

1/144

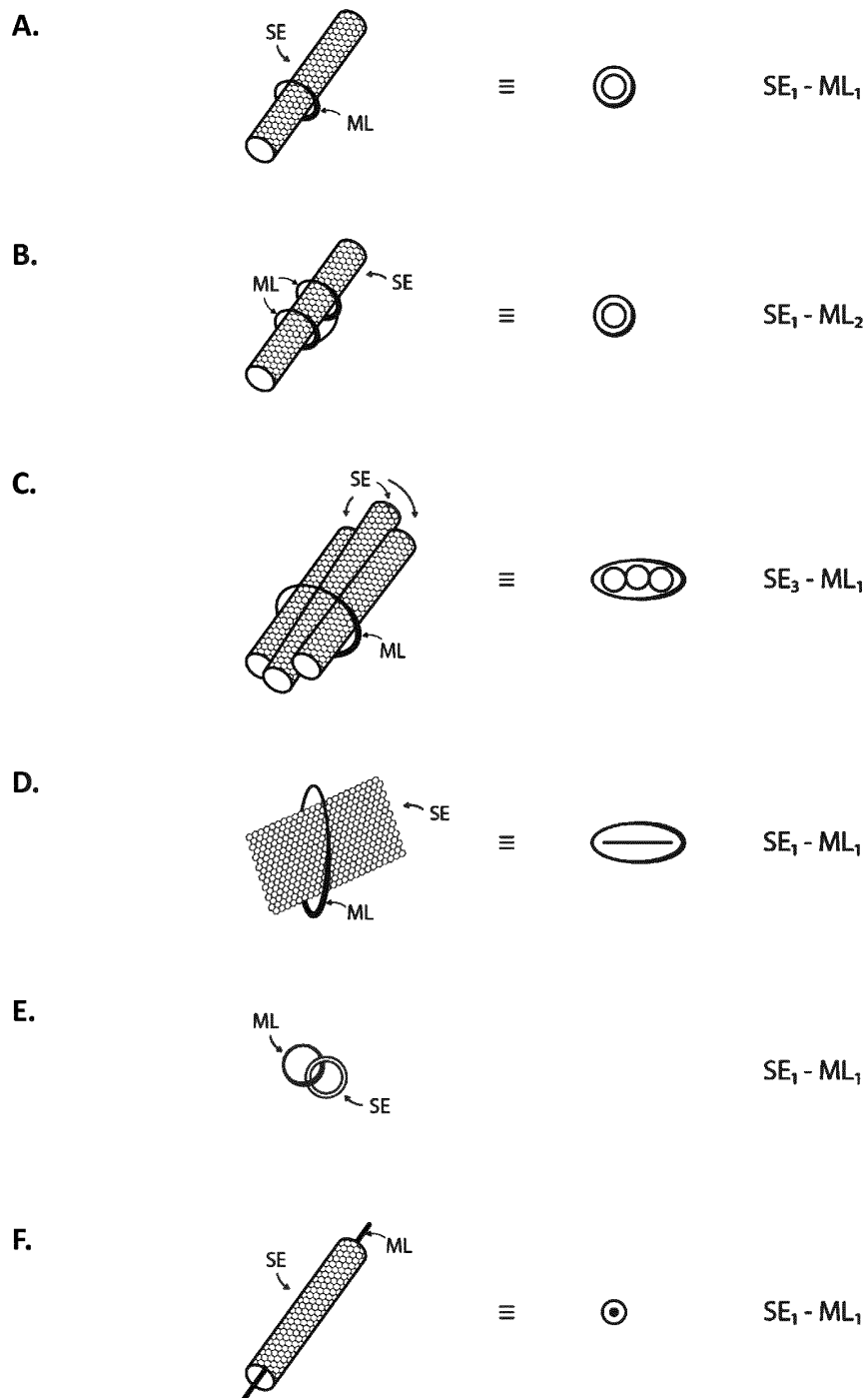
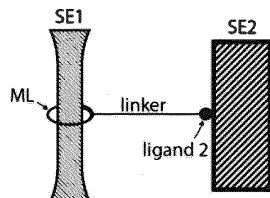


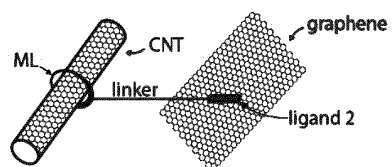
Fig. 1

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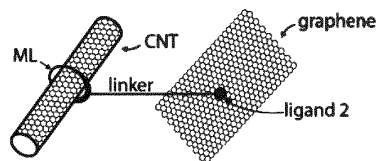
A.



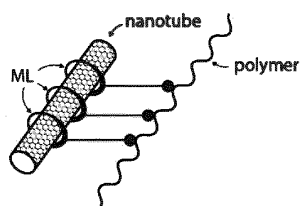
B.



C.



D.



E.

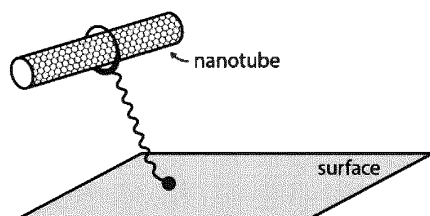


Fig. 2

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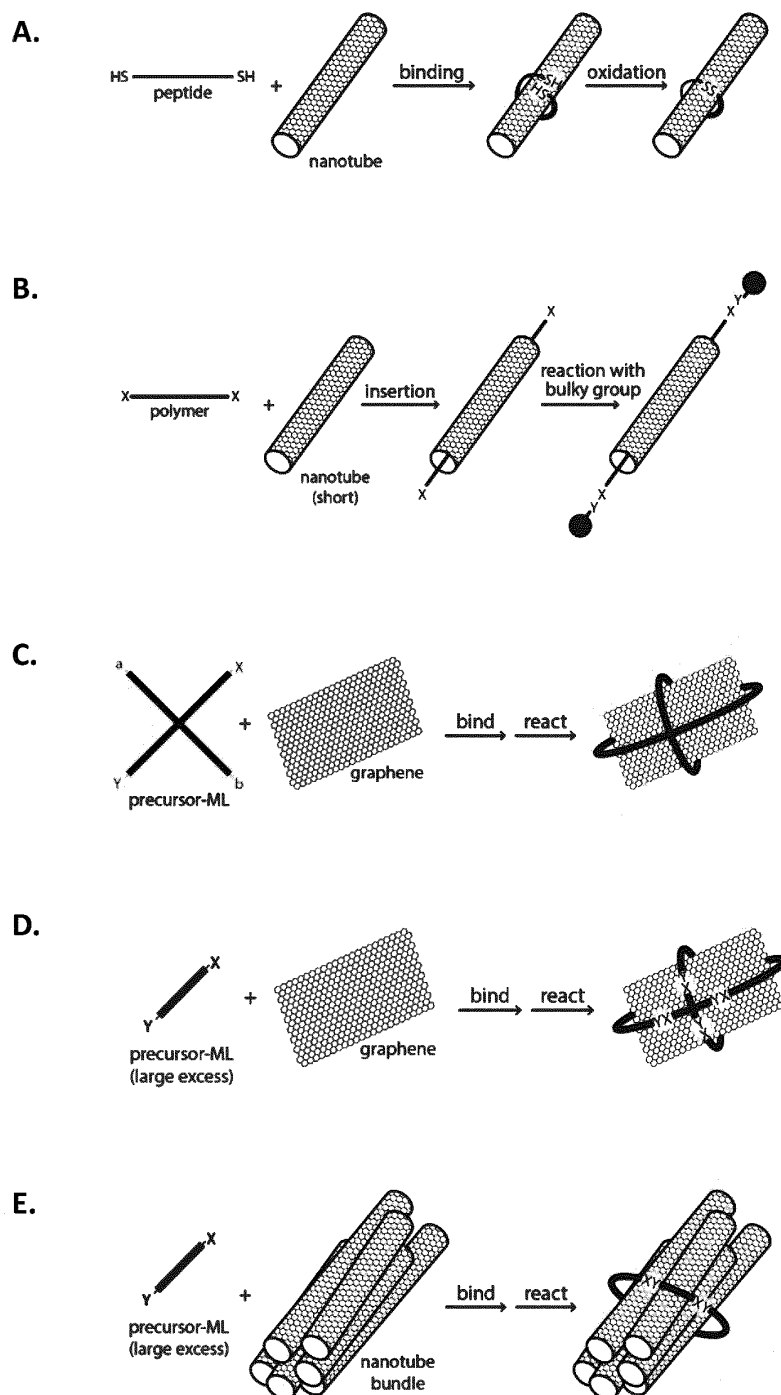


Fig. 3

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ROMP synthesis of 'Poly[N-(4-Tosylatebutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A1, synthesized in example A1).

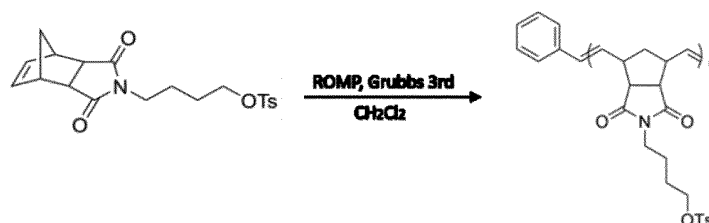


Fig. 4

¹H NMR of 'Poly[N-(4-Tosylatebutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A1, synthesized in example A1).

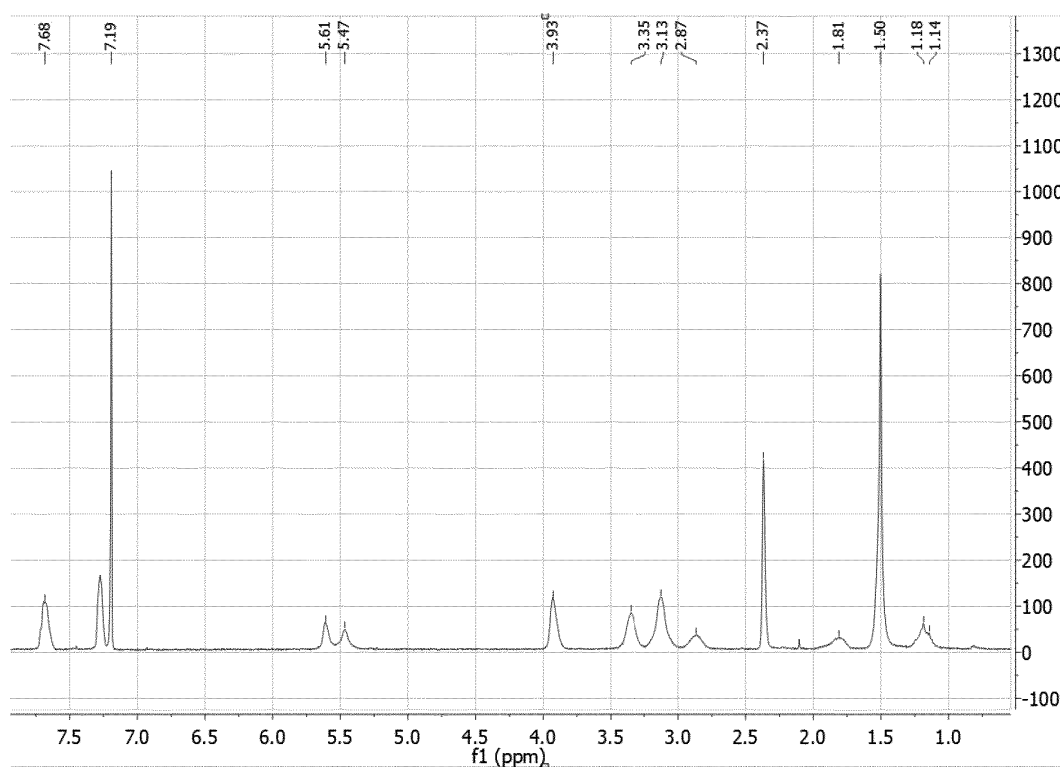


Fig. 5

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Synthesis of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A2, synthesized in example A3).

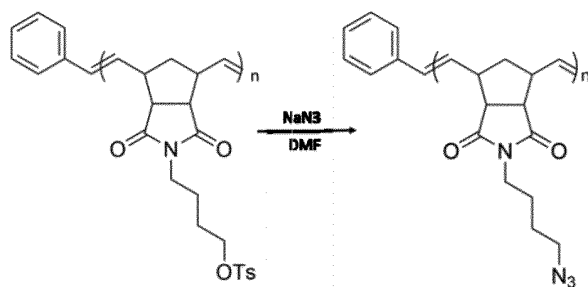


Fig. 6

¹H NMR of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A2, synthesized in example A3).

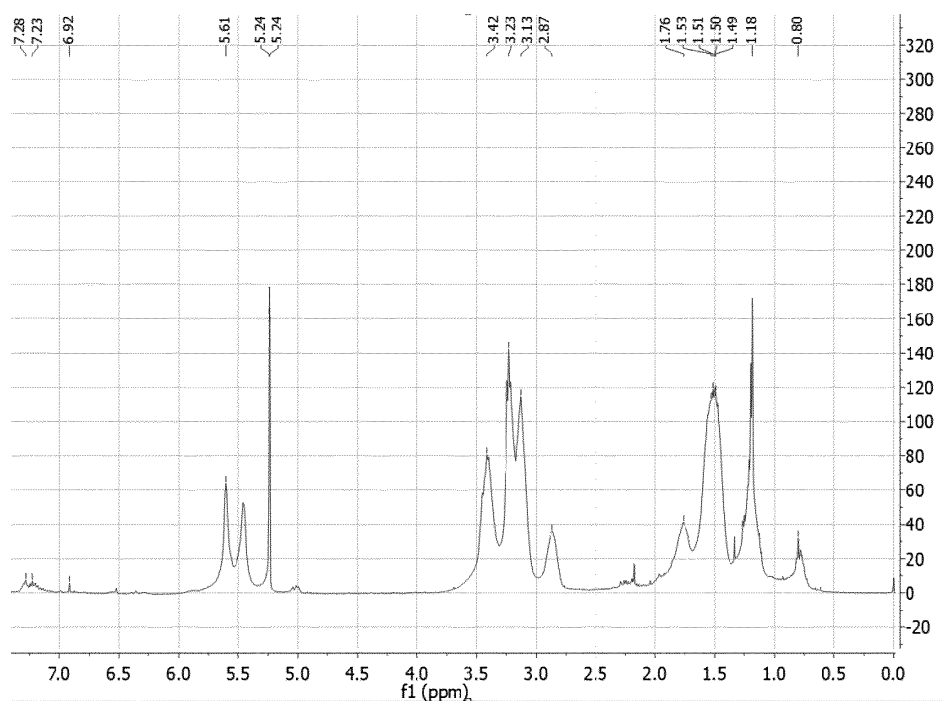


Fig. 7a

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FT-IR spectrum of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A2, synthesized in example A3).

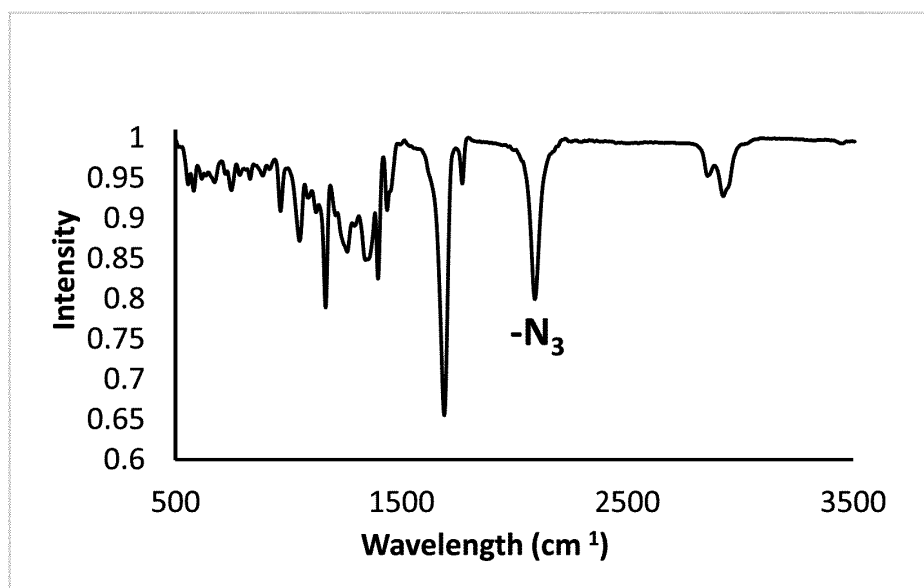


Fig. 7b

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End-group (1H NMR) analysis of 'Poly[N-(4-azidobutyl)]-cis-5-norborneneexo-2,3-dicarboximide' (compound A2, synthesized in example A3).

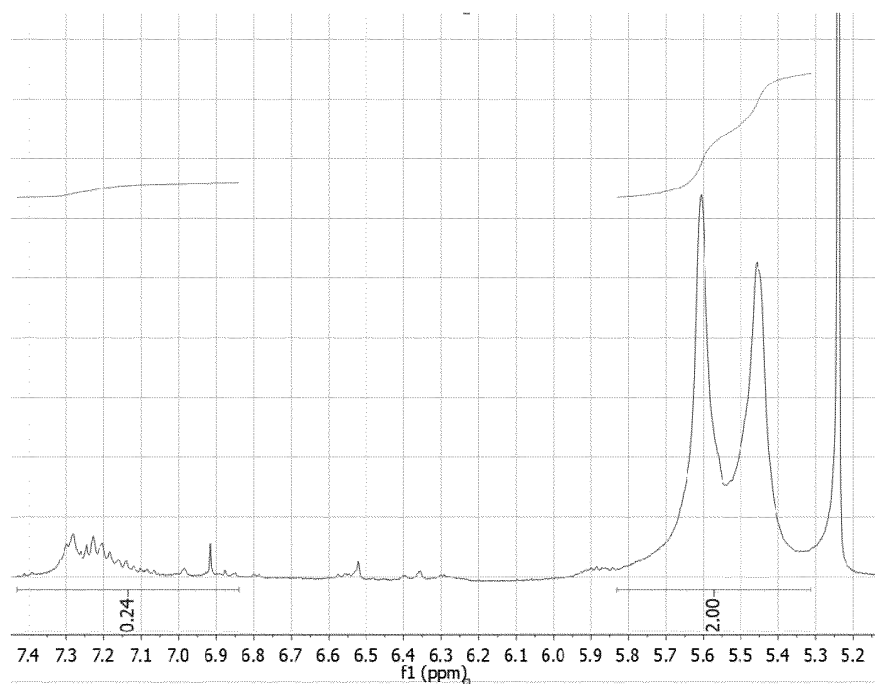


Fig. 8

Synthesis of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl)]-cis-5-norborneneexo-2,3-dicarboximide' (compound A3, synthesized in example A6).

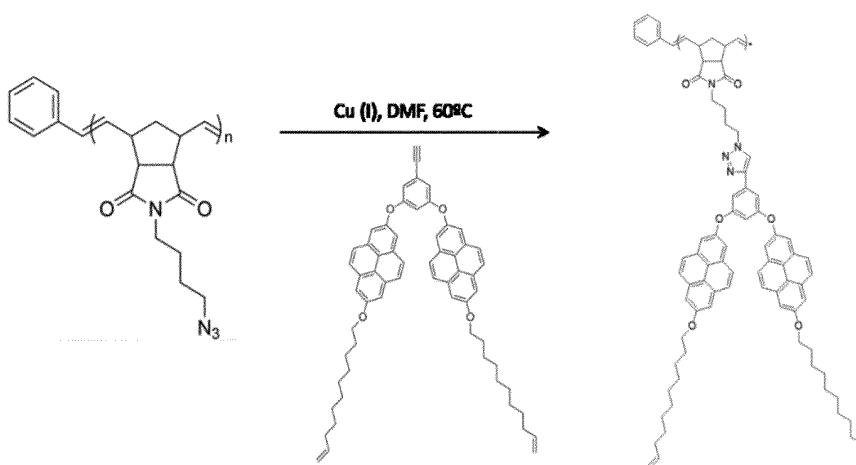


Fig. 9

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Comparative Infrared Spectra. Black: Pyrene_Ushape terminal alkyne, blue: 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A2, synthesized in example A3) and red: 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, synthesized in example A6).

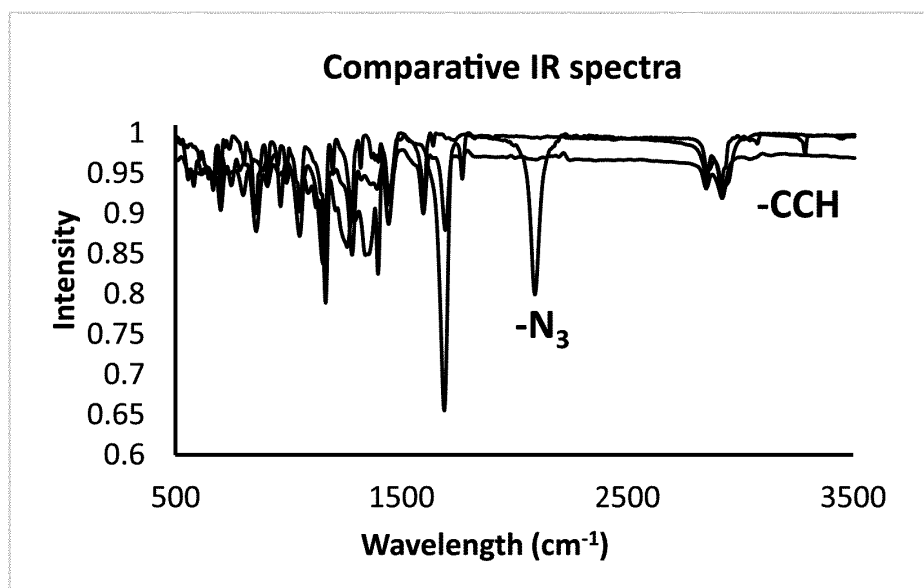


Fig. 10

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¹H NMR of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, synthesized in example A6).

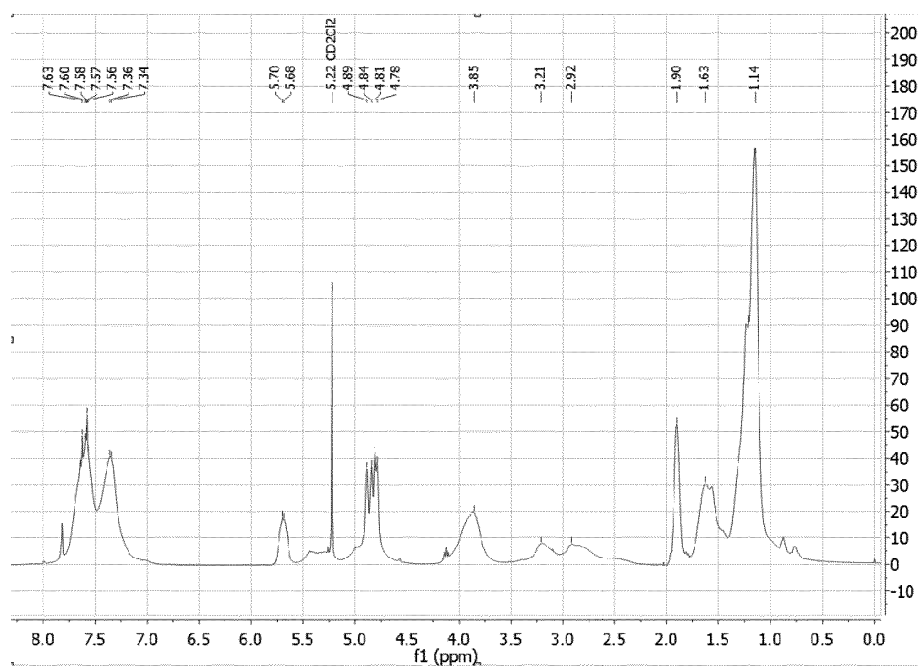


Fig. 11a

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UV-Vis. spectrum of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, synthesized in example A6).

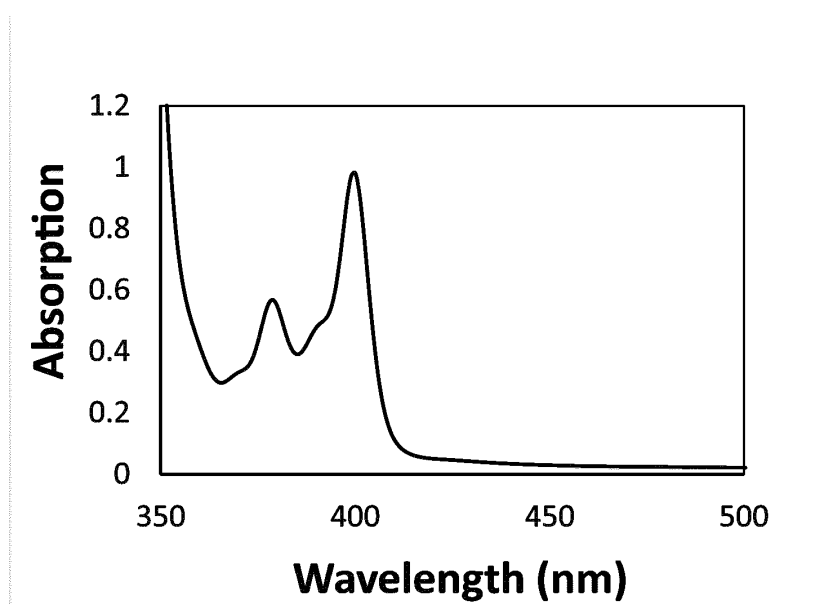


Fig. 11b

TGA spectrum of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, synthesized in example A6).

Fig. 11c

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Nanindentation measurement of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, synthesized in example A6).

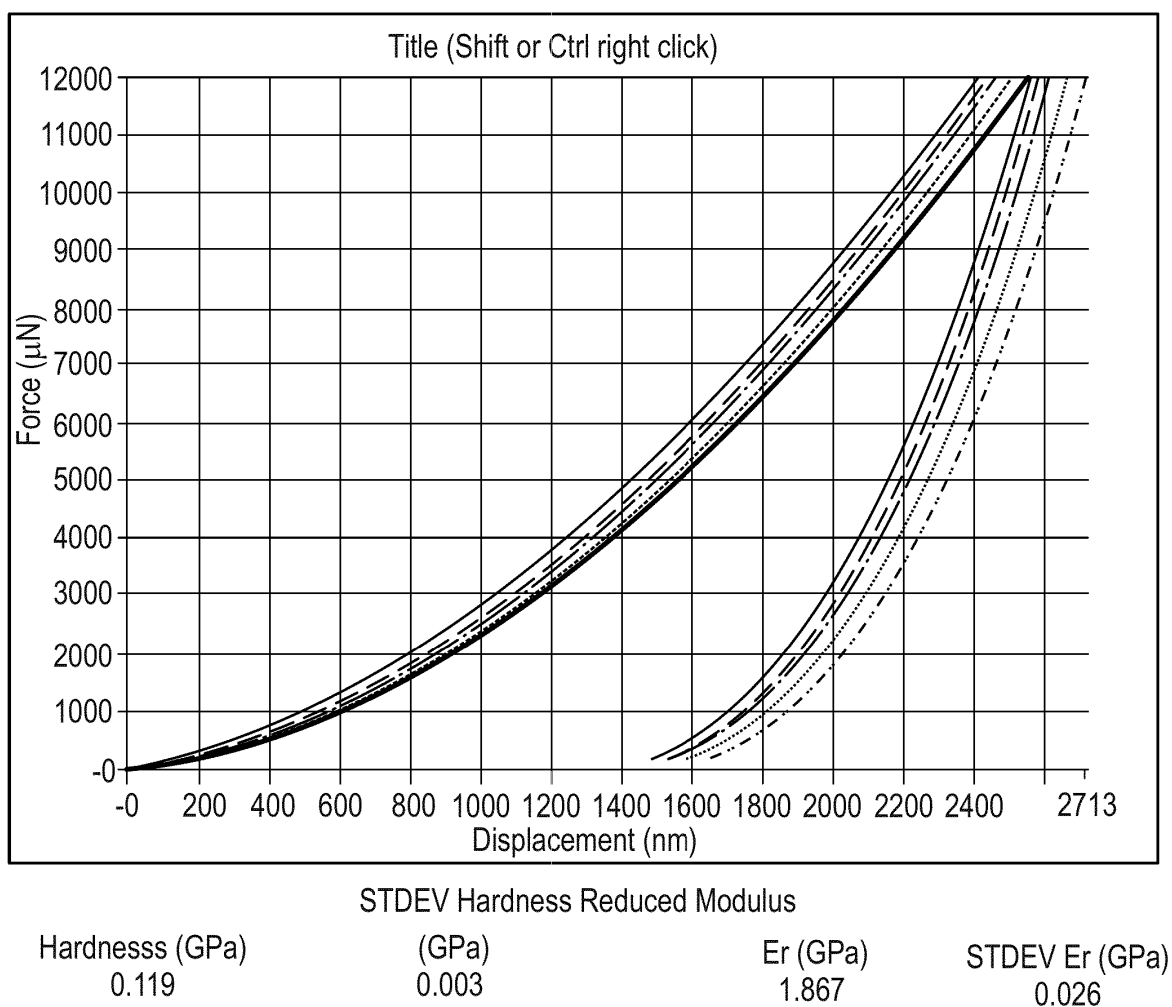
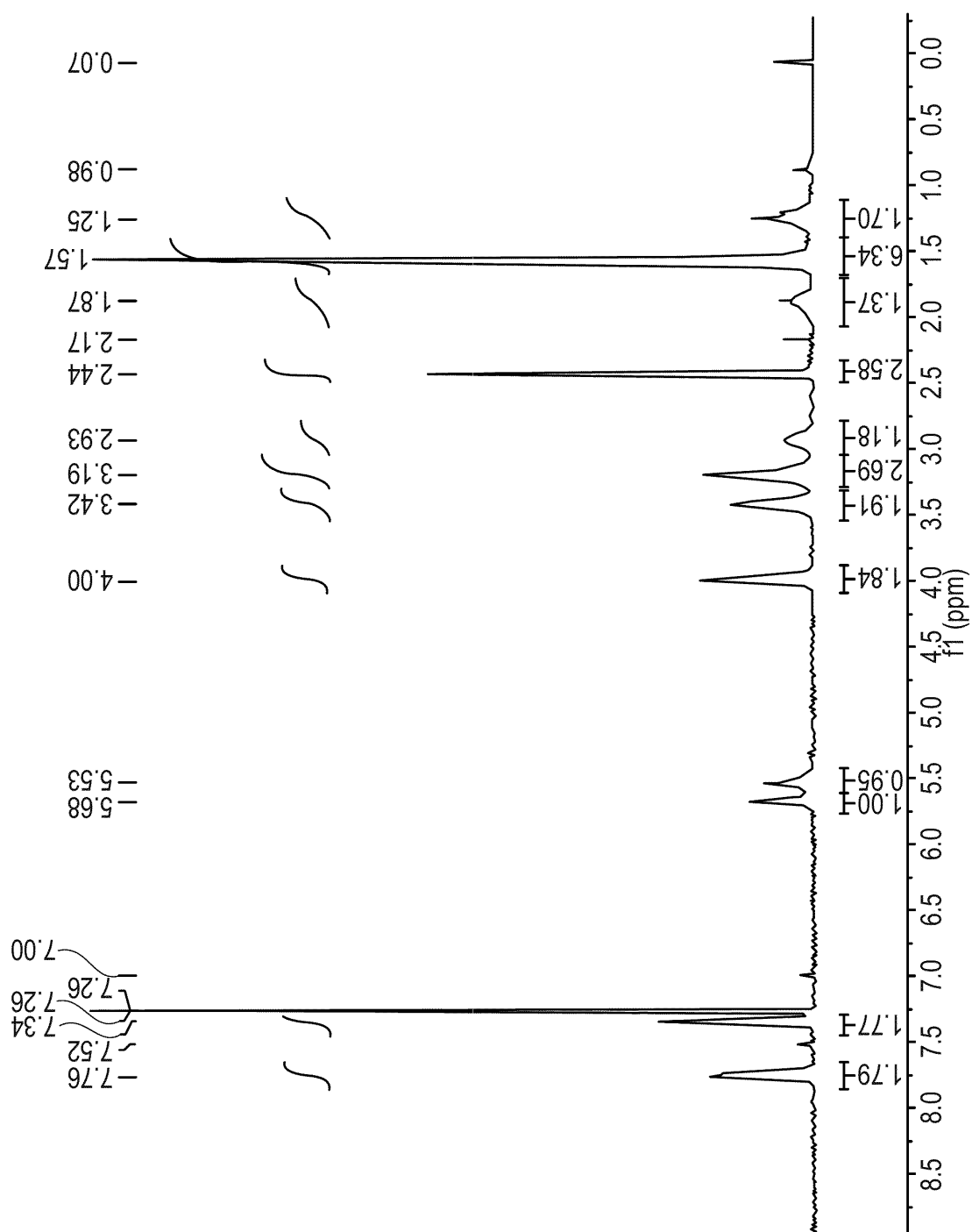


Fig. 12

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^1H NMR of 'Poly[N-(4-Tosylatebutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A4, synthesized in example A11).

Fig. 13

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¹H NMR of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A5, synthesized in example A13).

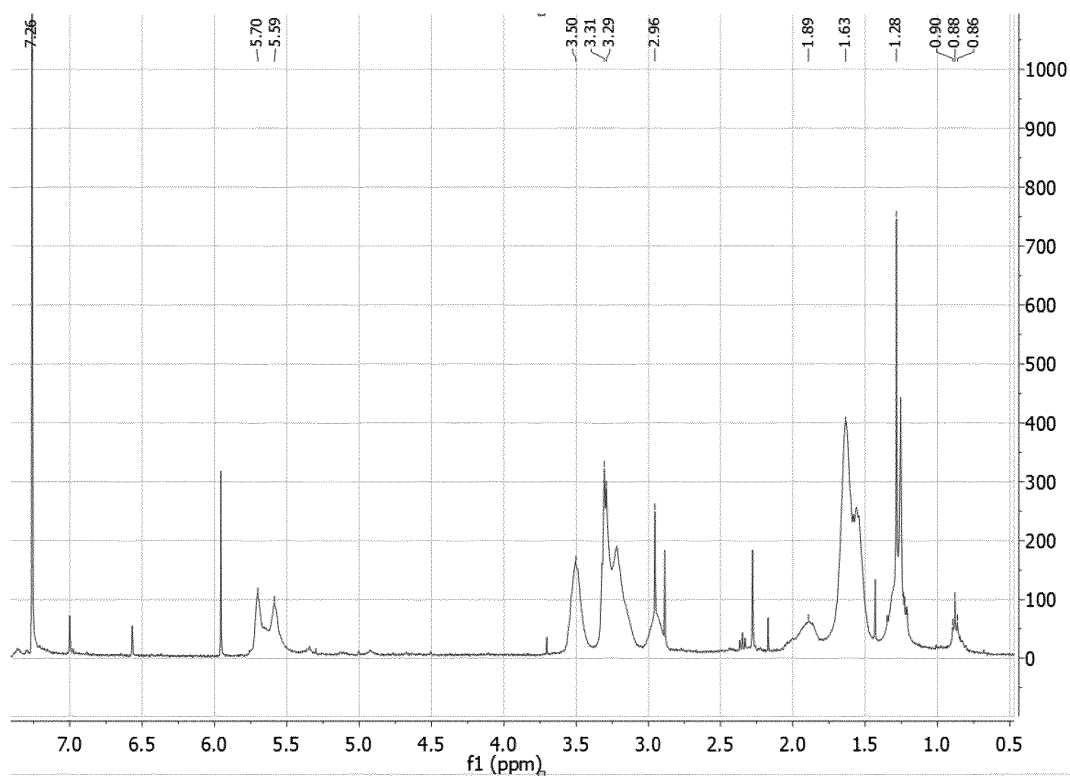
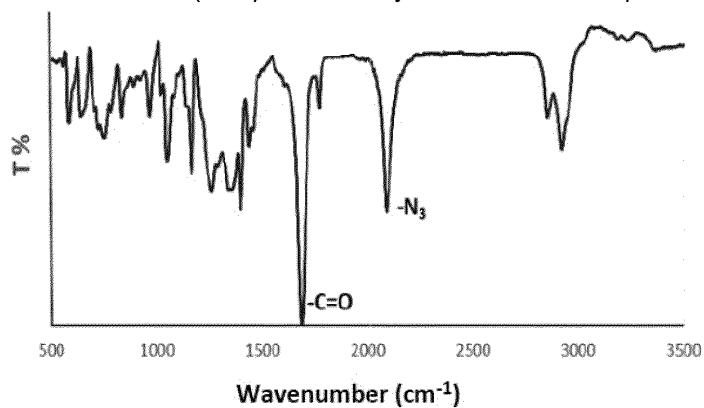


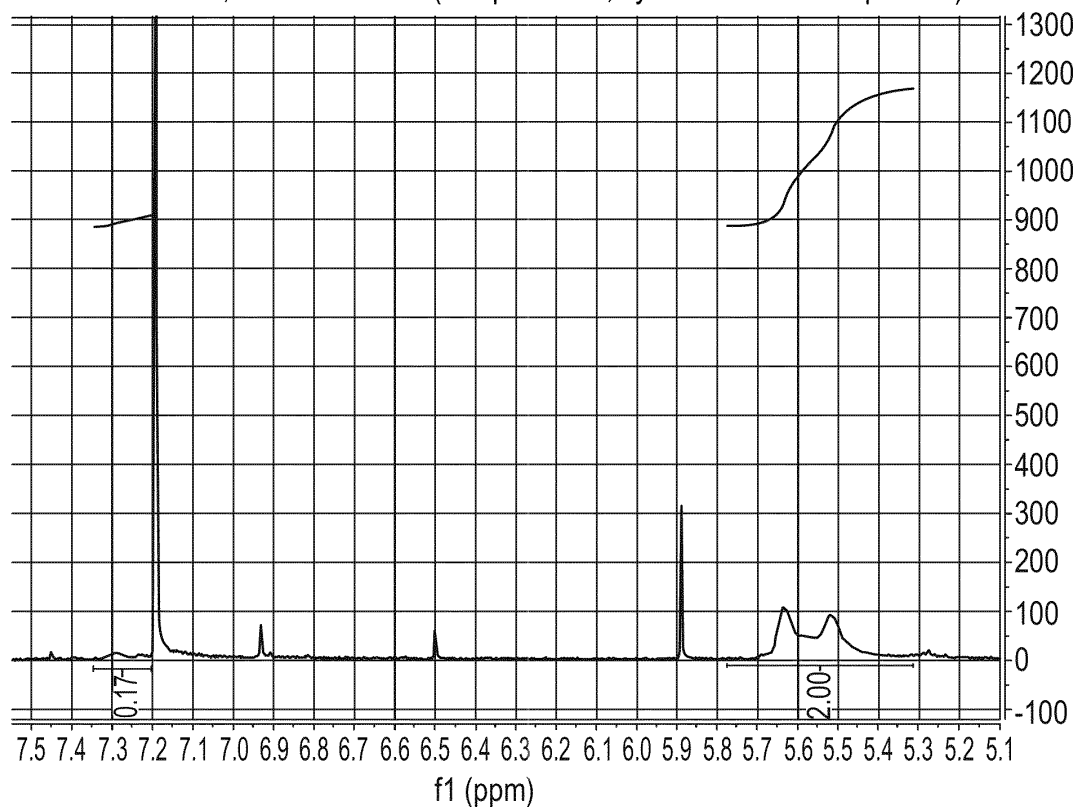
Fig. 14a

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FT-IR spectrum of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A5, synthesized in example A13).

**Fig. 14b**

End-group (¹H NMR) analysis of 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A5, synthesized in example A13).

**Fig. 15**

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Comparative Infrared Spectra. Black: Pyrene_Ushape terminal alkyne, blue: 'Poly[N-(4-azidobutyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A5, synthesized in example A13) and red: 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl)]-cis-5-norbornene-exo-2,3-dicarboximide' (compound A6, synthesized in example A16).

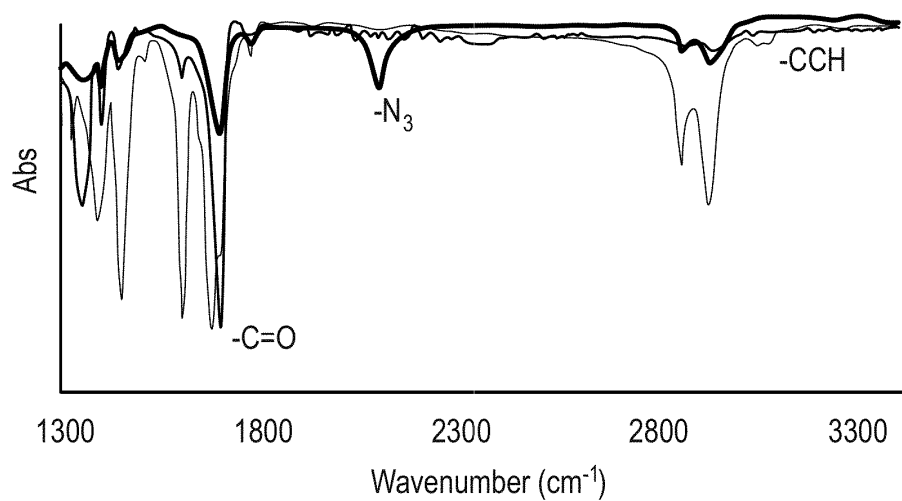


Fig. 16

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¹H NMR of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A6, synthesized in example A16).

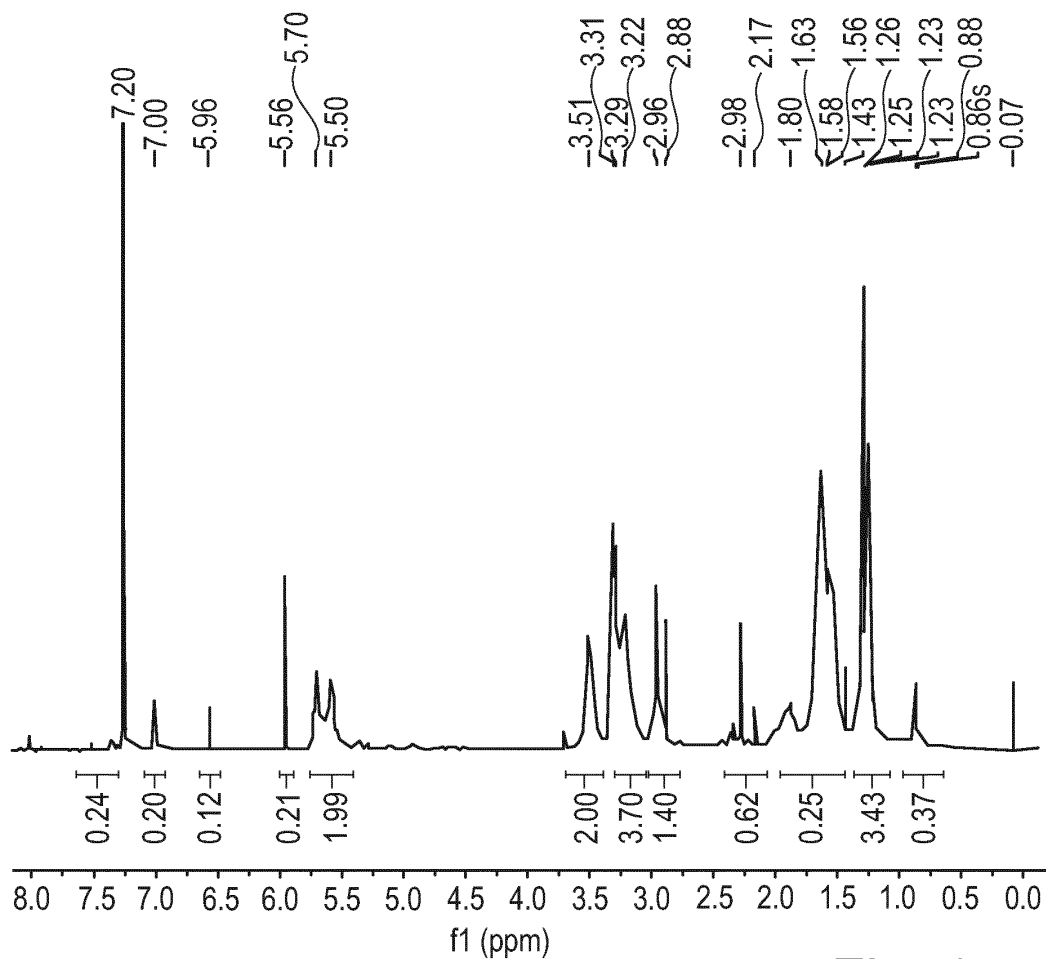
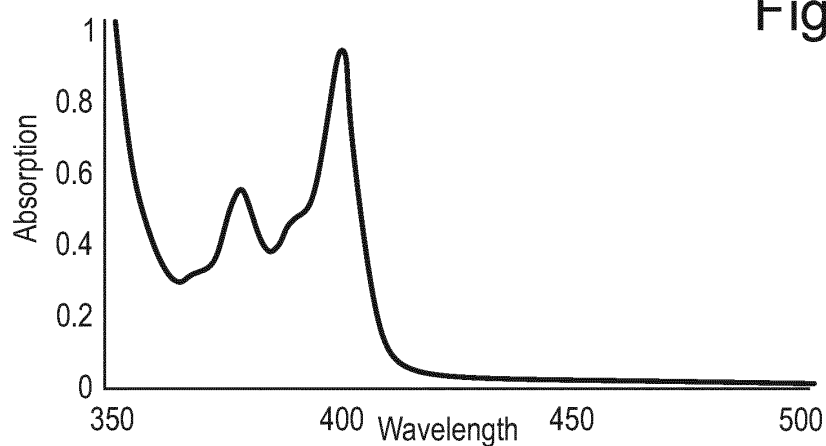


Fig. 17a



UV-Vis. spectrum of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A6, synthesized in example A16).

Fig. 17b

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TGA spectrum of 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide]' (compound A6, synthesized in example A16).

Fig. 17c

Synthesis of 'SWNT-polyUshape' composite (compound A8) with 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide]' (compound A3, from example A6).

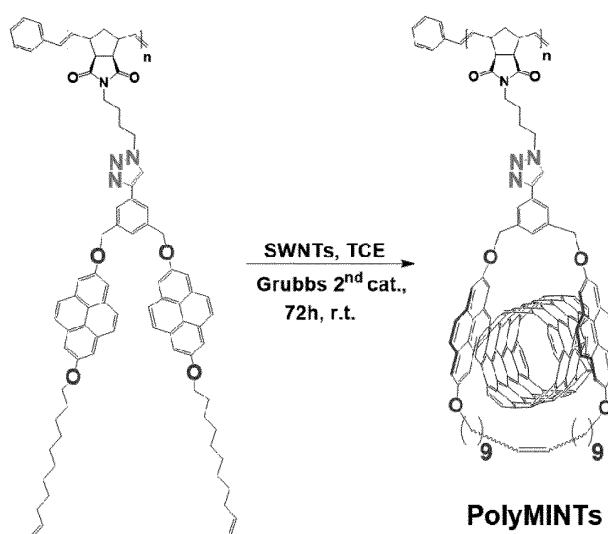


Fig. 18a

Optical Microscopy photo of compound A8

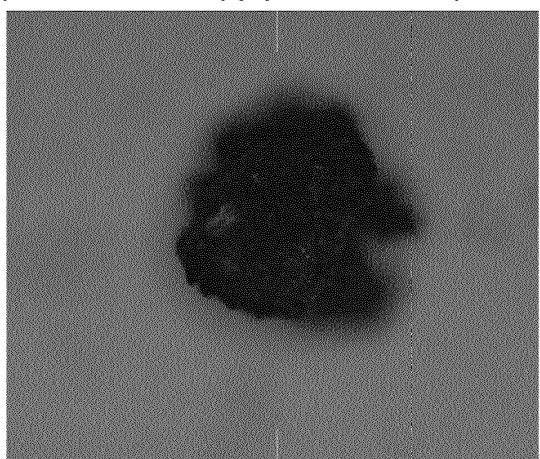


Fig. 18b

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Raman spectra of 'SWNT-polyUshape' composite (compound A8), measured at 785 nm and 532 nm.

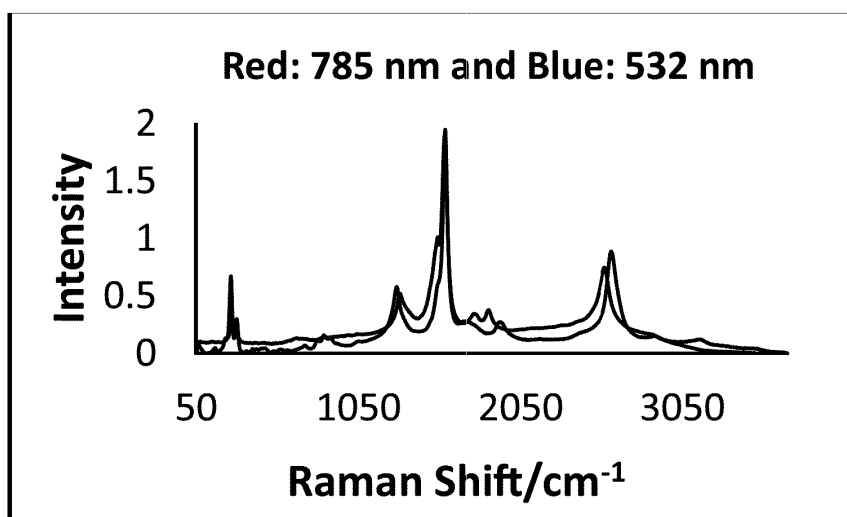


Fig. 19

Raman studies for a '2D versus G band' comparison of 'SWNT-polyUshape' composite (compound A8) and non-modified 6,5_SWNTs (compound A7) from example A19.

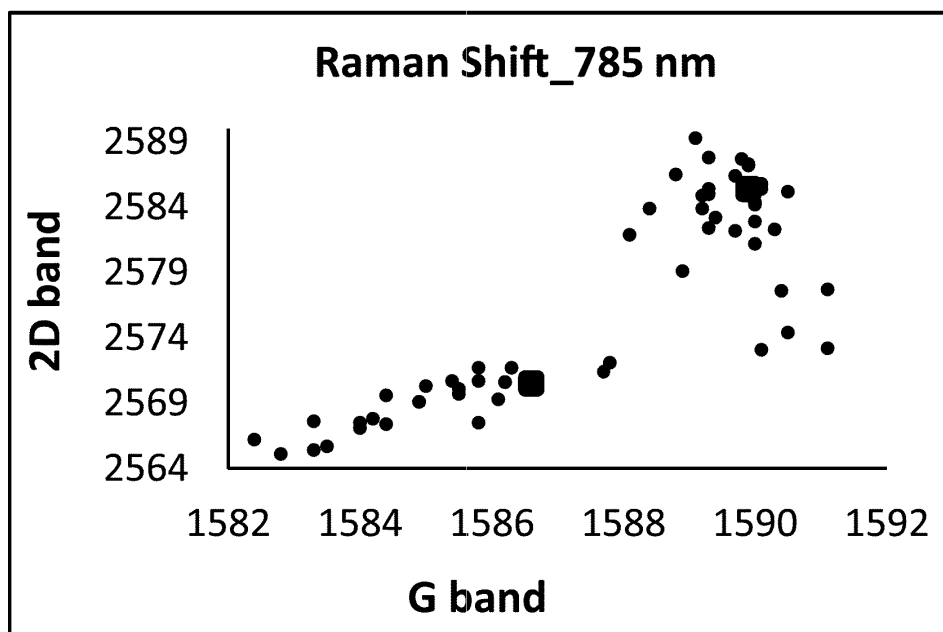


Fig. 20

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Average comparison of G and 2D band of 'SWNT-polyUshape' composite (compound A8) and non-modified 6,5_SWNTs (compound A7) from example A19.

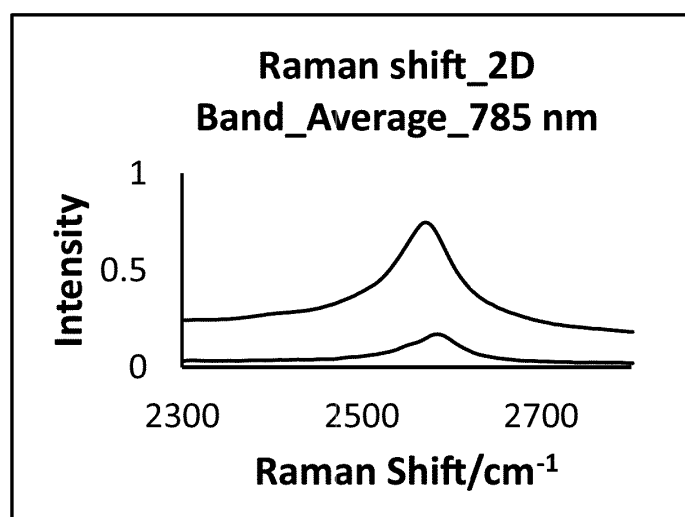
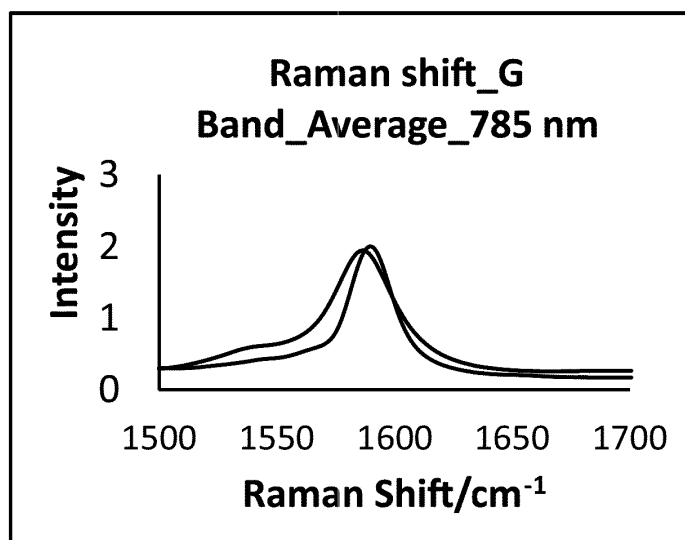


Fig. 21

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UV-Vis_NIR spectra (focused in the in the pyrene region) comparison between a) 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, from example A6) in black colour, b) 'SWNT-polyUshape' composite (compound A8) after step 8 in blue colour and c) 'SWNT-polyUshape' composite (compound A8) after step 11 in red colour.

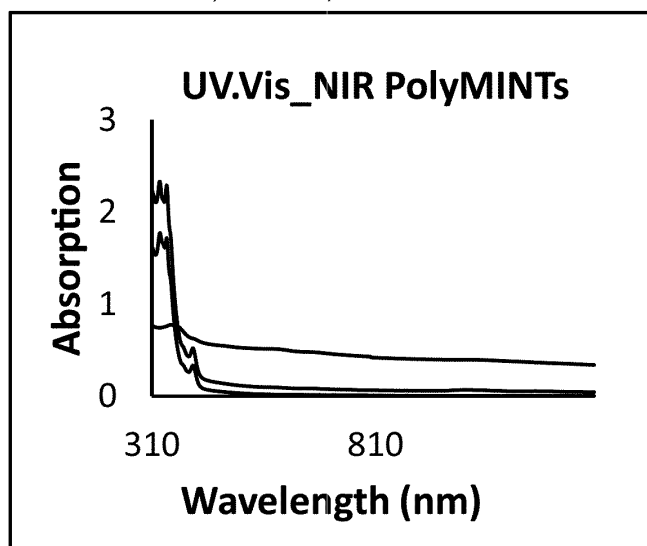


Fig. 22

UV-Vis_NIR spectra (focused in the in the nanotube region) comparison between 'SWNT-polyUshape' composite (compound A8) in red colour and 6,5_SWNTs (compound A7) from example A19 in blue colour.

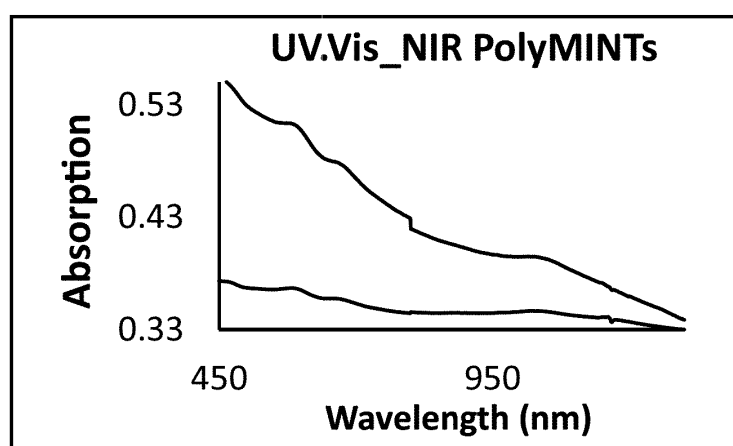
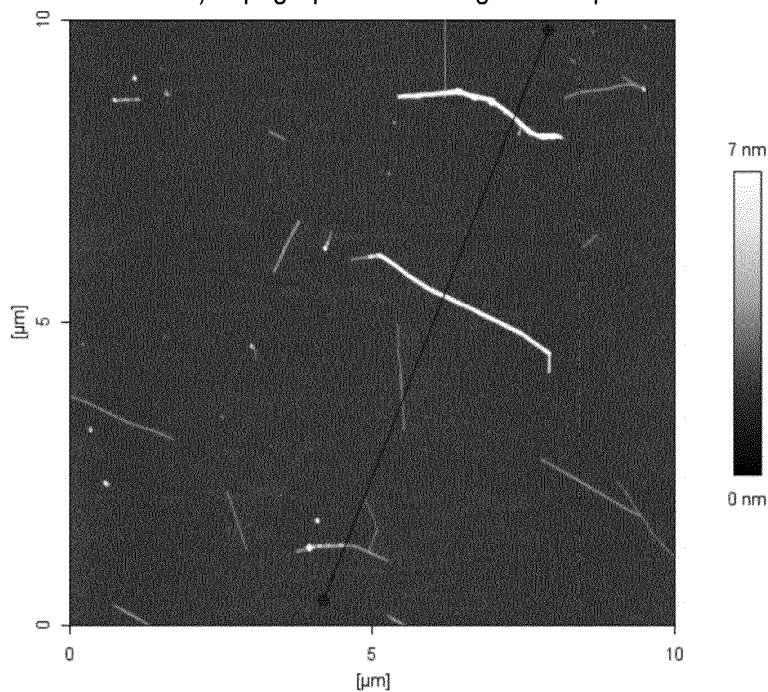


Fig. 23

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AFM of 'SWNT-polyUshape' composite (compound A8).

a) Topographic AFM image of compound A8.



b) 'Height measurements' of topographic AFM image from figure A30 (a).

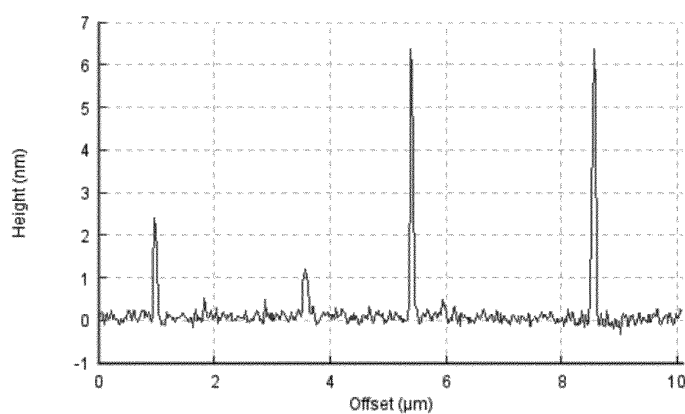
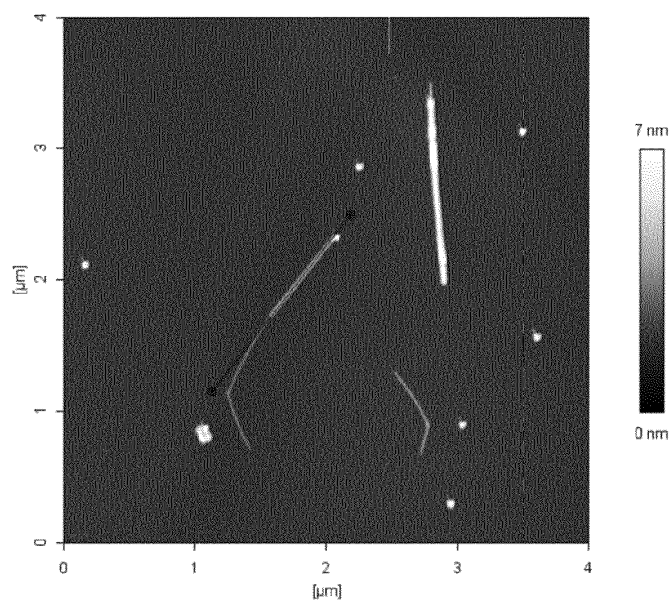


Fig. 24

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c) Topographic AFM image of compound A8.



d) 'Height measurements' of topographic AFM image from figure A30 (c).

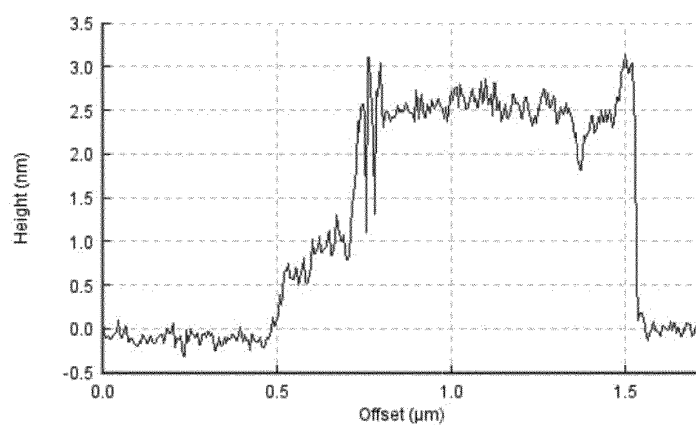


Fig. 24 (Continued)

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e) Phase AFM image from figure A30 (c).

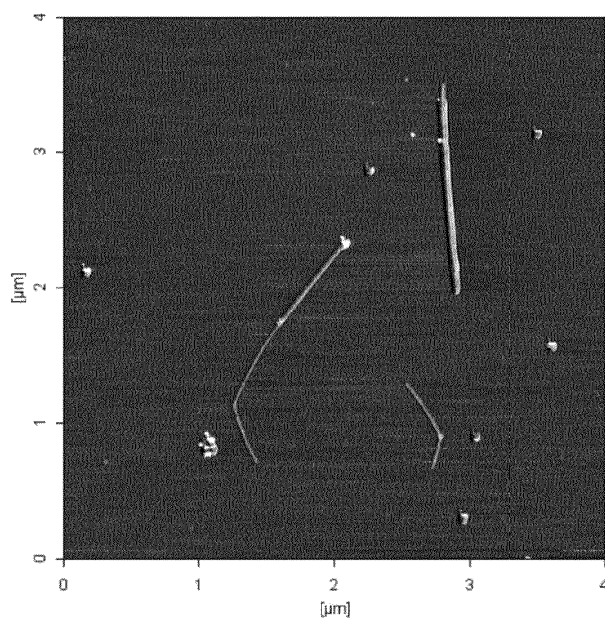


Fig. 24 (Continued)

SEM of 'SWNT-polyUshape' composite (compound A8).

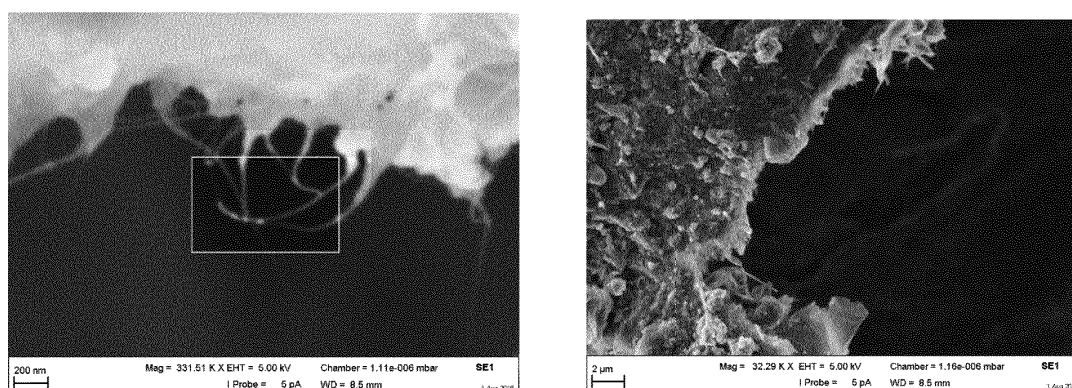


Fig. 25

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SEM-in-lens of 'SWNT-polyUshape' composite (compound A8).

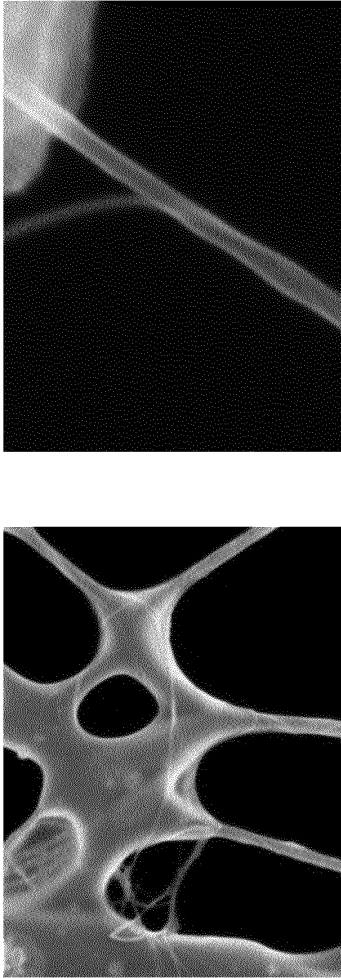


Fig. 26

TEM of 'SWNT-polyUshape' composite (compound A8).

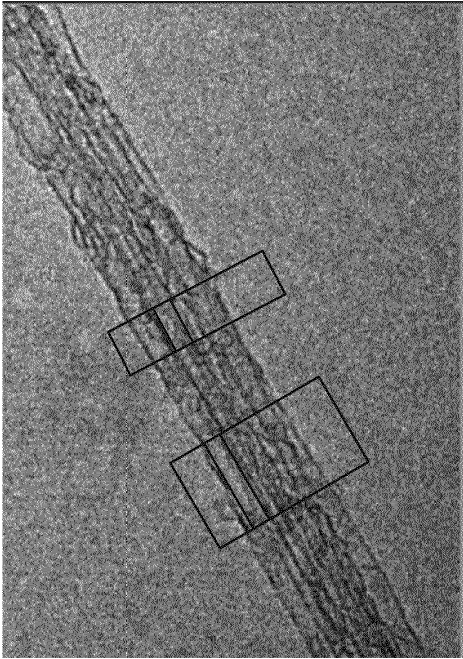
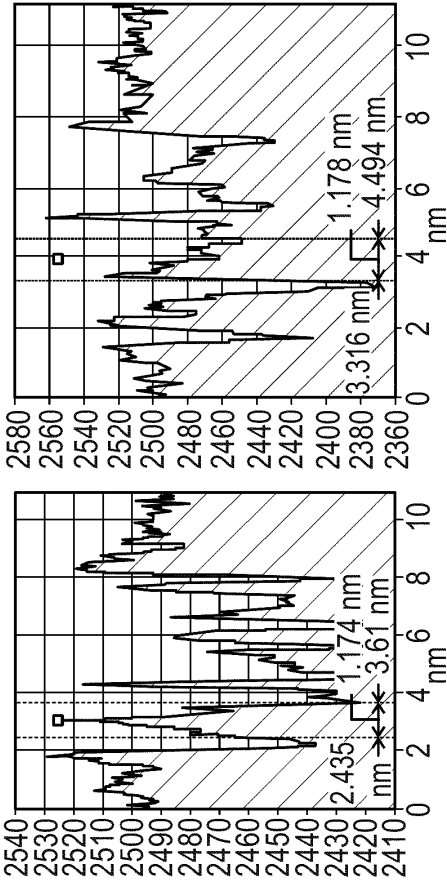


Fig. 27



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HRTEM of 'SWNT-polyUshape' composite (compound A8).

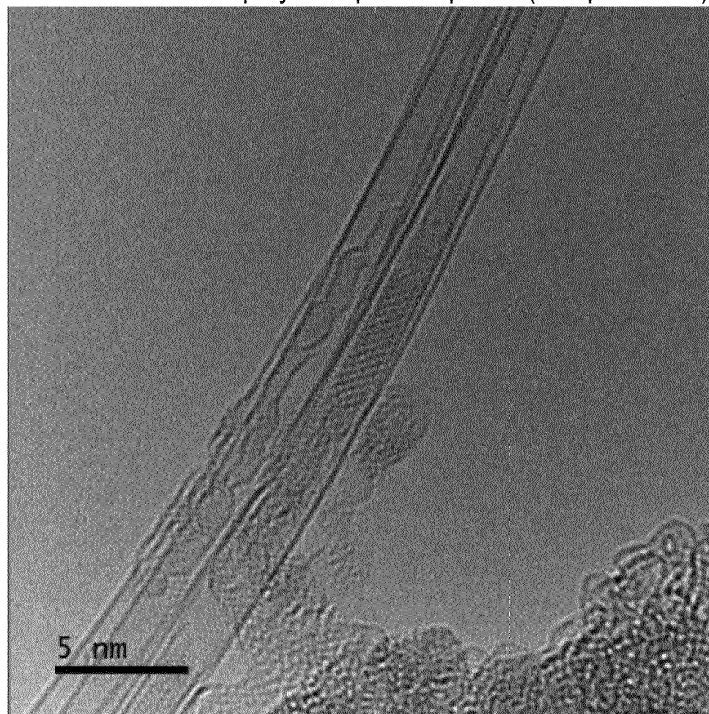


Fig. 28

Raman studies for a '2D versus G band' comparison of composites obtained in examples A20 (compound A8 in red) and A24 (in blue).

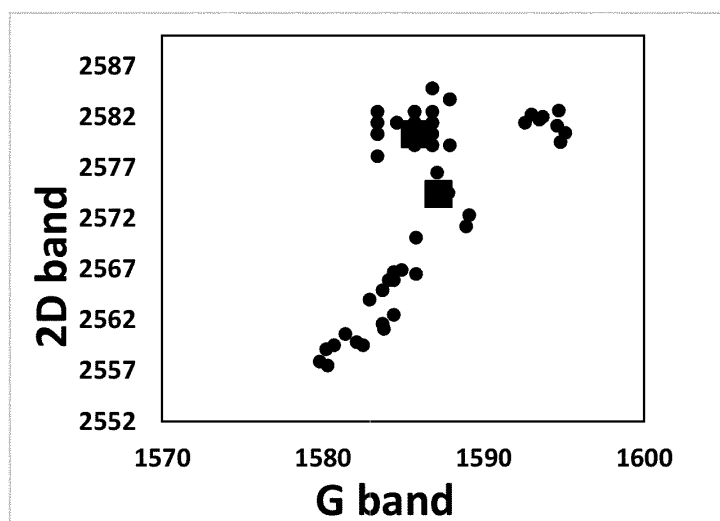


Fig. 29

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Raman spectra comparison of a) compound A9 in blue line (example A27), b) compound A8 in red line (example A20) and c) compound A7 in black line (example A19), measured at 785 nm.

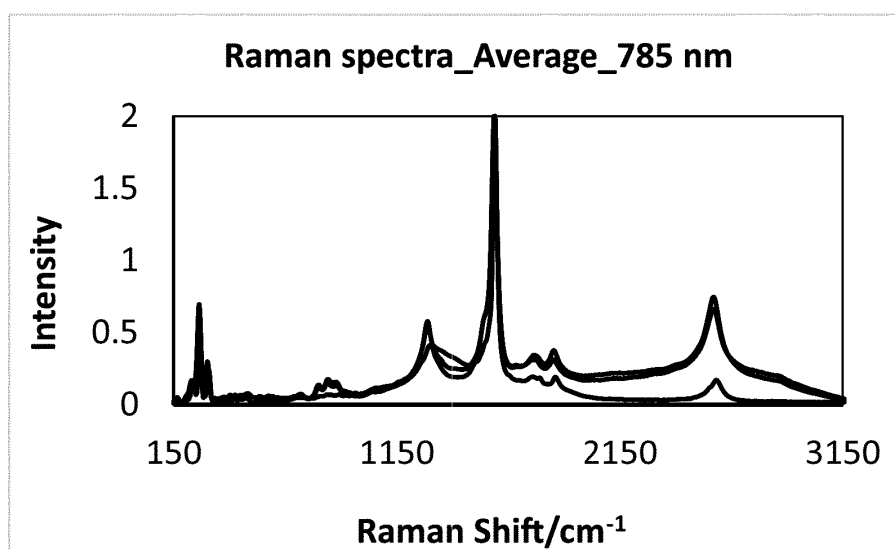


Fig. 30

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Raman studies for a '2D versus G band' comparison of a) compound A9 in green (example A27), b) compound A8 in red (example A20), c) compound A7 in orange (example A19) and d) compound obtained from 'control' experiment in blue.

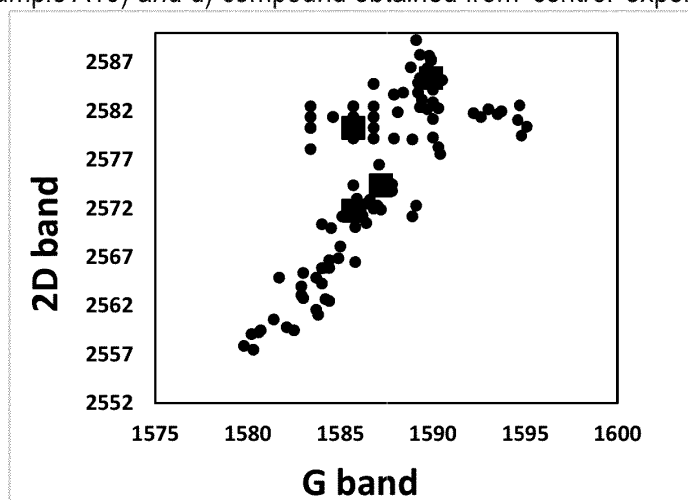


Fig. 31

Average comparison of G and 2D band of a) compound A9 (example A27), b) compound A8 (example A20) and c) compound A7 (example A19), measured at 785 nm.

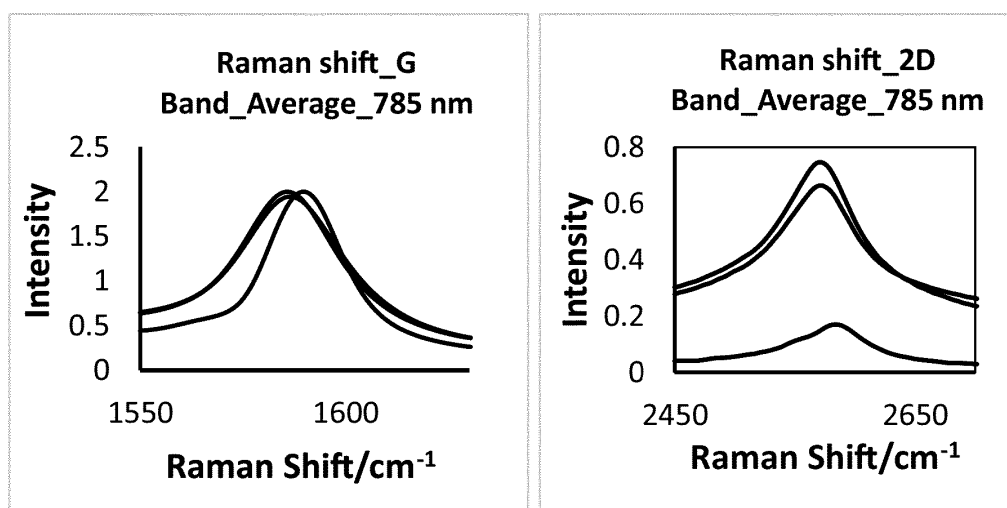


Fig. 32

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UV-Vis-NIR comparison spectra of 'SWNT-polyUshape Supramolecular' composite (compound A9) in blue, 'SWNT-polyUshape' composite (compound A8) in red and 'Poly[N-(4-triazole-Pyrene_Ushape-(butyl))-cis-5-norbornene-exo-2,3-dicarboximide' (compound A3, from example A6) in grey.

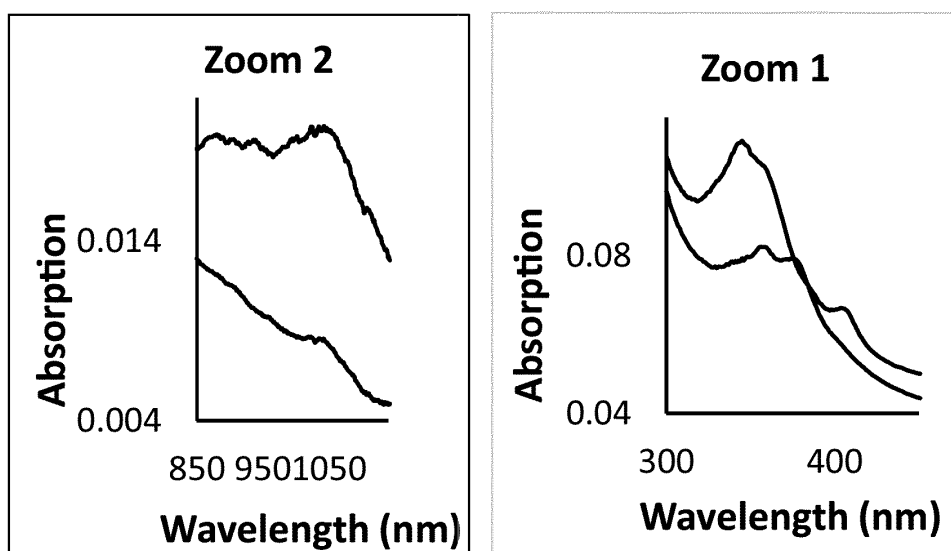
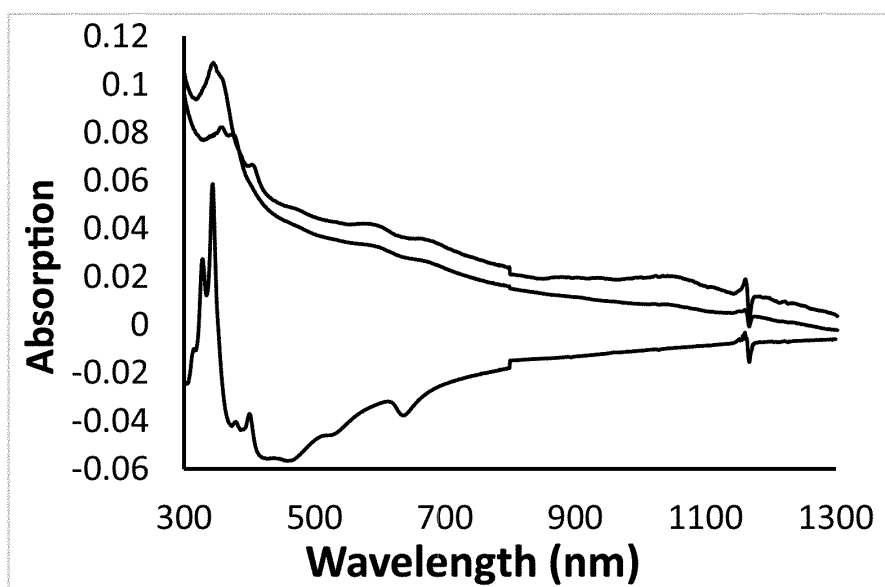


Fig. 33

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HRTEM of 'SWNT-polyUshape Supramolecular' composite (compound A9).

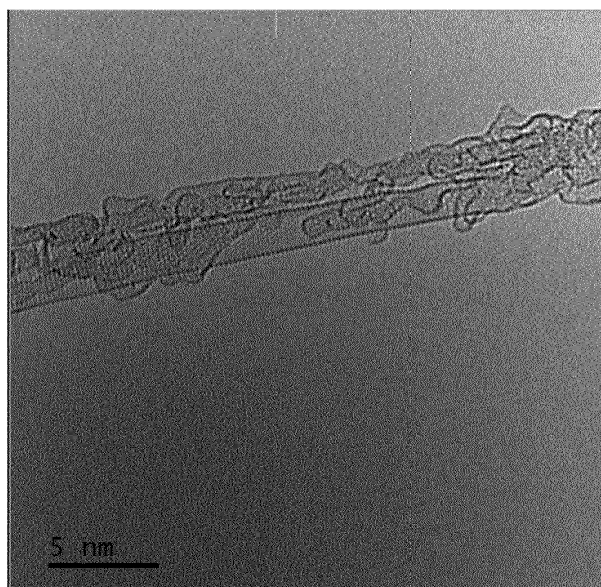


Fig. 34

Raman Spectroscopy of 'SWNT-polyUshape' composite in red line (compound A10) and non-modified 6,5_SWNTs (compound A7) in black line, measured at 785nm. Note: Both spectra are the average from 30 different measurements.

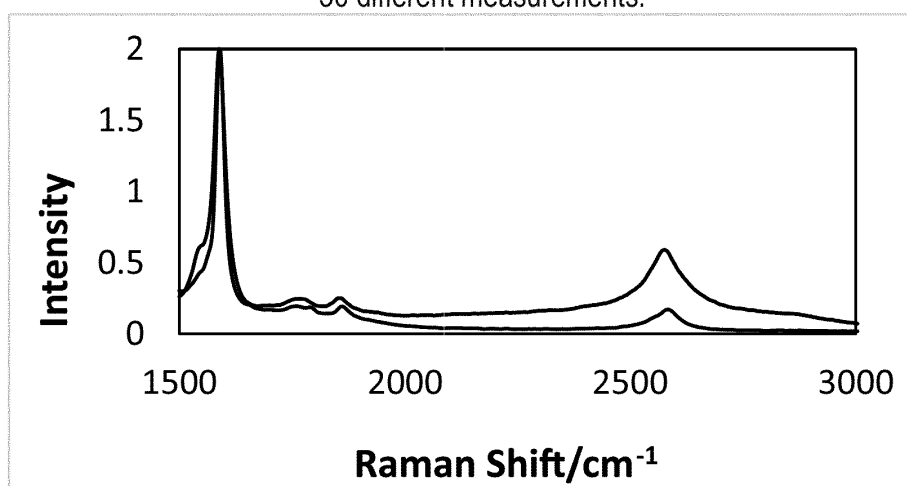


Fig. 35

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Raman studies for a '2D versus G band' comparison of 'SWNT-polyUshape' composite (compound A10) and non-modified 6,5_SWNTs (compound A7).

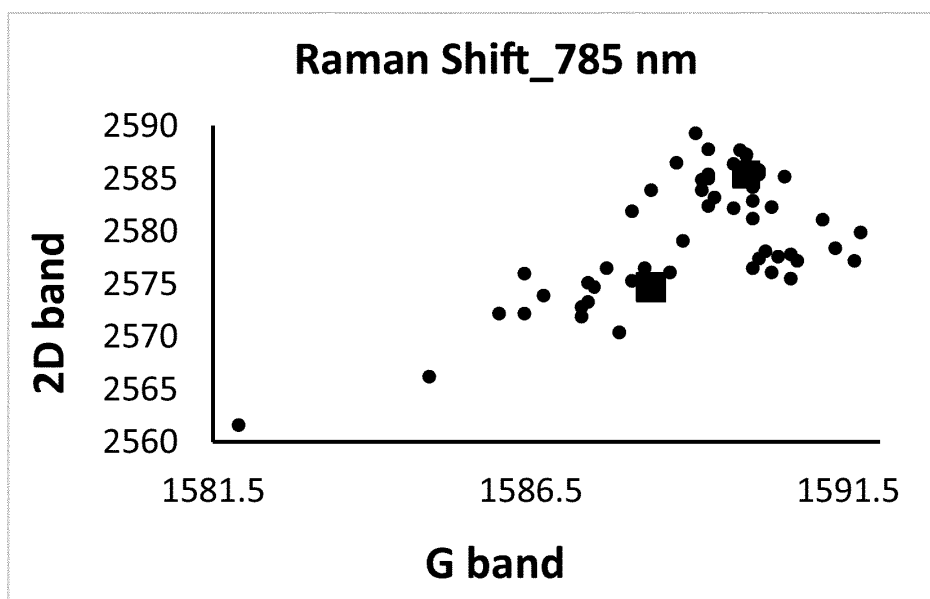


Fig. 36

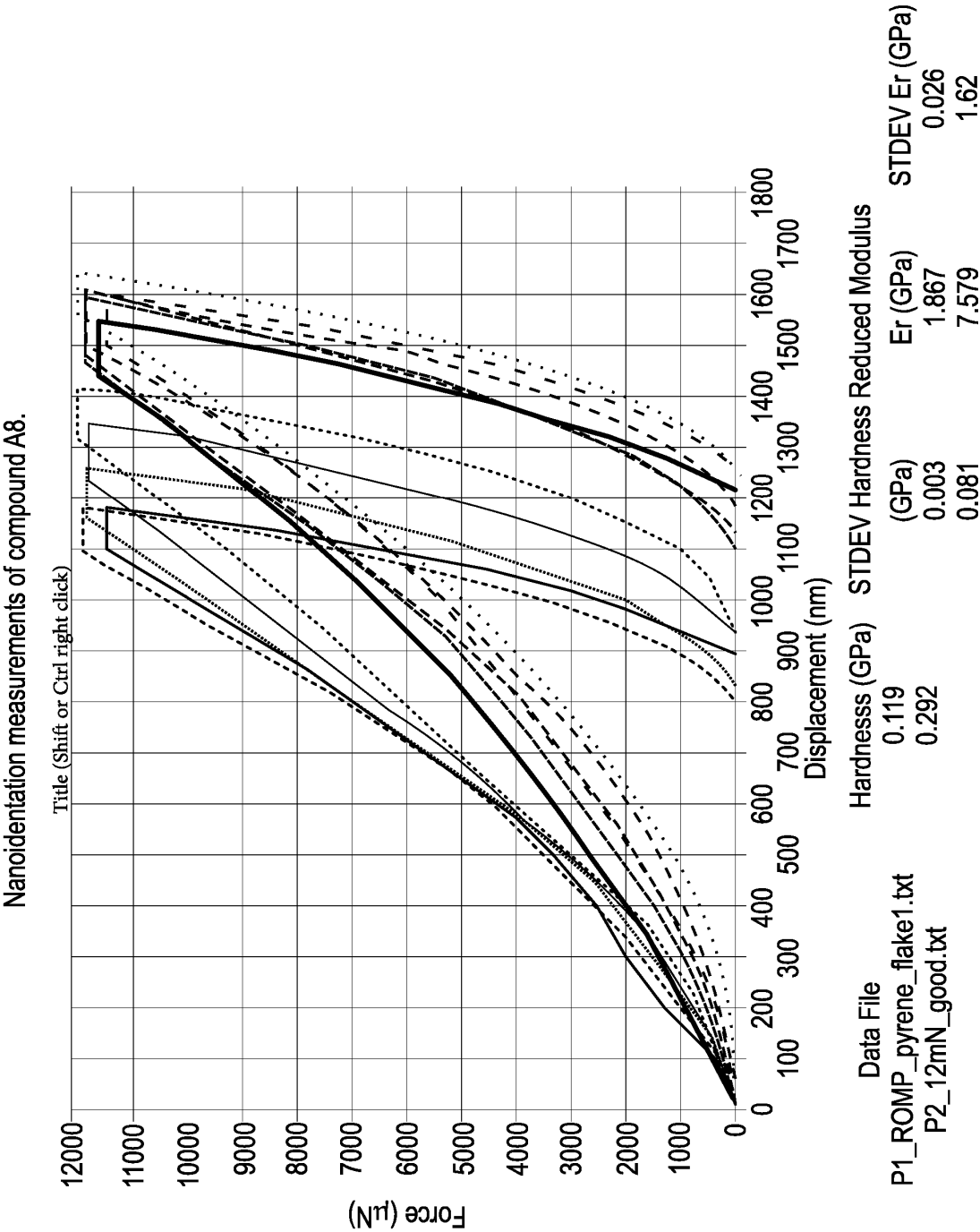


Fig. 37

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Synthesis of pyrene precursor-ML

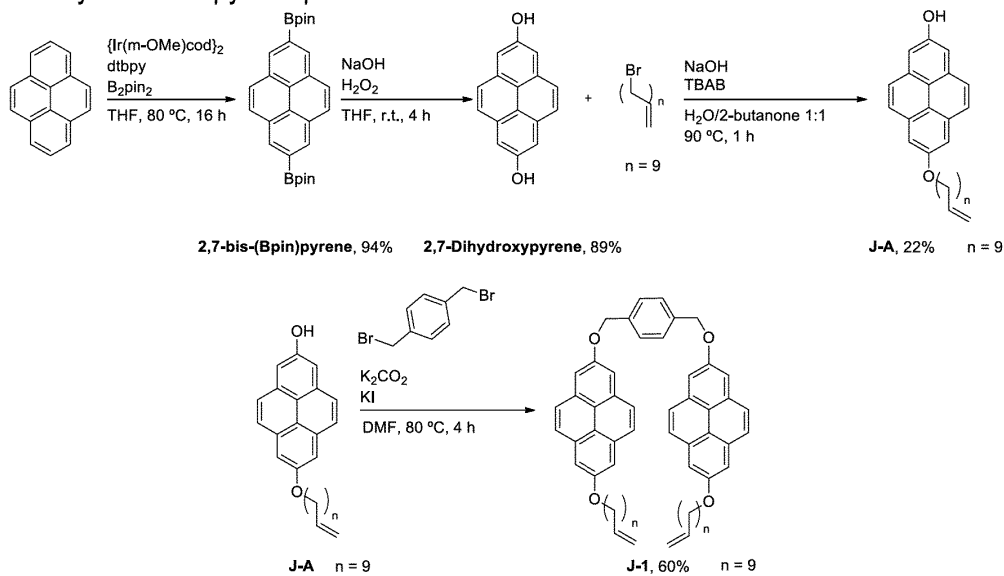


Fig. 38

Synthesis of Boc-diamine-carrying precursor-ML B2.1A. Synthesis of the spacer

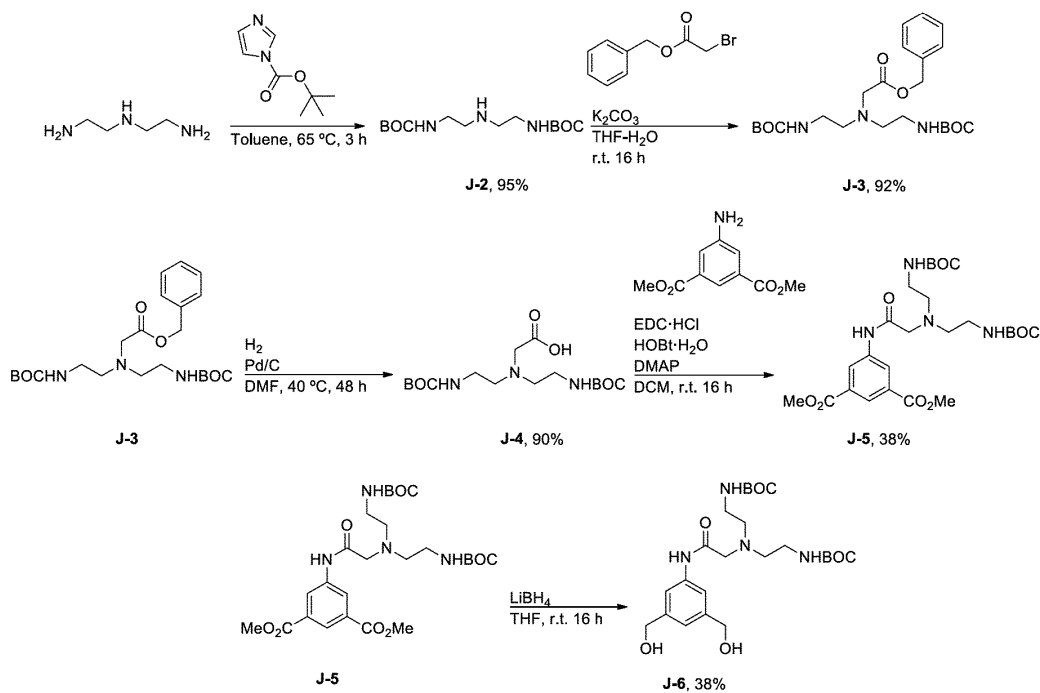


Fig. 39a

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Synthesis of the precursor-ML

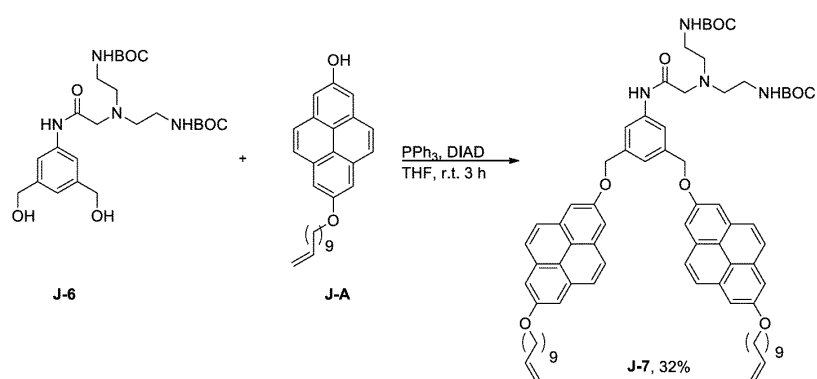


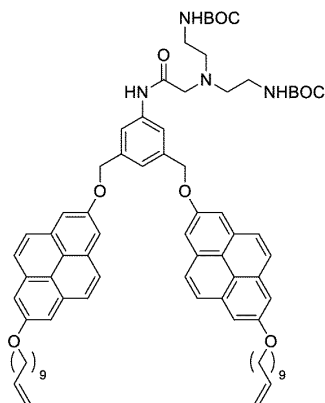
Fig. 39b

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Analytical data for "Boc-diamine-carrying precursor-ML of Example B2"

Boc-diamine-carrying precursor-ML of Example B2.

Data for mass spectrometry obtained: HRMS-



MALDI calcd. for $C_{78}H_{96}N_4Na_1O_9(M+Na)^+$: 1255.7070 Found: 1255.7062.

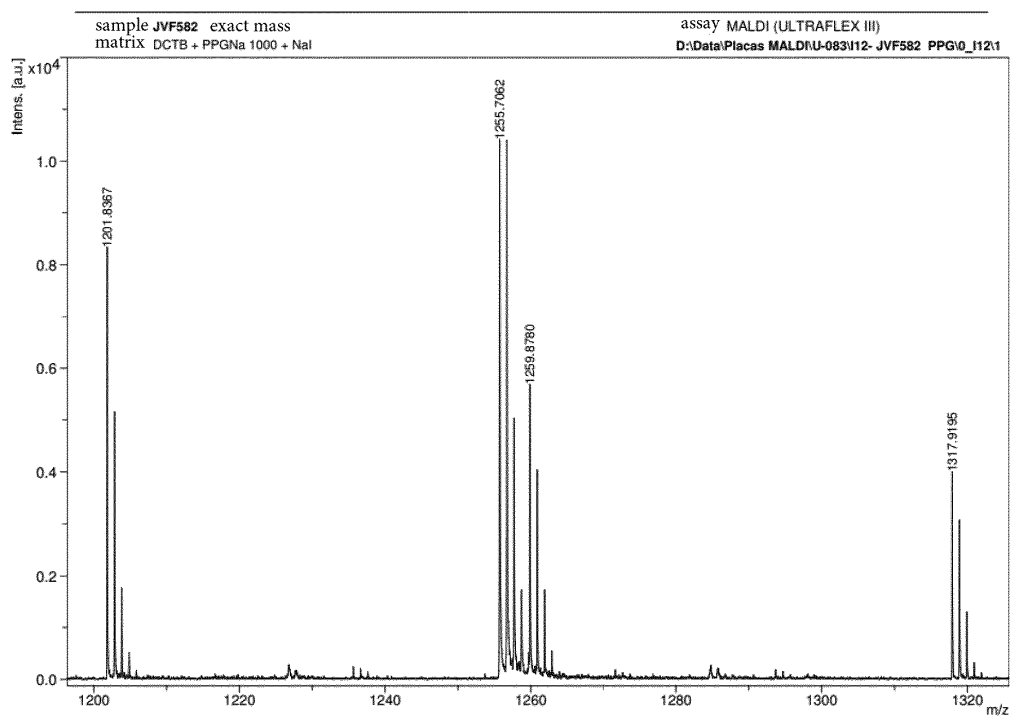


Fig. 39c

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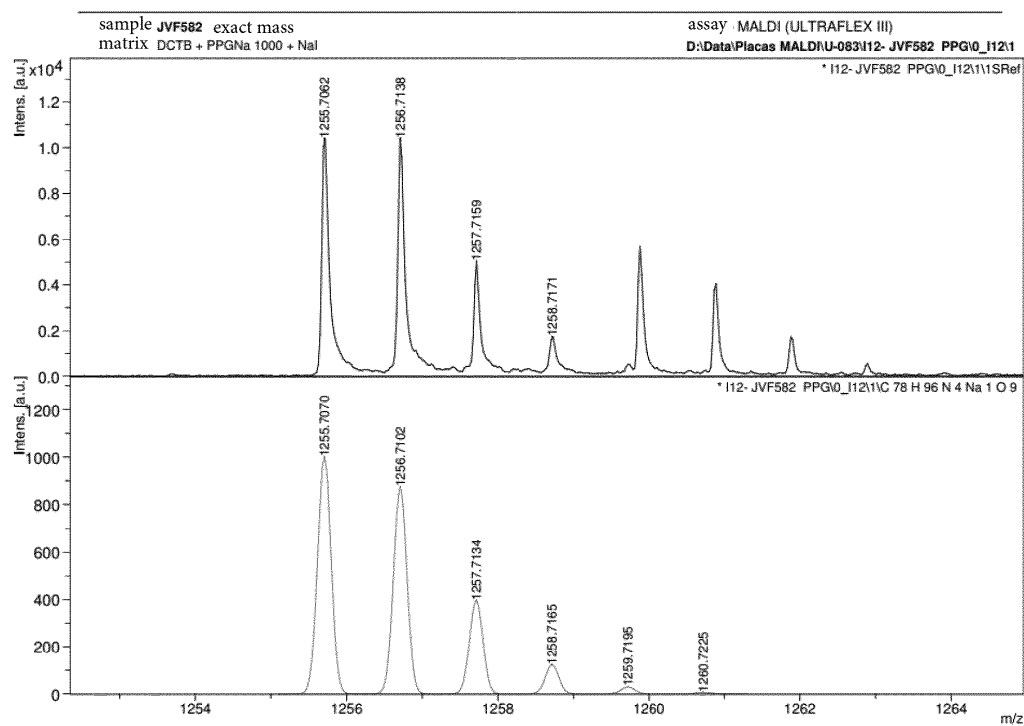
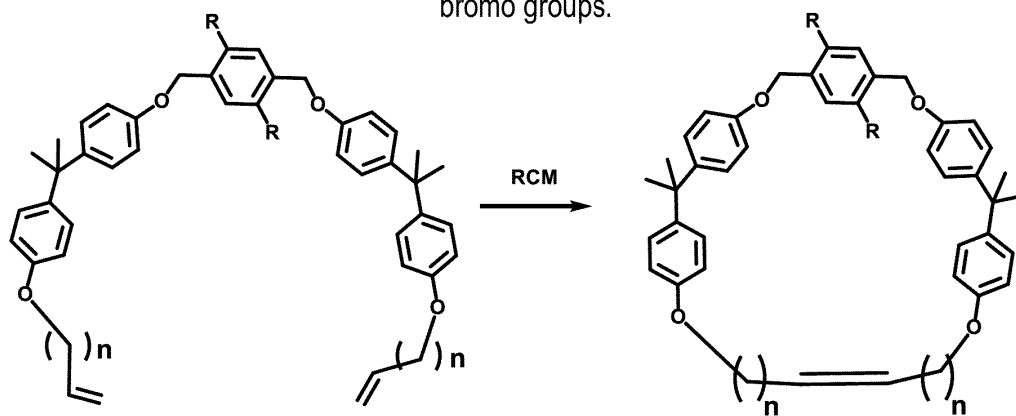


Fig. 39c (Continued)

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Preparation of macrocyclic molecule comprising bisphenol A (BPA)-motifs or bromo groups.

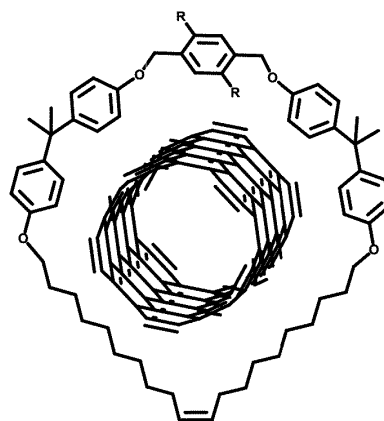


Z-3a, R = H, n = 9
Z-3b, R = Br, n = 9

Z-4a, R = H, n = 9
Z-4b, R = Br, n = 9

Fig. 40a

Structure of macrocyclic molecule around a single-walled carbon nanotube.



R = H or Br, n = 9

Fig. 40b

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Synthesis of bisphenol A (BPA) precursor-ML.

Scheme 1

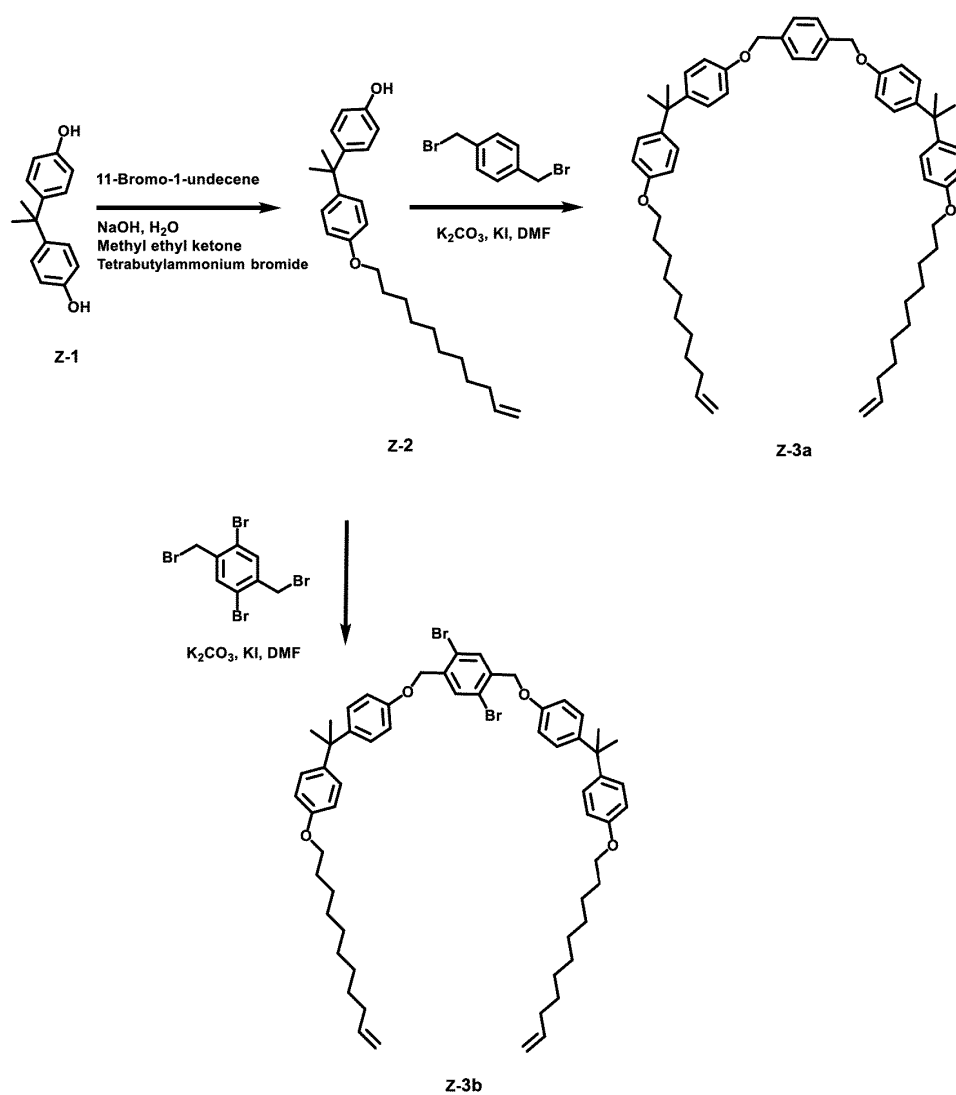
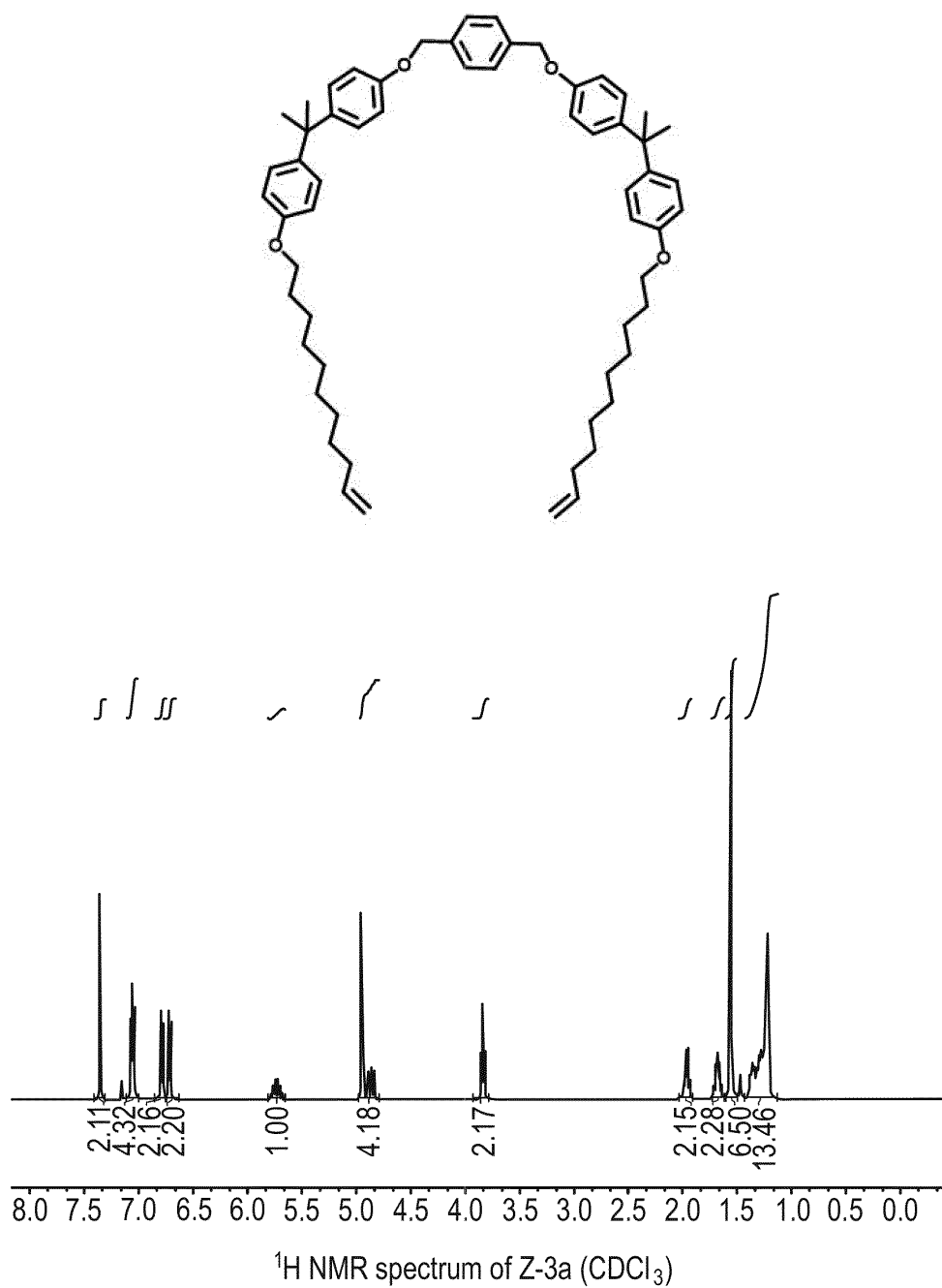


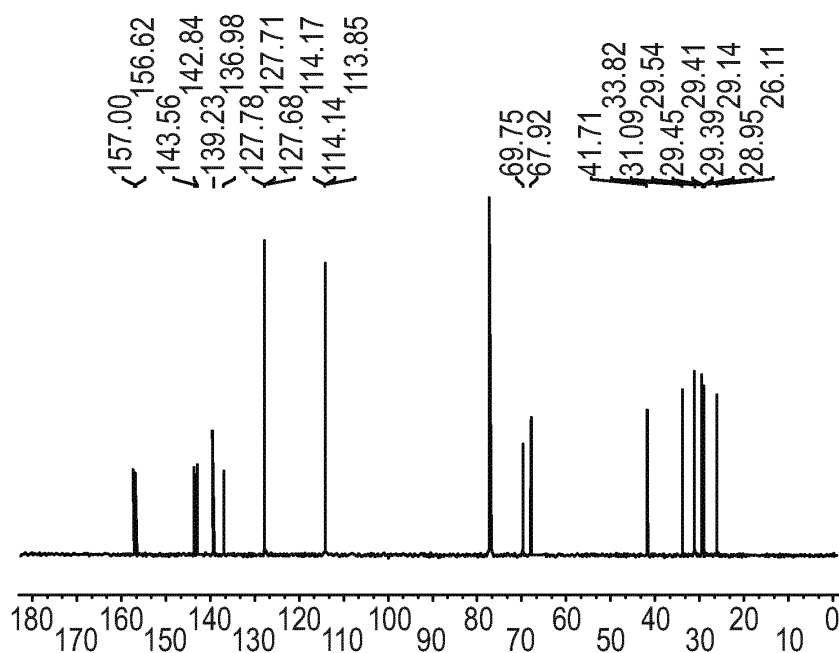
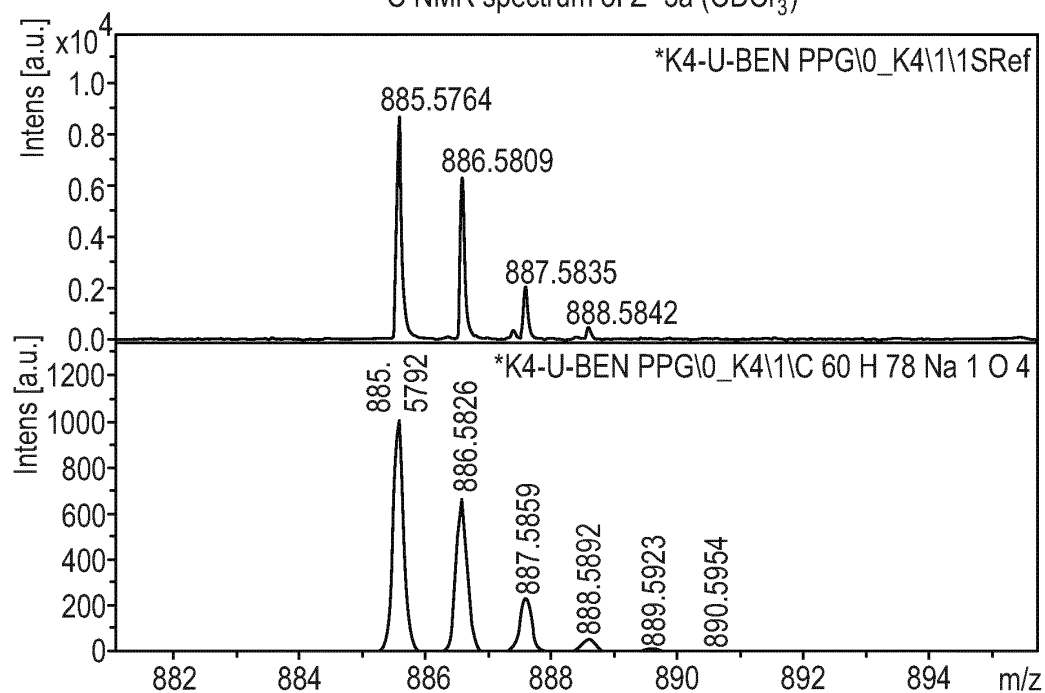
Fig. 40c

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Analytical data for bisphenol A (BPA) precursor-ML and macrocyclic molecule.

**Fig. 40d**

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¹³C NMR spectrum of Z-3a (CDCl₃)

calculated for C₆₀H₇₈O₄Na [M+Na]⁺ 885.5792, found MALDI 885.5764.

Fig. 40d (Continued)

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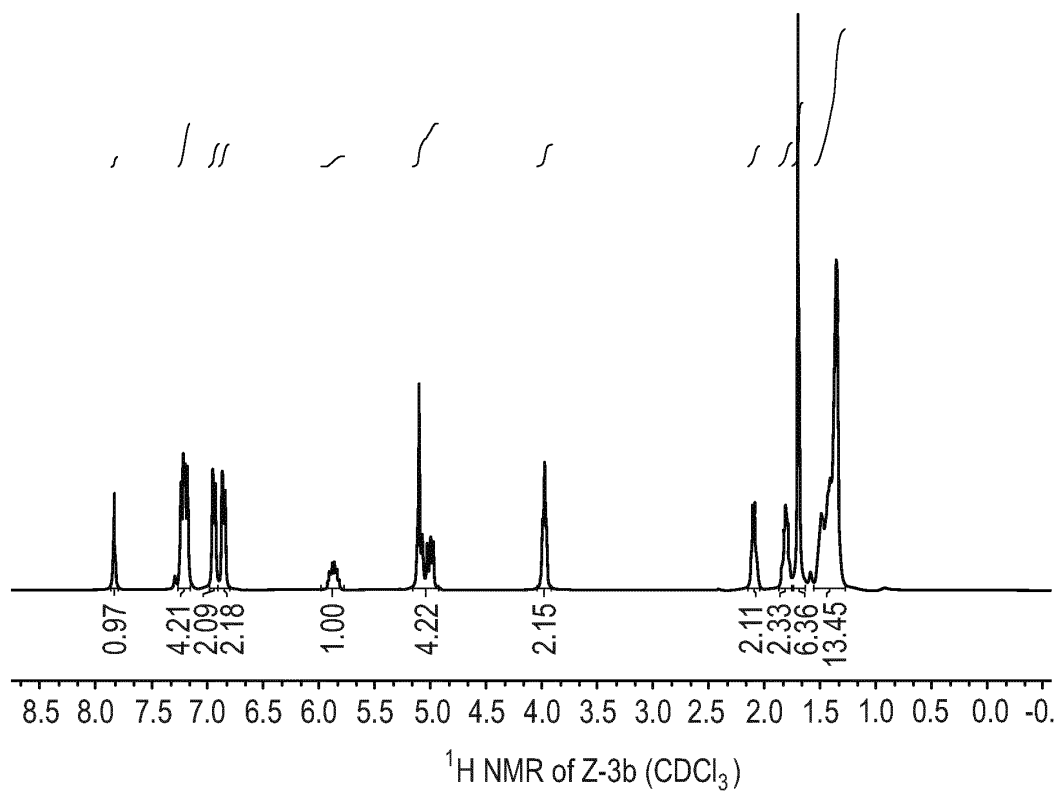
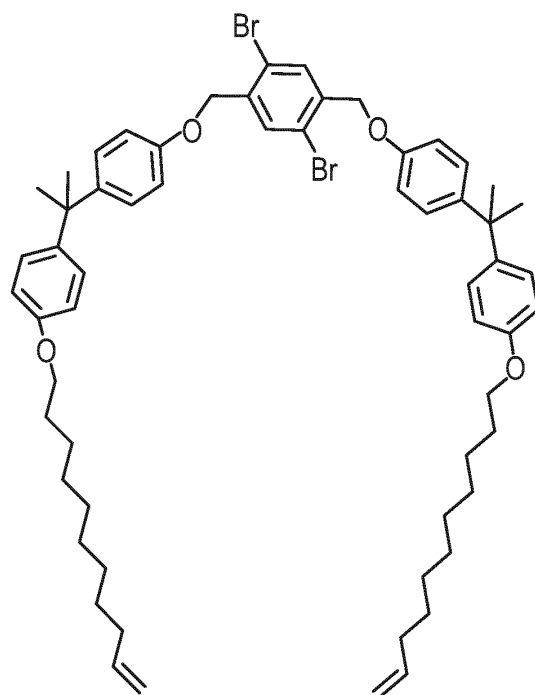


Fig. 40d (Continued)

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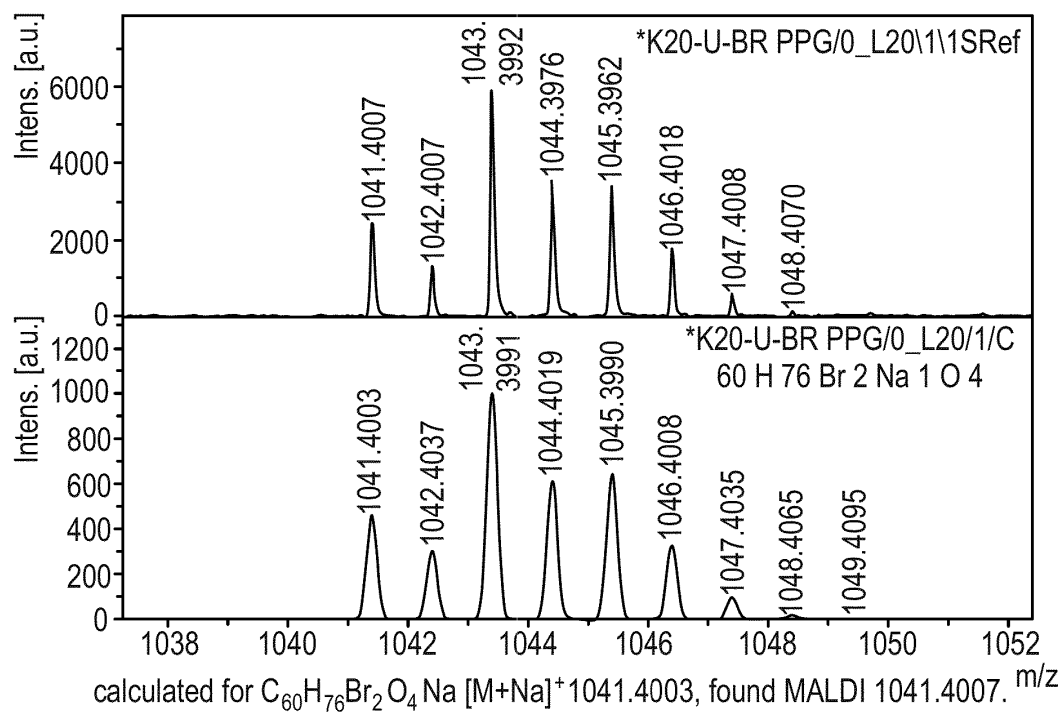
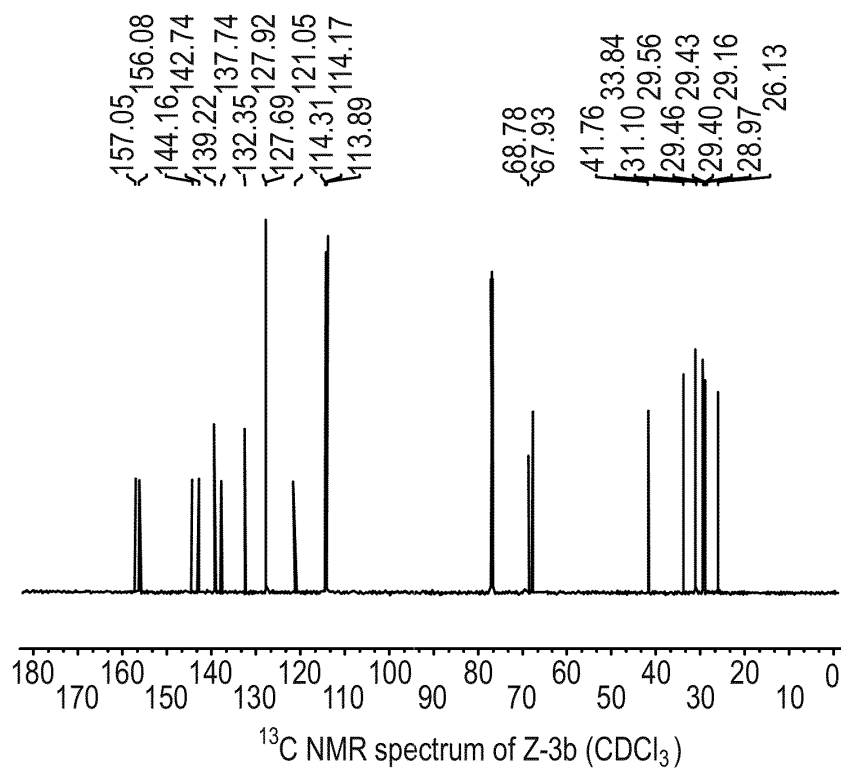


Fig. 40d (Continued)

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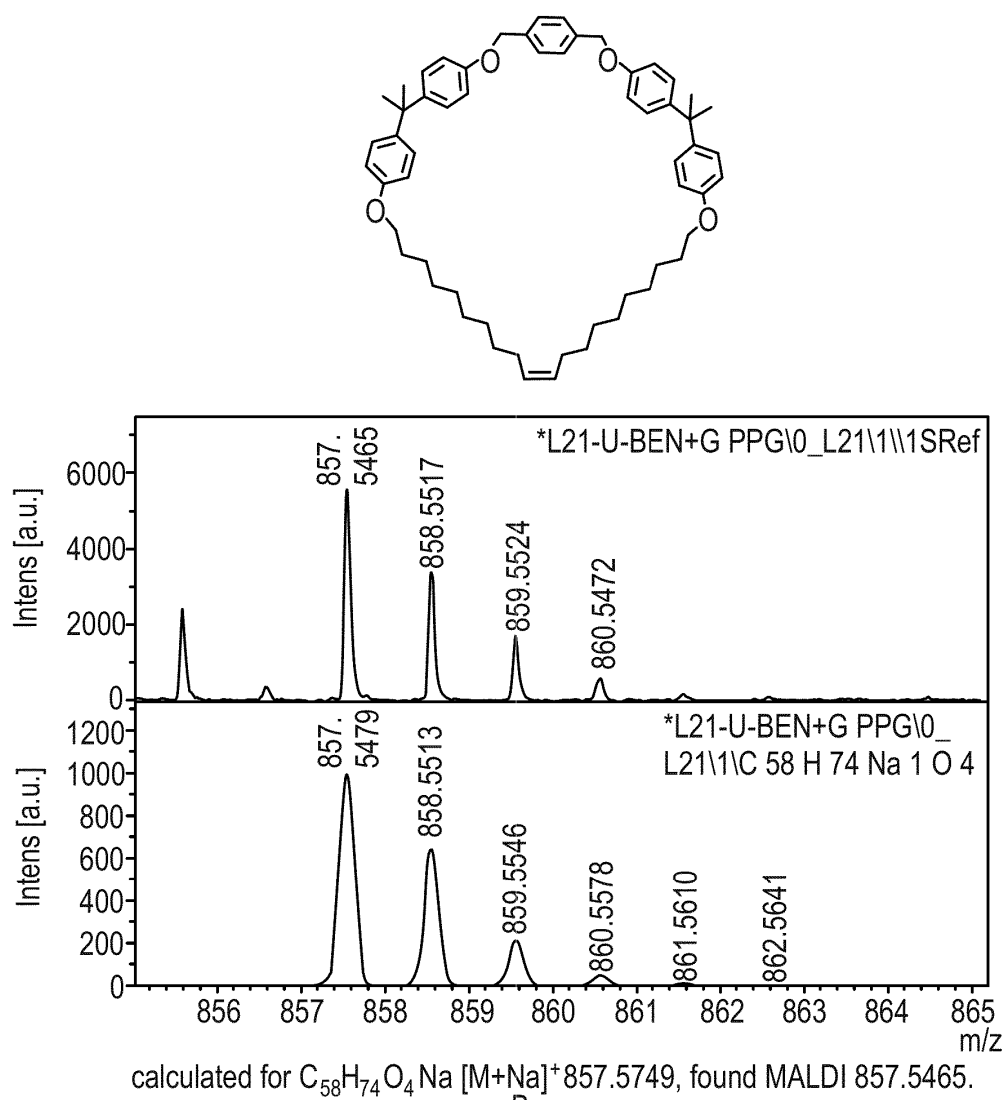


Fig. 40d (Continued)

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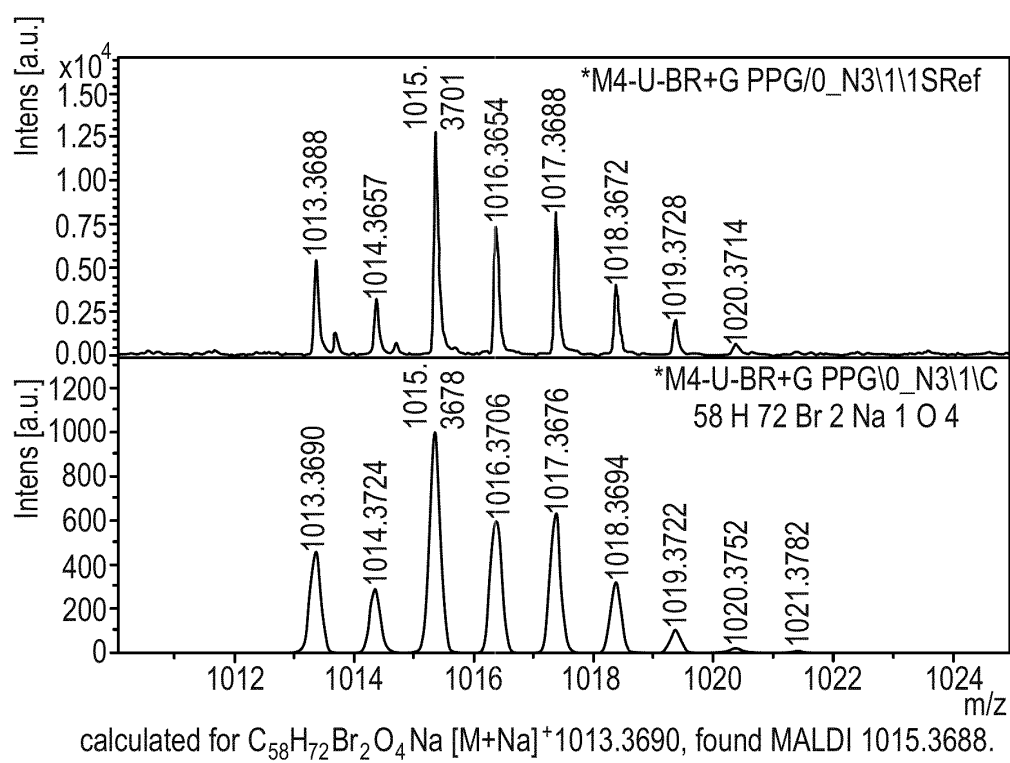


Fig. 40d (Continued)

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Preparation of macrocyclic molecule comprising tert-butoxycarbonyl (Boc)-protected amino groups.

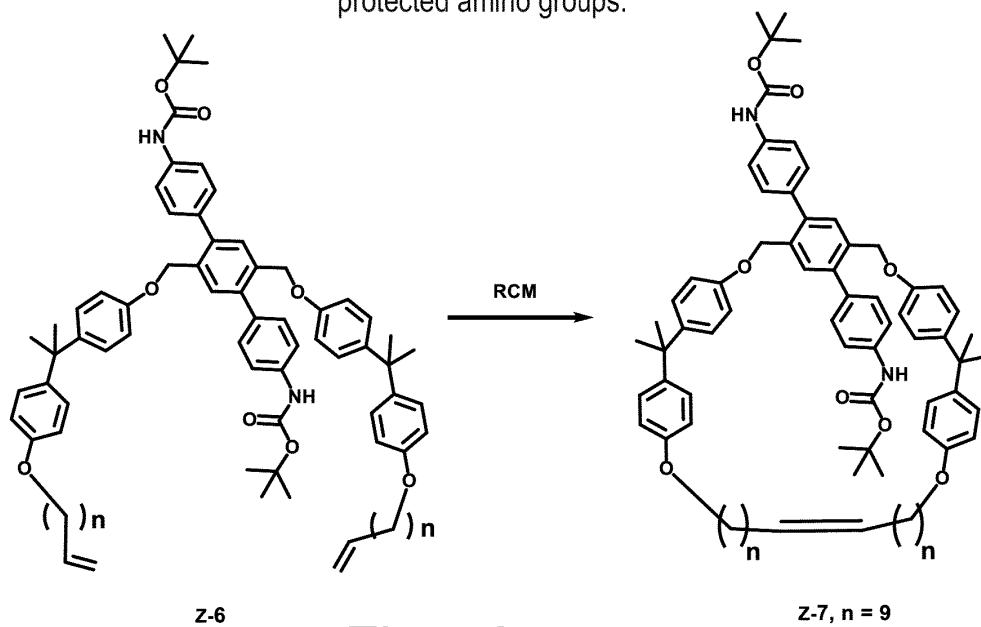


Fig. 40e

Structure of macrocyclic molecule comprising tert-butoxycarbonyl (Boc)-protected amino groups, wrapped around a single-walled carbon nanotube.

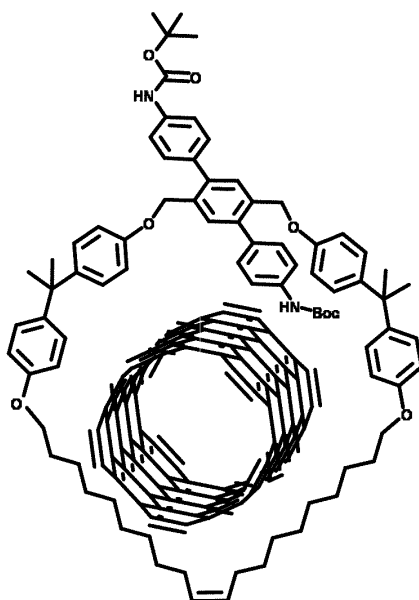


Fig. 40f

45/144

Preparation of macrocyclic molecule comprising amino groups.

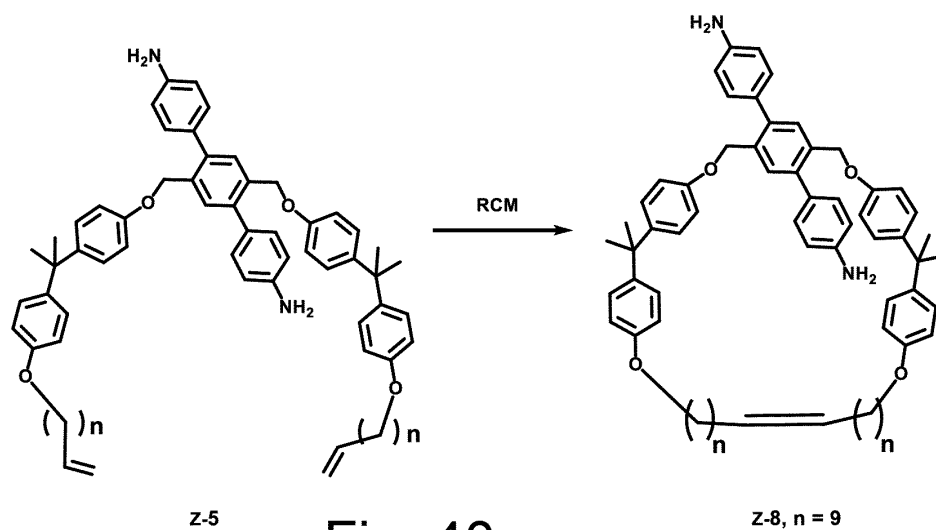


Fig. 40g

Structure of macrocyclic molecule comprising amino groups, wrapped around a single-walled carbon nanotube.

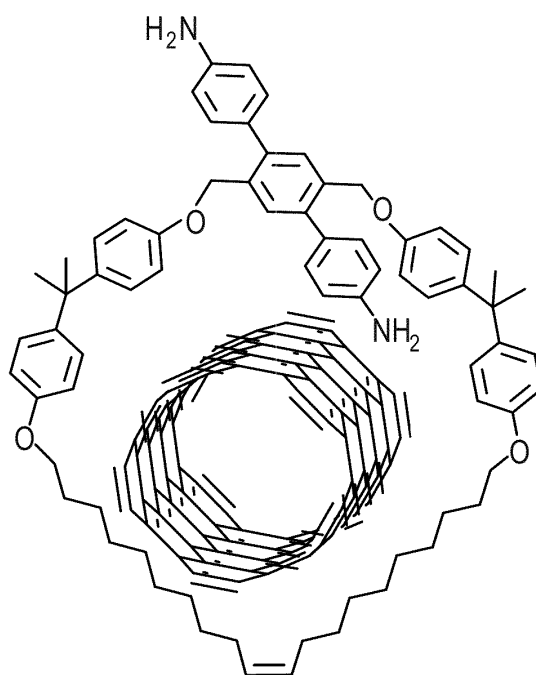


Fig. 40h

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Synthesis of bisphenol A (BPA) precursor-ML comprising amino groups.

Scheme 2

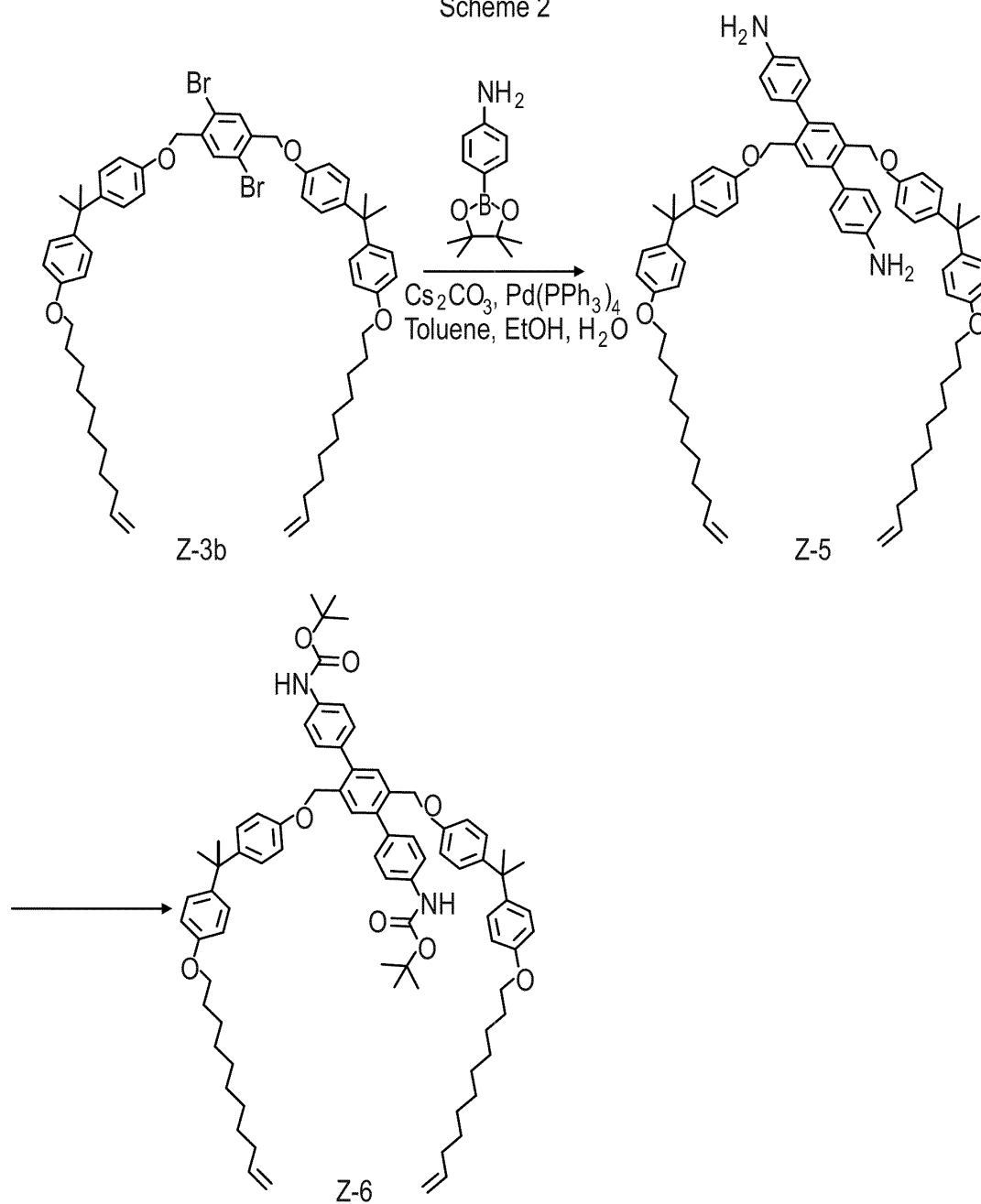


Fig. 40i

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Analytical data for bisphenol A (BPA) precursor-ML and macrocyclic molecule comprising amino groups.

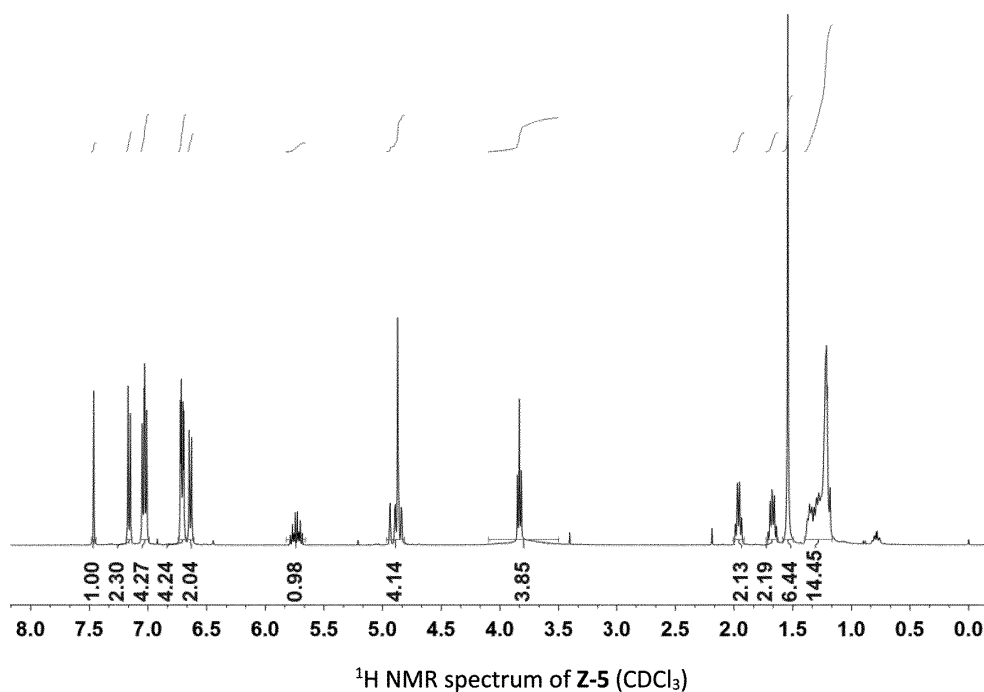
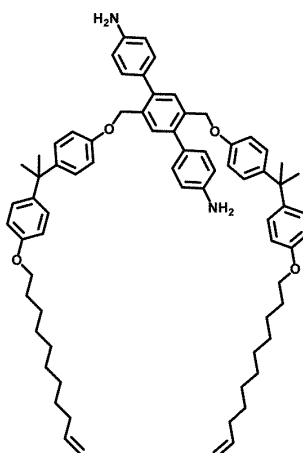
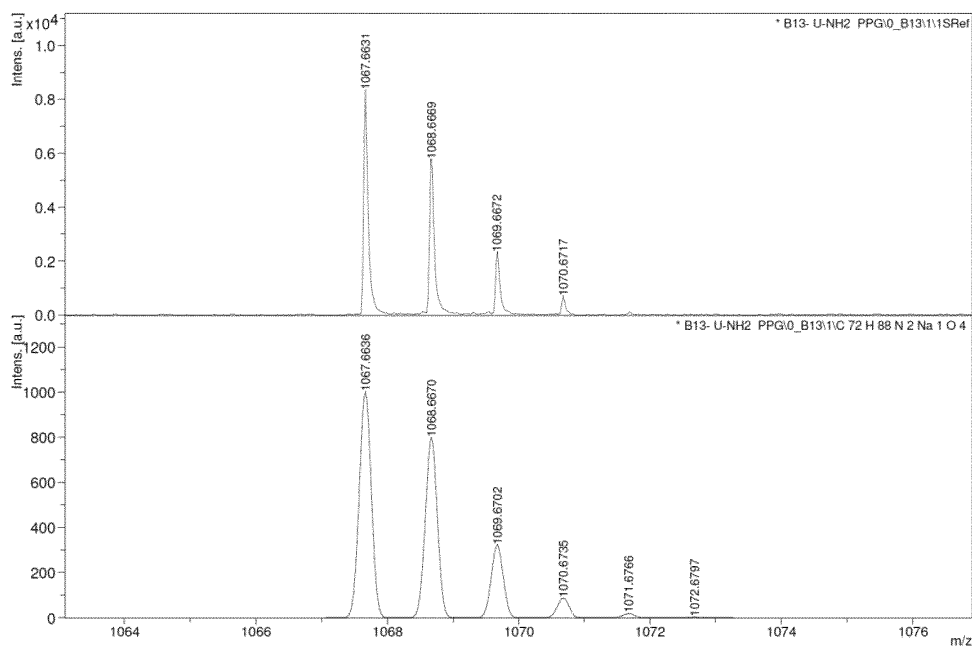
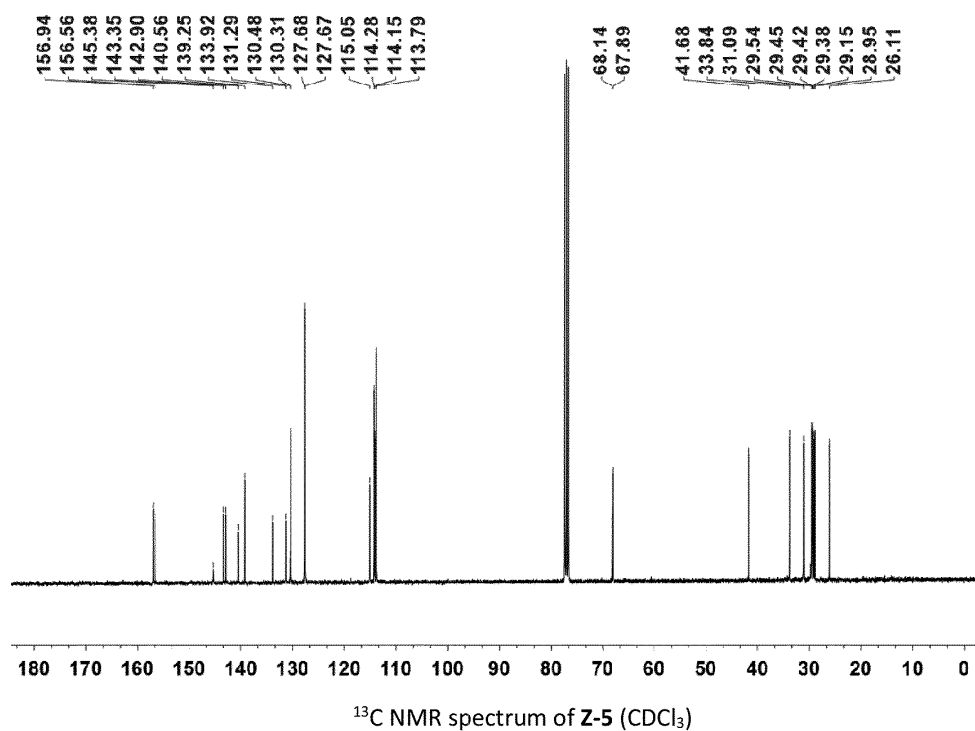


Fig. 40j

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calculated for C₇₂H₈₈N₂O₄Na [M+Na]⁺ 1067.6636, found MALDI 1067.6631.

Fig. 40j (Continued)

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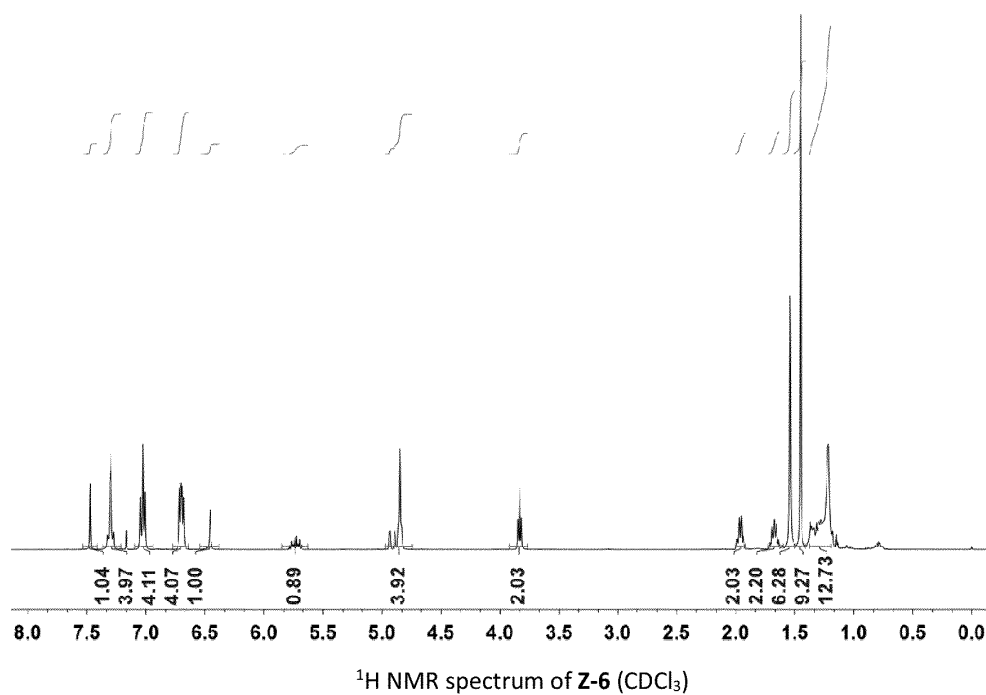
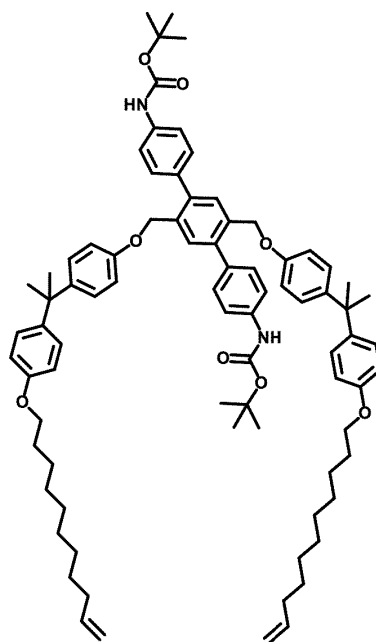
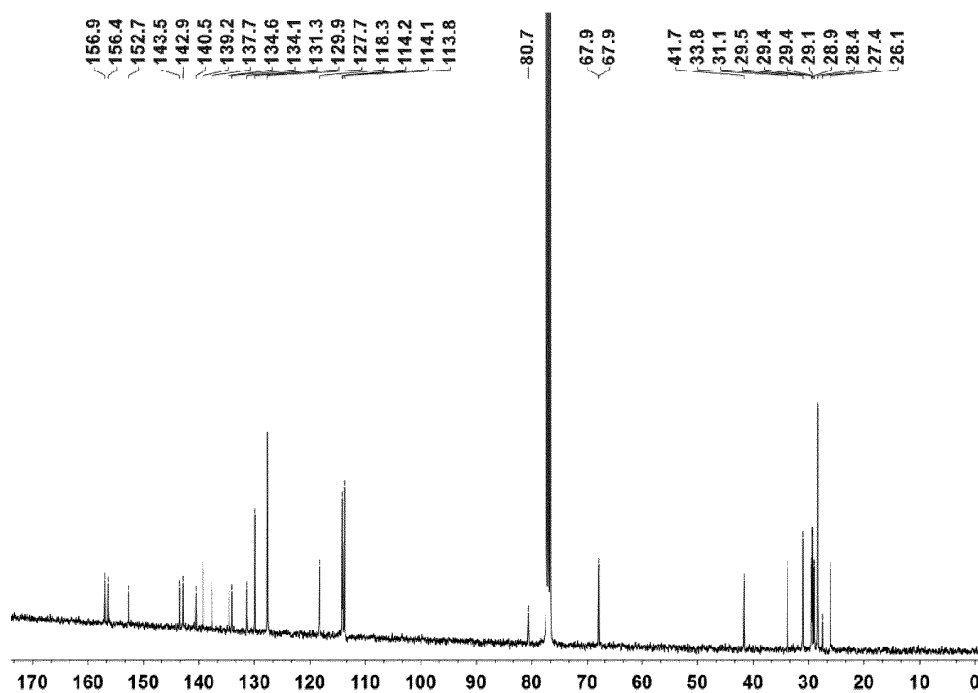
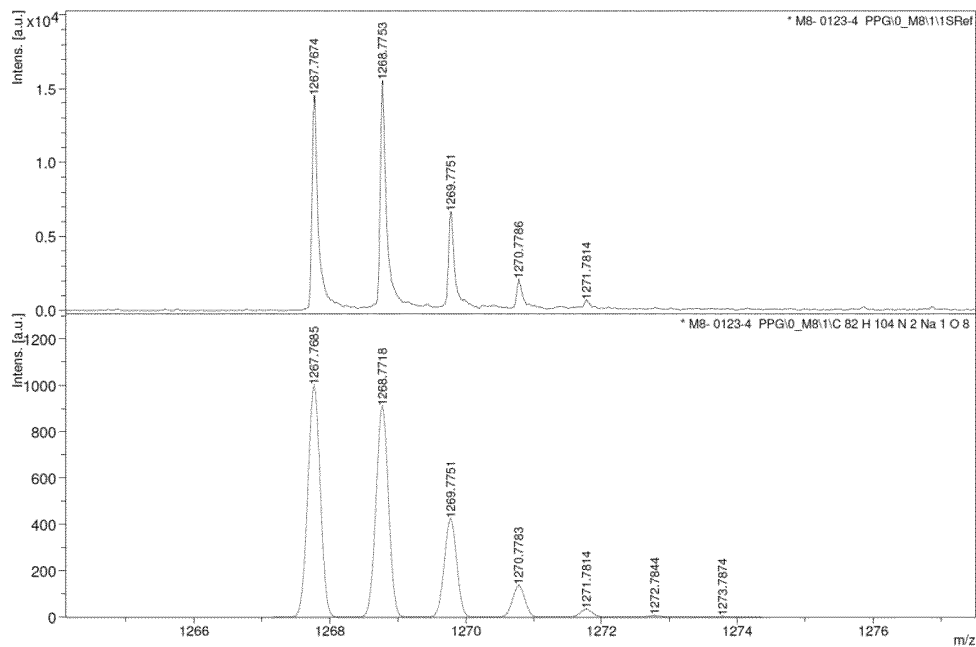


Fig. 40j (Continued)

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¹³C NMR spectrum of Z-6 (CDCl₃)

calculated for C₈₂H₁₀₄N₂O₈Na [M+Na]⁺ 1267.7685, found MALDI 1267.7674.

Fig. 40j (Continued)

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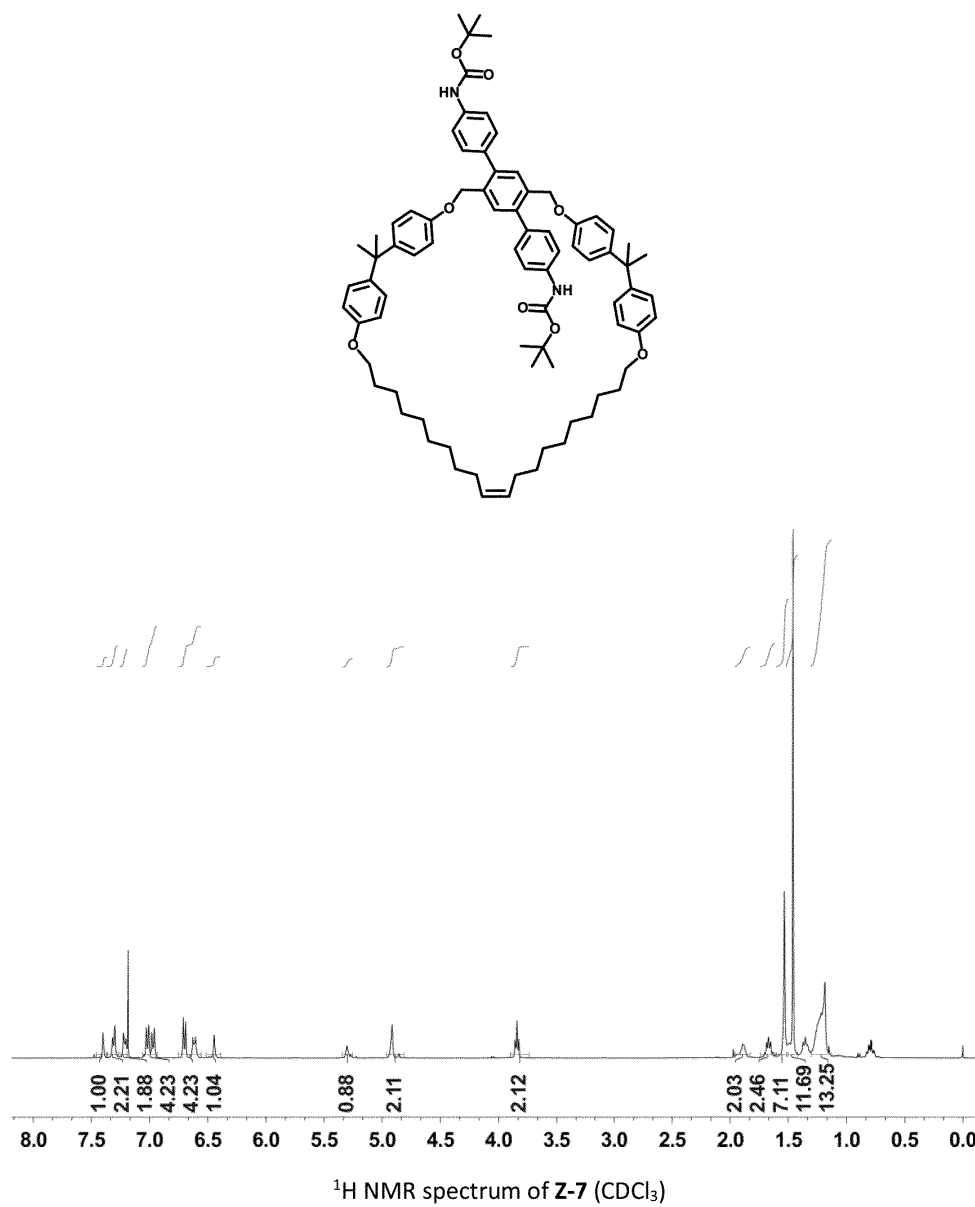
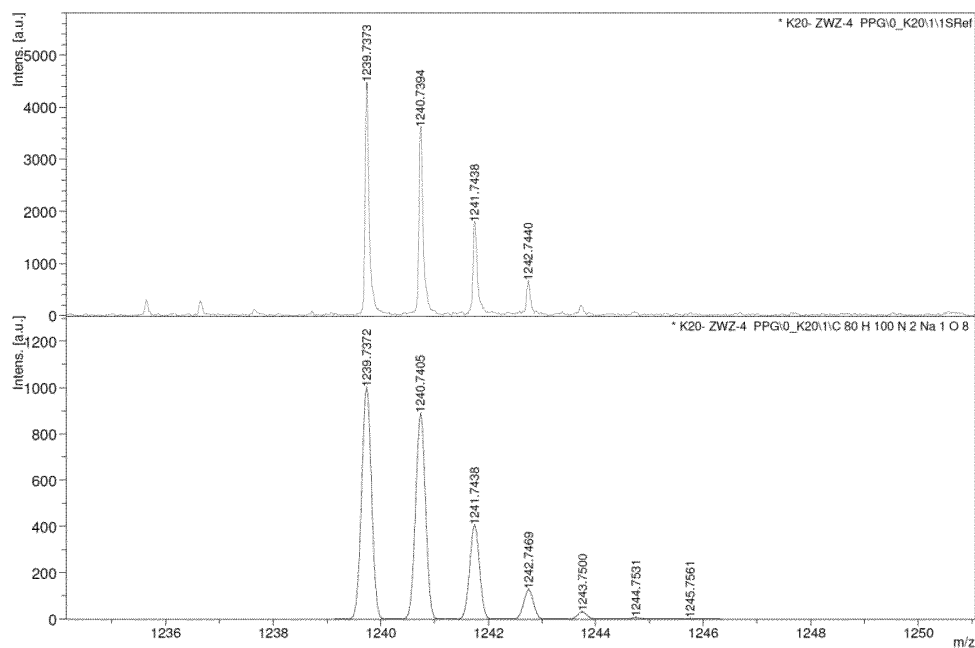


Fig. 40j (Continued)

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calculated for $C_{80}H_{100}N_2O_8Na$ $[M+Na]^+$ 1239.7372, found MALDI 1239.7373.

Fig. 40j (Continued)

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Different nanofillers used to prepare viscous suspensions of 10 (w/w) % PMMA polymer.

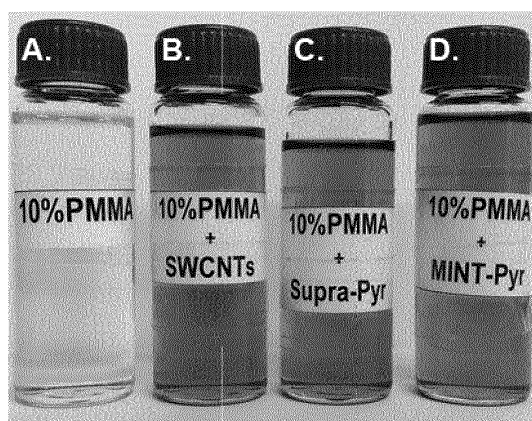


Fig. 41

Electrospun fibers of PMMA polymer (A) and PMMA with different nanofillers based on SWNT (B-D). No Macroscopic differences were observed.

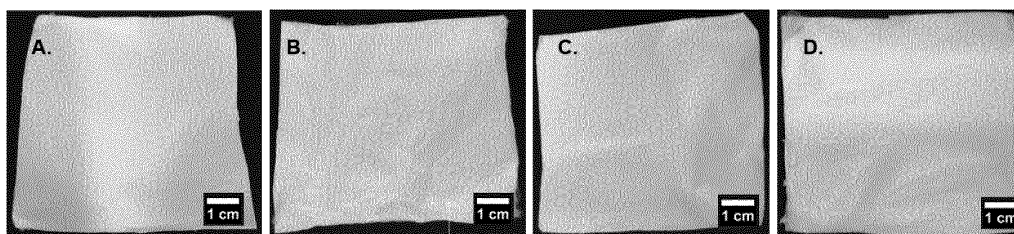


Fig. 42

Rectangular shaped PMMA fibers composite sample of dimensions of 1×4 cm placed at DMA Q800, TA instruments.

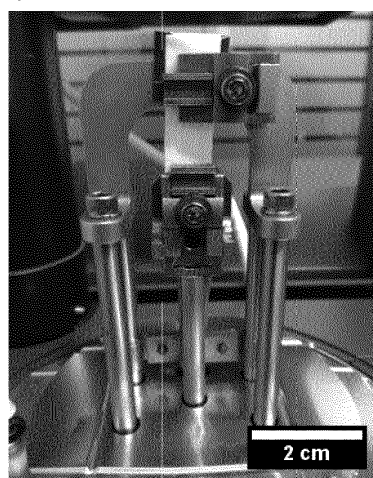


Fig. 43

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SEM pictures of PMMA polymer fibers (A) and PMMA with different nanofillers based on SWNT (B-D).

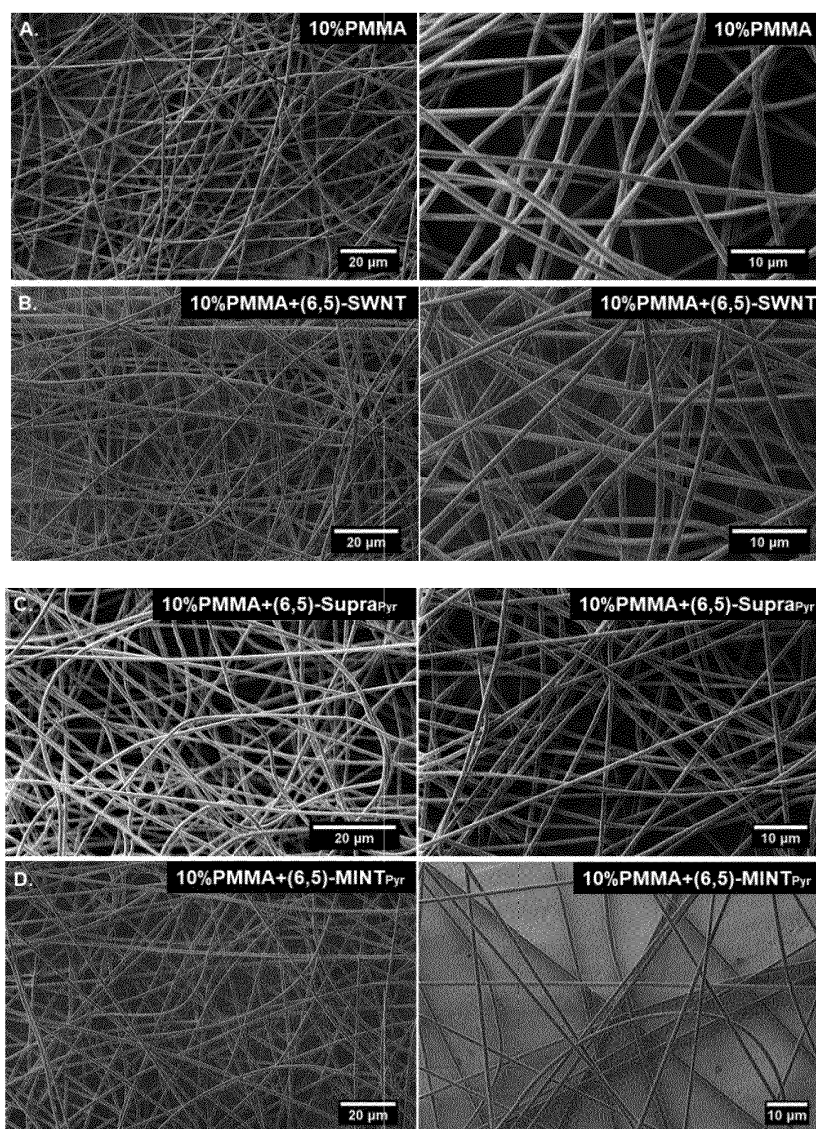


Fig. 44

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Diameter distributions for PMMA fibers estimated from SEM pictures.

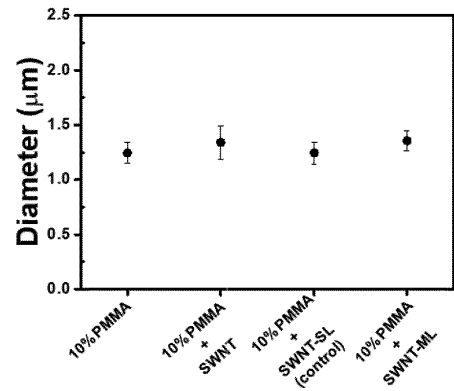


Fig. 45

Fiber area density distribution for PMMA electrospun fibers.

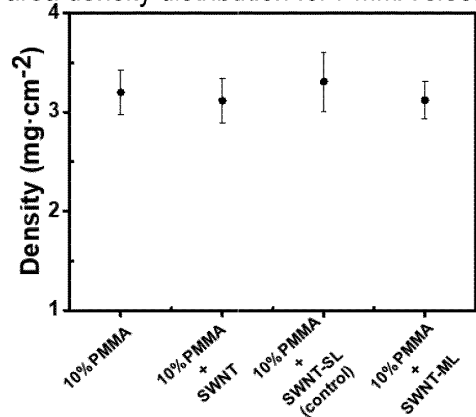


Fig. 46

Representative stress/strain curves of PMMA (grey) and its composites with SWNTs (black), “SWNT-SL of example H1” (blue) and “SWNT-ML of example B4” (red).

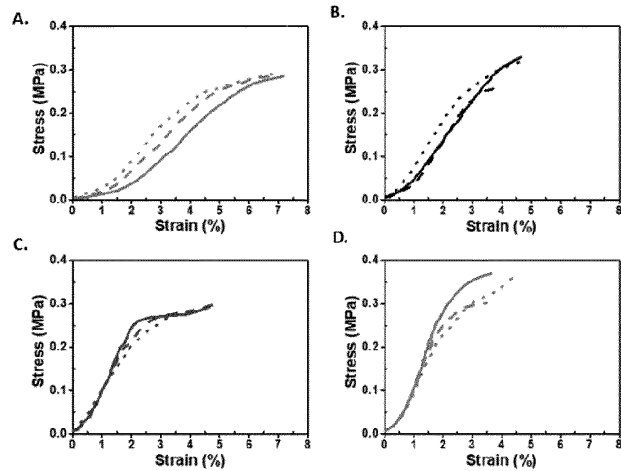


Fig. 47

Representative stress/strain curves of PMMA (grey), and its composites with SWNTs (black), “SWNT-SL of example H1” (blue) and “SWNT-ML of example B4” (red).

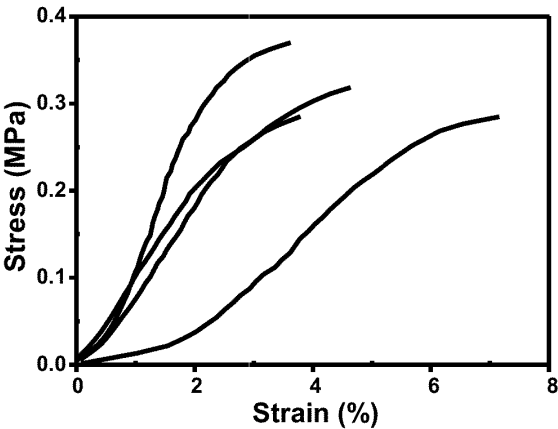


Fig. 48

Measured mechanical properties observed for PMMA polymer fibers and PMMA with different nanofillers based on SWNT. A. Young's Modulus. B. Tensile Strength C. Strain (%).

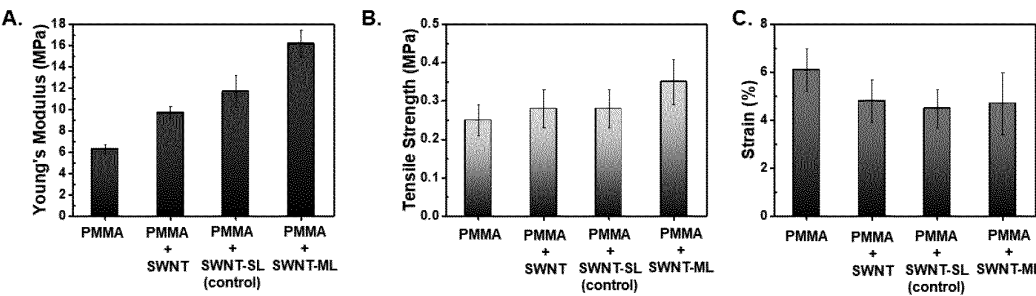


Fig. 49

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Different nanofillers used to prepare viscous suspensions of 25 (w/w) % PSU polymer.

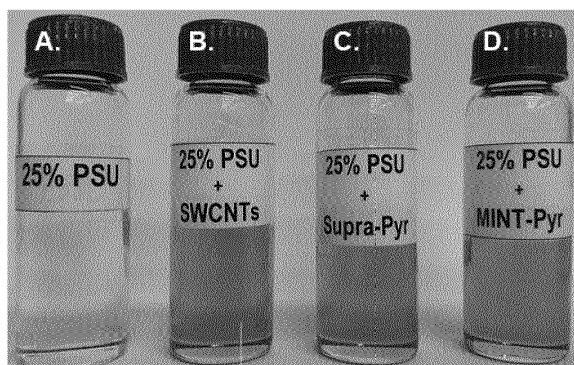


Fig. 50

Electrospun fibers of PSU polymer (A) and PSU with different nanofillers based on SWNT (B-D). No Macroscopic differences were observed.

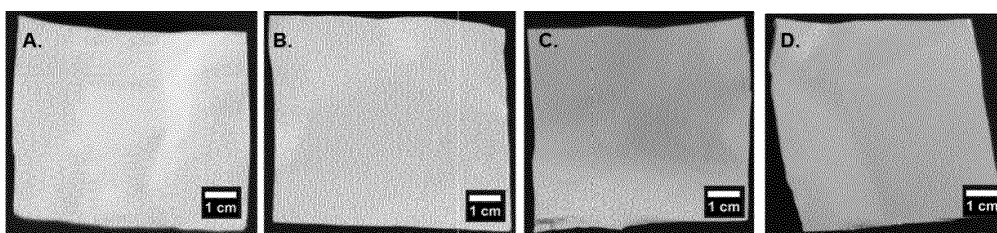


Fig. 51

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SEM pictures of PSU polymer fibers (A) and PSU with different nanofillers based on SWNT (B-D).

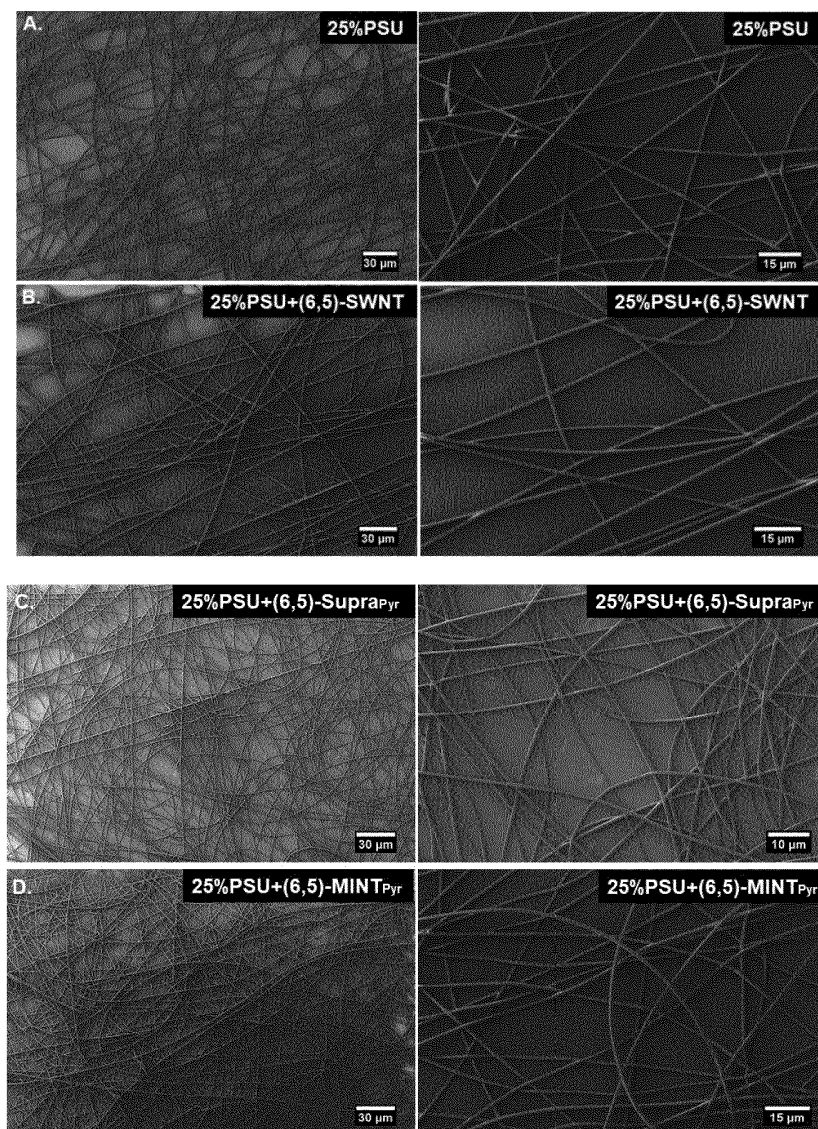


Fig. 52

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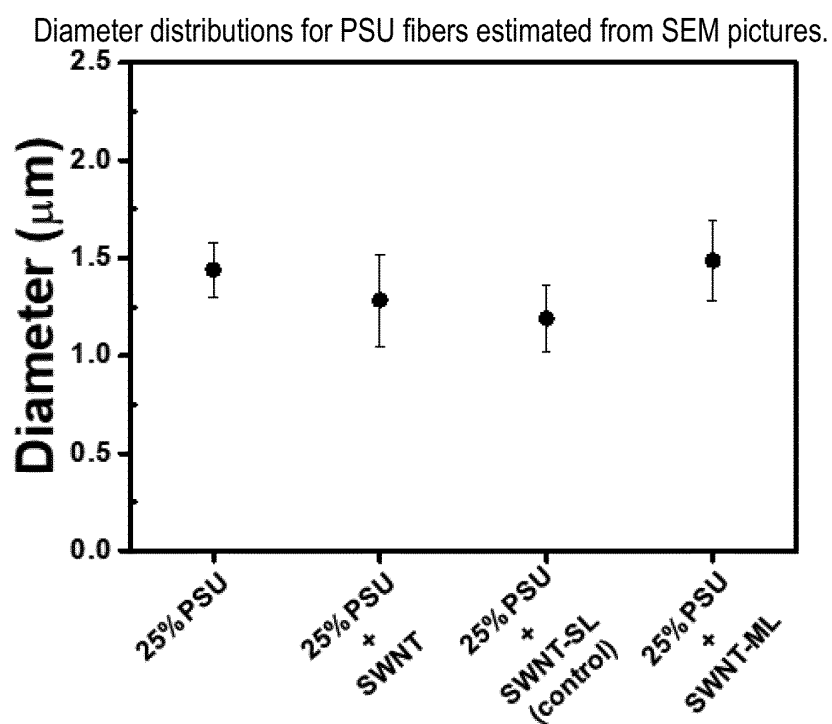


Fig. 53

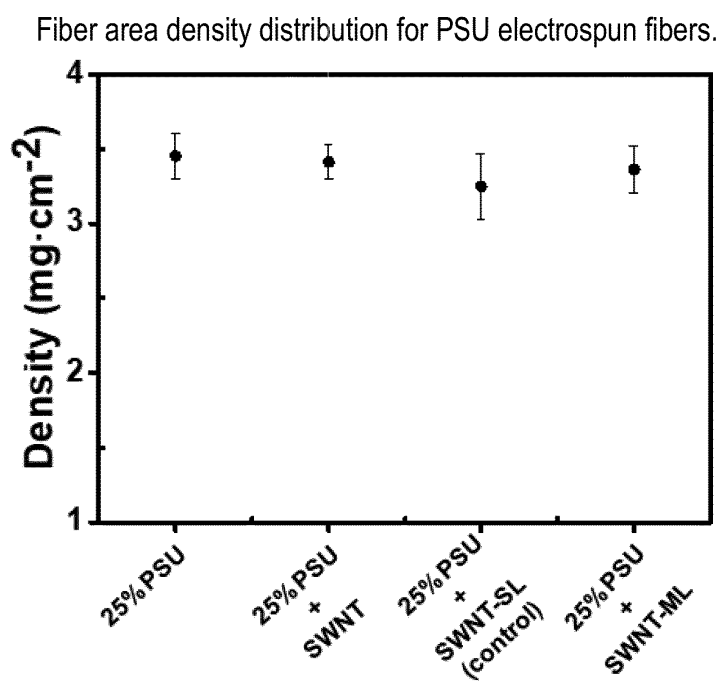


Fig. 54

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Representative Stress-Strain curves of PSU (grey) and its composites with SWNTs (black), "SWNT-SL of example H1" (blue); "SWNT-ML of example B4" (red).

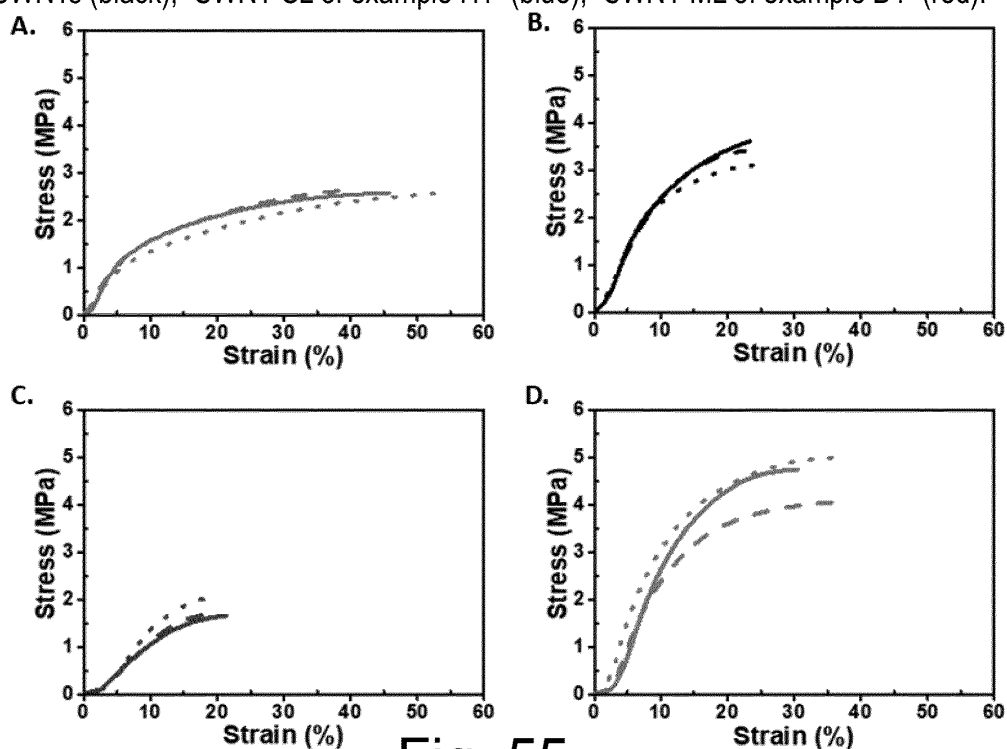


Fig. 55

Representative stress/strain curves of PSU (grey) and its composites with SWNTs (black), "SWNT-SL of example H1" (blue); "SWNT-ML of example B4" (red).

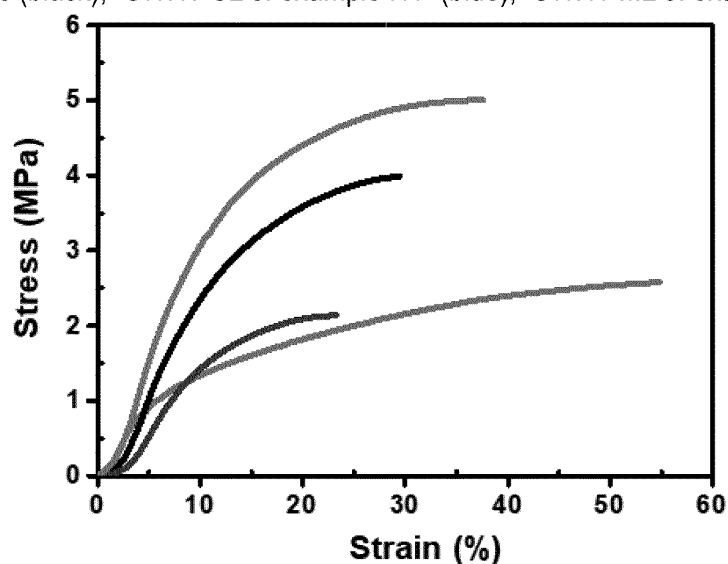


Fig. 56

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Measured mechanical properties observed for PSU polymer fibers and PSU with different nanofillers based on SWNT (B-D). A. Young's Modulus. B. Tensile Strength C. Strain (%).

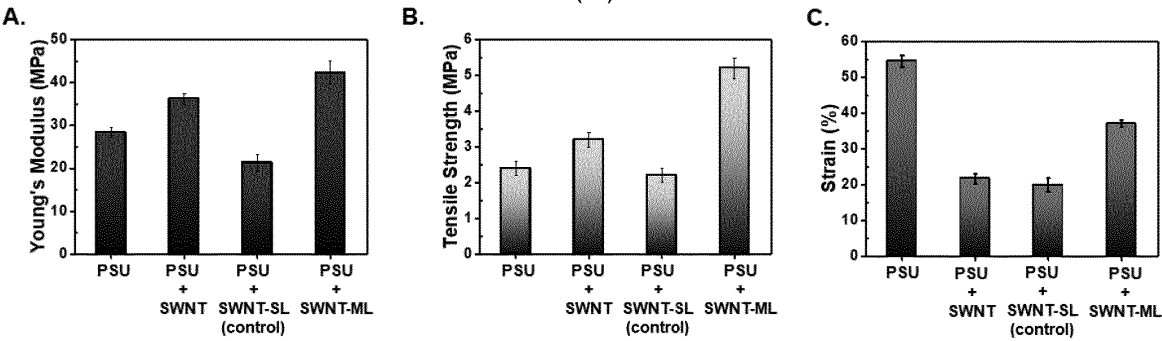


Fig. 57

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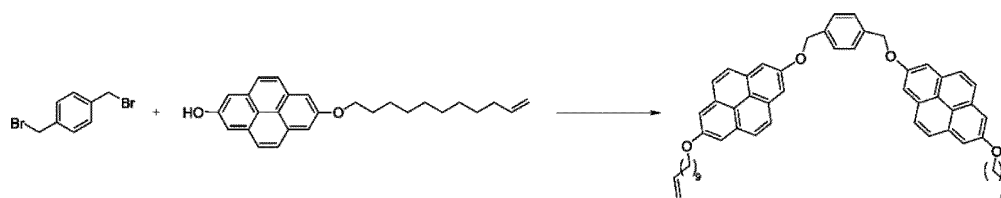


Fig. 58

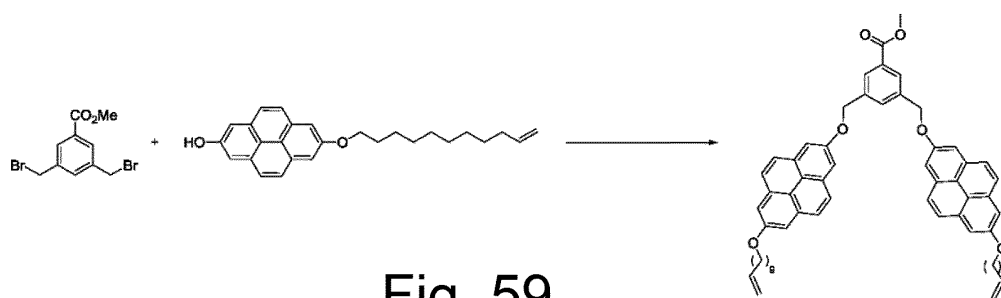


Fig. 59

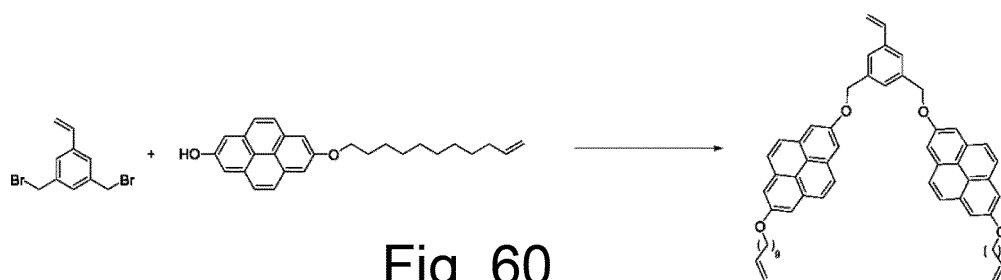


Fig. 60

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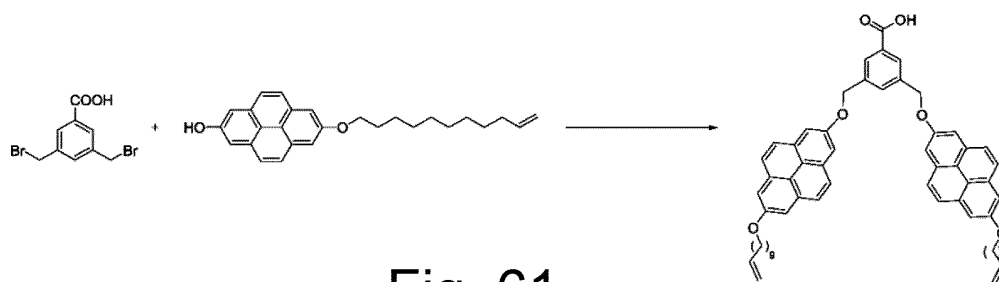


Fig. 61

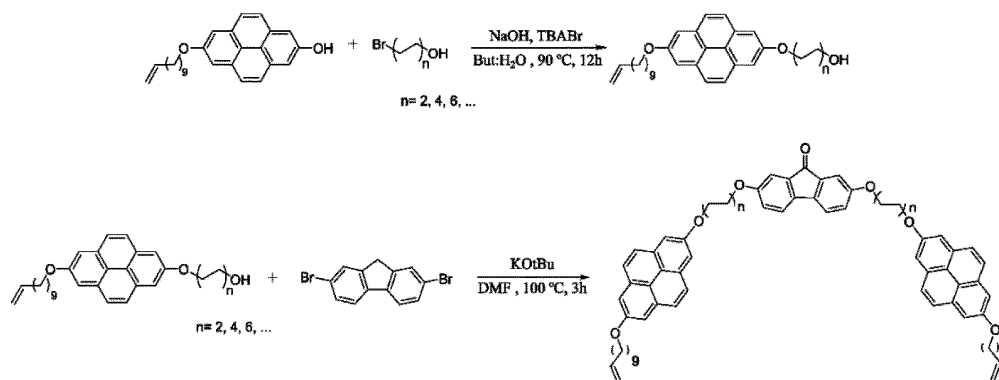


Fig. 62

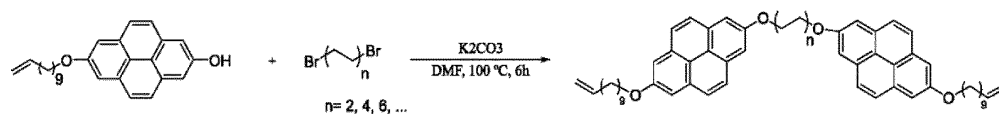


Fig. 63

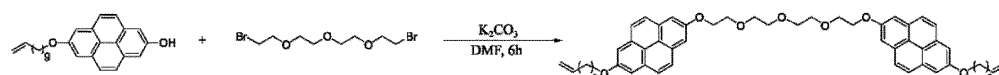


Fig. 64

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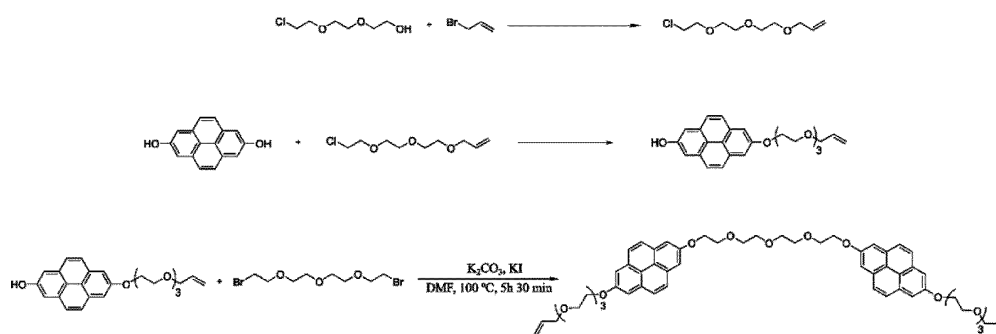


Fig. 65

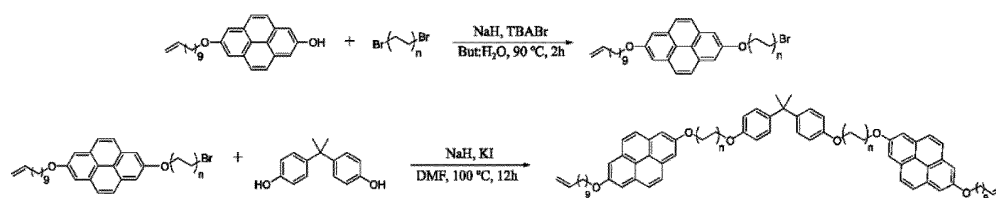


Fig. 66

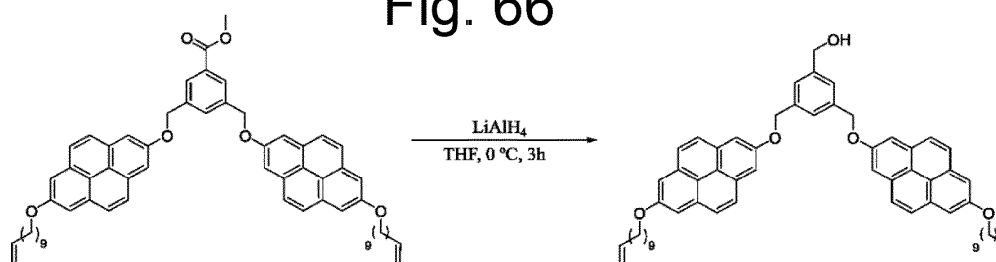


Fig. 67

Sample	Young's Modulus (MPa)	Standard deviation
Neat_PMMA	2360.97	107.05
PMMA_Tuball_0.1	2665.69	418.4
PMMA_Tuball_1.0	1860.08	238.14
PMMA_Chain_0.1	3732.77	1115.97
PMMA_Chain_1.0	3423.32	277.7
PMMA_Glycol_0.1	2910.89	140.35
PMMA_Glycol_1.0	2868.87	503.55

Fig. 68

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Sample	Young's Modulus (MPa)	Standard deviation
Neat_PVC	3235.51	-
PVC_Tuball_0.1	3515.42	191.3
PVC_Tuball_1.0	6694.85	236.2
PVC_Chain_0.1	3381.71	100.9
PVC_Chain_1.0	3672.11	31.2
PVC_Glycol_0.1	3970.43	500.7
PVC_Glycol_1.0	4119.14	61.5

Fig. 69

Sample	Young's Modulus (MPa)	Standard deviation
Neat_LDPE	322.18	16.25
LDPE_Tuball_0.1	332.51	36.16
LDPE_Tuball_1.0	343.32	28.75
LDPE_Chain_0.1	350.66	45.82
LDPE_Chain_1.0	342.32	28.75
LDPE_Glycol_0.1	406.44	88.03
LDPE_Glycol_1.0	449.68	91.14

Fig. 70

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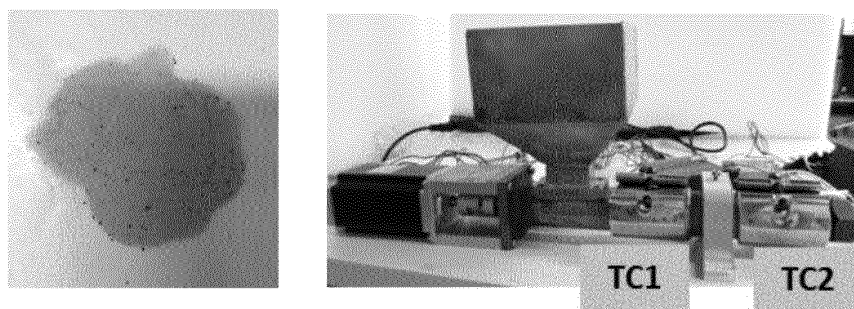


Fig. 71

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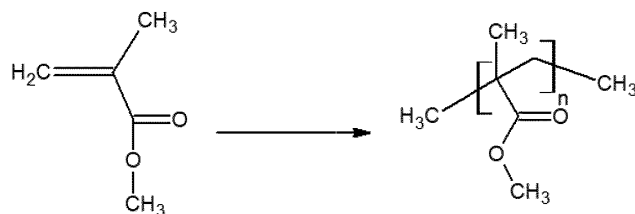


Fig. 72

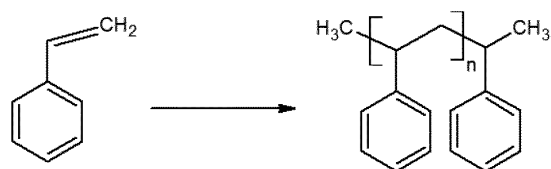


Fig. 73

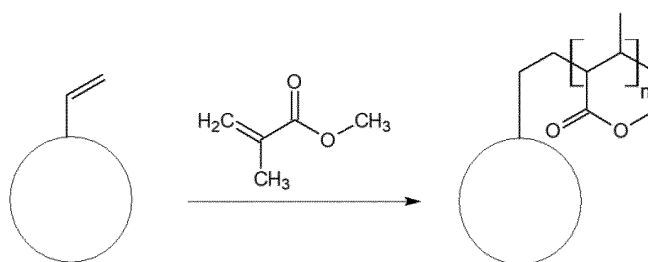


Fig. 74

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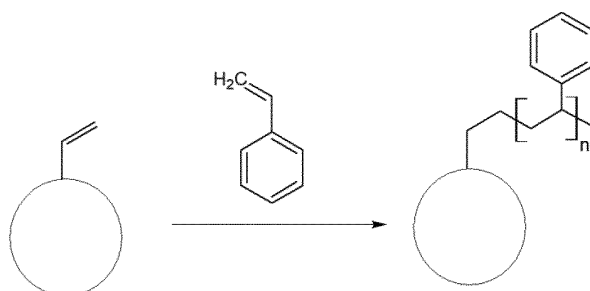


Fig. 75



Fig. 76

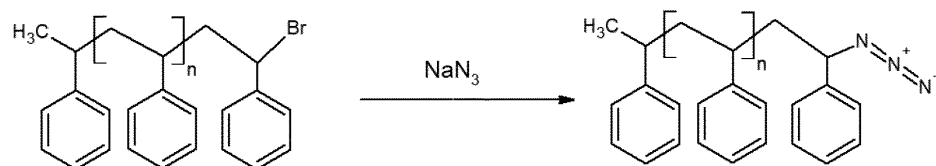


Fig. 77

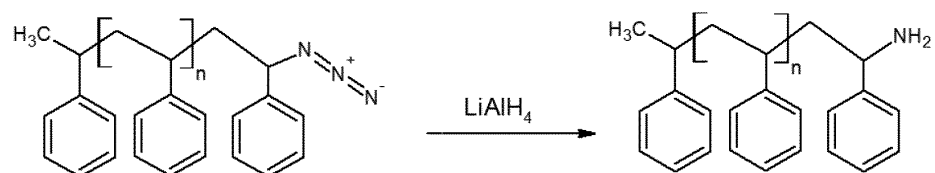


Fig. 78

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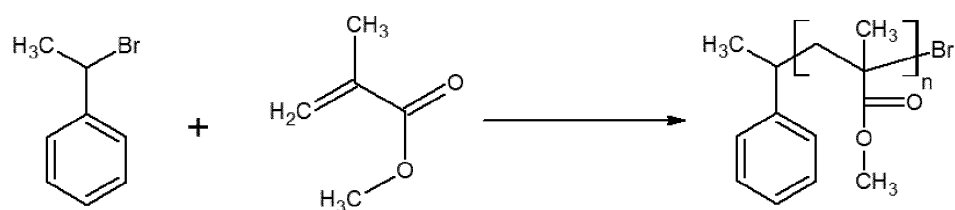


Fig. 79

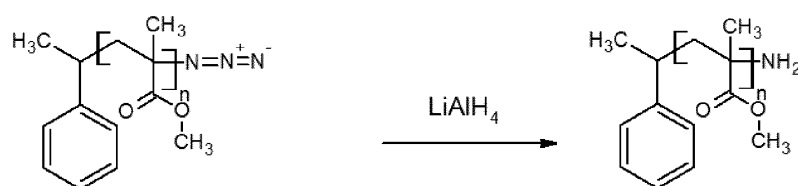


Fig. 80

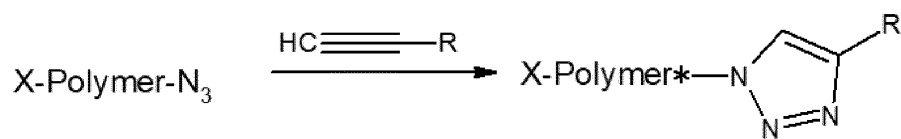


Fig. 81

Figure of "ATRP's initiator MINTs of Example CC 19"

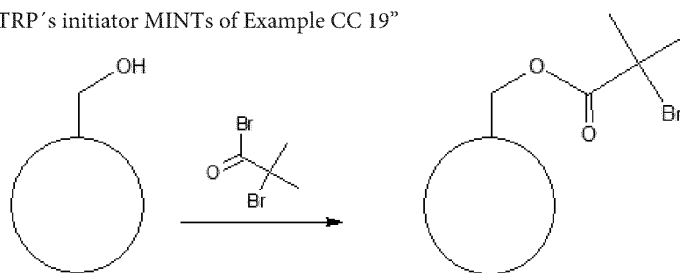


Fig. 82

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Figure of "ATRP PS grafting from of example CC 19"

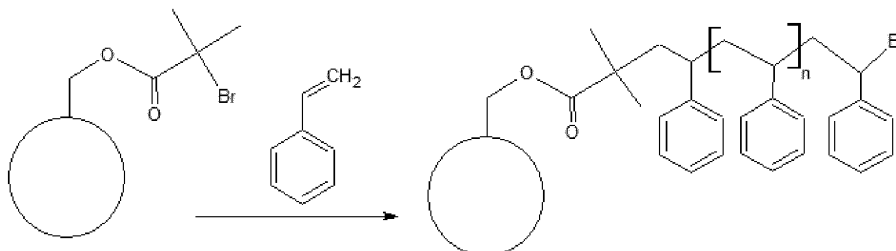


Fig. 83

Figure of "ATRP PMMA grafting from of example CC 20"

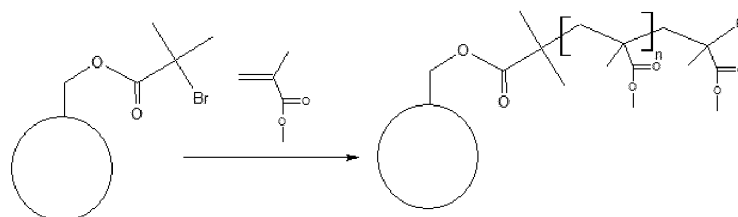


Fig. 84

Figure of "ROP PCL-MINTs composite".

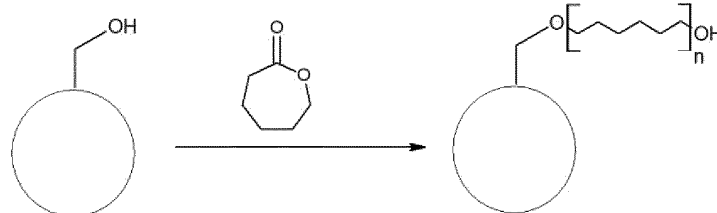


Fig. 85

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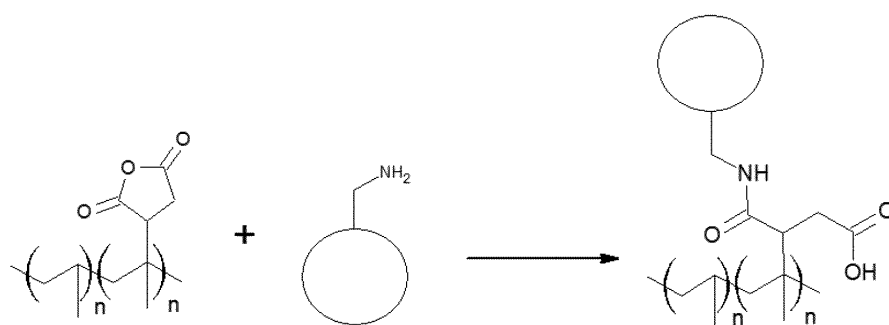
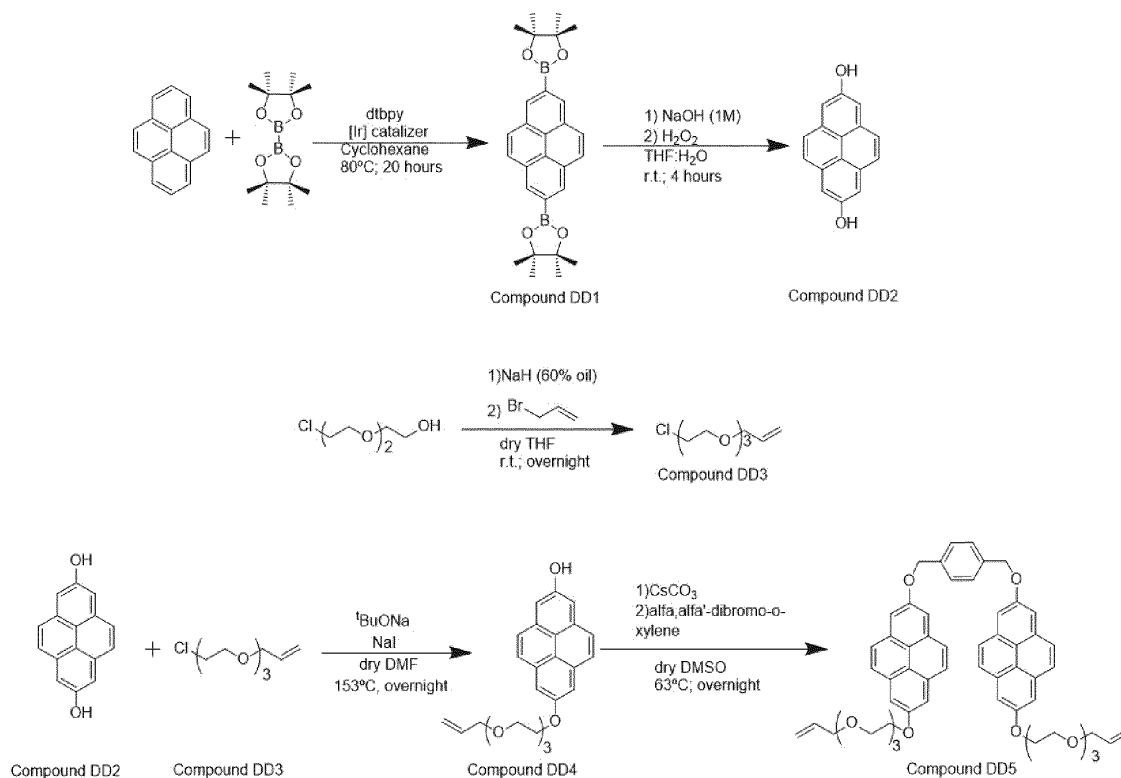


Fig. 86

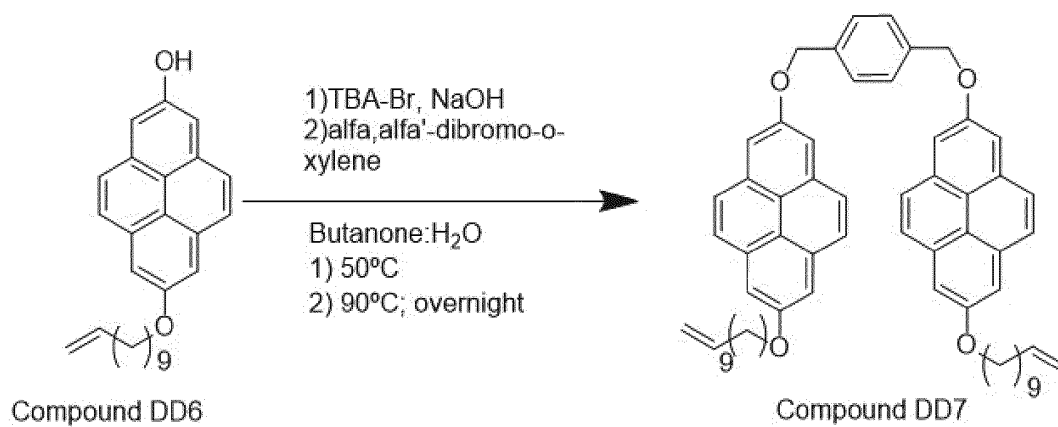
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The figure explains the synthetic route from commercial pyrene until the obtaining "Polyethoxy monoalkylated of Example DD4".

Fig. 87

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The figure explains the synthetic route from monoalkylated pyrene until the obtaining "Pyrene U-Shape of Example DD6".

Fig. 88

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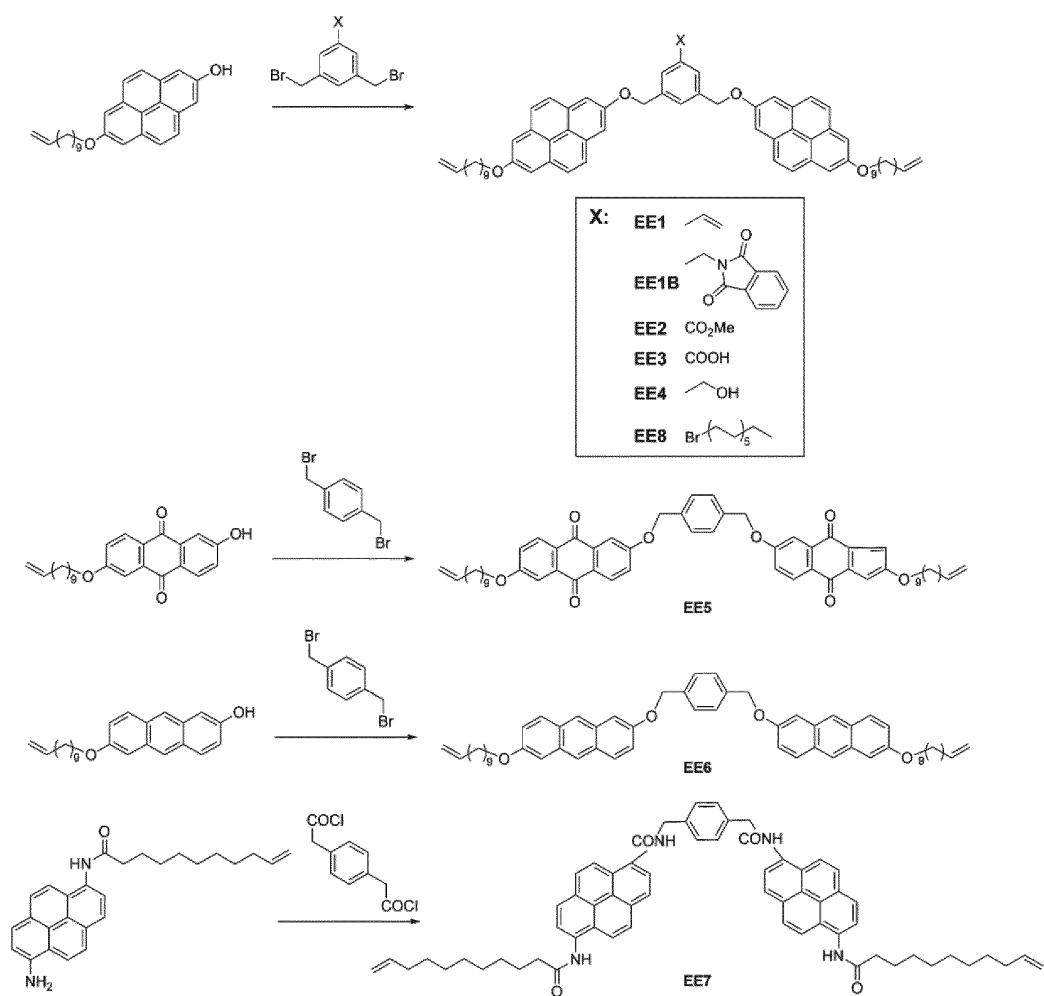


Fig. 89

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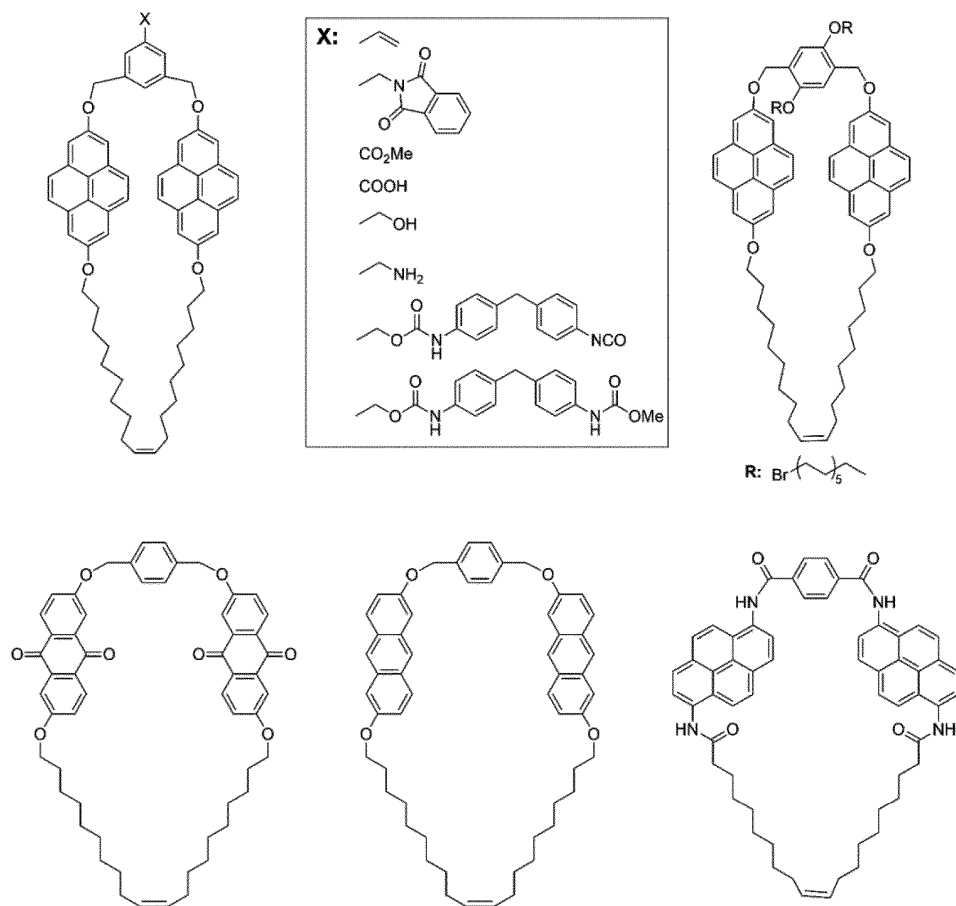


Fig. 90

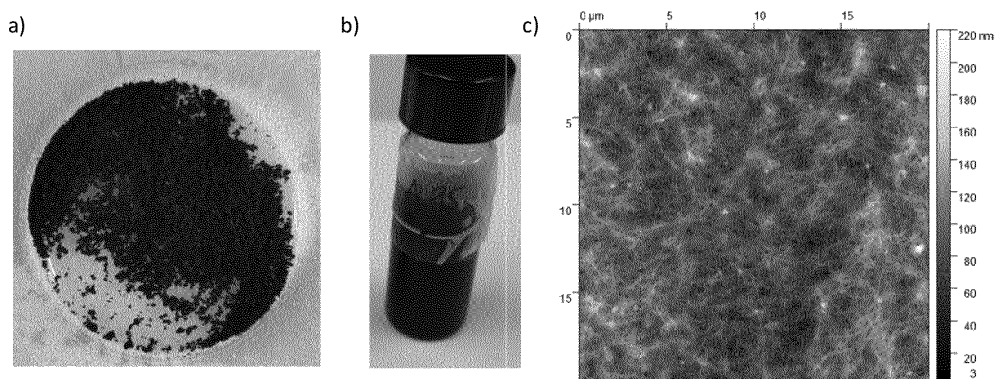


Fig. 91

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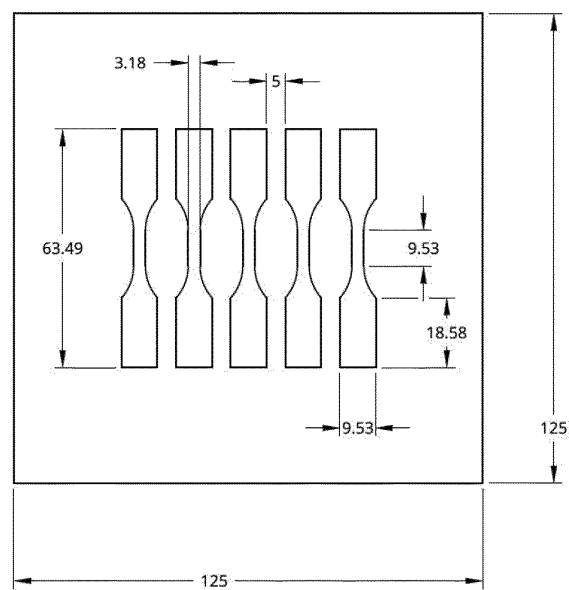


Fig. 92

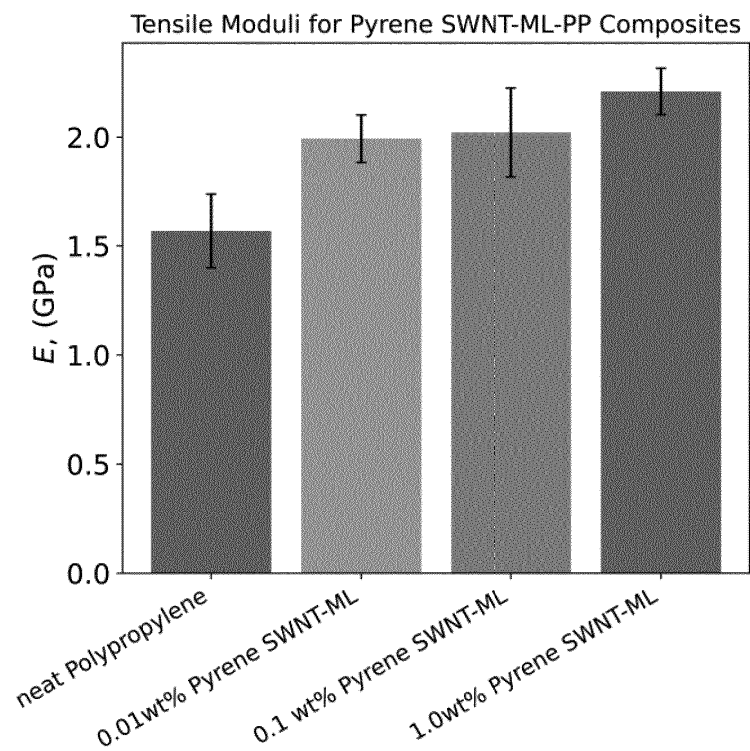


Fig. 93

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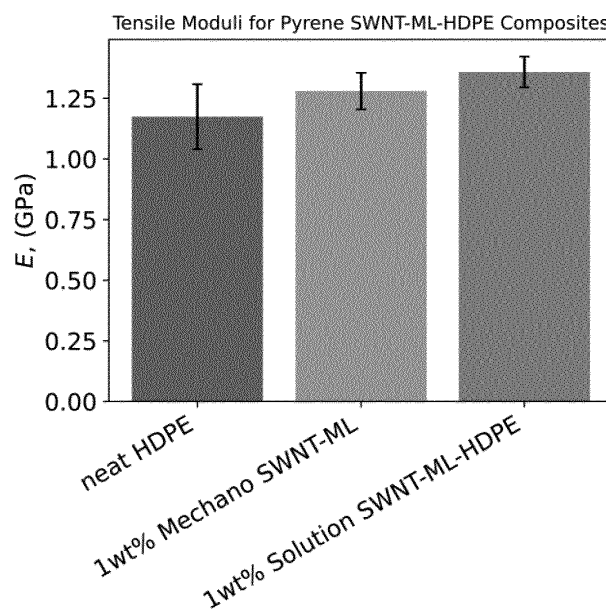


Fig. 94

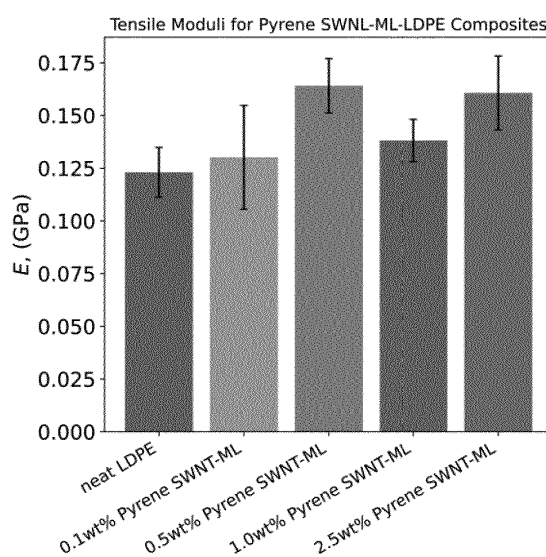


Fig. 95

78/144

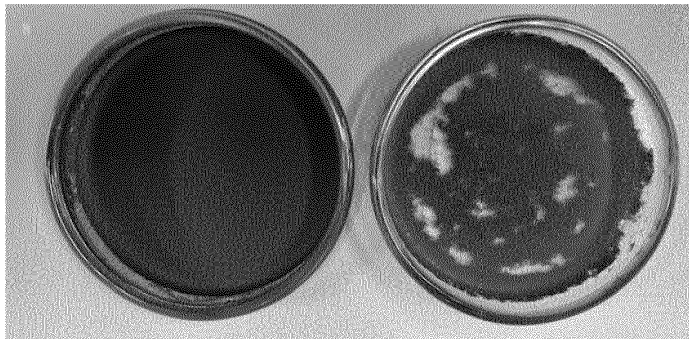


Fig. 96

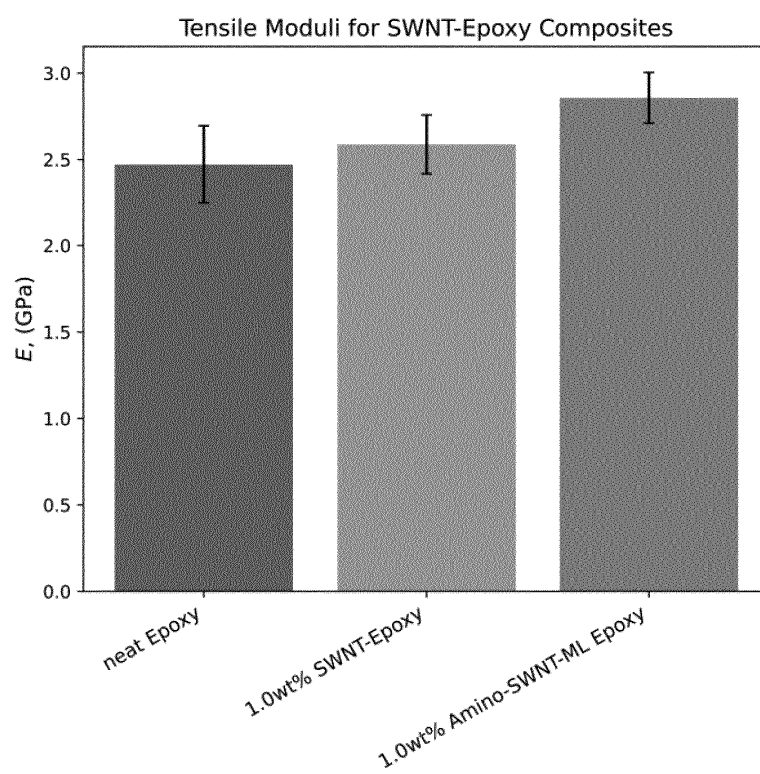


Fig. 97

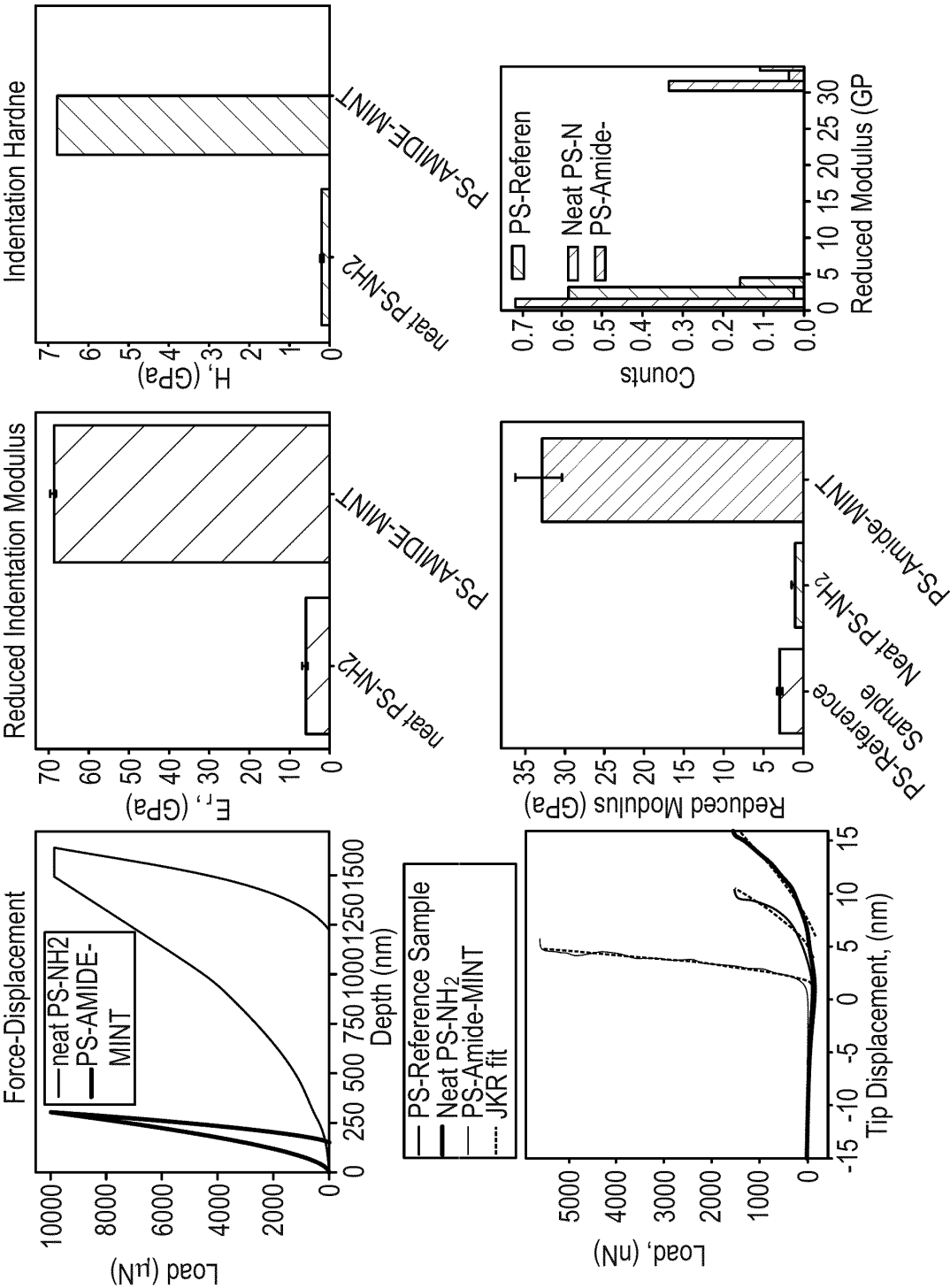


Fig. 98

Fig. 99

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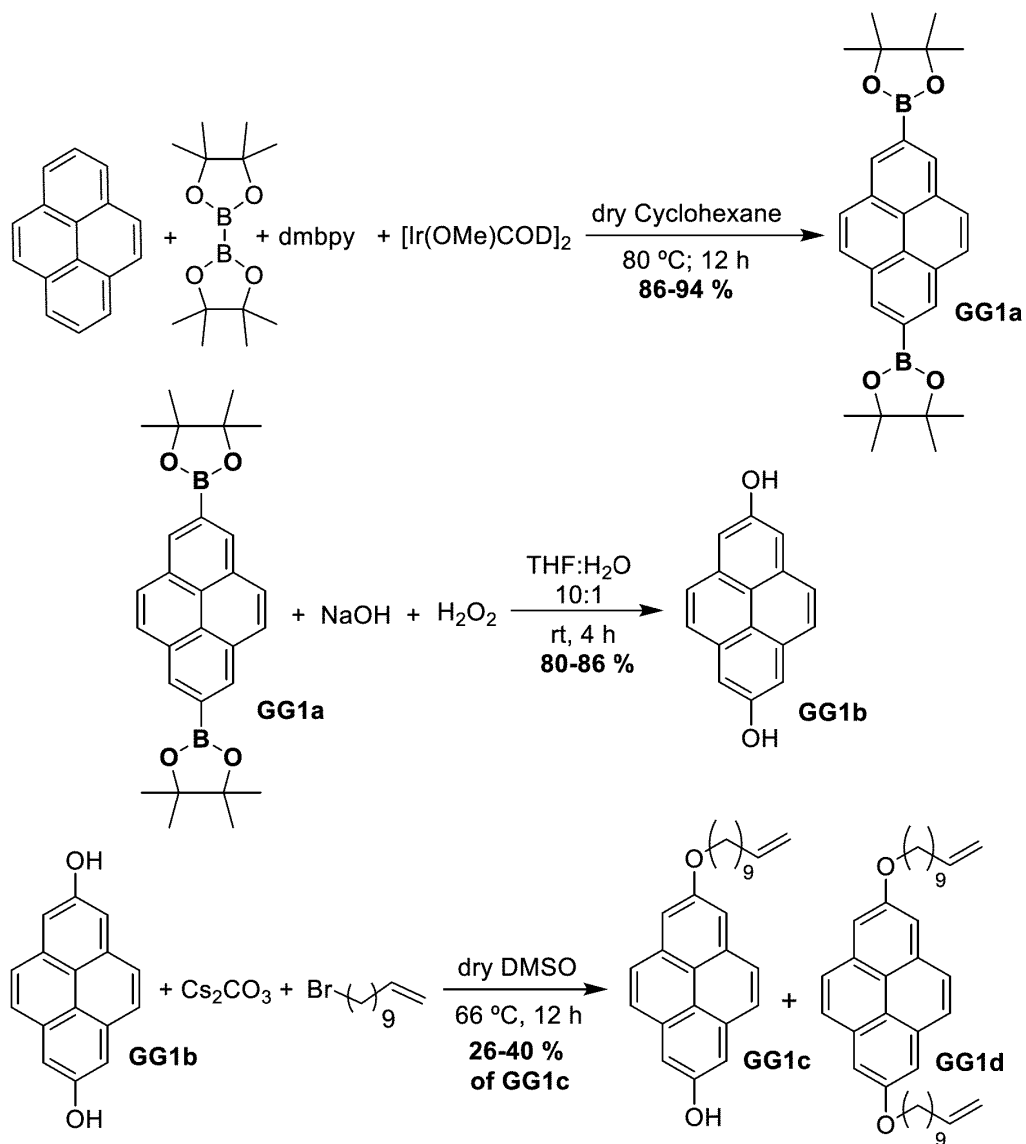


Fig. 100

Commercial $\xrightarrow[\text{ii) rt, 6h}]{\text{dry THF, i) } 0^\circ\text{C, 30 min, LiAlH}_4}$ GG2a (70-90%)

Imidazole + (Boc) $_2$ O $\xrightarrow[\text{rt; 2h}]{\text{dry DCM}}$ Boc-Imidazole (quant.)

Boc-Imidazole + H $_2$ N-CH $_2$ -CH $_2$ -NHBoc $\xrightarrow[\text{60 } ^\circ\text{C, 3h}]{\text{dry Toluene}}$ GG2b (94%)

GG2b + K $_2$ CO $_3$ + BnO-CO-Br $\xrightarrow[\text{rt; 12h}]{\text{THF:H}_2\text{O, 25:1}}$ GG2c (86%)

GG2c + Pd/C $\xrightarrow[\text{rt; 12h}]{\text{under H}_2, \text{MeOH}}$ GG2d (70%)

GG2d + GG2a + EEDQ $\xrightarrow[\text{rt; 16h}]{\text{dry DCM/ACN, (2:1)}}$ GG2e (70-80%)

GG2e + GG1c + PPh $_3$ + DIAD $\xrightarrow[\text{rt; 16h}]{\text{dry THF}}$ GG2f (42-53%)

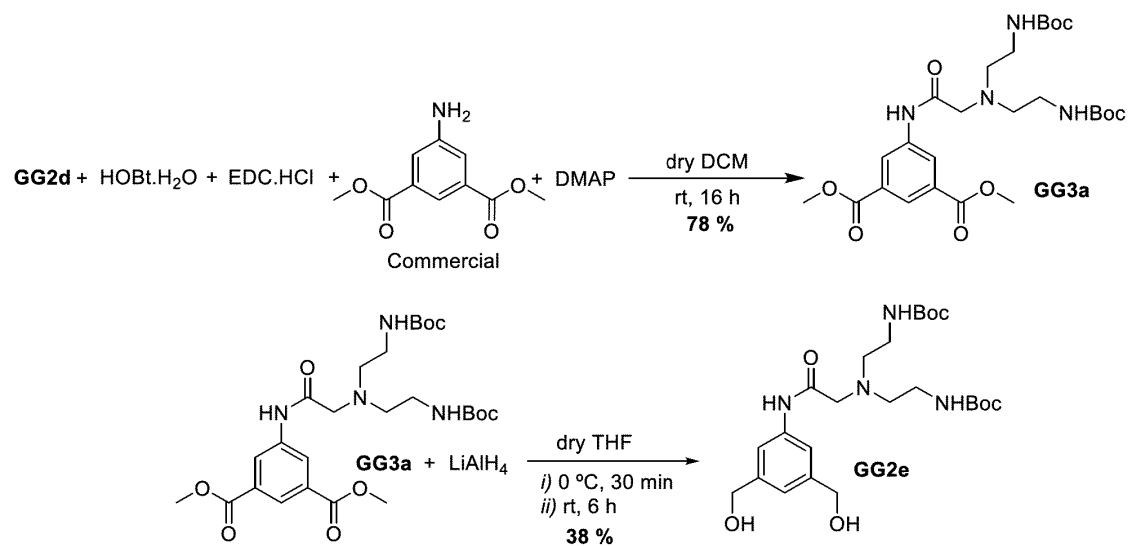
Crude GG2f + ZnCl $_2$ $\xrightarrow[\text{ii) rt, overnight}]{\text{i) } 78^\circ\text{C, 30 min, abs EtOH}}$ Zn(O=PPh $_3$) $_2$ Cl $_2$ + GG2f

Fig. 101

Fig. 101

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a.



b.

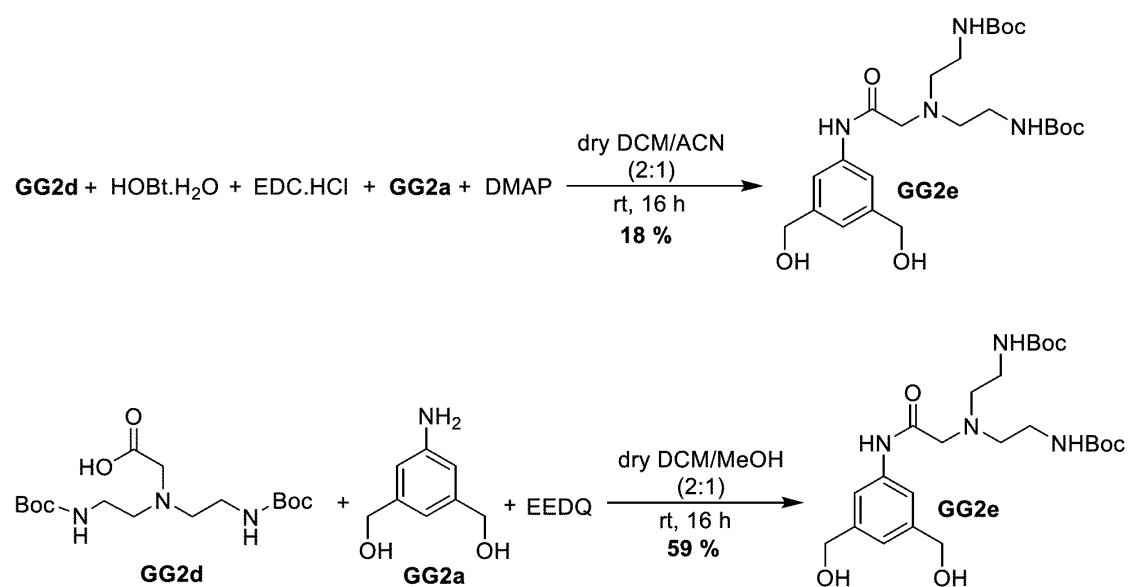


Fig. 102

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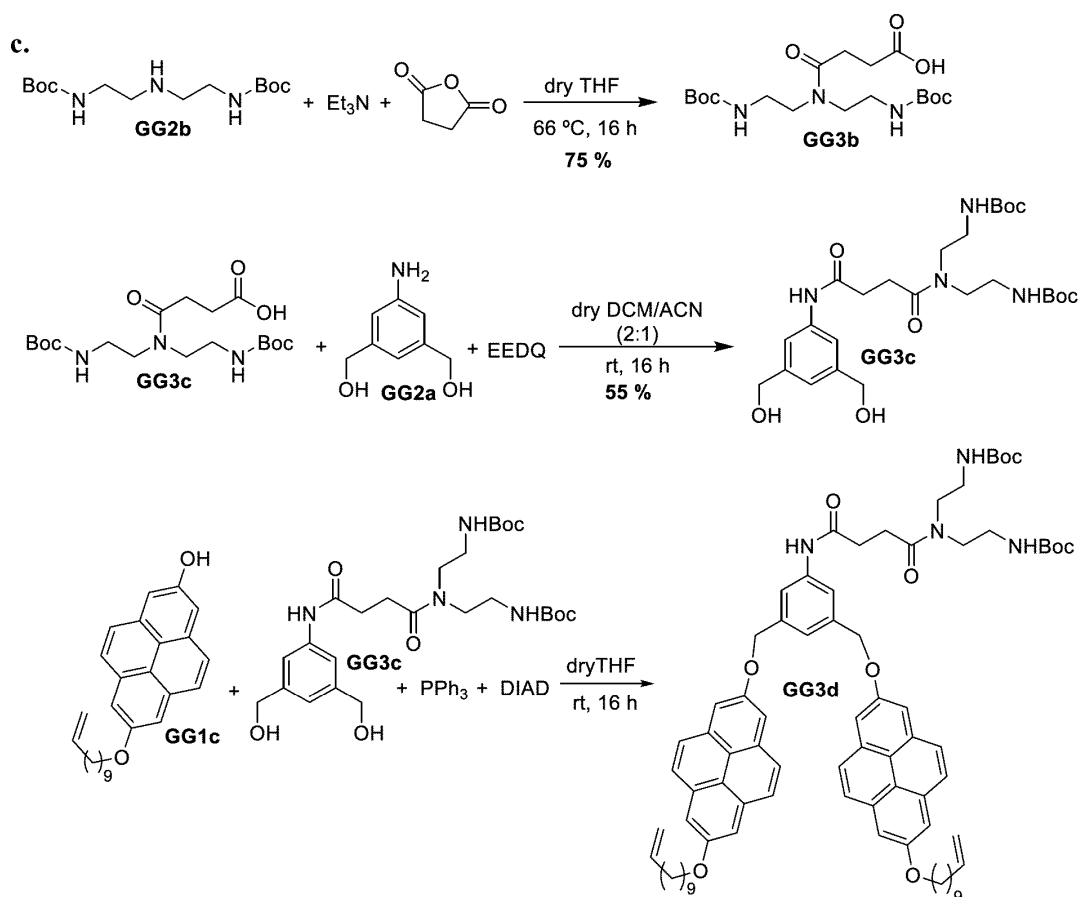


Fig. 102 (Continued)

84/144

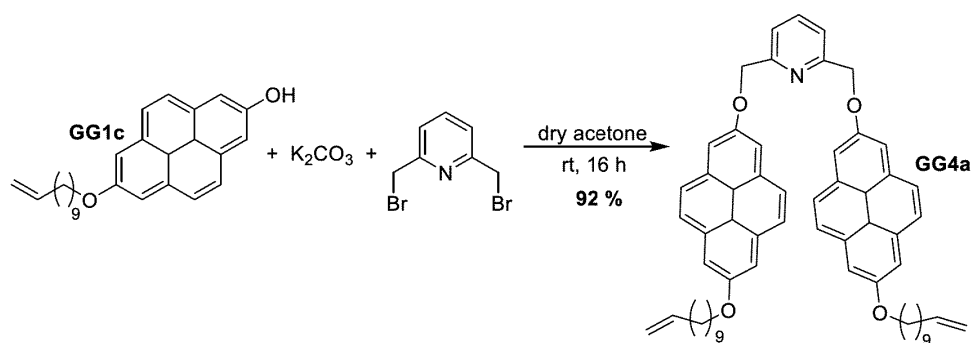


Fig. 103

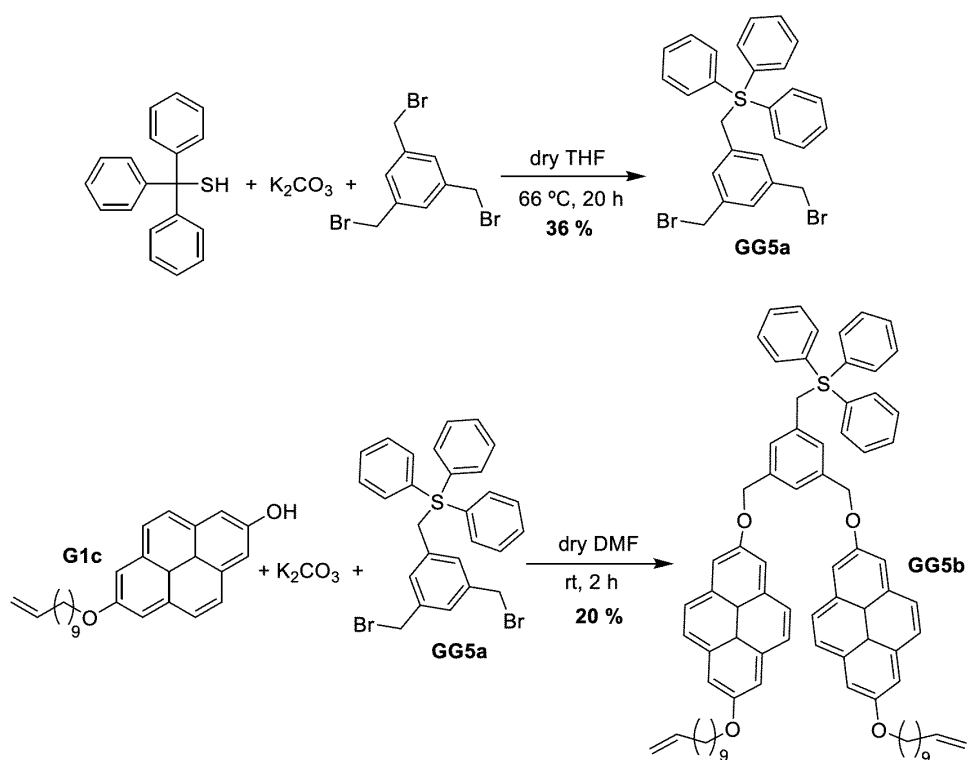


Fig. 104

85/144

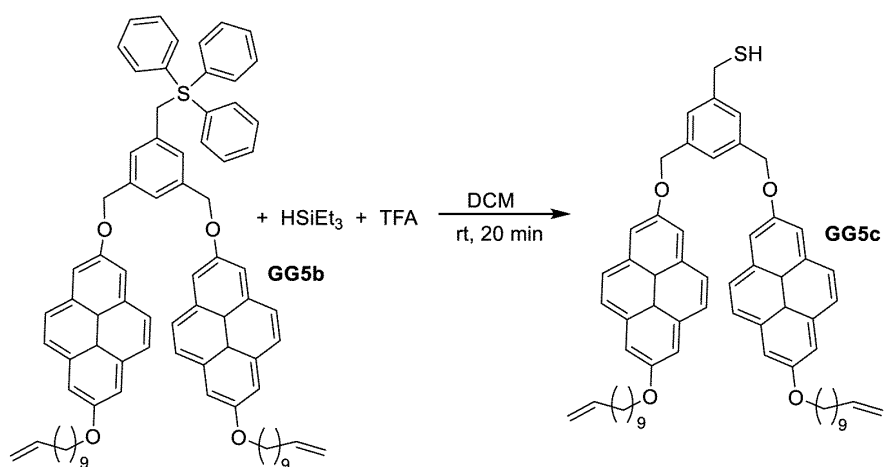


Fig. 104 (Continued)

a.

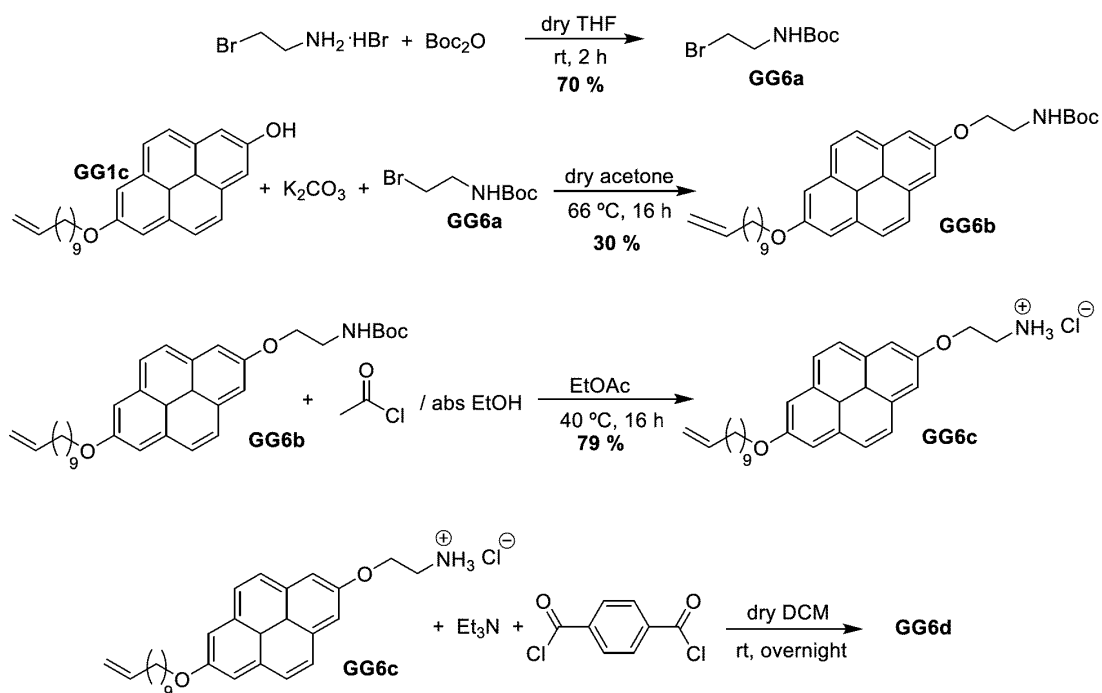
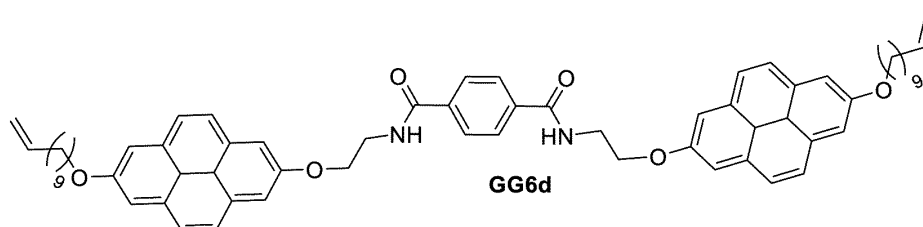


Fig. 105

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b.

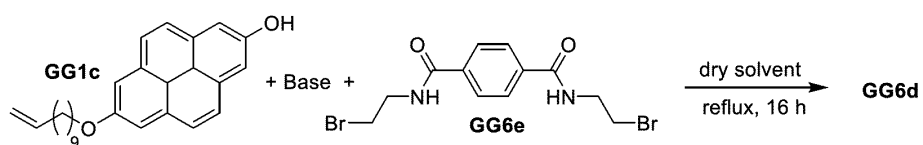
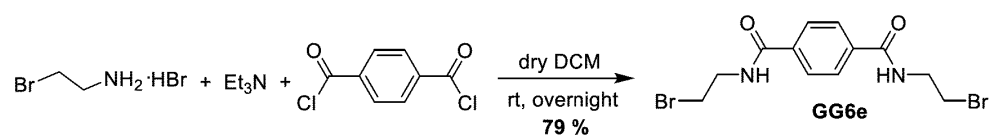


Fig. 105 (Continued)

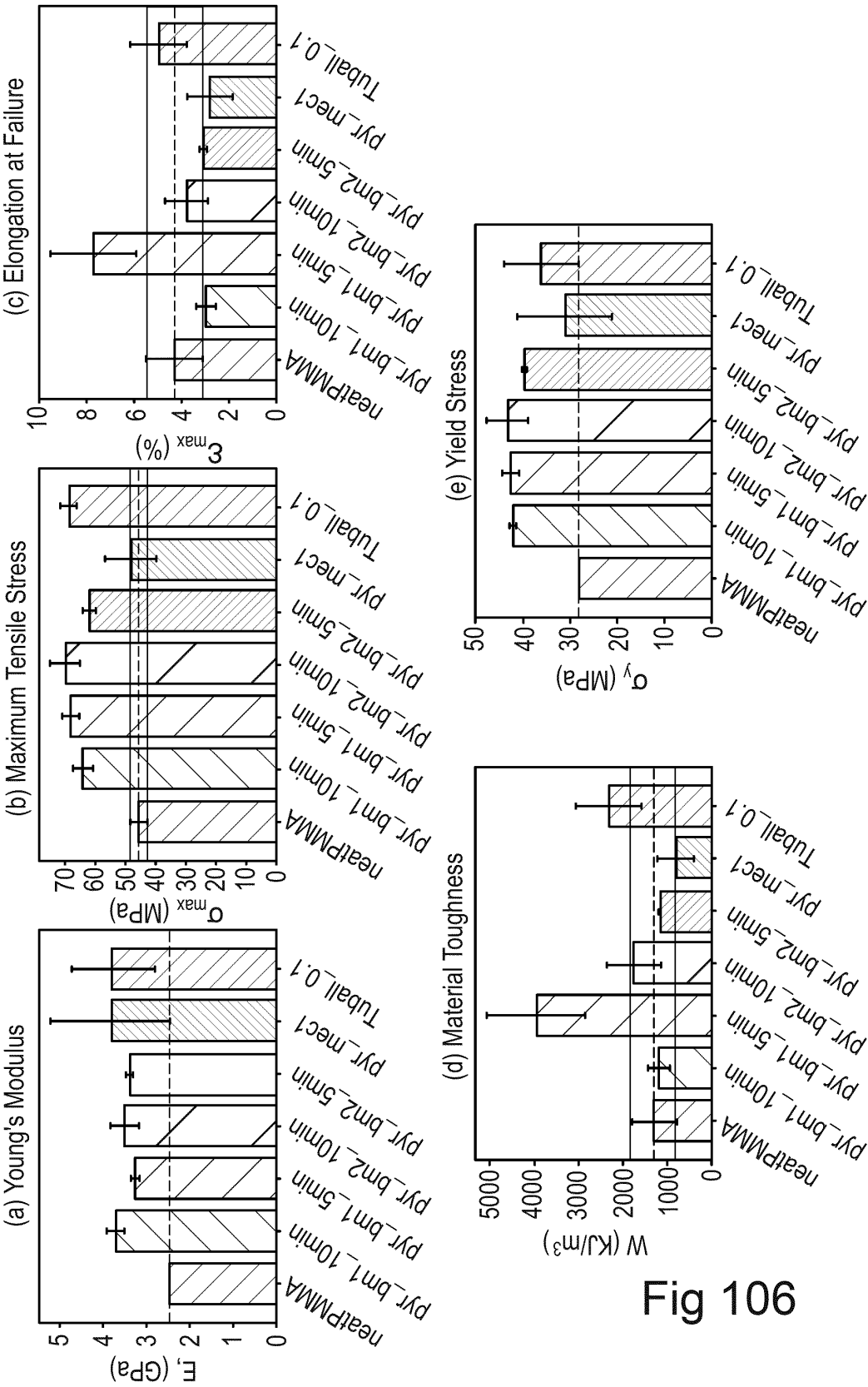


Fig 106

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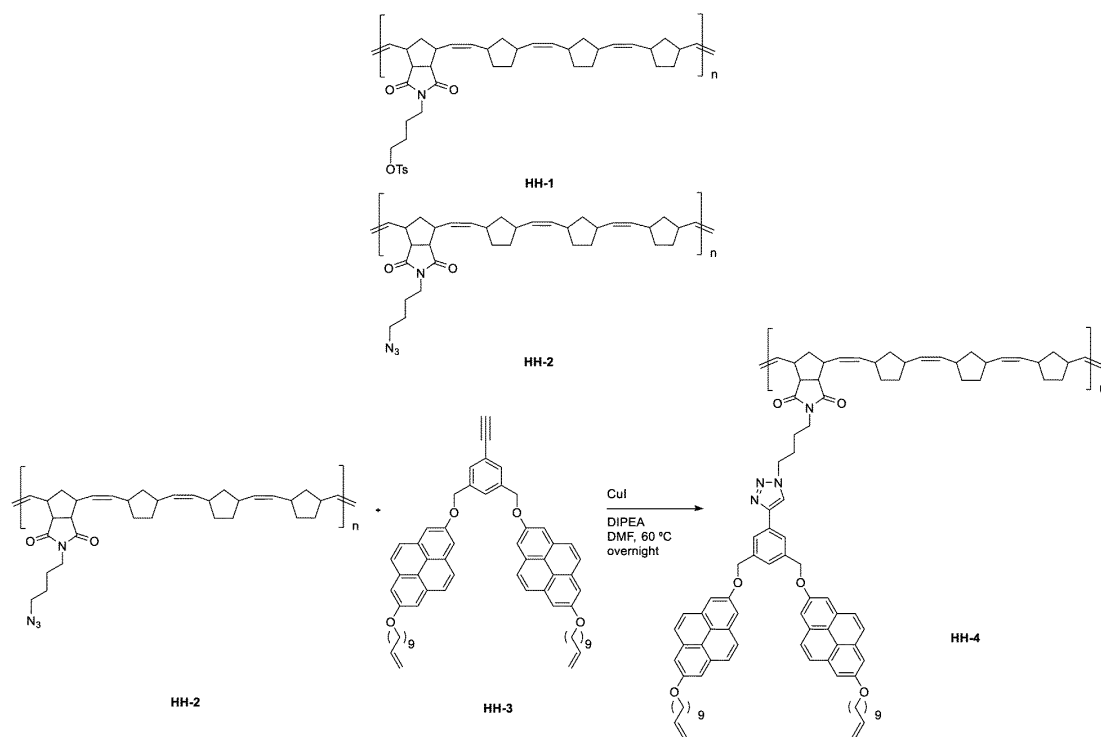


Fig. 107

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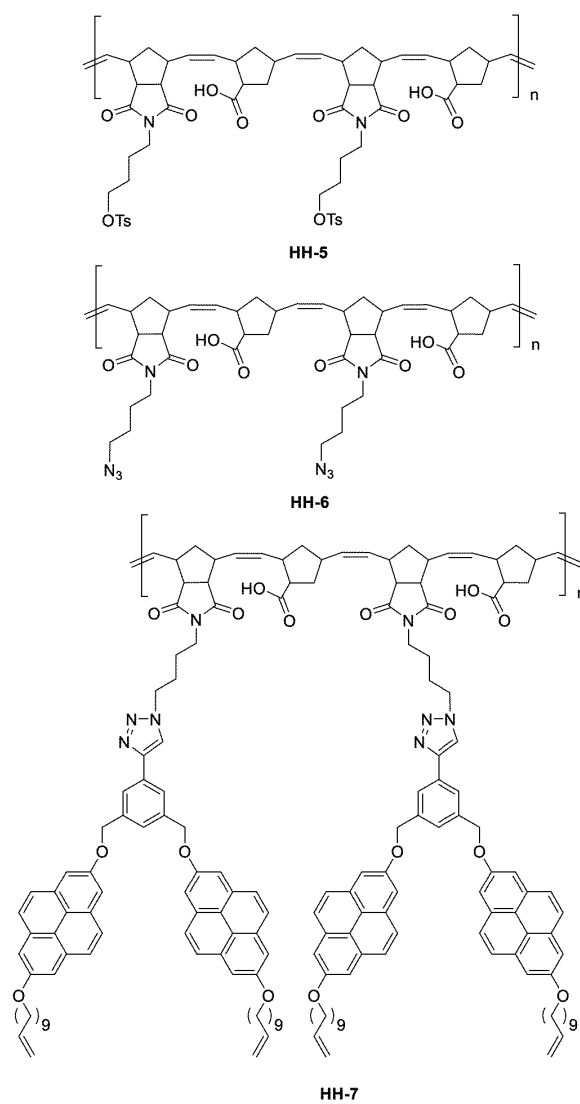
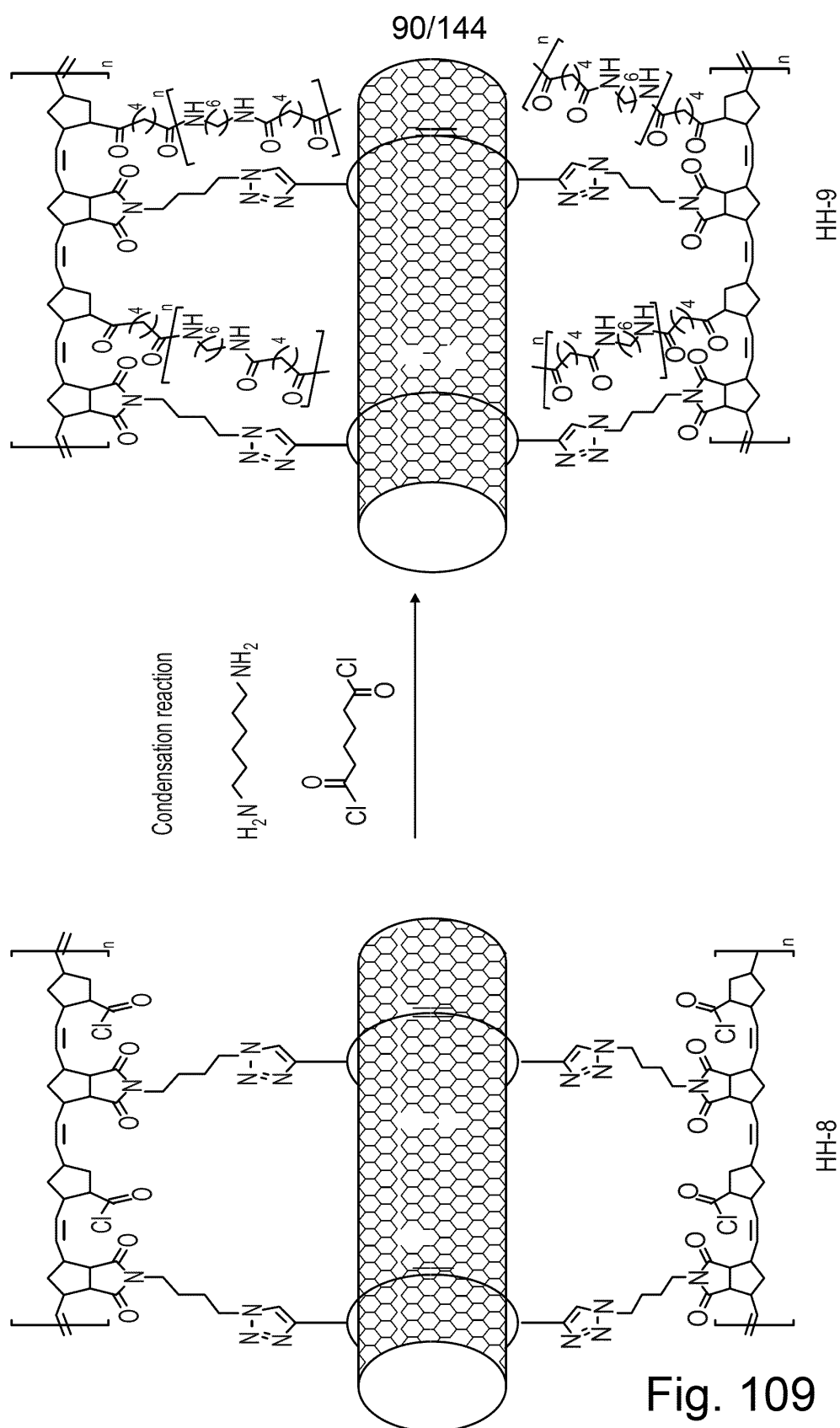
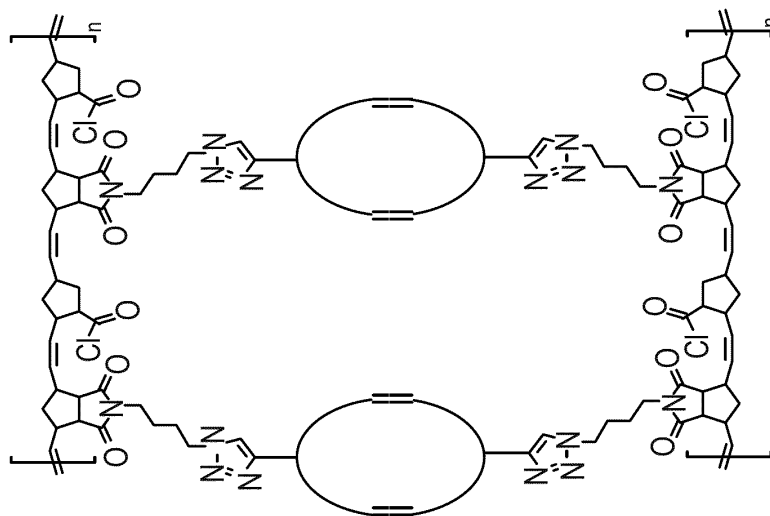


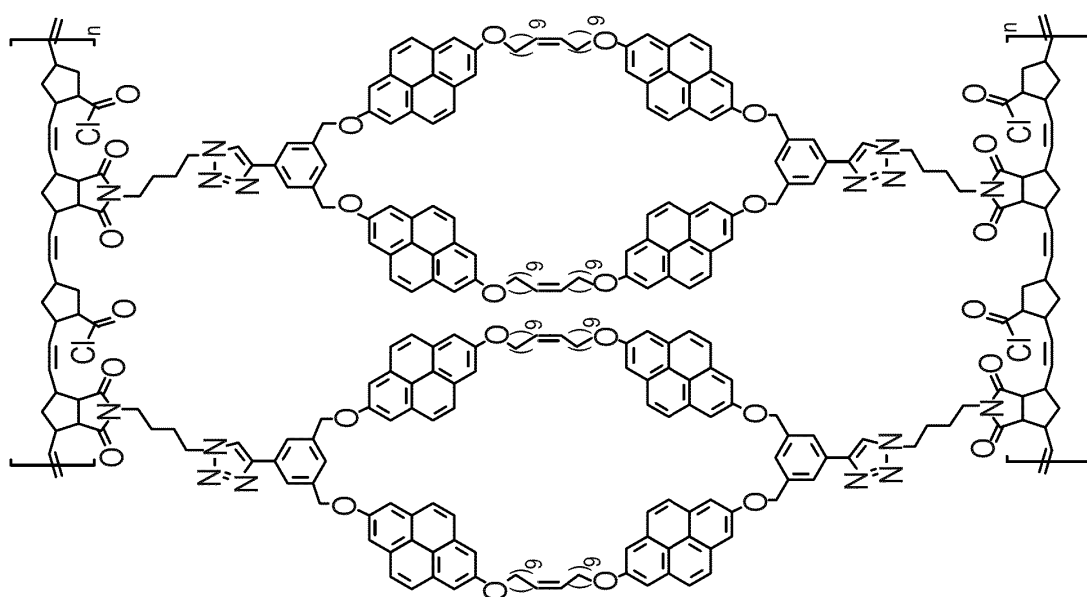
Fig. 108



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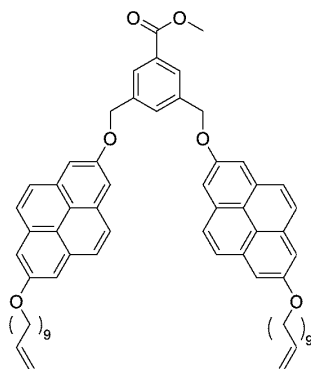
III



Symbols used:

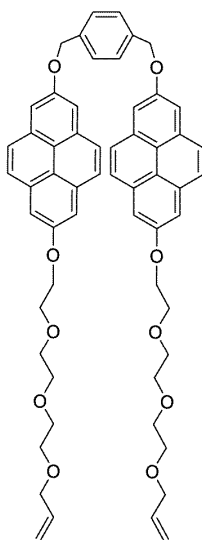
Fig. 109
(Continued)

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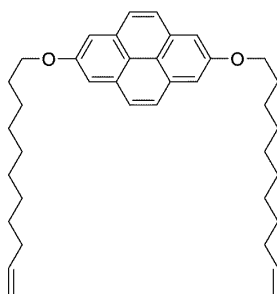
HH-10

Fig. 110



HH-11

Fig. 111

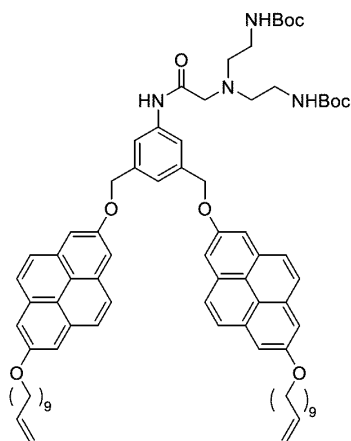


HH-12

Fig. 112

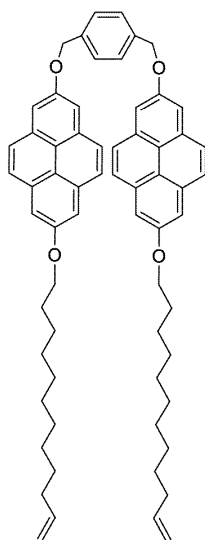
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Figure HH19



HH-13

Fig. 113



HH-14

Fig. 114

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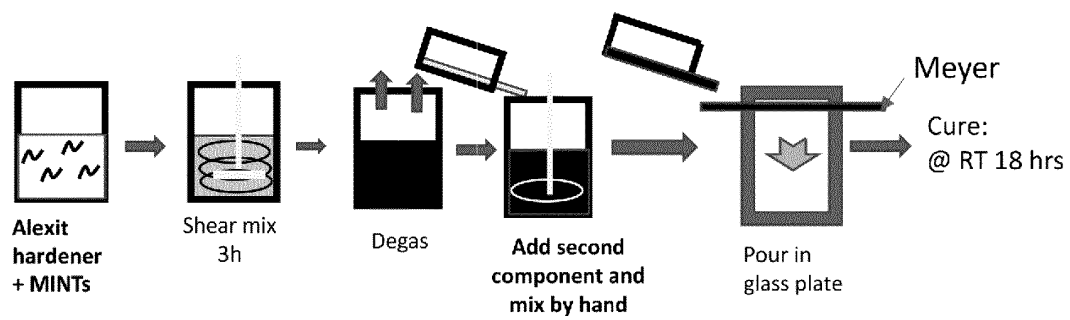


Fig. 115

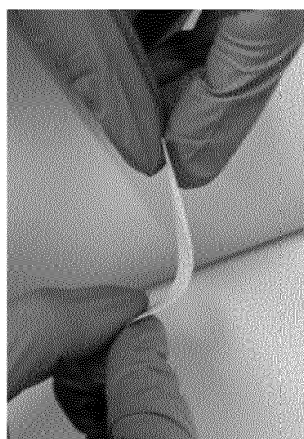


Fig. 116

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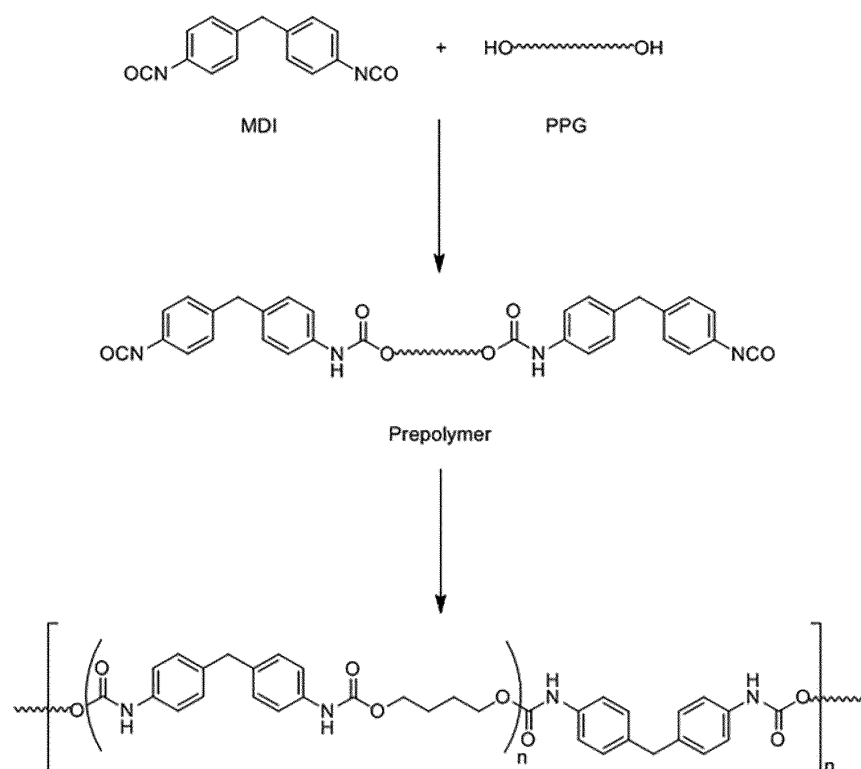


Fig. 117

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In situ polyurethane general formulation			OH:NCO Ratio
	mmol	Eq.	
MDI	16	6	1 : 1.07
PPG (Mw: 2000)	6	1	
BD	8	4.6	

Fig. 118

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Different sequences of events leading to polymer composites.

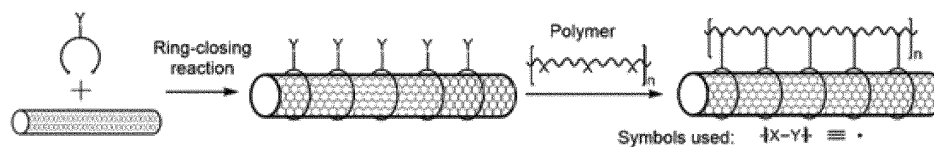
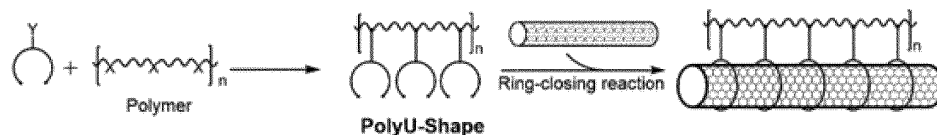
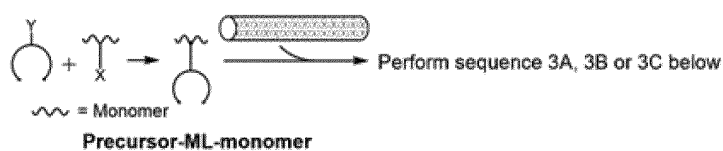
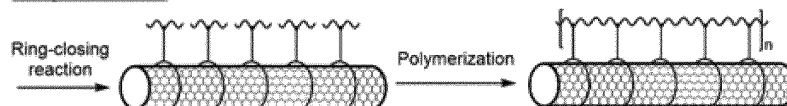
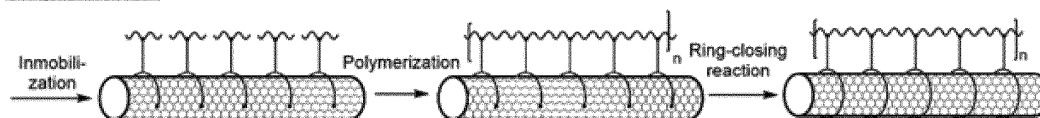
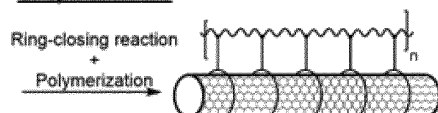
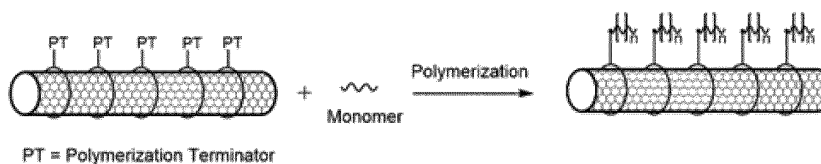
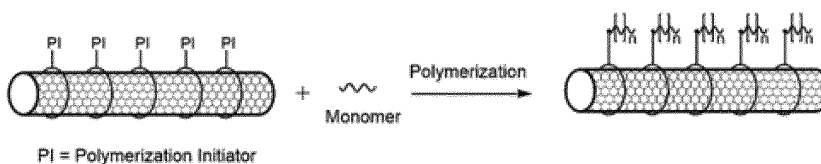
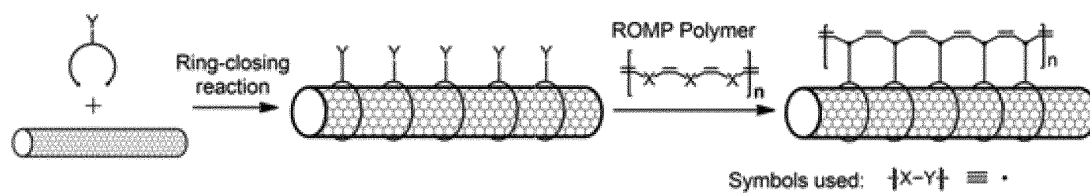
Sequence 1**Sequence 2****Sequences 3****Sequence 3A****Sequence 3B****Sequence 3C****Sequence 4A****Sequence 4B**

Fig. 119a
SUBSTITUTE SHEET (RULE 26)

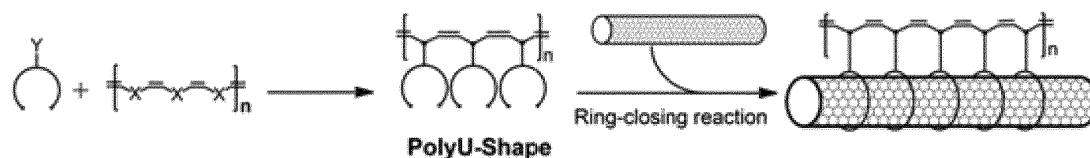
98/144

Different sequences of events leading to ROMP polymer-carbon nanotube composite materials.

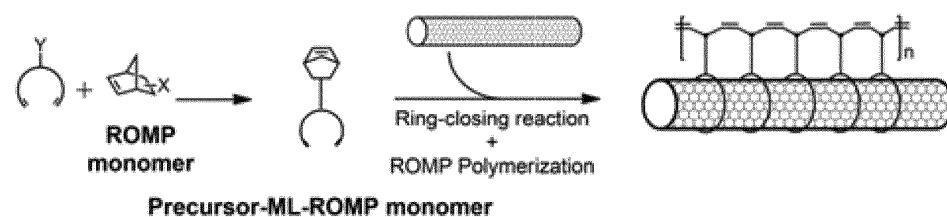
Sequence 1. ROMP Composite



Sequence 2. ROMP Composite



Sequence 3C. ROMP Composite



Sequence 4. ROMP Composite

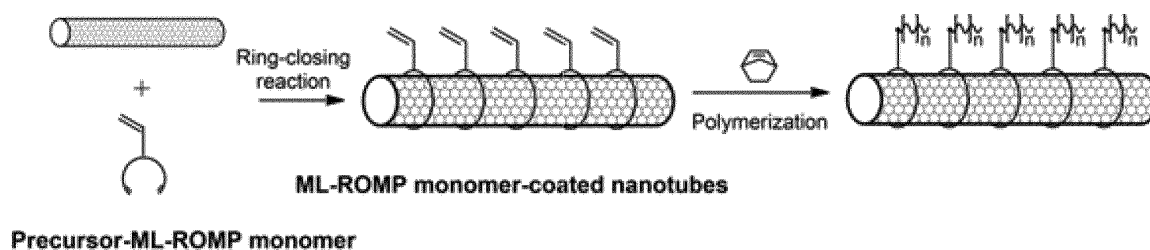


Fig. 119b

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Sequence 1, reaction used to generate polystyrene-coated tuball SWNTs.

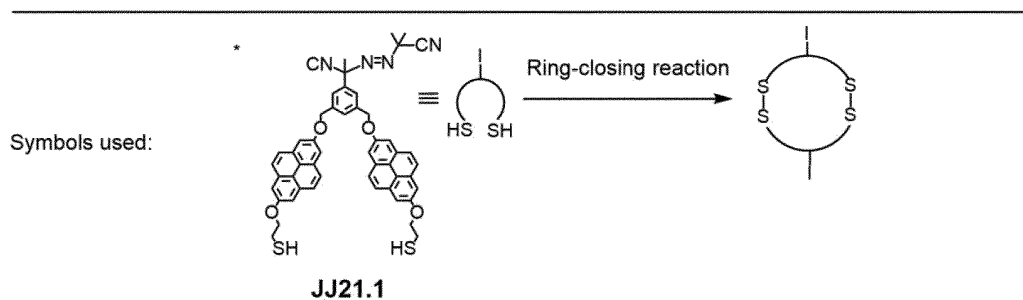
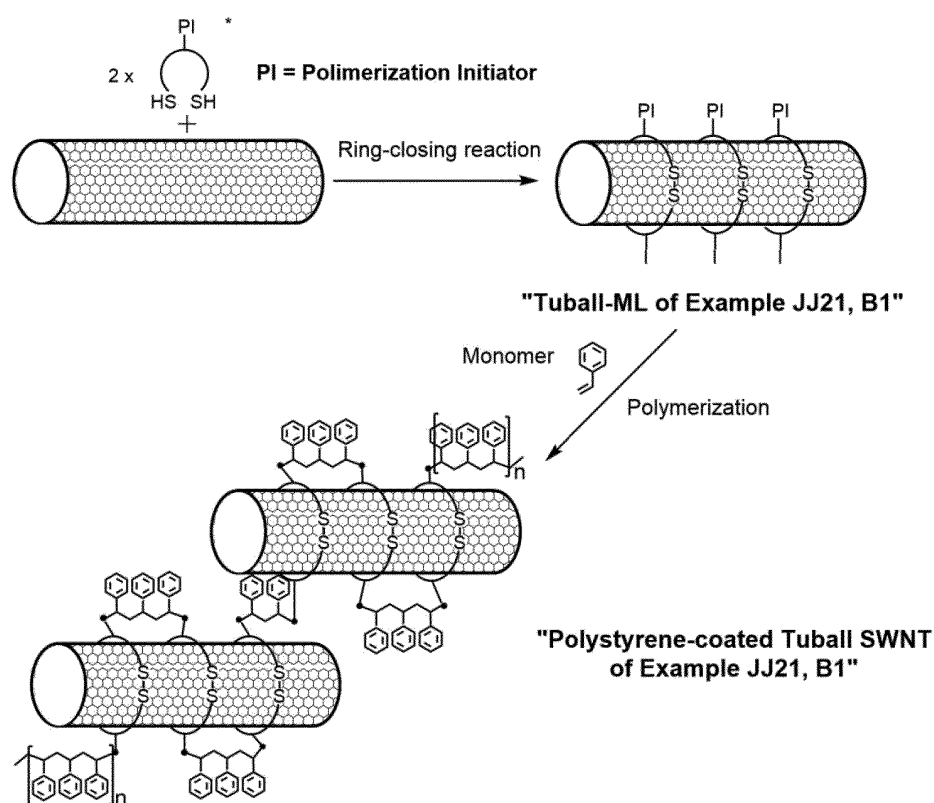


Fig. 119c

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Sequence 2, reaction used to generate polyaminoacid-coated SWNTs.

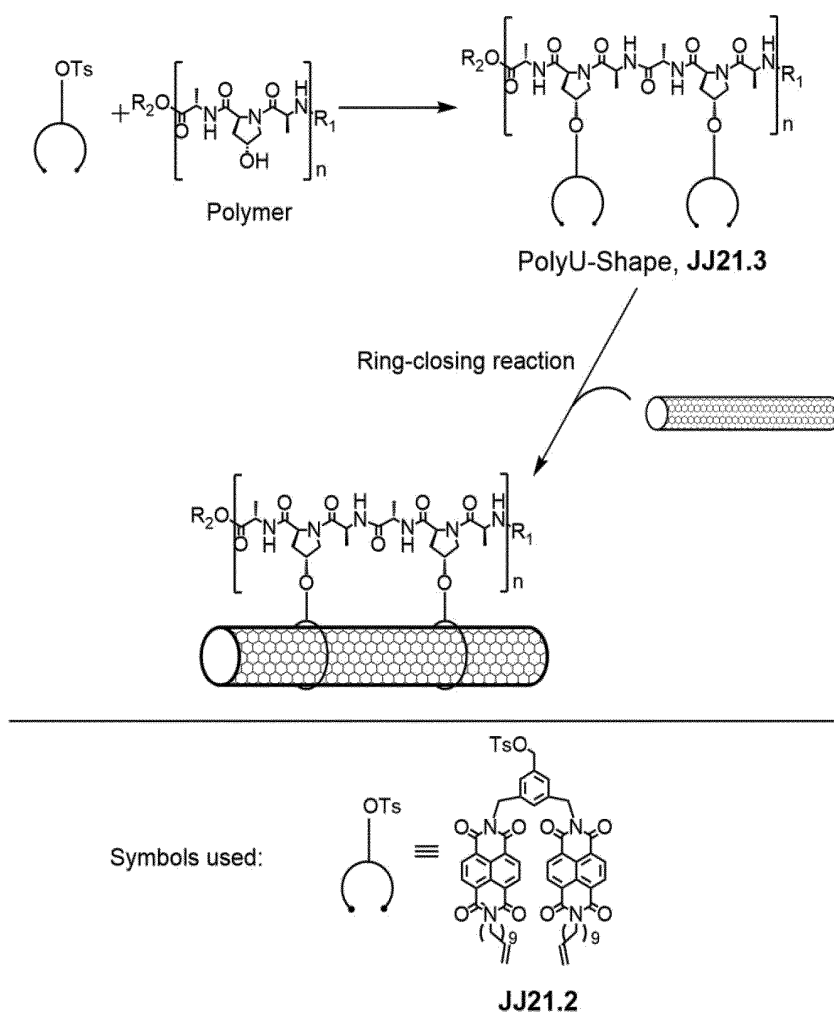


Fig. 119d

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Sequence 3A, reaction used to generate polyurethane-coated Tuball SWNTs.

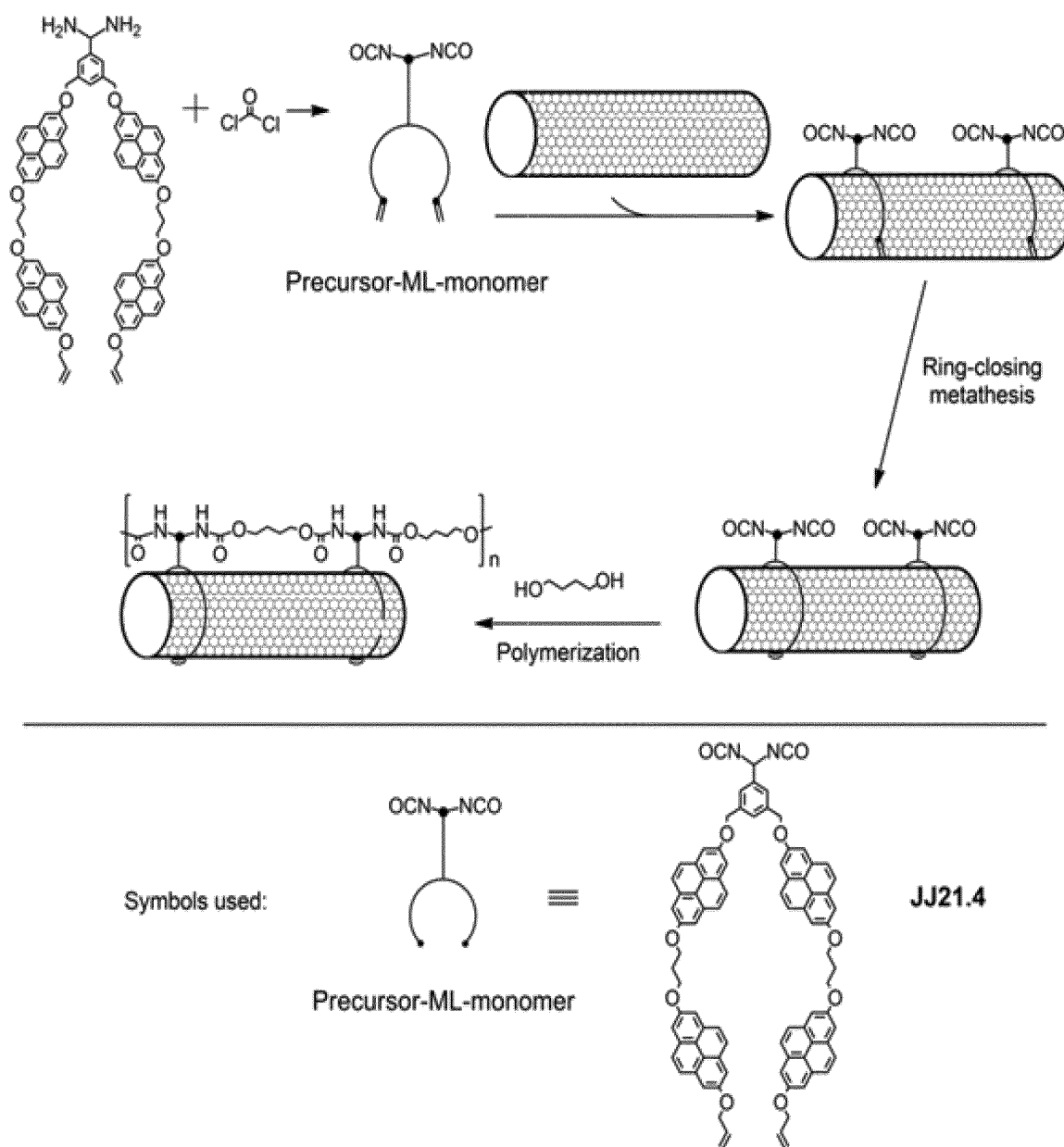


Fig. 119e

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Sequence 3B, reaction used to generate polyvinylchloride-coated SWNTs.

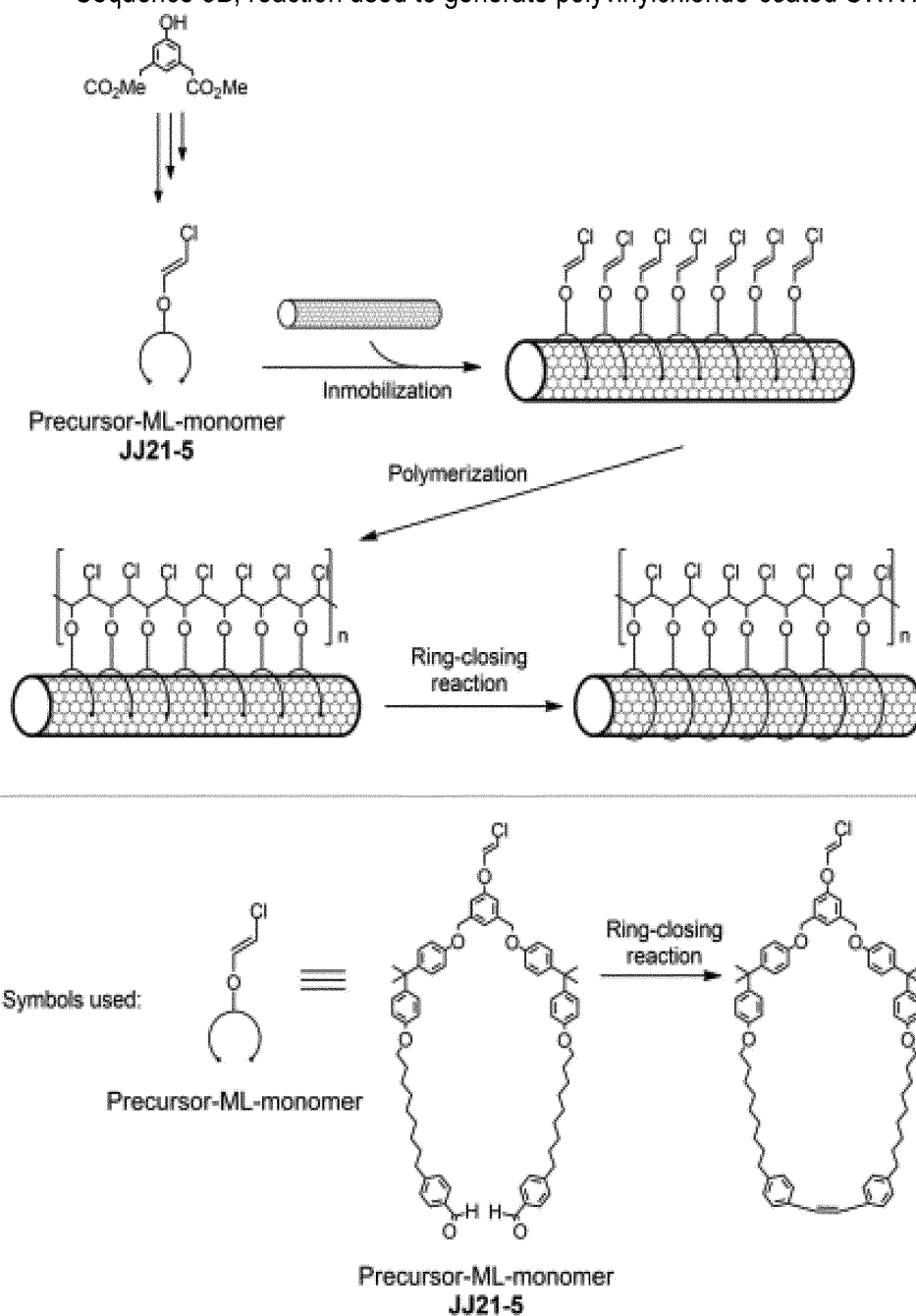


Fig.119f

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Sequence 3C, reaction used to generate epoxy-coated DWNTs.

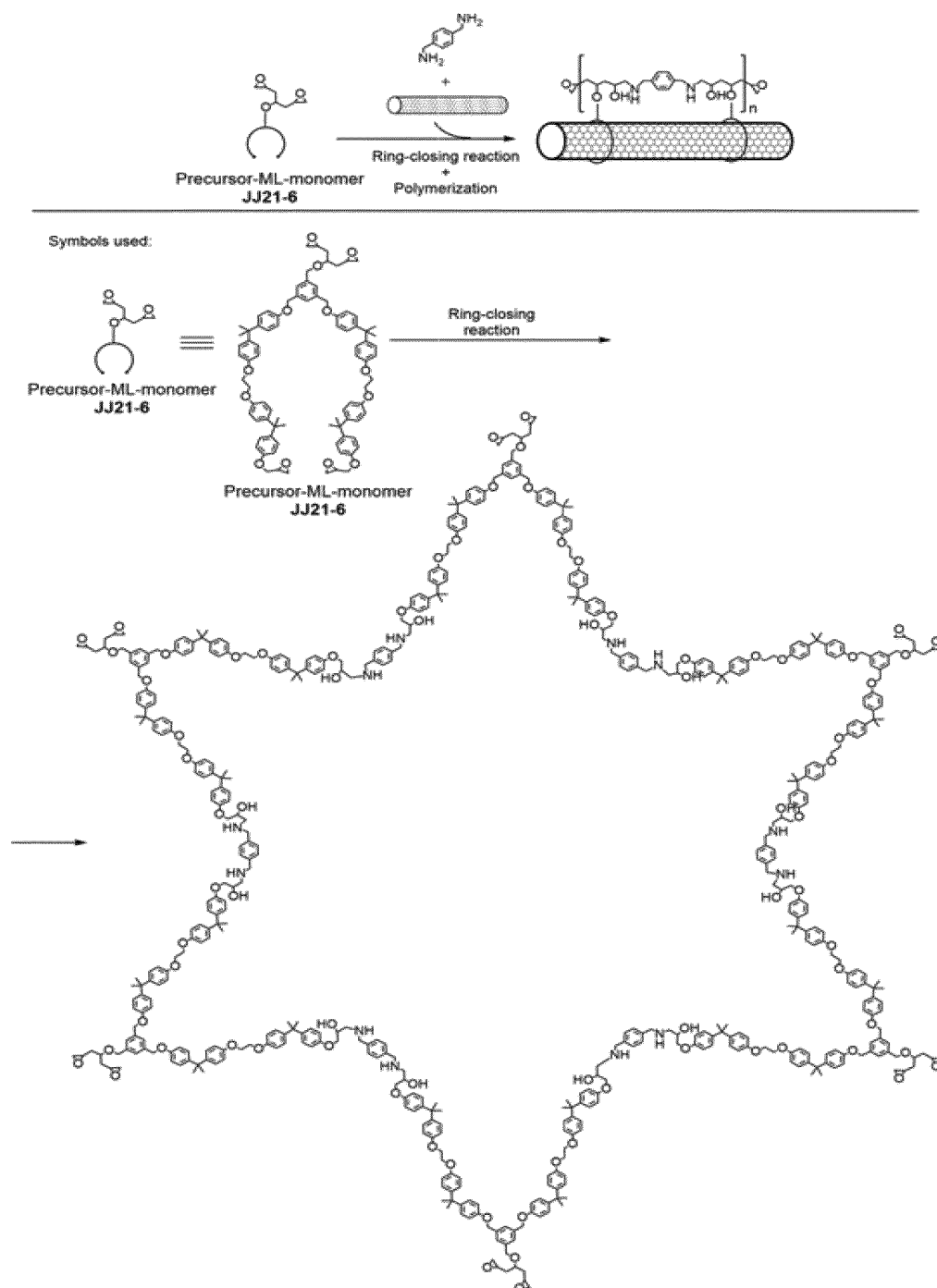
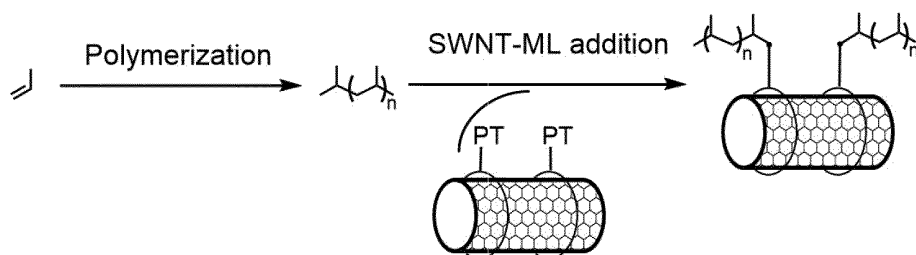


Fig. 119g

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Sequence 4, reaction used to generate polypropylene-coated SWNTs.



Symbols used:

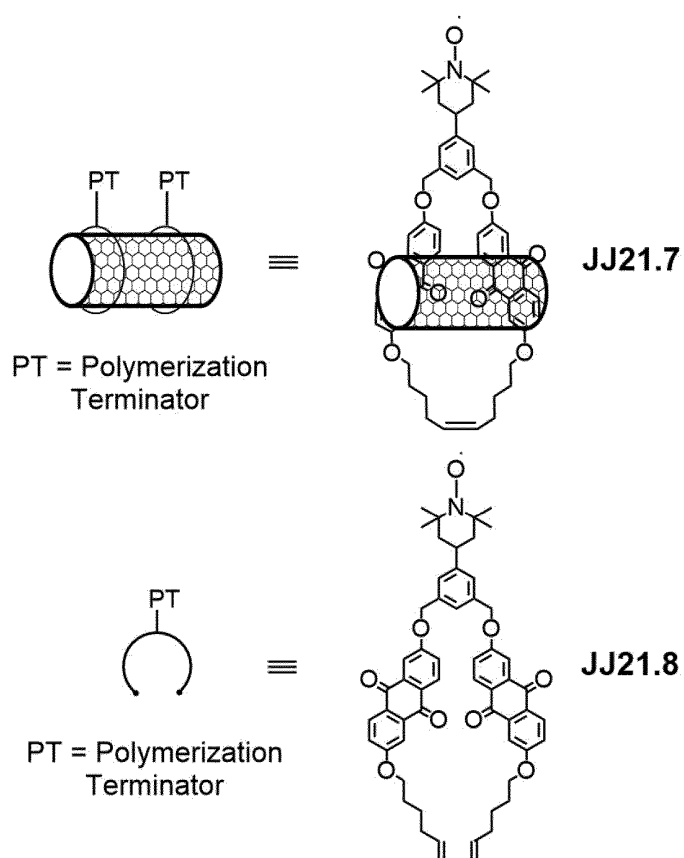


Fig. 119h

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Connecting polymer and ML by amide-bond formation.

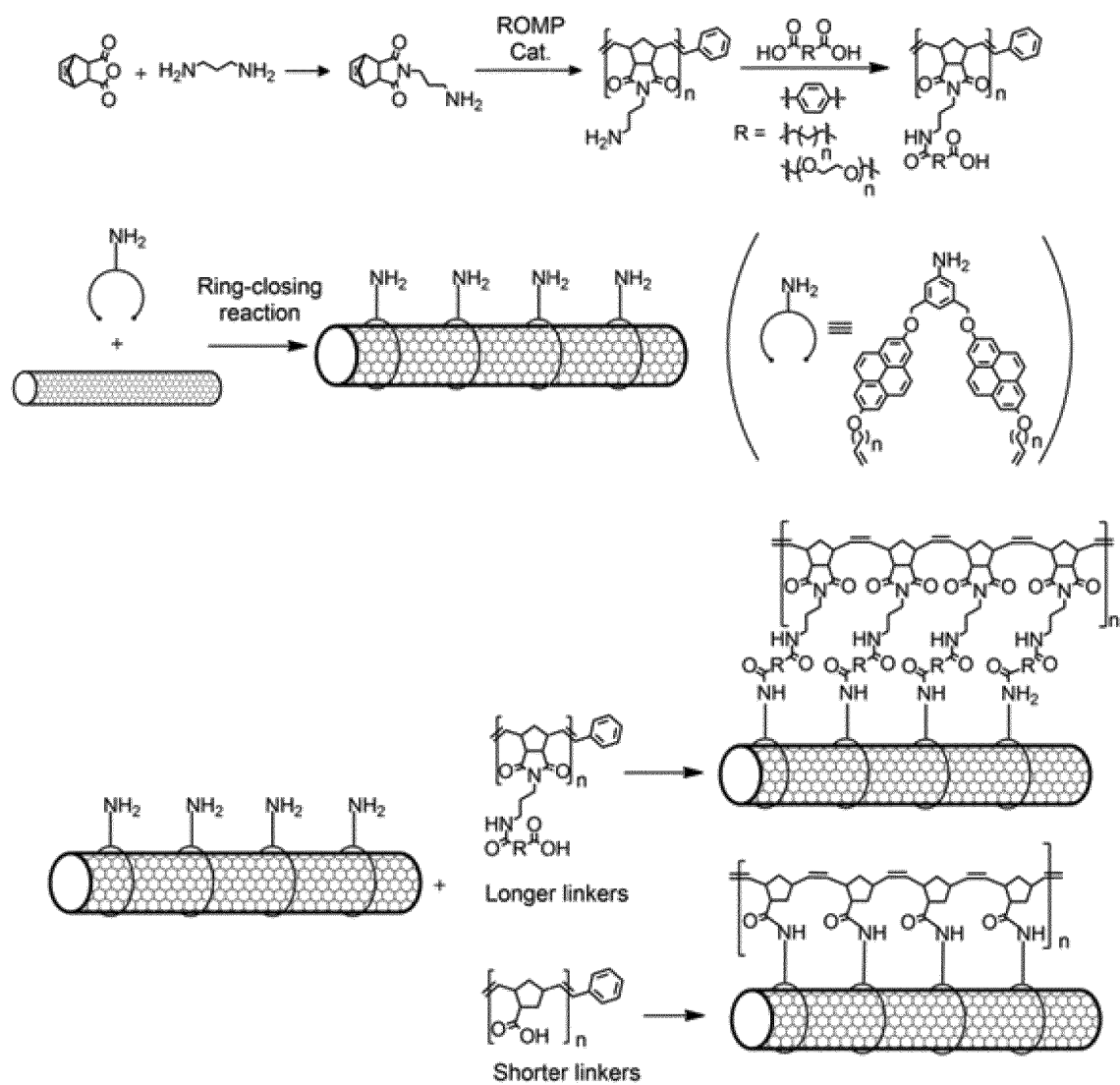


Fig. 120a

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Connecting polymer and ML by amide-bond formation.

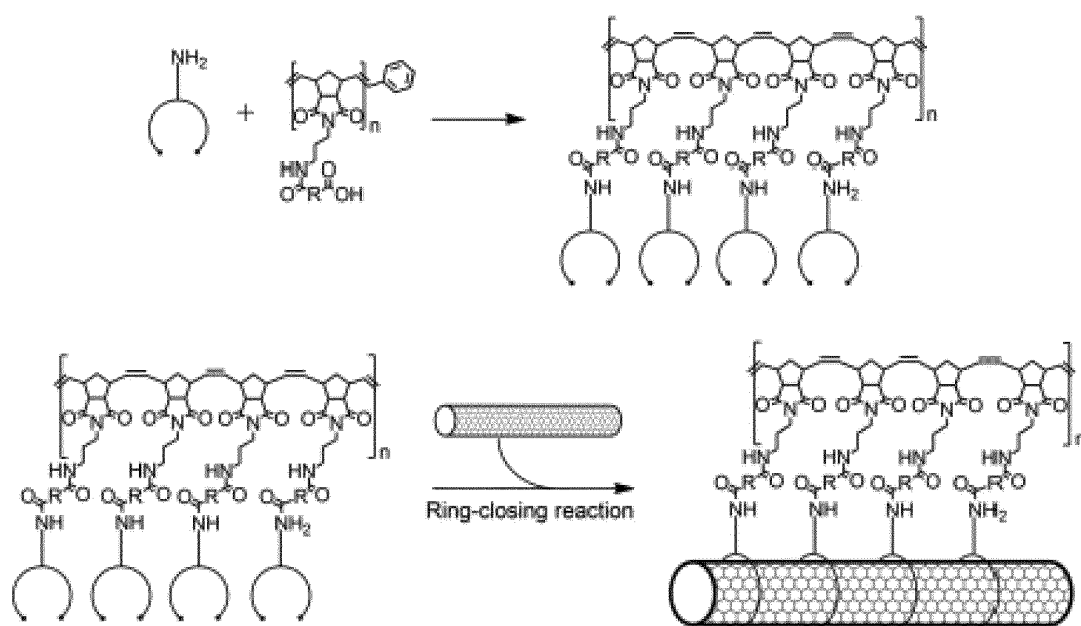


Fig. 120b

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Connecting polymer and ML by amide-bond formation.

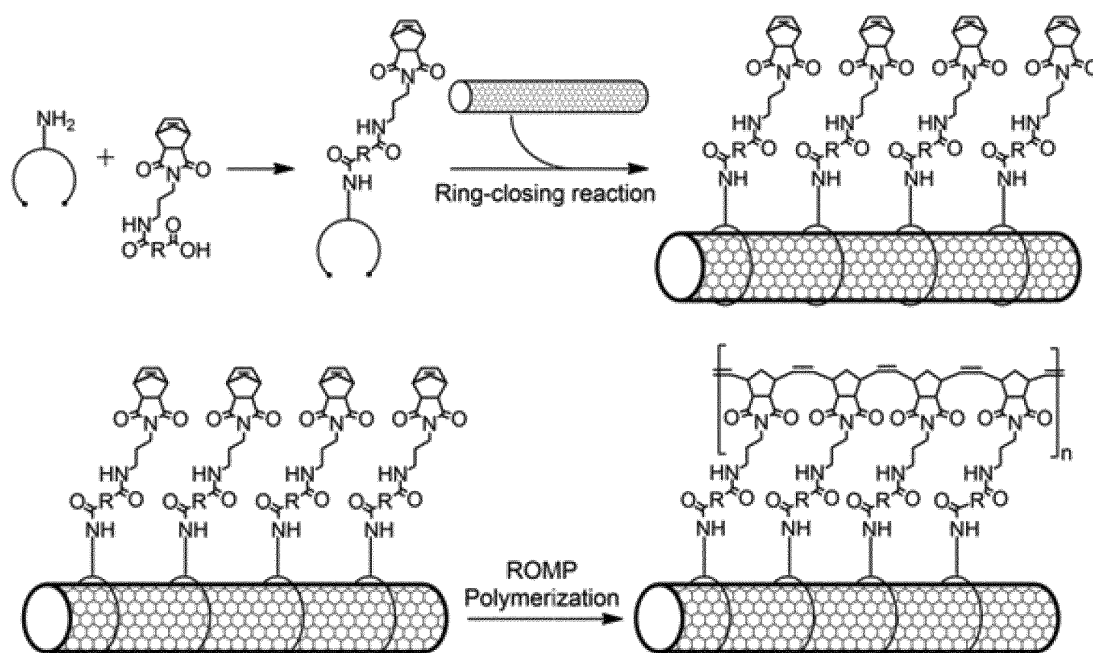


Fig. 120c

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Connecting polymer and ML by nucleophilic substitution.

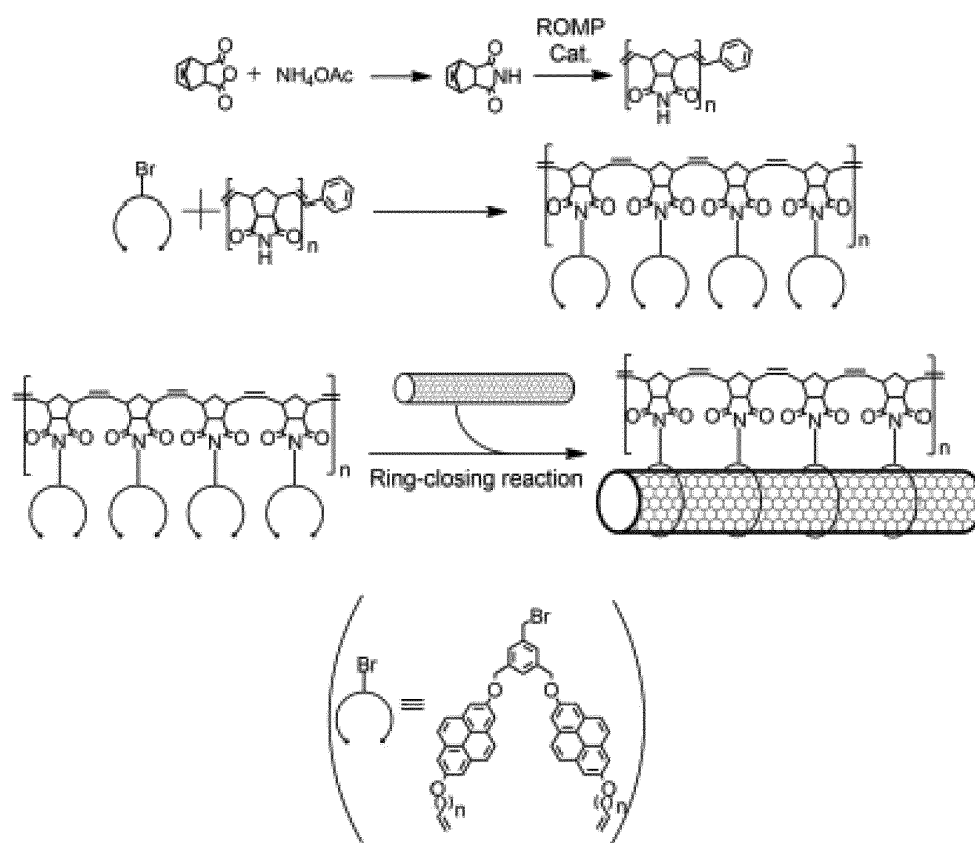


Fig. 121

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ROMP polymer-coated SWNT representations

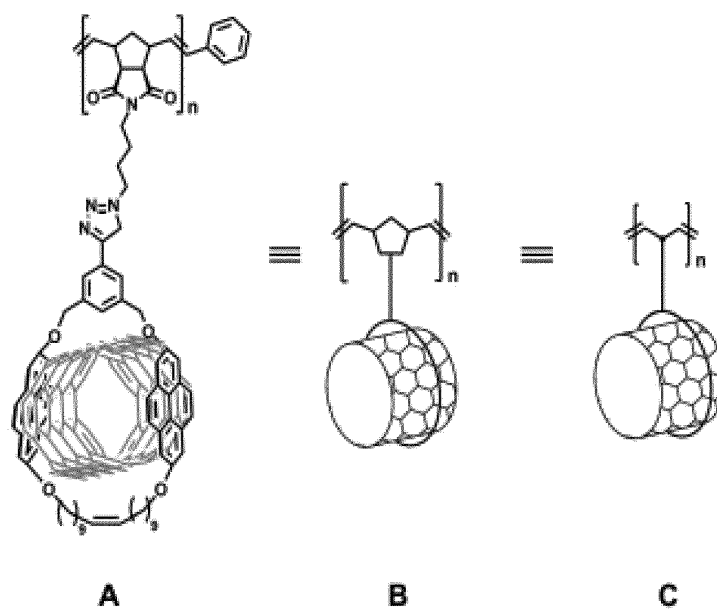
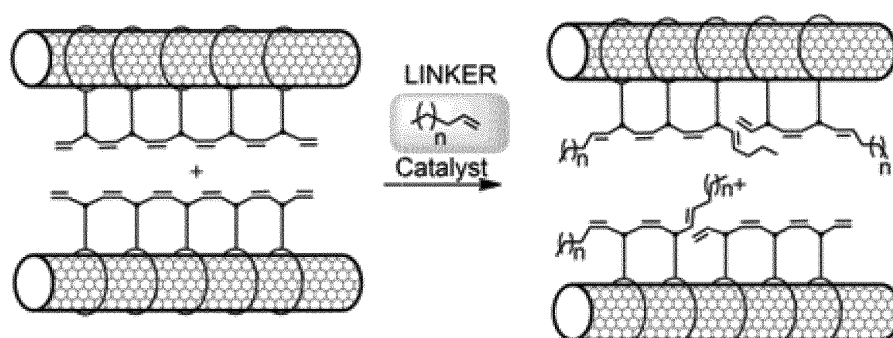


Fig. 122

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Metathesis of double bonds, leading to attachment of polymers to the ROMP polymercoated nanotubes or leading to crosslinking of the ROMP polymer-coated nanotubes.

a) LINKER COMPRISING ONE DOUBLE BOND



b) LINKER COMPRISING TWO DOUBLE BONDS

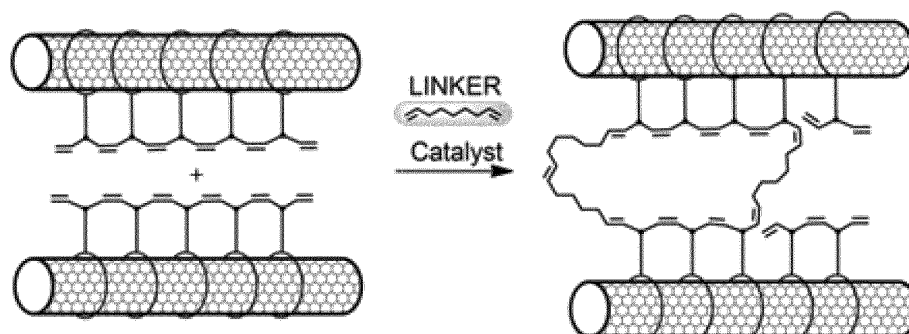


Fig. 123

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A fishing rod made from sized SWNTs to which is added linear polyethylene chains comprising at least two double bonds.

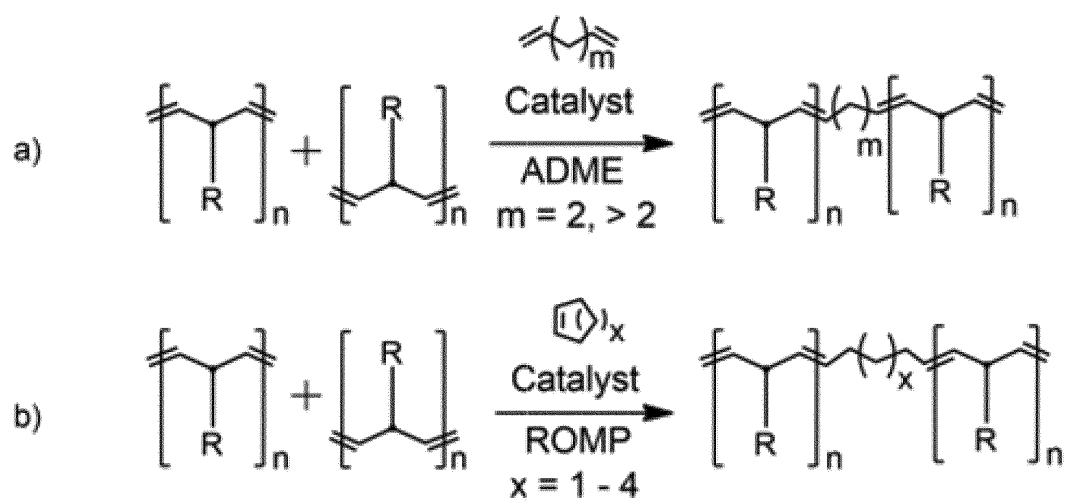


Fig. 124

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A gear made from ROMP polymer-coated SWNTs that become cross-linked by linkers comprising aromatic chains and two double bonds.

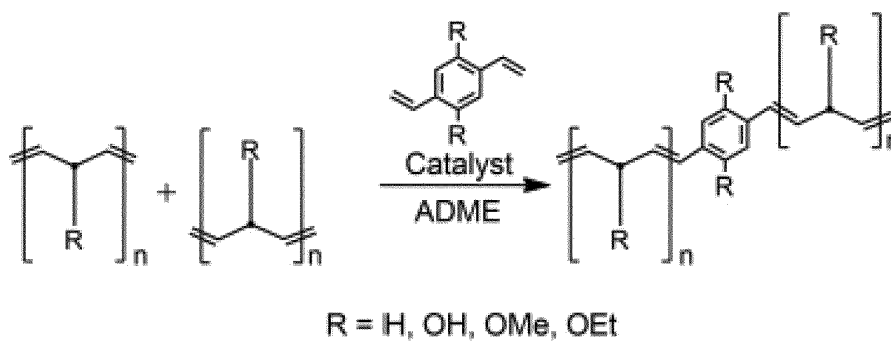


Fig. 125

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A suitcase made from ROMP polymer-coated SWNTs to which is attached polystyrene without crosslinking separate SWNTs.

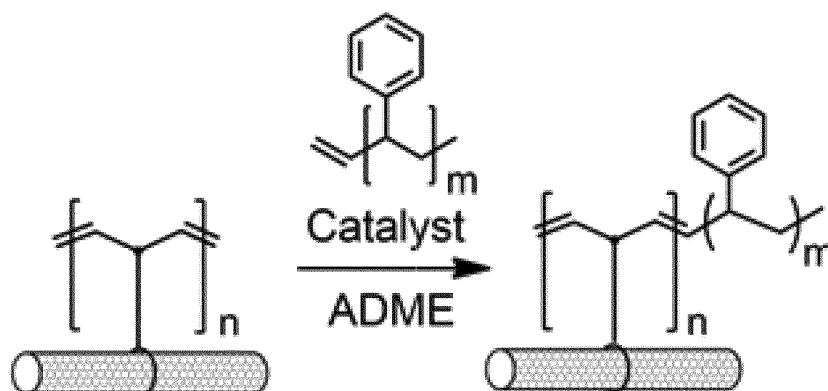


Fig. 126

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Introduction of functional groups, by using linkers carrying the desired functionalities.

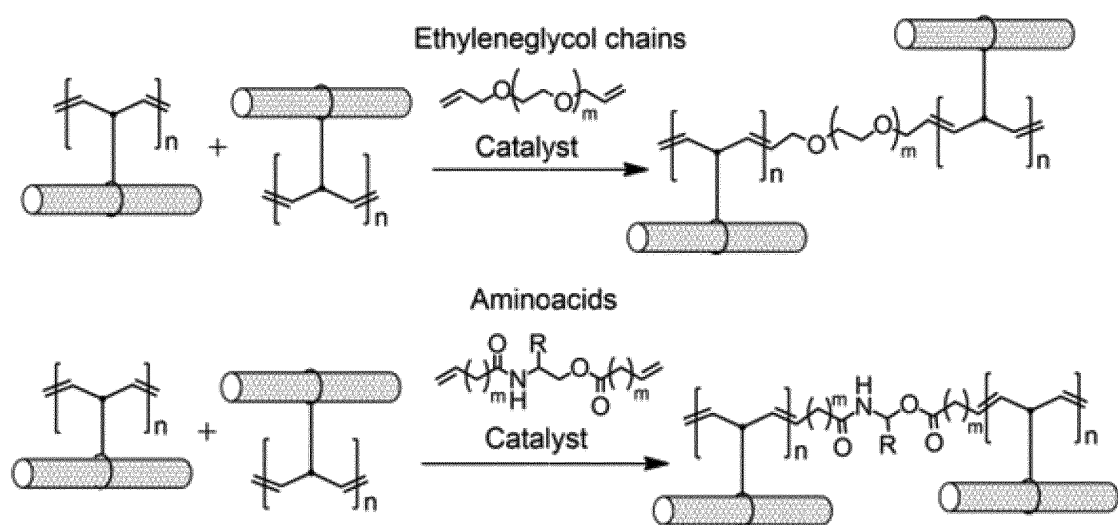


Fig. 127

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A roofing membrane made from ROMP polymer-coated SWNTs to which is added polypropylene by a Ziegler-Natta catalytic polymerization.

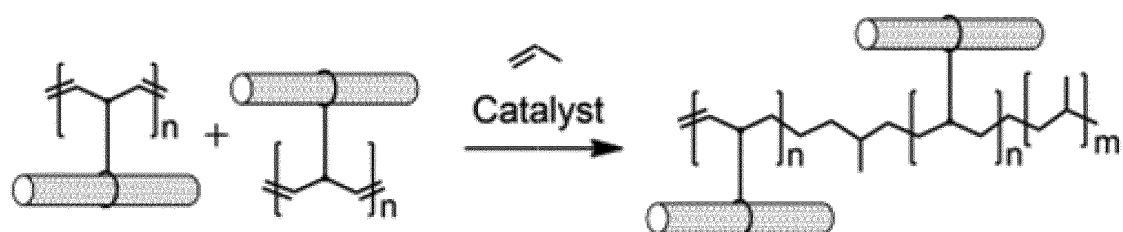


Fig. 128

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A fishing line made from sized SWNTs to which is added polystyrene chains comprising one thiol, as well as polystyrene chains not carrying any thiols that can react with double bonds, and where the majority of the polystyrene chains do not become covalently linked to the sized SWNT until after processing (here extrusion).

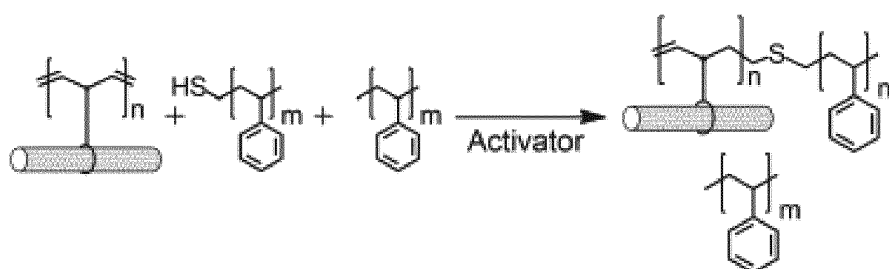


Fig. 129

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A tire made from ROMP polymer-coated SWNTs to which is covalently linked cis-1,4-Polybutadiene.

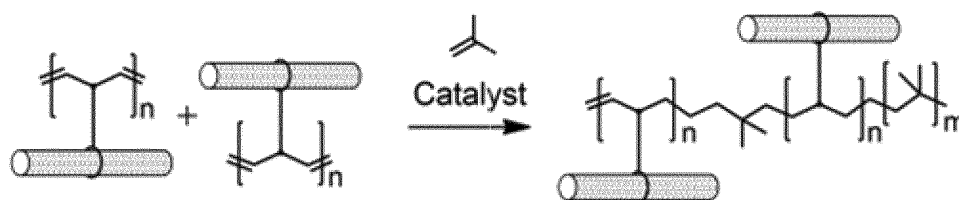


Fig. 130

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Vulcanization of modified SWNTs carrying double bonds.

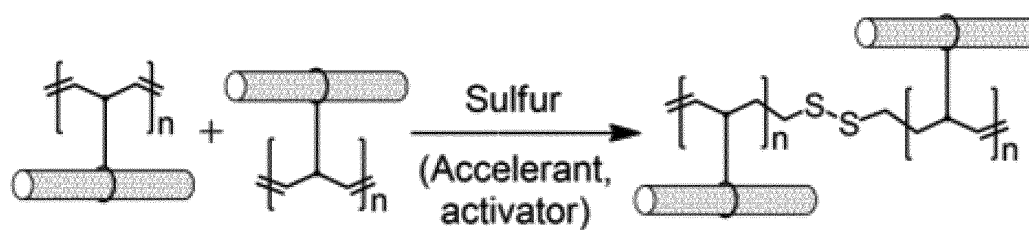


Fig. 131

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In situ polymerization leading to materials with thermoplastic or thermoset characteristics

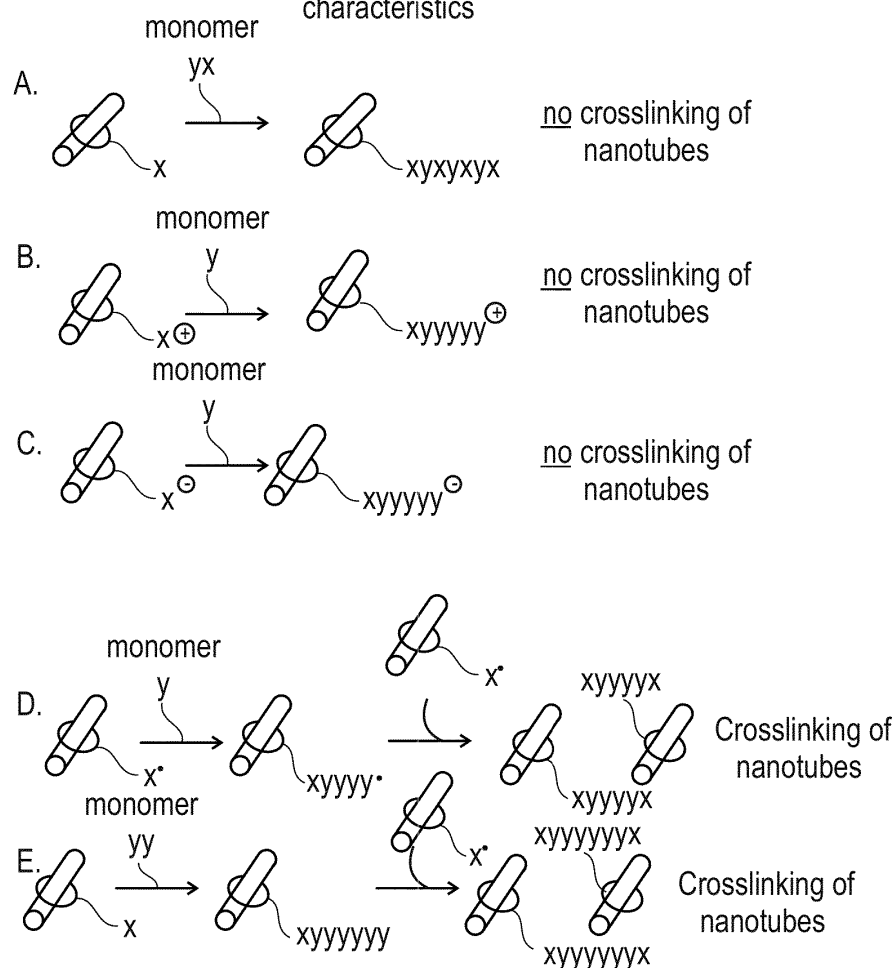
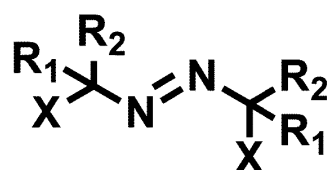


Fig. 132



Azo compounds

R=Alkyl group

X=Carboxylic acid derivative (e.g. nitrile, ester, amide)

General structure for azo compounds-based radical initiators

Fig. 133

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In situ polymerisation involving azo compounds as initiators

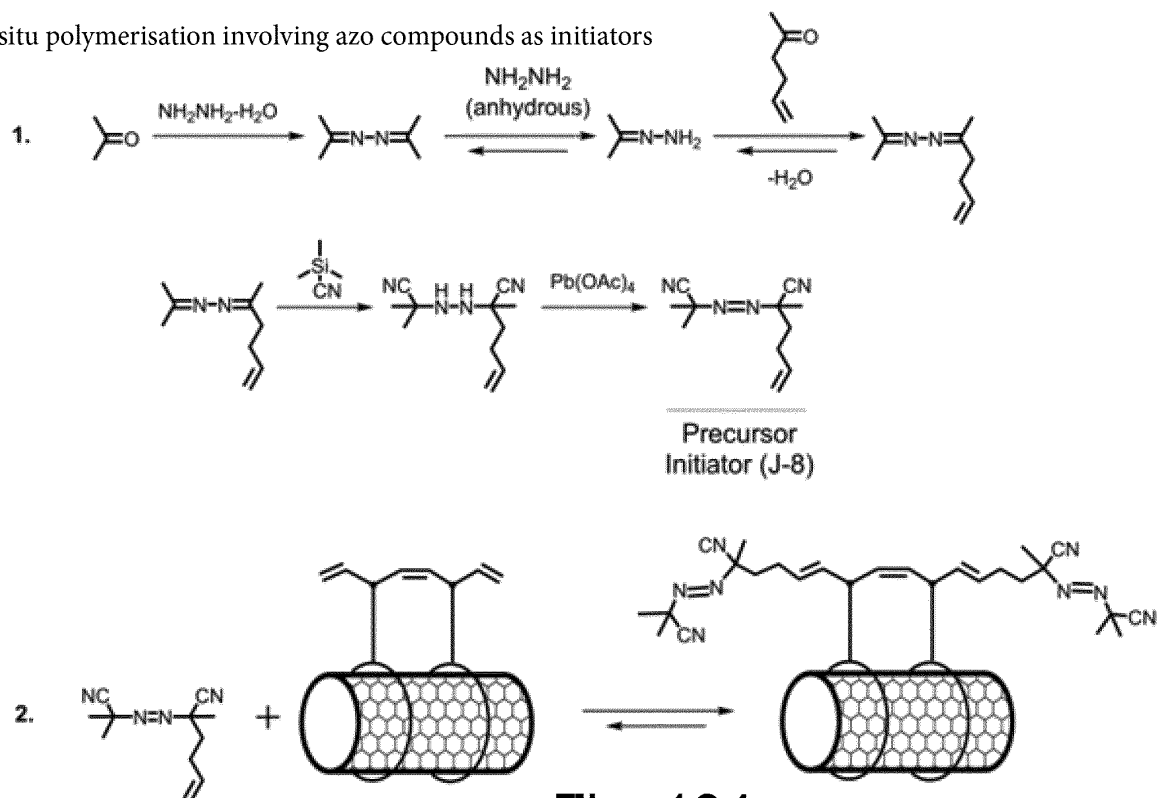


Fig. 134

SWNT carrying polystyrene

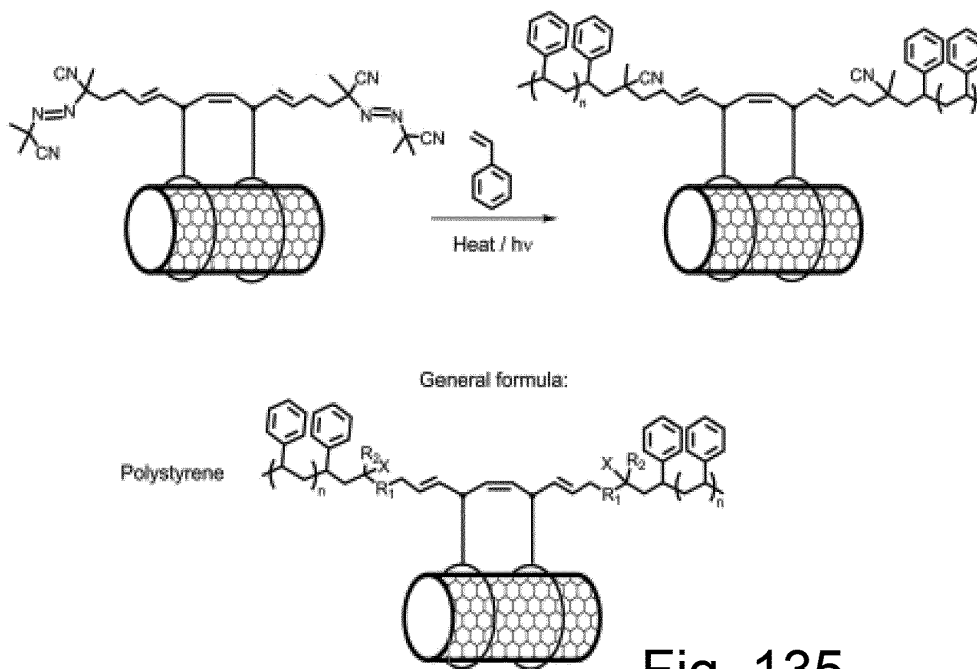


Fig. 135

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General structures generated by in situ polymerisation involving azo compounds as initiators.

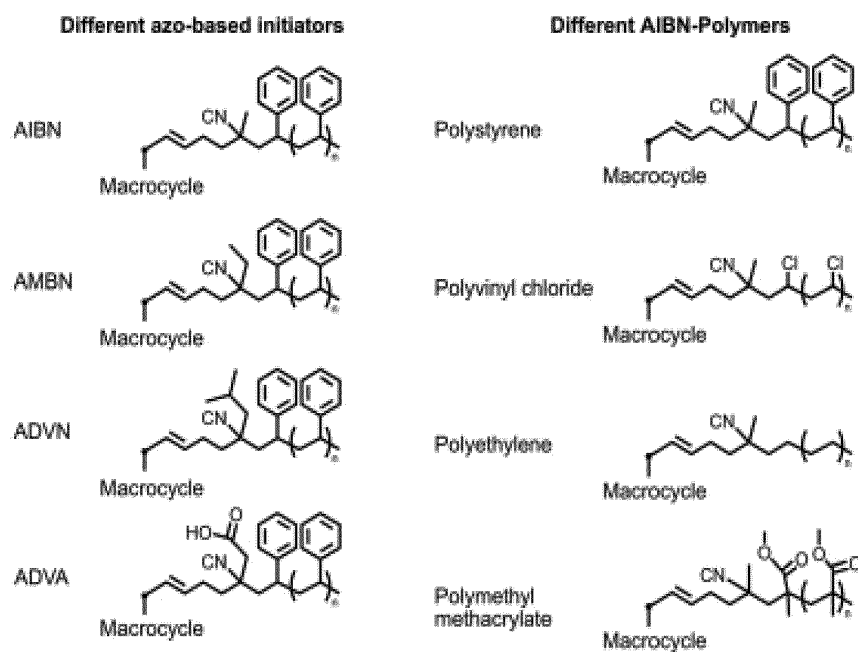


Fig. 136

General structure for alkoxyamine and nitroxide-based radical initiators

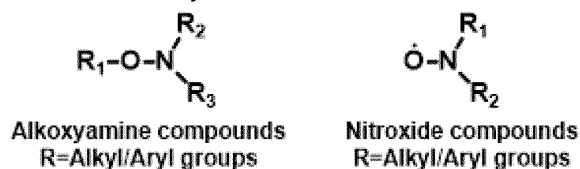


Fig. 137

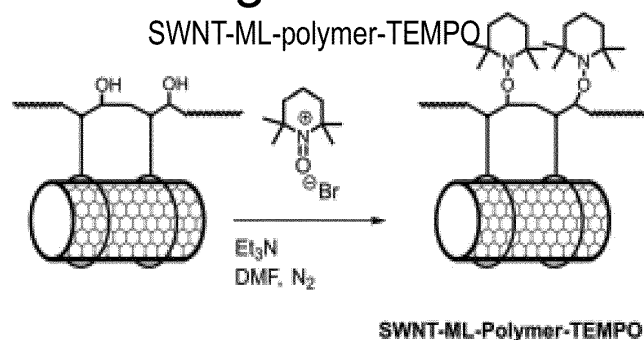
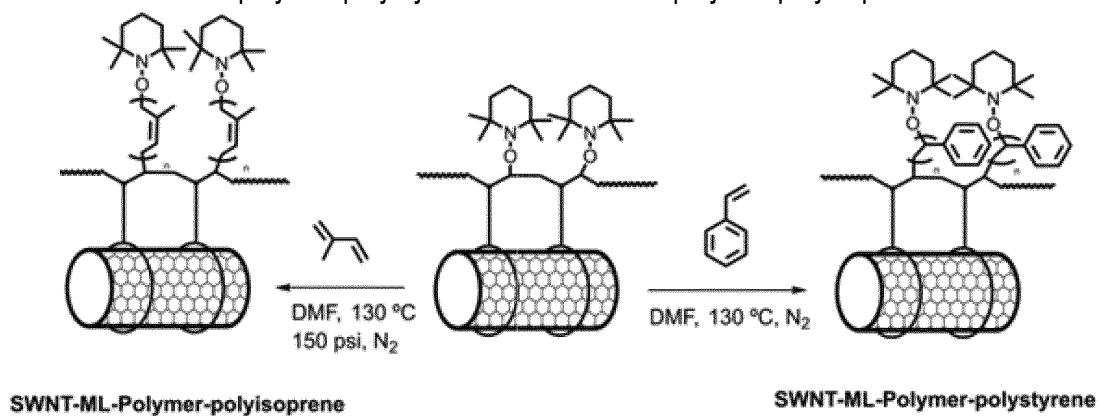


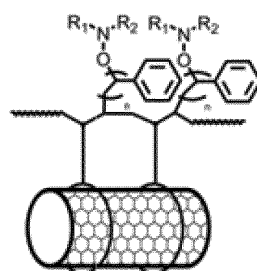
Fig. 138

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SWNT-ML-polymer-polystyrene and SWNT-ML-polymer-polyisoprene



General formula:



Different nitroxide-mediated radical polymerization (NMRP) initiators

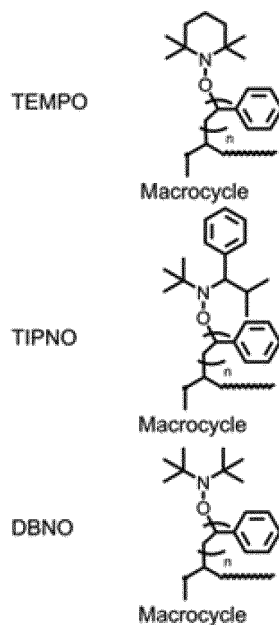


Fig. 139

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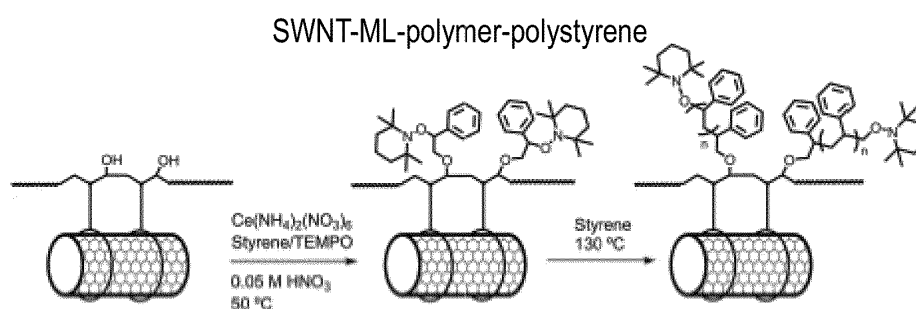


Fig. 140

General structure for organic peroxides-based radical initiators

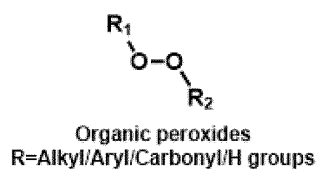


Fig. 141

SWNT carrying polystyrene

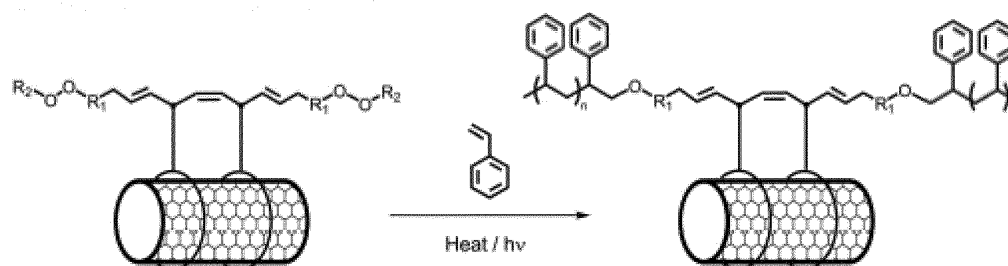
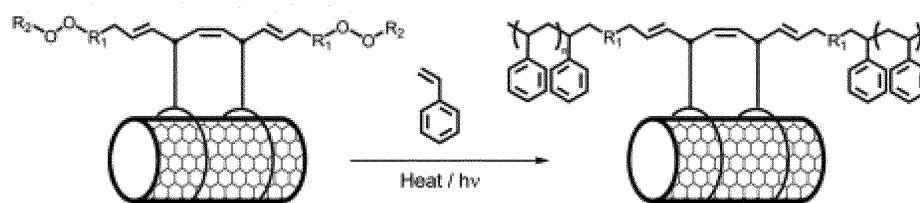
If the radical is generated in the $-\text{R}_1-\text{O}^\bullet$ If the radical is generated in the $-\text{R}_1^\bullet$ 

Fig. 142

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In situ polymerisation involving ATRP initiators such as alkyl halides, to produce e.g., polystyrene-SWNT composite.

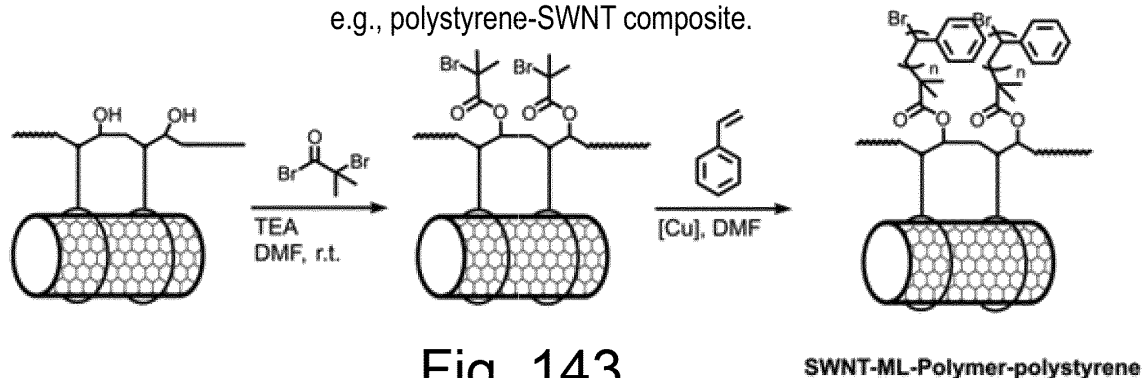


Fig. 143

General structures generated by in situ polymerisation involving ATRP initiators.

Different ATRP-Polymers

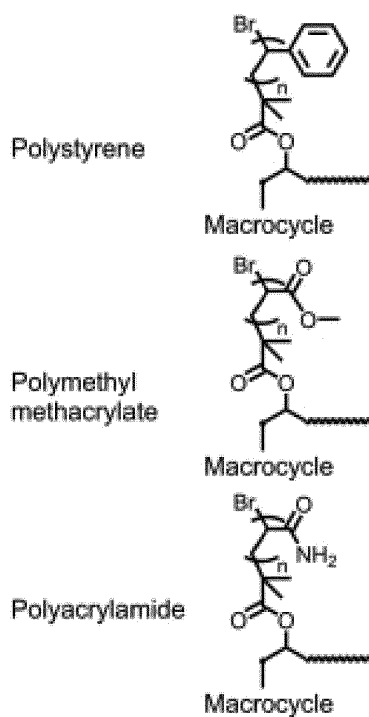


Fig. 144

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SWNT-ML-polymer-RAFT initiator

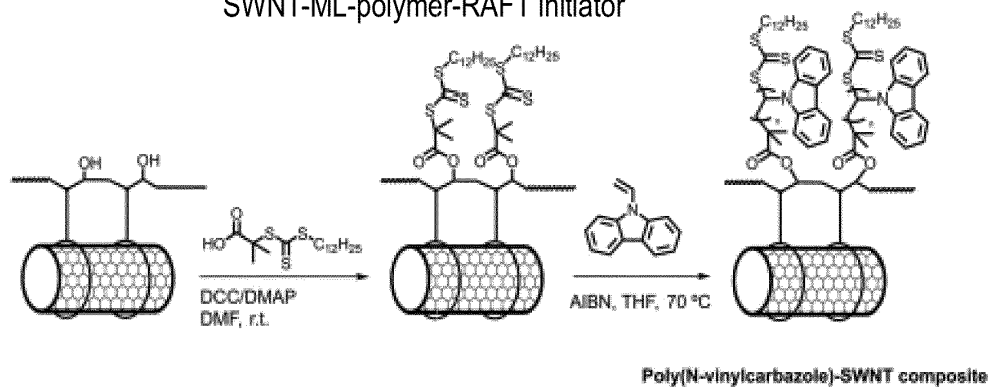


Fig. 145

General structures generated by in situ polymerisation involving RAFT initiators.

Different RAFT-Polymers

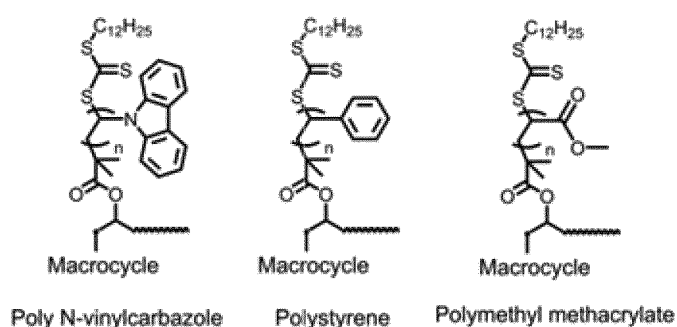


Fig. 146

In situ polymerisation involving organic photoinitiators

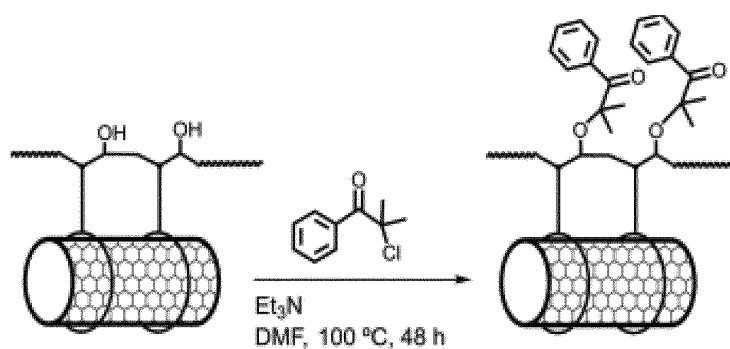
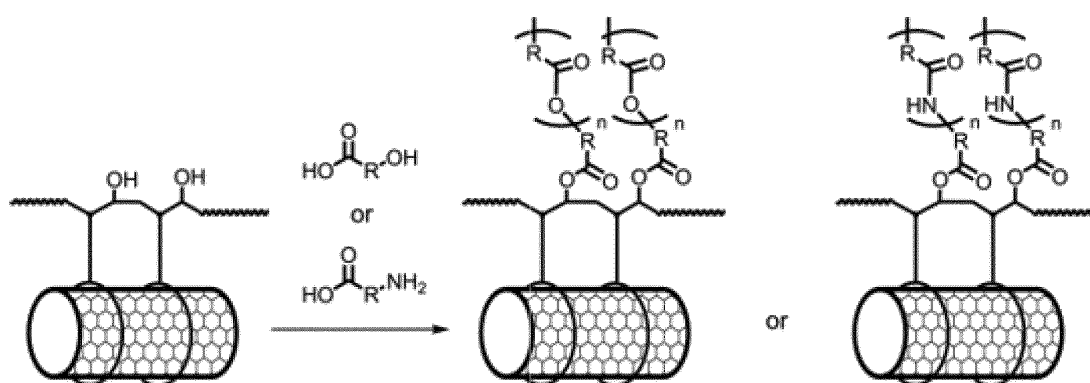


Fig. 147

In situ polymerisation involving initiators that only react with one reactive group of a monomer that is asymmetric in the sense that it comprises two different reactive groups, both of which are involved in the polymerization process.

AB-type polycondensation



AABB-type polycondensation

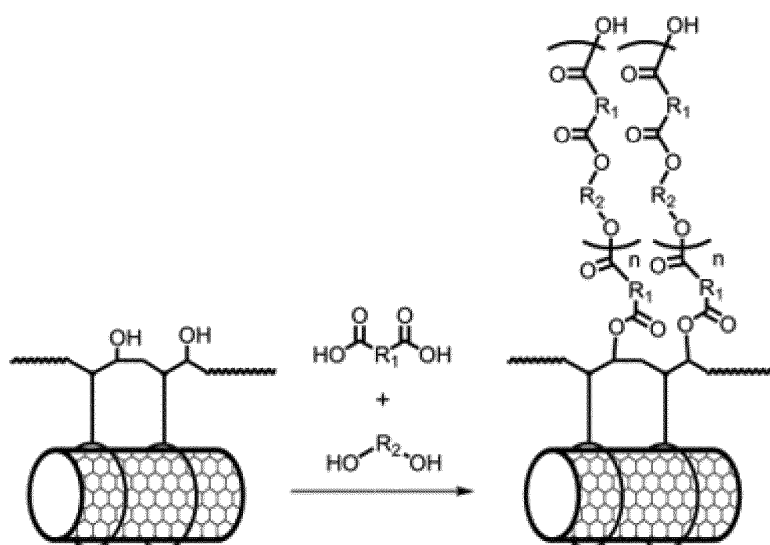


Fig. 148

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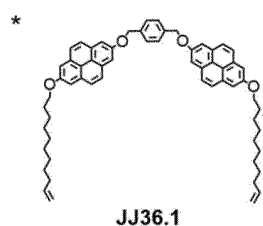
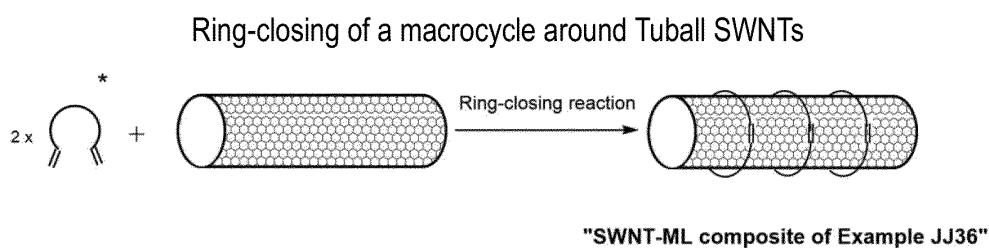


Fig. 149

TGA analysis of "SWNT-ML composite of Example JJ36".

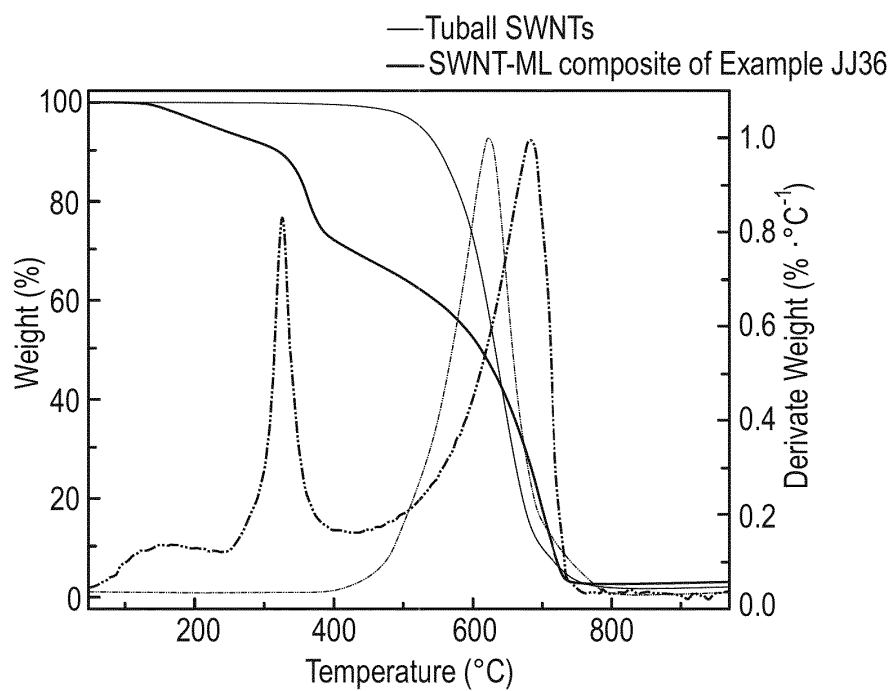


Fig. 150

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AC-HRTEM analysis of "SWNT-ML composite of Example JJ36".

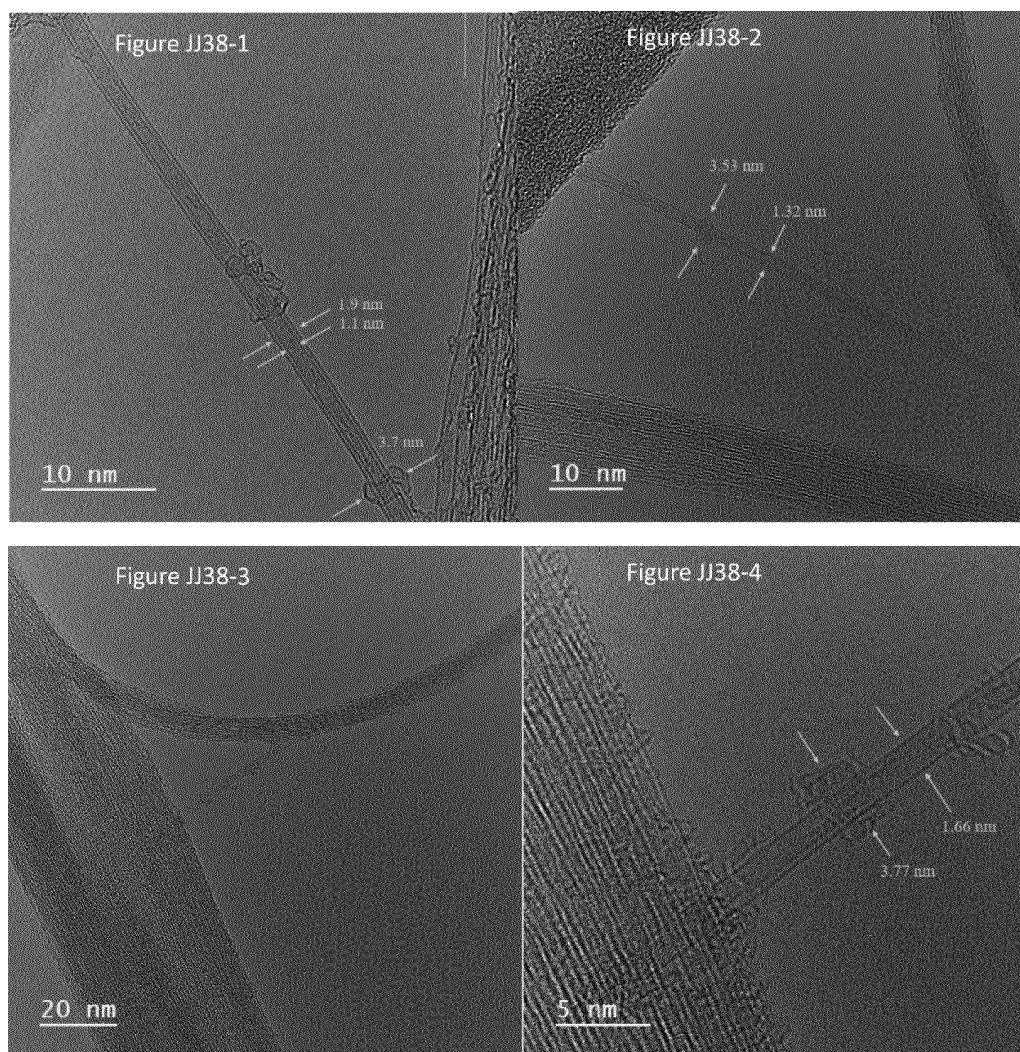


Fig. 151

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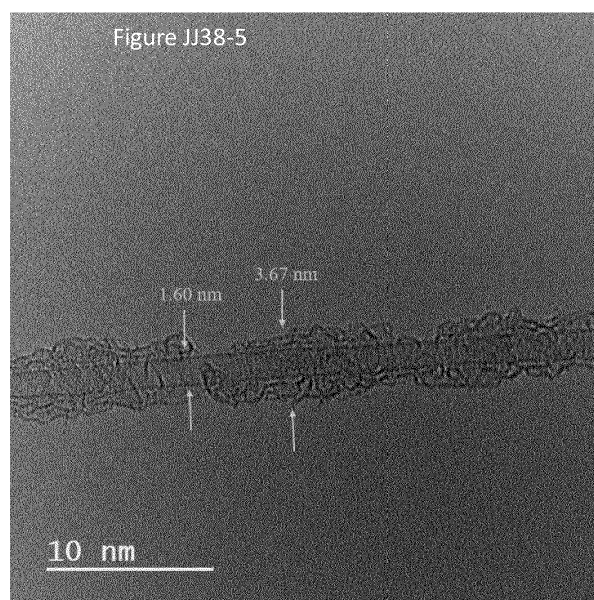


Fig. 151 (Continued)

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A.

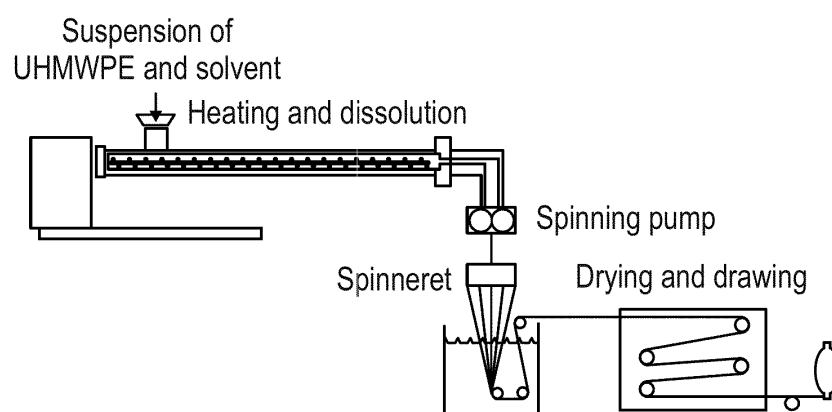
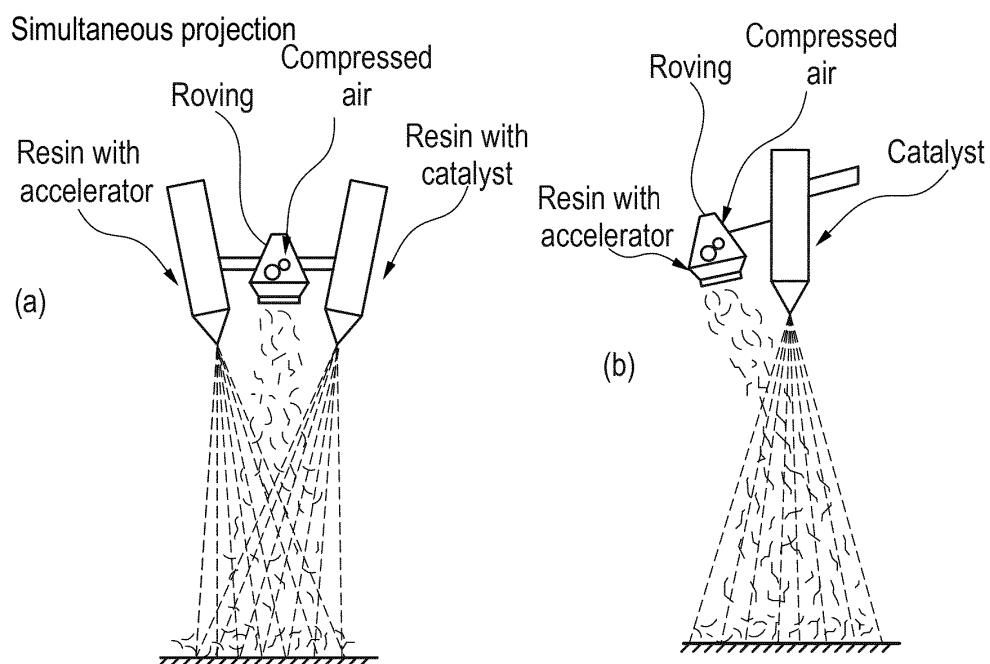


Fig. 152

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Sheet moulding compound.

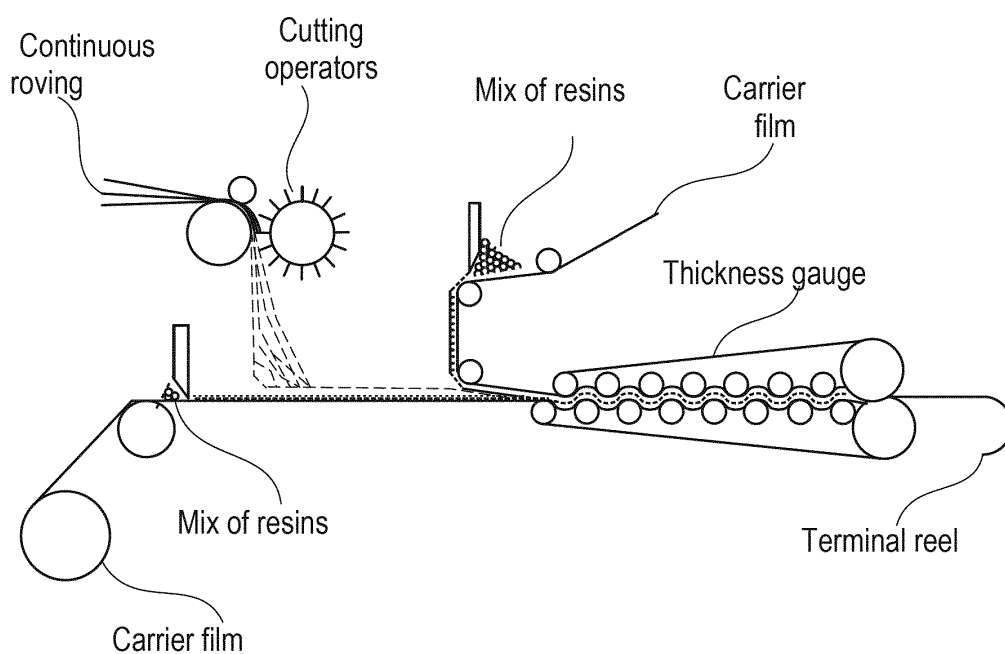


Fig. 152 (Continued)

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Bidentate compound carrying two MLs.

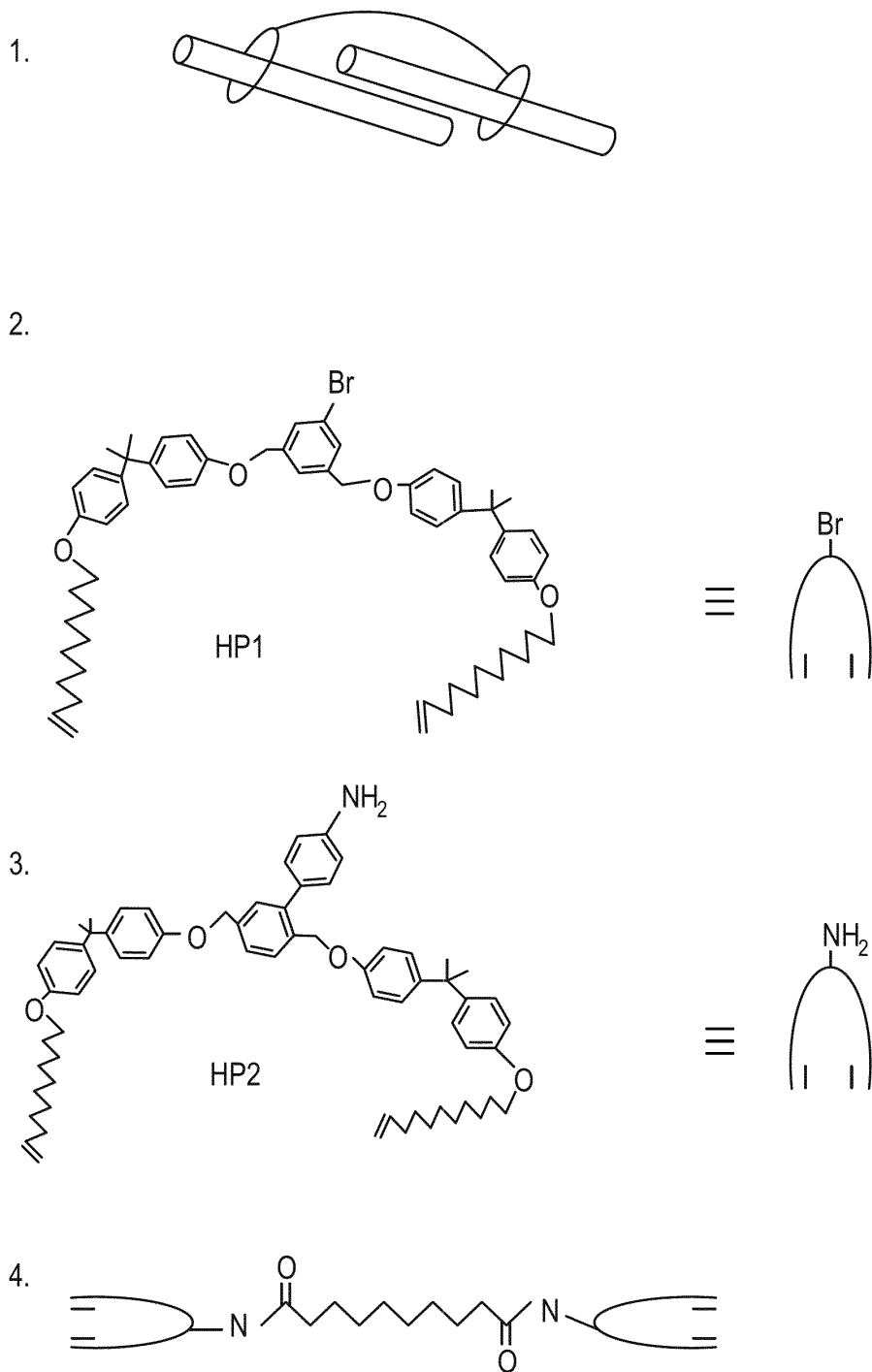
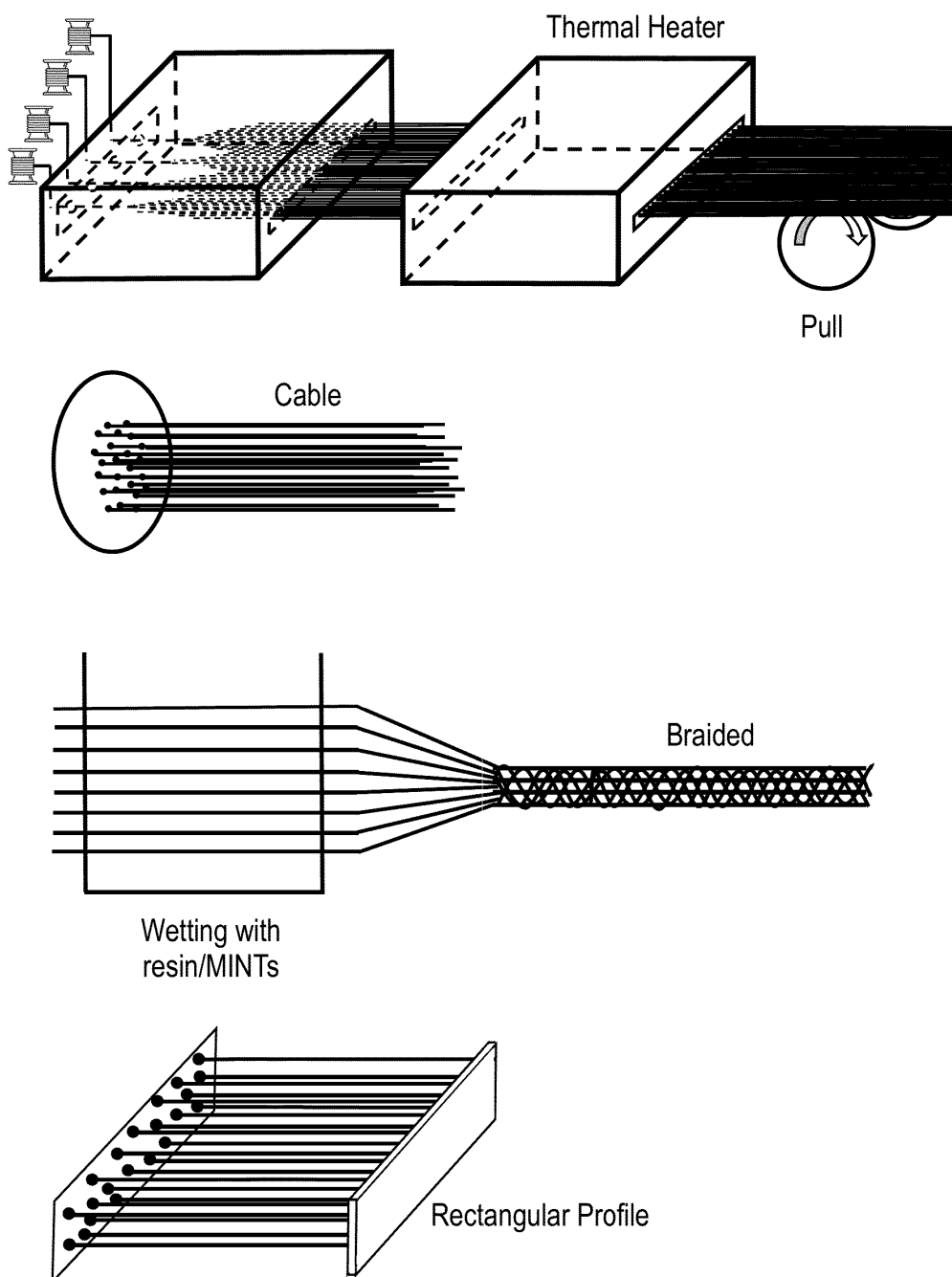


Fig. 153a

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Pultrusion using drawn CNT forests, CNT thread or other types of CNT fibers and -
lines.

**Fig. 153b**

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Precursor-ML carrying protonated amines, binding to a carbon nanotube.

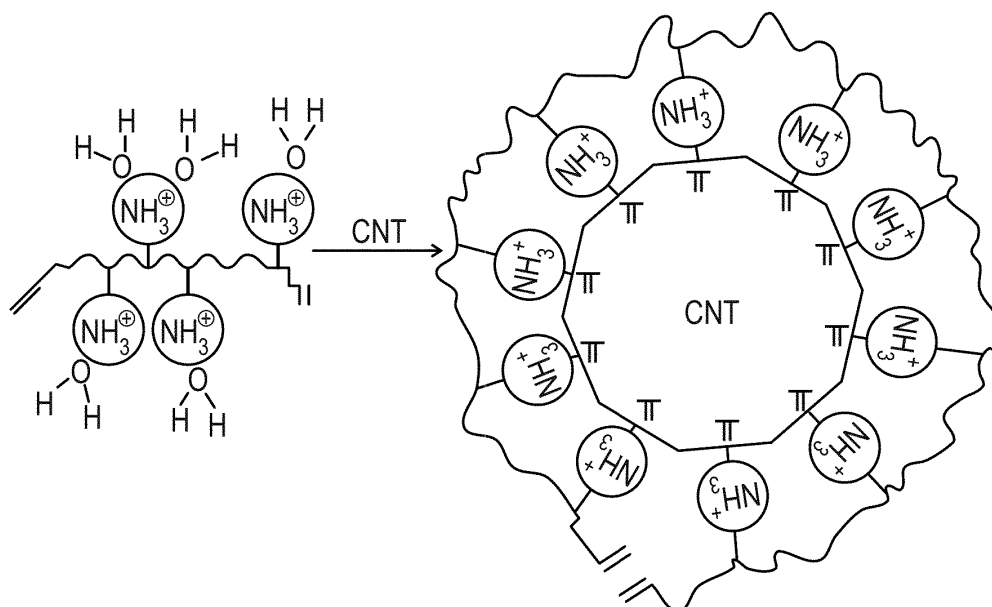


Fig. 154a

Precursor-ML carrying polar groups, binding to a carbon nanotube.

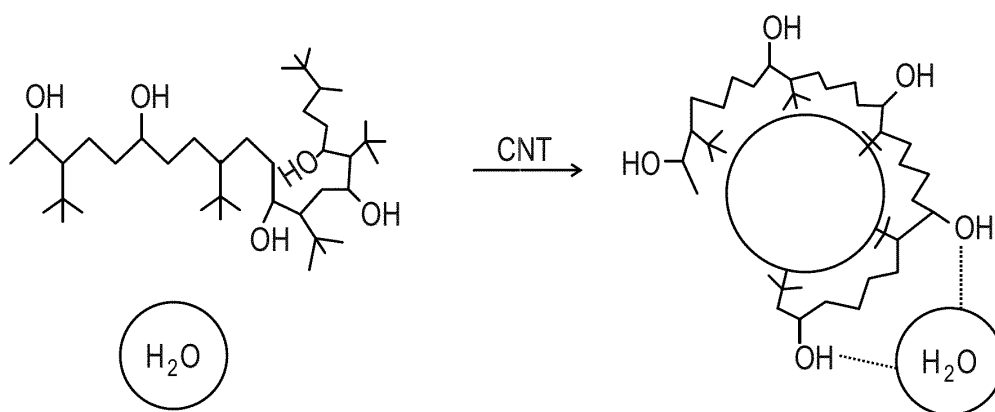


Fig. 154b

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Recycling a thermoset-nanotube composite.

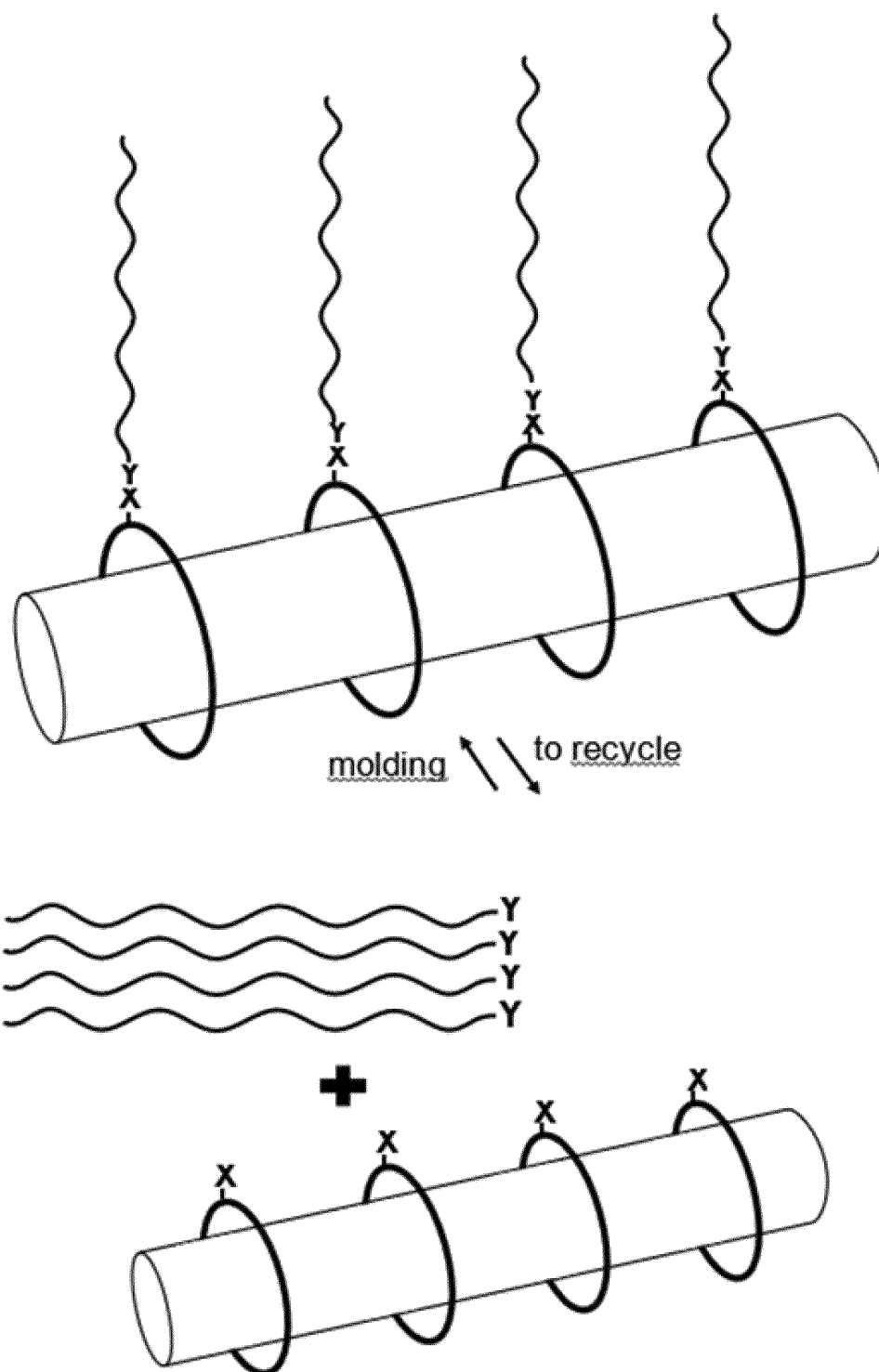


Fig. 155

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Two approaches for making CNT-reinforced Kevlar.

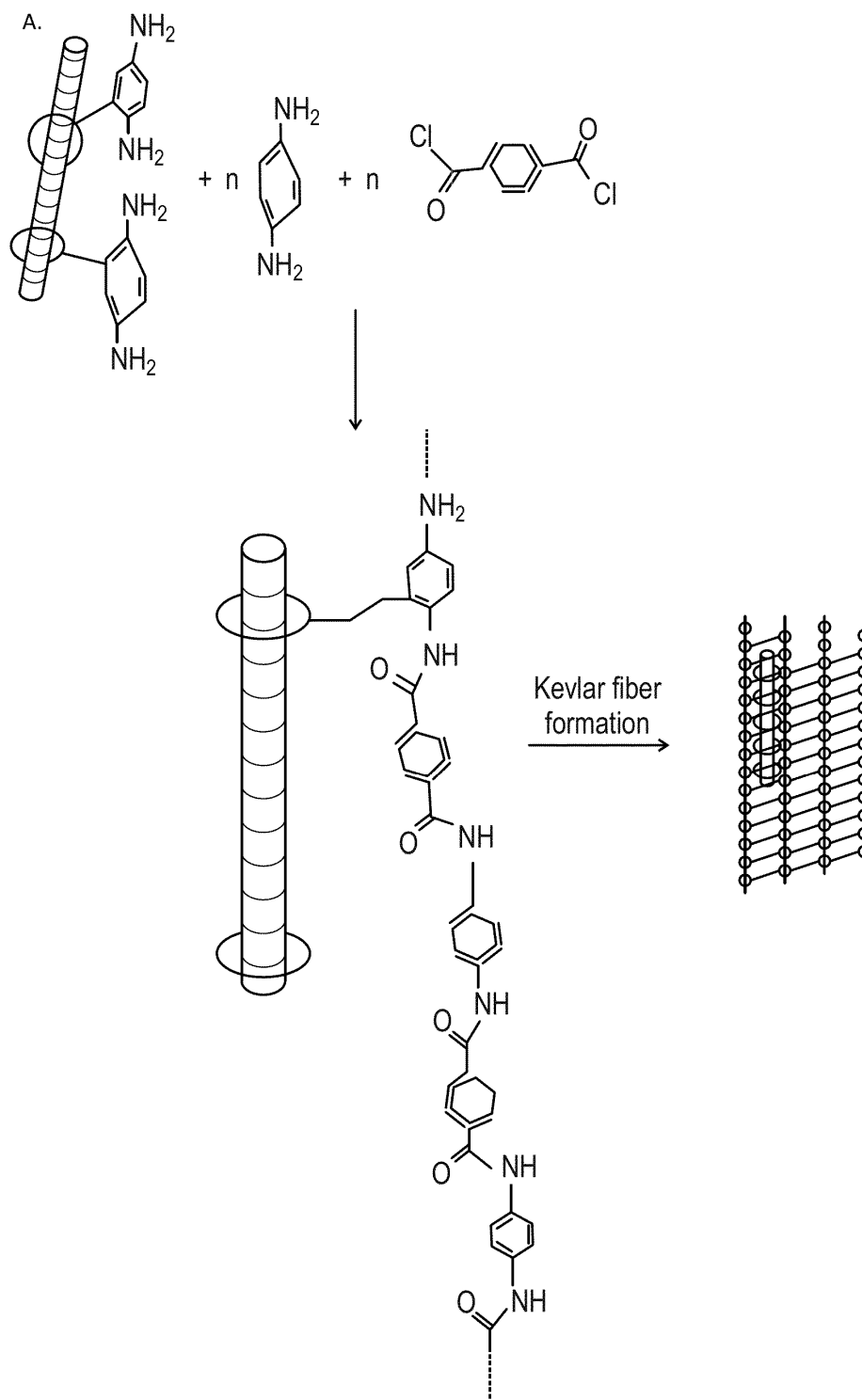
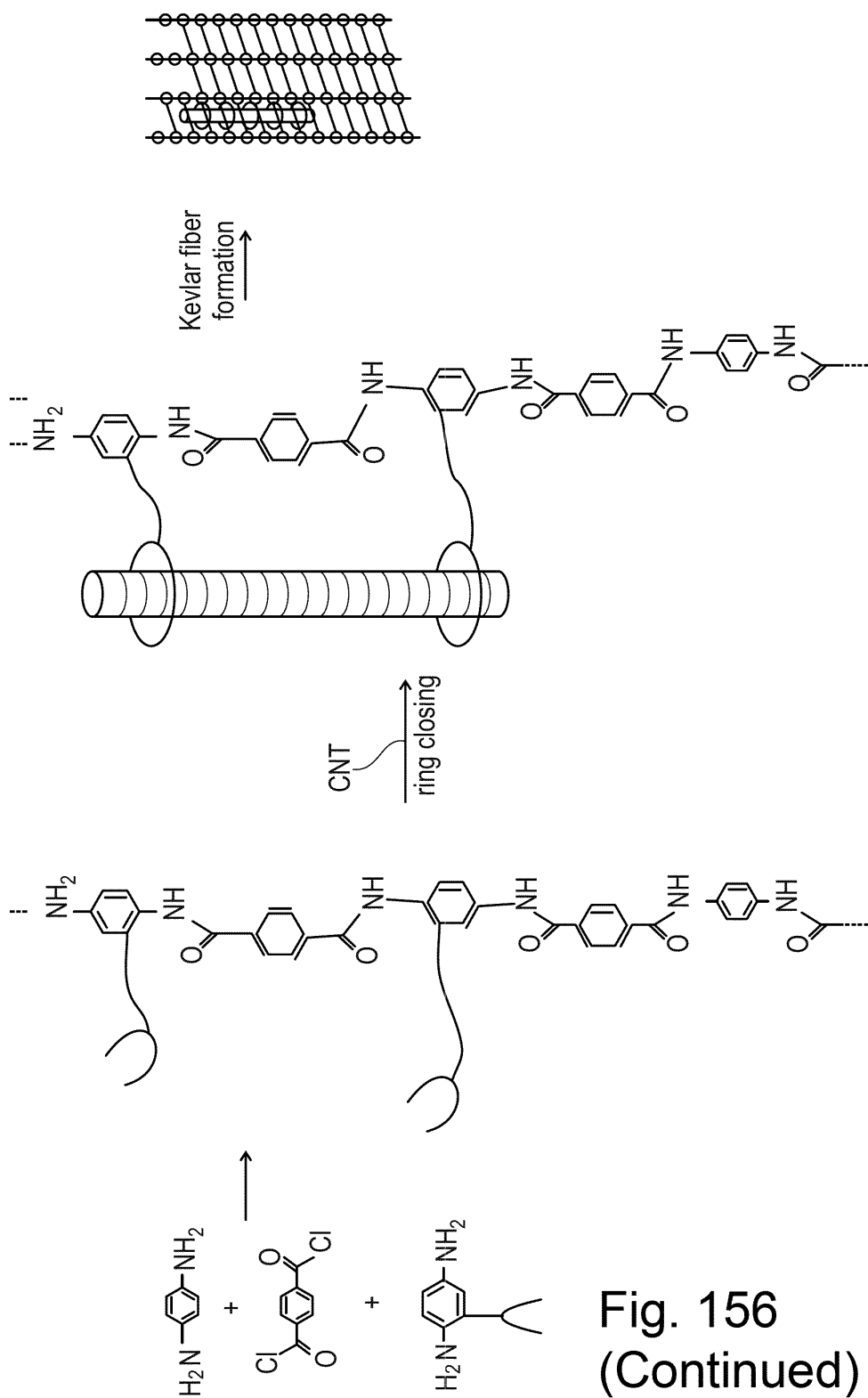


Fig. 156

SUBSTITUTE SHEET (RULE 26)

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Scheme 1

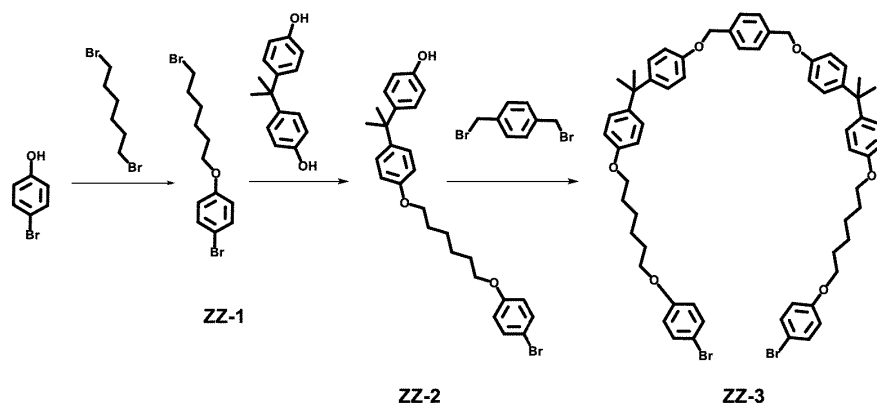


Fig. 157

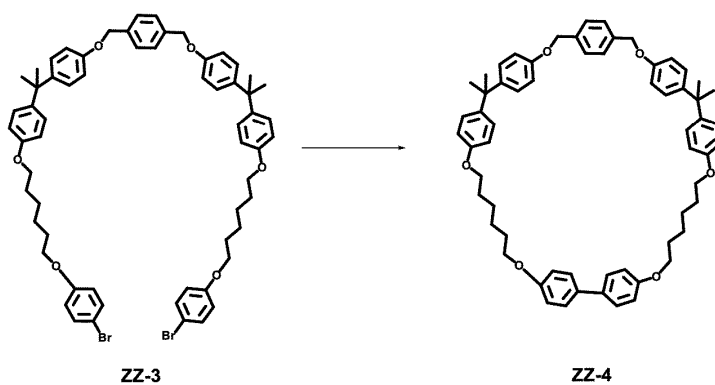


Fig. 158

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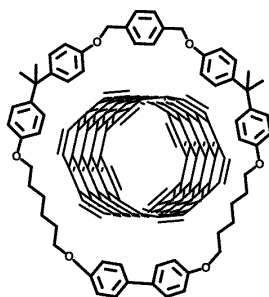


Fig. 159

Scheme 2

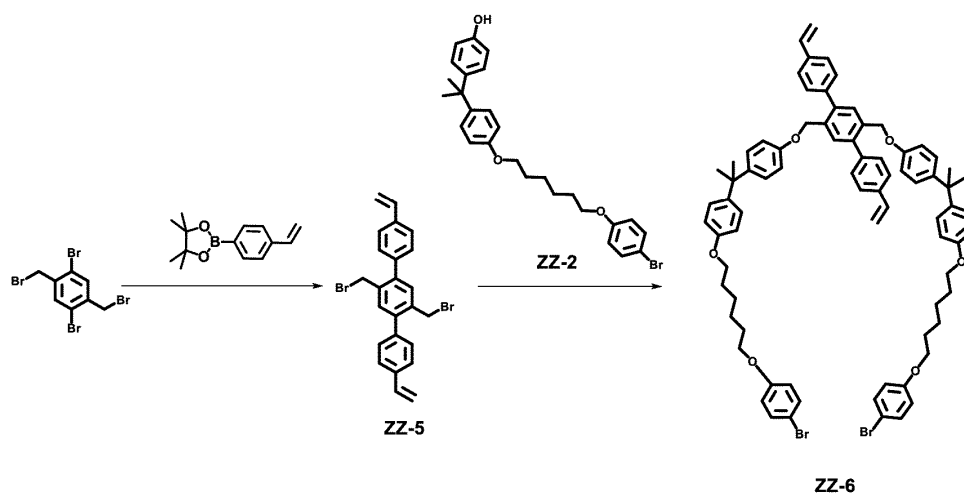


Fig. 160

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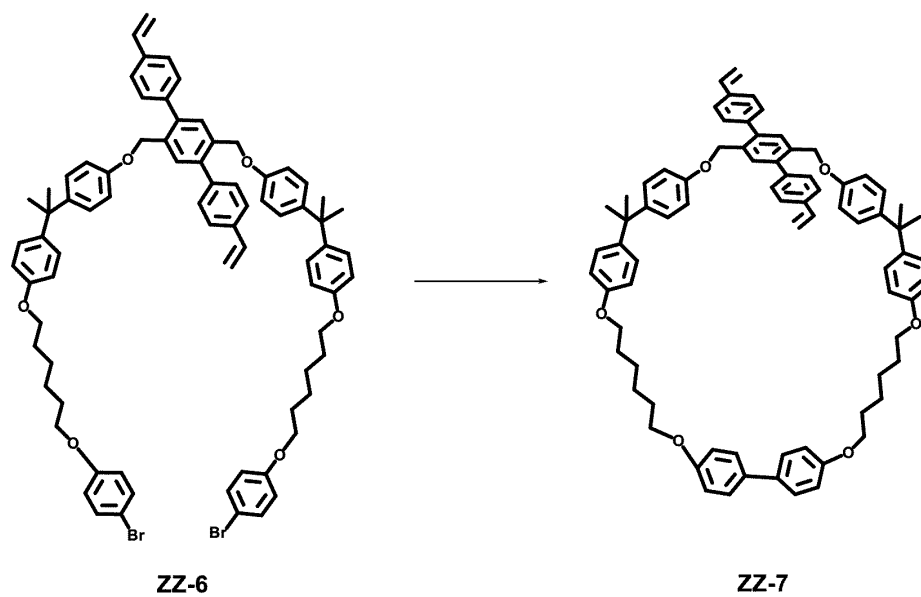


Fig. 161

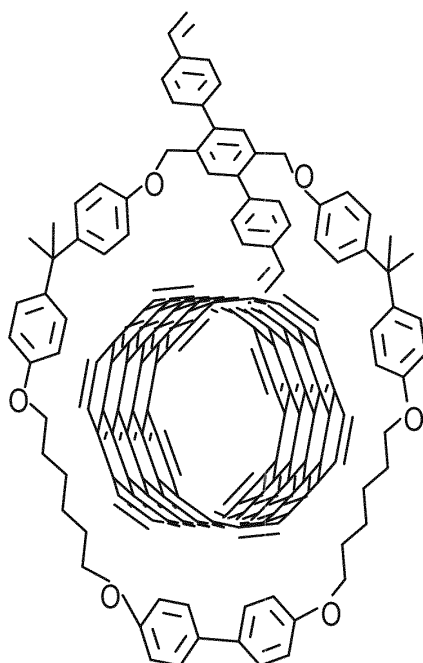


Fig. 162

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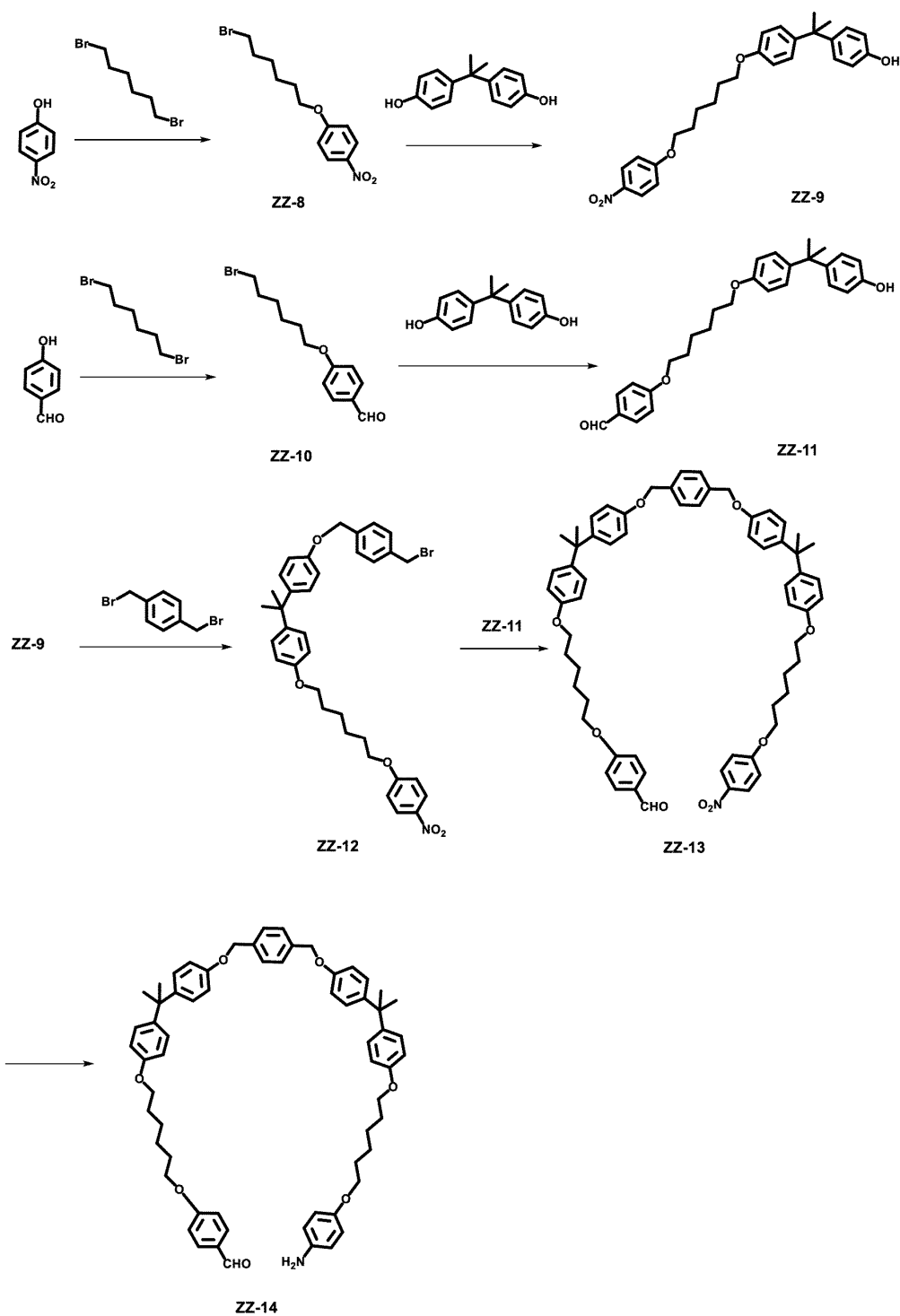


Fig. 163

SUBSTITUTE SHEET (RULE 26)

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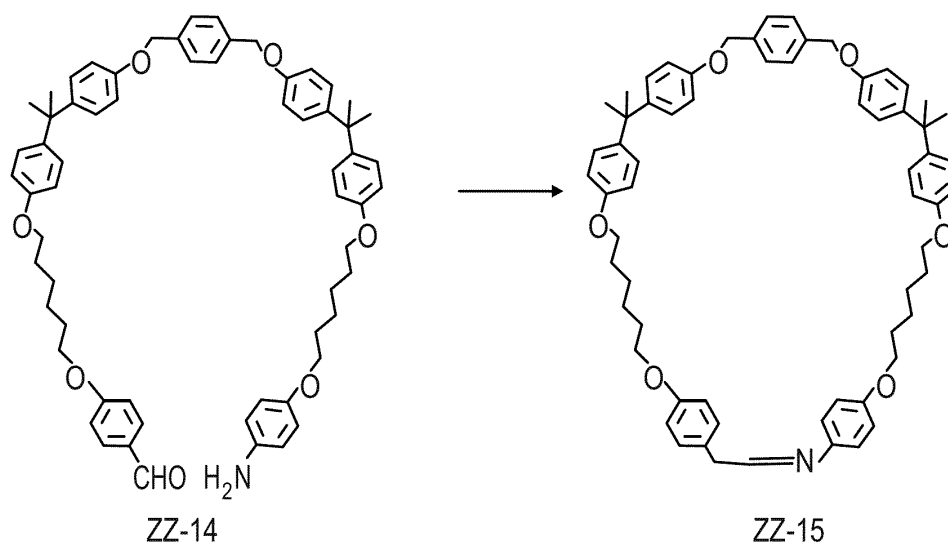


Fig. 164

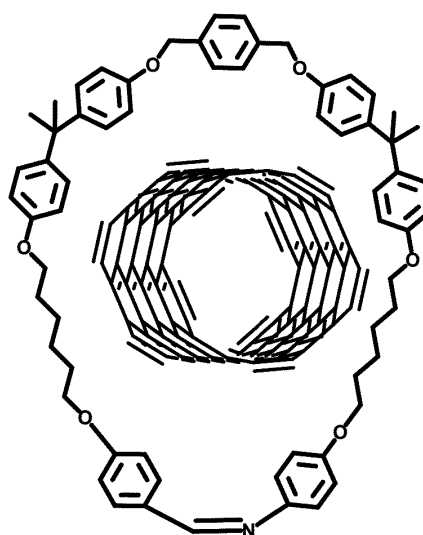


Fig. 165

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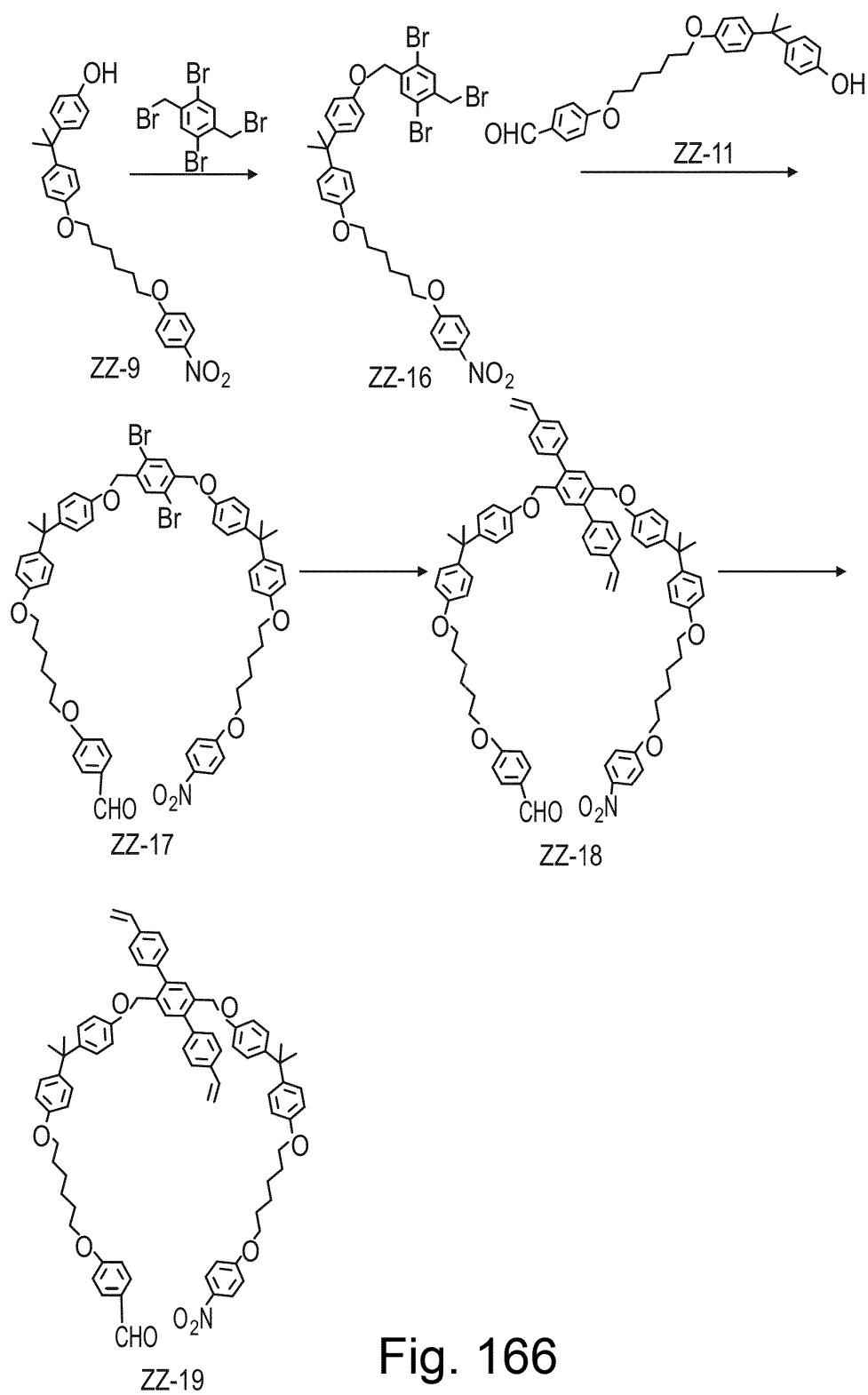


Fig. 166

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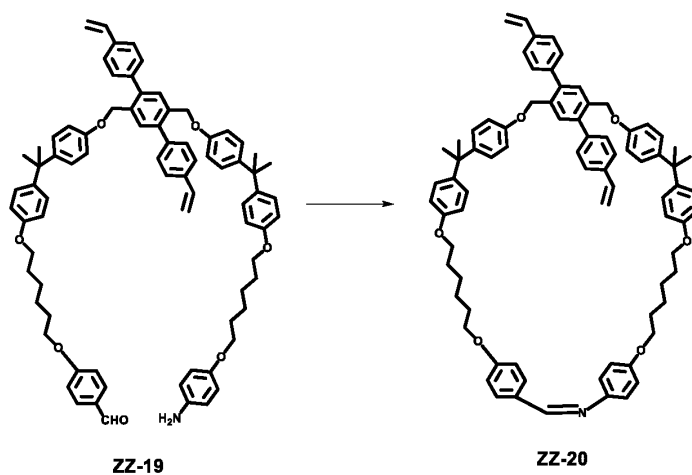


Fig. 167

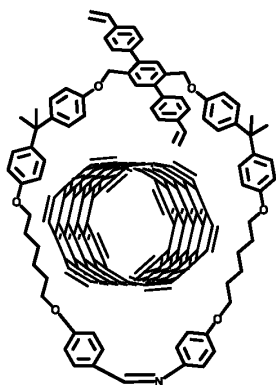


Fig. 168

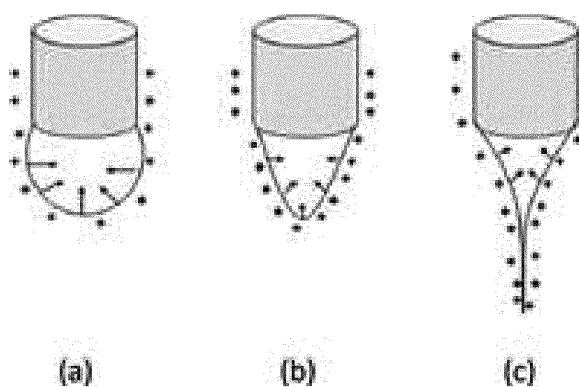


Fig. 169