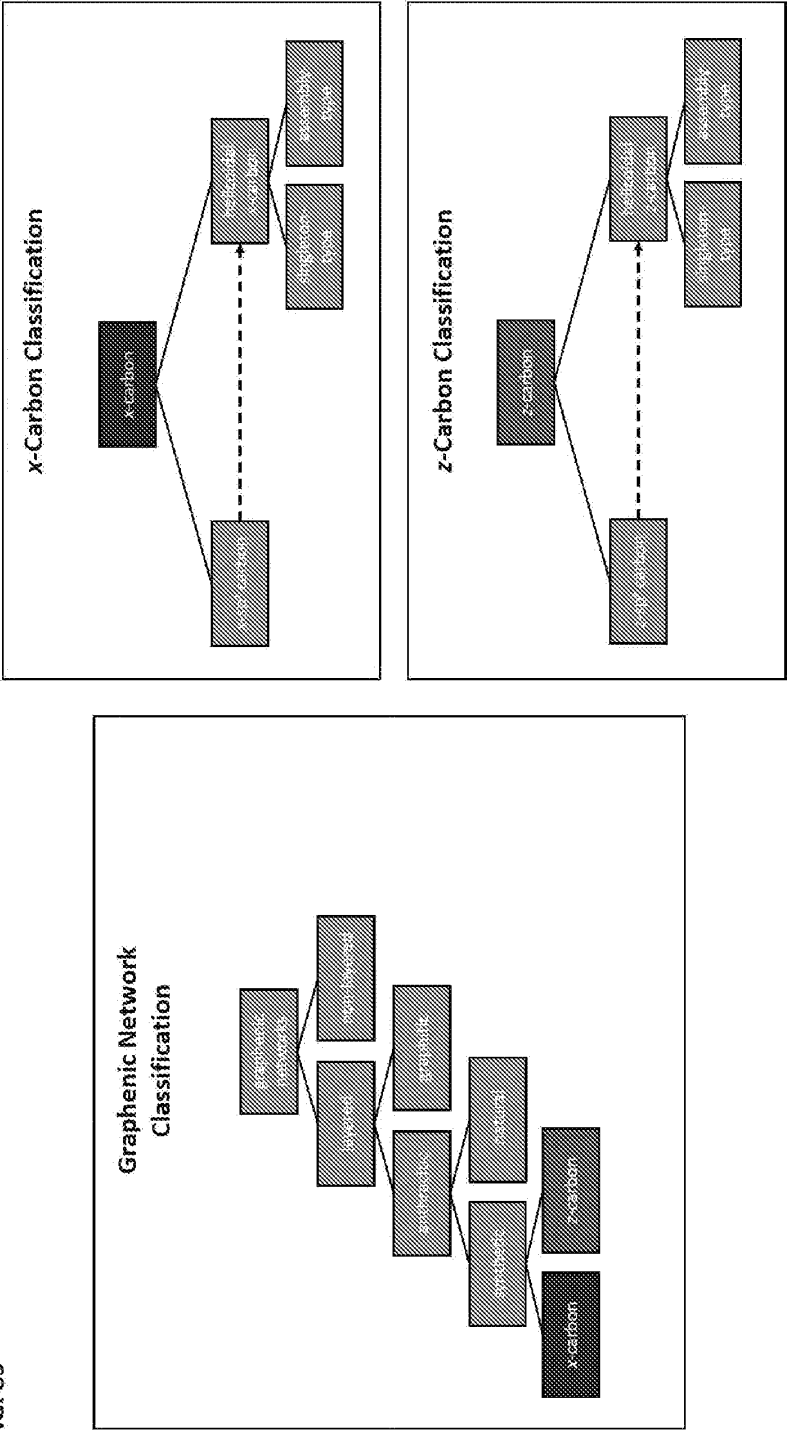


FIG. 89



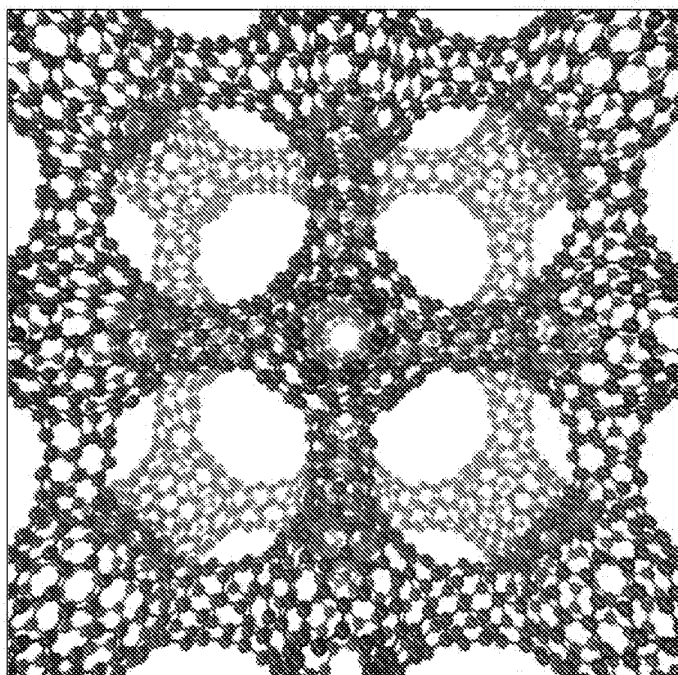
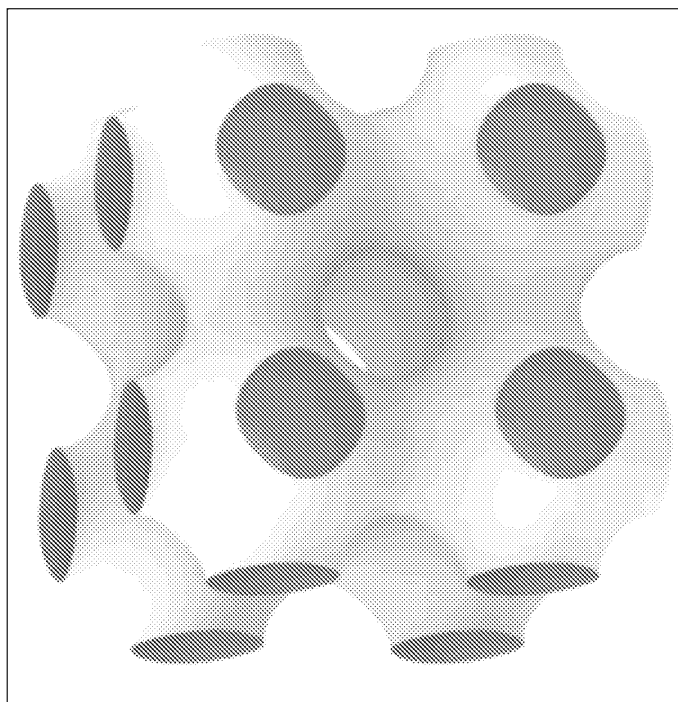


FIG. 90

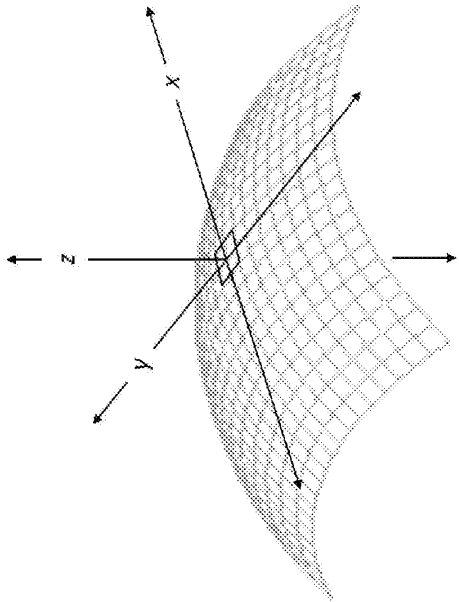


FIG. 91

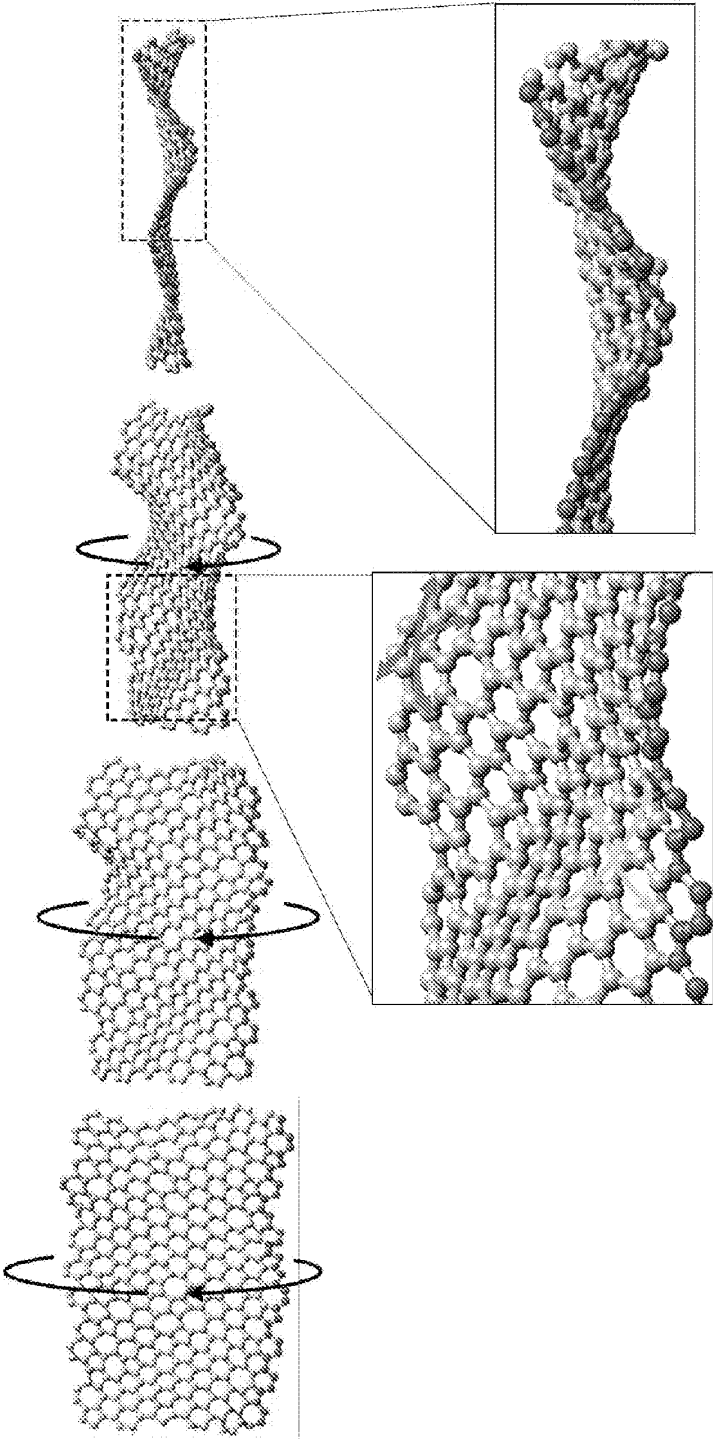
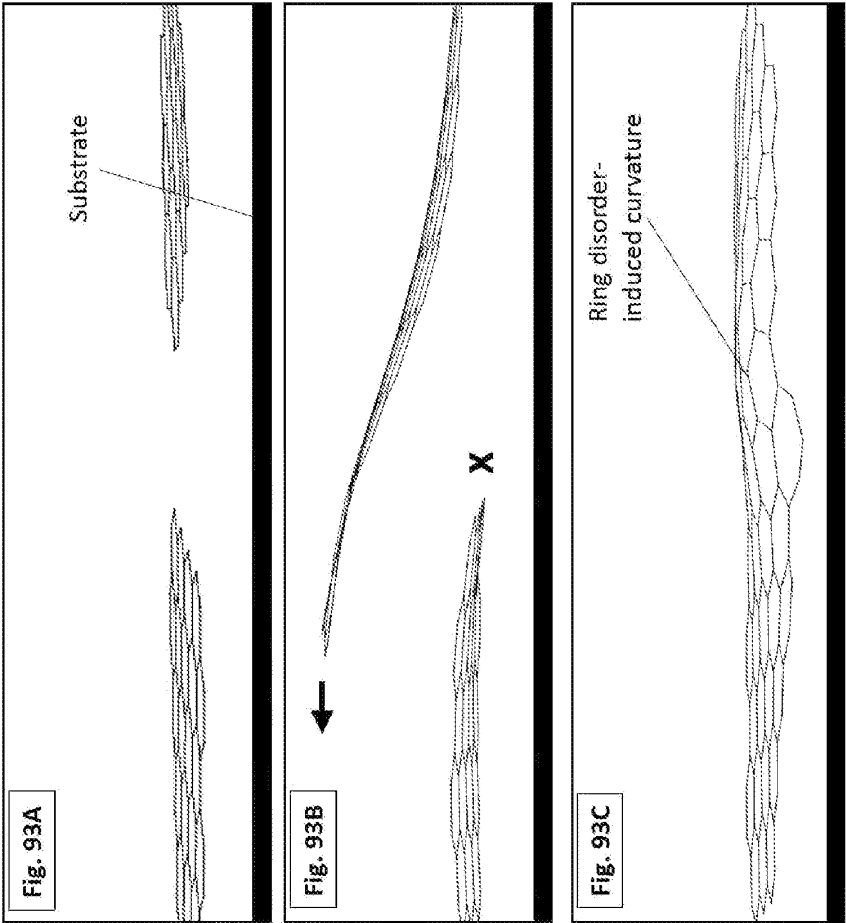
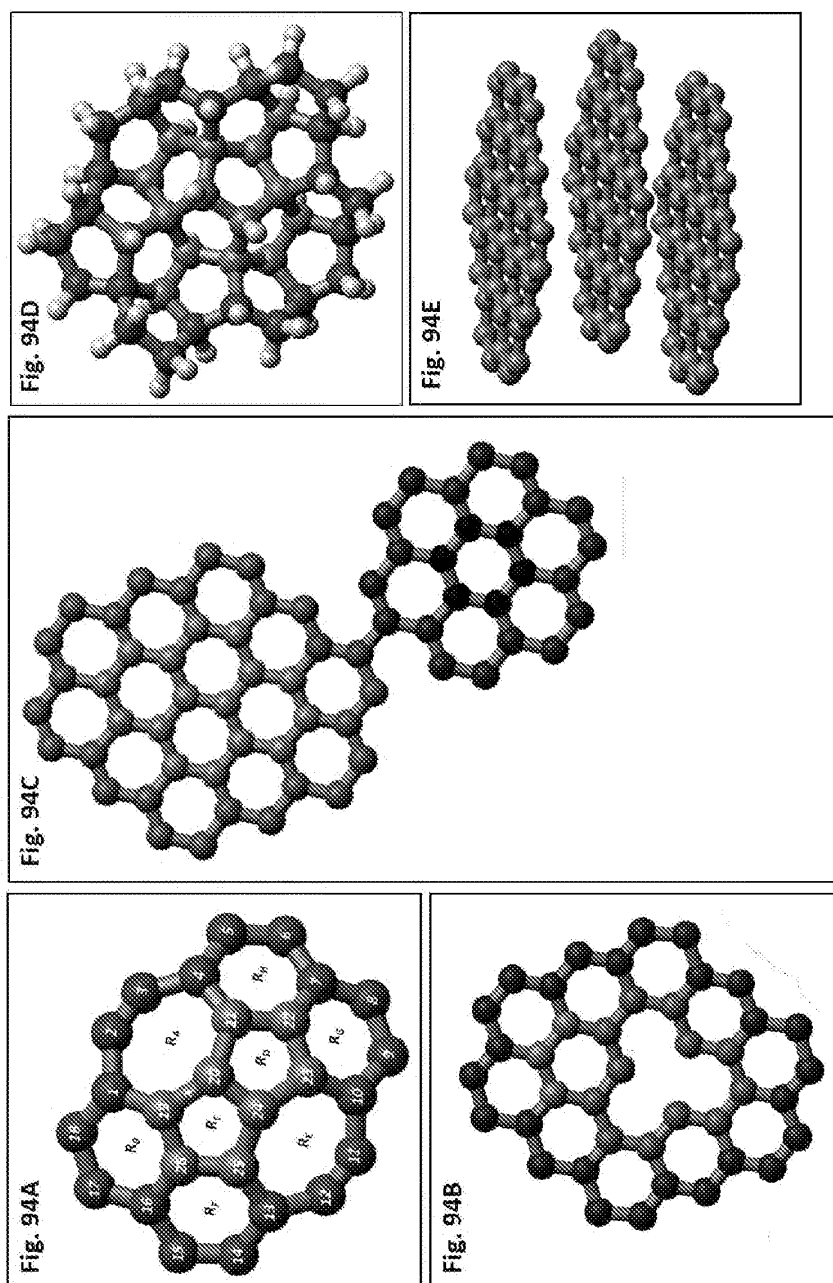
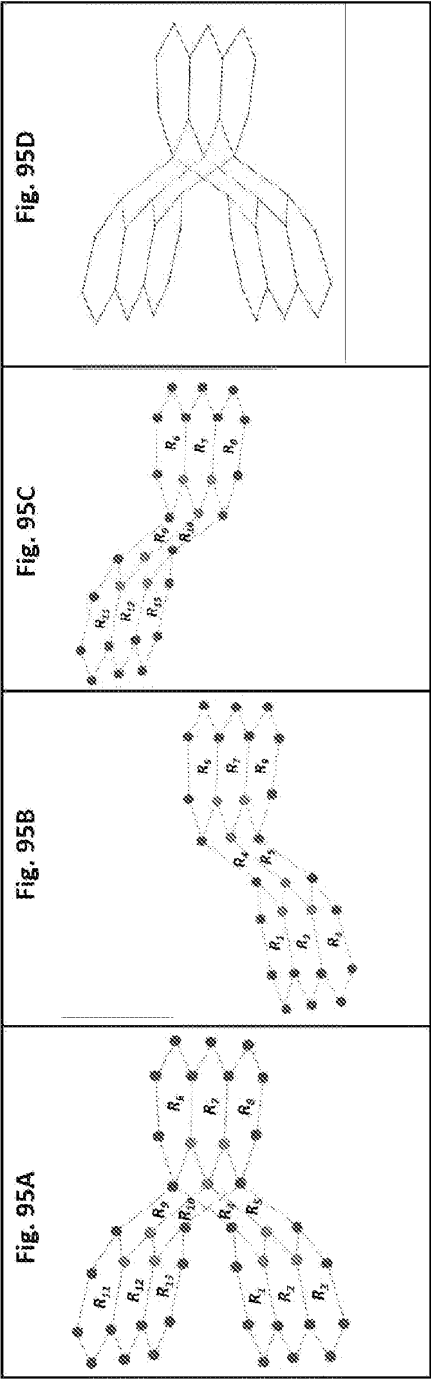


FIG. 92







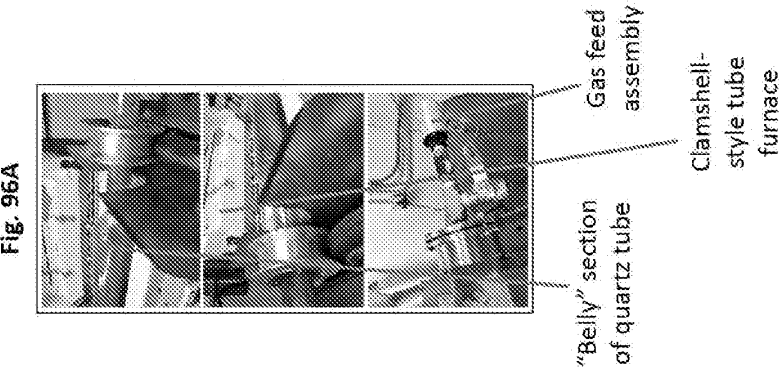
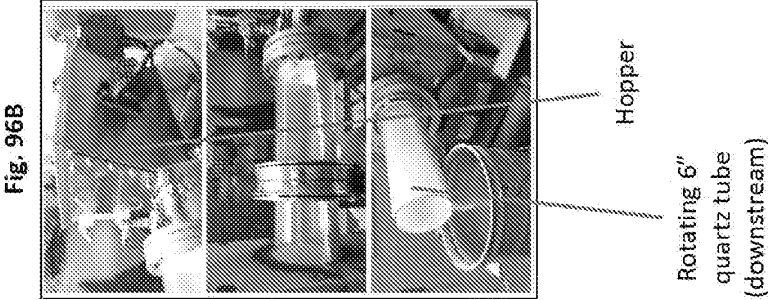
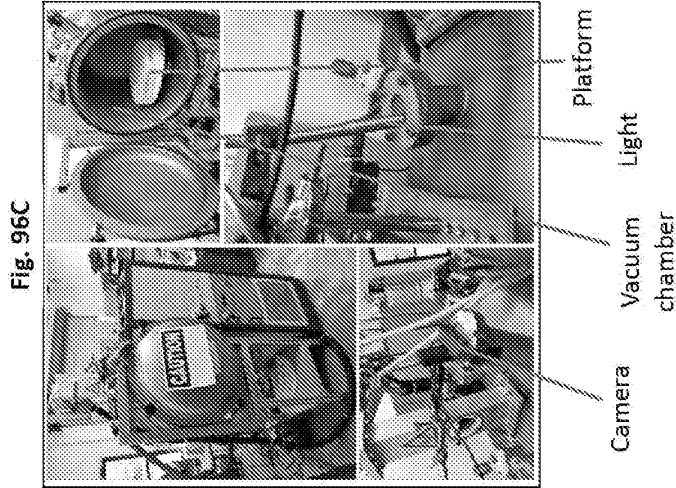
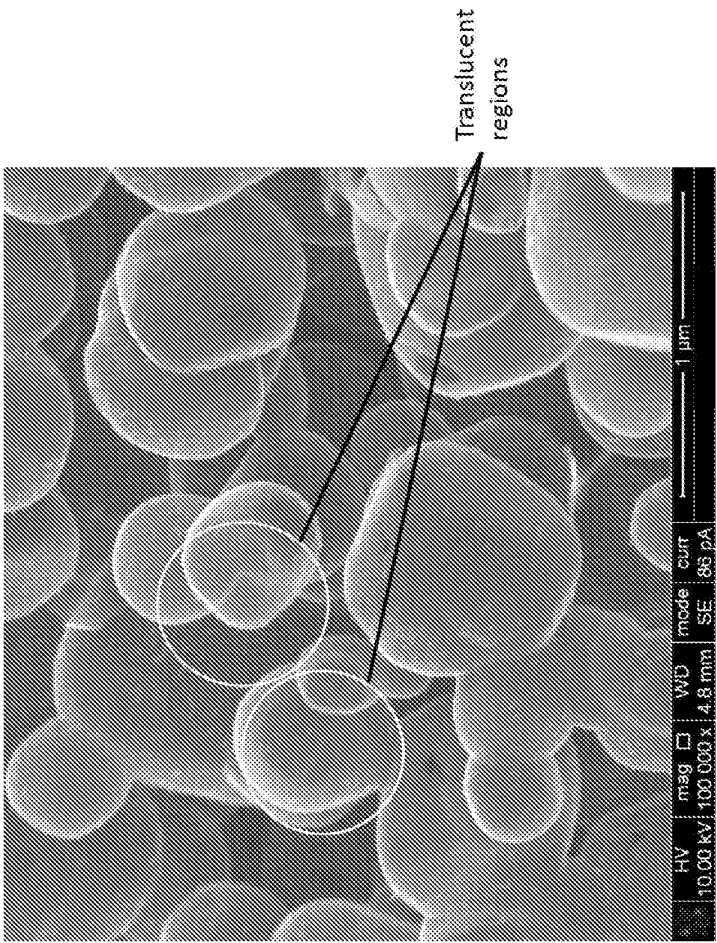
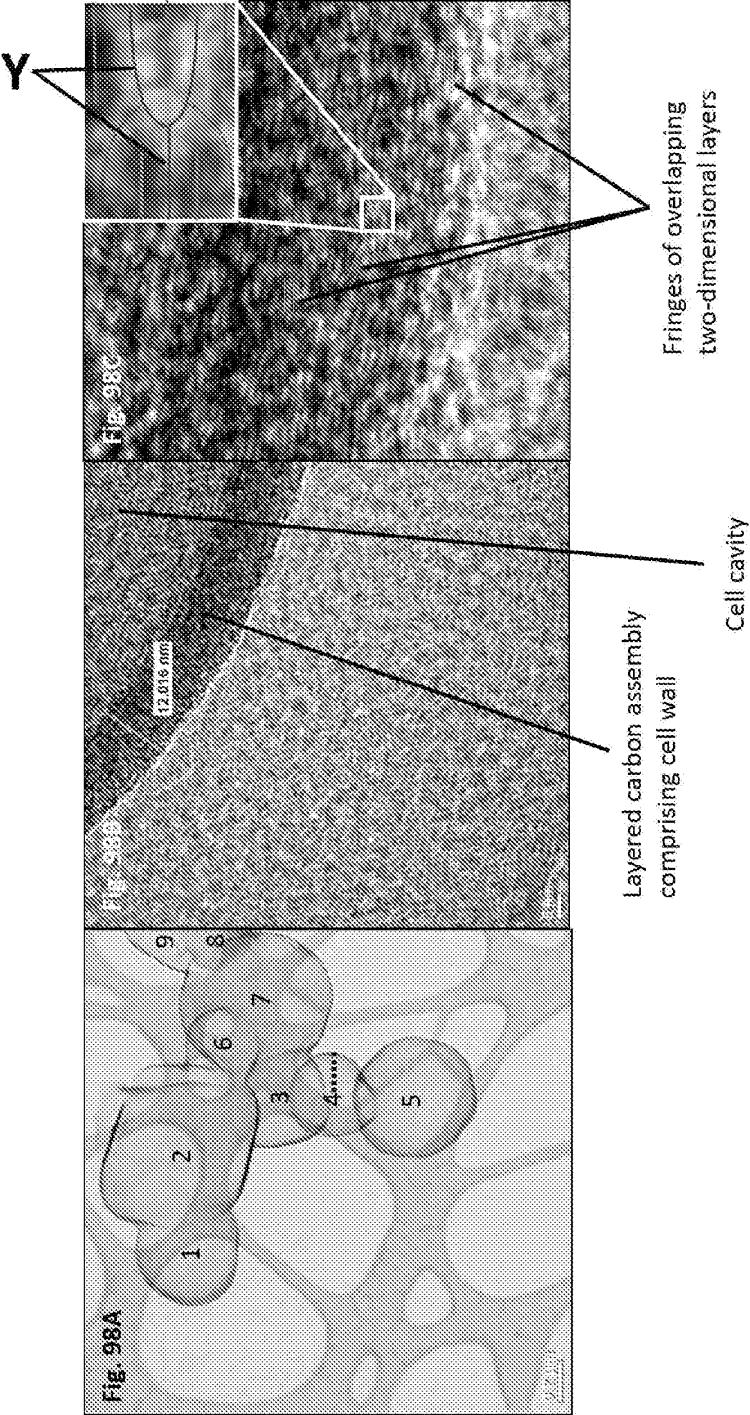


FIG. 97





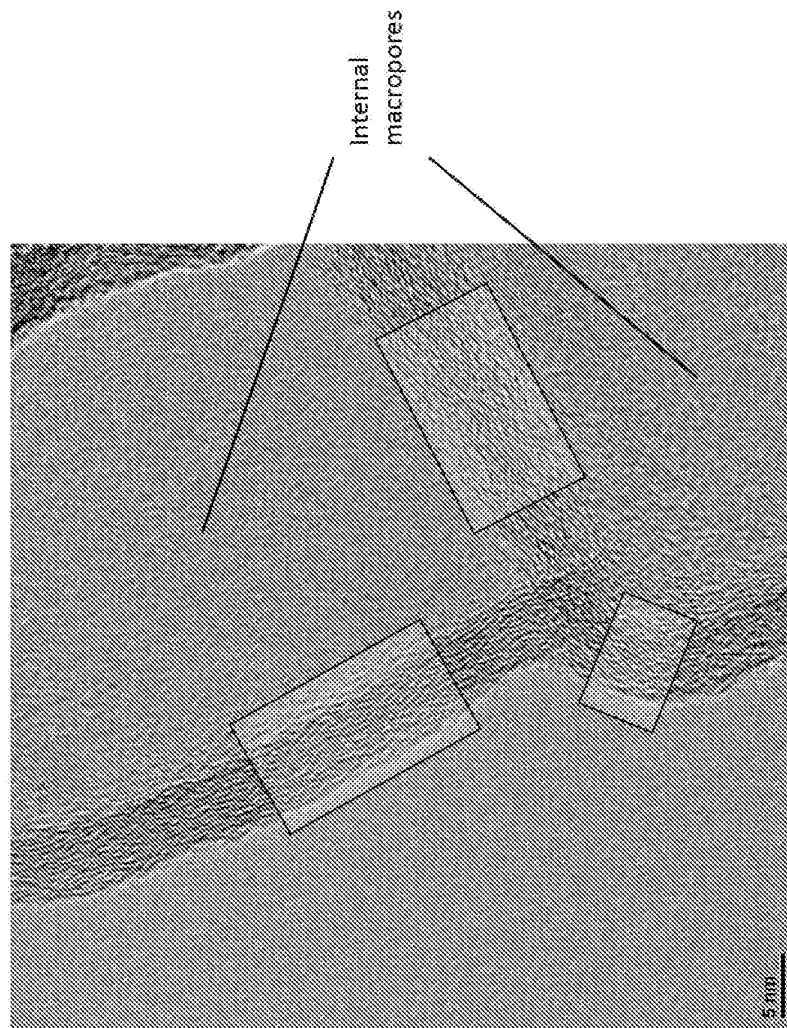


FIG. 99

Fig. 100D

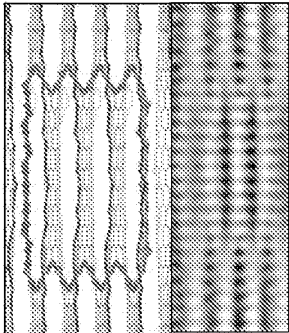


Fig. 100C

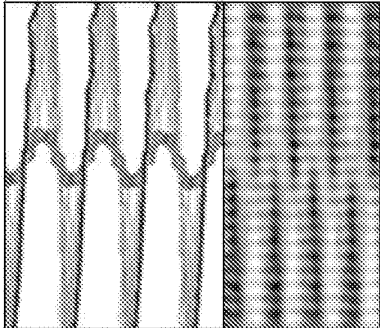


Fig. 100B

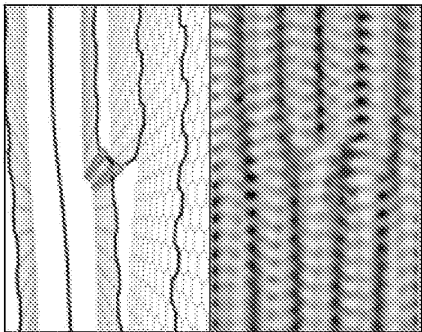
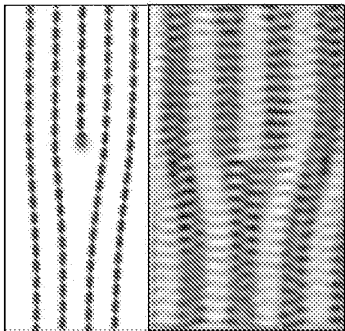


Fig. 100A



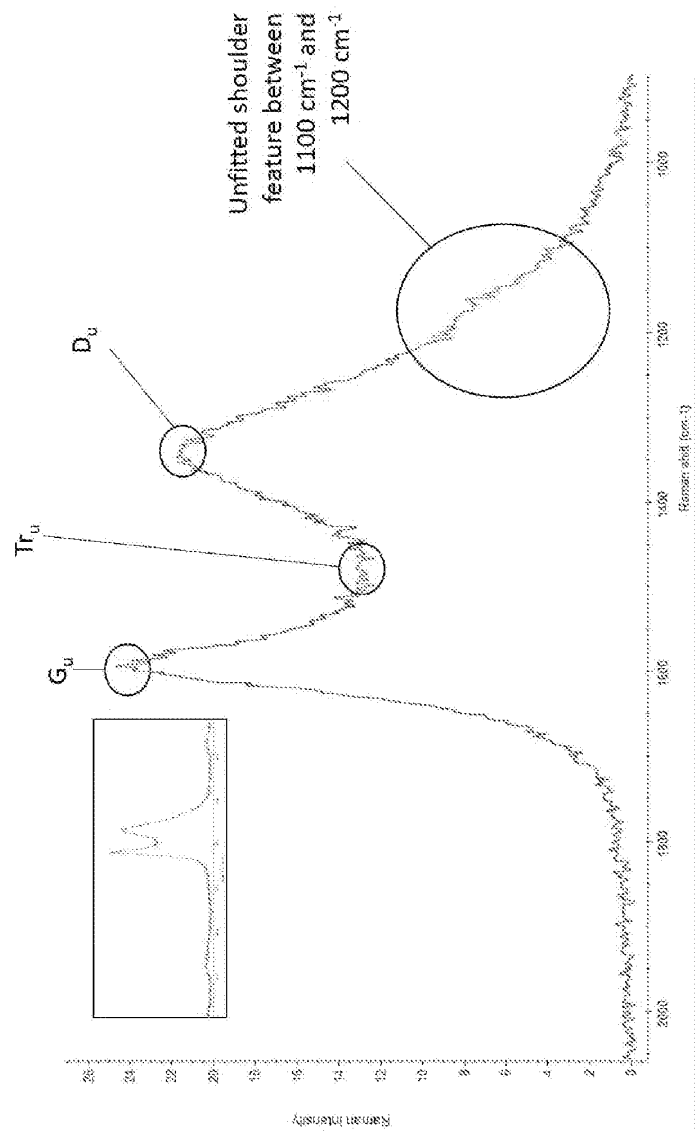


FIG. 101

FIG. 102

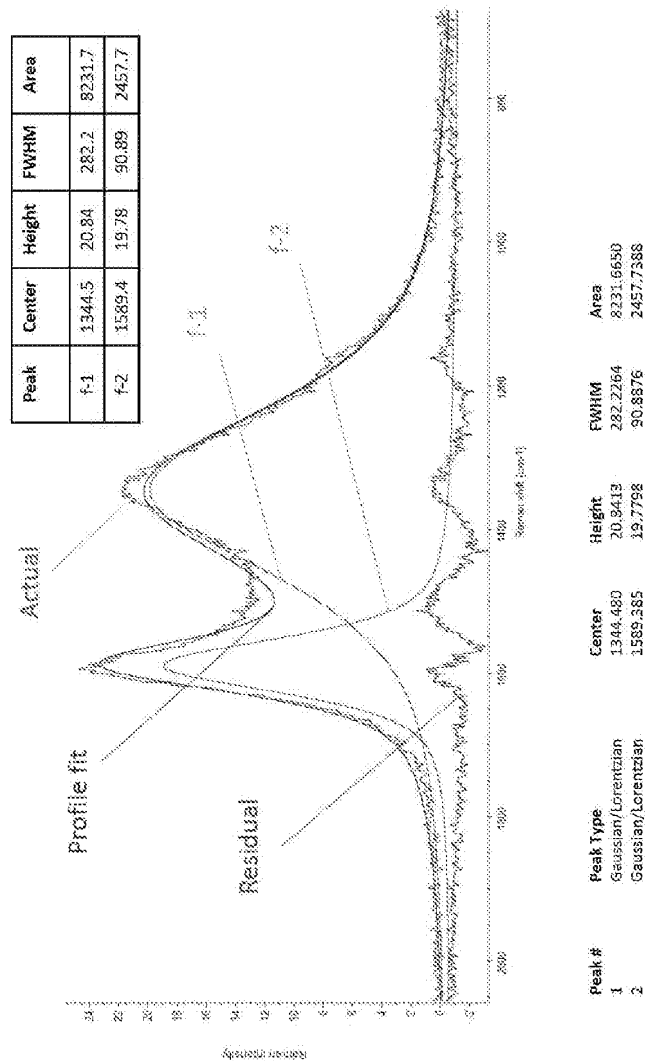


FIG. 103

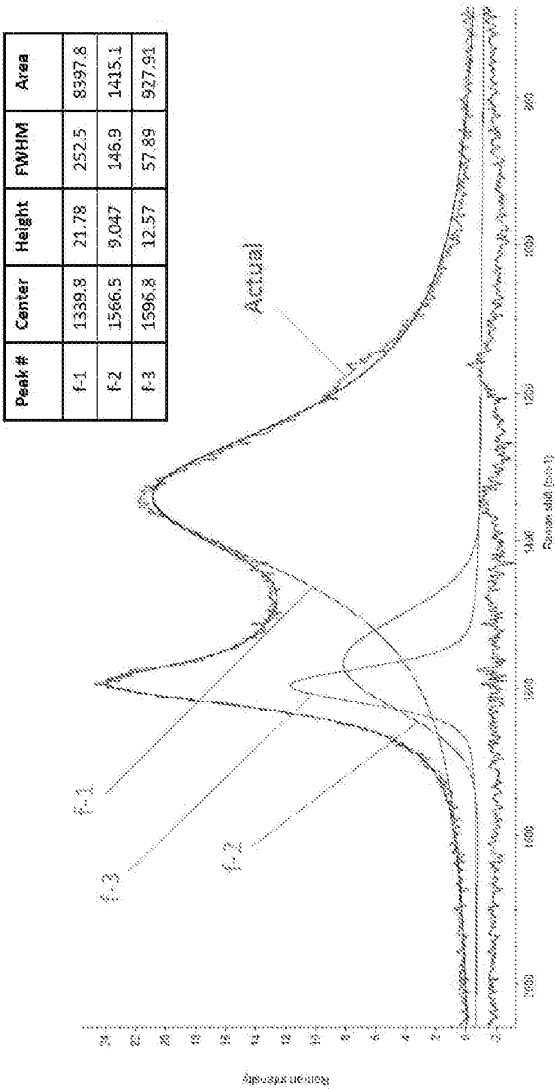


FIG. 104

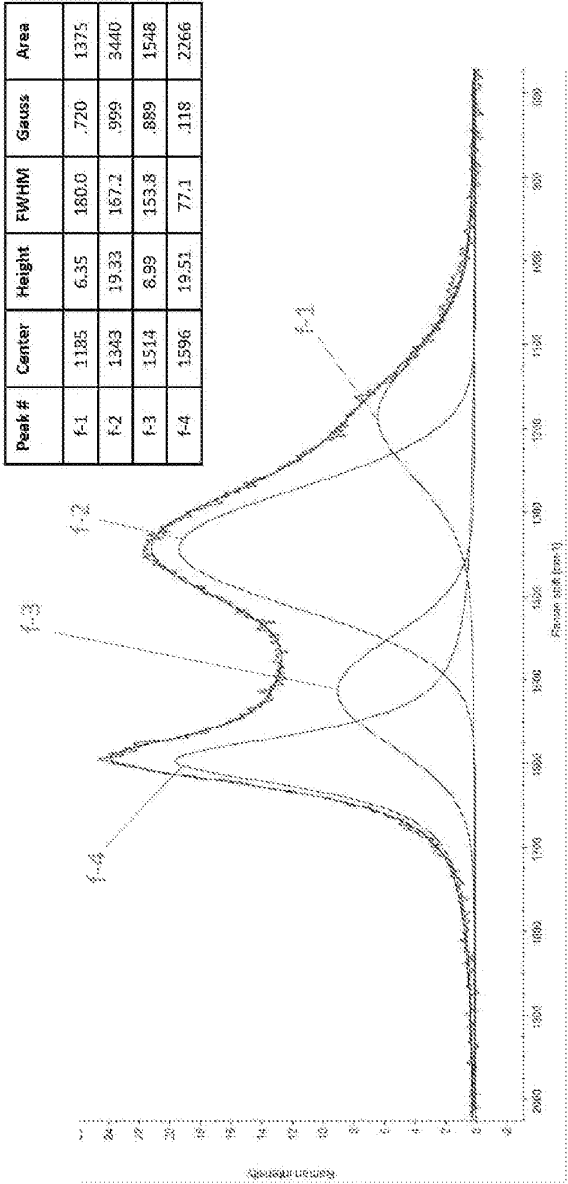
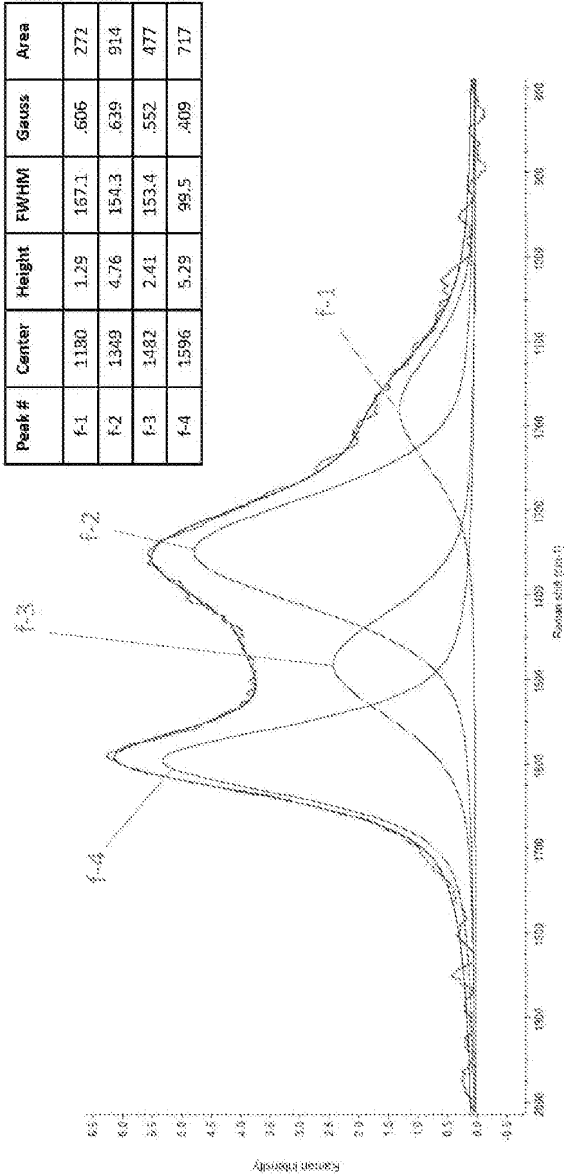


FIG. 105



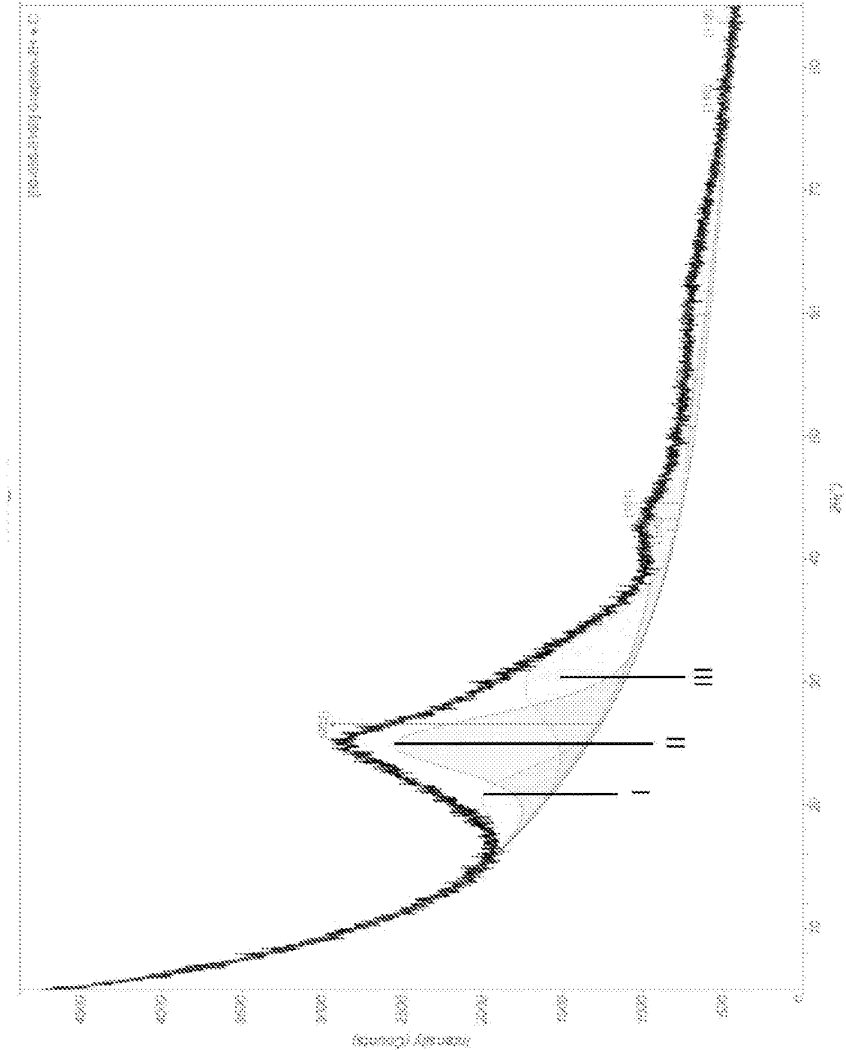


FIG. 106

FIG. 107

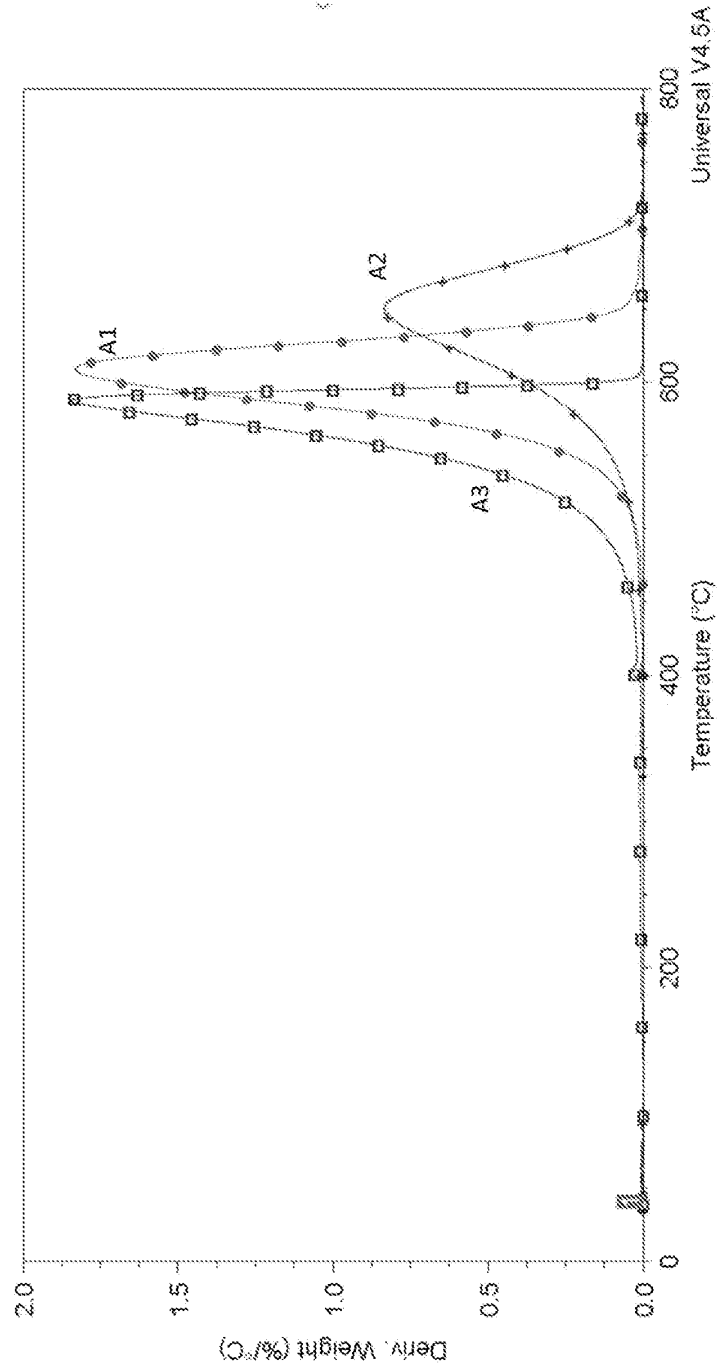
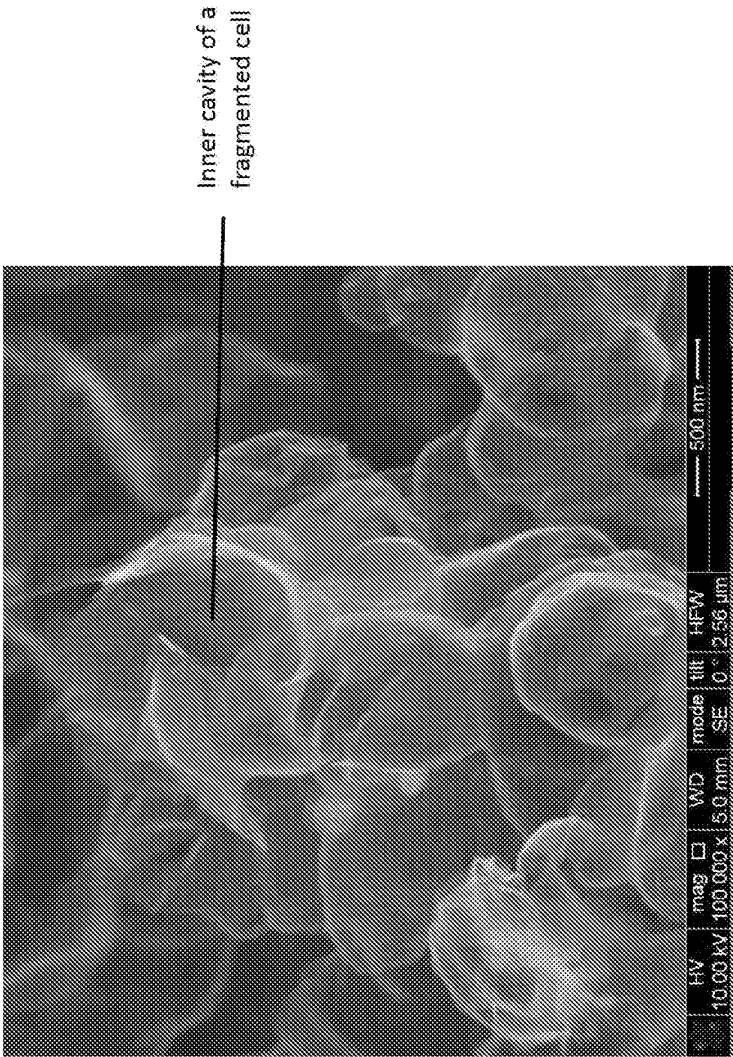


FIG. 108



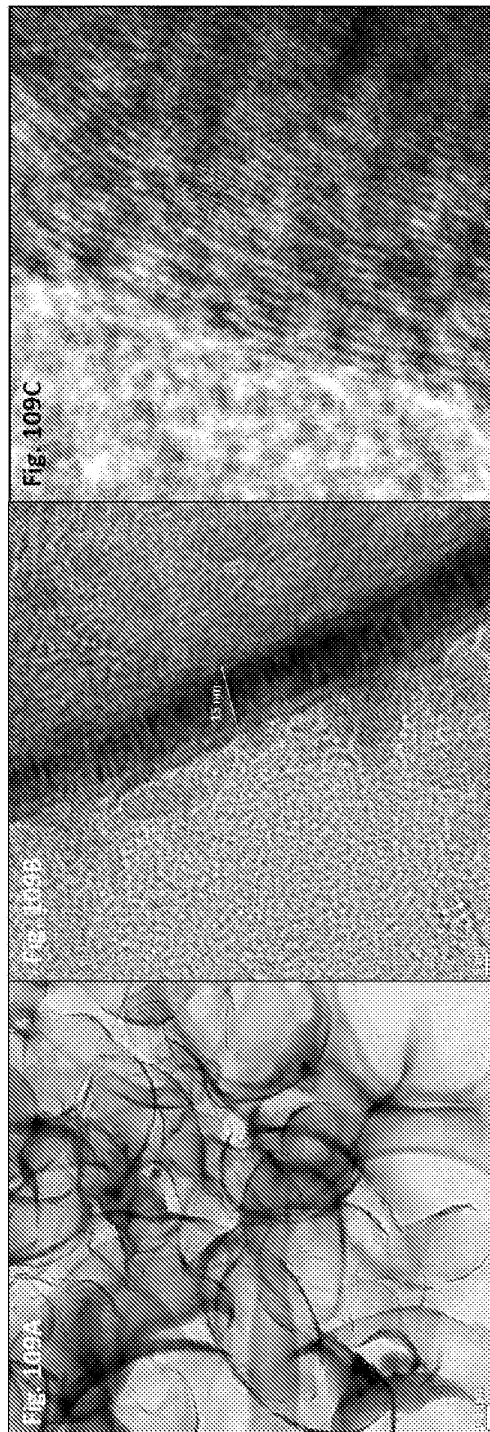
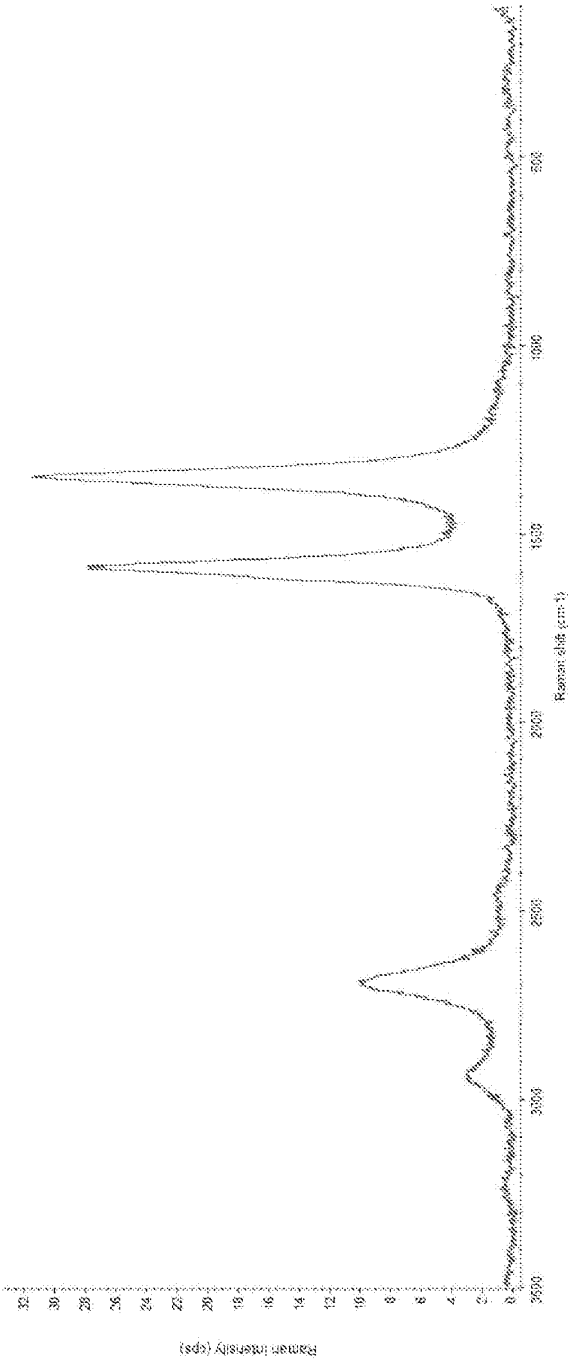
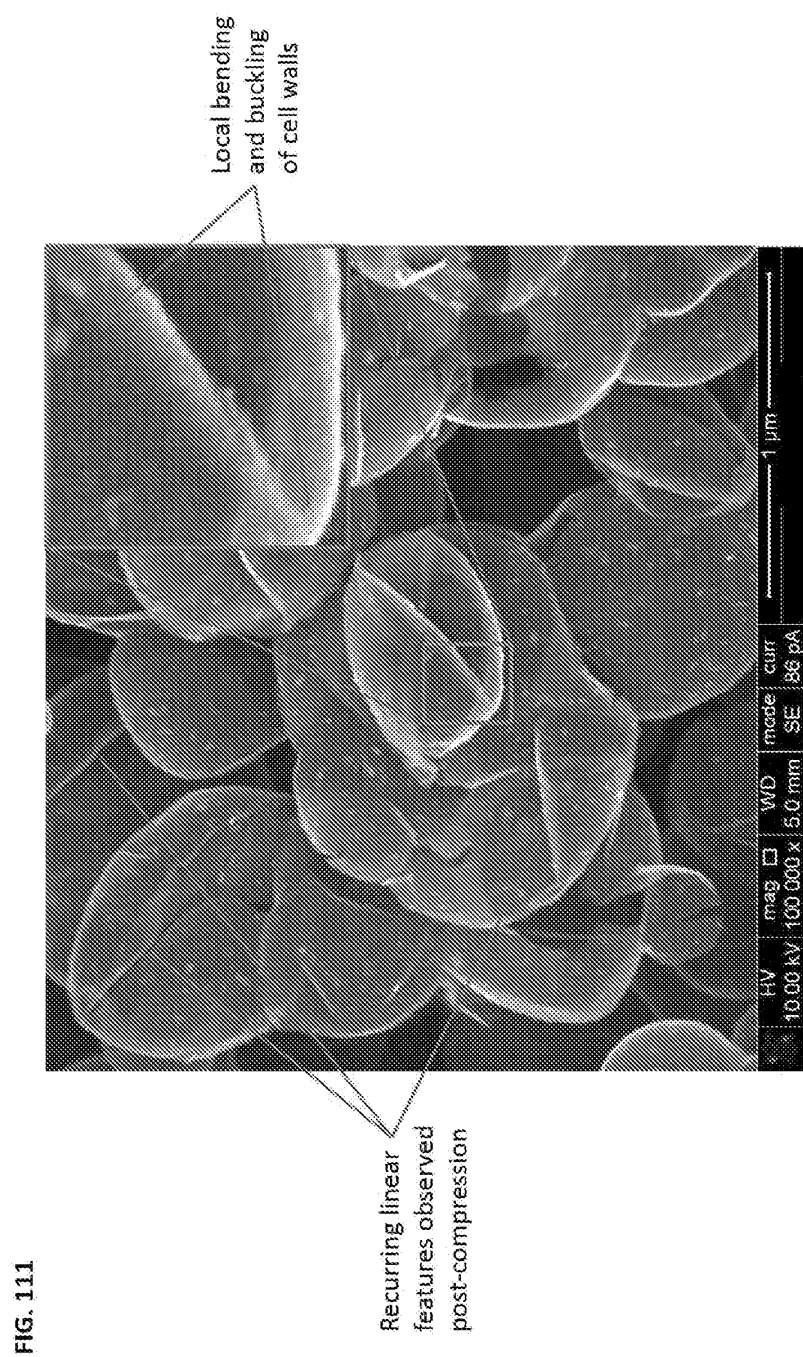


FIG. 110





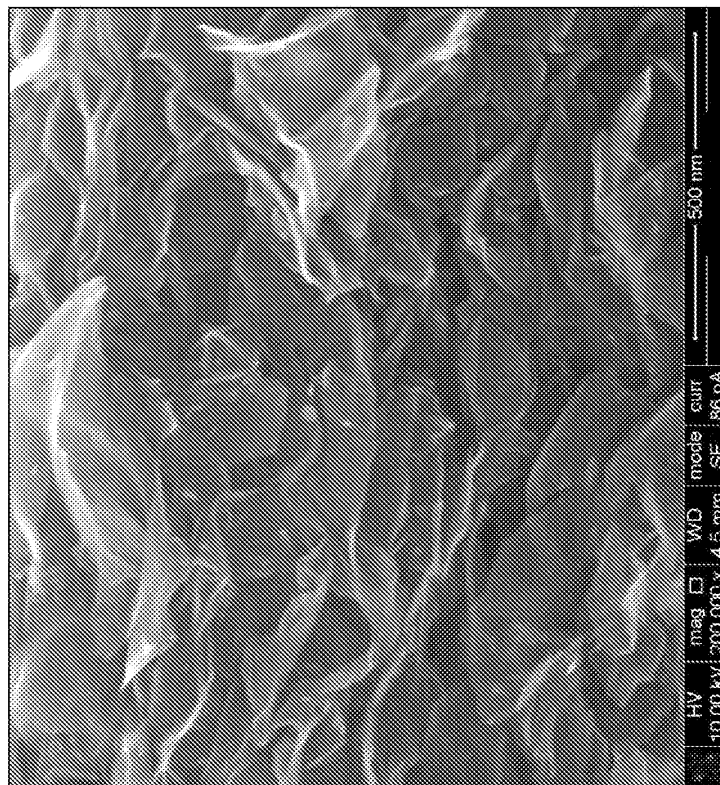
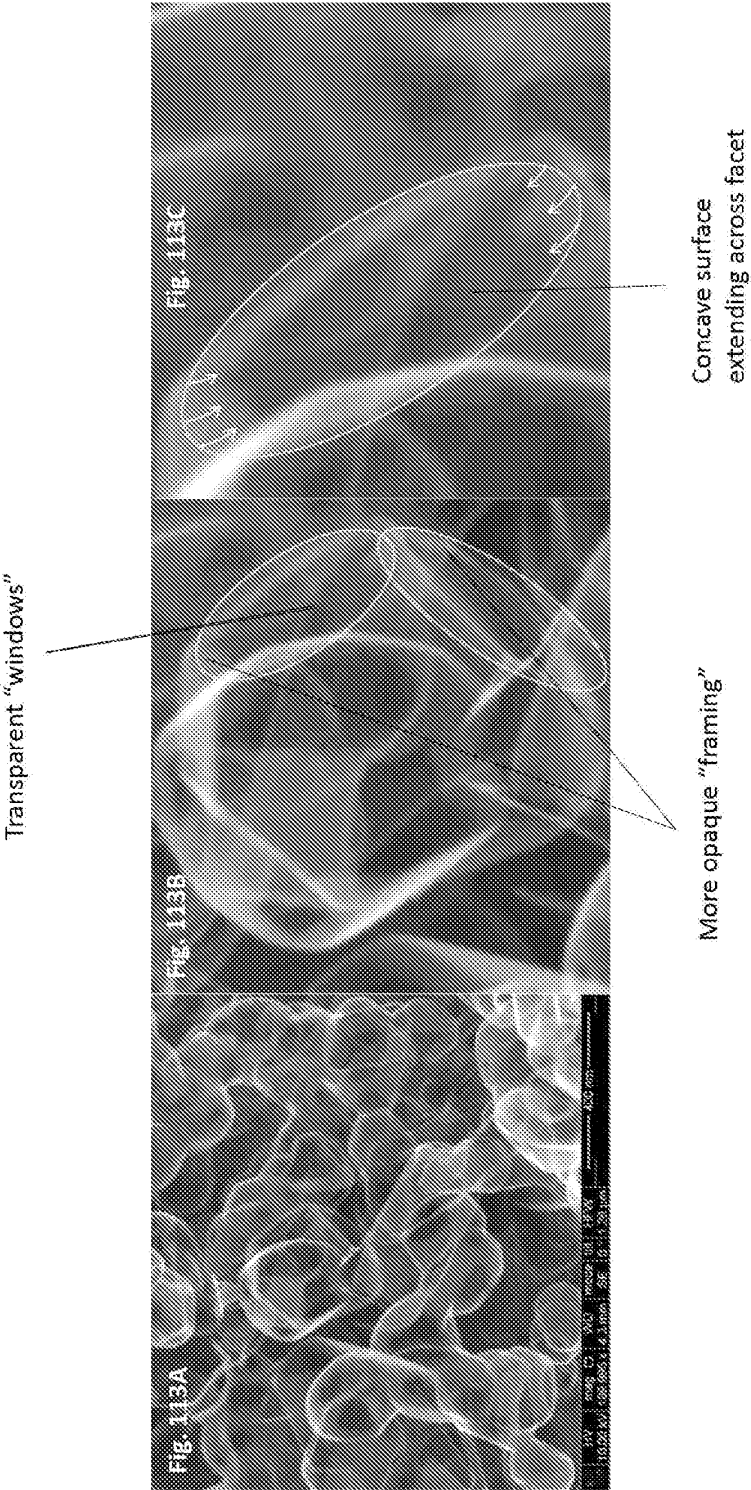


FIG. 112



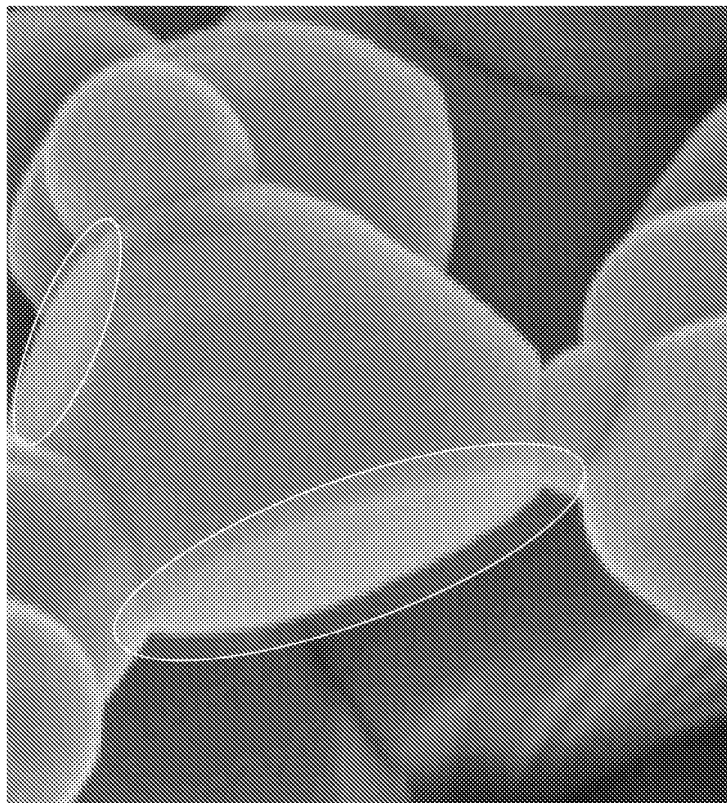
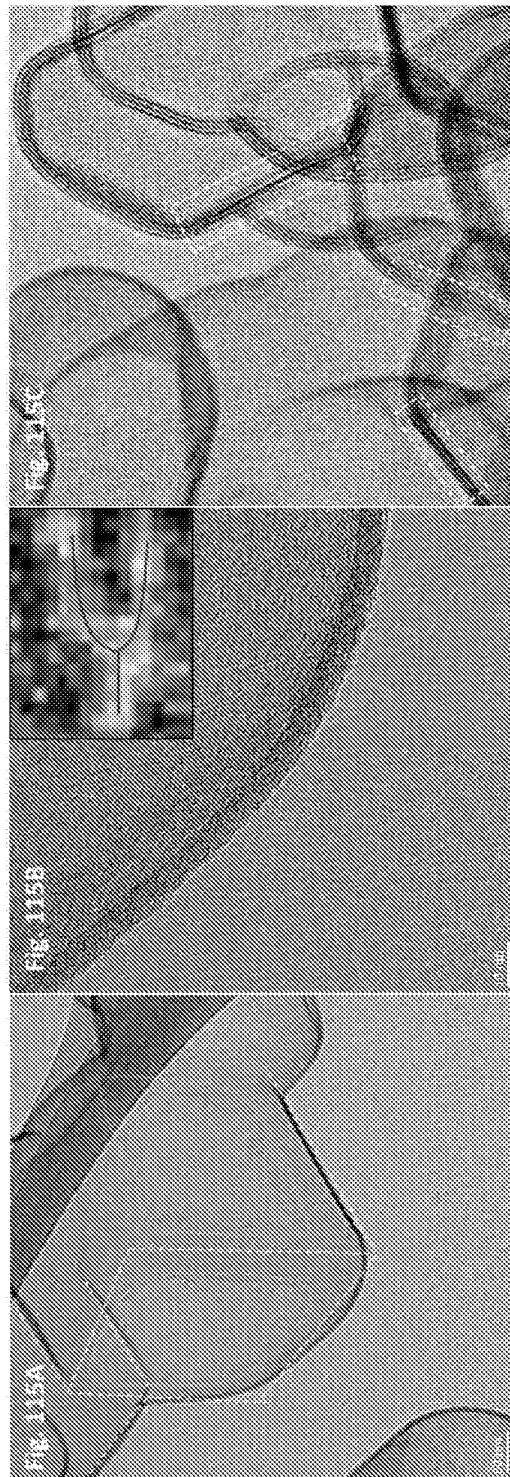
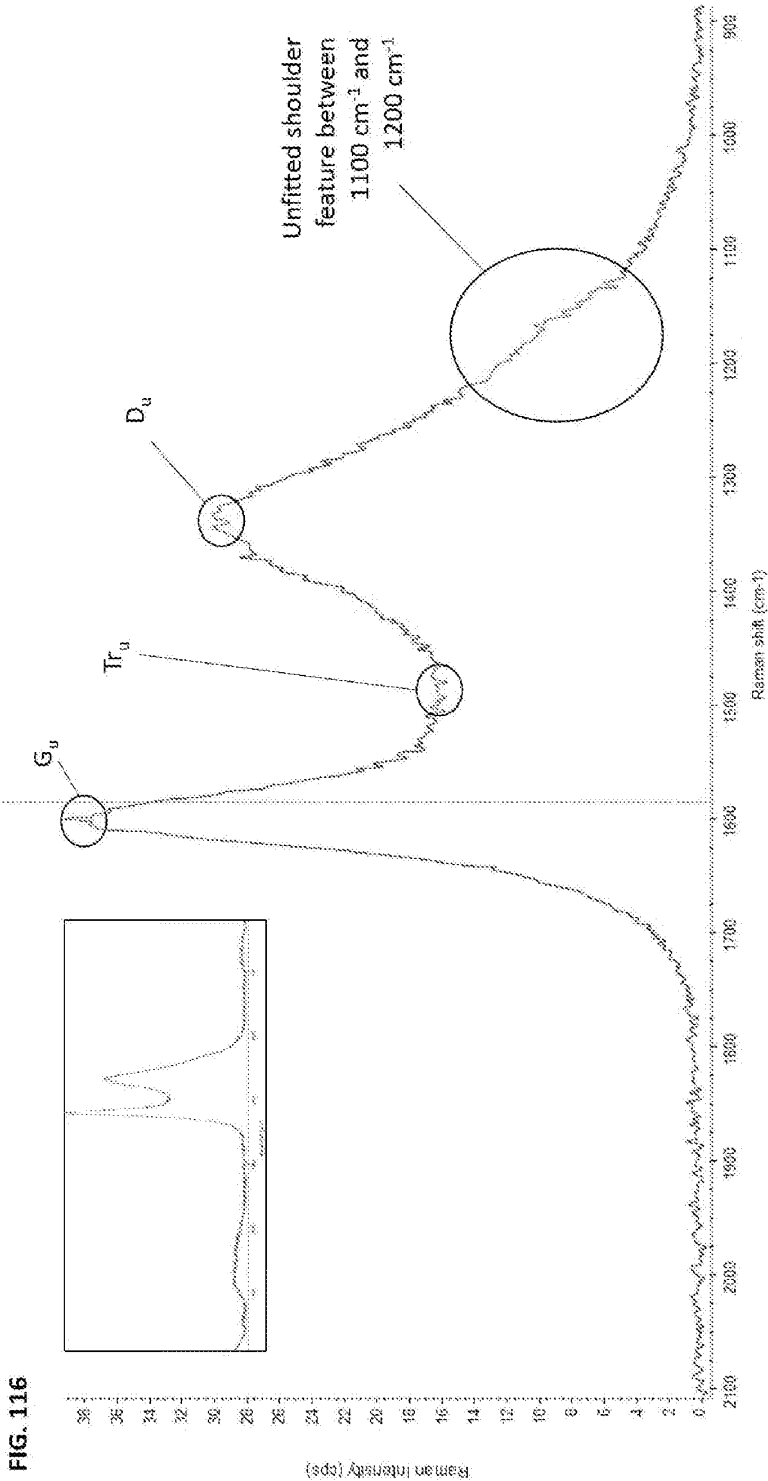
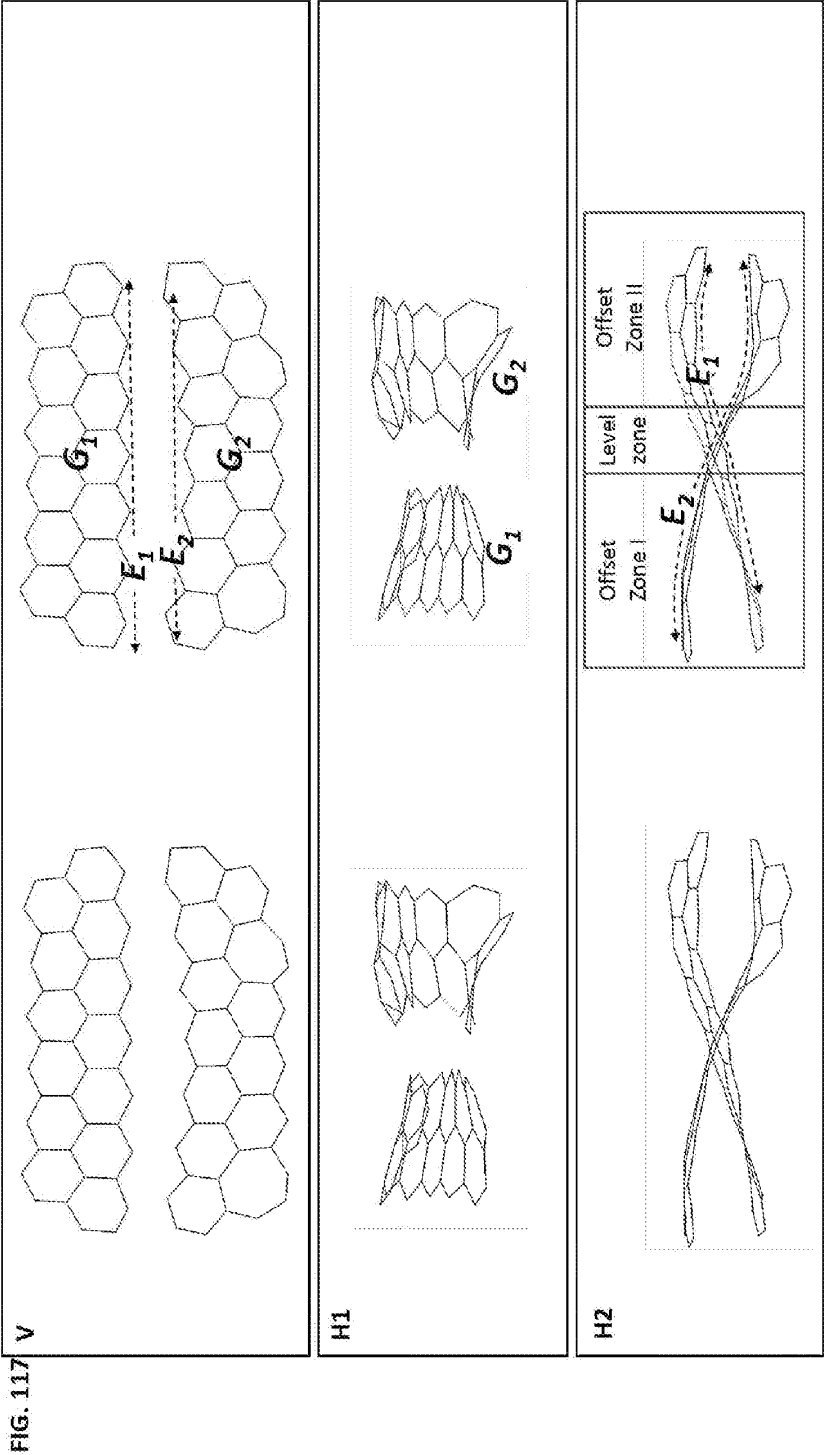
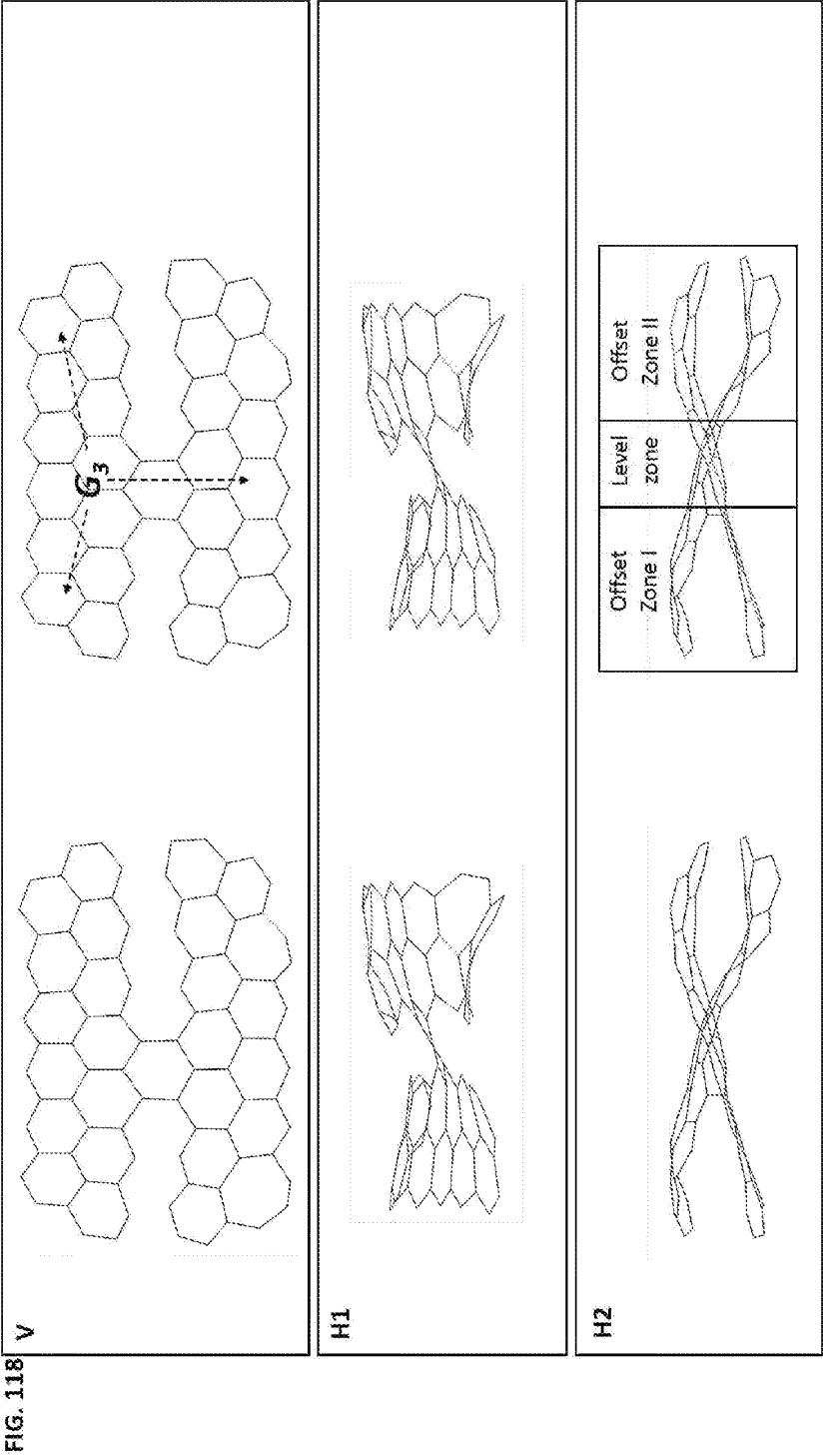


FIG. 114









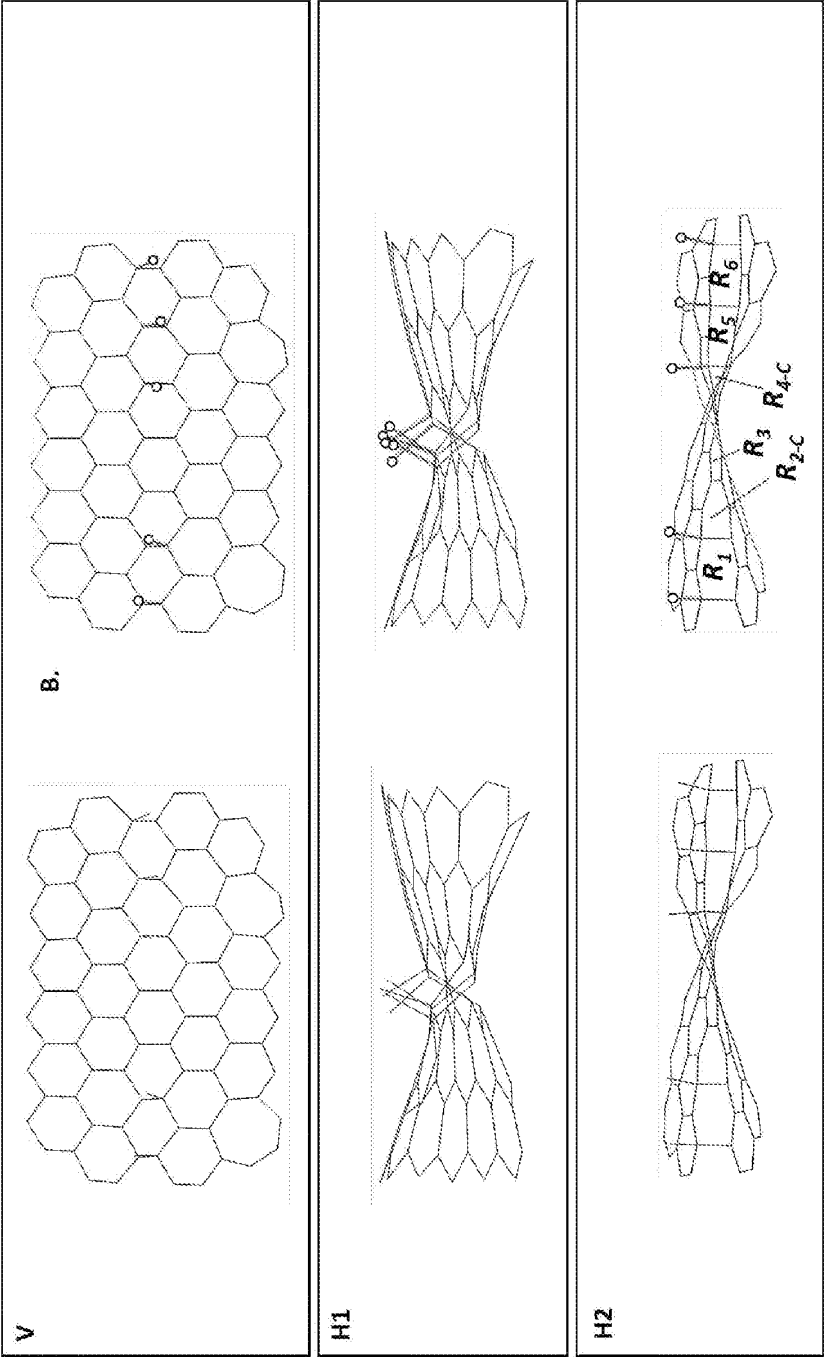
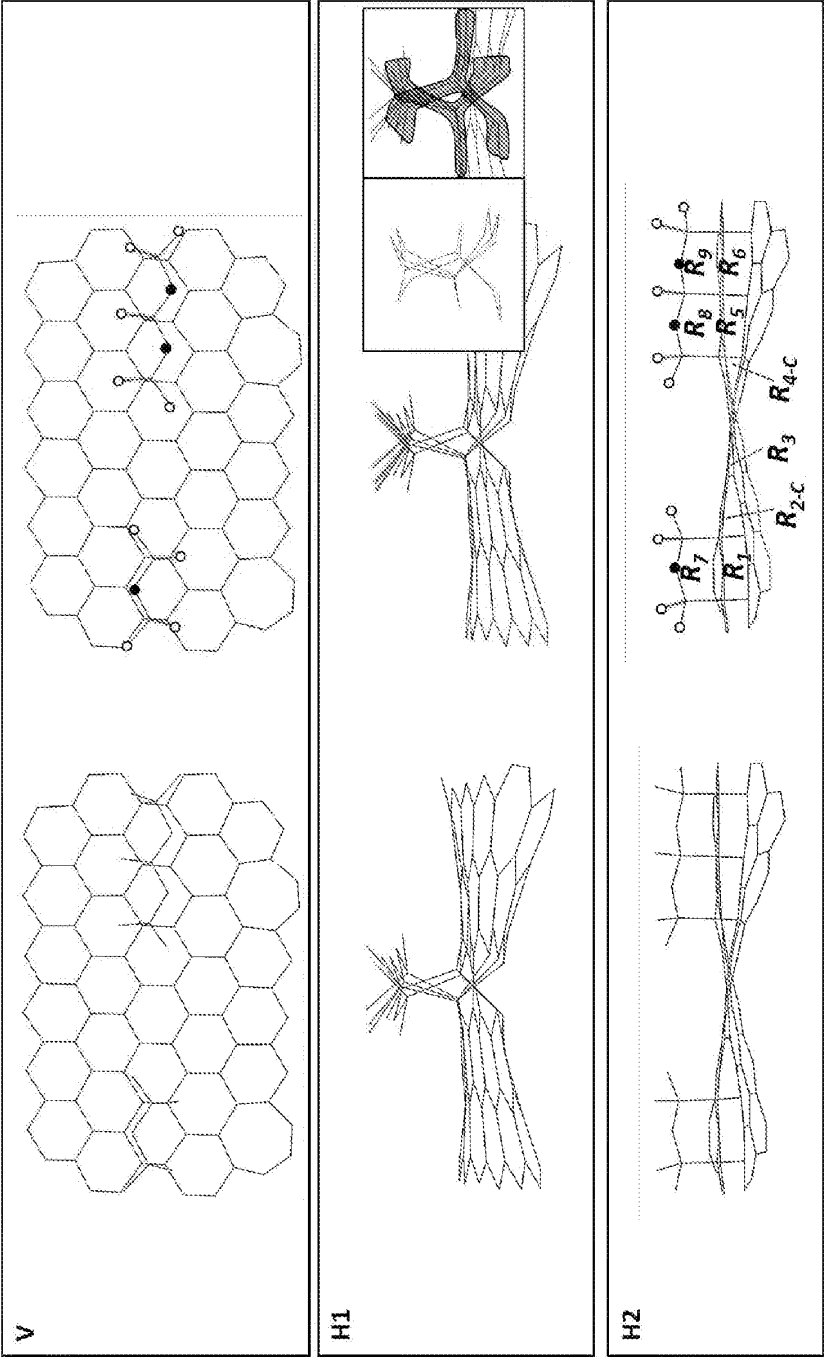
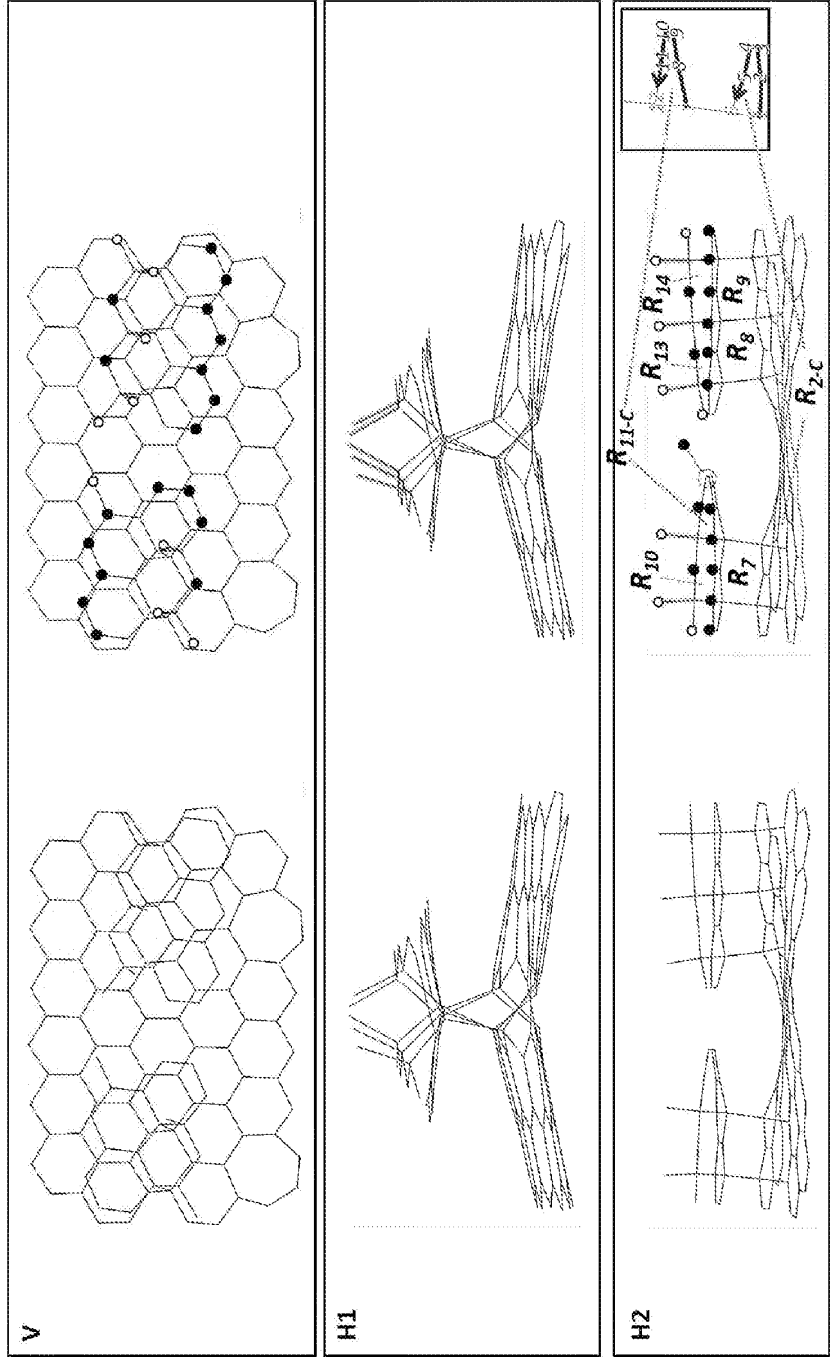
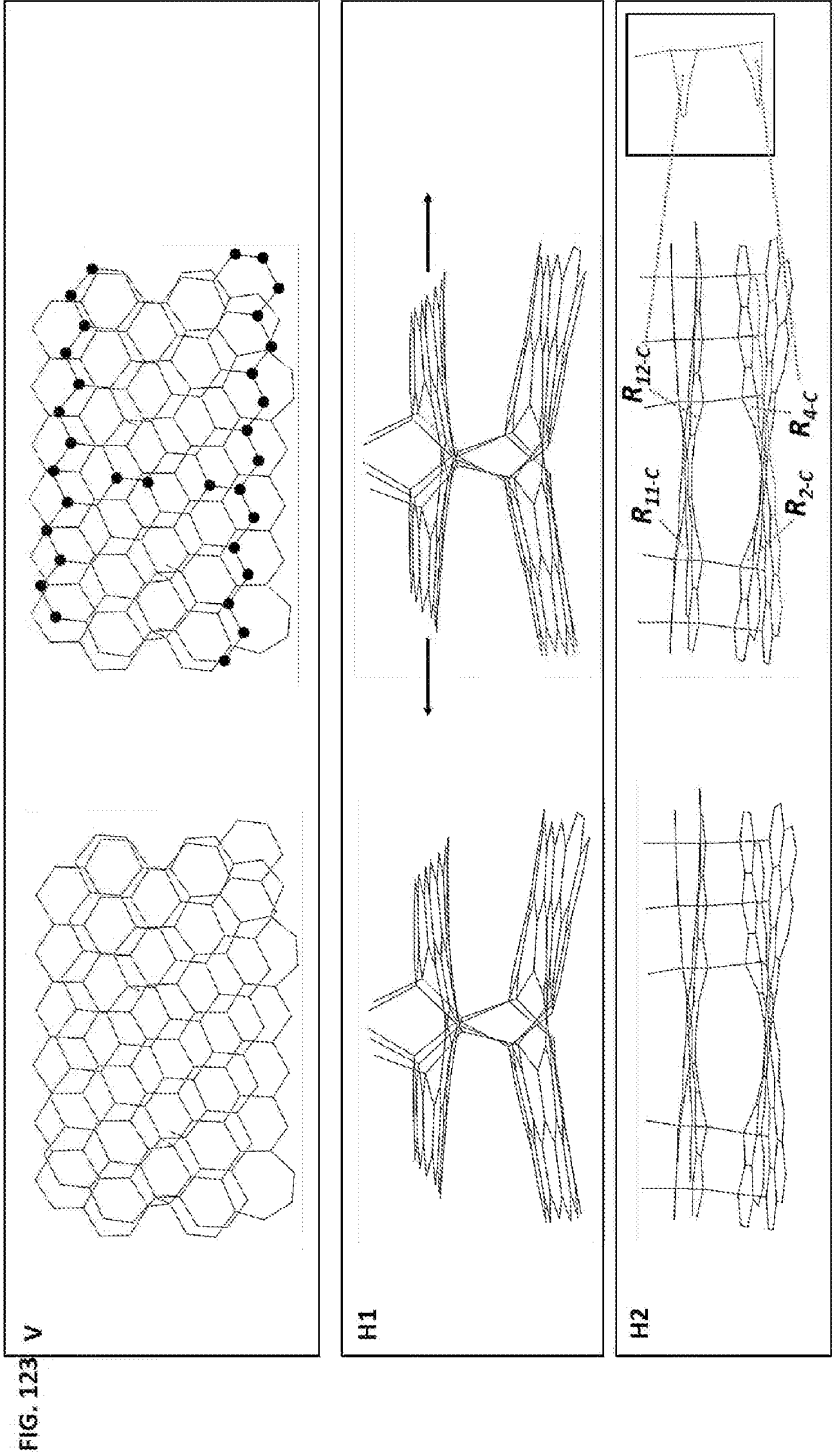
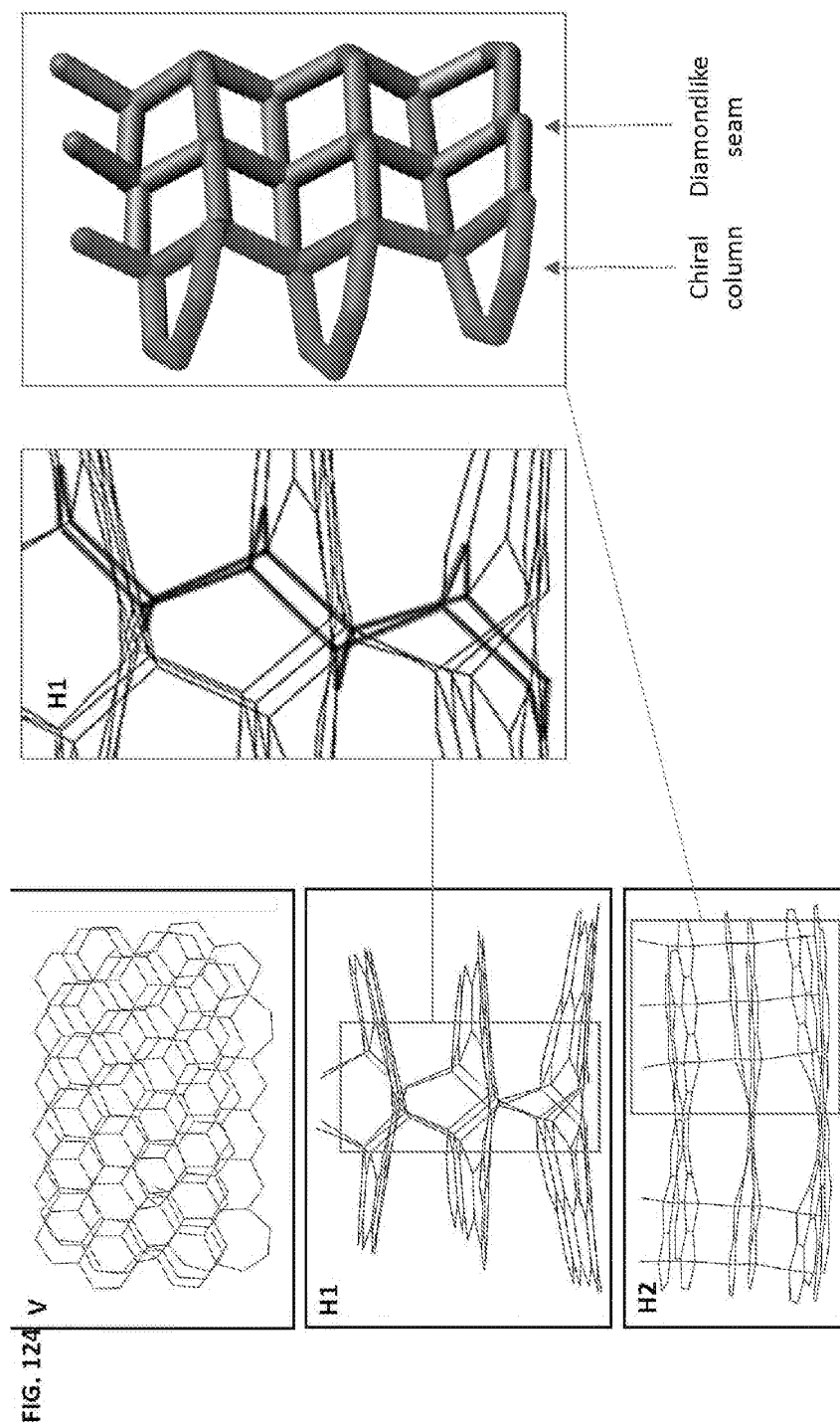


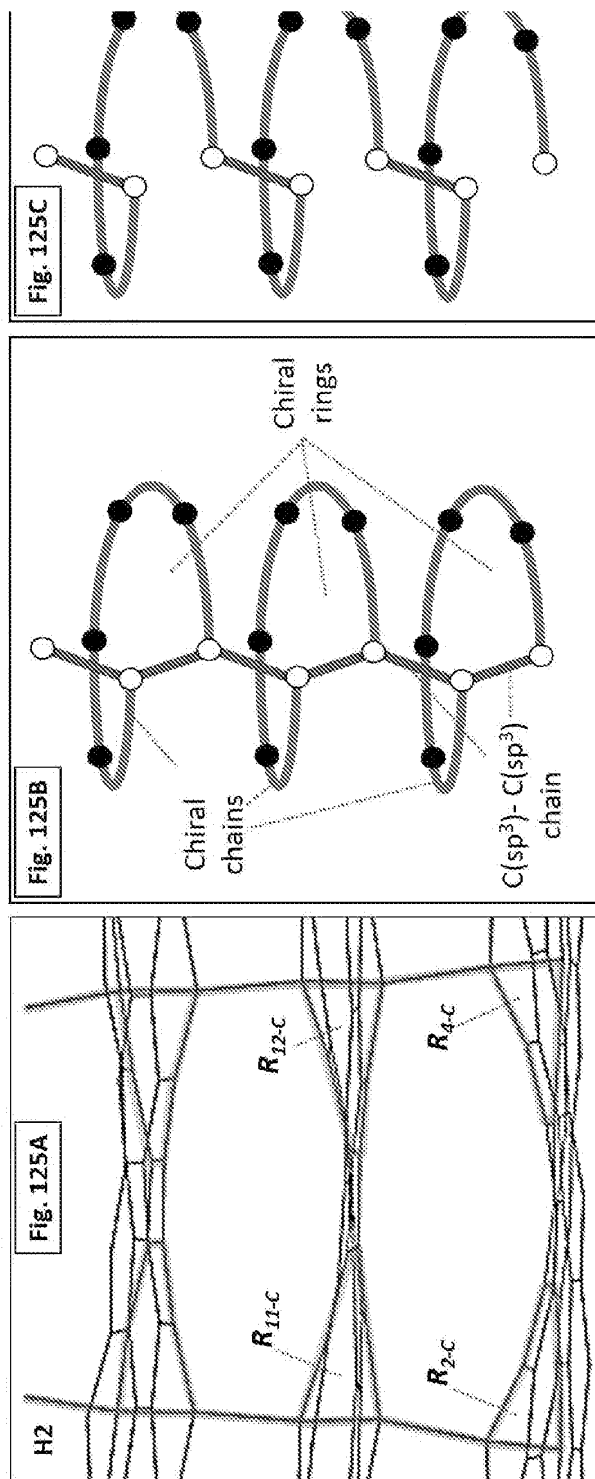
FIG. 120

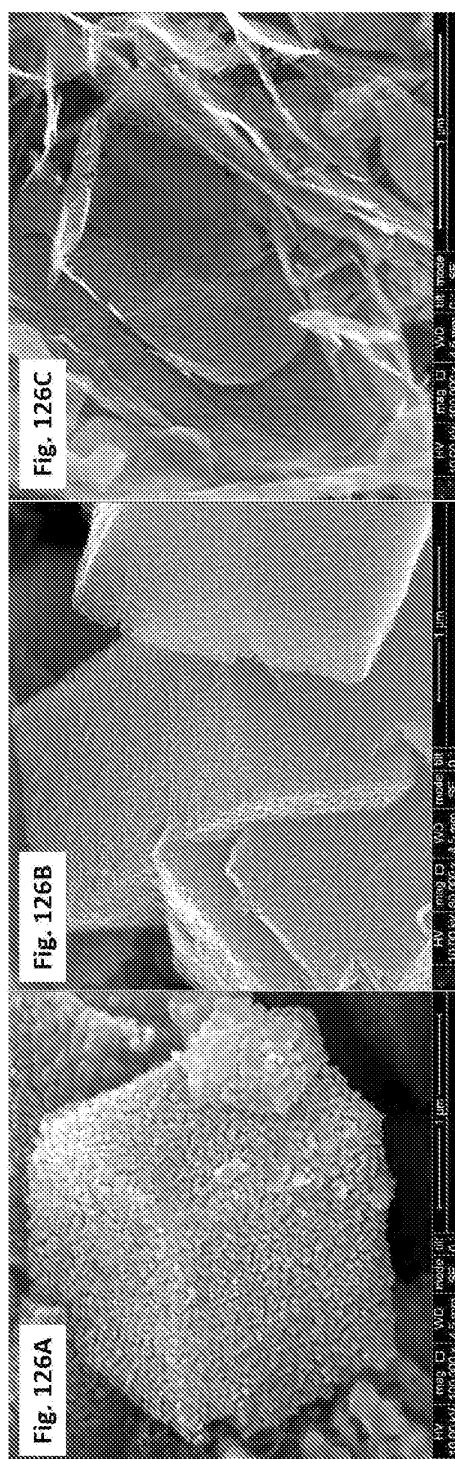












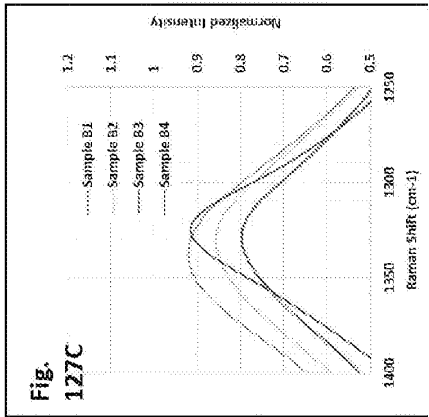
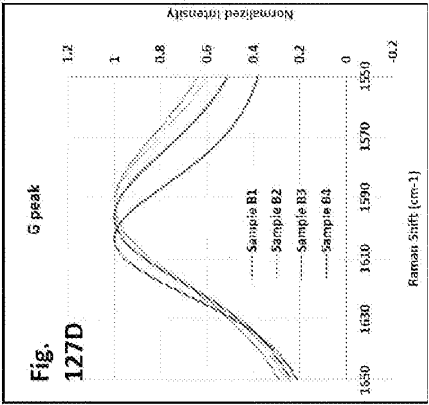
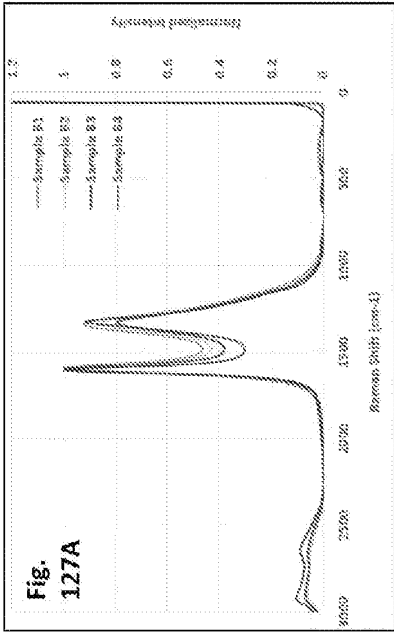
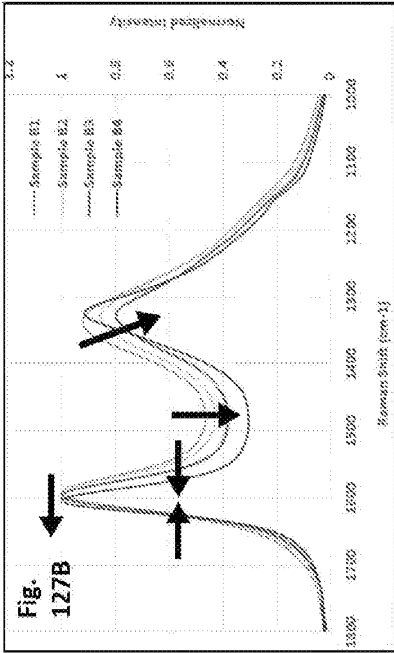


FIG. 128

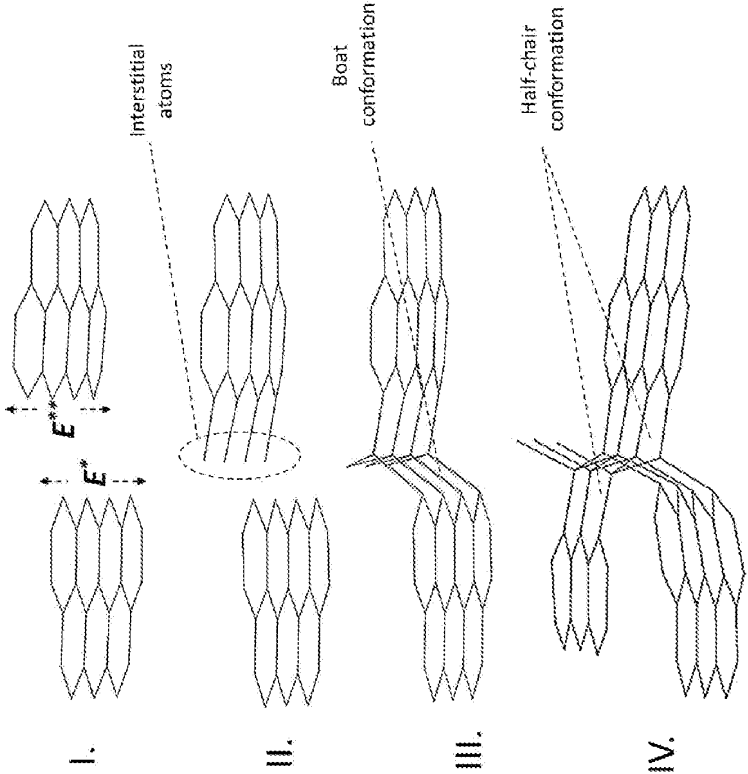
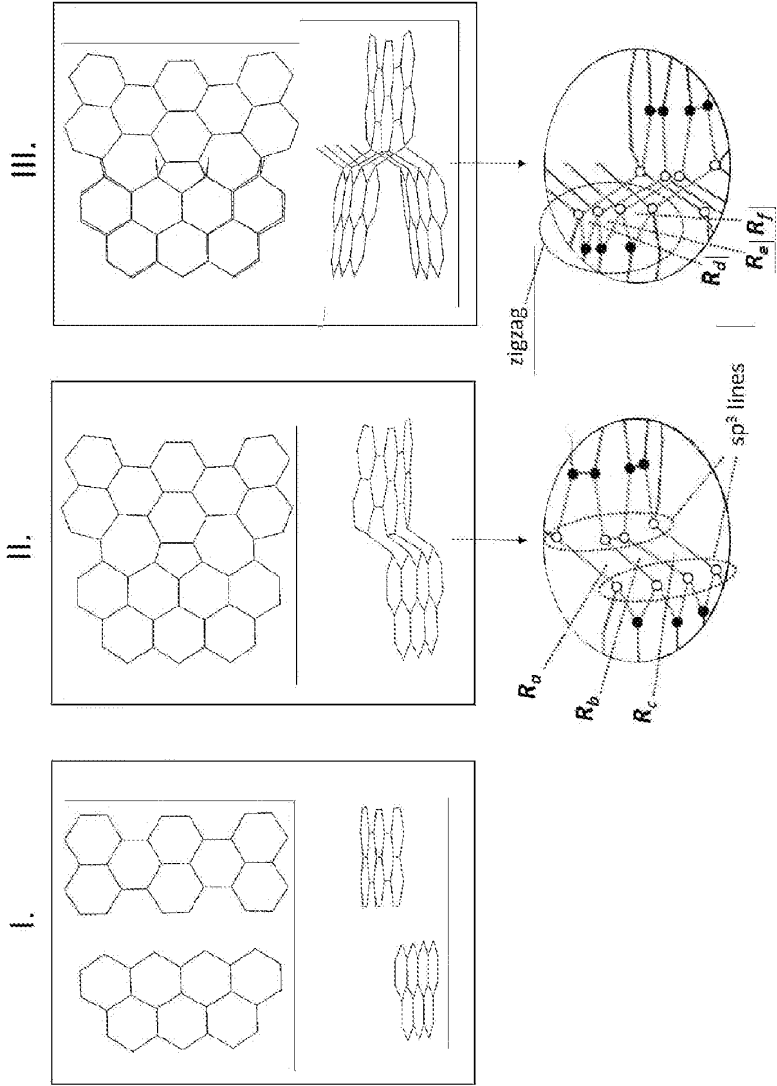
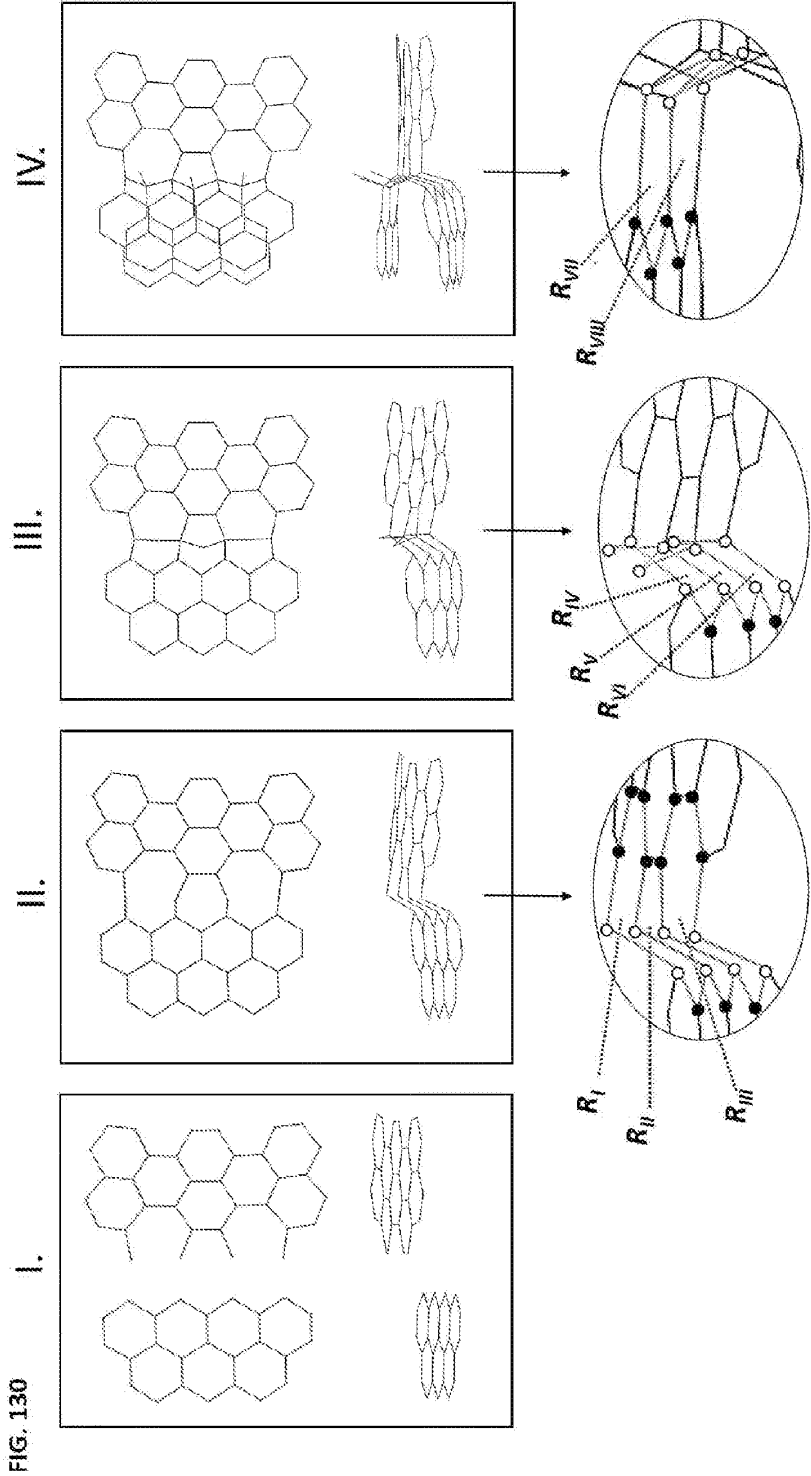
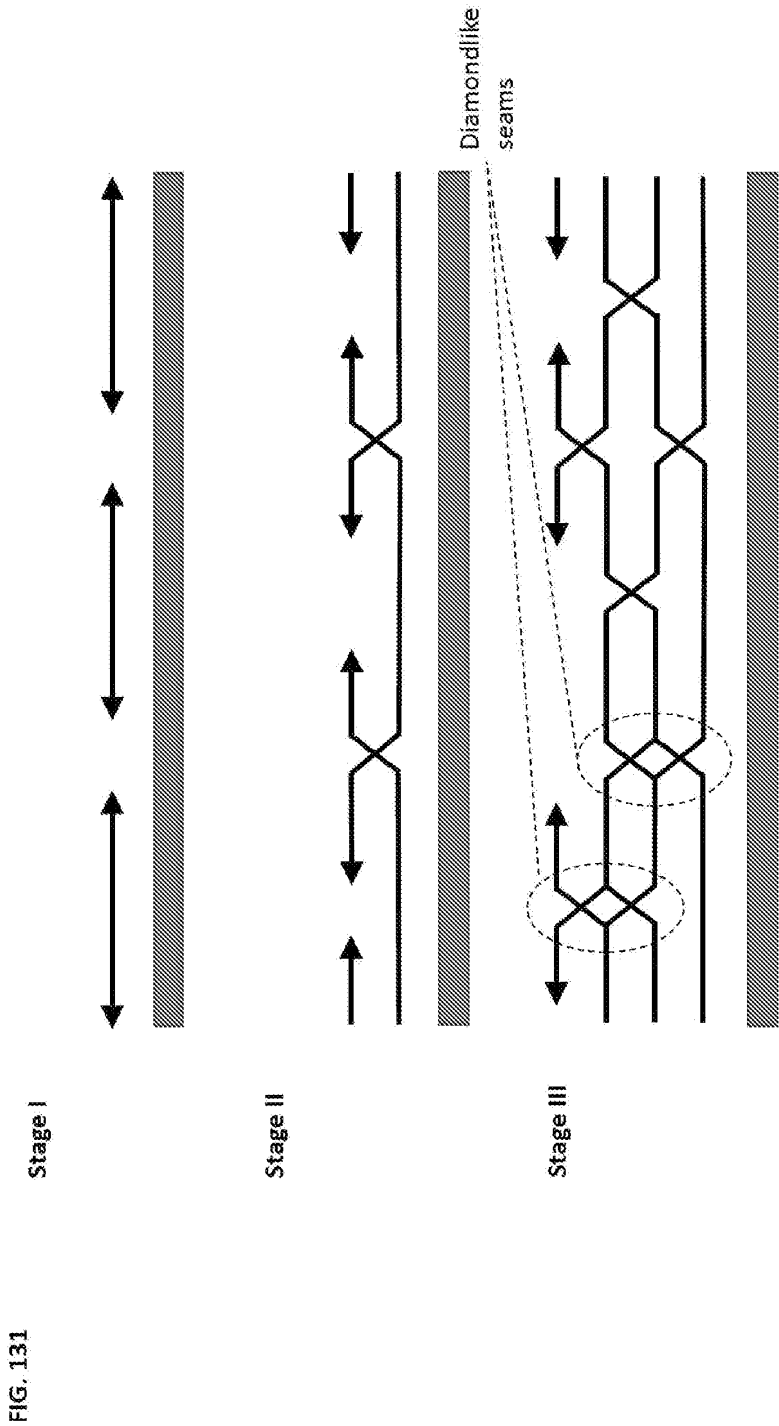
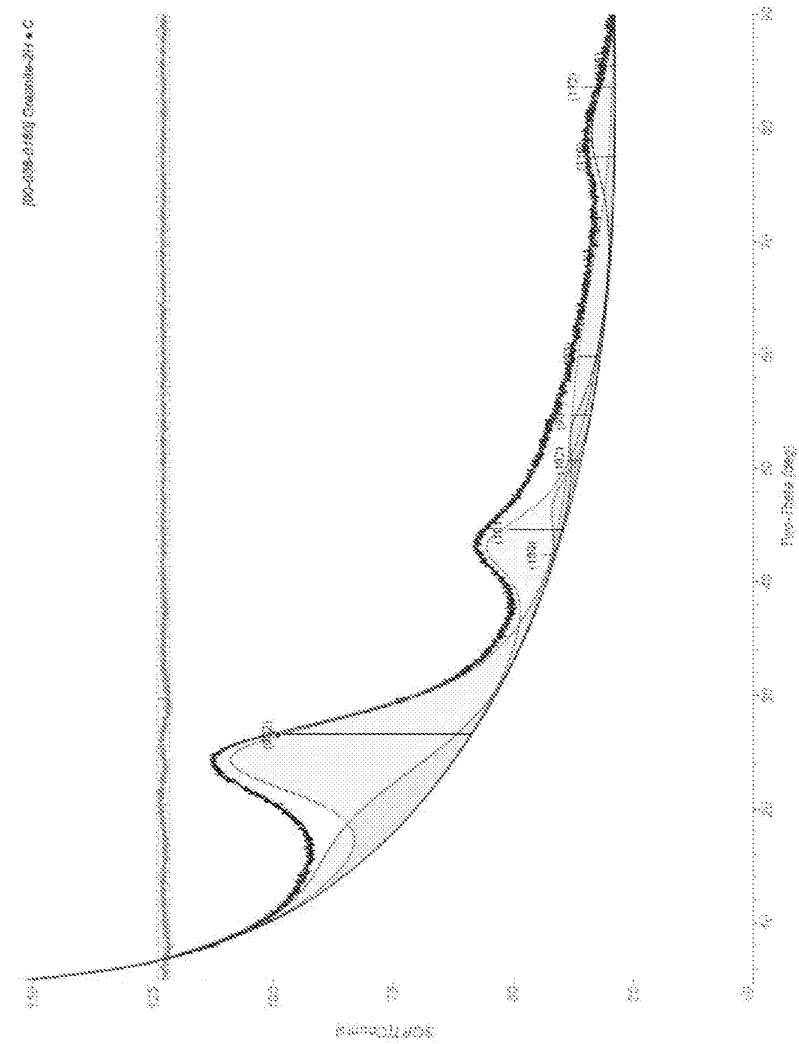


FIG. 129









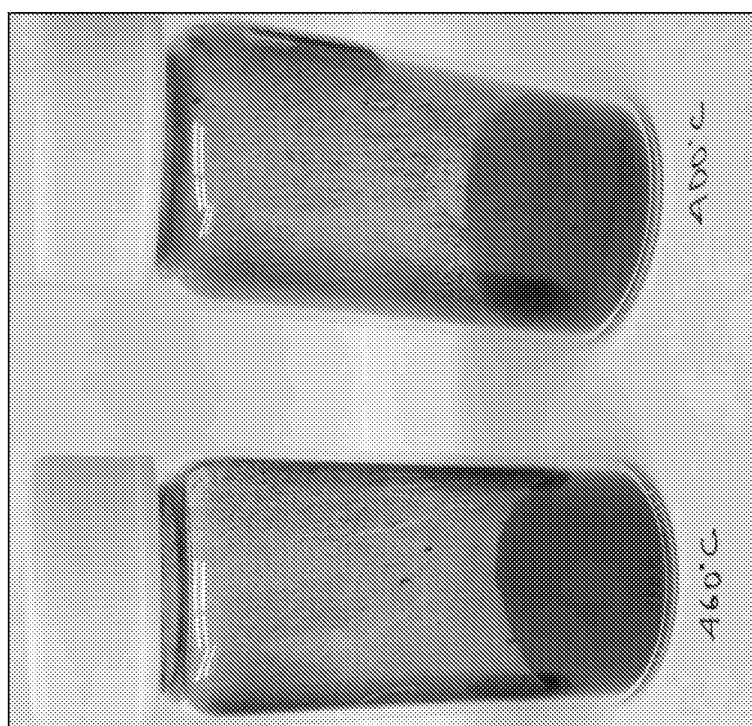


FIG. 133

FIG. 134

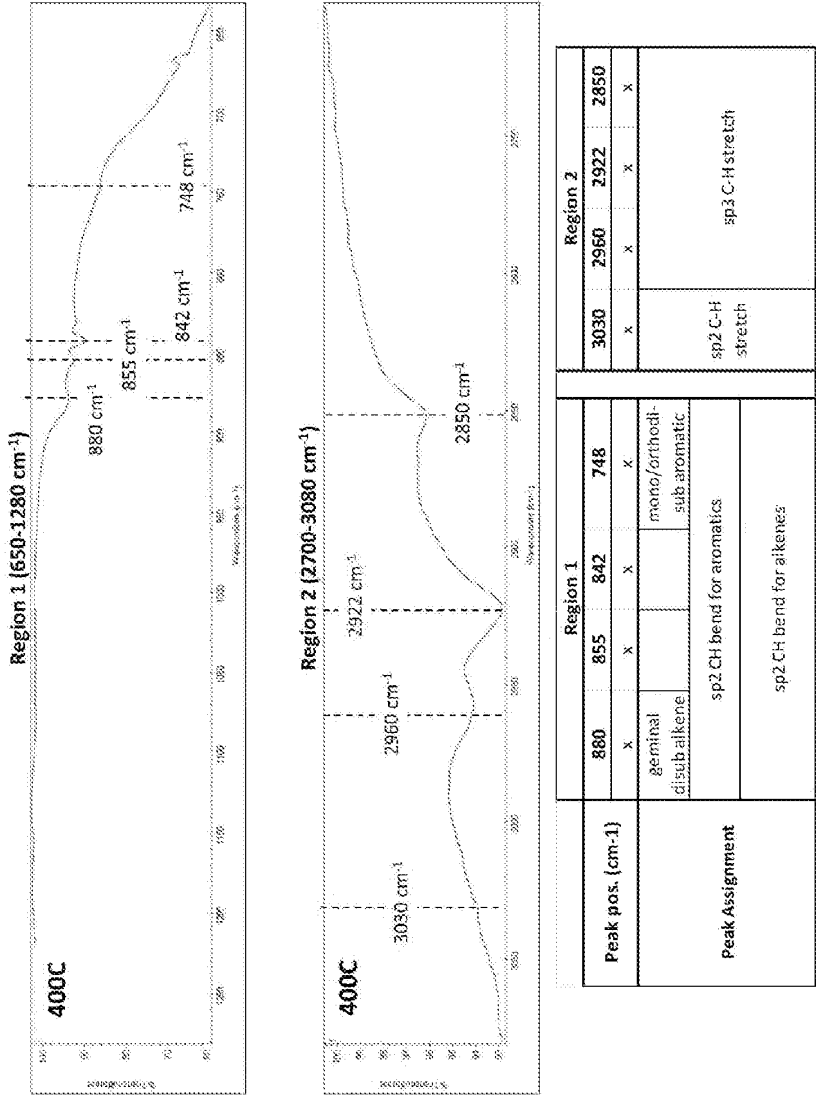
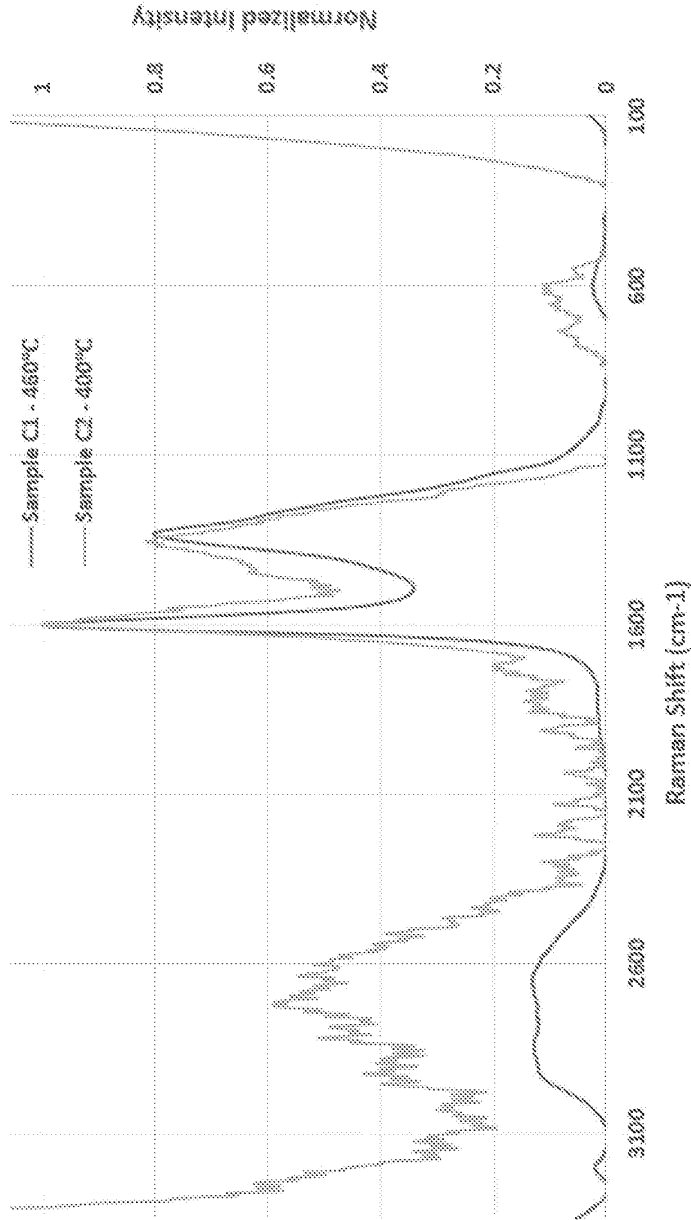


FIG. 135



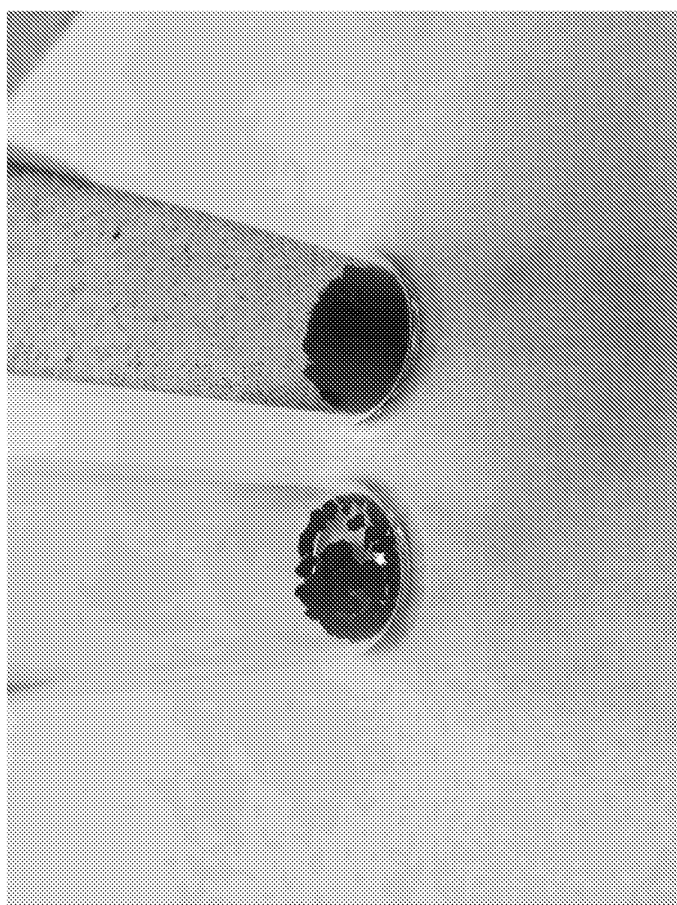
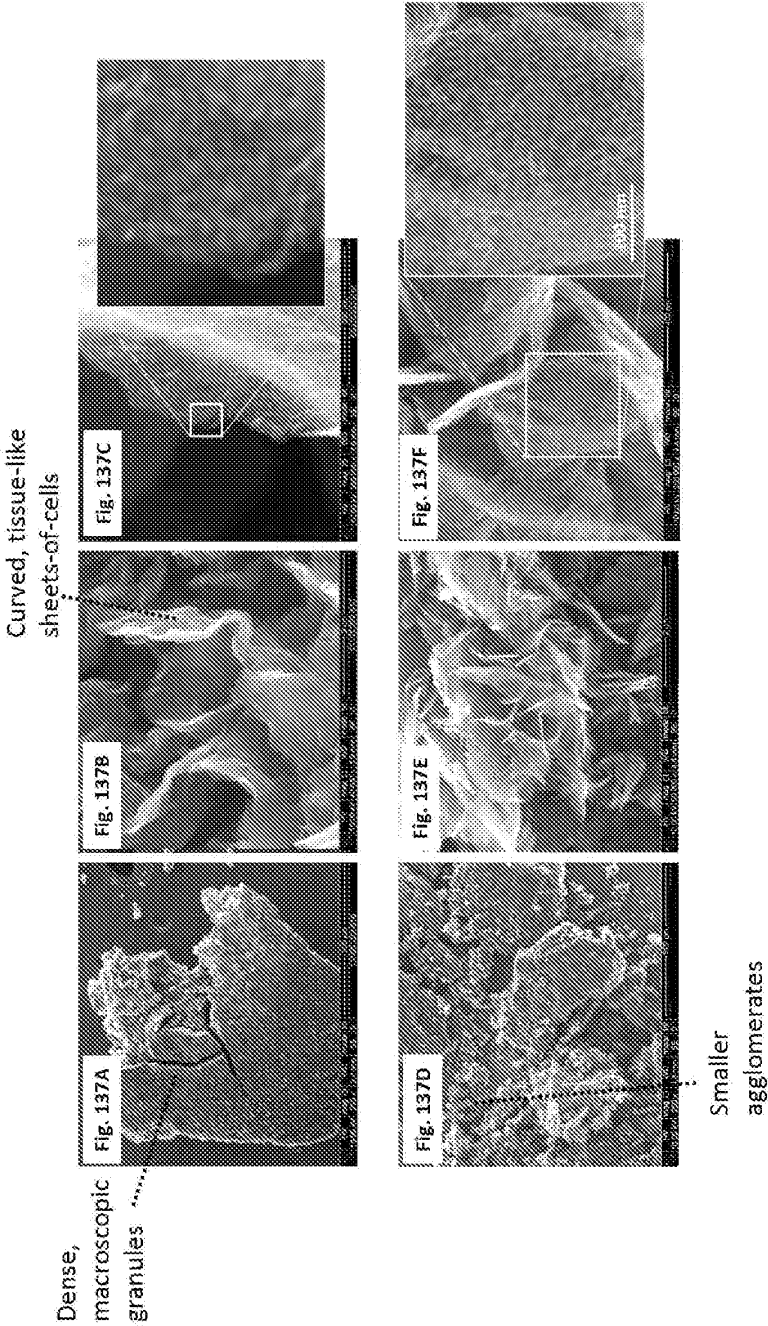


FIG. 136



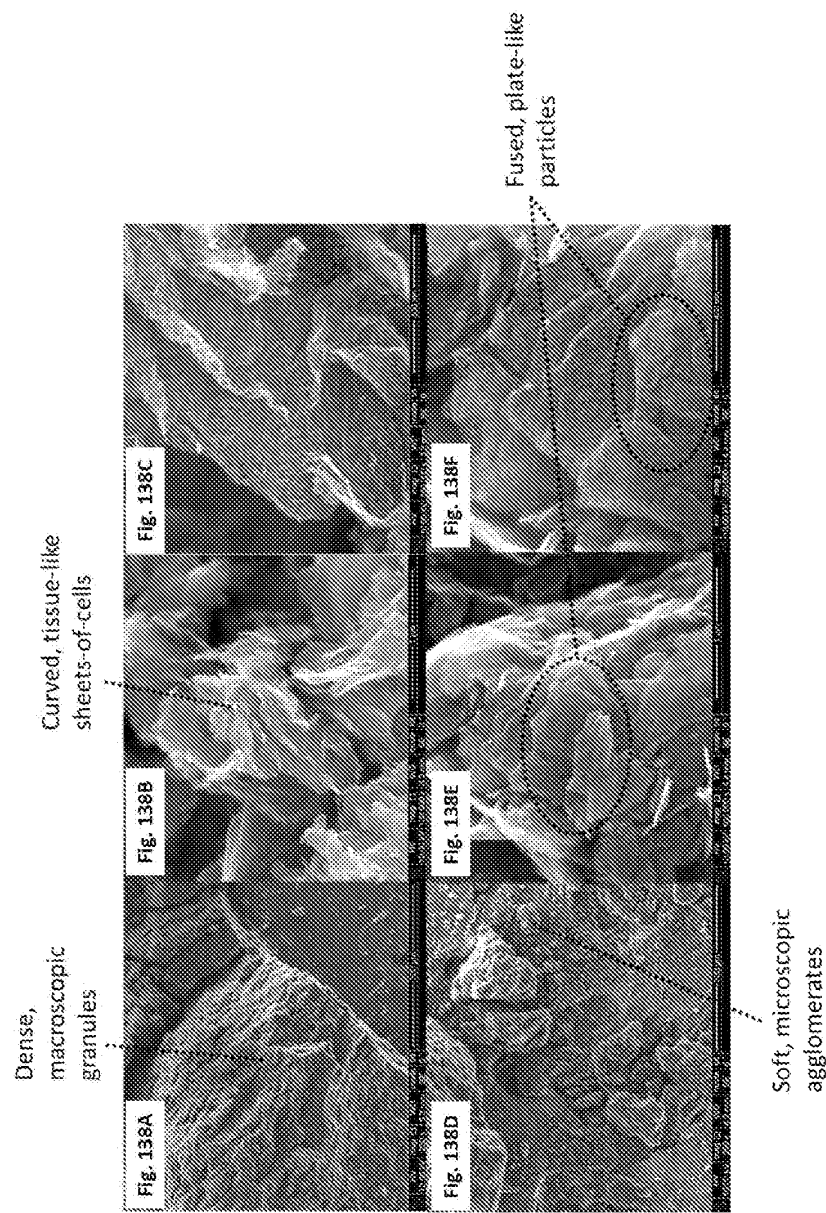
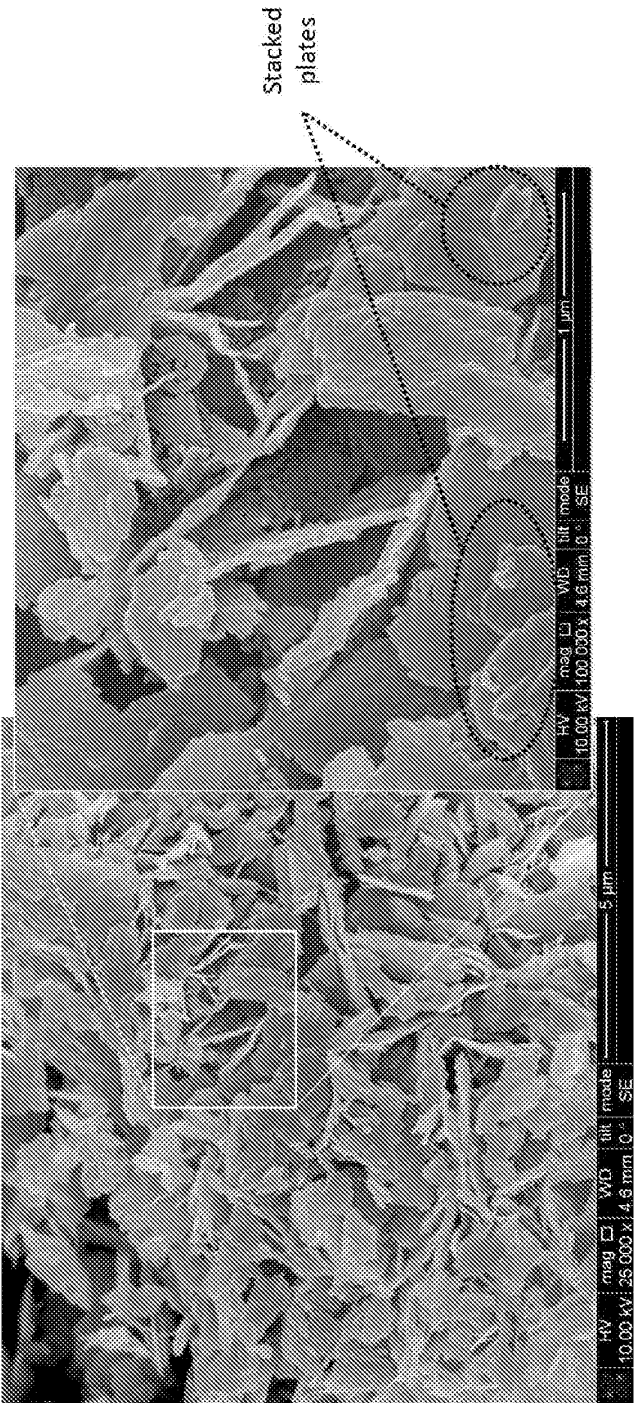
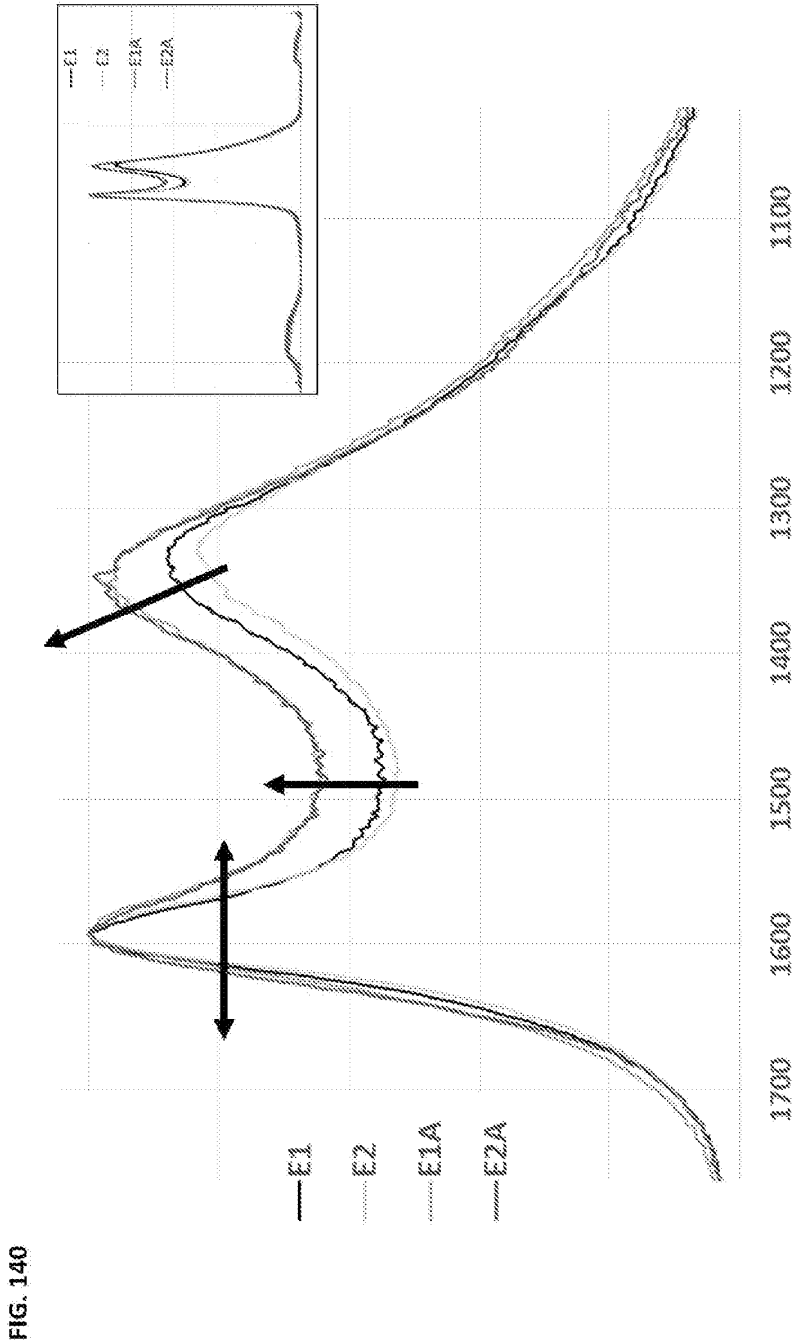


FIG. 139





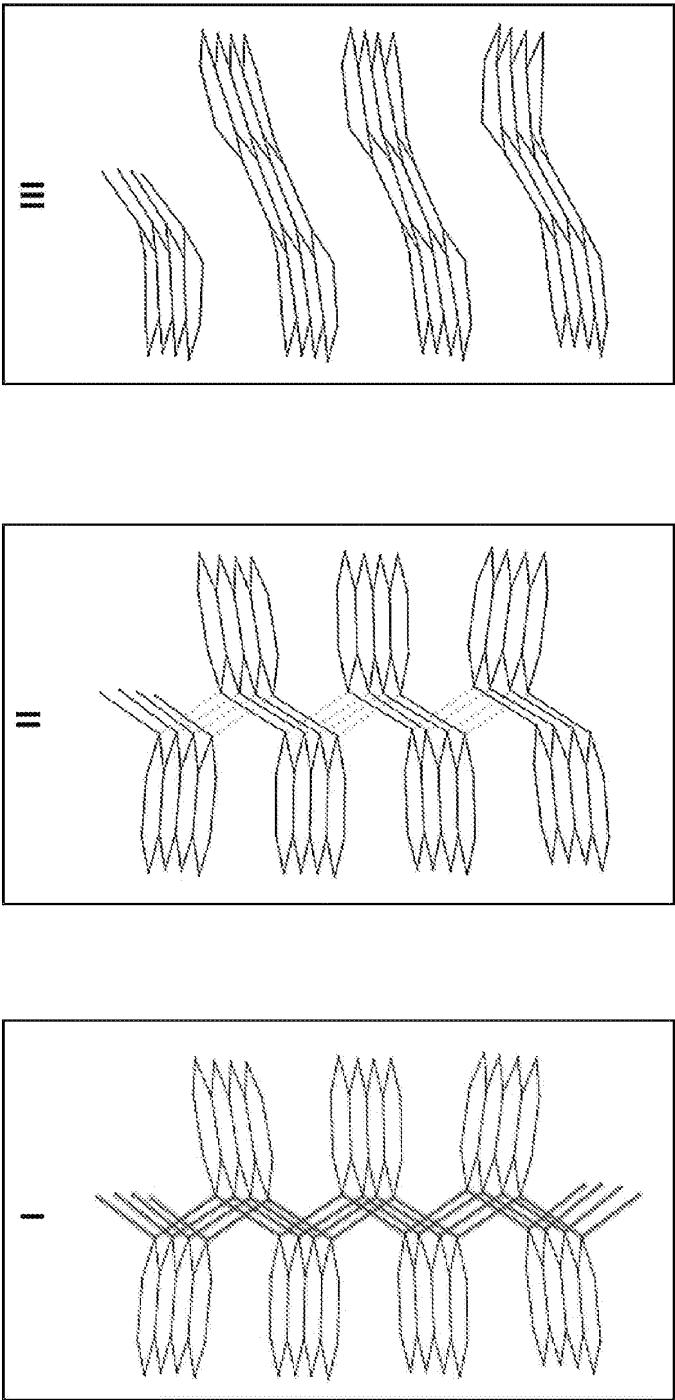


FIG. 141

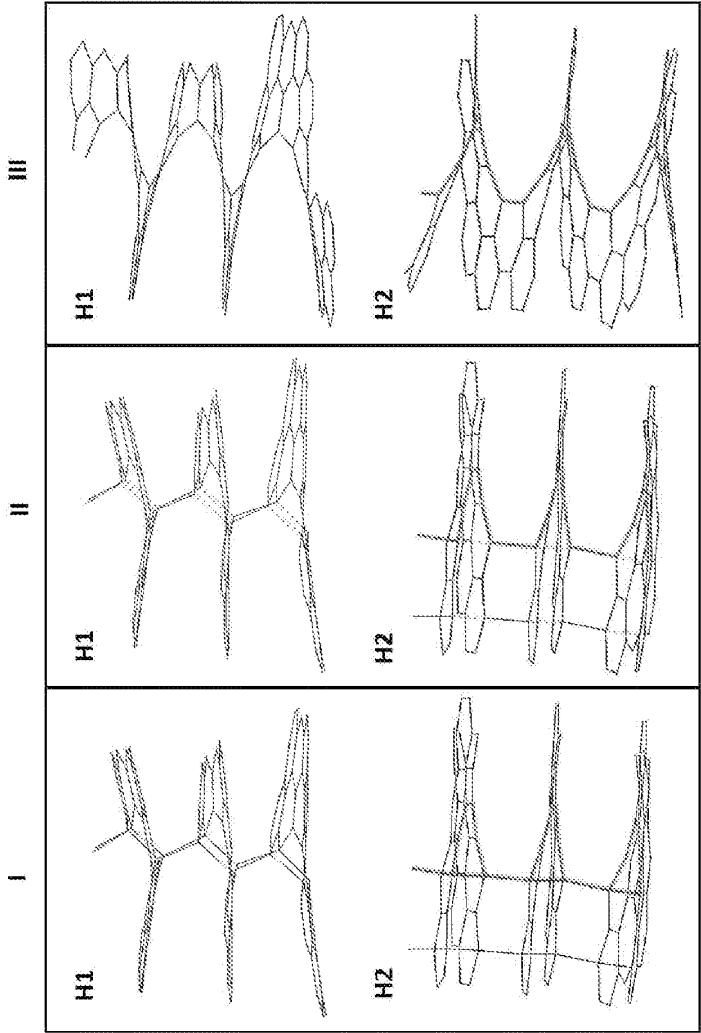
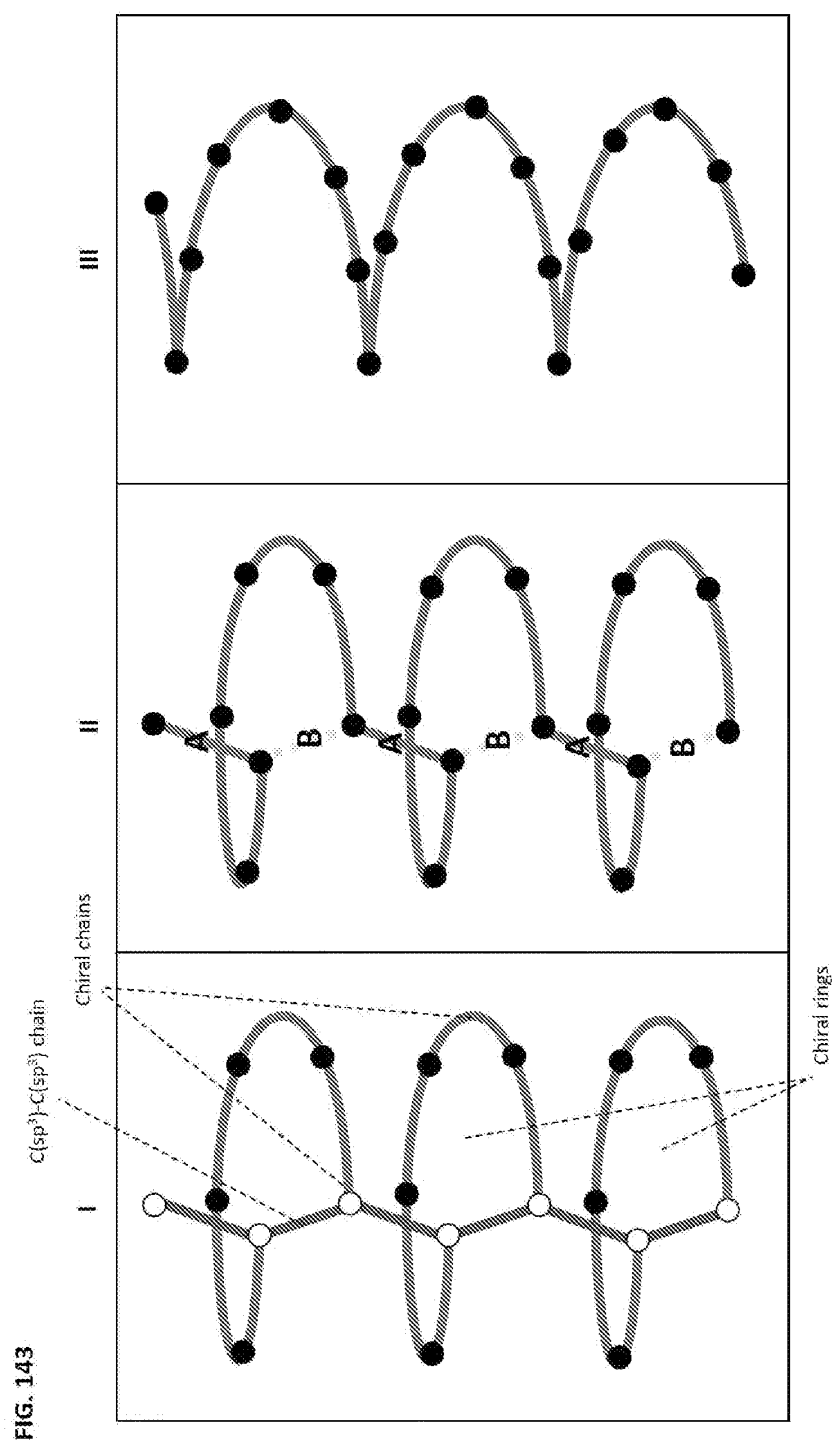


FIG. 142



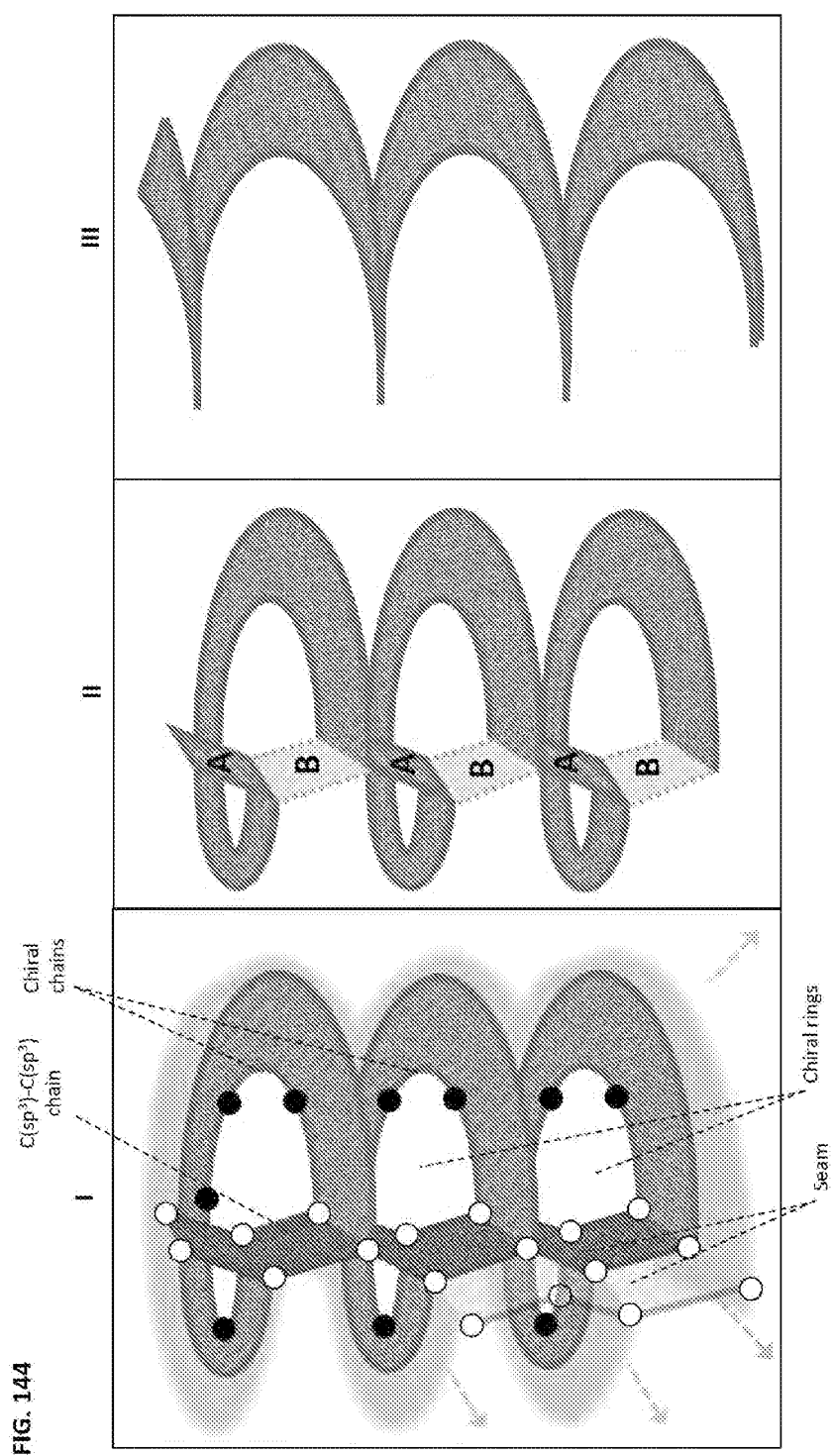
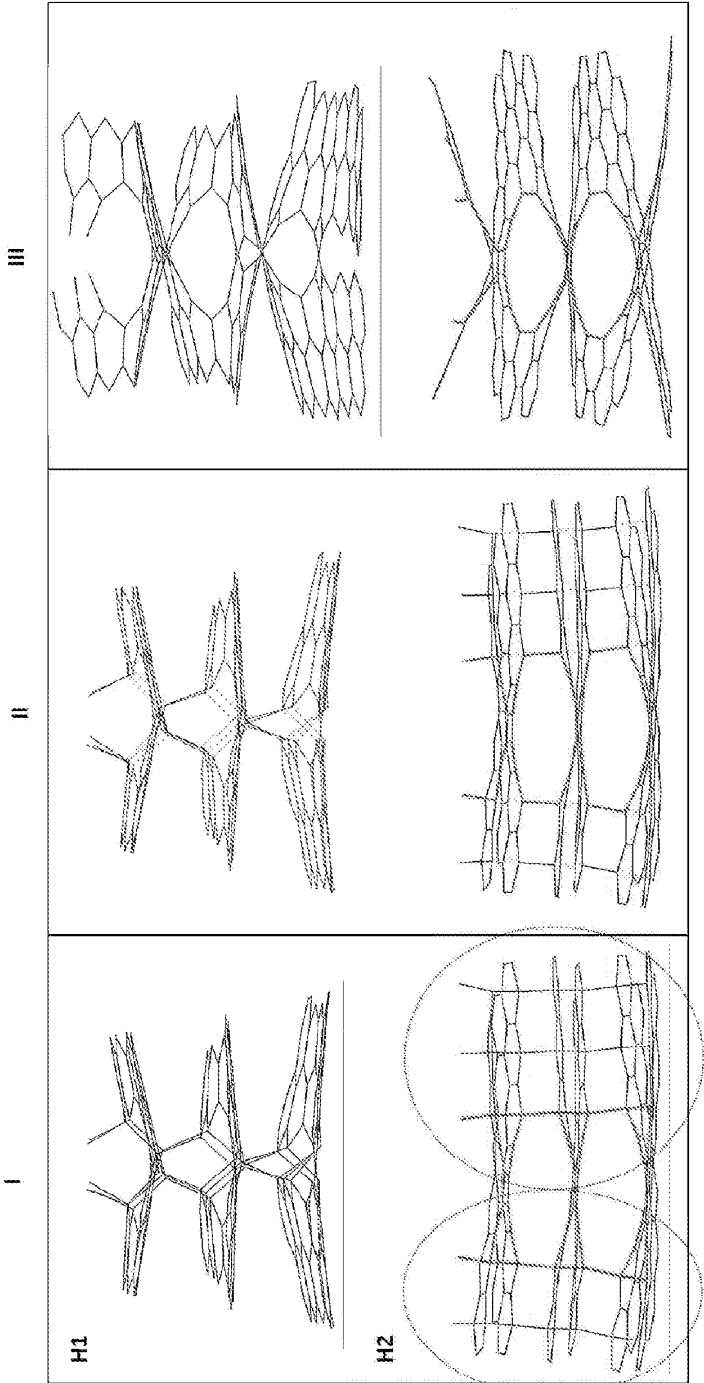


FIG. 145



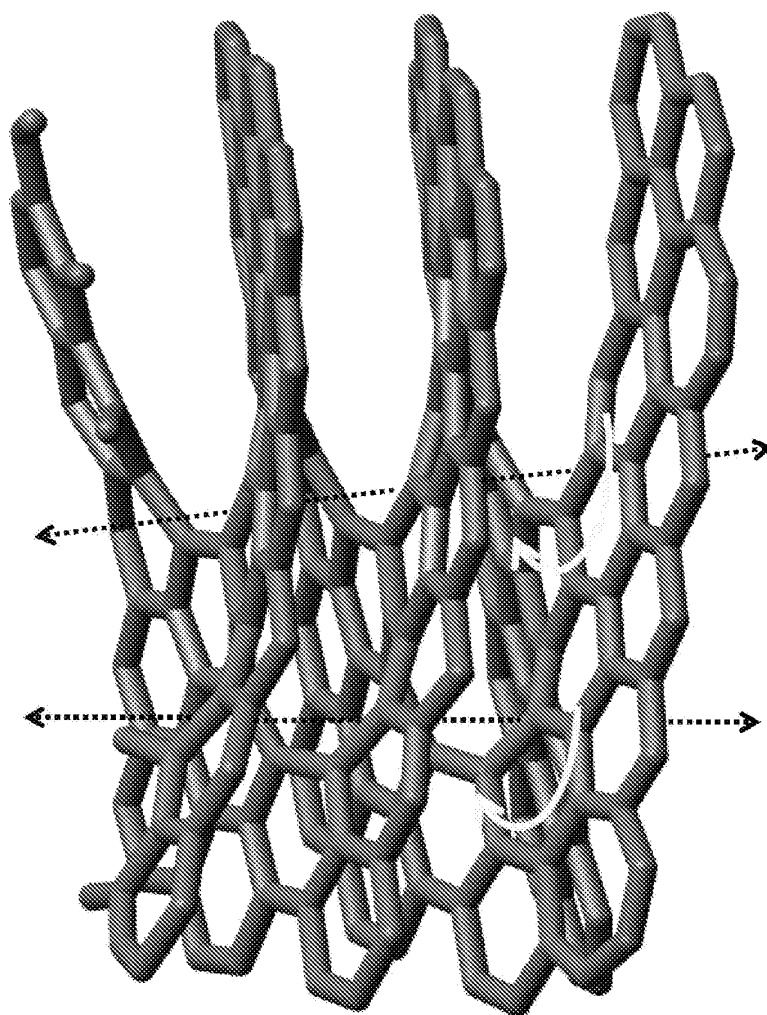
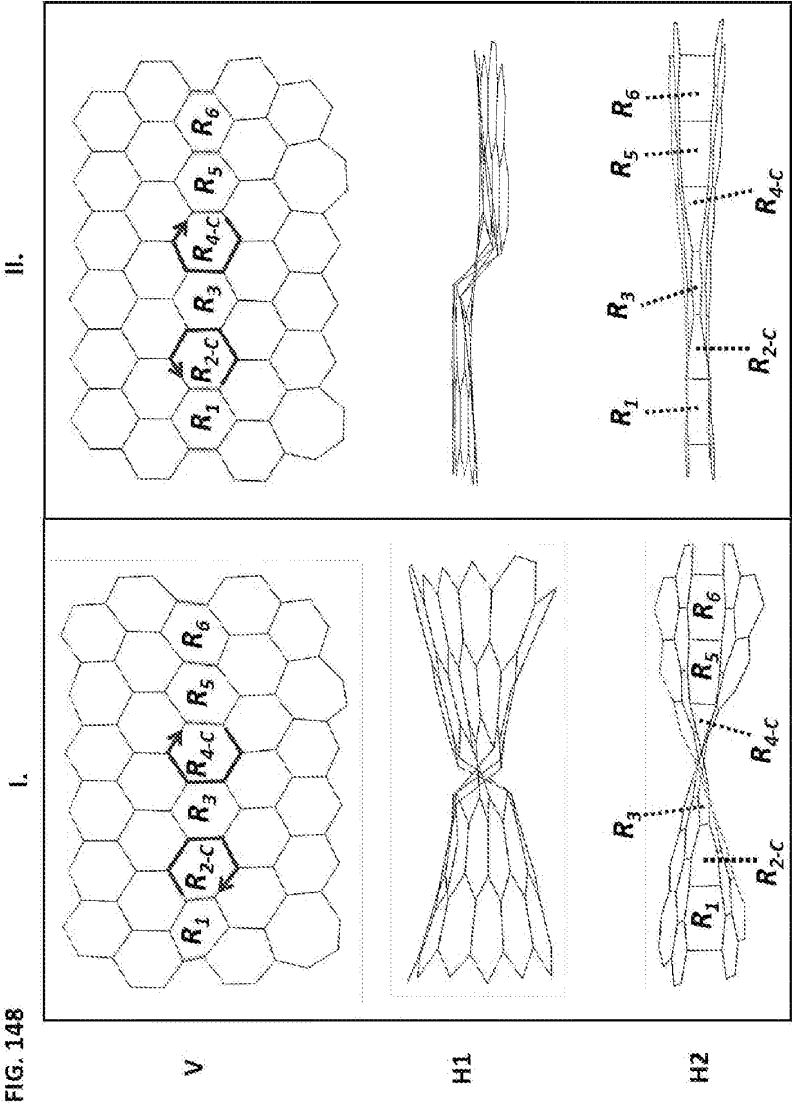
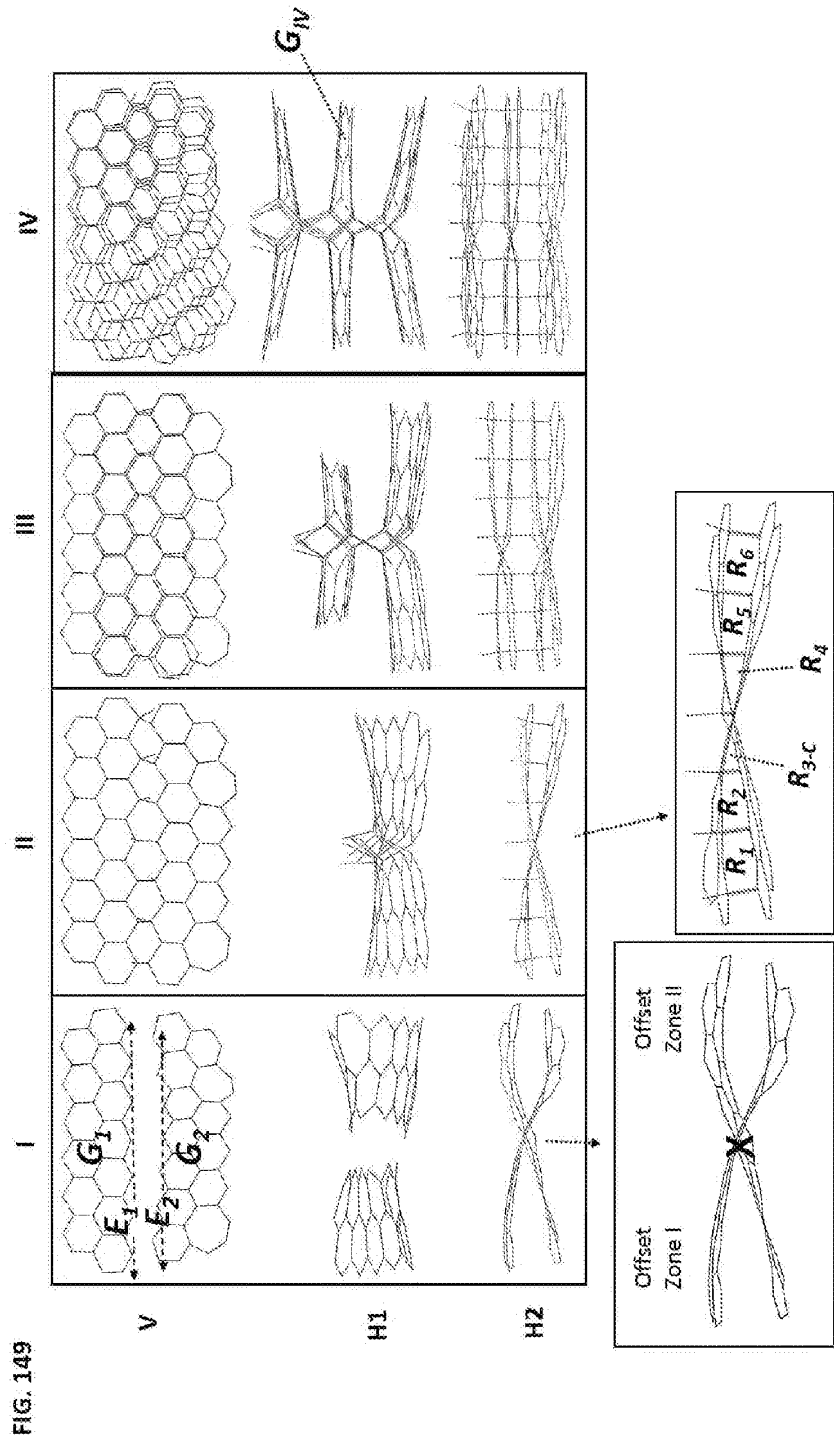


FIG. 146

FIG. 147







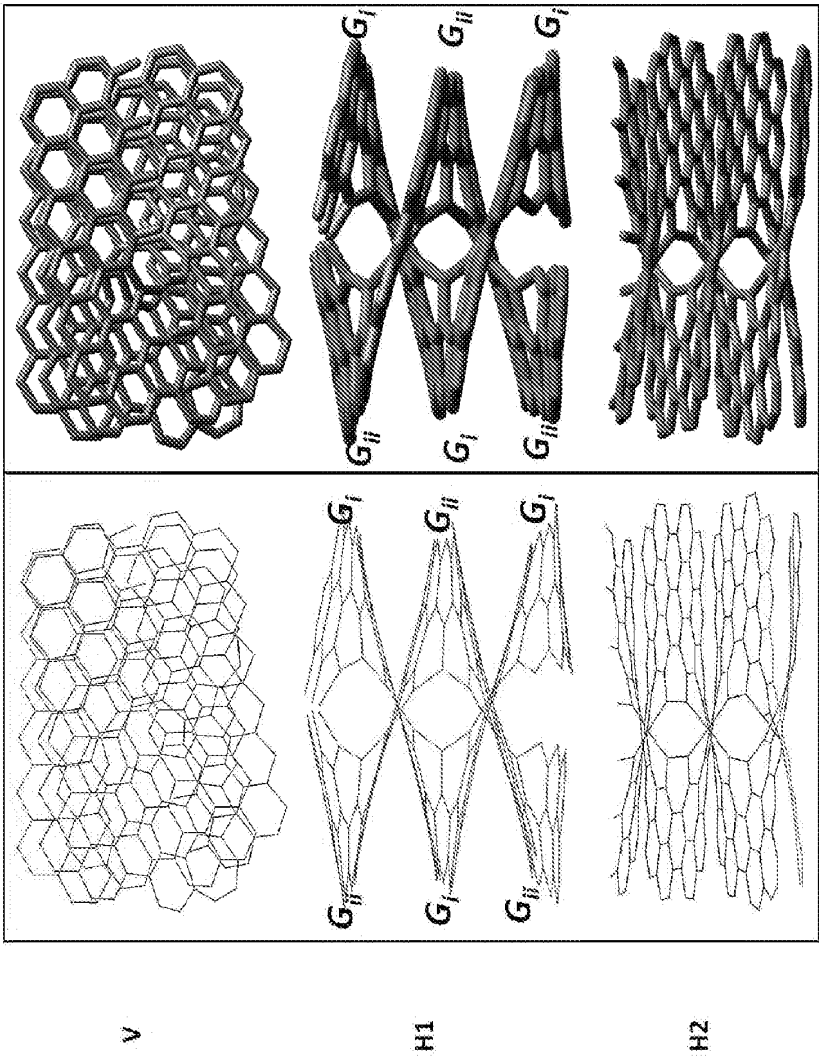
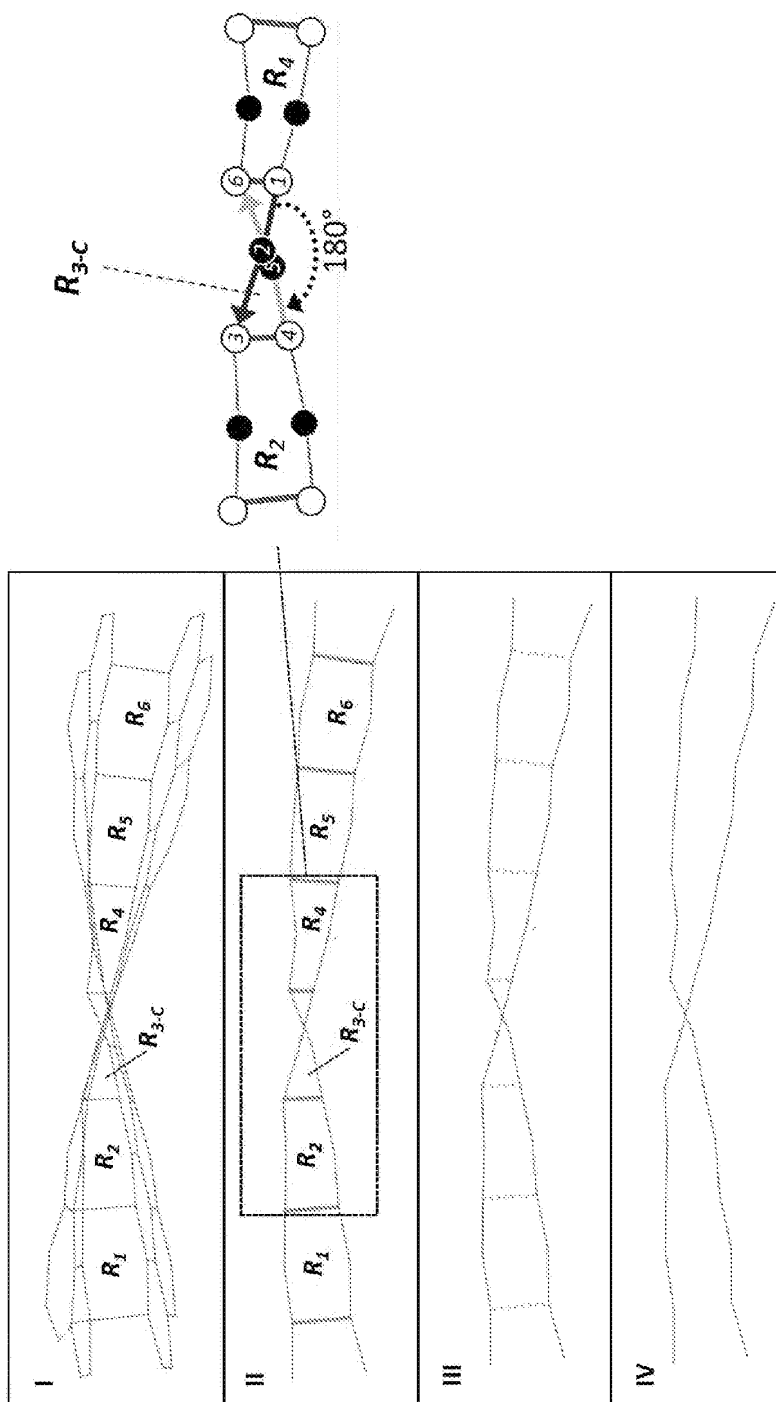
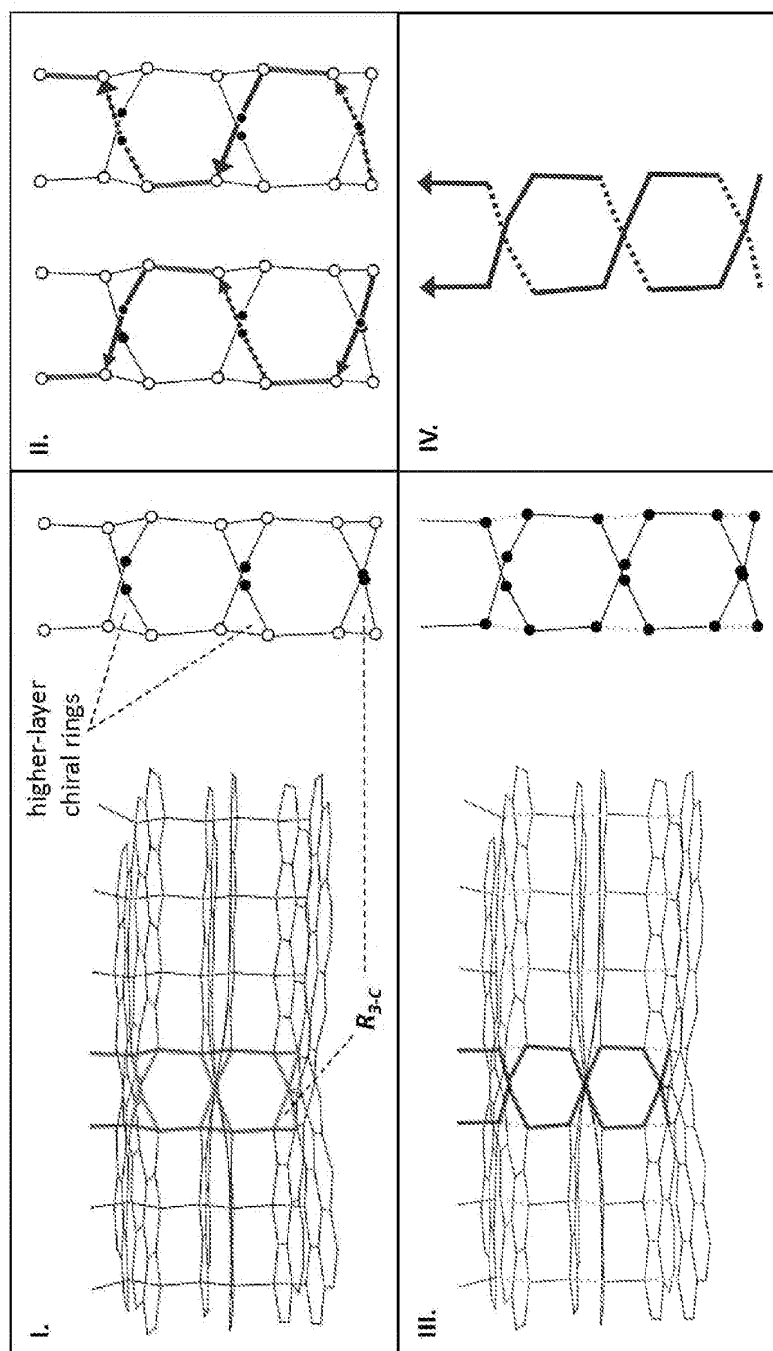
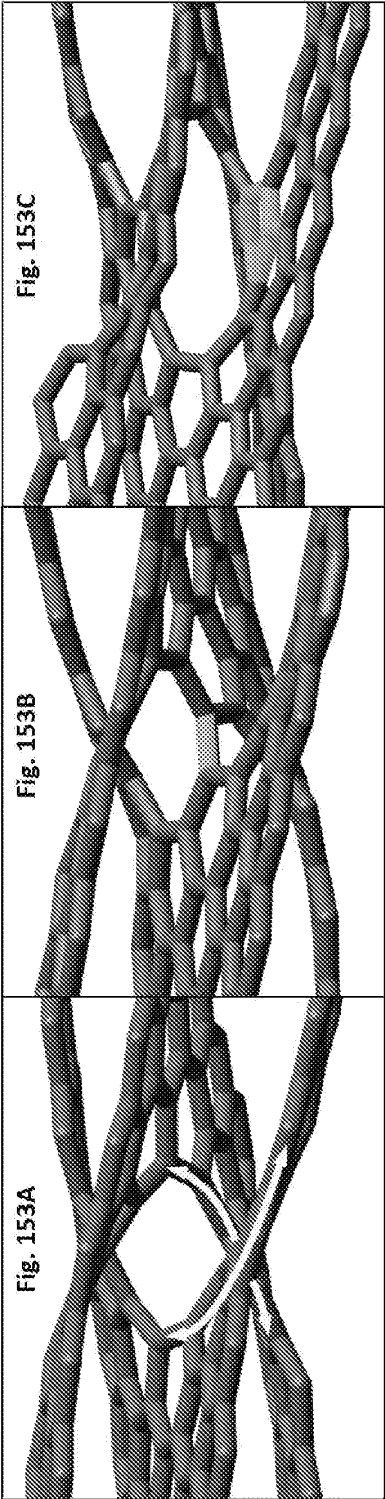
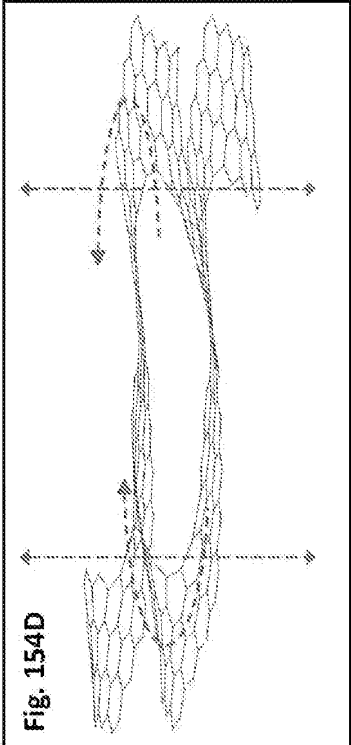
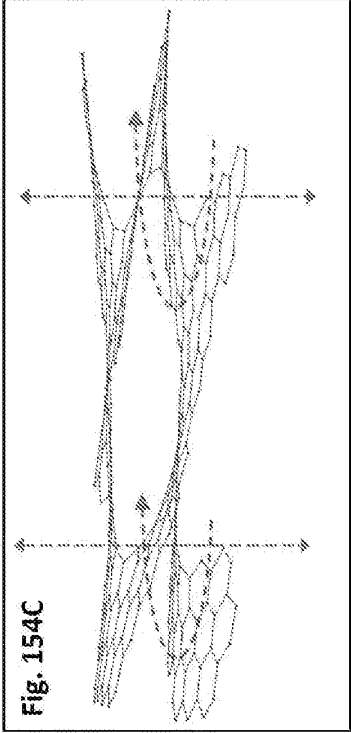
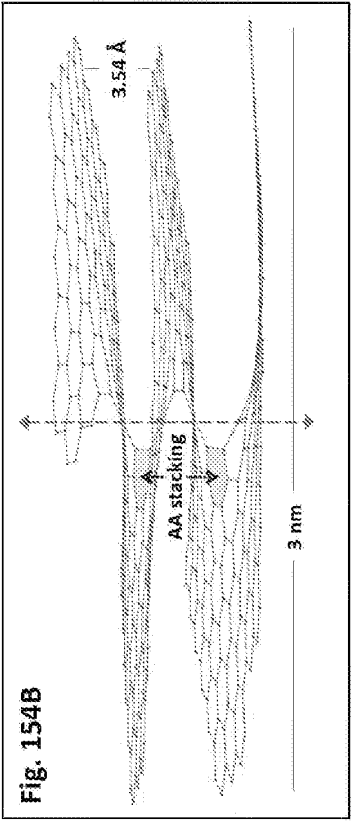
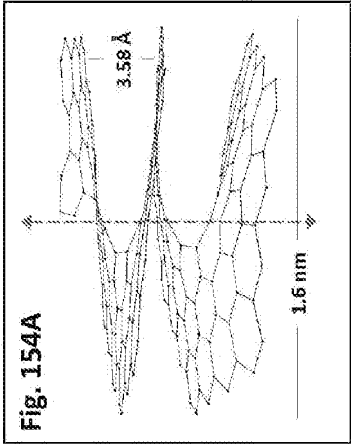


FIG. 150









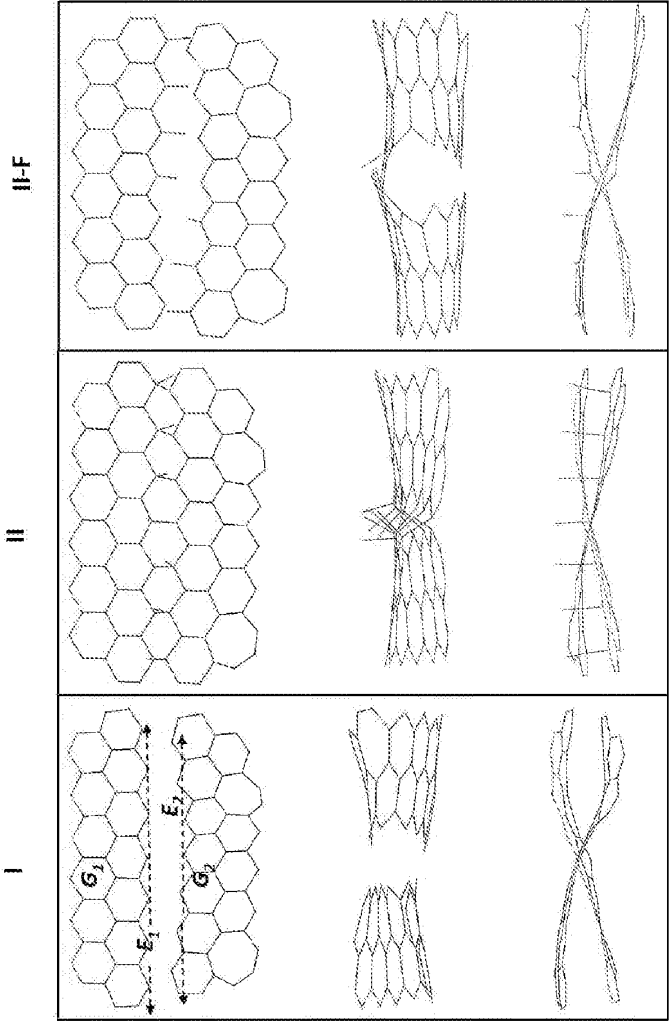
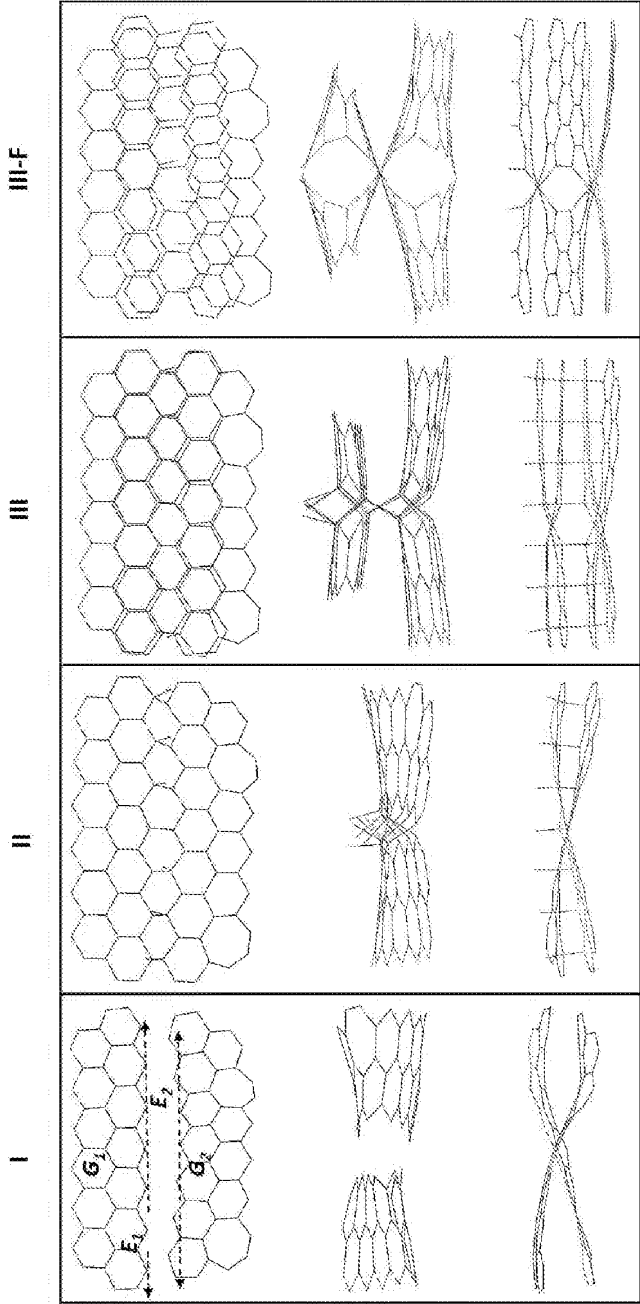
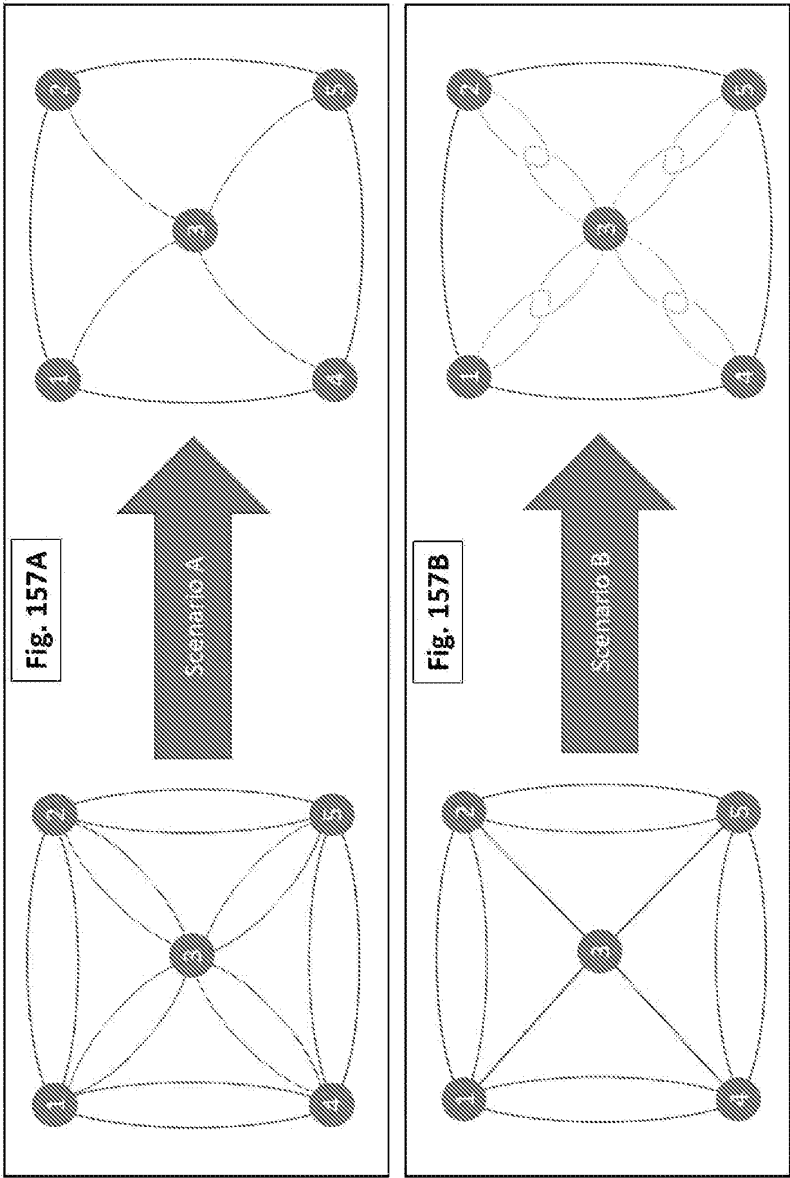


FIG. 155

FIG. 156





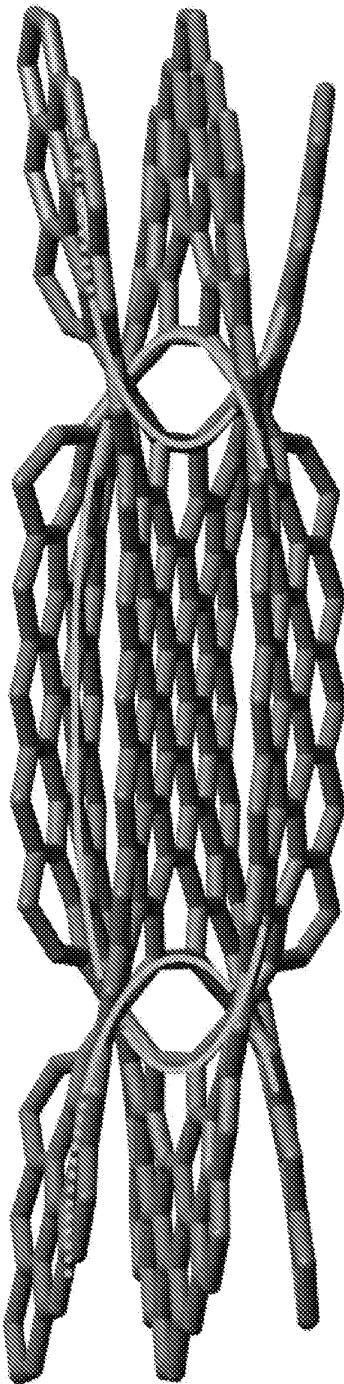
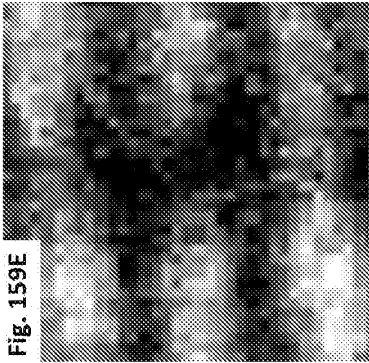
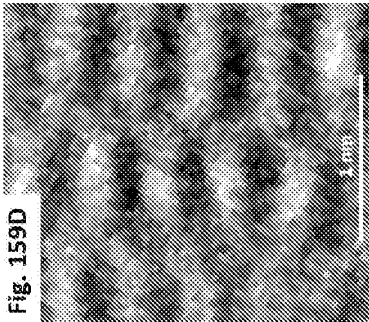
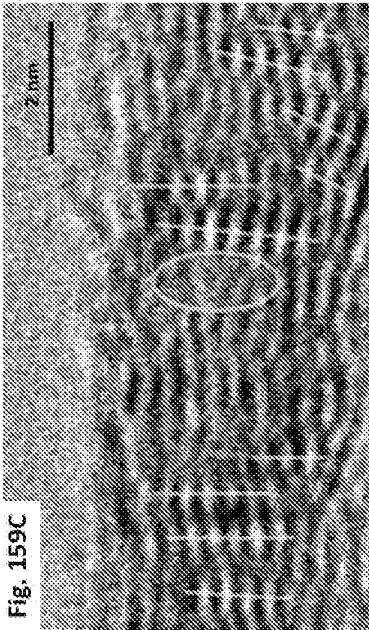
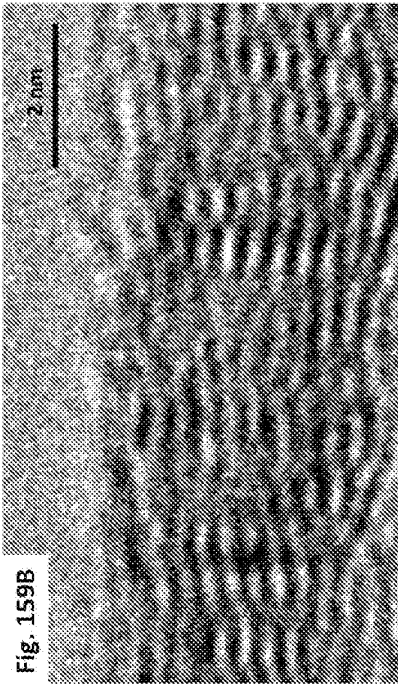
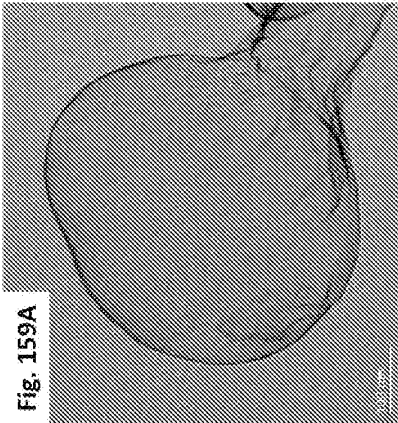
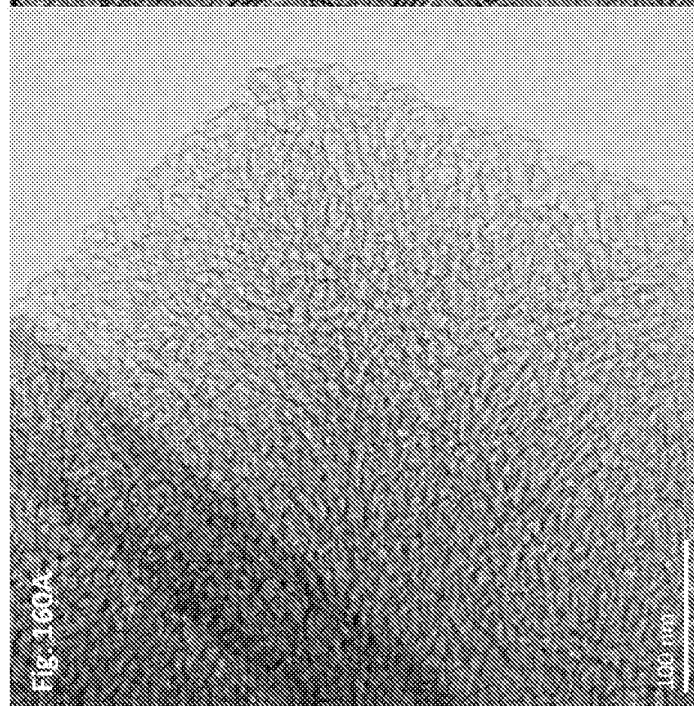
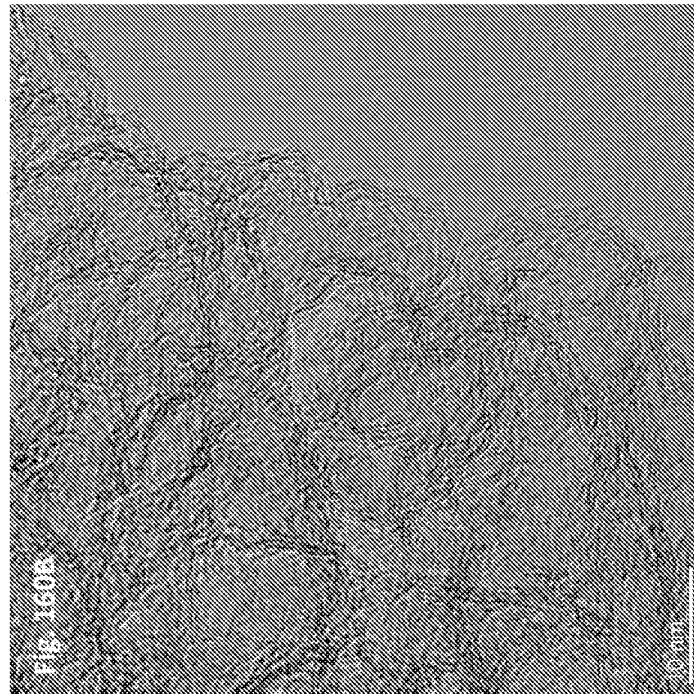


FIG. 158





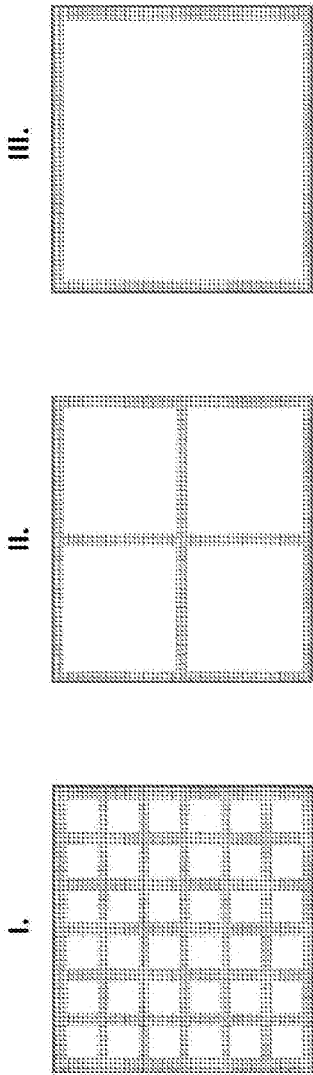
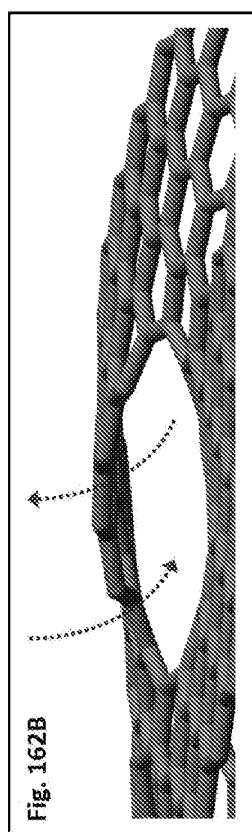
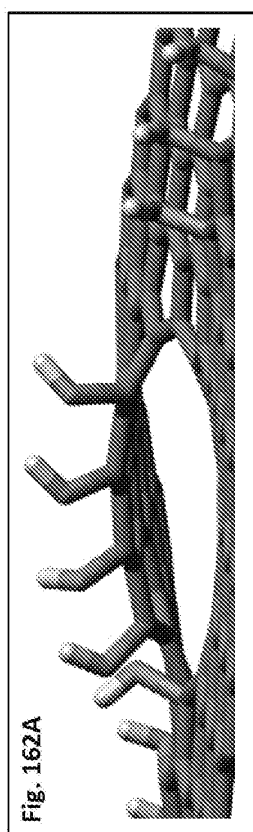
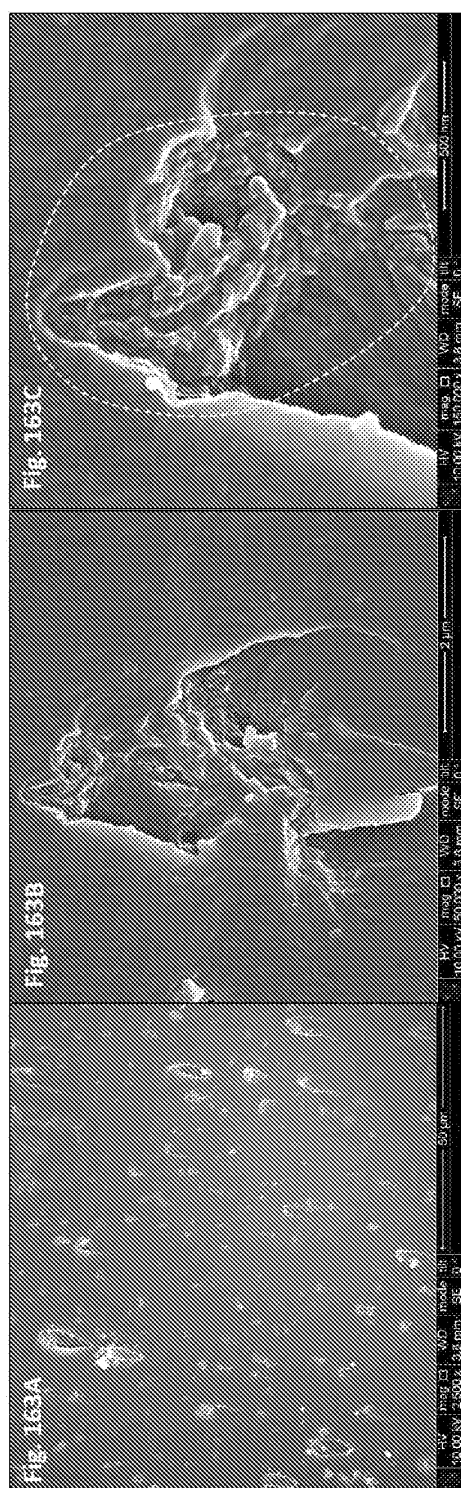
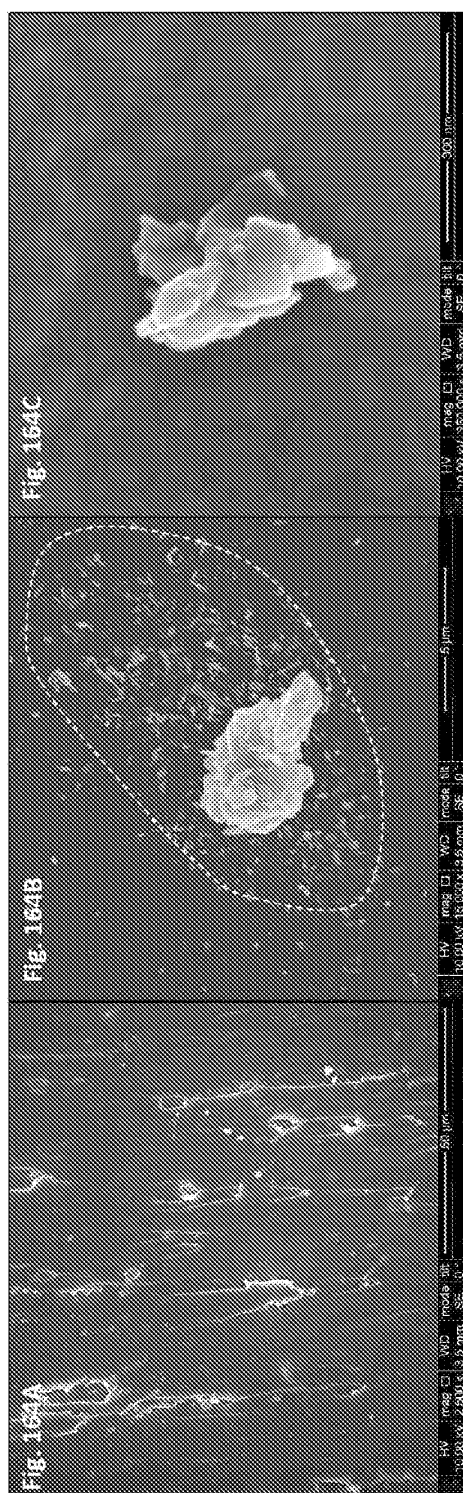


FIG. 161







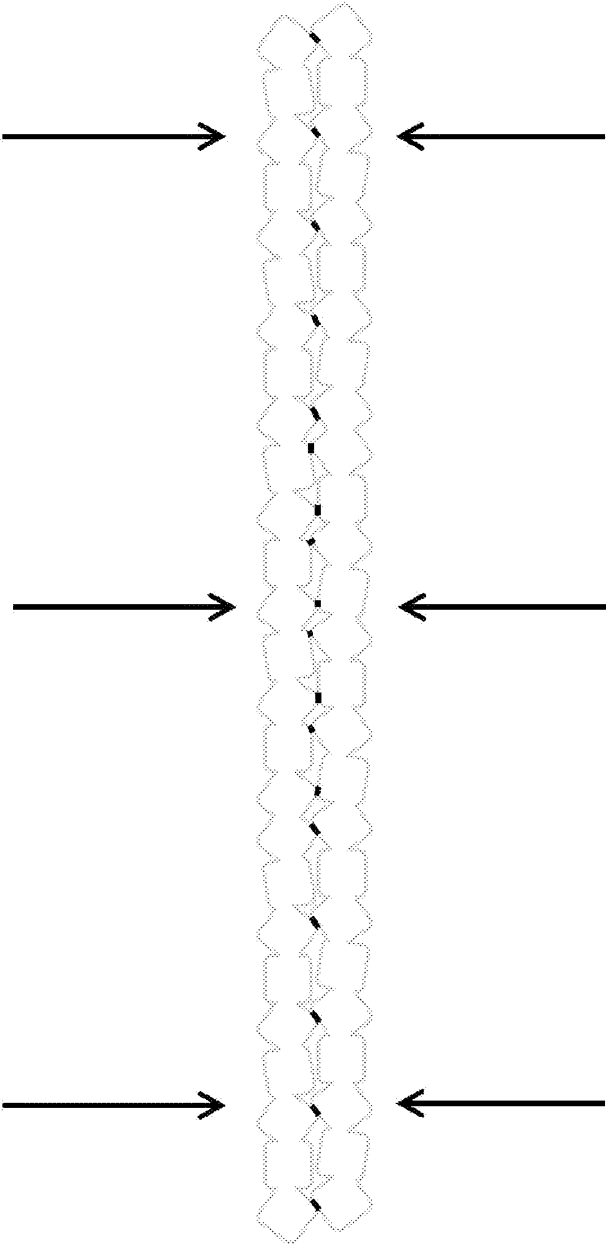
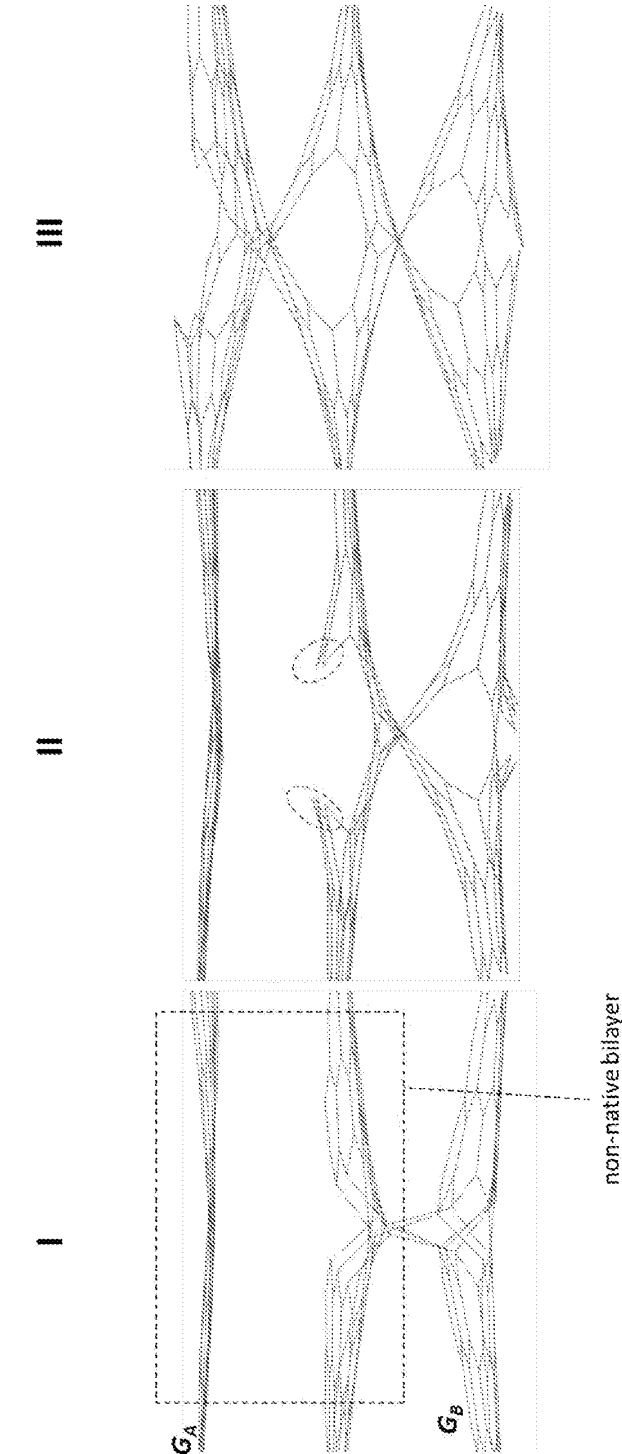
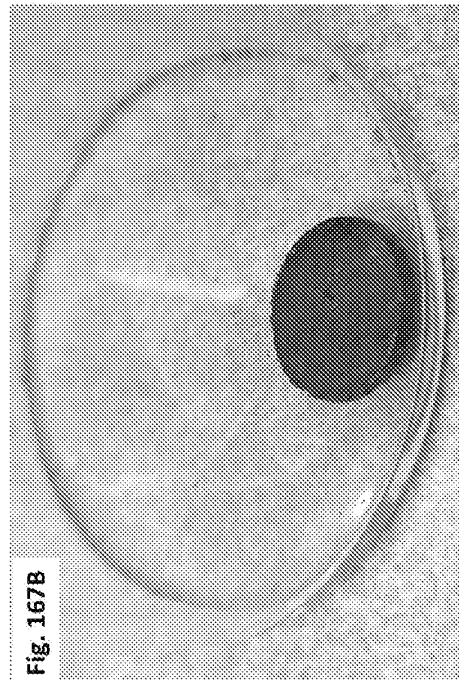


FIG. 165

FIG. 166





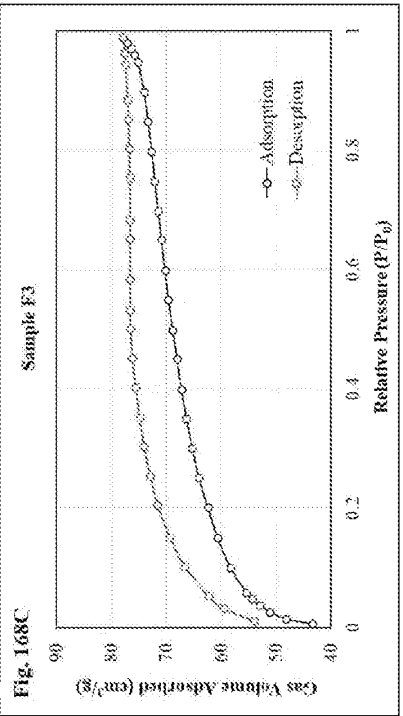
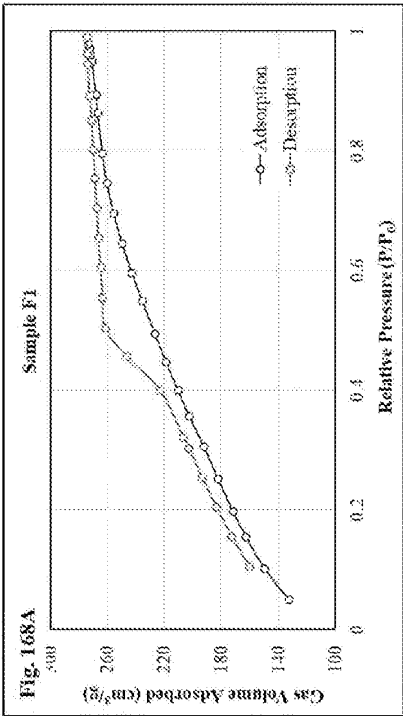
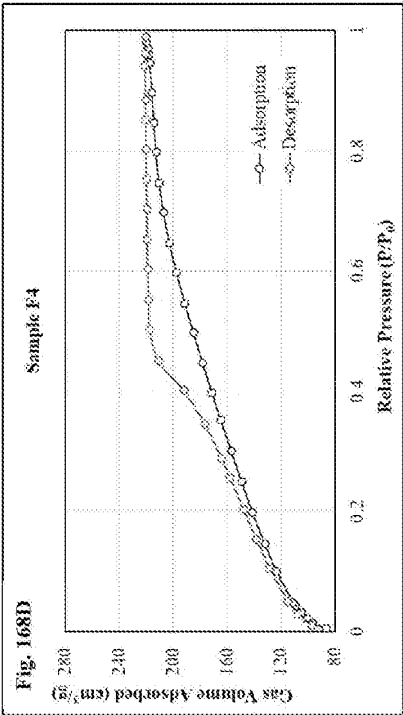
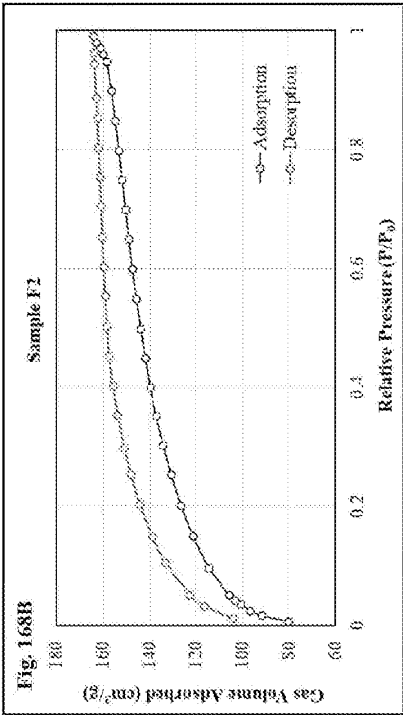
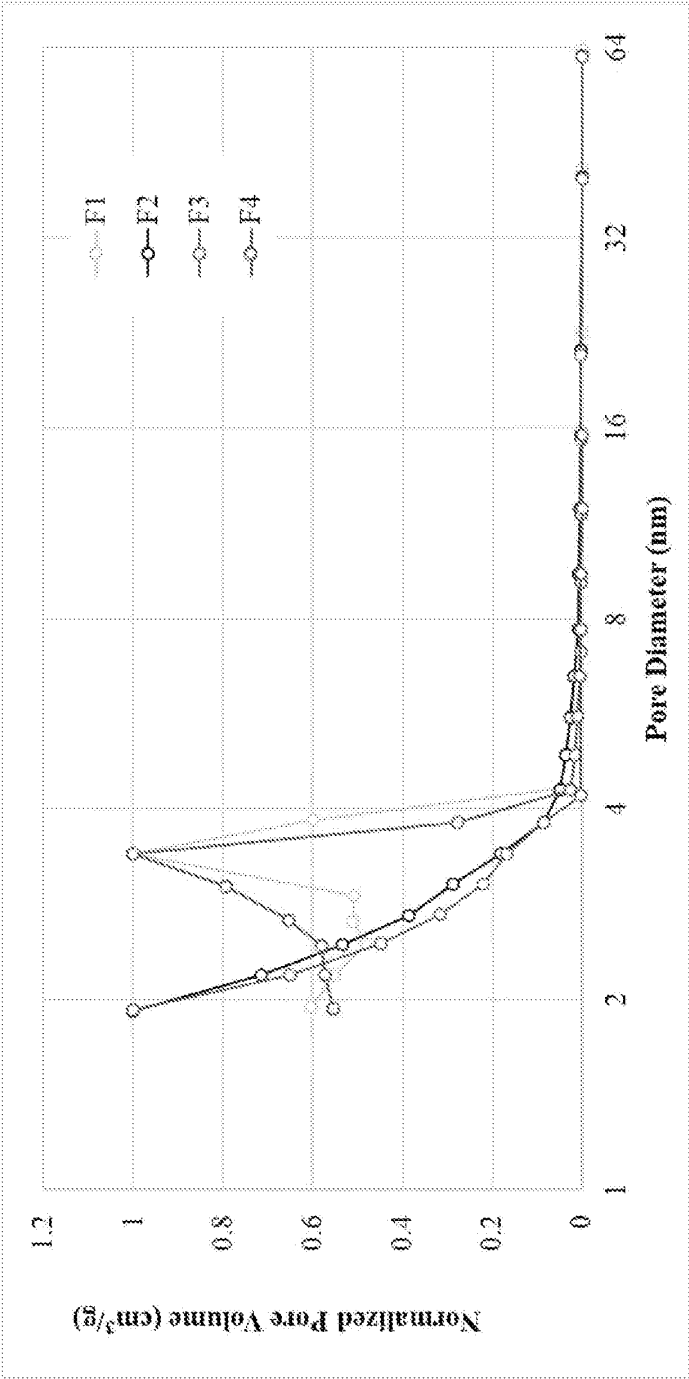


FIG. 169



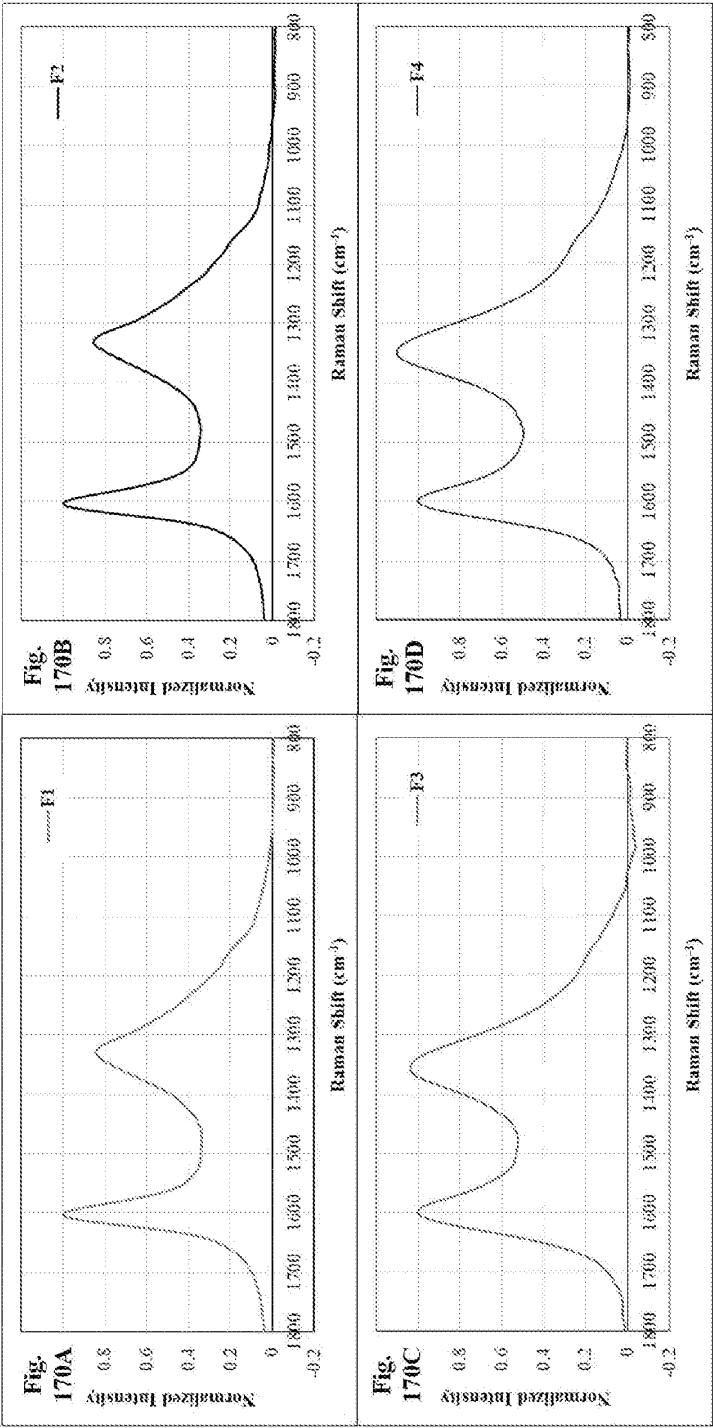
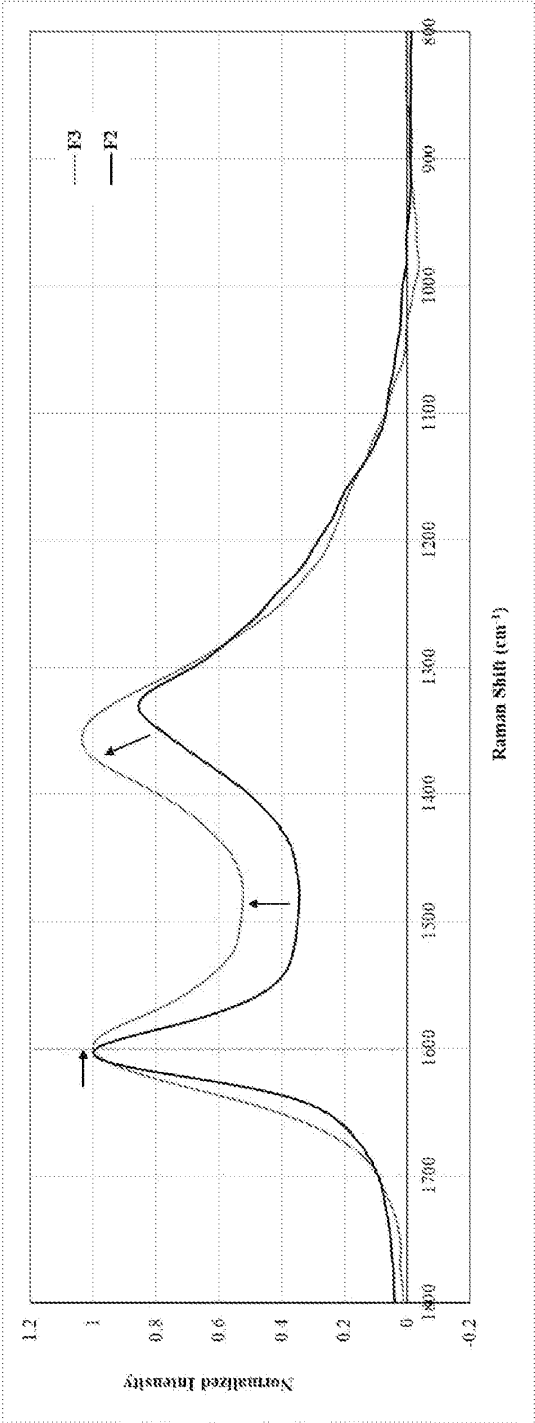
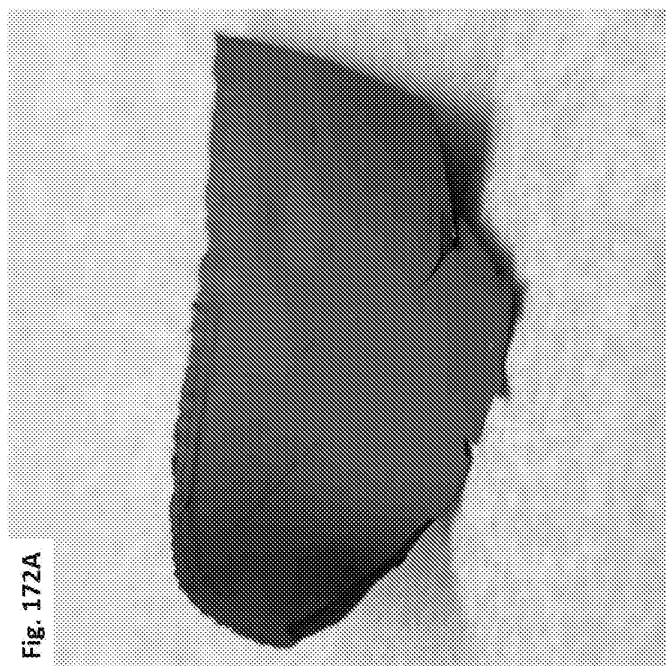
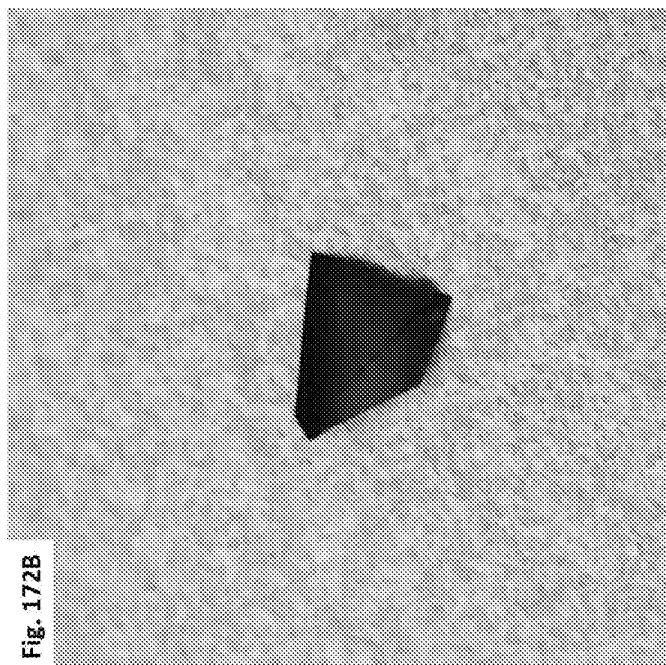
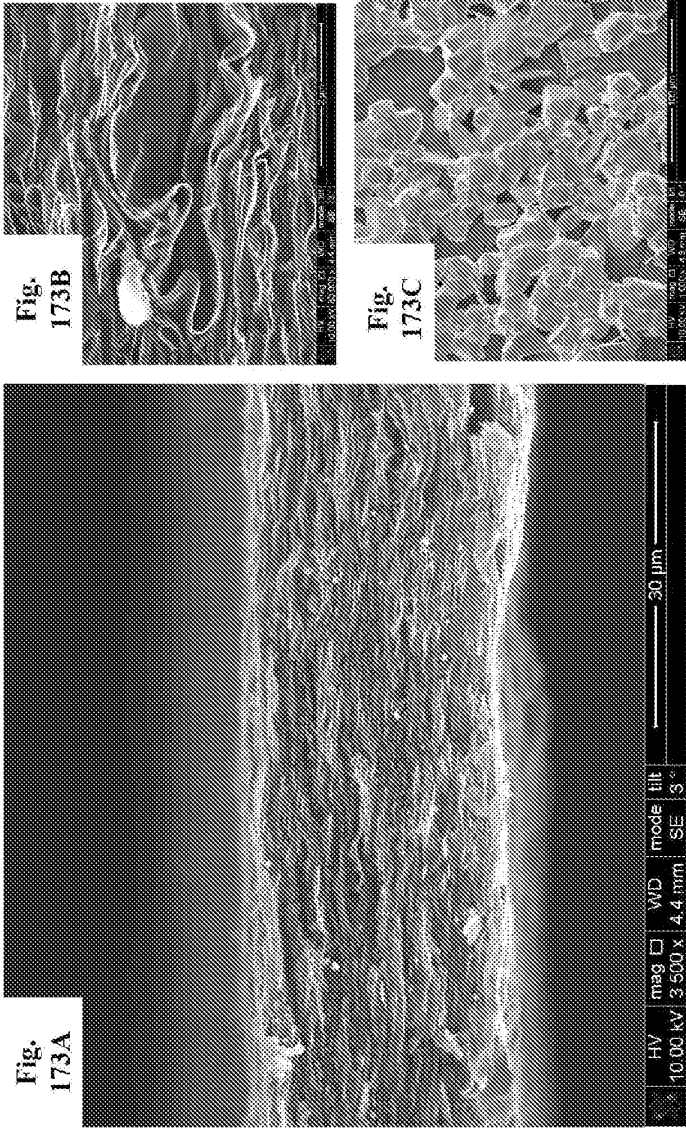


FIG. 171







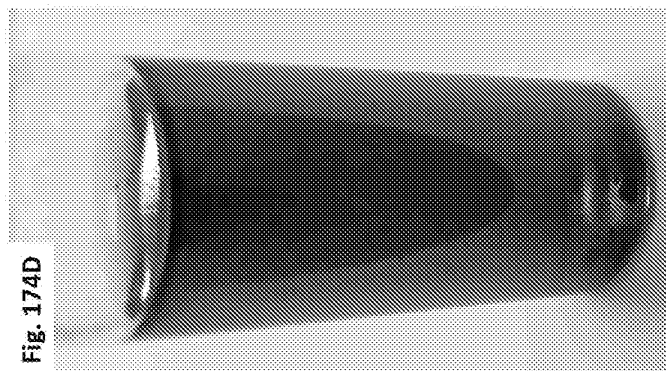


Fig. 174D

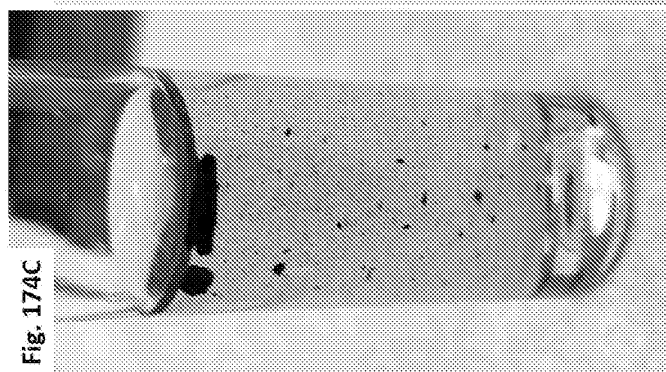


Fig. 174C

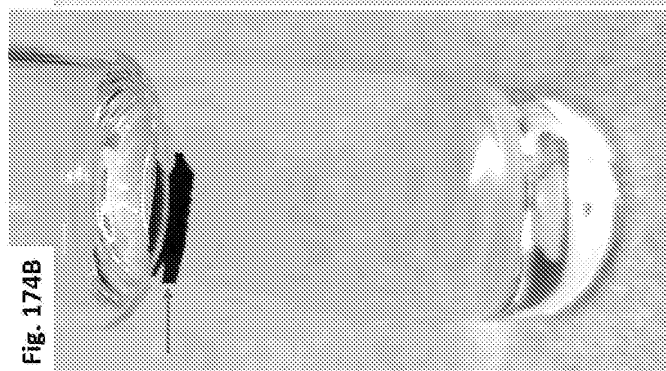


Fig. 174B

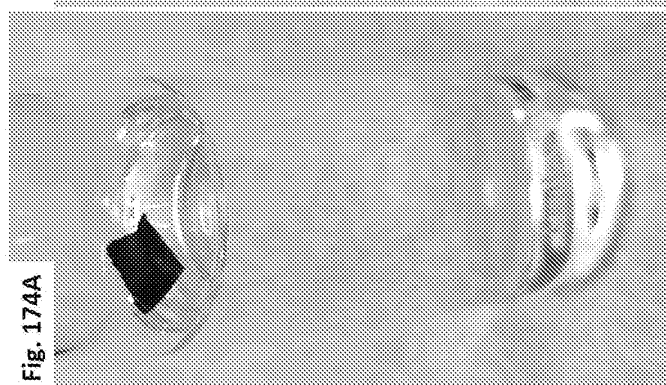
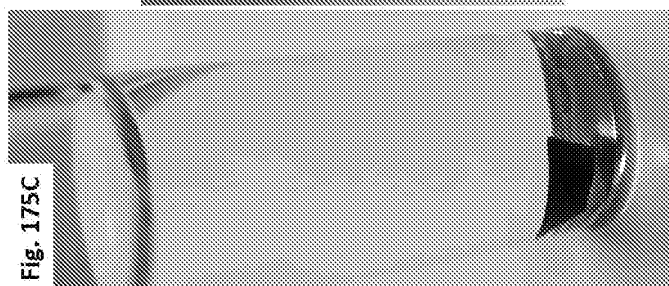
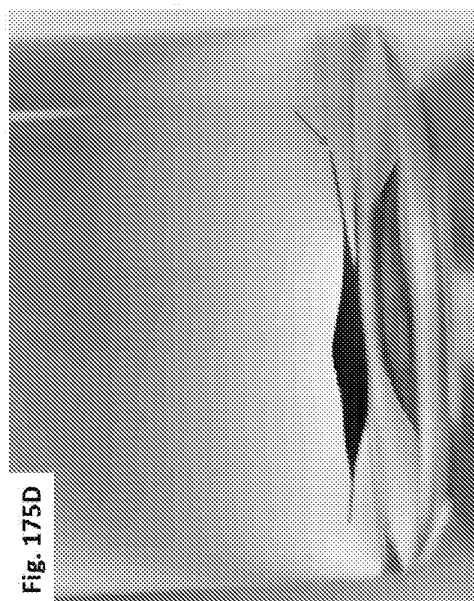
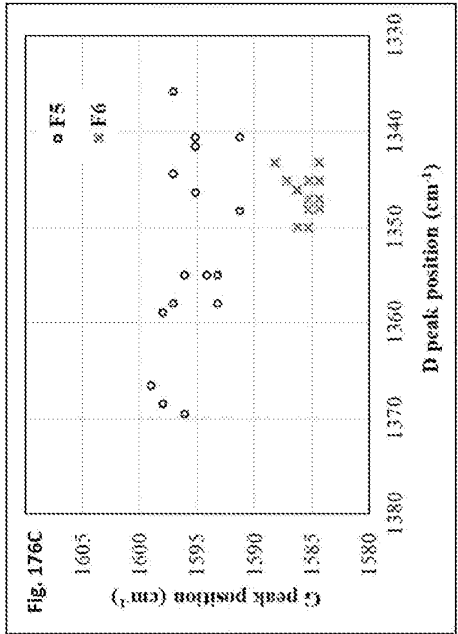
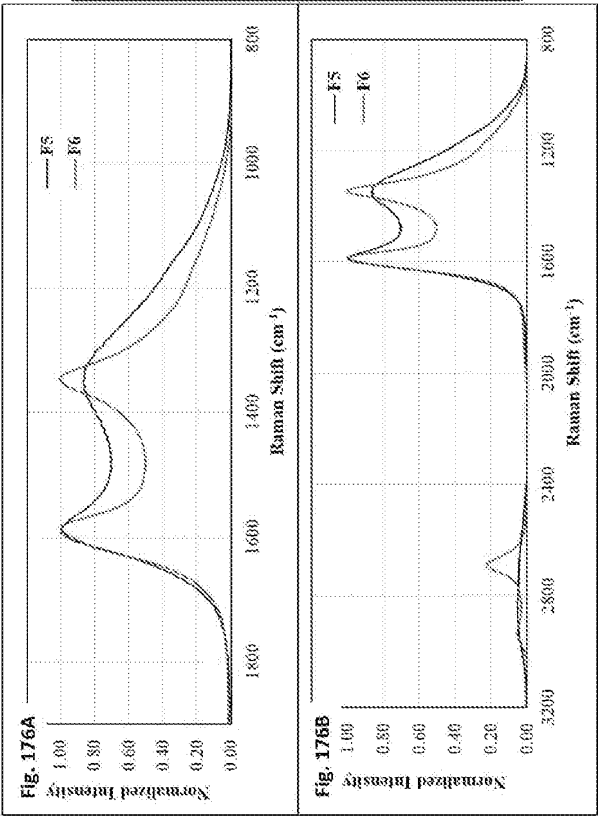


Fig. 174A





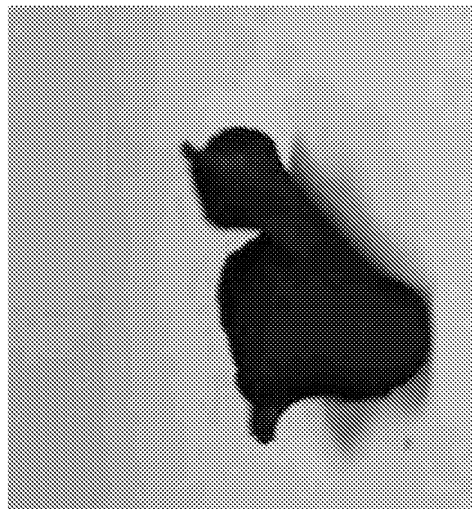
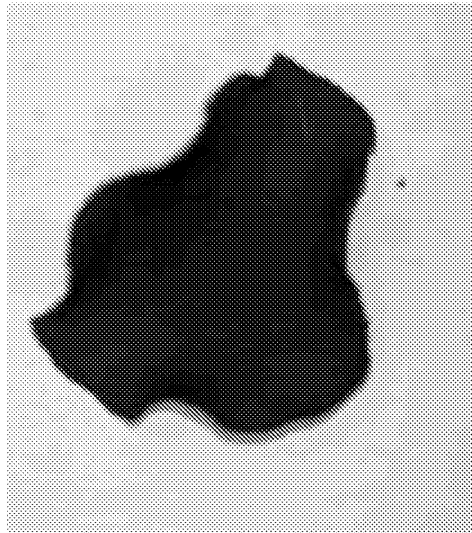
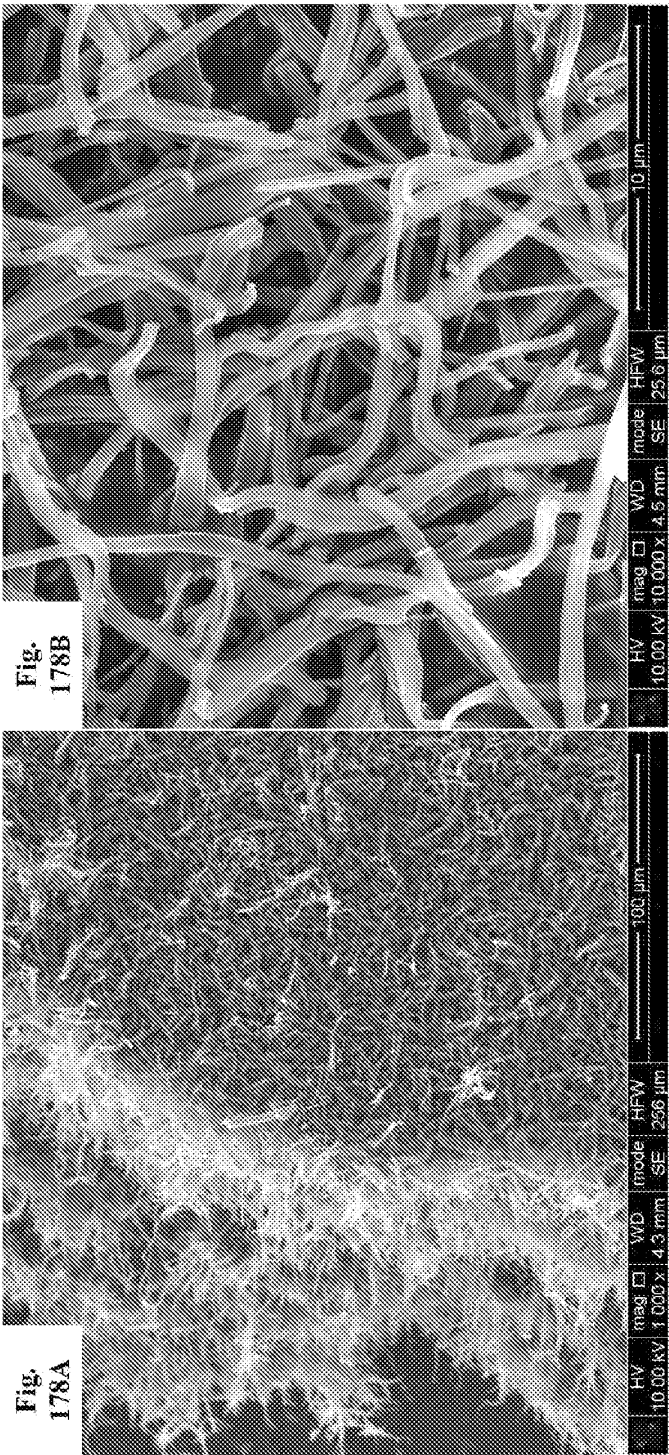
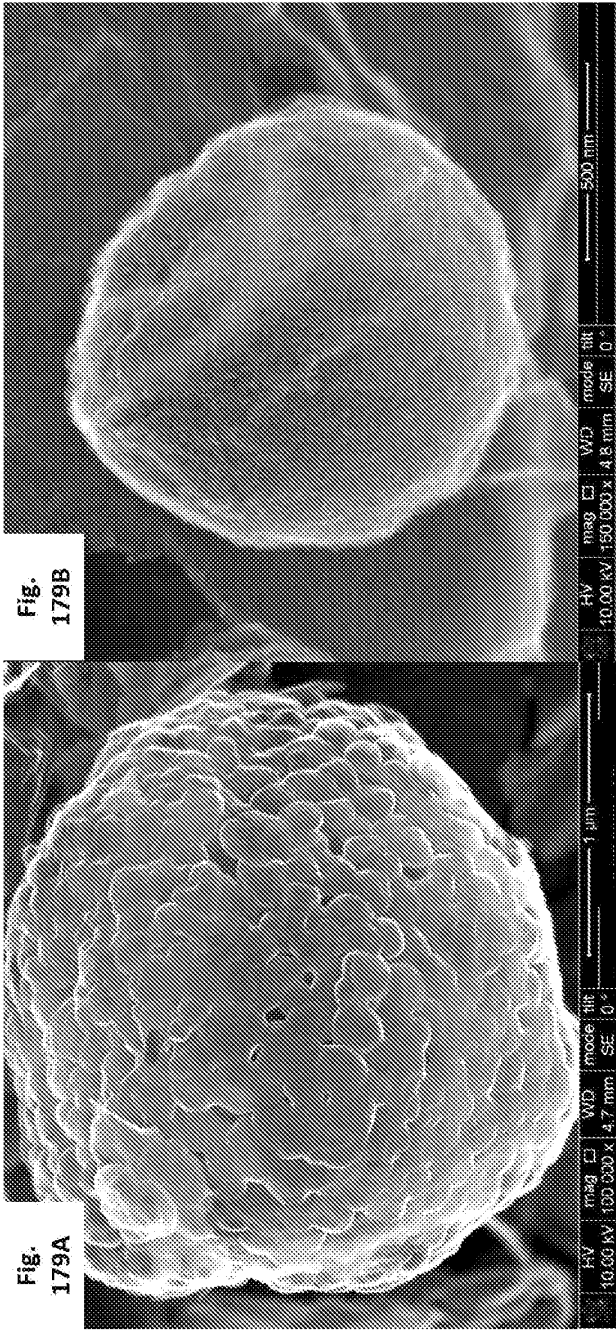


FIG. 177





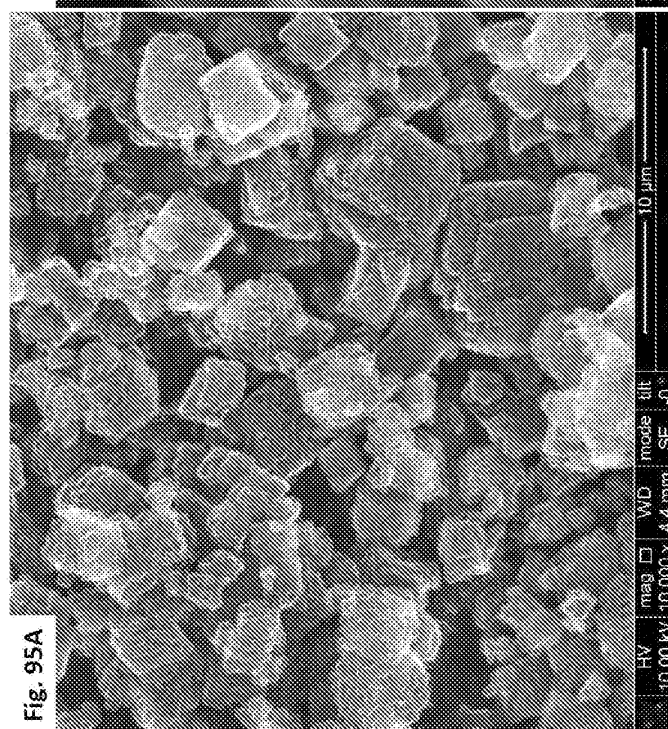
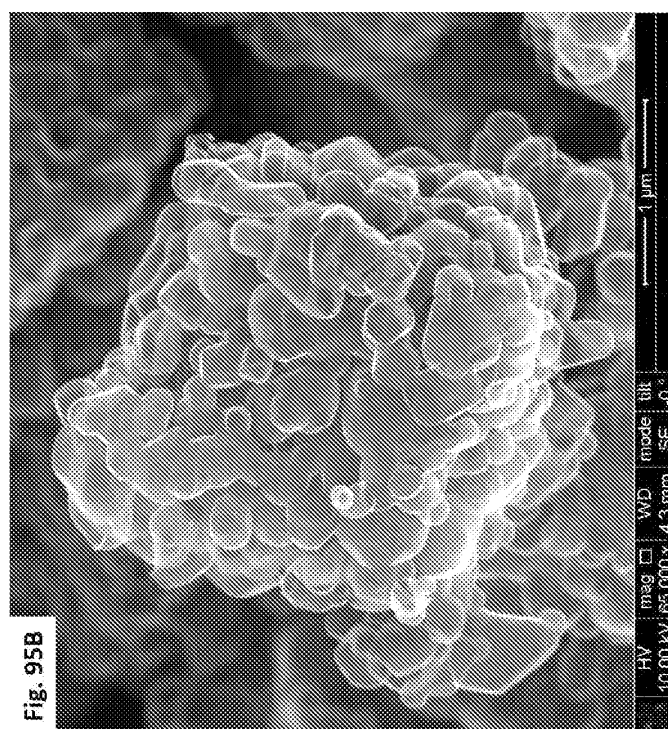
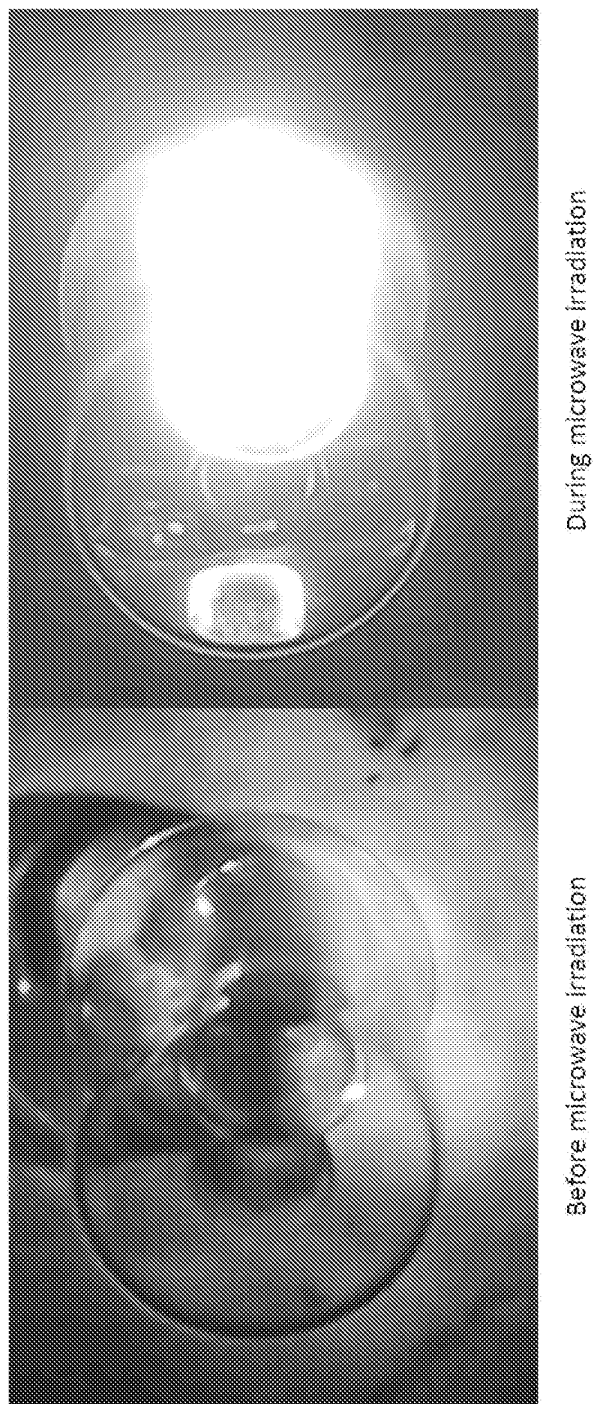
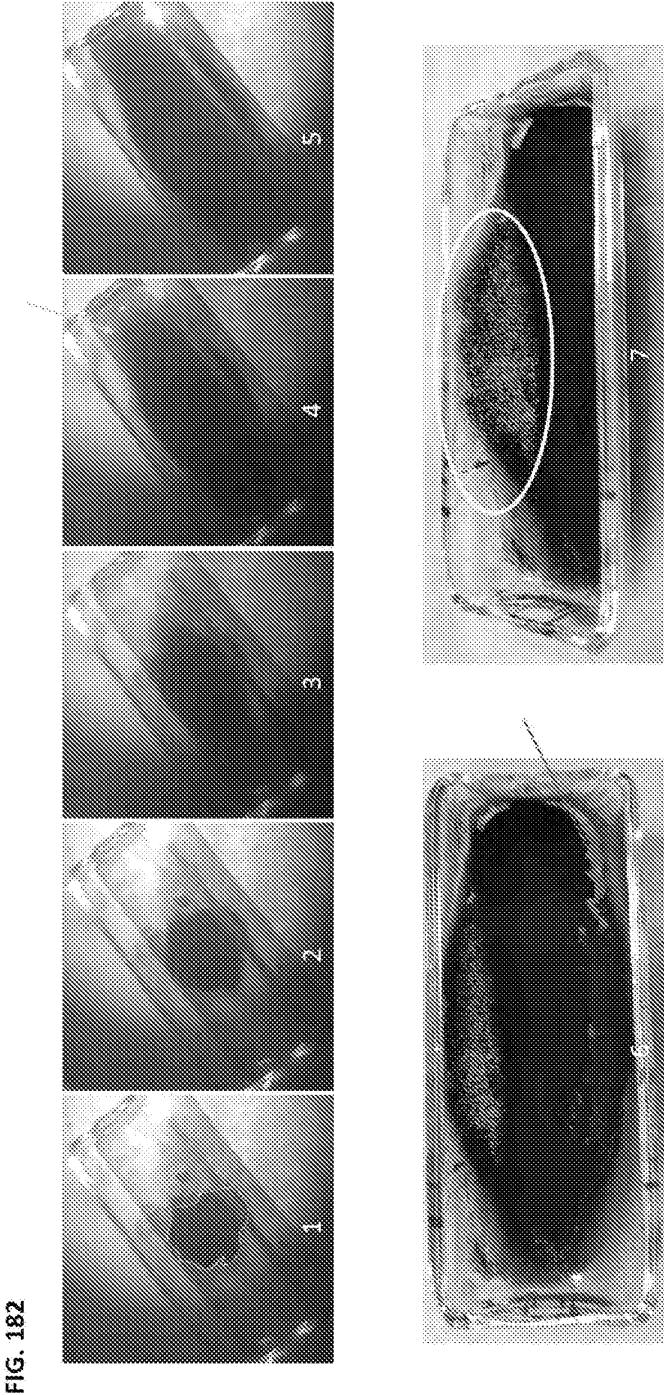
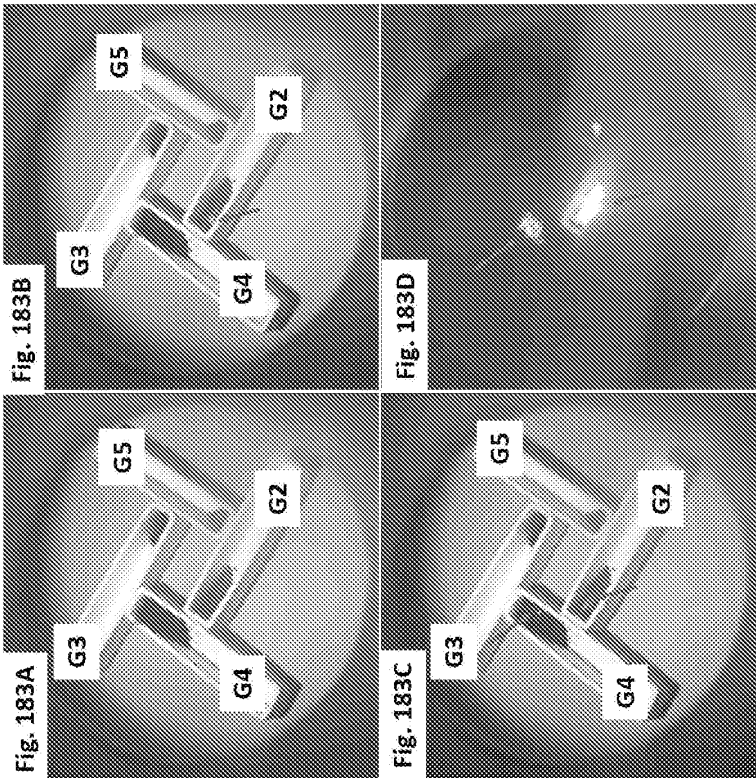
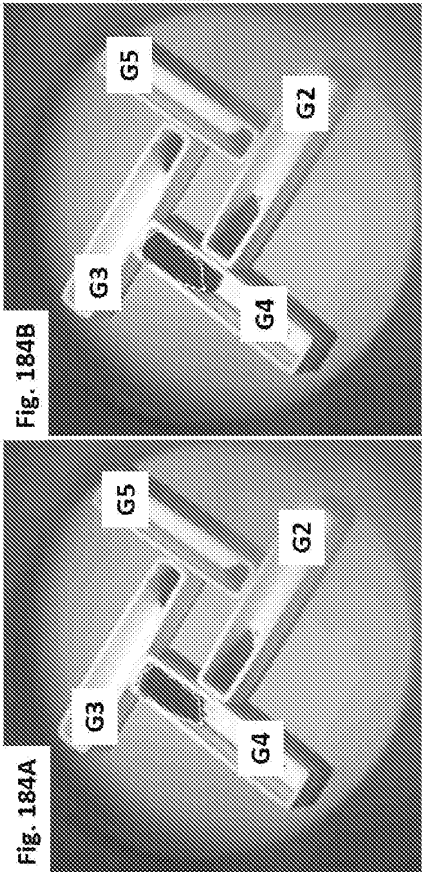


FIG. 181









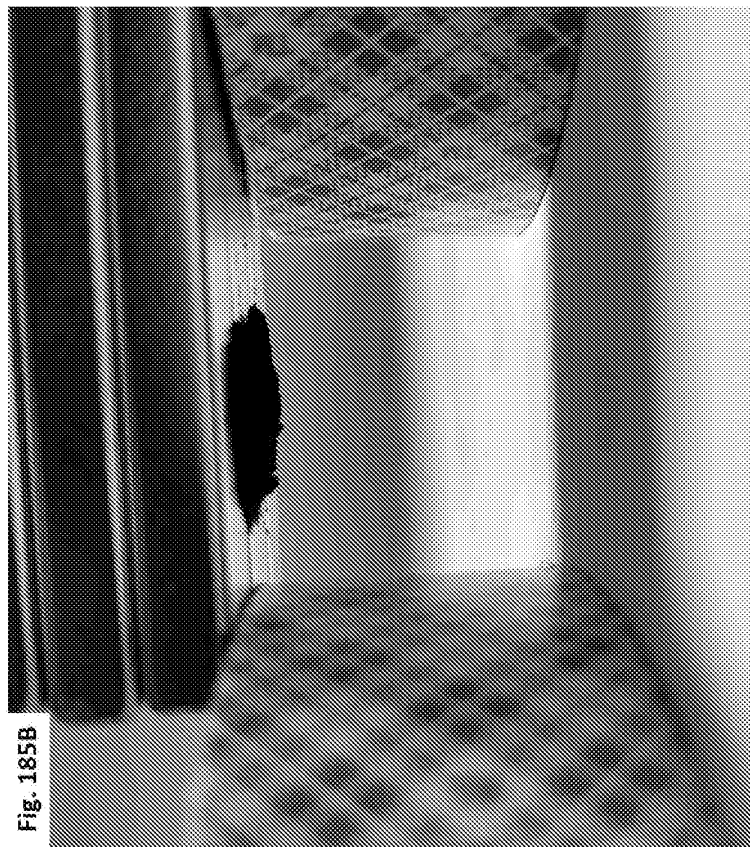


Fig. 185B

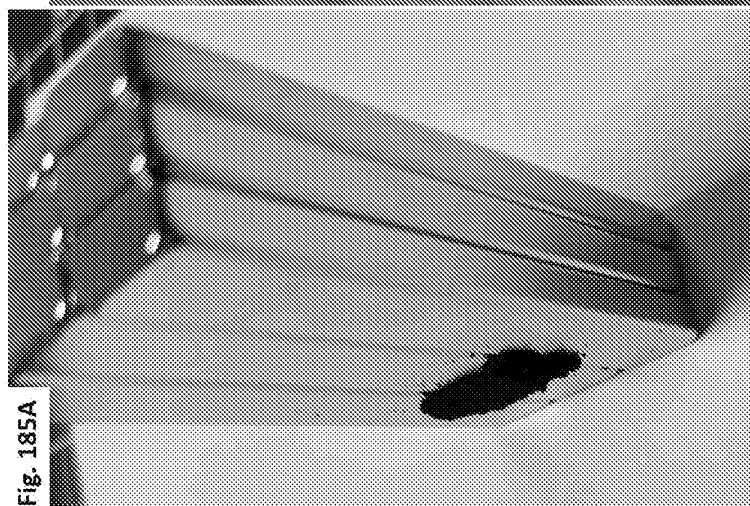


Fig. 185A

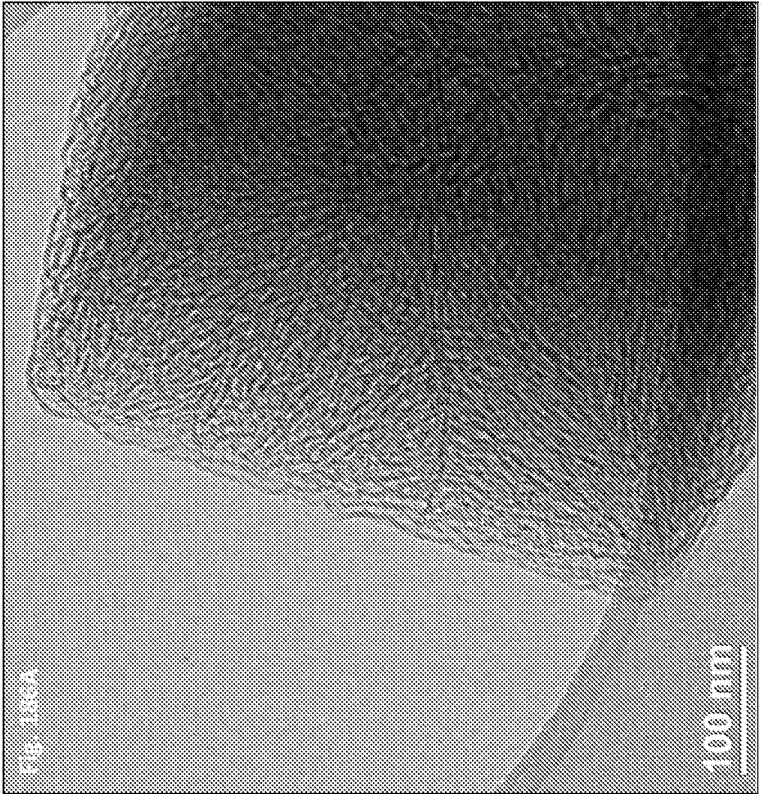
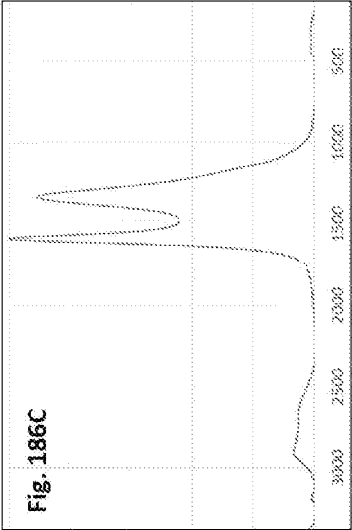
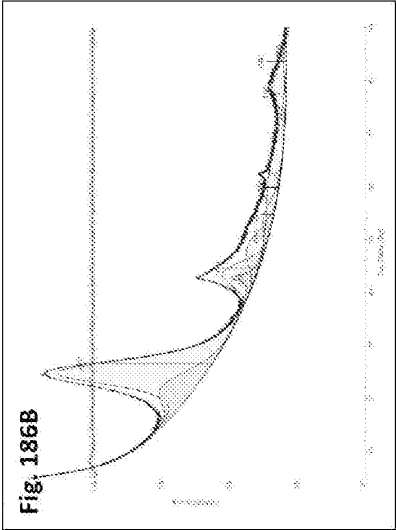
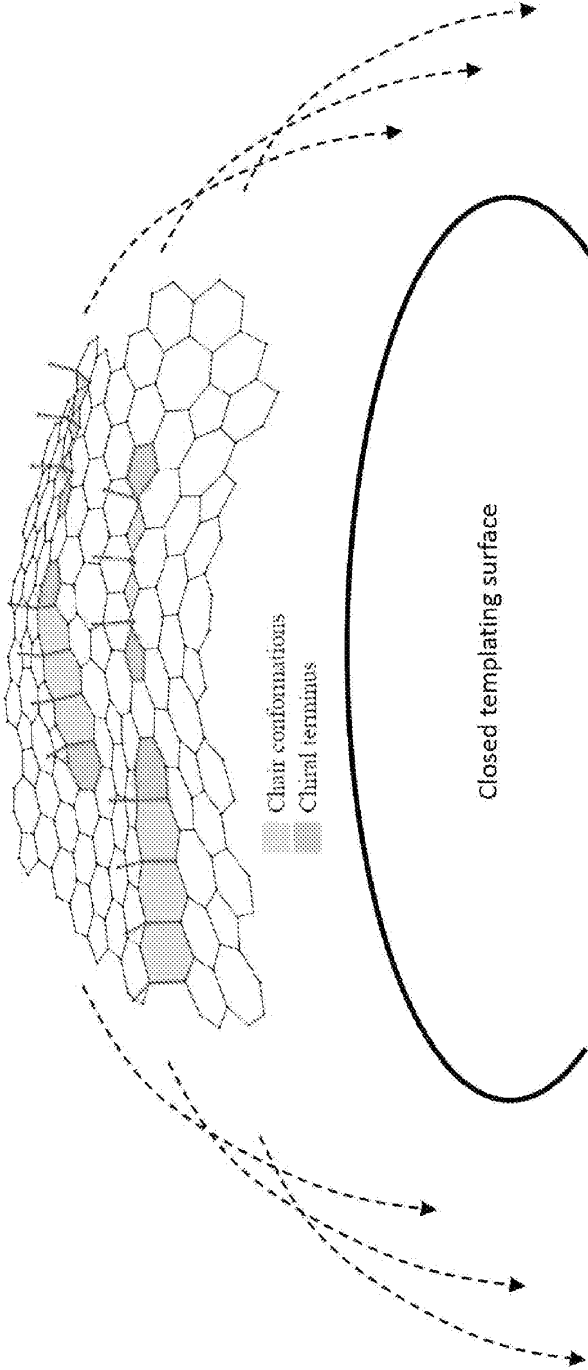


FIG. 187



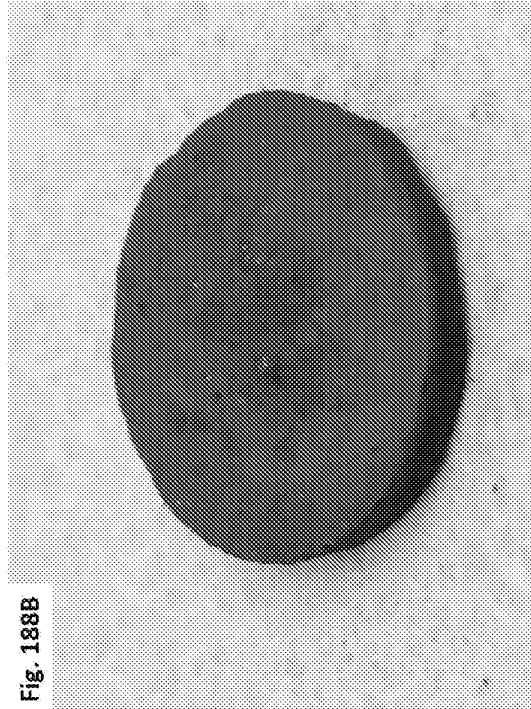


Fig. 188B

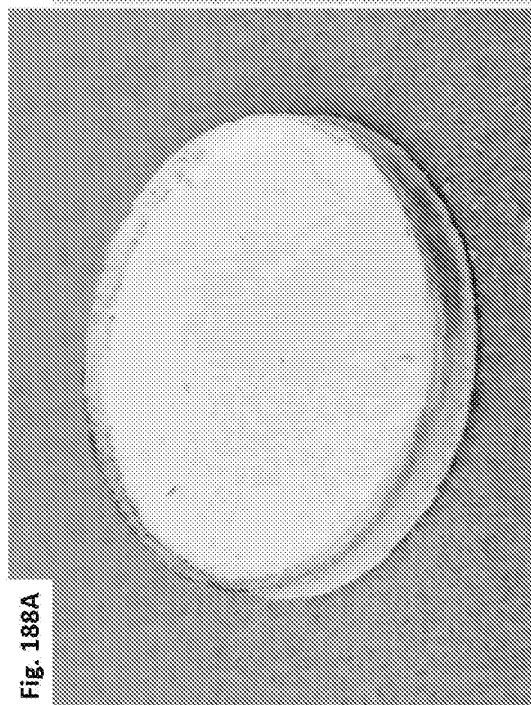


Fig. 188A



FIG. 189

FIG. 190

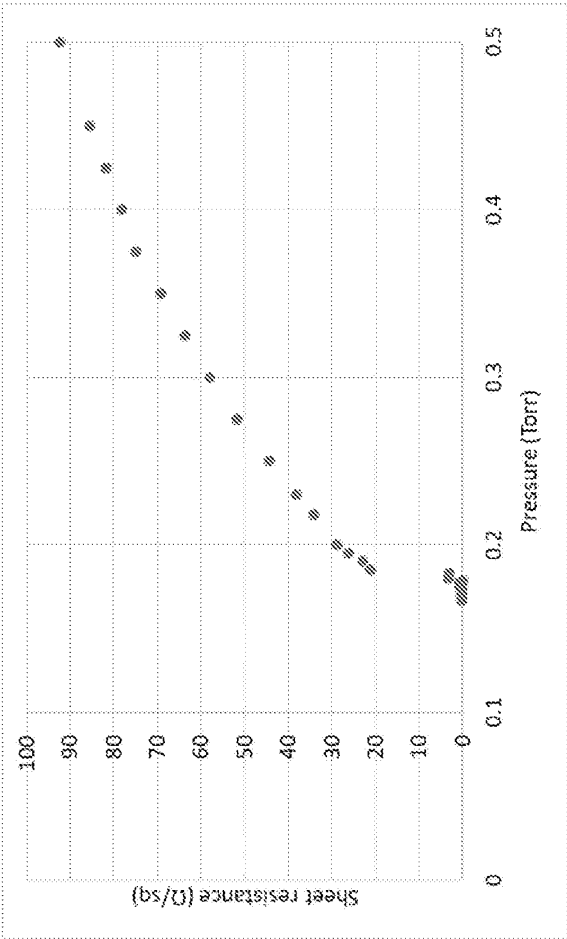


FIG. 191

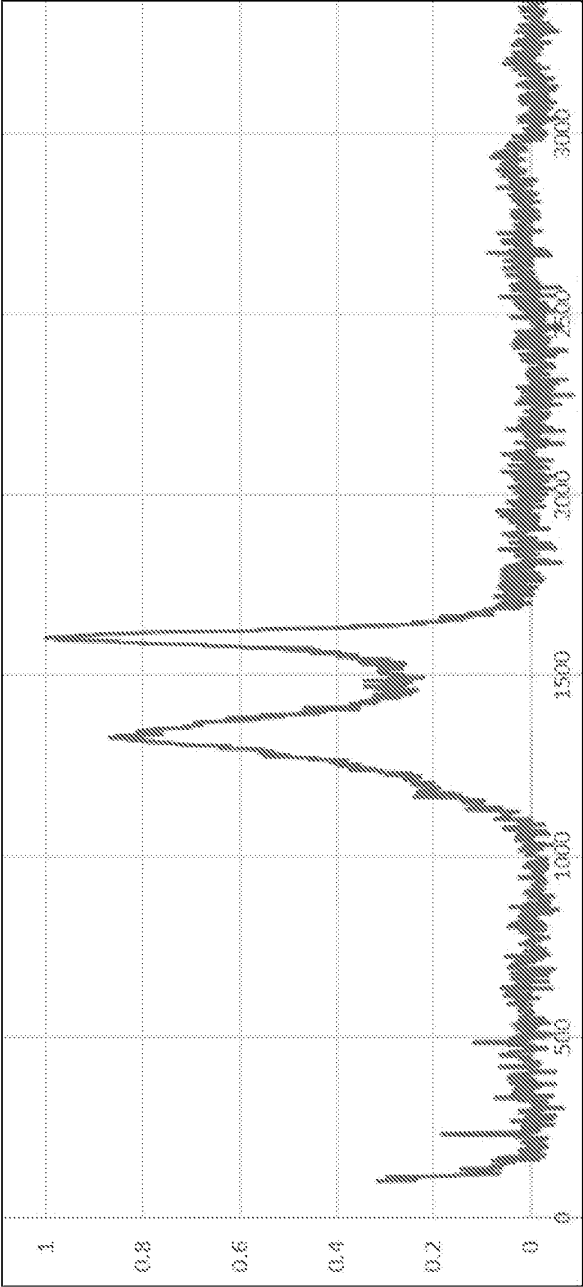


FIG. 192

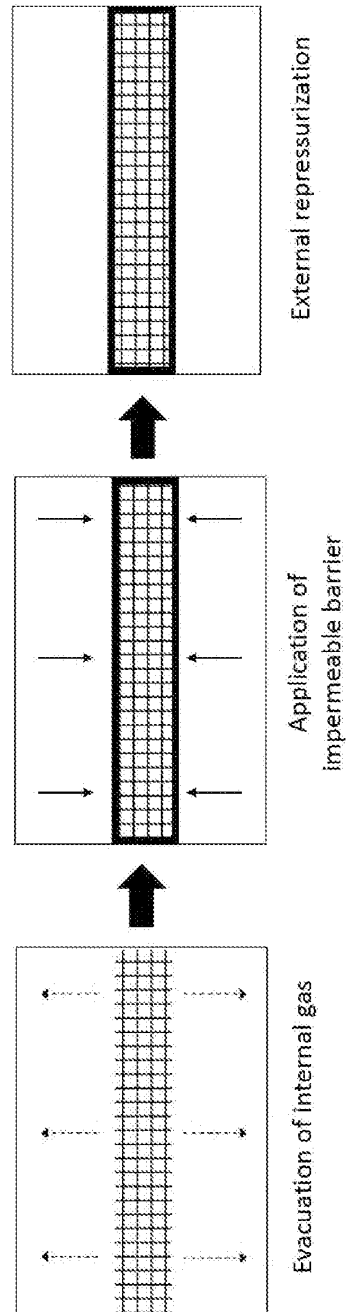
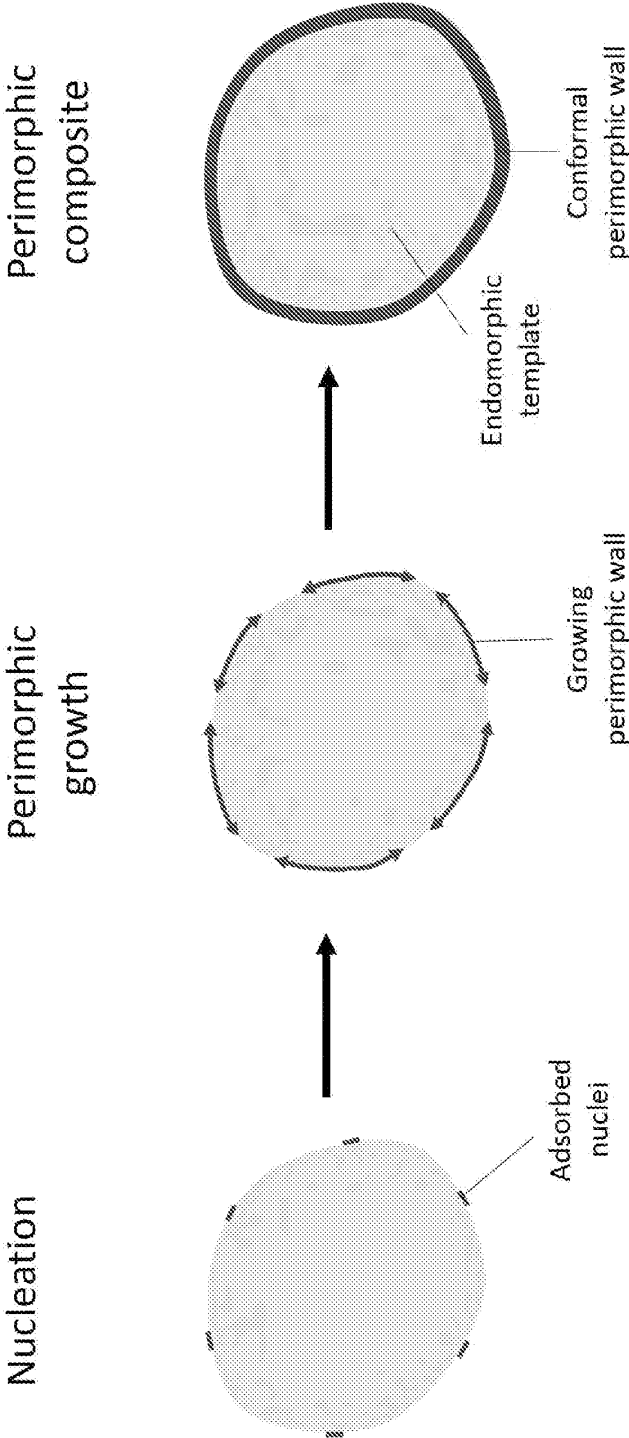




FIG. 193

FIG. 194



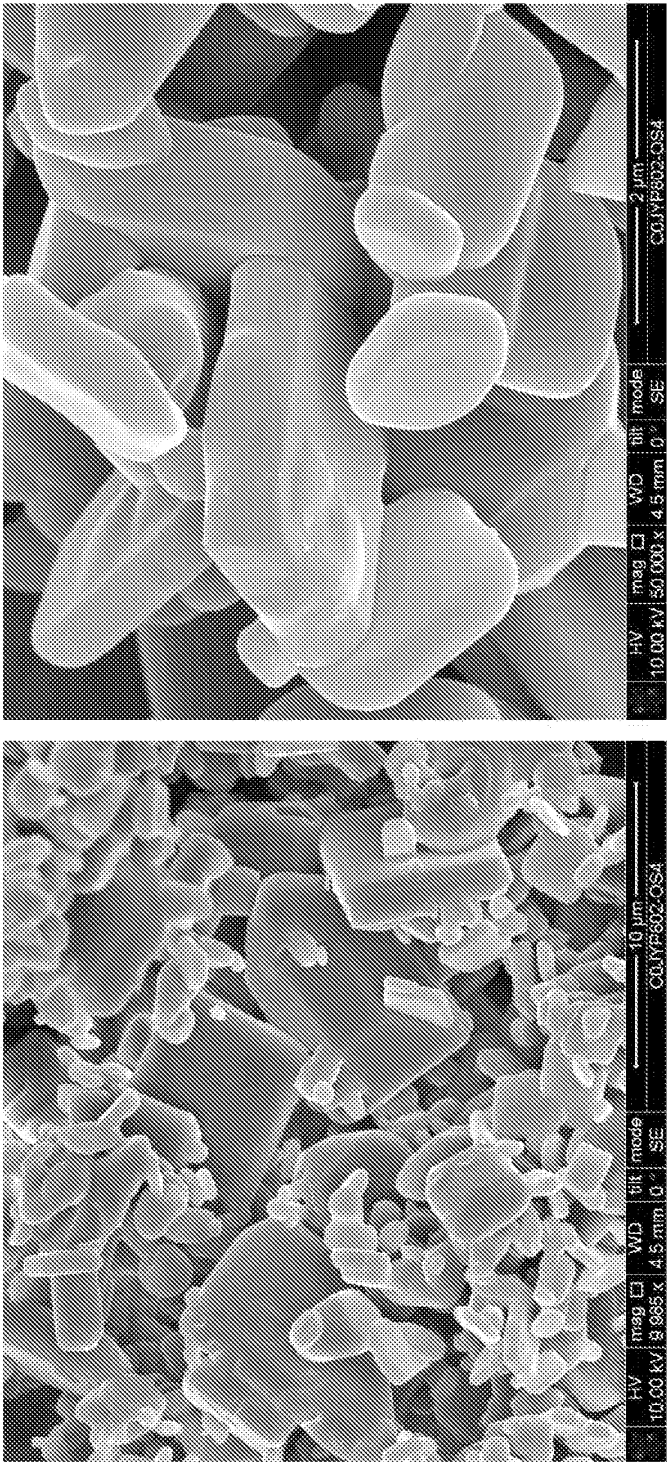
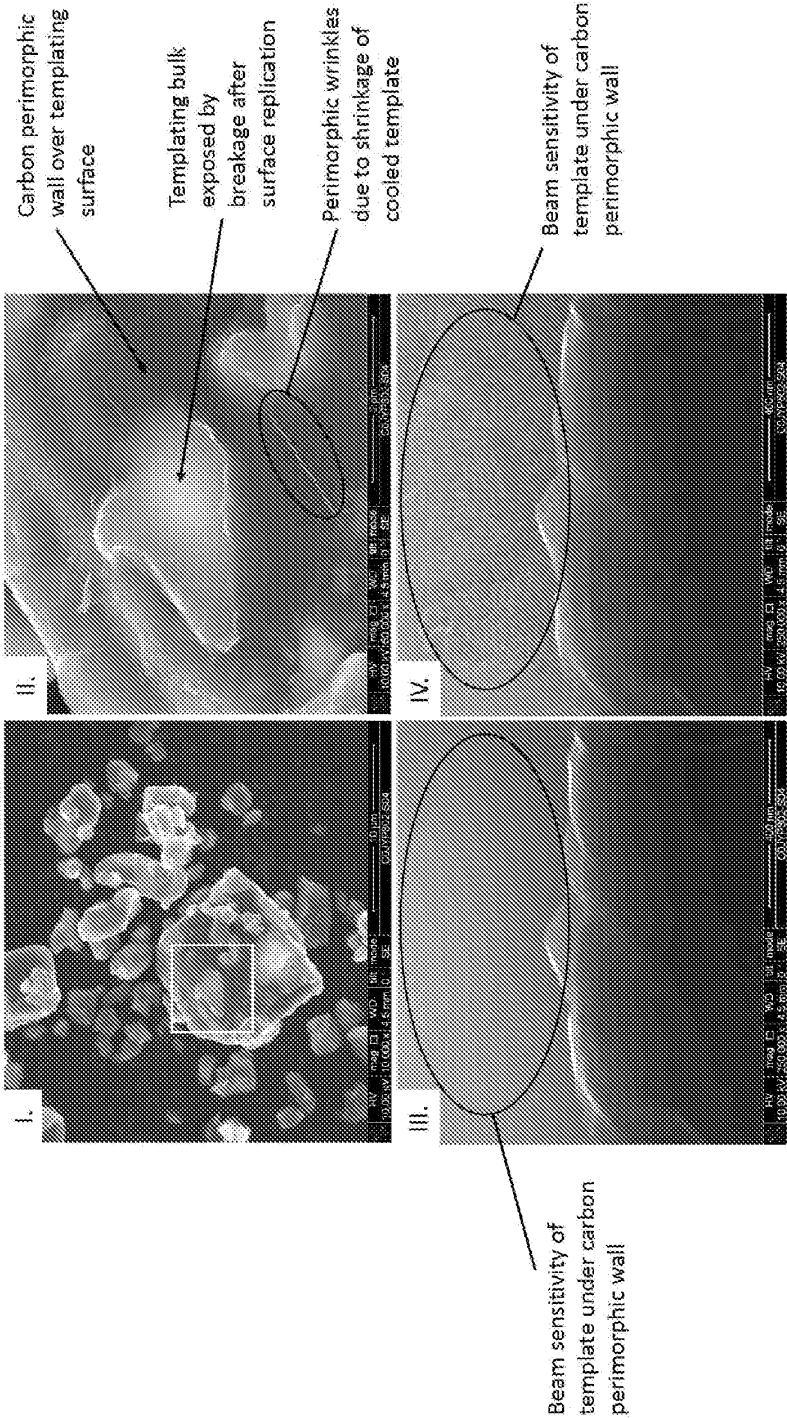


FIG. 195

FIG. 196



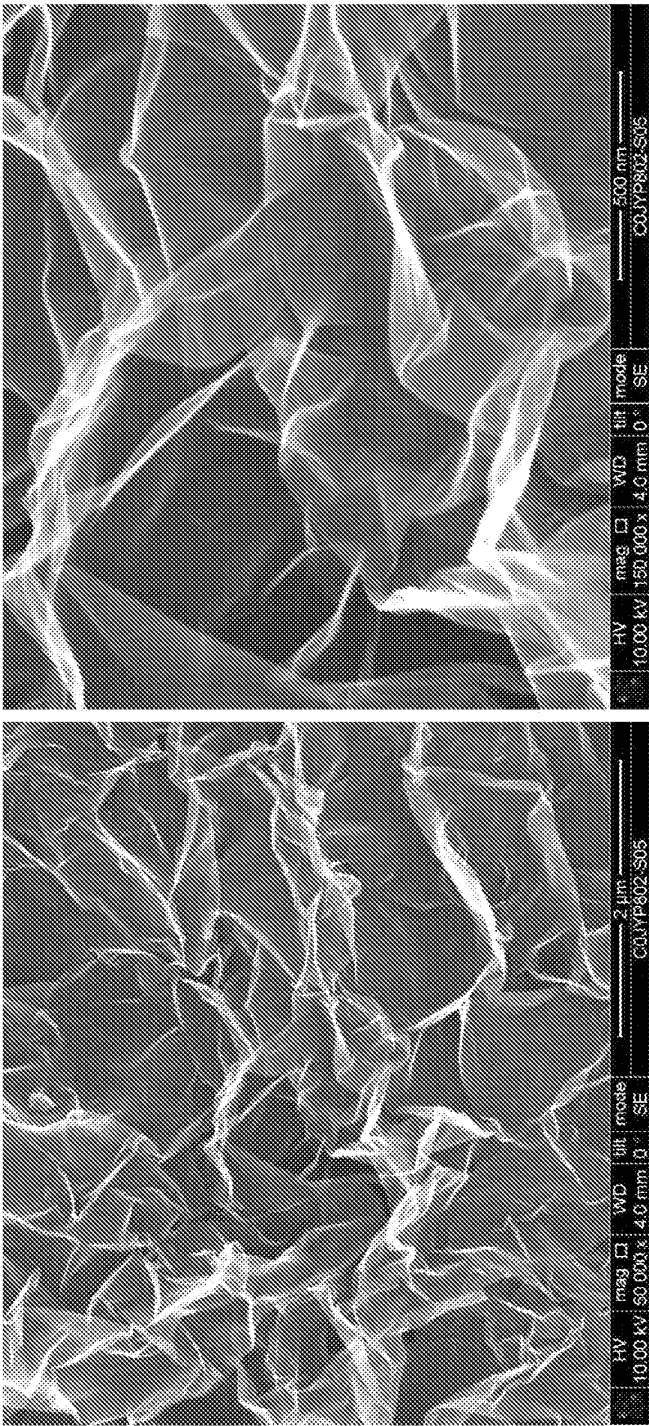


FIG. 197

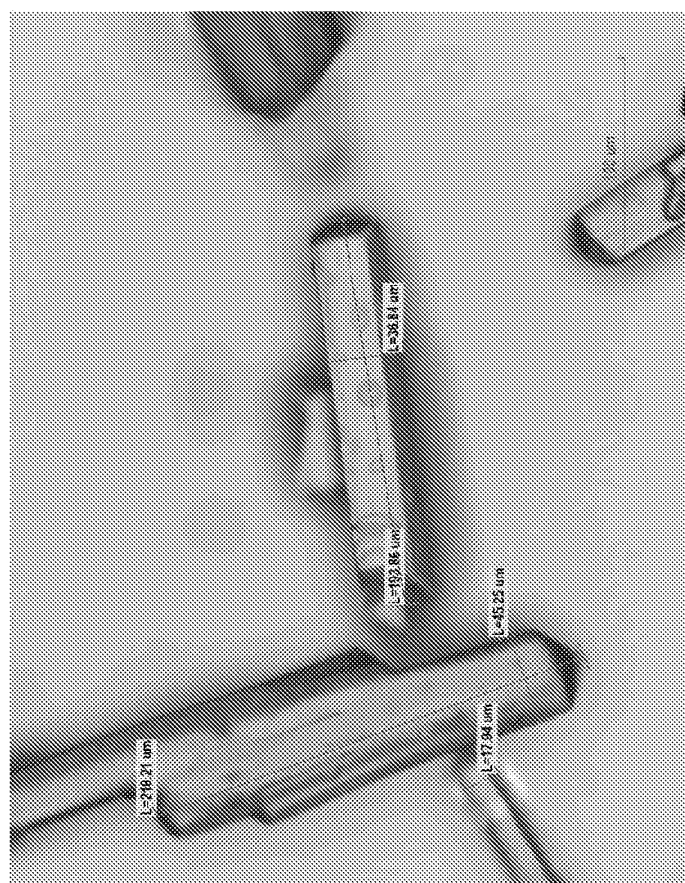
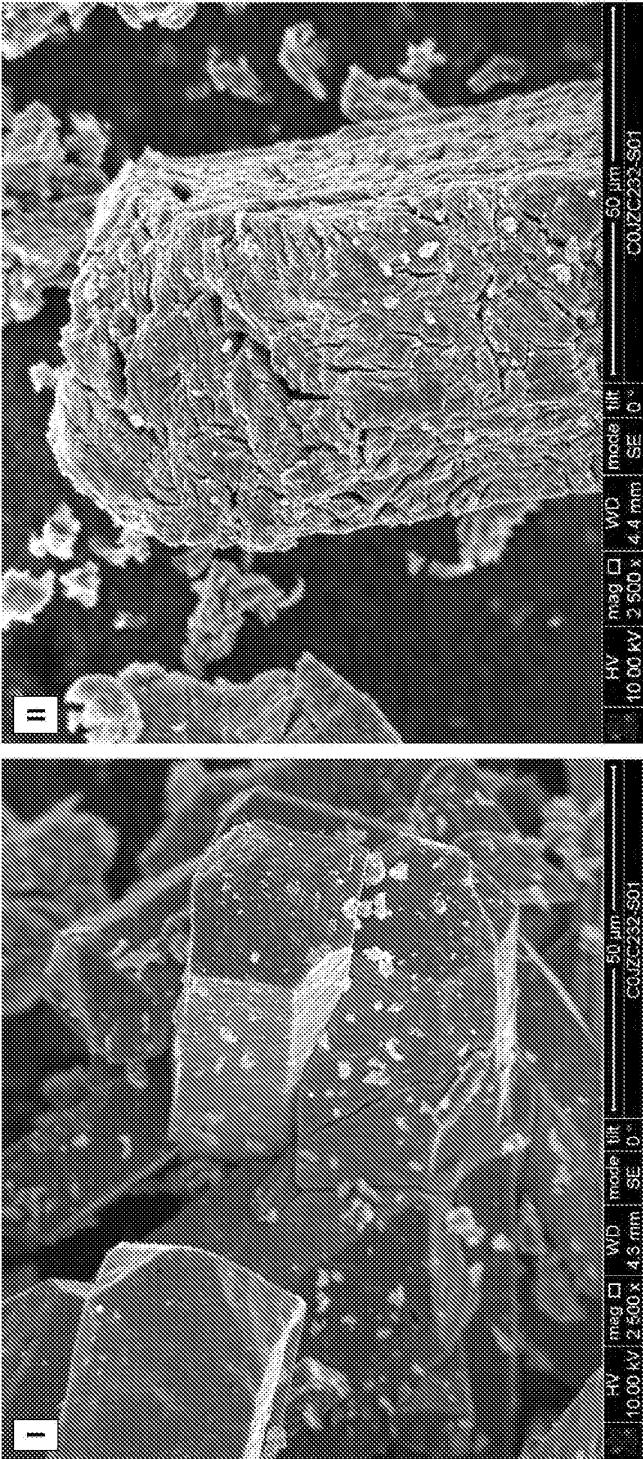


FIG. 198

FIG. 199



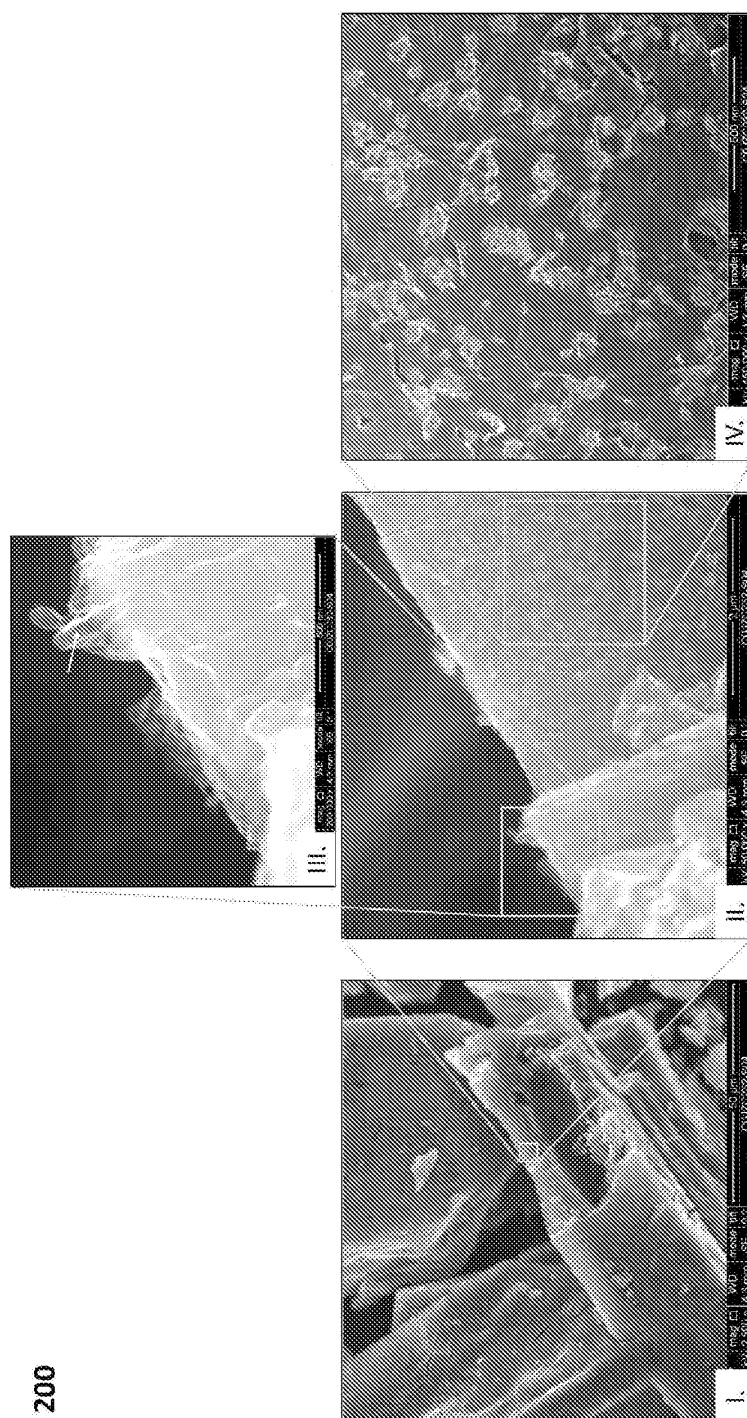


FIG. 200

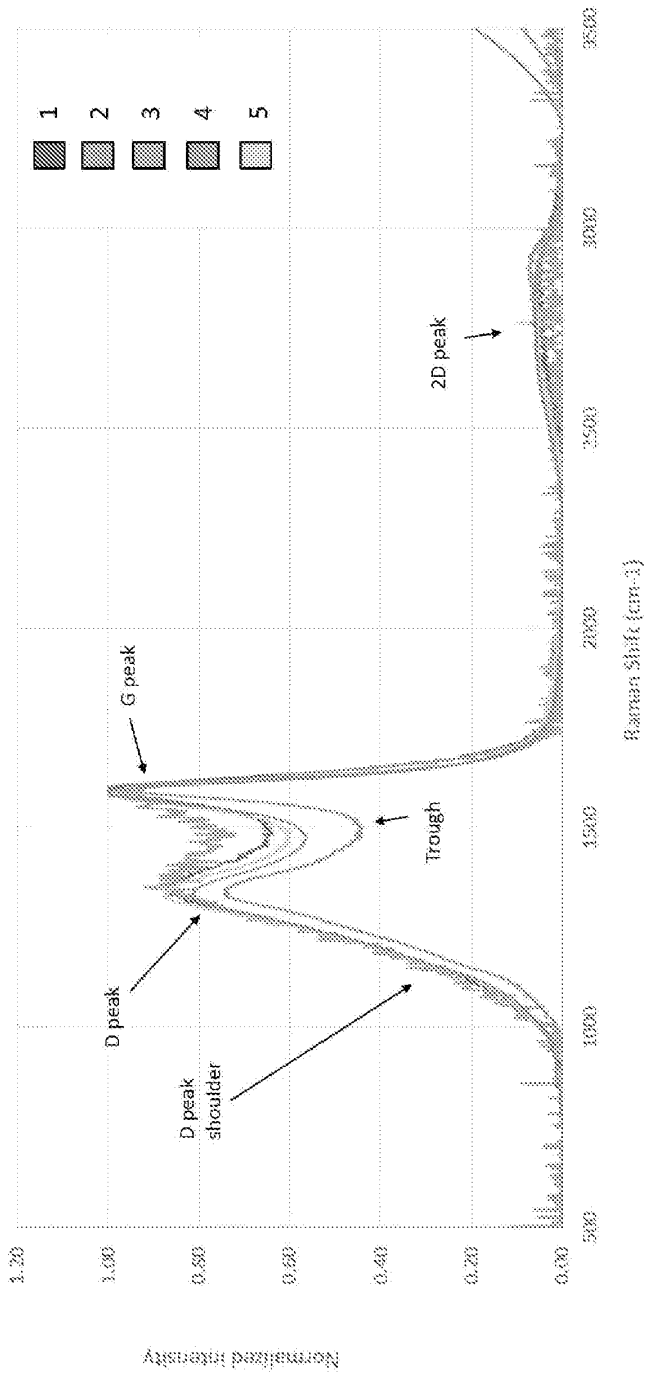
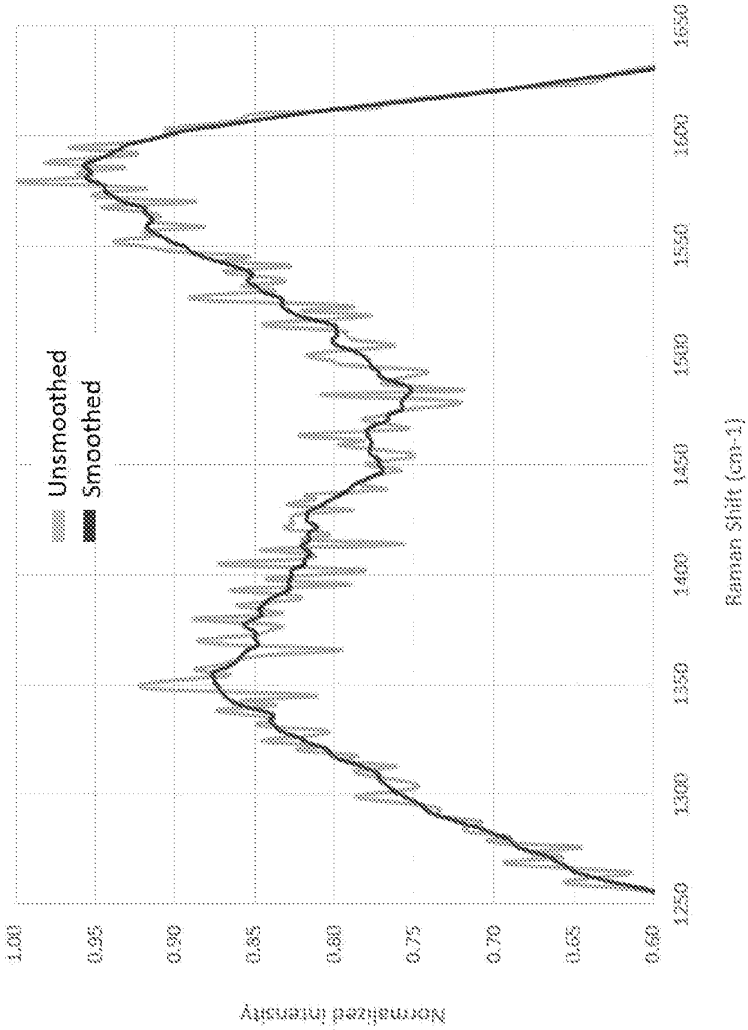


FIG. 201

FIG. 202



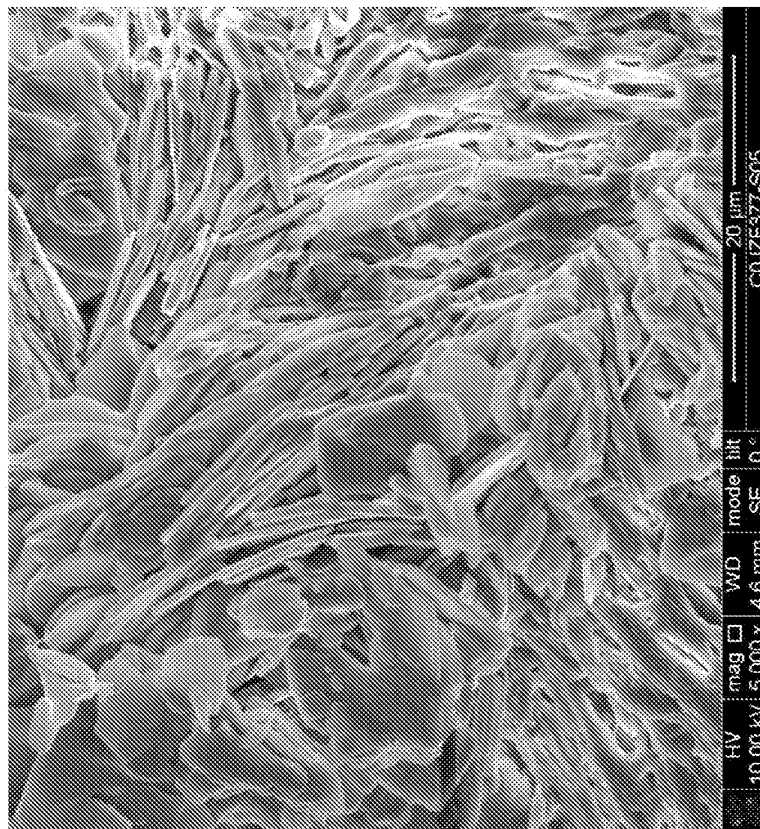


FIG. 203

FIG. 204

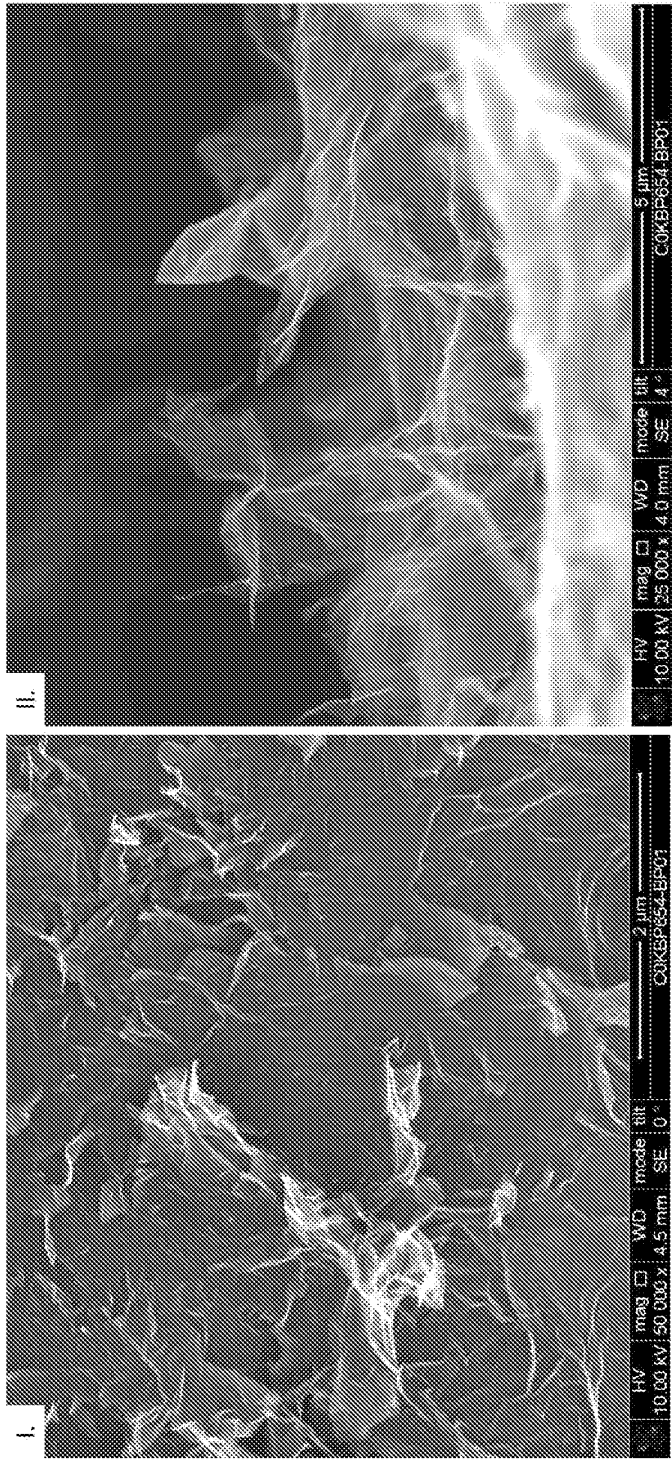


FIG. 205

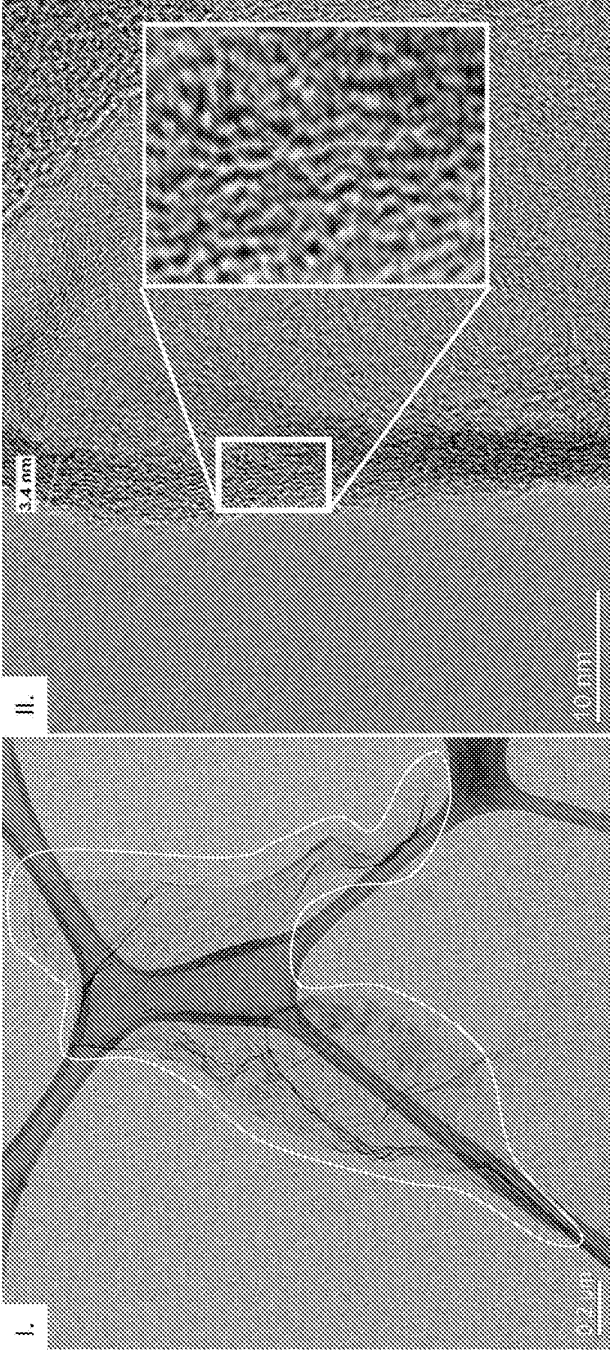


FIG. 206

Template Precursor Material	Template Material	Perimorphic Composite Material	Perimorphic Material
M ₃	M ₃ T ₃	M ₃ T ₃ P ₂₃	P ₂₄ [*]
M ₃	M ₃ T ₃	M ₃ T ₃ P ₂₃	P ₂₅ ^{**}
H ₆	H ₆ T ₁	H ₆ T ₁ P ₇	P ₂₆ ^{***}
H ₆	H ₆ T ₁	H ₆ T ₁ P ₇	P ₂₇ ^{****}
N ₂	N ₂ T ₁	N ₂ T ₁ P ₂₈	P ₂₈
N ₂	N ₂ T ₇	N ₂ T ₇ P ₂₉	P ₂₉
[*] P ₂₄ generated using post-extraction P ₂₃ frameworks			
^{**} P ₂₅ generated using post-extraction P ₂₃ frameworks			
^{***} P ₂₆ generated using post-extraction P ₇ frameworks			
^{****} P ₂₇ generated using post-extraction P ₇ frameworks			

[illegible]

FIG. 207

FIG. 208

	Lansfordite	Nesquehonite	Hydromagnesite	Magnesite
Raman Peak Position [†] (cm ⁻¹)	1083	1116	1094	1100
Theoretical mass loss (%)	76.9	70.9	56.9	52.2

[†] Raman characterization conducted as described in Section III

FIG. 209

Template Material	Template Precursor Material	Na Molality of Solution Stock ^{††} (mol/kg)	Furnace Scheme ^{††}	Treatment Temp. (°C)	BET Surface Area [*] (m ² /g)	BJH Pore Volume [*] (cm ³ /g)	Template Space (%)	Porosity (%)
M ₃ T ₁	M ₃	-	D	1050	24.1	0.169	62.2%	37.8%
M ₄ T ₁	M ₄	2.2·10 ⁻³	D	1050	16.7	0.137	67.1%	32.9%
M ₅ T ₁	M ₅	1.9·10 ⁻¹	D	1050	10.4	0.083	77.1%	22.9%
M ₃ T ₂	M ₃	-	D	900	56.6	0.309	47.5%	52.5%
M ₄ T ₂	M ₄	2.2·10 ⁻³	D	900	52.2	0.299	48.3%	51.7%
M ₅ T ₂	M ₅	1.9·10 ⁻¹	D	900	12.3	0.078	78.2%	21.8%

Notes:

[†] The Na concentration of the brine from which precursor particles were crystallized

[‡] Refer to Section III for description of gas adsorption analysis techniques

^{††} Refer to Section III for description of equipment schemes

FIG. 210

Template Material	Template Precursor Material	Furnace Scheme ^{††}	Treatment Temp. (°C)	Treatment Atmosphere	BET Surface Area [‡] (m ² /g)	BJH Pore Volume [‡] (cm ³ /g)	Template Space (%)	Porosity (%)
N ₂ T ₁	N ₂	A	1000	Ar + H ₂ O(g)	13.3	0.084	76.9%	23.1%
N ₂ T ₂	N ₂	A	1000	Ar	32.7	0.111	71.5%	28.5%

Notes:

[†] Refer to Section III for description of gas adsorption analysis techniques

^{††} Refer to Section III for description of equipment schemes

Template Material	Template Precursor Material	Furnace Scheme	Segment 1				Segment 2				Segment 3				Carrier Gas Type	Flow (sccm)
			Heating rate (°C/min)	Set temp. (°C)	Isotherm duration (min)	Heating rate (°C/min)	Set temp. (°C)	Isotherm duration (min)	Heating rate (°C/min)	Set temp. (°C)	Heating rate (°C/min)	Set temp. (°C)	Isotherm duration (min)	Carrier Gas Type		
N ₁ T ₁	N ₁	E	10	1000	0	-	-	-	-	-	-	-	-	Ar	100	100
N ₁ T ₂	N ₁	E	10	1200	10	-	-	-	-	-	-	-	-	Ar	100	100
N ₁ T ₃	N ₁	B	Max [†]	460	0	-	-	-	-	-	-	-	-	Ar	1271	1271
N ₂ T ₁	N ₂	V	5	450	60	5	500	60	5	1000	60	60	60	Ar + H ₂ O	2360	2360
N ₂ T ₂	N ₂	V	5	450	60	5	500	60	5	1000	60	60	60	Ar	2360	2360
N ₂ T ₃	N ₂	B	5	640	120	-	-	-	-	-	-	-	-	Ar	1271	1271
N ₂ T ₄	N ₂	B	20	640	120	-	-	-	-	-	-	-	-	Ar	1271	1271
N ₂ T ₅	N ₂	B	20	350	0	5	640	120	-	-	-	-	-	Ar	1271	1271
N ₂ T ₆	N ₂	B	5	640	120	-	-	-	-	-	-	-	-	CO ₂	815	815
H ₁ T ₁	H ₁	E	10	1000	0	-	-	-	-	-	-	-	-	Ar	100	100
H ₁ T ₂	H ₁	E	10	1200	10	-	-	-	-	-	-	-	-	Ar	100	100
H ₁ T ₃	H ₁	B	20	1050	120	-	-	-	-	-	-	-	-	Ar	2000	2000
H ₁ T ₄	H ₁	B	20	1050	20	-	-	-	-	-	-	-	-	Ar	2000	2000
H ₁ T ₅	H ₁	B	20	1050	20	-	-	-	-	-	-	-	-	Ar	2000	2000
H ₁ T ₆	H ₁	D	5	750	60	-	-	-	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₁ T ₁	M ₁	E	50	1050	1	-	-	-	-	-	-	-	-	Ar	100	100
M ₁ T ₂	M ₁	B	20	1050	240	-	-	-	-	-	-	-	-	Ar	2000	2000
M ₁ T ₃	M ₁	E	50	1200	1	-	-	-	-	-	-	-	-	Ar	100	100
M ₁ T ₄	M ₁	B	20	1200	240	-	-	-	-	-	-	-	-	Ar	2000	2000
M ₁ T ₅	M ₁	D	5	580	60	5	900	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₁ T ₆	M ₁	D	5	580	60	5	1050	180	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₁	M ₂	D	5	580	60	5	900	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₂	M ₂	D	5	580	60	5	1050	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₃	M ₂	D	5	580	60	5	900	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₄	M ₂	D	5	580	60	5	1050	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₅	M ₂	D	5	580	60	5	900	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
M ₂ T ₆	M ₂	D	5	580	60	5	1050	60	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
L ₂ T ₁	L ₂	B	20	640	120	-	-	-	-	-	-	-	-	Ar	1220	1220
L ₂ T ₂	L ₂	B	20	640	120	-	-	-	-	-	-	-	-	Ar	1220	1220
L ₂ T ₃	L ₂	B	Flash ^{††}	540	30	-	-	-	-	-	-	-	-	CO ₂	815	815
A ₁ T ₁	A ₁	B	20	100	60	20	500	60	20	640	180	180	180	Ar	1271	1271
A ₁ T ₂	A ₁	B	20	200	1	5	500	1	20	900	15	15	15	N ₂	2408	2408
C ₁ T ₁	C ₁	D	5	650	180	-	-	-	-	-	-	-	-	Ar [†]	N/A [†]	N/A [†]
E ₁ T ₁	E ₁	B	Max [†]	580	N/A ^{††}	-	-	-	-	-	-	-	-	Ar	1102	1102
C ₂ T ₁	C ₂	C	Max [†]	1050	N/A ^{††}	-	-	-	-	-	-	-	-	Ar	1102	1102
L ₁ T ₁	L ₁	C	Max [†]	580	N/A ^{††}	-	-	-	-	-	-	-	-	Ar	1271	1271

[†] "Max[†]" denotes that the furnace was heated at the maximum power setting.
^{††} "Flash^{††}" denotes that the sample was introduced into a preheated furnace.
^{†††} The procedure was performed in a forced air recirculation oven with no active gas flow.
^{††††} This segment did not include an isotherm.

FIG. 212

FIG. 213

Peritectic Material	Peritectic Composite Material	Template Material	Furnace Scheme	Primary Replication Stage Procedure - Segment 1						Primary Replication Stage Procedure - Segment 2						Annealing Segment				Secondary Replication Stage Procedure (If Applicable)		
				Heating rate (°C/min)	Set temp. (°C)	Isotherm duration (min)	Reactive Gas	Reactive Gas Flow (sccm)	Carrier Gas	Carrier Gas Flow (sccm)	Heating rate (°C/min)	Set temp. (°C)	Isotherm duration (min)	Reactive Gas	Reactive Gas Flow (sccm)	Carrier Gas	Carrier Gas Flow (sccm)	Heating rate (°C/min)	Set temp. (°C)		Isotherm duration (min)	CR ^{††} Type
P ₁	M ₁ T ₁ P ₁	M ₁ T ₁	A	Max [†]	640	960	C ₂ H ₆	127	CO ₂	1220	-	-	-	-	-	-	-	-	-	-	N/A	
P ₂	M ₁ T ₁ P ₂	M ₁ T ₁	A	Max [‡]	580	2400	C ₂ H ₆	127	CO ₂	1220	-	-	-	-	-	-	-	-	-	-	N/A	
P ₃	M ₁ T ₁ P ₃	M ₁ T ₁	A	Max [‡]	540	1950	C ₂ H ₆	127	CO ₂	1220	-	-	-	-	-	-	-	-	-	-	N/A	
P ₄	H ₁ T ₁ P ₄	H ₁ T ₁	B	Max [‡]	580	60	C ₂ H ₆	276	CO ₂	1220	-	-	-	-	-	-	-	-	-	-	N/A	
P ₅	M ₁ T ₁ P ₅	M ₁ T ₁	B	Max [‡]	1050	150	CH ₄	27	Ar	2000	Max [‡]	1050	90	CH ₄	54	Ar	2000	-	-	-	N/A	
P ₆	N ₁ T ₁ P ₆	N ₁ T ₁	B	N/A ^{†††}	460	180	C ₂ H ₆	42	Ar	1271	-	-	-	-	-	-	-	-	-	-	N/A	
P ₇	H ₁ T ₁ P ₇	H ₁ T ₁	B	Max [‡]	700	30	C ₂ H ₆	1274	Ar	2000	-	-	-	-	-	-	-	-	-	-	N/A	
P ₈	H ₁ T ₁ P ₈	H ₁ T ₁	B	Max [‡]	700	30	C ₂ H ₆	1274	Ar	2000	flash	1050	5	-	Ar	4000	-	-	-	-	N/A	
P ₉	H ₁ T ₁ P ₉	H ₁ T ₁	B	Max [‡]	580	180	C ₂ H ₆	1274	Ar	2000	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₀	H ₁ T ₁ P ₁₀	H ₁ T ₁	B	Max [‡]	580	180	C ₂ H ₆	1274	Ar	2000	Max [‡]	1050	60	-	Ar	4000	-	-	-	-	N/A	
P ₁₁	L ₁ T ₁ P ₁₁	L ₁ T ₁	B	20	540	30	C ₂ H ₆	812	CO ₂	815	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₂	L ₁ T ₁ P ₁₂	L ₁ T ₁	B	20	540	30	C ₂ H ₆	812	CO ₂	815	20	1050	30	-	Ar	2000	-	-	-	-	N/A	
P ₁₃	A ₁ T ₁ P ₁₃	A ₁ T ₁	A	20	580	240	C ₂ H ₆	127	CO ₂	1220	20	580	240	C ₂ H ₆	127	CO ₂	127	max	1050	30	Ar	1271
P ₁₄	A ₁ T ₁ P ₁₄	A ₁ T ₁	A	20	580	240	C ₂ H ₆	127	CO ₂	1220	20	580	240	C ₂ H ₆	127	CO ₂	127	max	1050	30	Ar	1271
P ₁₅	C ₁ T ₁ P ₁₅	C ₁ T ₁	B	Max [‡]	580	180	C ₂ H ₆	127	CO ₂	1220	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₆	E ₁ T ₁ P ₁₆	E ₁ T ₁	B	N/A ^{†††}	580	120	C ₂ H ₆	1147	Ar	1102	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₇	Cu ₁ T ₁ P ₁₇	Cu ₁ T ₁	C	N/A ^{†††}	1050	15	CH ₄	2027	Ar	1102	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₈	Li ₁ T ₁ P ₁₈	Li ₁ T ₁	C	N/A ^{†††}	580	870	C ₂ H ₆	208	Ar	1271	-	-	-	-	-	-	-	-	-	-	N/A	
P ₁₉	M ₁ T ₁ P ₁₉	M ₁ T ₁	B	Max [‡]	640	180	C ₂ H ₆	255	CO ₂	1220	Max [‡]	1050	30	-	Ar	2000	-	-	-	-	N/A	
P ₂₀	M ₁ T ₁ P ₂₀	M ₁ T ₁	B	Max [‡]	640	180	C ₂ H ₆	255	CO ₂	1220	Max [‡]	1050	30	-	Ar	2000	-	-	-	-	N/A	
P ₂₁	N ₁ T ₁ P ₂₁	N ₁ T ₁	A	20	540	8	C ₂ H ₆	815	CO ₂	812	20	540	8	C ₂ H ₆	815	CO ₂	812	max	1050	30	Ar	1271
P ₂₂	N ₁ T ₁ P ₂₂	N ₁ T ₁	B	20	540	4.5	C ₂ H ₆	815	CO ₂	812	-	-	-	-	-	-	-	-	-	-	N/A	
P ₂₃	M ₁ T ₁ P ₂₃	M ₁ T ₁	A	20	580	1800	C ₂ H ₆	127	CO ₂	1220	Max [‡]	1050	30	-	Ar	2000	-	-	-	-	N/A	

Notes:

The Replication Stage procedure occurred directly upon completion of the Template Stage procedure and at the same temperature. Therefore, the furnace was already at temperature and did not require heating.

[†] "Max[†]" denotes that the furnace was heated at the maximum power setting.

^{††} "Flash" denotes that the sample was introduced into a preheated furnace.

Notes:
^{†††} The Replication Stage procedure occurred directly upon completion of the Template Stage procedure and at the same temperature. Therefore, the furnace was already at temperature and did not require heating.
[†] "Max" denotes that the furnace was heated at the maximum power setting.
[‡] "Flash" denotes that the sample was introduced into a preheated furnace.

FIG. 214

Perimorphic Material	Replication Stage			Yield (%)	Raman laser power (mW)	I_D/I_G^{++}	I_D/I_G^{+++}	G Peak Position* (cm ⁻¹)	D Peak Position* (cm ⁻¹)	Interpeak Interval** (cm ⁻¹)
	CVD Temp. (°C)	Total Growth Time (min)	HC Type							
P ₁	640	960	C ₂ H ₆	18.3%	5.0	0.92	0.46	1592.0	1337.4	254.6
P ₂	580	2400	C ₂ H ₆	17.1%	5.0	0.86	0.43	1593.0	1330.7	262.3
P ₃	540	1950	C ₂ H ₆	15.8%	5.0	0.80	0.38	1596.6	1328.6	268.0
P ₄	580	60	C ₂ H ₂	19.0%	0.5	0.89	0.29	1603.3	1324.5	278.8
P ₅	1050	240	CH ₄	21.6%	5.0	1.29	0.17	1580.6	1337.4	243.2
P ₆	460	180	C ₂ H ₂	29.9%	0.5	0.80	0.32	1601.6	1332.7	268.9
P ₇	700	30	C ₂ H ₆	9.7%	5.0	0.88	0.55	1593.6	1334.3	259.3
P ₈	700, 1050 ‡	30, 5 ‡	C ₂ H ₆	9.7%	5.0	0.83	0.64	1590.7	1350.9	239.8
P ₉	580	180	C ₂ H ₆	7.7%	5.0	0.97	0.52	1592.7	1328.5	264.2
P ₁₀	580, 1050 ‡	180, 60 ‡	C ₂ H ₆	8.4%	5.0	0.99	0.63	1592.7	1346.8	245.9
P ₁₁	540	30	C ₂ H ₂	28.4%	0.5	0.85	0.25	1609.1	1331.8	277.3
P ₁₂	540, 1050 ‡	30, 30 ‡	C ₂ H ₂	9.2%	0.5	0.99	0.49	1603.0	1352.8	250.2
P ₁₃	580	480	C ₂ H ₆	19.3%	5.0	0.80	0.42	1593.6	1327.5	266.1
P ₁₄	580, 1050 ‡	480, 30 ‡	C ₂ H ₆	-	5.0	0.99	0.58	1593.0	1349.8	243.2
P ₁₅	580	180	C ₂ H ₆	11.8%	0.5	0.78	0.40	1605.4	1343.3	262.1
P ₁₆	580	120	C ₂ H ₆	5.7%	2.0	0.88	0.57	1584.3	1336.0	248.3
P ₁₇	1050	15	CH ₄	7.5%	2.0	1.24	0.45	1592.5	1340.6	251.9
P ₁₈	580	870	C ₂ H ₆	1.9%	0.5	0.80	0.35	1602.1	1341.0	261.2
P ₁₉	640, 1050 ‡	180	C ₂ H ₆	8.0%	2.0	0.96	0.47	1591.3	1367.4	223.9
P ₂₀	640, 1050 ‡	180	C ₂ H ₆	3.8%	0.5	0.94	0.64	1591.8	1360.0	231.8
P ₂₁	540, 1050 ‡	16	C ₂ H ₂	1.9%	2.0	0.99	0.57	1598.3	1353.6	244.7
P ₂₂	540	4.5	C ₂ H ₂	9.8%	2.0	0.93	0.53	1597.8	1324.9	272.9
P ₂₃	580, 1050 ‡	1800	C ₂ H ₆	14.4%	5.0	1.01	0.54	1589.5	1347.0	242.5

Notes:

† Hydrocarbon gas

†† I_D/I_G is a Raman metric indicating a ratio of I_D to I_G peak height††† I_D/I_G is a Raman metric indicating a ratio of I_D to I_G peak height

* Raman peak position of the D and G bands

** Defined as the spread between the G Peak position and the D Peak position

‡ The Replication Stage procedures utilized to make these exemplary perimorphic materials involved a growth segment and an annealing segment hence there are two temperatures and times associated with these perimorphic materials.

FIG. 215

Minimally grafted z-sp ^x carbon			
Spectral positions	Avg.	Pt.	
1342 cm ⁻¹ < D ₀	✓	✓	
D ₀ < 1342 cm ⁻¹	x	x	
1342 cm ⁻¹ > D ₀	✓	✓	

Partially grafted z-sp ^x carbon			
Spectral positions	Avg.	Pt.	
1342 cm ⁻¹ < D ₀	x	x	
1332 cm ⁻¹ < D ₀ < 1342 cm ⁻¹	✓	✓	
1332 cm ⁻¹ > D ₀	x	x	
or			
1342 cm ⁻¹ < D ₀	✓	✓	
1332 cm ⁻¹ < D ₀ < 1342 cm ⁻¹	x	✓	
1332 cm ⁻¹ > D ₀	x	x	

Highly grafted x-sp ^x carbon			
Spectral positions	Avg.	Pt.	
1332 cm ⁻¹ < D ₀	x	x	
1332 cm ⁻¹ > D ₀	✓	✓	
or			
1332 cm ⁻¹ > D ₀	✓	✓	
1332 cm ⁻¹ < D ₀	x	✓	

FIG. 216

Peak Angle (°)	d(Å)	Height	Area (a1)	Area (a1)%	FWHM(°)
20.995	4.2280	288.4	1519.1	32.0	4.865
25.044	3.5527	810.5	4748.2	100.0	5.237
30.401	2.9378	417.4	3792.4	79.9	8.304
43.282	2.0887	133.5	2168.3	45.7	8.503

FIG. 217

Peak Angle (°)	d(Å)	Height	Area(aI)	Area(aI)%	FWHM(°)
22.9703	3.86861	1547.6	11733.5	13	7.123
25.8319	3.44618	31354.2	90198.4	100	2.042
31.2063	2.86384	420.4	4622.9	5.1	10.333
42.6906	2.11627	2129.6	2995.2	3.3	1.073

FIG. 218

Sample	CVD Temp	Carbon Source	Laser power (mW)	I_{D_u}/I_{G_u}	I_{Tr_u}/I_{G_u}	G_u Peak Pos.	D_u Peak Pos.	Interpeak Interval
B1	640°C	C ₃ H ₆	5	0.92	0.46	1592.0	1337.4	254.6
B2	580°C	C ₃ H ₆	5	0.86	0.43	1593.0	1330.7	262.3
B3	540°C	C ₃ H ₆	5	0.80	0.38	1596.6	1328.6	268.0
B4	580°C	C ₂ H ₂	0.5	0.89	0.29	1603.3	1324.5*	278.8

*Recurring point spectra were found between 1318 cm⁻¹ and 1320 cm⁻¹

FIG. 219

#	Angle(°)	d(Å)	Height	Area(α1)	Area(α1)%	FWHM(°)
1	18.454	4.8041	1197.9	13842.4	30.4	10.835
2	24.489	3.6321	5357.7	45491	100	7.088
3	43.138	2.0954	971.8	8585.4	18.9	6.115
4	46.927	1.9346	206.5	1258	2.8	5.695
5	50.192	1.8162	52.1	199.2	0.4	3.583
6	53.208	1.7201	174.3	1755.3	3.9	6.699
7	59.671	1.5483	213.9	5712.9	12.6	23.714
8	79.501	1.2046	207.4	2196.6	4.8	9.257

FIG. 220

Sample	CVD Temp	Carbon Source	I_{u-D}/I_{u-G}	I_{u-Tr}/I_{u-G}	u-G Peak Pos.	u-D Peak Pos.	Interpeak Interval
C1	460°C	C ₂ H ₂	0.80	0.32	1601.6	1332.7	268.9
C2	400°C	C ₂ H ₂	0.92	0.41	1597.5	1358.0	239.5

FIG. 221

Sample	H ₂ flow	C ₃ H ₆ flow	Ar flow	D _u peak position	Yield (%)
D1	0 sccm	20 sccm	1270 sccm	1341.9 cm ⁻¹	8.2%
D2	60 sccm	20 sccm	1186 sccm	1329.5 cm ⁻¹	4.2%

FIG. 222

Sample	I_{D_u}/I_{G_u}	$I_{T_{r_u}}/I_{G_u}$	G_u Peak Pos.	D_u Peak Pos.	Interpeak Interval
E1	0.88	0.54	1594	1335	259
E2	0.83	0.52	1593	1328	265
E1A	0.97	0.64	1592	1352	240
E2A	0.99	0.63	1594	1347	247

FIG. 223

#	Angle(°)	d(Å)	Height	Area(α1)	Area(α1)%	FWHM(°)
1	21.660	4.0997	472	134.6	0.3	0.267
2	23.535	3.7771	5329.3	51104.9	100	8.653
3	29.489	3.0266	1136.7	16961.9	33.2	13.963
4	35.944	2.4965	83.5	30.8	0.1	0.336
5	43.396	2.0835	1187.5	6574.5	12.9	4.965
6	48.065	1.8914	524	6632.7	13.0	10.788
7	61.044	1.5167	518.5	12423.7	24.3	22.455
8	79.639	1.2029	306.3	3136.1	6.1	8.942

FIG. 224

Sample ID	Step 1	Step 2	BET Surface Area (m ² /g)	BJH Desorption Pore Volume (cm ³ /g)
F1	-	-	599	0.289
F2	Pressing	-	451	0.079
F3	Pressing	Annealing	233	0.028
F4	Annealing	Pressing	473	0.248

FIG. 225

Sample	D _u peak position	G _u peak position	I _{D_u} /I _{G_u}	I _{Tr_u} /I _{G_u}	I _{2D} /I _G	Interpeak Interval
F5	1352	1596	0.88	0.68	< 0.10	243.0
F6	1347	1586	1.00	0.49	0.40	239.0

FIG. 226

Angle(°)	d(Å)	Height	Area(α1)	Area(α1)%	FWHM(°)
21.893	4.0564	1156.9	8881.5	23.8	7.099
24.829	3.5831	6361.6	37281.2	100	4.84
42.745	2.1137	588.5	2280.1	6.1	1.309
43.364	2.085	799.3	4237	11.4	4.96
48.239	1.885	373.6	3065.9	8.2	7.679
53.927	1.6989	180.5	1686.9	4.5	7.721
61.288	1.5113	194.5	4096.7	11	19.621
62.16	1.4921	141.9	198.1	0.5	0.995

FIG. 227

Experiment	Precursor Type	Melting point	Mass Solute (g)	DI H ₂ O (g)	Solvent	Solvent Mass (g)
1	Potassium Sulfate	1069°C	9.94	100	Isopropanol	101
2	Potassium Sulfate	1069°C	50.015	500	Isopropanol	500
3	Potassium Carbonate	891°C	150.004	150	Isopropanol	667
4	Lithium Sulfate	859°C	51.000	150	Acetone	604
5	Magnesium Sulfate	1124°C	100.06	100	Acetone	411

FIG. 228

Experiment	Chemical Formula	Initial Mass (g)	Final Mass (g)	CVD Temp. (°C)	Time (min)	Gas 1	Flow (sccm)	Gas 2	Flow (sccm)
1	K ₂ SO ₄	3.9396	-	650	30	C ₃ H ₆	1270	Ar	1100
2	K ₂ SO ₄	2.1639	2.1565	580	120	C ₃ H ₆	1150	Ar	1100
3	K ₂ CO ₃	7.4404	6.5665	580	120	C ₃ H ₆	1150	Ar	1100
4	Li ₂ SO ₄	3.0589	3.0088	580	120	C ₃ H ₆	1150	Ar	1100
5	MgSO ₄	3.4571	2.6162	580	120	C ₃ H ₆	1150	Ar	1100

FIG. 229

Experiment No.	I _D /I _G	I _T /I _G	I _D /I _G	D peak pos. (cm ⁻¹)	G peak pos. (cm ⁻¹)
1	0.87	0.64	0.06	1336	1594
2	0.75	0.44	0.07	1331	1601
3	0.92*	0.79*	0.03*	1354*	1587*
4	0.82	0.56	0.07	1331	1585
5	0.88	0.60	0.10	1328	1583
* Derived from smoothed, average spectrum					