Highly Selective Suppression of Melanoma Cells by Inducible DNA Cross-Linking Agents: Bis(catechol) Derivatives

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Scheme S1

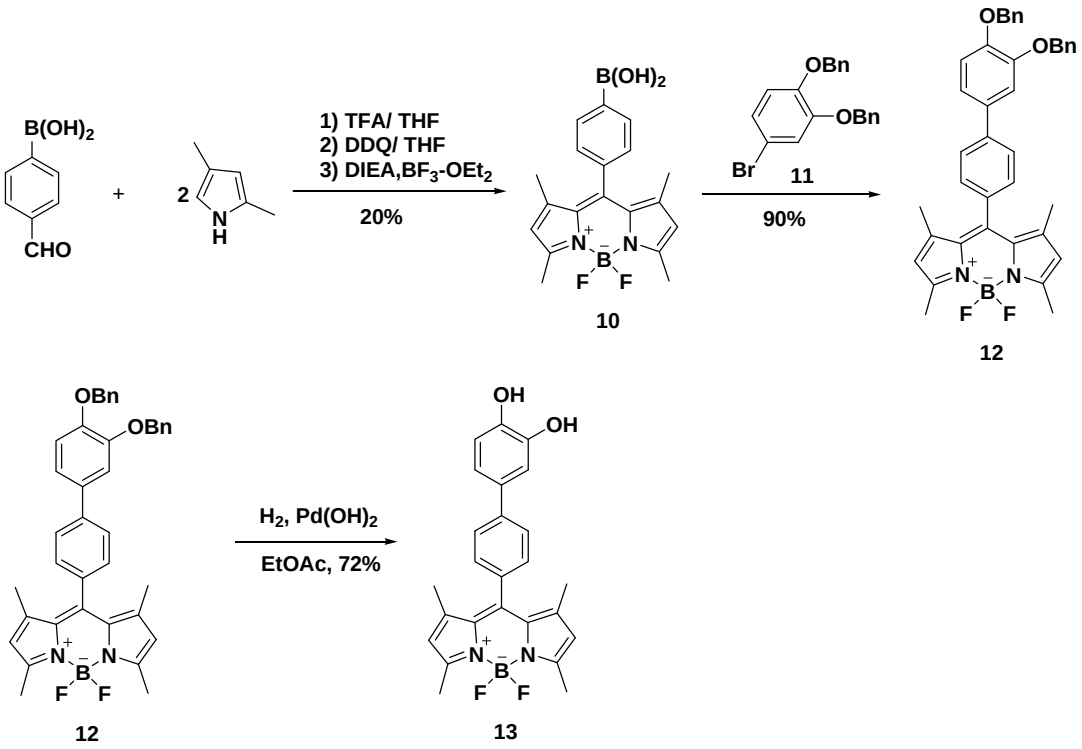


Figure S1 UV/Vis absorbance changes of compound **9f** (25 μM) and MBTH (50 μM) with varied concentration of tyrosinase (0 U, 0.2 U, 0.4 U, 0.6 U, 0.8 U, 1.0 U/mL) over an incubation time of 1 h in phosphate buffer (20 mM, pH 6.4). Arrows indicate trends in absorbance with the addition of tyrosinase.

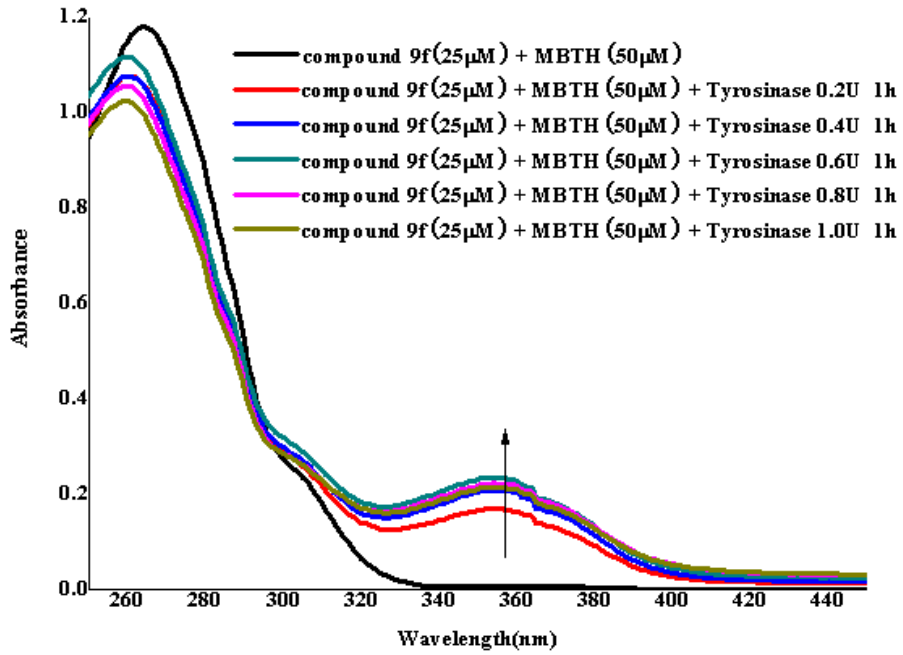
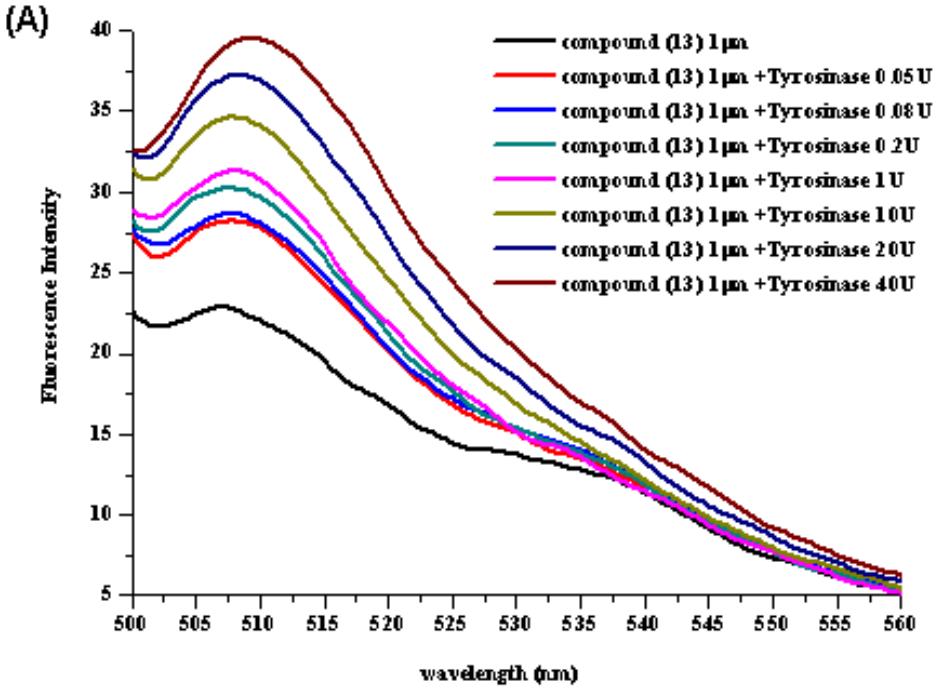


Figure S2 (A) Emission spectra of BODIPY-modified catechol (**13**) (1μM) over an incubation time of 1 h with varied concentrations of tyrosinase (from bottom to top): 0 (control), 0.05, 0.08, 0.12, 0.2, 1, 10, 20 and 40 U/mL. (B) Changes in the emission intensity of BODIPY-modified catechol (**13**) (1μm) upon addition of tyrosinase (40 U/ml) at a fixed time interval of 2 min over a period of 50 min. The measurements were performed in phosphate buffer solution (20 mM, pH 6.4) with λ_{ex} = 480 nm.


(A)
Fluorescence Intensity
wavelength (nm)
compound (13) 1μm
compound (13) 1μm +Tyrosinase 0.05U
compound (13) 1μm +Tyrosinase 0.08U
compound (13) 1μm +Tyrosinase 0.2U
compound (13) 1μm +Tyrosinase 1U
compound (13) 1μm +Tyrosinase 10U
compound (13) 1μm +Tyrosinase 20U
compound (13) 1μm +Tyrosinase 40U

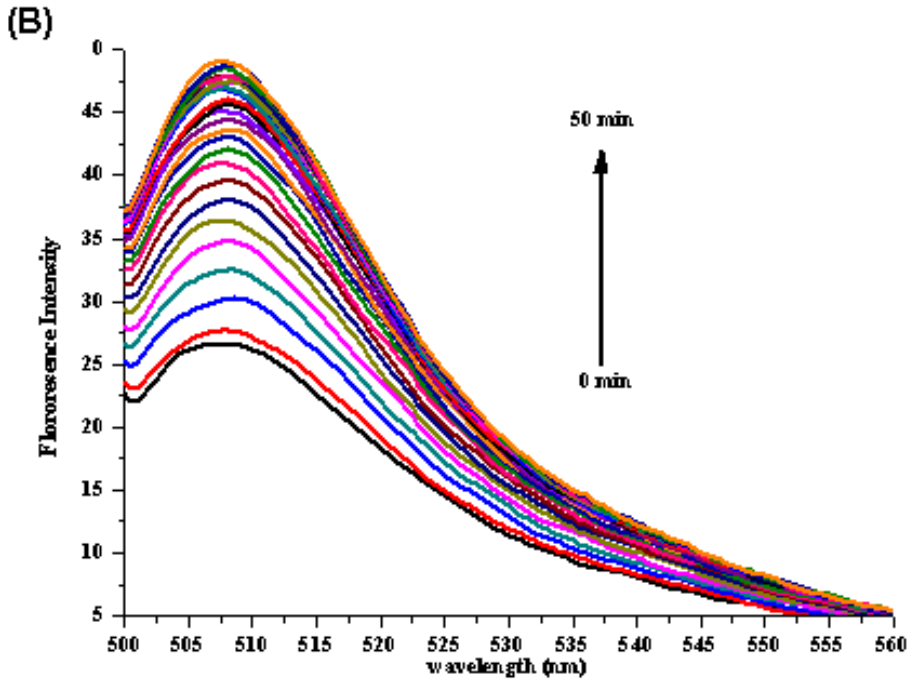
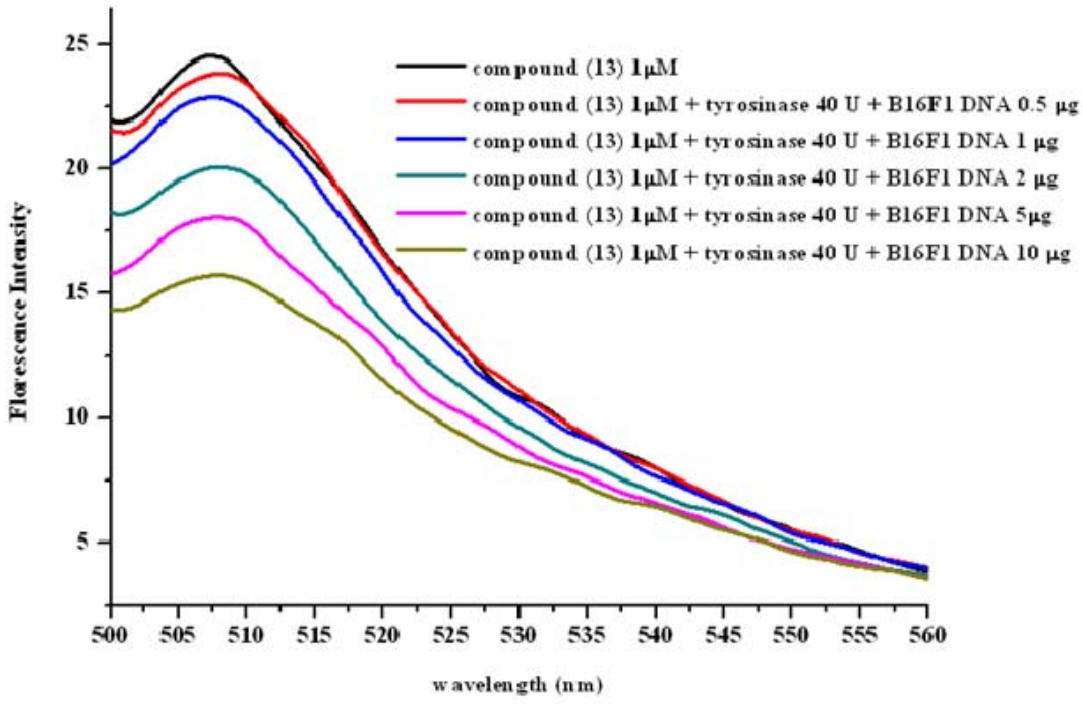

(B)
Florescence Intensity
wavelength (nm)
50 min
0 min

Figure S3 Changes in the emission intensity of BODIPY-modified catechol (**13**) (1μM) and tyrosinase (40 U/mL) upon addition of varied weight of genomic DNA extraction from B16F1 cells. (from top to bottom): 0 (control), 0.5, 1, 2, 10, 20 μg.



Genomic DNA extraction from B16F1 cells. The cell lines were grown in1640 culture media with 10% fetal bovin serum. Cells were collected and washed with PBS twice. Then they were lysed in TES buffer(10 mM Tris pH 8.0, 100 mM EDTA, 0.5% SDS) and incubated at 55 °C overnight with the addition of protease K (100 μg/mL) and RNAse (20 μg/mL). Digested lysates were extracted twice with phenol/ chloroform/isoamyl alcohol (25:24:1) centrifuged at 10000 × g for 15 min and the organic layer was removed. Then the resulting aqueous layer was incubated with 0.1 volume sodium acetate and 0.8 volume of ice ethanol at -20°C overnight. DNA was precipitated after centrifugation at 12000×g for 15min and was left to air dry. Then it was resuspended in TE buffer (10 mM Tris pH 7.2, 2 mM EDTA pH 8.0).

Figure S4 Changes in the emission intensity of BODIPY-modified catechol (**13**) (1 μM) and tyrosinase (40 U/mL) upon addition of varied concentrations of reduced glutathione (from bottom to top): 0 (control), 0.1, 0.5, 1, 2, 5, 10 μM.

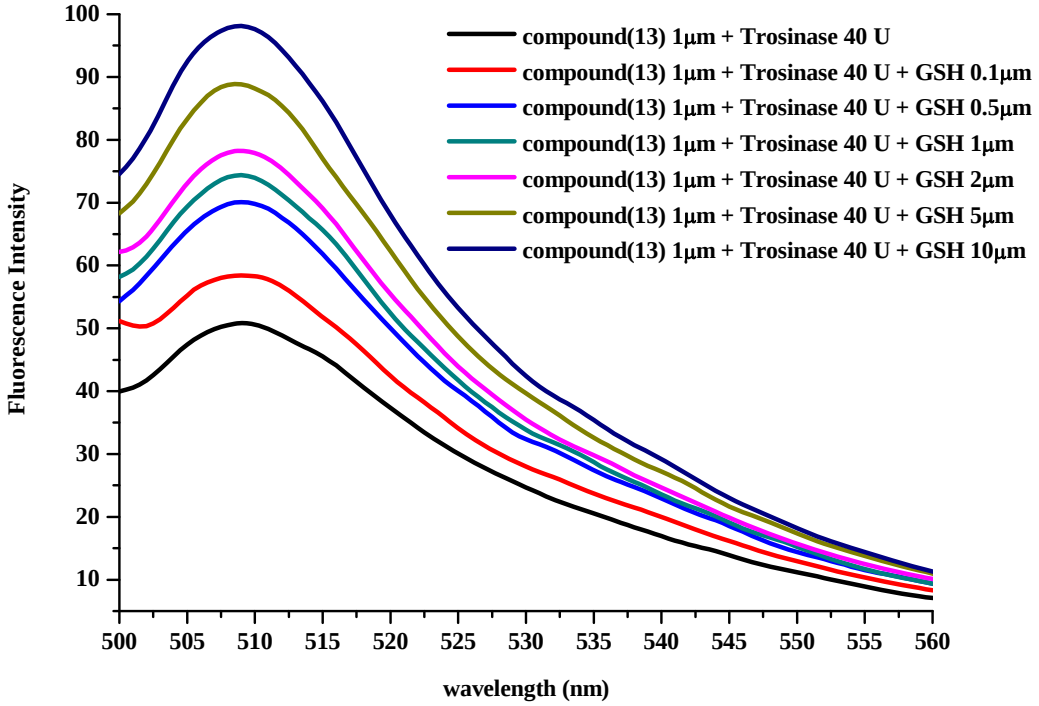


Figure S5 Alkaline comet assay for Hela cells (A) and CHO (B) cells treated with compound **9f**. Cells were incubated with increasing concentrations of compound **9f** (0, 5, 10, 20 and 40 μM) for 48 h. The DNA was stained with propidium iodide (PI).

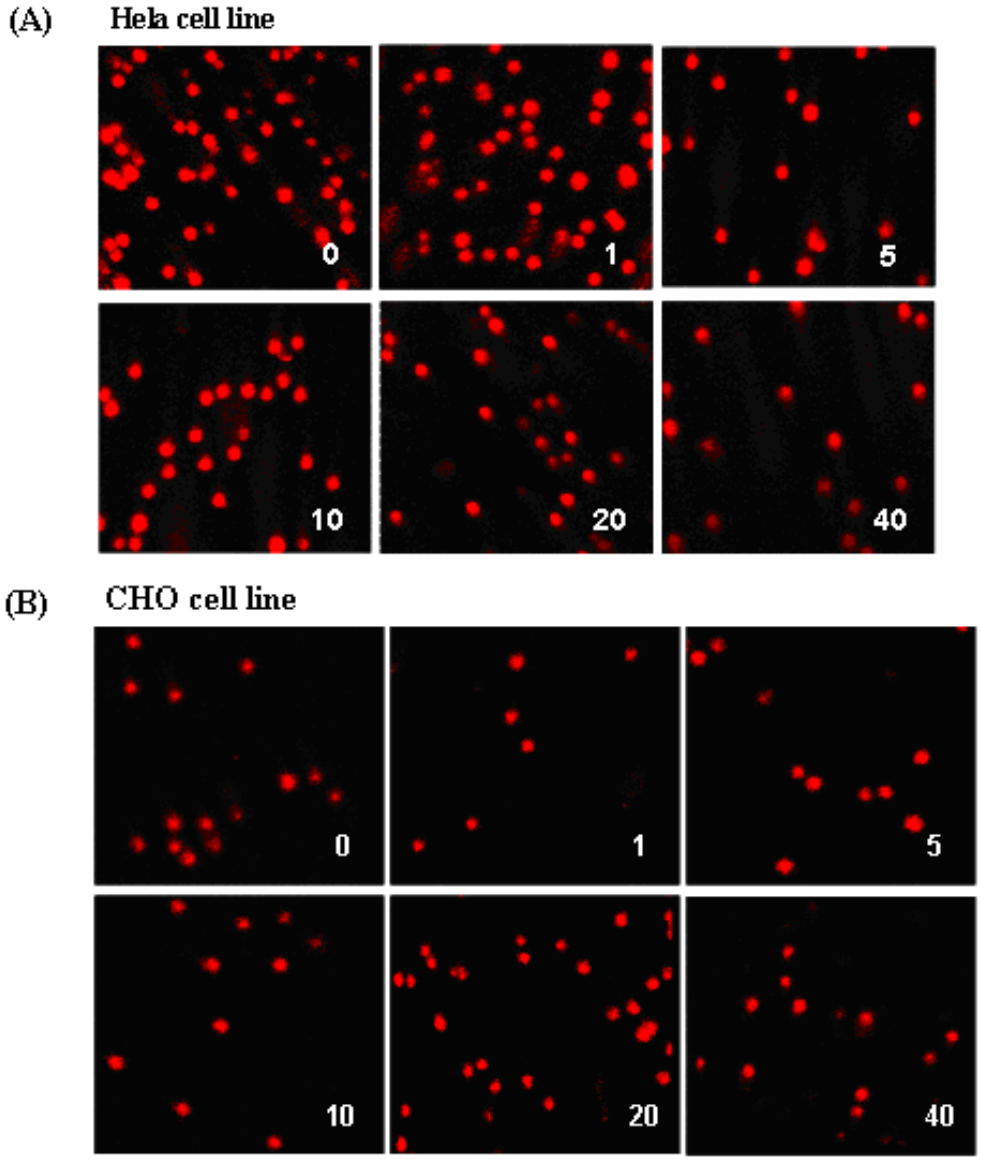


Figure S6 γ-H2AX immunofluorescence in CHO and Hela cells after incubation with treatment of 20 μM compound **9f** for 48 h.

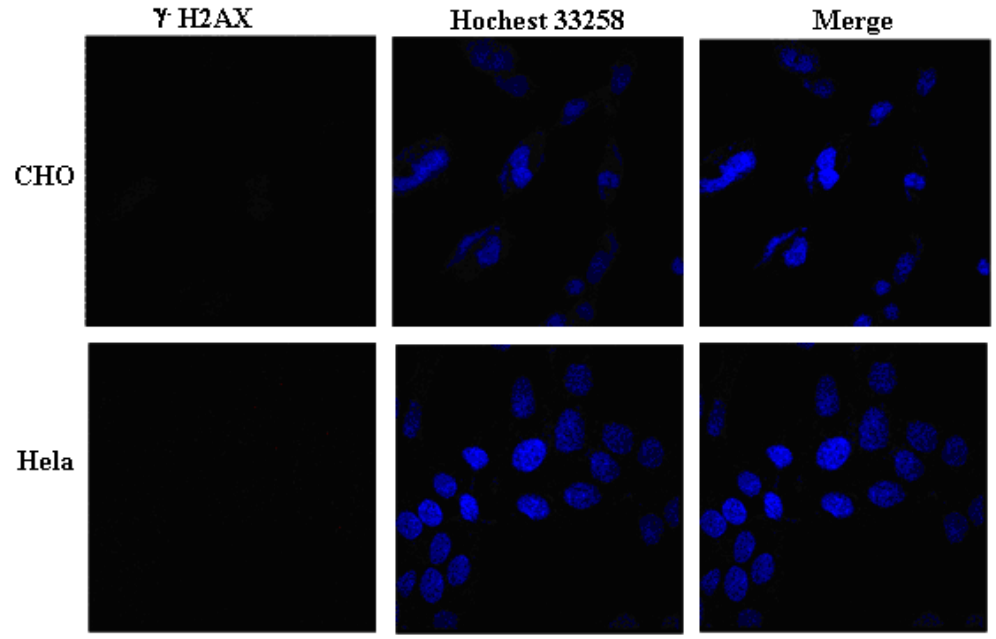
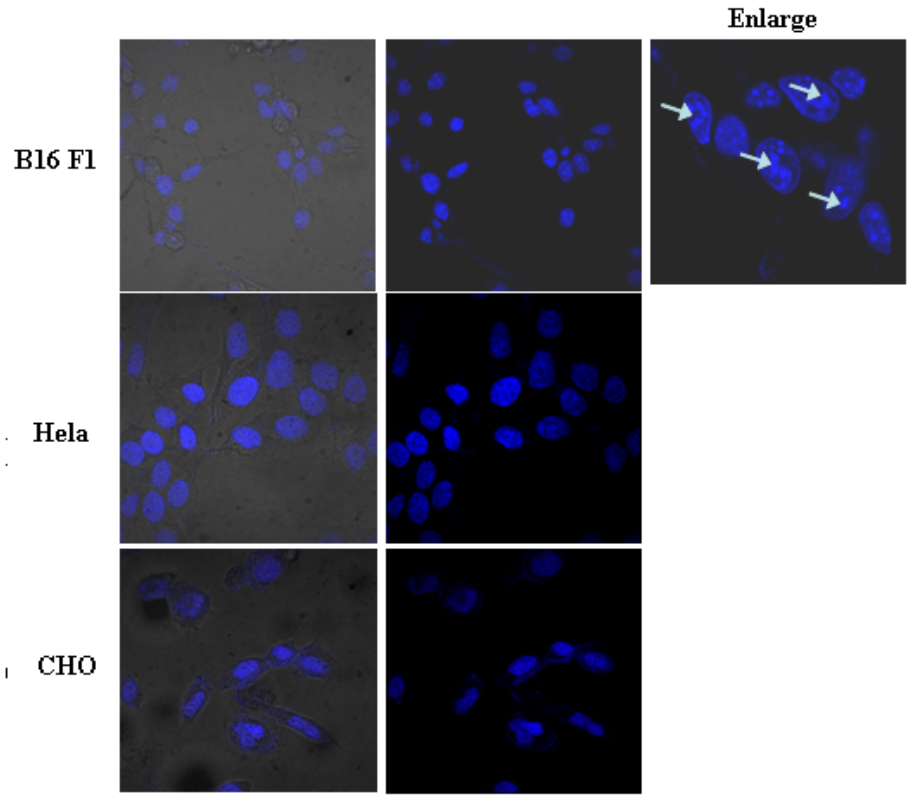


Figure S7 Microphotographs of three different cells after treatment with the compound **9f** (5μM). All the cells were incubated for 48 h with the compound **9f**, and stained with 5μg/L Hoechst-**33258**.



Procedures of Synthesis

8-[benzeneboromic acid]-1, 3, 5, 7-tetramethyl-4, 4-difluoro-4-bora-3a, 4a-diaza-s-indacene (10) [1] TFA (8 drops) was added dropwise to a stirred solution of 2, 4-dimethyl-1H-pyrrole (633 mg, 7 mmol) and 4-Formylbenzeneboromic acid (500 mg, 3.33 mmol) in dry THF (30 mL). The reaction was stirred at room temperature until TLC showed complete consumption of the aldehyde. DDQ (756 mg, 3.33 mmol) was added in a single portion, and the reaction was stirred at room temperature overnight. N, N-Diisopropylethylamine (4 mL, 23 mmol) and $BF_3 \cdot Et_2O$ (6 mL, 47 mmol) were added, and the reaction was stirred at room temperature for 6 h. The reaction mixture was washed with water (3×100 mL) and brine (3×100 mL). The separated organic fractions were dried with Na_2SO_4, and the solids were removed by gravity filtration. The crude product was preadsorbed onto 5 mL of silica and dried under vacuum filtered. Flash chromatography (1:3 hexanes/EtOAc) provided **10** as a bright orange powder (250 mg, 20%) after solvent removal.

4-bromo-3, 4-Bis(benzyloxy) phenyl (11) [2] Benzyl bromide (720 μL, 6 mmol) and K_2CO_3 (560 mg, 4 mmol) and were added to the solution of 4-Bromocatechol (500 mg, 2.67 mmol) in acetone (30 mL). And the mixture was refluxed overnight. The reaction mixture was filtered, and the reaction solvent removed to yield the crude product. And then purified on a silica gel using petroleum ether /EtOAc (1:10) as eluant afford a white solid (880 mg, 90 %).

8-[3, 4-Bis(benzyloxy)biphenyl]-1, 3, 5, 7-tetramethyl-4, 4-difluoro-4-bora-3a, 4a-diaza-s-indacene (12) [2] The compounds **10** (100 mg, 0.27 mmol) and **11** (110 mg, 0.3 mmol) were dissolved in dry THF (10 mL), and the resulting solution was purged with nitrogen for 1 h. To this solution was added a nitrogen-purged aqueous solution of 2 M Na_2CO_3 (2 mL, 4 mmol), followed by $Pd(PPh_3)_4$ (10 mg, 3 mol-%). The reaction mixture was refluxed overnight. The THF was removed under reduced pressure and the residue was taken up into DCM (100 mL), which was washed with brine (2×50 mL), separated and dried with Na_2SO_4. After filtration, the solvent was removed under reduced pressure, to yield a dark red residue. The residue was chromatographed on silica gel with a solvent gradient (first petroleum ether/ EtOAc (100:1), then petroleum ether/ EtOAc (10:1)) to afford an orange solid (145 mg, 90% yield).

8-[3,4-Dihydroxybiphenyl]-1,3,5,7-tetramethyl-4,4-difluoro-4-bora-3a,4a-diaza-s-indacene (13).[3] The compounds **12** (10 mg, 0.016 mmol) in 20 mL THF was mixed with 10% $Pd(OH)_2$ (1 mg) and stirred overnight under hydrogen from a balloon. The suspension was filtered and the solvent was removed under reduced pressure, to yield a dark red residue. The residue was chromatographed on silica gel with a solvent gradient (first CH_2Cl_2, then CH_3OH) to afford an orange solid (5 mg, 72% yield).

References

(1) Sunahara, H.; Urano, Y.; Kojima, H.; Nagano, T.; *J. Am. Chem. Soc*. **2007**, *129*, 5597-5604.

(2) Andrew, C. B.; Graeme, C.; Kristopher, J. E.; Ross, W. H.; William, C.; *Eur. J. Org. Chem.* **2008**, 2705-2713.

(3) Yue, Q. Y.; Hiroyuki, K.; Jun-ichi, O.; Kunie. Y.; Naoki, A.; Shunya, T.; *Org. Lett.* **2009**, *11*, 5074–5077.

Characterization Data

^{1}H NMR, ^{13}C NMR and HRMS data for individual compounds *N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,5-pentanediamine dibromide (5a) ^{1}H NMR (D_2O): δ = 7.13 (m, 4 H), 6.95 (m, 2 H), 4.35 (s, 4 H), 3.77 (s, 6 H), 3.70 (s, 6 H), 3.14-3.19 (m, 4 H), 2.87 (s, 12 H), 1.79 (br s, 4 H), 1.28 (br s, 2 H); ^{13}C NMR (D_2O): δ = 24.67, 25.40, 52.62, 58.64, 63.94, 65.13, 66.59, 118.59, 123.77, 127.82, 128.44, 151.40, 155.35 ppm. ESI-MS for $C_{27}H_{44}Br_2N_2O_4$: calcd. $(M-Br)^+$: 539.2479, found: 539.2488.

***N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,6-hexanediamine dibromide (5b)** ^{1}H NMR (D_2O): δ = 7.06-7.09 (m, 4 H), 6.90 (m, 2 H), 4.29 (s, 4 H), 3.73 (s, 6 H), 3.66 (s, 6 H), 3.07-3.12 (m, 4 H), 2.81 (s, 12 H), 1.68 (br s, 4 H), 1.23 (br s, 4 H); ^{13}C NMR (D_2O): δ = 22.36, 25.49, 49.99, 56.14, 61.41, 62.50, 64.46, 116.06, 121.28, 125.25, 125.92, 148.86, 152.81 ppm. ESI-MS for $C_{28}H_{46}Br_2N_2O_4$: calcd. $(M-Br)^+$: 553.2635, found: 553.2636.

***N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,7-heptanediamine dibromide (5c)** ^{1}H NMR (D_2O): δ = 7.04 (m, 4 H), 6.85-6.87 (m, 2 H), 4.26 (s, 4 H), 3.69 (s, 6 H), 3.62 (s, 6 H), 3.03-3.11 (m, 4 H), 2.77 (s, 12 H), 1.63 (br s, 4 H), 1.18 (m, 6H); ^{13}C NMR (D_2O): δ = 22.16, 25.45, 27.91, 49.79, 55.92, 61.24, 62.24, 64.45, 115.79, 121.14, 125.09, 125.72, 148.63, 152.64 ppm. ESI-MS for $C_{29}H_{48}Br_2N_2O_4$: calcd. $(M-Br)^+$: 567.2792, found: 567.2794.

***N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,8-octanediamine dibromide (5d)** ^{1}H NMR (D_2O): δ = 7.06-7.08 (m, 4 H), 6.87-6.89 (m, 2 H), 4.28 (s, 4 H), 3.72 (s, 6 H), 3.65 (s, 6 H), 3.06-3.09 (m, 4 H), 2.80 (s, 12 H), 1.66 (br s, 4 H), 1.19 (m, 8H); ^{13}C NMR (D_2O): δ = 22.24, 25.55, 28.13, 49.77, 55.94, 61.24, 62.27, 64.59, 115.83, 121.24, 125.15, 125.75, 148.70, 152.72 ppm. ESI-MS for $C_{30}H_{50}Br_2N_2O_4$: calcd. $(M-Br)^+$: 581.2948, found: 581.2935.

***N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,9-nonanediamine dibromide (5e)** ^{1}H NMR (D_2O): δ = 7.05-7.07 (m, 4 H), 6.87-6.89 (m, 2 H), 4.28 (s, 4 H), 3.71 (s, 6 H), 3.64 (s, 6 H), 3.05-3.10 (m, 4 H), 2.79 (s, 12 H), 1.64 (br s, 4 H), 1.15 (m, 10H); ^{13}C NMR (D_2O): δ = 21.62, 24.98, 27.52, 27.66, 49.24, 55.39, 60.61, 61.41, 63.77, 115.14, 120.39, 124.32, 125.08, 148.00, 151.89 ppm. ESI-MS for $C_{31}H_{52}Br_2N_2O_4$: calcd. $(M-Br)^+$: 595.3105, found: 595.3101.

***N,N'*-(2,3-dimethoxybenzyl)-*N,N,N',N'*–tetramethyl-4,4'-biphenyldiamine dibromide (5f).** ^{1}H NMR (D_2O): δ = 7.67 (d, *J* = 8.4, 4 H), 7.47 (d, *J* = 8.4, 4 H), 7.08-7.10 (m, 4 H), 6.91-6.93 (m, 2 H), 4.43 (s, 4 H), 4.41 (s, 4 H), 3.73 (s, 6 H), 3.62 (s, 6 H), 2.77 (s, 12 H); ^{13}C NMR (D_2O): δ = 48.76, 55.92, 56.01, 61.13, 62.74, 68.02, 115.98, 120.91, 125.21, 125.86, 127.14, 127.69, 133.88, 141.50, 148.65, 152.74 ppm. ESI-MS for $C_{36}H_{46}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 649.2635, found: 649.2630.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-l,5-pentanediamine dibromide (6a)** ^{1}H NMR (D_2O): δ = 6.90-6.93 (m, 2 H), 6.76-6.80 (m, 4 H), 4.34 (s, 4 H), 3.19-3.20 (m, 4 H), 2.88 (s, 12 H), 1.80 (br s, 4 H), 1.29 (br s, 2 H); ^{13}C NMR (D_2O): δ = 22.00, 22.83, 49.92, 62.57, 63.96, 115.31, 118.24, 120.57, 125.71, 144.84, 145.67 ppm. ESI-MS for $C_{22}H_{34}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 591.0958, found: 591.0963.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,6-hexanediamine dibromide (6b)** ^{1}H NMR (D_2O): δ = 6.95-6.97 (m, 2 H), 6.80-6.87 (m, 4 H), 4.38 (s, 4 H), 3.19-3.25 (m, 4 H), 2.91 (s, 12 H), 1.78 (br s, 4 H), 1.34 (br s, 4 H); ^{13}C NMR (D_2O): δ = 22.30, 25.48, 49.93, 62.57, 64.52, 115.49, 118.34, 120.65, 125.84, 144.92, 145.74 ppm. ESI-MS for $C_{24}H_{38}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 497.2009, found: 497.2018.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,7-heptanediamine dibromide (6c)** ^{1}H NMR (D_2O): δ = 6.72-6.75 (m, 2 H), 6.57-6.42 (m, 4 H), 4.16 (s, 4 H), 3.00-3.01 (m, 4 H), 2.69 (s, 12 H), 1.55 (br s, 4 H), 1.10 (br s, 6 H); ^{13}C NMR (d_6-DMSO): δ = 27.36, 31.08, 33.47, 54.73, 67.25, 68.94, 120.51, 122.62, 124.54, 129.97, 151.17, 152.50 ppm. ESI-MS for $C_{25}H_{40}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 511.2166, found: 511.2164.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,8-octanediamine dibromide (6d)** ^{1}H NMR (D_2O): δ = 6.82 (m, 2 H), 6.67-6.72 (m, 4 H), 4.25 (s, 4 H), 3.12 (m, 4 H), 2.78 (s, 12 H), 1.64 (br s, 4 H), 1.17 (br s, 8 H); ^{13}C NMR (D_2O): δ = 22.21, 25.56, 28.05, 49.70, 62.21, 64.59, 115.30, 118.08, 120.47, 125.64, 144.76, 145.58 ppm. ESI-MS for $C_{26}H_{42}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 525.2322, found: 525.2328.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,9-nonanediamine dibromide (6e)** ^{1}H NMR (D_2O): δ = 6.53 (m, 2 H), 6.38-6.43 (m, 4 H), 3.96 (s, 4 H), 2.82-2.83 (m, 4 H), 2.50 (s, 12 H), 1.37 (br s, 4 H), 0,86 (br s, 10 H); ^{13}C NMR (D_2O): δ = 22.20, 25.61, 28.14, 49.69, 62.23, 64.65, 115.36, 118.11, 120.47, 125.64, 144.78, 145.59 ppm. ESI-MS for $C_{27}H_{44}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 539.2478, found: 539.2481.

***N,N'*-(2,3-dihydroxylbenzyl)-*N,N,N',N'*–tetramethyl-4,4'-biphenyldiamine dibromide (6f)** ^{1}H NMR (D_2O): δ = 7.68 (m, 4 H), 7.52 (m, 4 H), 6.93 (m, 2 H), 6.78-6.81 (m, 4 H), 4.47 (s, 4 H), 4.44 (s, 4 H), 2.83 (s, 12 H); ^{13}C NMR (D_2O): δ = 48.77, 63.10, 68.06, 115.05, 118.29, 120.55, 125.87, 127.21, 127.68, 133.80, 141.54, 144.87, 145.67 ppm. ESI-MS for $C_{32}H_{38}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 593.2009, found: 593.2006.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,5-pentanediamine dibromide (8a)** ^{1}H NMR (D_2O): δ = 6.97 (m, 6 H), 4.28 (s, 4 H), 3.72 (m, 12 H), 3.11-3.19 (m, 4 H), 2.87 (s, 12 H), 1.78 (br s, 4 H), 1.28 (br s, 2 H); ^{13}C NMR (D_2O): δ = 21.91, 43.25, 49.72, 55.88, 56.02, 63.63, 68.01, 111.91, 115.83, 119.94, 126.60, 148.36, 150.20 ppm. ESI-MS for $C_{26}H_{42}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 539.2479, found: 539.2487.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,6-hexanediamine dibromide (8b)** ^{1}H NMR (D_2O): δ = 6.93 (m, 6 H), 4.23 (s, 4 H), 3.68 (m, 12 H), 3.07 (m, 4 H), 2.81 (s, 12 H), 1.66 (br s, 4 H), 1.22 (br s, 4 H); ^{13}C NMR (D_2O): δ = 22.20, 25.43, 49.72, 55.85, 56.00, 64.02, 67.65, 111.76, 115.60, 119.88, 126.53, 148.23, 150.02 ppm. ESI-MS for $C_{28}H_{46}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 553.2635, found: 553.2637.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,7-heptanediamine dibromide (8c)** ^{1}H NMR (D_2O): δ = 6.90 (m, 6 H), 4.20 (s, 4 H), 3.65 (m, 12 H), 2.99-3.04 (m, 4 H), 2.78 (s, 12 H), 1.64 (br s, 4 H), 1.17 (m, 6 H); ^{13}C NMR (D_2O): δ = 221.98, 25.39, 27.80, 49.56, 55.66, 63.88, 67.43, 111.58, 115.42, 119.80, 126.35, 148.06, 149.86 ppm. ESI-MS for $C_{29}H_{48}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 567.2792, found: 567.2795.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,8-octanediamine dibromide (8d)** ^{1}H NMR (D_2O): δ = 6.93 (m, 6 H), 4.22 (s, 4 H), 3.68 (m, 12 H), 3.02-3.07 (m, 4 H), 2.81 (s, 12 H), 1.66 (br s, 4 H), 1.18 (m, 8 H); ^{13}C NMR (D_2O): δ = 22.10, 25.55, 28.08, 49.70, 55.77, 55.89, 63.98, 67.44, 111.71, 115.54, 119.92, 126.48, 148.19, 149.98 ppm. ESI-MS for $C_{30}H_{50}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 581.2948, found: 581.2936.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*-tetramethyl-1,9-nonanediamine dibromide (8e)** ^{1}H NMR (D_2O): δ = 6.97-6.99 (m, 6 H), 4.28 (s, 4 H), 3.74-3.75 (m, 12 H), 3.07-3.13 (m, 4 H), 2.86 (s, 12 H), 1.71 (br s, 4 H), 1.21 (m, 10 H); ^{13}C NMR (D_2O): δ = 22.23, 25.72, 27.88, 28.27, 49.39, 49.82, 55.88, 56.03, 64.17, 67.39, 111.74, 115.53, 119.91, 126.50, 148.26, 150.02 ppm. ESI-MS for $C_{31}H_{52}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 595.3105, found: 595.3121.

***N,N'*-(3,4-dimethoxybenzyl)-*N,N,N',N'*–tetramethyl-4,4'-biphenyldiamine dibromide (8f)** ^{1}H NMR (D_2O): δ = 7.71 (d, *J* = 7.8, 4 H), 7.51 (d, *J* = 7.8, 4 H), 6.98-7.00 (m, 6 H), 4.43 (s, 4 H), 4.37 (s, 4 H), 3.75 (s, 6 H), 3.73 (s, 6 H), 2.81 (s, 12 H); ^{13}C NMR (D_2O): δ = 48.56, 56.02, 68.10, 68.60, 111.88, 115.93, 119.67, 126.83, 127.07, 127.78, 133.90, 141.57, 148.37, 150.22, 152.84 ppm. ESI-MS for $C_{36}H_{46}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 649.2635, found: 649.2629.

***N,N'*-(3,4-Dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-l,5-pentanediamine dibromide (9a)** ^{1}H NMR (D_2O): δ = 6.78-6.84 (m, 6 H), 4.19 (s, 4 H), 3.05-3.10 (m, 4 H), 2.84 (s, 12 H), 1.73 (br s, 4 H), 1.25 (br s, 2 H); ^{13}C NMR (D_2O): δ = 24.45,

25.18, 52.37, 56.84, 70.37, 118.92, 122.04, 122.81, 128.47, 146.91, 149.01 ppm. ESI-MS for $C_{23}H_{36}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 483.1852, found: 483.1848.

***N,N'-(*3,4-Dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,6-hexanediamine dibromide (9b)** ^1H NMR (D_2O): δ = 6.86-6.90 (m, 6 H), 4.23 (s, 4 H), 3.09-3.15 (m, 4 H), 2.88 (s, 12 H), 1.73 (br s, 4 H), 1.31 (br s, 4 H); ^{13}C NMR (D_2O): δ = 22.17, 25.39, 49.79, 63.82, 67.80, 116.43, 119.64, 120.41, 126.01, 144.36, 146.50 ppm. ESI-MS for $C_{24}H_{38}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 497.2009, found: 497.2019.

***N,N'-(*3,4-Dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,7-heptanediamine dibromide (9c)** ^1H NMR (D_2O): δ = 6.82-6.85 (m, 6 H), 4.20 (s, 4 H), 3.07 (br s, 4 H), 2.84 (s, 12 H), 1.69 (br s, 4 H), 1.25 (br s, 6 H); ^{13}C NMR (D_2O): δ = 22.66, 26.08, 50.30, 64.35, 68.20, 116.93, 120.15, 120.91, 126.54, 144.89, 147.03 ppm. ESI-MS for $C_{25}H_{40}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 511.2166, found: 511.2163.

***N,N'-(*3,4-Dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,8-octanediamine dibromide (9d)** ^1H NMR (D_2O): δ = 6.74-6.77 (m, 6 H), 4.11 (s, 4 H), 2.99 (br s, 4 H), 2.76 (s, 12 H), 1.60 (br s, 4 H), 1.14 (br s, 8 H); ^{13}C NMR (d_6-DMSO): δ = 22.44, 26.44, 28.97, 49.47, 63.35, 67.08, 116.26, 119.20, 120.58, 125.04, 145.94, 147.88 ppm. ESI-MS for $C_{26}H_{42}Br_2N_2O$: calcd. $(M\text{-}Br)^+$: 525.2322, found: 525.2327.

***N,N'-(*3,4-Dihydroxylbenzyl)-*N,N,N',N'*-tetramethyl-1,9-nonanediamine dibromide (9e)** ^1H NMR (D_2O): δ = 6.76-6.79 (m, 6 H), 4.13 (s, 4 H), 2.98-3.03 (m, 4 H), 2.78 (s, 12 H), 1.62 (br s, 4 H), 1.43 (br s, 10 H); ^{13}C NMR (d_6-DMSO): δ = 22.48, 26.49, 29.06, 49.41, 63.31, 66.90, 116.26, 119.26, 120.61, 125.07, 145.89, 147.84 ppm. ESI-MS for $C_{27}H_{44}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 539.2479, found: 539.2475.

***N,N'-(*3,4-Dihydroxylbenzyl)-*N,N,N',N'*–tetramethyl-4,4'-biphenyldiamine dibromide (9f)** ^1H NMR (D_2O): δ = 7.72-7.74 (m, 4 H), 7.51-7.54 (m, 4 H), 6.88-6.92 (m, 6 H), 4.44 (s, 4 H), 4.34 (s, 4 H), 2.82 (s, 12 H); ^{13}C NMR (d_6-DMSO): δ = 48.34, 66.37, 67.93, 116.36, 119.07, 120.88, 125.36, 127.82, 128.59, 134.50, 141.21, 145.97, 148.00 ppm. ESI-MS for $C_{32}H_{38}Br_2N_2O_4$: calcd. $(M\text{-}Br)^+$: 693.2009, found: 693.1999.

8-[benzeneboromic acid]-1, 3, 5, 7-tetramethyl-4, 4-difluoro-4-bora-3a, 4a-diaza-s-indacene (10) ^1H NMR ($CDCl_3$): δ = 7.87-7.88 (m, 2 H), 7.33-7.35 (m, 2 H), 5.98 (s, 2 H), 2.55 (s, 6 H), 1.36 (s, 6 H); ESI-MS for $C_{19}H_{20}B_2F_2N_2O_2$: calcd. $(M+H)^+$: 369.1752, found: 369.1722.

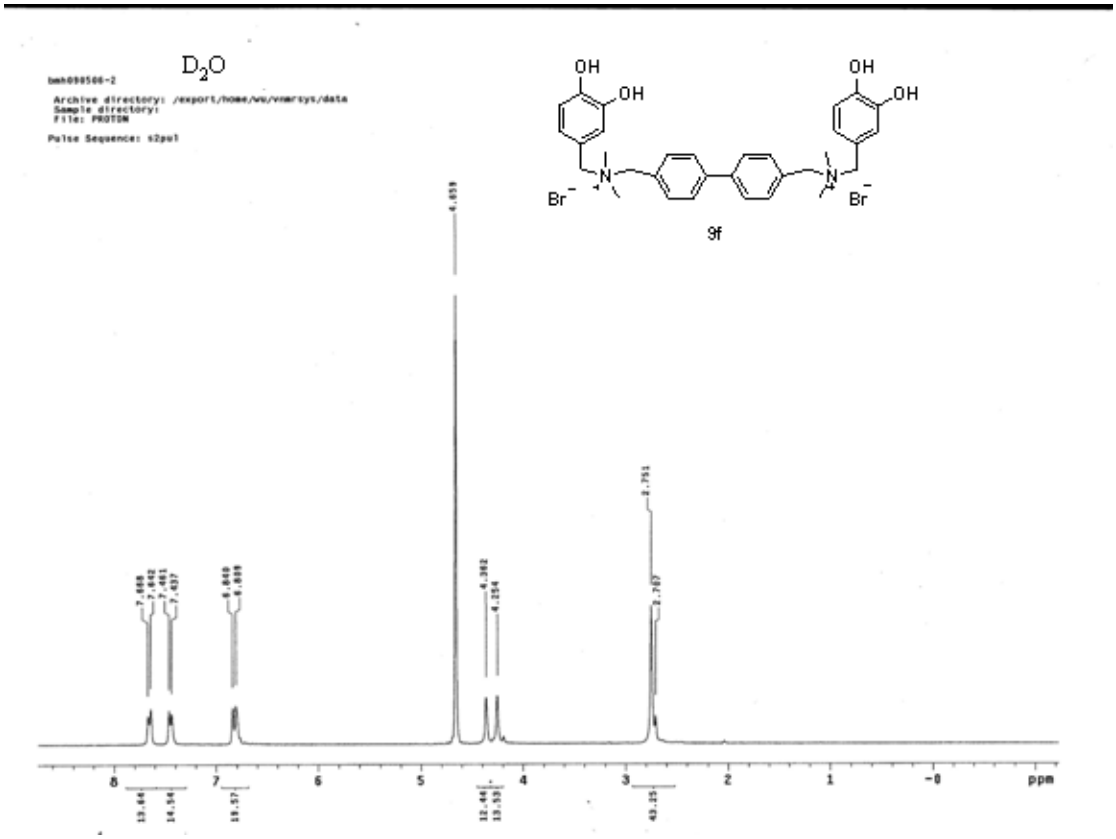
4-bromo-3, 4-Bis(benzyloxy) phenyl (11) ^1H NMR ($CDCl_3$): δ = 7.44-7.29 (m, 10 H), 7.05 (s, 1 H), 6.97 (d, *J* = 8.4 Hz, 1 H), 6.77 (d, *J* = 8.7 Hz, 1 H), 5.12 (s, 4 H); ^{13}C NMR ($CDCl_3$): δ = 67.68, 67.77, 73.09, 73.30, 73.51, 109.73, 112.76, 114.43, 120.46, 123.56, 123.64, 124.21, 124.30, 124.81, 124.85, 132.87, 133.17, 144.43, 146.12 ppm.

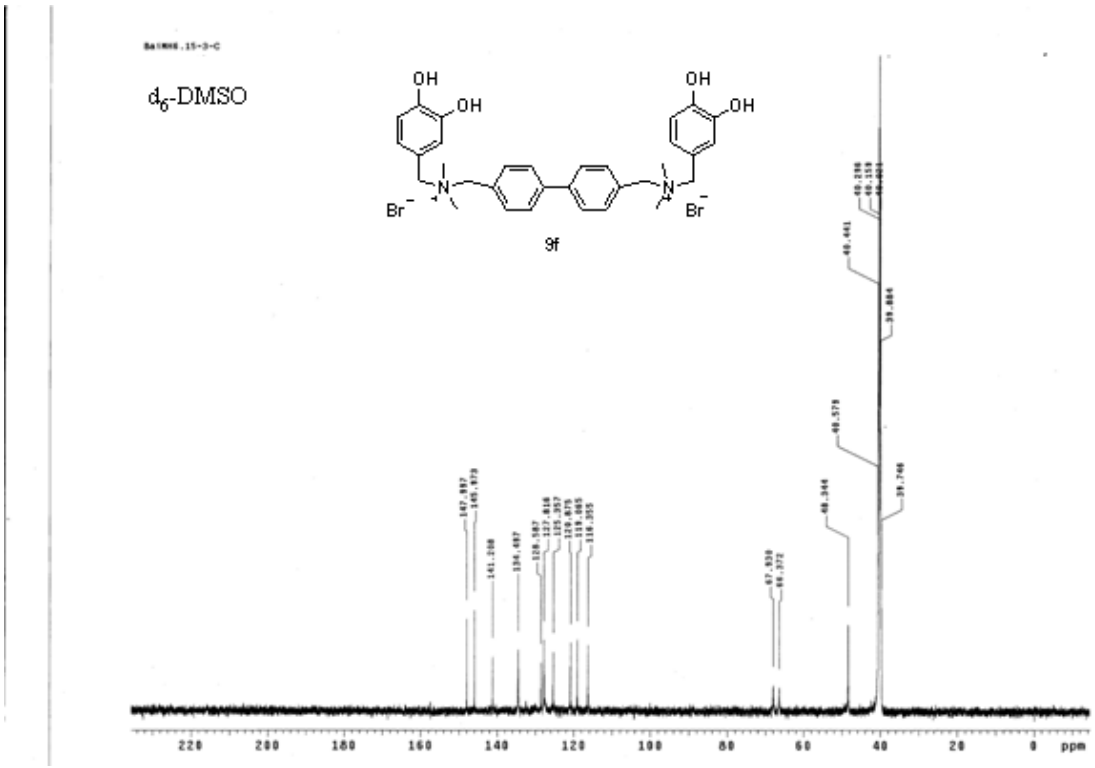
8-[3, 4-Bis(benzyloxy)biphenyl]-1, 3, 5, 7-tetramethyl-4, 4-difluoro-4-bora-3a, 4a-diaza-s-indacene (12) ^1H NMR ($CDCl_3$): δ = 7.61 (m, 2 H), 7.45-7.48 (m, 4 H), 7.37 (m, 6 H), 7.19-7.30 (m, 3 H), 7.03 (m, 2 H), 5.97 (s, 2 H), 5.25 (s, 2 H), 5.22 (s, 2 H), 2.55 (s, 6 H), 1.42 (s, 6 H); ^{13}C NMR ($CDCl_3$): δ = 14.85, 71.48, 71.82, 77.05,

77.27, 77.48, 114.33, 115.48, 120.44, 121.44, 127.37, 127.49, 127.70, 128.12, 128.17, 128.65, 128.78, 129.94, 131.70, 133.66, 134.95, 135,39, 137,34, 137.38, 141.40, 141.81, 143.36, 149.26, 149.47, 155.68 ppm. ESI-MS for $C_{39}H_{35}BF_2N_2O_2$: calcd. $(M+H)^+$: 613.2832, found: 613.2811.

8-[3, 4-Dihydroxybiphenyl]-1, 3, 5, 7-tetramethyl-4, 4-difluoro-4-bora-3a, 4a-diaza-s-indacene (13). ^{1}H NMR (d_6-DMSO): δ = 9.14 (s, 1 H), 9.04 (s, 1 H), 7.70 (d, *J* = 8.1 Hz, 2 H), 7.33 (d, *J* = 8.1 Hz, 2 H), 7.05-7.02 (m, 1 H), 6.82-6.80 (m, 1 H), 6.15 (s, 2 H), 2.42 (s, 6 H), 1.39 (s, 1 H); ^{13}C NMR (d_6-DMSO): δ = 14.89, 29.30, 114.64, 116.90, 118.50, 122.10, 127.12, 128.16, 129.01, 130.98, 131.55, 132.58, 141.72, 142.75, 143.48, 146.46, 155.54 ppm. ESI-MS for $C_{25}H_{23}BF_2N_2O_2$: calcd. $(M+H)^+$: 433.1893, found: 433.1883.

^{1}H NMR, ^{13}C NMR spectra of compound 9f.




d6-DMSO
OH
OH
OH
OH
Br-
Br-
N+
N+
9f
ppm