Supplementary Information (SI) for ChemComm.

Supplementary Material

# Unified Approach to Indolosesquiterpene Alkaloids: Total Syntheses of Anti-Viral Agents, Xiamycin A and Oridamycin A

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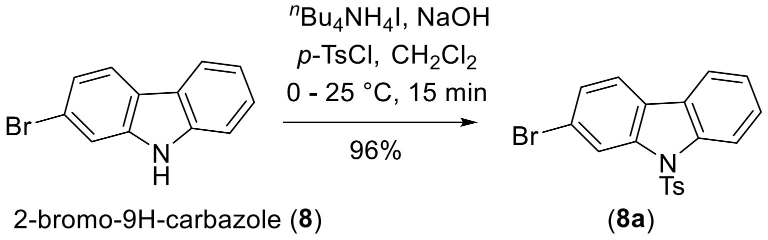
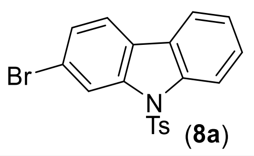
## Materials and Methods

Unless otherwise stated, reactions were carried out using oven dried glass ware with Teflon coated magnetic stirring bars were used to stir the reactions. The Syringe was used to transfer solvents and liquid reagents. Tetrahydrofuran (THF) Diethyl ether ($Et_2O$) was distilled over sodium/benzophenone ketyl. Dichloromethane $CH_2Cl_2$) was distilled over calcium hydride. All other solvents like MeOH, EtOAc, DMF, Dichloroethane (DCE) and reagents were used as received. Reaction temperatures above 25 °C were maintained by using an oil bath on a magnetic stirrer. Thin layer chromatography (TLC) analysis was performed by using silica gel precoated plates (0.25 mm) 60 (F-254), Visualized by UV irradiation, yellow dip stain and other stains. Silica gel of particle size 230-400 and 100-200 mesh were used to perform flash chromatography. Digital melting point apparatus is used to record the melting points. $^1$H-NMR spectra were recorded by using 400, 500 MHz spectrometers, $^{13}$C {$^1$H} NMR operating frequencies are 101, 126 MHz respectively. Chemical shifts (δ) are reported in ppm relative to the residual solvents ($CDCl_3$) signal ($\delta = 7.29$ for $^1$H NMR and $\delta = 77.0$ for $^{13}$C {$^1$H} NMR) and ($CD_3OD$) signal ($\delta = 3.31$ for $^1$H NMR and $\delta = 49$ for $^{13}$C {$^1$H} NMR). Data for $^1$H NMR spectra are reported as follows: chemical shift (multiplicity, coupling constants, and number of hydrogen). Abbreviations are as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad). IR spectra were recorded on a FT-IR system (Spectrum BX) and are reported in frequency of absorption ($cm^{-1}$). Only selected IR absorbencies are reported. High Resolution Mass Spectrometry (HRMS) data was recorded on MicrOTOF-Q-II mass spectrometer using methanol or acetonitrile as solvent.

**Tosylation of 2-bromo carbazole (8a):**



In a flame-dried round-bottom flask equipped with a septum and stirring bar. Then 2-Bromo-9*H*-carbazole (16.25 g, 40.60 mmol, 1.0 equiv.) was dissolved in dichloromethane then tetrabutyl ammonium iodide (0.15 g, 0.406 mmol, 0.1 equiv.) and NaOH (3.25 g, 81.20 mmol, 2.0 equiv.) was added and stirred for 5 min followed by the addition of *p*-TsCl (7.90 g, 41.41 mmol, 1.02 equiv.) at 0 °C. Then the reaction mixture was allowed to room temperature for 15 min. After completion of the reaction (monitored by TLC in 20% EtOAc in *n*-hexane) the crude reaction mixture was extracted with $CH_2Cl_2$ and water. The organic layer was concentrated through vacuum and the crude product was purified by recrystallization using a mixture of EtOAc and $CH_2Cl_2$ or column chromatography (by eluting with 30% EtOAc in *n*-hexane) to afford **8a**.



***N*-tosyl 2-bromo Carbazole** (**8a**): **8a** was obtained as a white crystalline solid (m.p.:140-145 °C, 40.60 mmol scales of reaction, 14.0 g of product, 96% yield); $R_f$ = 0.6 (20% EtOAc in *n*-hexane).

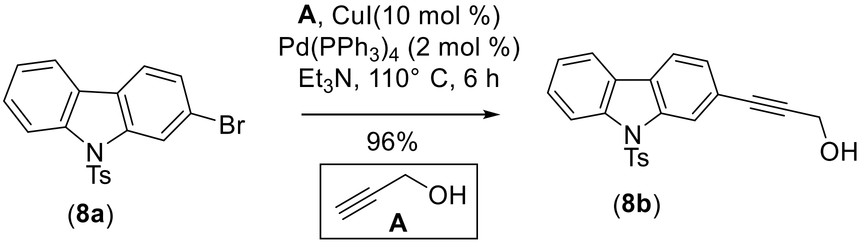
**$^1$H NMR** (500 MHz, $CDCl_3$): δ 8.55 (d, *J* = 1.6 Hz, 1H), 8.32 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 7.7 Hz, 1H), 7.78 (d, *J* = 8.2 Hz, 1H), 7.74 (s, 1H), 7.72 (s, 1H), 7.52 (dt, *J* = 8.3, 7.0 Hz, 2H), 7.39 (t, *J* = 7.5 Hz, 1H), 7.16 (d, *J* = 8.1 Hz, 2H), 2.31 (s, 3H).

**$^{13}$C {$^{1}$H} NMR** (126 MHz, CDCl$_3$): δ 145.4, 139.2, 138.5, 134.9, 130.0, 127.9, 127.3, 126.7, 125.7, 125.4, 124.3, 121.2, 121.1, 120.2, 118.3, 115.2, 21.7.

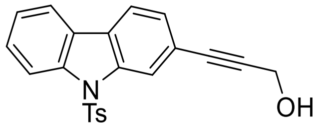
**IR** (neat)$\upsilon_{max}$: 3081,1580, 1245, 1233, 1047, 690 cm$^{-1}$.

**HRMS** (ESI-MS) *m/z*: [M + K]$^+$ calcd. for [$C_{19}H_{14}BrO_2NS$ + K]$^+$ 437.9560, found: 437.9570.

**Sonogashira Coupling Reaction of 8a with Propargyl alcohol:**



In a flame-dried sealed tube equipped with a septum and stirring bar. Then Et$_3$N was added to the sealed tube and purged argon gas for 15 min followed by *N*-tosyl 2-bromo carbazole (0.576 g, 1.44 mmol, 1.0 equiv.) and propargyl alcohol (**A**, 0.125 ml, 2.16 mmol, 1.5 equiv.). After another 10 min CuI (27 mg, 0.144 mmol, 0.1 equiv.) and [Pd (PPh$_3$)$_2$Cl$_2$, (20 mg, 0.029 mmol, 0.02 equiv.)] were added to the reaction mixture and tube was sealed. Then the reaction mixture was allowed to heat at 100 °C on a pre-heated oil-bath for 6 h. After completion of the reaction (monitored by TLC in 40 % EtOAc and *n*-hexane), the crude reaction mixture was extracted with EtOAc (30 mL) and 5 ml of water. The organic layer was concentrated through vacuum and the crude product was purified by column chromatography (40 % EtOAc and *n*-hexane) to afford **8b**.



(**8b**)

**3-(9-Tosyl-9*H*-carbazol-2-yl)-prop-2-yn-1-ol** (**8b**): **8b** was obtained as yellowish foam (1.44 mmol scale of reaction, 0.443 g of product, 96% yield). R$_f$ = 0.3 (40% EtOAc in *n*-hexane).

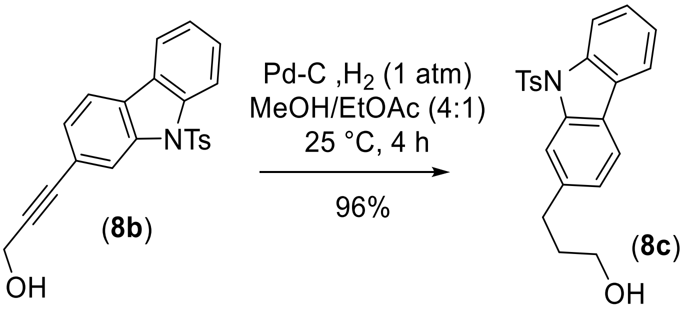
**$^1$H NMR** (500 MHz, CDCl$_3$): δ 8.47 (s, 1H), 8.33 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 7.7 Hz, 1H), 7.85 (d, *J* = 8.0 Hz, 1H), 7.73 (d, *J* = 8.1 Hz, 2H), 7.54 – 7.50 (m, 1H), 7.46 – 7.44 (m, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.14 (d, *J* = 8.1 Hz, 2H), 4.60 (s, 2H), 2.29 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, CDCl$_3$): δ 145.1, 138.9, 138.1, 134.9, 129.8, 129.8, 127.9, 127.5, 126.5, 126.5, 126.5, 125.8, 124.1, 121.4, 120.2, 119.9, 118.4, 115.2, 87.8, 86.2, 51.8, 21.5.

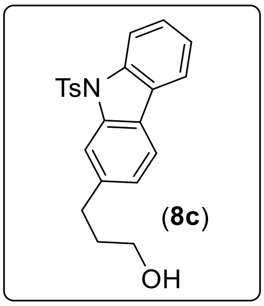
**IR** (neat) $\upsilon_{max}$ 3584, 2981, 2895, 2240, 1698, 1387, 1280, 1152, 836 cm$^{-1}$.

**HRMS** (ESI) *m/z*: [M + Na]$^+$ calcd. for [$C_{22}H_{17}O_3NS$ + Na]$^+$ 398.0821, found: 398.0808;
[M + K]$^+$ calcd. for [$C_{22}H_{17}O_3NS$ + K]$^+$ 414.0561, found: 414.0547.

**Synthesis of Primary Alcohol 8c:**



The propargyl alcohol derivative (**8b**, 0.530 g, 1.411 mmol) was dissolved in 4:1 mixture of MeOH/EtOAc and transferred into an oven-dried vessel and degassing was done using $N_2$ gas for 10 mins. Then Pd/C (5 % w/w) was added and hydrogenation was done in high pressure hydrogenator (1 atm) for 4 h. After complete consumption of starting material (monitored by TLC), the reaction mixture was evaporated and purified through flash column chromatography using 20% EtOAc in *n*-hexane. The alcohol **8c** was obtained as yellowish liquid.



**3-(9-Tosyl-9*H*-carbazol-2-yl)-propan-1-ol (8c): 8c** was obtained as yellowish foam (1.411 mmol, 0.514 g of product, 96% yield). $R_f$ = 0.2 (30% EtOAc in *n*-hexane).

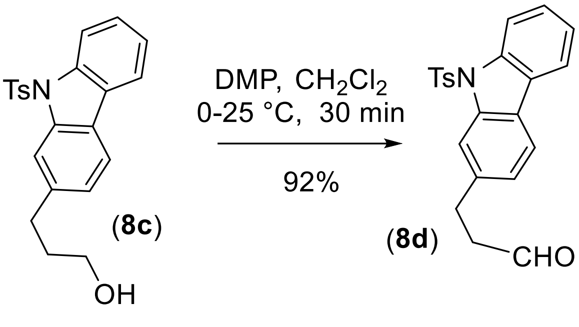
**$^1$H NMR** (500 MHz, $CDCl_3$): δ 8.30 (d, *J* = 8.4 Hz, 1H), 8.17 (d, *J* = 1.3 Hz, 1H), 7.84 (dd, *J* = 7.7, 1.2 Hz, 1H), 7.78 (d, *J* = 7.9 Hz, 1H), 7.68 (d, *J* = 8.4 Hz, 2H), 7.45 (ddd, *J* = 8.4, 7.3, 1.3 Hz, 1H), 7.33 (t, *J* = 7.5 Hz, 1H), 7.20 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.08 (d, *J* = 8.1 Hz, 2H), 3.72 (t, *J* = 6.4 Hz, 2H), 2.91 (dd, *J* = 8.6, 6.8 Hz, 2H), 2.24 (s, 3H), 2.01 – 1.97 (m, 2H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 144.9, 141.8, 138.8, 138.5, 135.0, 129.6, 129.6, 127.0, 126.5, 126.5, 126.5, 124.6, 124.5, 123.9, 119.8, 119.7, 115.2, 114.9, 62.2, 34.7, 32.8, 21.5.

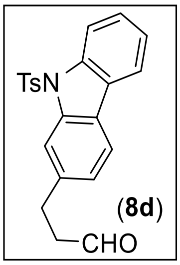
**IR** (neat) $\upsilon_{max}$ 2981, 2895, 1698, 1280, 1152, 836 cm$^{-1}$.

**HRMS** (ESI-MS) *m/z*: $[M + Na]^+$ calcd. for $[C_{22}H_{21}NO_3S + Na]^+$ 402.1134, found: 402.1133.

**Synthesis of Aldehyde 8d:**



In an oven-dried round-bottom flask, the primary alcohol intermediate **8c** (0.51 g, 1.34 mmol, 1.0 equiv.) in $CH_2Cl_2$ (8 mL) was charged with Dess-Martin Periodinane (0.63 g, 1.48 mmol, 1.1 equiv.) at 0 ºC over a period of 10 minutes with continuous stirring over an ice bath. After the complete addition of DMP, the ice bath was removed, and the reaction mixture was allowed to stir for additional 30 minutes until the consumption of the starting material (monitored by TLC analysis). After completion of the reaction, was quenched with saturated $NaHCO_3$ (30 mL) at 0 ºC. The biphasic mixture was then transferred to a separatory funnel and the organic part was collected. The aqueous part was further extracted with $CH_2Cl_2$ (5 mL X 3). The combined organic layers were washed with brine, dried over $Na_2SO_4$ and concentrated in vacuo under reduced pressure. Finally, the crude product was purified through flash column chromatography using 10% EtOAc in *n*-hexane. Pure aldehyde **8d** was obtained after column chromatography as yellowish foam.



(**8d**)

**3-(9-Tosyl-9*H*-carbazol-2-yl) propanal (8d)**: **8d** was obtained as yellowish foam (1.34 mmol, 0.466 g of product, 92% yield). $R_f = 0.5$ (30% EtOAc in *n*-hexane).

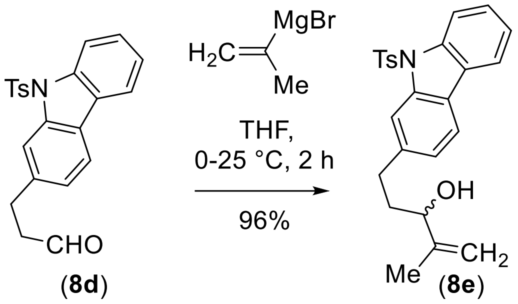
**$^1$H NMR** (500 MHz, $CDCl_3$): δ 9.86 (d, $J = 1.5$ Hz, 1H), 8.30 (d, $J = 8.4$ Hz, 1H), 8.17 (d, $J = 1.4$ Hz, 1H), 7.85 – 7.83 (m, 1H), 7.79 – 7.77 (m, 1H), 7.68 (d, $J = 8.4$ Hz, 2H), 7.47 – 7.44 (m, 1H), 7.32 (d, $J = 7.5$ Hz, 1H), 7.20 – 7.17 (m, 1H), 7.09 (d, $J = 8.1$ Hz, 2H), 3.15 (s, 2H), 2.89 – 2.86 (m, 2H), 2.24 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 201.4, 144.9, 140.1, 138.8, 138.5, 134.9, 129.7, 129.7, 127.1, 126.5, 126.5, 126.3, 124.8, 124.4, 123.9, 120.1, 119.8, 115.2, 114.8, 45.6, 28.8, 21.5.

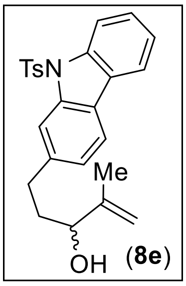
**IR** (neat) $\upsilon_{max}$ 2981, 2895, 1740, 1698, 1280, 1152, 836 $cm^{-1}$.

**HRMS** (ESI) *m/z*: $[M + Na]^+$ calcd. for $[C_{22}H_{19}O_3NS + Na]^+$ 400.0978, found: 400.0974.

**Isopropenyl Grignard addition onto aldehyde 8d:**



An oven-dried round-bottom flask was charged with the aldehyde **8d** (400 mg, 1.06 mmol, 1.0 equiv.) in anhydrous THF (120 mL) and was cooled to 0 °C, over an ice bath followed by addition of isopropenyl magnesium bromide (0.5 *M* in THF, 2.33 mL, 1.166 mmol, 1.1 equiv.) over a period of 30 minutes with continuous stirring at the same temperature. After the complete addition of the Grignard reagent the ice bath was removed and stirred at 25 °C for an additional 2 h until the full consumption of the starting material. After completion of the reaction (as judged by running TLC) was quenched with saturated $NH_4Cl$ solution (30 mL). The organic layer from the biphasic solution was separated by a separatory funnel and the aqueous phase was further extracted with EtOAc (25 mL X 2). The combined organic layers were washed with brine, dried over $Na_2SO_4$, and concentrated in vacuo under the reduced pressure. Finally, the crude product was purified through column chromatography using EtOAc in *n*-hexane (10% EtOAc in *n*-hexane) to afford the allyl alcohol **8e** as a pale-yellow oil.



(**8e**)

**2-Methyl-5-(9-tosyl-9*H*-carbazol-2-yl)-pent-1-en-3-ol (8e)**: **8e** was obtained as a pale-yellow oil (1.06 mmol, 425 mg of product, 96% yield). $R_f = 0.3$ (10% EtOAc in *n*-hexane).

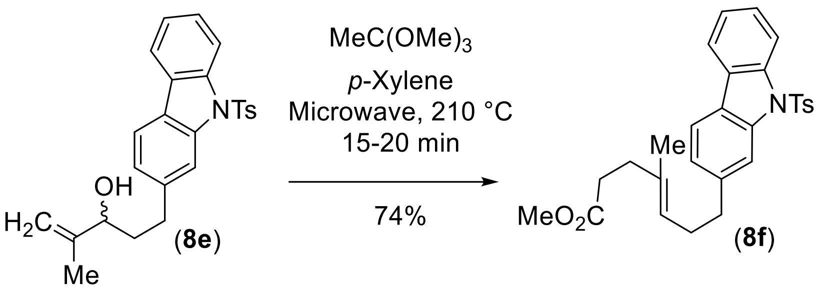
**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.29 (d, *J* = 8.5 Hz, 1H), 8.16 (d, *J* = 1.4 Hz, 1H), 7.85 – 7.82 (m, 1H), 7.78 (d, *J* = 7.9 Hz, 1H), 7.67 (d, *J* = 8.4 Hz, 2H), 7.44 (ddd, *J* = 8.5, 7.3, 1.3 Hz, 1H), 7.34 (d, *J* = 1.1 Hz, 1H), 7.22 – 7.19 (m, 1H), 7.08 (d, *J* = 8.6 Hz, 2H), 5.02 – 4.97 (m, 1H), 4.90 (t, *J* = 1.6 Hz, 1H), 4.11 (t, *J* = 6.4 Hz, 1H), 2.95 – 2.80 (m, 2H), 2.24 (s, 3H), 1.95 (td, *J* = 8.0, 6.4 Hz, 2H), 1.77 (s, 3H).

**$^{13}$C {$^1$H} NMR (**126 MHz, $CDCl_3$): δ 147.5, 144.9, 142.1, 138.9, 138.6, 135.2, 129.8, 129.8, 127.1, 126.6, 126.6, 124.8, 124.6, 124.0, 119.9, 119.8, 115.3, 115.1, 111.5, 75.3, 37.1, 32.7, 25.9, 21.6, 17.8.

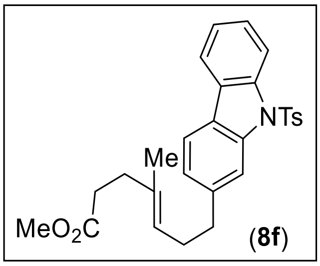
**IR** (neat) $\upsilon_{max}$ 2981, 2895, 1698, 1680, 1280, 1152, 836 cm$^{-1}$.

**HRMS** (ESI) *m/z*: $[M + Na]^+$ calcd. for $[C_{25}H_{25}O_3NS + Na]^+$ 442.1447, found: 442.1442.

**Synthesis of *γ,δ*-unsaturated ester 8f *via* Johnson-Claisen rearrangement:**



Allyl alcohol (**8e**, 2.5 g, 5.96 mmol, 1.0 equiv.) was dissolved in minimum volume of *p*-xylene (5 mL) with trimethylorthoacetate (11.17 mL, 59.58 mmol, 10.0 equiv.) in a microwave vial and *p*-nitrophenol (45 µL, 0.596 mmol, 0.1 equiv.) was added to it. The resulting solution was charged under microwave irradiation maintaining the temperature at 210 °C for 15 min. Next, the reaction mixture was cooled down to 25 °C and was diluted with EtOAc (10 mL) and water (10 mL). The resulting biphasic mixture was transferred to a separatory funnel and the layers that formed were separated. The aqueous phase was further extracted with EtOAc (15 mL X 2). The combined organic layers were washed with 1 (*N*) HCl solution (30 mL), brine and dried over $Na_2SO_4$ and concentrated under reduced pressure. Then the crude product was purified by flash chromatography by eluting with a gradient of 10% EtOAc/*n*-hexane to afford the *γ*, *δ* unsaturated ester compound **8f** as pale-yellow oil.



(**8f**)

**Methyl** (*E*)**-4-methyl-7-**(**9-tosyl-9*H*-carbazol-2-yl**) **hept-4-enoate** (**8f**): (**8f**) was obtained as pale-yellow oil (5.96 mmol scale of reaction, 2.097 g of product, 74% yield). R*f* = 0.6 (10% EtOAc in *n*-hexane).

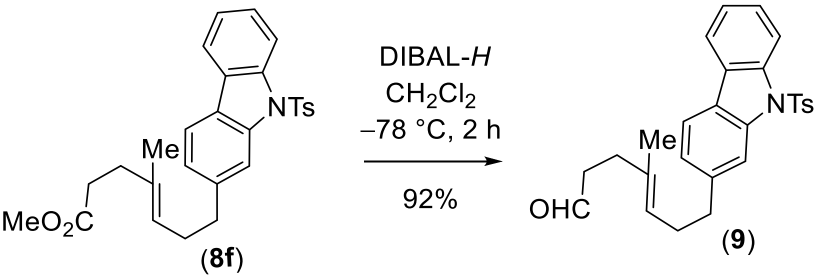
**$^1$H NMR** (500 MHz, $CDCl_3$): δ 8.33 (d, *J* = 8.3 Hz, 1H), 8.19 (s, 1H), 7.87 (d, *J* = 7.6 Hz, 1H), 7.80 (d, *J* = 7.8 Hz, 1H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.49 – 7.44 (m, 1H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.20 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.11 (d, *J* = 8.1 Hz, 2H), 5.28 (t, *J* = 7.2 Hz, 1H), 3.68 (s, 3H), 2.86 (t, *J* = 7.7 Hz, 2H), 2.44 (dd, *J* = 10.1, 4.8 Hz, 4H), 2.37 – 2.33 (m, 2H), 2.27 (s, 3H), 1.60 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 173.9, 144.8, 142.2, 138.8, 138.5, 135.1, 134.4, 129.6, 126.9, 126.5, 126.5, 124.7, 124.4, 124.2, 123.8, 119.7, 119.7, 119.6, 115.2, 114.9, 53.4, 51.5, 36.6, 34.7, 33.0, 30.3, 21.5, 16.0.

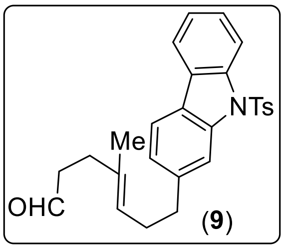
**IR** (neat) $\upsilon_{max}$ 2981, 2895, 1735, 1668, 1450, 1233, 956, 835 cm$^{-1}$.

**HRMS** (ESI) *m/z*: $[M + Na]^+$ calcd. for $[C_{28}H_{29}O_4NS + Na]^+$ 498.1710, found: 498.1698.

**DIBAL-H Reduction of *γ*, *δ*-unsaturated ester 8f:**



An oven-dried round-bottom flask was charged with the *γ*, *δ*-unsaturated ester (**8f**, 12.0 g, 25.231 mmol, 1.0 equiv.) in dry $CH_2Cl_2$ (80 ml) and was cooled to −78 °C over an acetone bath followed by the addition of a solution of DIBAL-*H* (1 *M* in hexane, 26.49 mL, 26.49 mmol, 1.05 equiv.) in dropwise manner over 10 minutes at −78 °C. The reaction mixture was stirred at the same temperature for an additional 2 h until the full consumption of the starting material. After complete consumption of the starting material, a saturated aqueous solution of potassium sodium tartrate (30 mL) was added slowly to the reaction mixture, and the resultant mixture was stirred vigorously for another 1 h at 25 °C. The resulting biphasic mixture was then transferred to a separating funnel and the organic layer was separated. The aqueous layer was further extracted with $CH_2Cl_2$ (30 mL X 2). The combined organic layers were concentrated under reduced pressure and the residue was purified by silica gel column chromatography with a gradient of 10% EtOAc/*n*-hexane to afford *γ*,*δ*-unsaturated aldehyde (**9)** as pale-yellow liquid.



(**9**)

(*E*)-**4-Methyl-7-(9-tosyl-9*H*-carbazol-2-yl)-hept-4-enal** (**9**): **9** was obtained as a yellow oil (25.23 mmol scale of reaction, 10.37 g, 92% yield). $R_f$ = 0.45 (10% EtOAc in *n*-hexane).

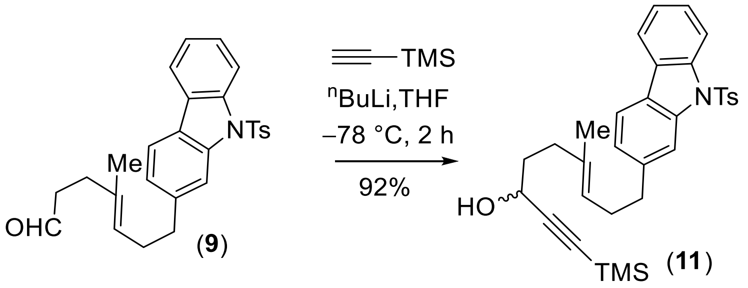
**$^1$H NMR** (400 MHz, $CDCl_3$): δ 9.74 (t, *J* = 1.8 Hz, 1H), 8.30 – 8.27 (m, 1H), 8.13 (dd, *J* = 1.4, 0.7 Hz, 1H), 7.84 (ddd, *J* = 7.7, 1.3, 0.7 Hz, 1H), 7.77 (dd, *J* = 7.9, 0.6 Hz, 1H), 7.67 (d, *J* = 8.4 Hz, 2H), 7.44 (ddd, *J* = 8.5, 7.3, 1.3 Hz, 1H), 7.32 (td, *J* = 7.5, 1.0 Hz, 1H), 7.16 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.08 (dt, *J* = 8.0, 0.7 Hz, 2H), 5.26 – 5.22 (m, 1H), 2.82 (t, *J* = 7.6 Hz, 2H), 2.51 (tdd, *J* = 6.9, 1.9, 0.6 Hz, 2H), 2.42 – 2.37 (m, 2H), 2.31 (t, *J* = 7.5 Hz, 2H), 2.25 (s, 3H), 1.55 (d, *J* = 1.3 Hz, 3H).

**$^{13}$C {$^{1}$H} NMR** (126 MHz, $CDCl_3$): δ 202.6, 144.8, 142.1, 138.8, 138.5, 135.1, 134.2, 129.6, 126.9, 126.5, 126.5, 125.6, 124.7, 124.4, 124.4, 123.9, 119.7, 119.6, 115.2, 114.9, 42.2, 36.6, 31.8, 30.3, 21.5, 16.2.

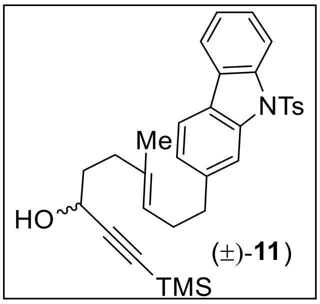
**IR** (neat) $\upsilon_{max}$ 2980, 2895, 1785, 1660, 1455, 1233, 956, 840 cm$^{-1}$.

**HRMS** (ESI-TOF) *m/z*: $[M + Na]^+$ calcd. for $[C_{27}H_{27}NO_3S + Na]^+$ 468.1609, found: 468.1592.

**Synthesis of Enyne-ol (11):**



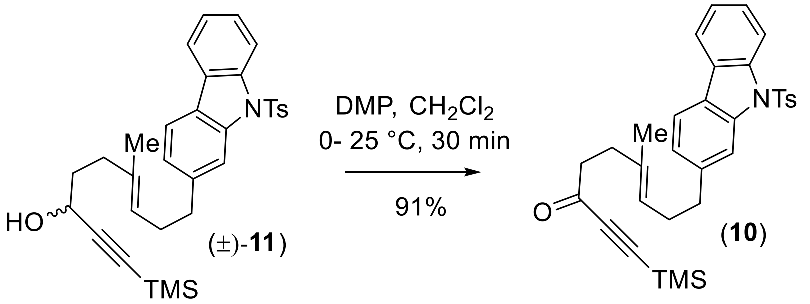
An oven-dried round-bottom flask was charged with a solution of trimethylsilylacetylene (0.470 mL, 3.36 mmol, 1.5 equiv.) in anhydrous THF (40 mL) and was cooled to −78 °C over an acetone bath followed by a slow addition of *n*-BuLi (2.5 *M* in hexane, 2.91 mmol, 1.3 equiv.) The resulting reaction mixture was allowed to stir at the same temperature for 30 minutes followed by a slow addition of the *γ*, *δ*-unsaturated aldehyde [(**9**), 1.0 g, 2.24 mmol, 1.0 equiv.] dissolved in anhydrous THF (30 mL) over a period of 10 minutes. The reaction mixture was then allowed to stir at 25 °C for an additional 2 h until the full consumption of the starting material. After completion of the reaction (as judged by running TLC), was quenched with saturated $NH_4Cl$ solution (25 mL). The organic layer from the biphasic solution was separated by a separatory funnel and the aqueous phase was further extracted with EtOAc (20 mL X 2). The combined organic layers were washed with brine, dried over $Na_2SO_4$, and concentrated in vacuo under reduced pressure. Finally, the crude product was purified through flash column chromatography using EtOAc in *n*-hexane (10% EtOAc in *n*-hexane) to afford the propargyl alcohol **11** as yellowish gel.



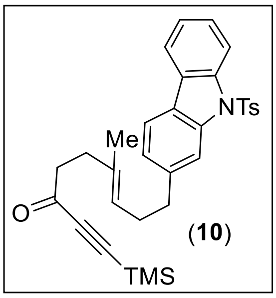
(±)-**11**

*(E)-***6-methyl-9-(9-tosyl-9*H*-carbazol-2-yl)-1-(trimethylsilyl) non-6-en-1-yn-3-ol** (**11**): The propargyl alcohol **11** was obtained as a yellowish gel (2.24 mmol scale, 1.12 g of product, 92% yield). $R_f = 0.4$ (20% EtOAc in *n*-hexane).

**DMP-Oxidation of Propargyl alcohol 11:**



In an oven-dried round-bottom flask, the propargyl alcohol **11** (1.0 g, 1.83 mmol, 1.0 equiv.) in DCM (5 mL) was charged with Dess-Martin Periodinane (0.856 g, 2.01 mmol, 1.1 equiv.) at 0 ºC over a period of 10 minutes with continuous stirring over an ice bath. After the complete addition of DMP, the ice bath was removed, and the reaction mixture was allowed to stir for additional 30 minutes until the full consumption of the starting material (monitored by TLC analysis). After completion of the reaction, was quenched with saturated $NaHCO_3$ (30 mL) at 0 ºC. The biphasic mixture was then transferred to a separatory funnel and the organic part was collected. The aqueous part was further extracted with $CH_2Cl_2$ (30 mL X 3). The combined organic layers were washed with brine, dried over $Na_2SO_4$ and concentrated in vacuo under reduced pressure. Finally, the crude product was purified through flash column chromatography using 5% EtOAc in *n*-hexane to afford pure compound **10** as pale-yellowish gel.



(**10**)

(*E)*-**6-methyl-9-(9-tosyl-9*H*-carbazol-2-yl)-1-(trimethylsilyl) non-6-en-1-yn-3-one (10)** was obtained as a pale-yellowish gel (1.83 mmol scale of reaction, 905 mg of product, 91% yield). $R_f$ = 0.4 (10% EtOAc in *n*-hexane).

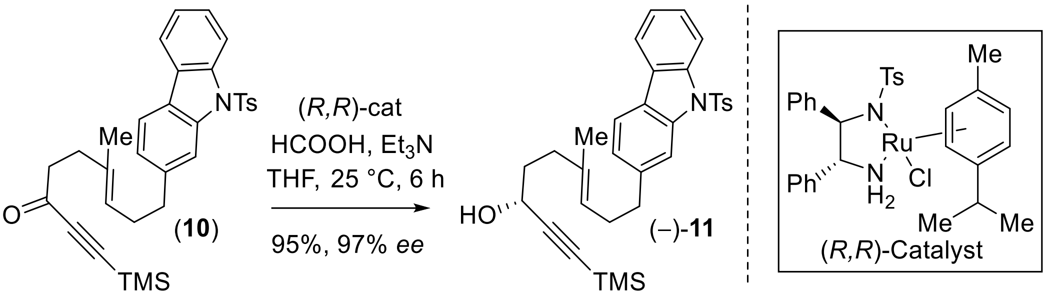
**$^1$H NMR** (500 MHz, $CDCl_3$): δ 8.32 (d, *J* = 8.2 Hz, 1H), 8.17 (d, *J* = 1.5 Hz, 1H), 7.88 (d, *J* = 7.6 Hz, 1H), 7.81 (d, *J* = 7.8 Hz, 1H), 7.70 (d, *J* = 8.4 Hz, 2H), 7.49 – 7.45 (m, 1H), 7.36 (td, *J* = 7.5, 1.0 Hz, 1H), 7.20 (dd, *J* = 7.9, 1.4 Hz, 1H), 7.12 (d, *J* = 8.2 Hz, 2H), 5.32 – 5.25 (m, 1H), 2.85 (t, *J* = 7.7 Hz, 2H), 2.69 (dd, *J* = 8.5, 6.9 Hz, 2H), 2.40 (dt, *J* = 23.5, 7.6 Hz, 4H), 2.29 (s, 3H), 1.58 (s, 3H), 0.27 (s, 9H).

**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 187.7, 144.9, 142.2, 138.8, 138.5, 135.1, 134.1, 129.7, 127.0, 126.6, 126.5, 124.8, 124.6, 124.5, 123.9, 119.8, 119.7, 115.3, 114.9, 106.4, 102.0, 98.0, 44.0, 36.7, 33.7, 30.5, 29.8, 21.6, 16.2, –0.7, –0.7, –0.7.

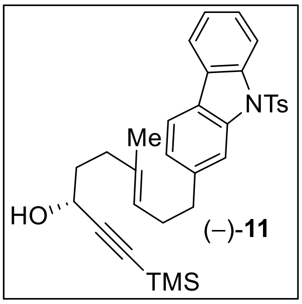
**IR** (neat) $\upsilon_{max}$ 2958, 2835, 2170, 1770, 1660, 1587, 1495, 1455, 1233, 1112, 1052, 840, 752 $cm^{-1}$.

**HRMS** (ESI-TOF) *m/z*: $[M + Na]^+$ calcd. for $[C_{32}H_{35}O_3SiNS + Na]^+$ 564.2005, found: 564.1993.

**Noyori's Asymmetric Transfer Hydrogenation of Ynone 10:**



In a flame-dried three-neck 250 mL round-bottomed flask with a $N_2$ inlet adapter, rubber septa were charged with ketone [(**10**), 1.0 g, 1.84 mmol, 1.0 equiv.) in anhydrous THF (4 mL). Then $Et_3N$ (7.38 mmol, 4.0 equiv.), HCOOH (0.694 ml, 18.40 mmol, 10.0 equiv.) and the Noyori's Ru-catalyst, (*R, R*)-cat. (11.45 mg, 0.018 mmol, 0.01 equiv.) were added sequentially. The reaction mixture was stirred at 25 ºC for an additional 6 h until the completion of the reaction. Next the reaction mixture was diluted with ethyl acetate (30 mL) and water (30 mL). The resulting biphasic mixture was transferred to a separatory funnel and the layers that formed were separated. The aqueous phase was further extracted with EtOAc (25 mL X 2). The combined organic layers were washed with excess water, brine and dried over $Na_2SO_4$ and concentrated under reduced pressure. Then the crude product was purified by flash chromatography by eluting with a gradient of 10% EtOAc/*n*-hexane to afford (−)-**11** as colorless oil.



*(R,E)*-**6-methyl-9-(9-tosyl-9*H*-carbazol-2-yl)-1-(trimethylsilyl)non-6-en-1-yn-3-ol** [(−)-**11**] was obtained as a pale-yellowish gel (1.84 mmol scale, 925 mg of product, 95% yield, 97% *ee*). $R_f$ = 0.3 (10% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.29 (dt, *J* = 8.4, 0.9 Hz, 1H), 8.14 (d, *J* = 0.8 Hz, 1H), 7.85 – 7.82 (m, 1H), 7.77 (d, *J* = 7.9 Hz, 1H), 7.69 – 7.65 (m, 2H), 7.43 (ddd, *J* = 8.5, 7.3, 1.3 Hz, 1H), 7.32 (td, $J$ = 7.4, 1.0 Hz, 1H), 7.18 (dd, $J$ = 7.9, 1.5 Hz, 1H), 7.09 (dt, $J$ = 8.1, 0.8 Hz, 2H), 5.28 (tt, $J$ = 7.1, 1.4 Hz, 1H), 4.31 (s, 1H), 2.83 (t, $J$ = 7.6 Hz, 2H), 2.39 (q, $J$ = 7.4 Hz, 2H), 2.25 (s, 3H), 2.15 (t, $J$ = 7.6 Hz, 2H), 1.81 – 1.76 (m, 2H), 1.57 (s, 3H), 0.16 (s, 9H).

**$^{13}$C {$^{1}$H} NMR** (101 MHz, $CDCl_3$): δ 144.9, 142.3, 138.8, 138.5, 135.3, 135.1, 129.7, 129.7, 127.0, 126.6, 126.6, 126.6, 124.8, 124.4, 124.4, 123.9, 119.8, 119.7, 115.3, 115.0, 106.8, 89.6, 62.6, 36.8, 36.0, 35.3, 30.5, 21.6, 16.1, –0.1, –0.1, –0.1.

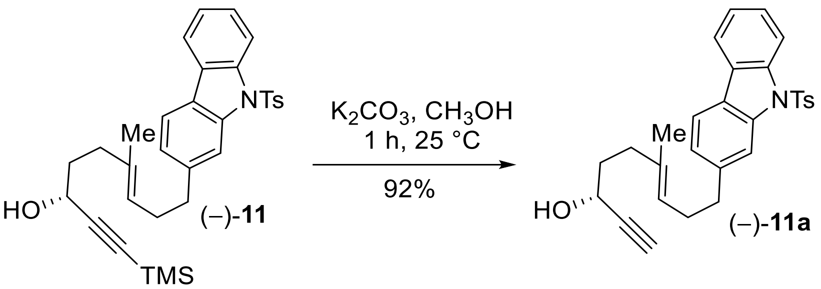
**IR** (neat) $\upsilon_{max}$ 3360, 2982, 2895, 1785, 1660, 1455, 1233, 956, 845, 750 cm$^{-1}$.

**HRMS** (ESI-TOF) *m/z*: $[M + Na]^+$ calcd. for $[C_{32}H_{37}NO_3SiS + Na]^+$ 566.2161, found: 566.2157.

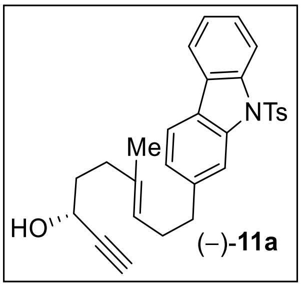
$[\alpha]^{20}_{589} = -7.00$ ($c$ = 0.1, $CHCl_3$).

N.B: Enantiomeric excess (*ee*) of pure compound was determined *via* HPLC analysis using a Chiralpak AD-*H* column; solvent: *n*-hexane/2-propanol = 90/10; flow rate: 0.5 mL/min; detection at 254 nm): $t_R$ minor= 25.926 min, $t_R$ major = 30.815 min., 97% *ee*).

**TMS Deprotection of propargyl alcohol 11a:**



In an oven dried round-bottom flask, the TMS-protected propargyl alcohol (–)-**11** (1.0 g, 1.83 mmol, 1.0 equiv.) was taken in a mixed solvent system of methanol (10 mL). Next, $K_2CO_3$ (304 mg, 2.20 mmol, 1.2 equiv.) was added to this solution at 25 ºC and stirring was continued for an additional 1 h. After completion of the reaction (judged by TLC analysis), the solvent of the reaction mixture was evaporated to dryness and further diluted with ethyl acetate (20 mL) and water (10 mL). The resulting biphasic mixture was transferred to a separatory funnel and the layers that formed were separated. The aqueous phase was further extracted with ethyl acetate (10 mL X 2) and concentrated under reduced pressure. Then the crude product was purified by flash chromatography by eluting with a gradient of 10% EtOAc/*n*-hexane to afford (−)**-11a** as pale-yellowish gel.



(*R,E*)-**6-methyl-9-(9-tosyl-9*H*-carbazol-2-yl)non-6-en-1-yn-3-ol** (−)**-11a** was obtained as a pale-yellowish gel (1.83 mmol scale, 797 mg of product, 92% yield). R*f* = 0.10 (20% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.28 (dt, *J* = 8.4, 0.9 Hz, 1H), 8.13 (dd, *J* = 1.4, 0.6 Hz, 1H), 7.84 (ddd, *J* = 7.7, 1.4, 0.7 Hz, 1H), 7.78 (dd, *J* = 7.9, 0.6 Hz, 1H), 7.67 (dd, *J* = 8.4, 1.9 Hz, 2H), 7.43 (ddd, *J* = 8.5, 7.3, 1.3 Hz, 1H), 7.34 – 7.30 (m, 1H), 7.18 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.09 (dt, *J* = 8.0, 0.7 Hz, 2H), 5.31 – 5.26 (m, 1H), 4.30 (dd, *J* = 7.3, 5.2 Hz, 1H), 2.83 (t, *J* = 7.6 Hz, 2H), 2.43 (d, *J* = 2.1 Hz, 1H), 2.40 (d, *J* = 7.5 Hz, 2H), 2.25 (s, 3H), 2.19 – 2.12 (m, 2H), 1.83 – 1.77 (m, 2H), 1.55 (d, *J* = 1.2 Hz, 3H).

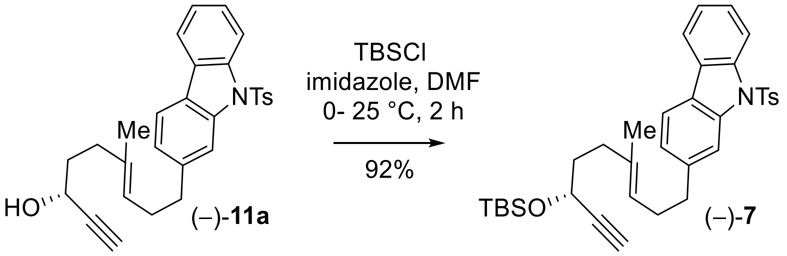
**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 144.8, 142.2, 138.5, 135.0, 129.6, 129.6, 129.6, 126.9, 126.5, 126.5, 126.5, 124.7, 124.4, 124.4, 123.8, 119.7, 119.6, 115.2, 114.9, 84.9, 73.0, 61.9, 36.7, 35.7, 35.0, 30.3, 25.4, 21.5, 16.0.

**IR** (neat) $\upsilon_{max}$ 3182, 2980, 2895, 1785, 1660, 1455, 1233, 956, 840 cm$^{-1}$.

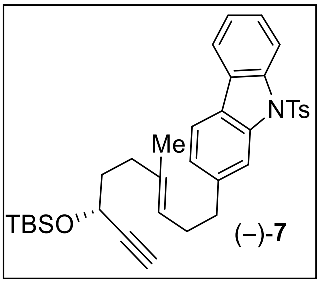
**HRMS** (ESI-TOF) *m/z*: $[M + Na]^+$ calcd. for $[C_{29}H_{29}NO_3S + Na]^+$ 494.1766, found: 494.1756.

$[\alpha]^{25}_{589} = -3.0$ ($c = 0.1$, $CHCl_3$).

**TBS protection of propargyl alcohol 11a:**



In an oven dried round bottom flask compound [(**11a**), 1.0 g, 2.12 mmol, 1.0 equiv.] was dissolved in anhydrous DMF (5 ml). Next, Imidazole (288.65 mg, 4.24 mmol, 2 equiv.), TBSCl (383 mg, 2.54 mmol, 1.2 equiv.) were sequentially added to the reaction vessel at 25 ºC and stirred for 2 h. After completion of the reaction, water (30 mL) was added, and the resulting mixture was extracted twice with ethyl acetate (30 X 2 mL). The combined organic extracts were washed with brine and excess water, dried over $Na_2SO_4$, filtered, and concentrated to give a crude product which was purified by flash chromatography on silica gel with 5% EtOAc in *n*-hexane to afford the TBS protected propargyl alcohol derivative (−)**-7.**



*(R,E)*-2-(7-((**tert-butyldimethylsilyl)oxy)-4-methylnon-3-en-8-yn-1-yl)-9-tosyl-9*H*-carbazole** [(−)**-7**]**:** [(−)**-7**] was obtained as pale-yellowish gel (2.12 mmol scale, 1.14 g of product, 92% yield). $R_f = 0.5$ (20% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.29 (dd, *J* = 8.4, 0.9 Hz, 1H), 8.15 (s, 1H), 7.88 – 7.80 (m, 1H), 7.77 (d, *J* = 7.9 Hz, 1H), 7.68 (s, 2H), 7.46 – 7.38 (m, 1H), 7.35 – 7.27 (m, 1H), 7.17 (d, *J* = 7.8 Hz, 2H), 7.08 (d, *J* = 8.2 Hz, 1H), 5.25 (t, *J* = 7.5 Hz, 1H), 4.32 (td, *J* = 6.6, 2.5 Hz, 1H), 2.87 – 2.76 (m, 2H), 2.42 – 2.34 (m, 2H), 2.29 (t, *J* = 7.4 Hz, 1H), 2.25 (s, 3H), 2.12 (q, *J* = 7.0 Hz, 2H), 1.77 (q, *J* = 7.1 Hz, 2H), 1.55 (s, 3H), 0.89 (s, 6H), 0.06 (s, 9H).

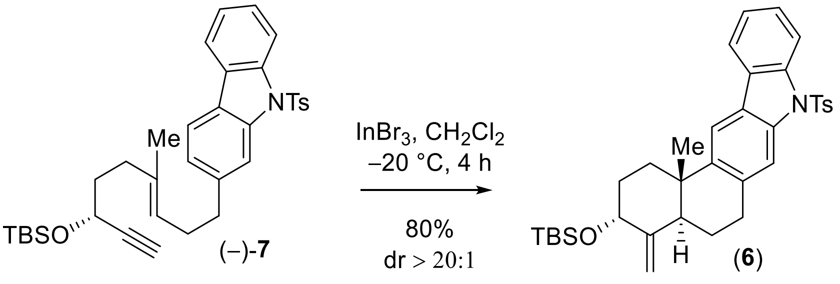
**$^{13}$C {$^{1}$H} NMR** (101 MHz, $CDCl_3$): δ 146.3, 144.9, 142.4, 138.9, 138.5, 135.1, 129.7, 127.9, 127.0, 126.8, 126.6, 125.7, 124.8, 123.9, 123.9, 119.8, 119.7, 115.3, 115.0, 81.8, 72.3, 62.5, 37.1, 35.2, 32.0, 30.6, 29.8, 27.1, 25.9, 25.7, 25.7, 22.8, 21.6, –4.4, –5.0.

**IR** (neat) $\upsilon_{max}$ 3160, 2952, 2856, 1600, 1587, 1495, 1456, 1243, 1052, 956, 840, 752 cm$^{-1}$.

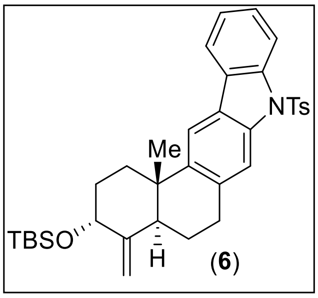
**HRMS** (ESI-TOF) *m/z*: $[M + Na]^+$ calcd. for $[C_{35}H_{43}O_3NSSi + Na]^+$ 608.2625, found: 608.2640.

$[\alpha]^{25.0}_{589} = -2.6$ ($c = 0.1$, $CHCl_3$).

**In(III)-Catalyzed ene-yne cyclization of 7:**



In an oven dried round-bottom flask, TBS-protected propargyl alcohol [(−)-**7**, 2.58 g, 4.403 mmol, 1.0 equiv.] was taken in anhydrous dichloromethane (25 mL) and was cooled to −20 ºC. Next, solid $InBr_3$ (0.312 mg, 0.880 mmol, 0.2 equiv.) was added to this solution at once and stirring was continued for an additional 4 h at −20 ºC. Upon completion of the reaction (as monitored by TLC analysis), the reaction mixture was quenched with saturated $NaHCO_3$ (15 mL). The resulting biphasic mixture was then transferred to a separatory funnel and the organic part was collected. The aqueous part was further extracted with $CH_2Cl_2$ (10 mL X 2). The combined organic layers were washed with brine, dried over $Na_2SO_4$ and concentrated in vacuo under reduced pressure. Finally, the crude product was purified through flash column chromatography using *n*-hexane to afford the TBS-protected pentacyclic allyl alcohol **6**.



(**6**)

(3*R*,4*aR*,13*bS*)**-3-((tert-butyldimethylsilyl)oxy)-13*b*-methyl-4-methylene-8-tosyl-2,3,4,4a,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole** [(+)-**6**]: (+)**-6** was obtained as a colourless liquid (4.403 mmol scale, 2.063 g, 80% yield); R$_f$ = 0.6 (20% EtOAc in *n*-hexane).

$^1$**H NMR** (400 MHz, CDCl$_3$): δ 8.24 (d, *J* = 8.3 Hz, 1H), 7.99 (s, 1H), 7.83 (d, *J* = 7.6 Hz, 1H), 7.81 (s, 1H), 7.74 – 7.71 (m, 2H), 7.43 – 7.39 (m, 1H), 7.32 – 7.28 (m, 1H), 7.12 (d, *J* = 8.1 Hz, 2H), 4.97 (d, *J* = 1.7 Hz, 1H), 4.68 (d, *J* = 1.7 Hz, 1H), 4.30 (s, 1H), 3.15 (s, 1H), 2.83 – 2.78 (m, 1H), 2.27 (s, 3H), 2.15 – 2.09 (m, 1H), 2.08 – 2.02 (m, 1H), 1.86 – 1.83 (m, 2H), 1.81 (d, *J* = 7.3 Hz, 1H), 1.00 (s, 3H), 0.88 (d, *J* = 1.9 Hz, 1H), 0.85 (d, *J* = 2.4 Hz, 1H), 0.82 (s, 9H), 0.06 (s, 3H), 0.04 (s, 3H).

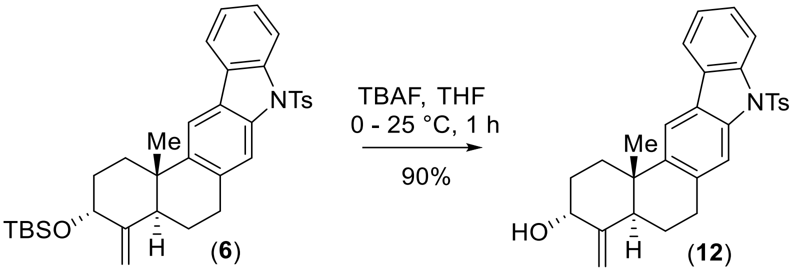
$^{13}$**C {$^1$H} NMR** (126 MHz, CDCl$_3$): δ 152.3, 144.7, 143.6, 138.5, 136.7, 135.6, 135.4, 129.7, 126.7, 126.6, 124.4, 123.6, 119.6, 116.5, 114.9, 114.9, 108.3, 73.3, 41.5, 39.4, 32.9, 31.8, 31.0, 29.1, 25.8, 22.8, 21.5, 20.9, 18.1, 14.1, 1.0, –4.6, –5.0.

**IR** (neat) $\upsilon_{max}$ 3160, 2952, 2856, 1600, 1587, 1495, 1456, 1243, 1052, 956, 752 cm$^{-1}$.

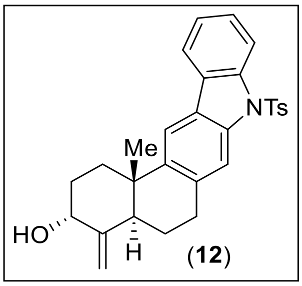
**HRMS** (ESI) *m/z*: [M + H]$^+$ calcd. for [$C_{35}H_{43}NO_3SSi$ + H]$^+$ 586.2811, found: 586.2813.

$[\alpha]^{25}_{589}$ = +6.0 (*c* = 0.2, CHCl$_3$).

**TBS Deprotection of Compound 6:**



A solution of tetrabutylammonium fluoride in tetrahydrofuran (1.0 *M*, 4.3 mL, 4.318 mmol, 1.1 equiv.) was added to a solution of the silyloxy olefin [(+)-**6**, 2.3 g, 3.925 mmol, 1.0 equiv.] in tetrahydrofuran (30 mL) at 0 ºC. The reaction mixture was stirred for 1 h at 25 ºC until the full consumption of the starting material (monitored by TLC). The reaction mixture was diluted sequentially with saturated aqueous ammonium chloride solution (15 mL), and ethyl acetate (15 mL). The resulting biphasic mixture was transferred to a separatory funnel and the layers that formed were separated. The organic layer was washed with brine, dried over $Na_2SO_4$ and concentrated under reduced pressure. Then the crude product was purified by flash column chromatography by eluting with a gradient of 10% EtOAc/*n*-hexane to afford allyl alcohol (+)-**12** as colorless foam.



**(**3*R*,4*aR*,13*bS*)**-13*b*-methyl-4-methylene-8-tosyl-2,3,4,4a,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazol-3-ol** [(+)-**12**]: (+)-**12** was obtained as colorless foam (4.318 mmol scale; 1.67 g, 90% yield). $R_f = 0.2$ (30% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.25 (dq, *J* = 8.4, 0.8 Hz, 1H), 8.00 (s, 1H), 7.83 (ddt, *J* = 7.7, 1.3, 0.7 Hz, 1H), 7.80 (s, 1H), 7.70 – 7.67 (m, 2H), 7.43 – 7.38 (m, 1H), 7.32 – 7.28 (m, 1H), 7.10 – 7.07 (m, 2H), 5.11 (d, *J* = 1.5 Hz, 1H), 4.78 (d, *J* = 1.8 Hz, 1H), 4.41 – 4.38 (m, 1H), 3.18 – 3.13 (m, 2H), 2.86 – 2.80 (m, 1H), 2.25 (s, 3H), 2.21 – 2.16 (m, 1H), 2.06 – 2.03 (m, 1H), 1.99 – 1.95 (m, 2H), 1.88 – 1.82 (m, 2H), 1.03 (s, 3H).

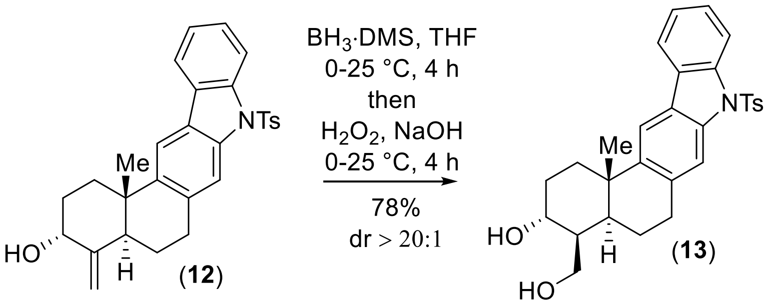
**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 151.5, 144.8, 143.3, 138.6, 136.8, 135.5, 135.2, 129.8, 129.7, 126.9, 126.8, 126.6, 126.6, 124.6, 123.8, 119.7, 116.6, 115.1, 115.1, 110.3, 77.3, 72.9, 41.6, 39.5, 32.9, 30.9, 30.2, 22.6, 21.6, 21.0.

**IR** (neat) $\upsilon_{max}$ 3641, 2958, 1749, 1622, 1456, 1254, 986 $cm^{-1}$.

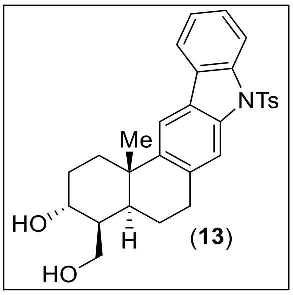
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd for $[C_{29}H_{30}NO_3S + H]^+$ 472.1946, found: 472.1936.

$[\alpha]^{25}_{589} = +25.40$ ($c = 0.2$, $CHCl_3$).

**Hydroboration-oxidation of allyl alcohol 12:**



In an oven dried round-bottom flask the allyl alcohol (**12**, 2.23 g, 4.732 mmol, 1.0 equiv.) was dissolved in anhydrous THF (20 mL). Then $Me_2S{\cdot}BH_3$ (5.90 mL, 4.732 mmol, 1.0 equiv.) was added dropwise under an $N_2$ atmosphere at 0 °C. The mixture was then stirred at 25 °C for 4 h. Then 4 (*M*) NaOH (10 mL), and 30% $H_2O_2$ (10 mL) were added and stir the mixture was stirred at 25 °C for 4 h. After completion of the reaction (confirmed by TLC analysis), the reaction mixture was then extracted with 50% EtOAc in *n*-hexane (30 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. It was purified by flash chromatography using 40% EtOAc in *n*-hexane to afford (+)-**13** as white foam.



**(*3R,4S,4aS,13bS*)-4-(hydroxymethyl)-13*b*-methyl-8-tosyl-2,3,4,4a,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-b]carbazol-3-ol** [(+)-**13**]: (+)-**13** was obtained as colorless foam (4.732 mmol scale; 1.81 g, 78% yield). $R_f$ = 0.20 (50% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.23 (dt, *J* = 8.4, 0.9 Hz, 1H), 7.93 (s, 1H), 7.81 (dt, *J* = 7.7, 1.0 Hz, 1H), 7.72 (s, 1H), 7.68 – 7.64 (m, 2H), 7.42 – 7.37 (m, 1H), 7.29 (td, *J* = 7.5, 1.0 Hz, 1H), 7.10 – 7.05 (m, 2H), 4.24 (q, *J* = 2.6 Hz, 1H), 3.81 (dd, *J* = 10.7, 2.7 Hz, 1H), 3.68 – 3.65 (m, 3H), 3.18 – 3.09 (m, 2H), 2.31 (ddd, *J* = 13.0, 5.3, 2.2 Hz, 2H), 2.24 (s, 3H), 1.96 – 1.89 (m, 3H), 1.82 – 1.78 (m, 1H), 1.68 – 1.65 (m, 3H), 1.05 (s, 3H).

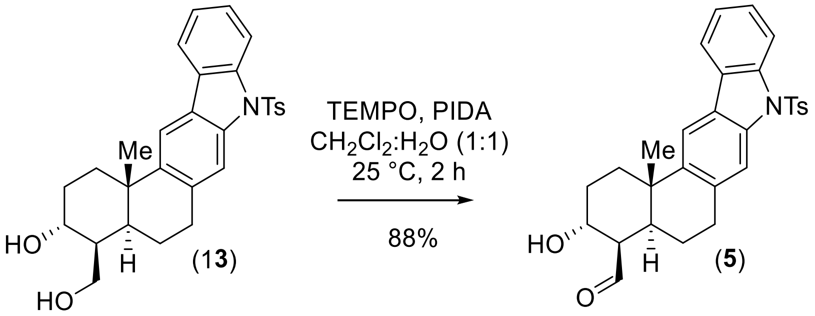
**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 144.8, 138.6, 136.8, 135.5, 135.2, 129.7, 129.7, 126.9, 126.8, 126.6, 126.6, 124.6, 123.8, 119.7, 115.9, 115.1, 114.9, 67.3, 62.8, 51.6, 37.6, 37.2, 32.3, 31.5, 29.9, 25.1, 23.6, 21.6.

**IR** (neat) $\upsilon_{max}$ 3636, 3624, 2958, 1622, 1456, 1254, 983 $cm^{-1}$.

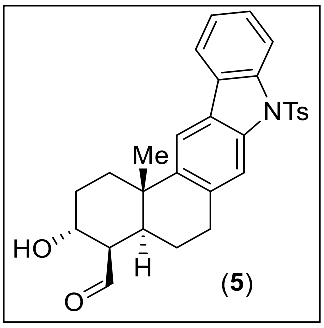
**HRMS** (ESI) m/z: $[M + H]^+$ calcd for $[C_{29}H_{31}NO_4S + H]^+$ 490.2052, found: 490.2025.

$[\alpha]^{25}_{589}$ = +45.6 (*c* = 0.1, $CHCl_3$).

**Oxidation of Di-ol (13) in the presence of PIDA and catalytic TEMPO:**



In an oven dried round-bottom flask the diol **13** (1.8 g, 3.679 mmol, 1.0 equiv.) was dissolved in 20 mL of $CH_2Cl_2/H_2O$ (1:1). Then TEMPO (0.632 g, 4.047 mmol, 1.1 equiv.) and PIDA (1.303 g, 4.047 mmol, 1.1 equiv.) were added at 25 °C. The mixture was then stirred at 25 °C for 2 h. After completion of the reaction (confirmed by TLC analysis), the reaction mixture was quenched with saturated $Na_2S_2O_3$ solution then extracted with $CH_2Cl_2$ (30 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. The crude was purified by flash chromatography using 40% EtOAc in *n*-hexane to afford (+)-**5** as white foam.



**(**3*R*,4*S*,4*aS*,13*bS*)**-4-(hydroxymethyl)-13b-methyl-8-tosyl-2,3,4,4a,5,6,8,13b-octahydro-1H-naphtho[2,1-b]carbazol-3-ol** [(+)-**5**]: (+)-**5** was obtained as white foam (3.679 mmol scale; 1.578 g, 88% yield). $R_f = 0.5$ (50% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 9.99 (s, 1H), 8.27 – 8.23 (m, 2H), 7.99 (s, 1H), 7.83 (dd, *J* = 1.3, 0.7 Hz, 1H), 7.75 (s, 1H), 7.68 (dd, *J* = 4.3, 2.2 Hz, 2H), 7.42 – 7.40 (m, 1H), 7.31 (dd, *J* = 3.6, 1.1 Hz, 1H), 7.12 – 7.10 (m, 2H), 4.62 (s, 1H), 3.25 (d, *J* = 5.2 Hz, 1H), 3.22 (d, *J* = 4.0 Hz, 1H), 2.63 (s, 1H), 2.36 – 2.33 (m, 2H), 2.27 (s, 3H), 2.21 – 2.19 (m, 1H), 2.02 (s, 1H), 1.39 (s, 1H), 1.29 (s, 1H), 1.10 (d, *J* = 1.4 Hz, 1H), 1.07 (s, 3H).

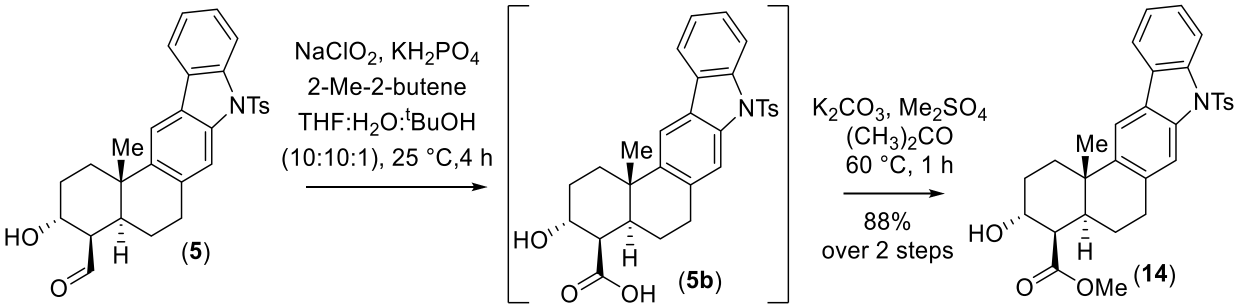
**$^{13}$C {$^{1}$H} NMR** (126 MHz, $CDCl_3$): δ 203.3, 144.8, 138.6, 135.2, 129.8, 127.0, 126.6, 126.6, 126.6, 126.6, 124.8, 123.8, 119.7, 116.2, 115.6, 115.2, 115.1, 64.4, 58.9, 38.6, 37.9, 27.0, 23.6, 23.5, 21.6.

**IR** (neat) $\upsilon_{max}$ 3624, 2958, 1749, 1622, 1456, 1254, 986 cm$^{-1}$.

**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd for $[C_{29}H_{30}NO_4S + H]^+$ 488.1895, found: 488.1862.

$[\alpha]^{25}_{589} = +56.20$ ($c = 0.1$, $CHCl_3$).

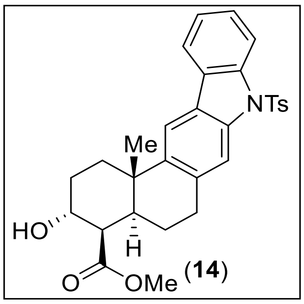
**Synthesis of *β*-hydroxy ester (14):**



In an oven dried round-bottom flask to a solution of the aldehyde compound **5** (0.850 g, 1.743 mmol, 1.00 equiv.) in 10 ml of mixed solvent system of THF: $H_2O$: $^{t}$BuOH (10:10:1). Next, 2-Methyl 2-butene (1.850 mL, 17.43 mmol, 10.0 equiv.) was added. Then a mixture of $NaClO_2$ (0.472 g, 5.229 mmol, 3.0 equiv.) and $KH_2PO_4$ (1.186 g, 8.715 mmol, 5.0 equiv.) at 0 °C. The mixture was warmed to room temperature and stirred for 4 h and 10 ml of water was added. Then it was extracted three times with EtOAc and dried over $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum to afford the corresponding acid compound **5b** as white foam. The crude product was charged for the next step without further purification.

In an oven-dried round-bottom flask crude acid (**5b**) was taken and dissolved in acetone solvent then $K_2CO_3$ (481 mg, 3.486 mmol, 2.0 equiv.) and $Me_2SO_4$ (0.605 mL, 3.486 mmol, 2.0 equiv.)

added simultaneously and stirred for 1 h at 60 ºC. Finally work up was done with $CH_2Cl_2/H_2O$. The organic filtrate was dried over anhydrous $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum. The crude products were purified by flash chromatography with 30% EtOAc in *n*-hexane to afford compound **14** as yellow gel.



**1-(**3*R*,4*R*,4*aS*,13*bS*)**-3-hydroxy-13b-methyl-8-tosyl-2,3,4,4a,5,6,8,13b-octahydro-1*H*-naphtho[2,1-*b*]carbazol-4-yl)ethan-1-one** [(+)-**14**]: (+)-**14** was obtained as yellow gel. (1.743 mmol scale; 0.769 g, 88% yield). $R_f$ = 0.2 (30% EtOAc in *n*-hexane).

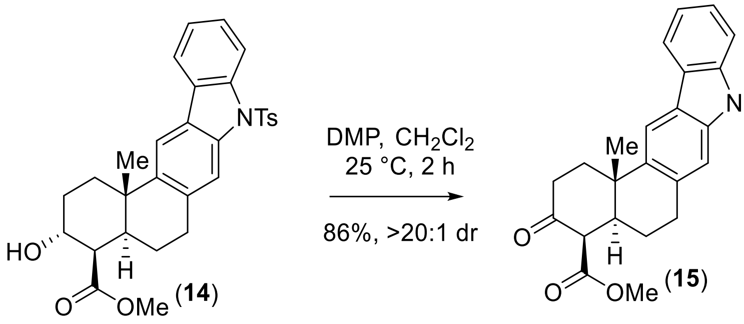
**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.24 (d, *J* = 8.4 Hz, 1H), 7.95 (s, 1H), 7.82 (d, *J* = 7.2 Hz, 1H), 7.75 (s, 1H), 7.68 (d, *J* = 8.5 Hz, 2H), 7.40 (d, *J* = 7.4 Hz, 1H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.10 (d, *J* = 8.2 Hz, 2H), 4.46 (q, *J* = 2.6 Hz, 1H), 3.70 (s, 3H), 3.13 (dd, *J* = 9.1, 4.2 Hz, 2H), 2.73 (dd, *J* = 5.2, 2.3 Hz, 1H), 2.51 – 2.35 (m, 2H), 2.26 (s, 4H), 2.21 – 2.14 (m, 2H), 1.86 (dd, *J* = 13.1, 4.4 Hz, 1H), 1.79 (d, *J* = 15.3 Hz, 1H), 1.10 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 174.3, 144.6, 144.0, 138.6, 136.7, 135.5, 135.2, 129.6, 126.8, 126.6, 126.5, 124.6, 123.7, 119.6, 116.3, 115.1, 114.9, 66.5, 51.3, 50.0, 38.4, 37.9, 32.9, 32.0, 27.0, 24.9, 22.7, 21.5.

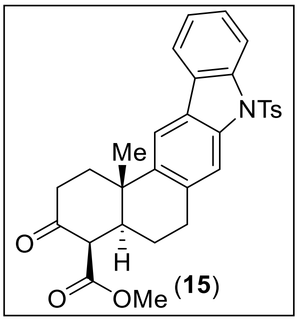
**IR** (neat) $\nu_{max}$ 3641, 2958, 1690, 1622, 1456, 1254, 986 $cm^{-1}$.

$[\alpha]^{25}_{589}$ = +112.6 (*c* = 0.2, $CHCl_3$).

**Synthesis of *β*-keto Ester (15):**



In an oven-dried round-bottom flask, the alcohol intermediate **14** (0.680 g 1.355 mmol, 1.0 equiv.) in DCM (10 mL) was charged with Dess-Martin Periodinane (0.632 g, 1.491 mmol, 1.1 equiv.) at 0 ºC over a period of 10 minutes with continuous stirring over an ice bath. After the complete addition of DMP, the ice bath was removed, and the reaction mixture was allowed to stir for additional 2 h until the consumption of the starting material (monitored by TLC analysis). After completion of the reaction, was quenched with saturated $NaHCO_3$ (10 mL) at 0 ºC. The biphasic mixture was then transferred to a separatory funnel and the organic part was collected. The aqueous part was further extracted with $CH_2Cl_2$ (10 mL X 2). The combined organic layers were washed with brine, dried over $Na_2SO_4$ and concentrated in vacuo under reduced pressure. Finally, the crude product was purified through flash column chromatography using 20% EtOAc in *n*-hexane. Pure aldehyde **15** was obtained after column chromatography as yellowish foam.



**Methyl (4*R*,4*aS*,13*bS*)-13*b*-methyl-3-oxo-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carboxylate** [(+)-**15**]: (+)-**15** was obtained as yellow foam (1.355 mmol scale; 0.582 g, 86% yield). $R_f$ = 0.5 (30% EtOAc in *n*-hexane).

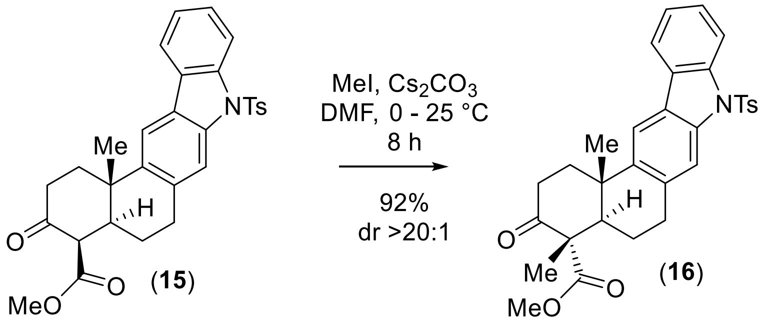
**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.26 (d, *J* = 8.5 Hz, 1H), 8.02 (s, 1H), 7.83 (d, *J* = 7.5 Hz, 1H), 7.80 (s, 1H), 7.68 (d, *J* = 8.5 Hz, 2H), 7.47 – 7.42 (m, 1H), 7.33 (d, *J* = 7.5 Hz, 1H), 7.11 (d, *J* = 8.3 Hz, 2H), 3.81 (s, 3H), 3.44 (d, *J* = 13.2 Hz, 1H), 3.20 – 3.11 (m, 2H), 2.74 – 2.59 (m, 4H), 2.53 – 2.44 (m, 1H), 2.27 (s, 4H), 2.01 – 1.67 (m, 2H), 1.39 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 205.2, 170.2, 144.8, 141.2, 138.6, 137.1, 135.1, 135.0, 129.7, 127.1, 126.5, 126.4, 124.7, 123.8, 119.6, 116.1, 115.1, 115.1, 60.0, 52.2, 44.7, 37.9, 37.5, 36.4, 30.3, 24.1, 22.5, 21.5.

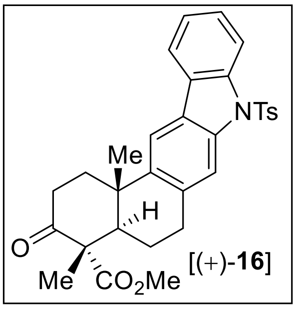
**IR** (neat) $\nu_{max}$ 3641, 2958, 1690, 1622, 1456, 1254, 986 $cm^{-1}$.

$[\alpha]^{25}_{589}$ = +125.40 (*c* = 0.3, $CHCl_3$).

**Synthesis of *β*-keto ester (16):**



In an oven dried round-bottom flask compound **15** (420 mg, 0.814 mmol, 1.0 equiv.) was taken in DMF (5 mL). To this solution, $Cs_2CO_3$ (292 mg, 0.896 mmol, 1.1 equiv.) and methyl iodide (0.055 mL, 0.896 mmol, 1.1 equiv.) was added at 0 ºC under an argon atmosphere and stirred for an additional 8 h. After completion of the reaction (confirmed by TLC analysis), it was quenched with saturated aqueous $Na_2S_2O_3$ solution (10 mL). The reaction mixture was then extracted with EtOAc (10 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. It was purified through flash column chromatography using 30% EtOAc in *n*-hexane.



[(+)-**16**]

**Methyl** (4*S*,4*aR*,13*bS*)-**4,13*b*-dimethyl-3-oxo-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*] carbazole-4-carboxylate** [(+)-**16**]**:** [(+)-`**16**] was obtained as a white foam (0.814 mmol scale, 0.397 g, 92% yield); $R_f$ = 0.7 (30% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.28 (d, *J* = 8.3 Hz, 1H), 8.02 (s, 1H), 7.87 (d, *J* = 7.8 Hz, 1H), 7.81 (s, 1H), 7.74 – 7.71 (m, 2H), 7.46 (t, *J* = 7.5 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 1H), 7.15 (d, *J* = 7.7 Hz, 2H), 3.77 (d, *J* = 1.6 Hz, 3H), 3.19 (t, *J* = 6.4 Hz, 1H), 2.92 – 2.88 (m, 1H), 2.85 – 2.80 (m, 1H), 2.73 (dt, *J* = 9.9, 5.6 Hz, 2H), 2.30 (s, 3H), 2.17 – 1.97 (m, 3H), 1.65 (dd, *J* = 13.7, 6.0 Hz, 1H), 1.52 (s, 3H), 1.42 (s, 3H).

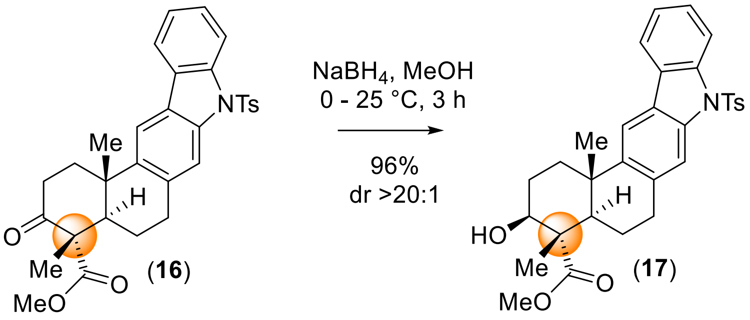
**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 210.3, 173.6, 144.9, 143.2, 138.6, 137.1, 135.2, 135.0, 129.8, 129.8, 127.2, 126.6, 126.4, 124.9, 123.9, 119.7, 116.4, 115.1, 114.9, 61.1, 52.8, 46.8, 37.4, 37.0, 35.3, 31.4, 24.9, 21.6, 21.5, 16.9.

**IR** (neat) $\upsilon_{max}$ 2930, 2866, 1710, 1680, 1602, 1455, 1243, 915, 788, 540 $cm^{-1}$

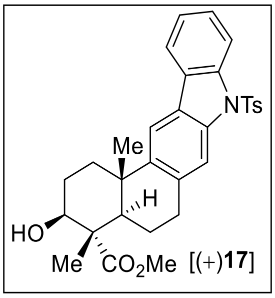
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd for $[C_{31}H_{31}NO_5S + H]^+$ 530.2001, found: 530.2014.

$[\alpha]^{25}_{589}$ = +77.8° (*c* = 0.1, $CH_3OH$).

**Synthesis of *β*-hydroxy ester (17):**



In an oven-dried round-bottom flask, the compound **16** (0.396 g, 0.748 mmol, 1.0 equiv.) was taken in MeOH (4 mL) at 0 ºC, $NaBH_4$ (14 mg, 0.374 mmol, 0.5 equiv.) was added at 0 ºC and the reaction mixture was stirred at 25 ºC temperature for 3 h. After complete consumption of starting material (monitored by TLC analysis), it was quenched with saturated $NH_4Cl$ (2 mL) and extracted with EtOAc (4 mL X 2). The organic layers were dried over $Na_2SO_4$ and concentrated on a rotary evaporator under reduced pressure. The crude product was purified through flash column chromatography using 40% EtOAc in *n*-hexane.



**Methyl** (3S,4S,4aR,13bS)-**3-hydroxy-4,13b-dimethyl-8-tosyl-2,3,4,4a,5,6,8,13b-octahydro-1H-naphtho[2,1-b] carbazole-4-carboxylate** [(+)-**17**]**:** [(+)-**17**] was obtained as a white foam (0.748 mmol scale, 0.381 g, 96% yield); $R_f$ = 0.32 (30% EtOAc in *n*-hexane).

$^1$**H NMR** (400 MHz, $CDCl_3$): δ 8.26 – 8.23 (m, 1H), 7.95 (s, 1H), 7.82 (ddd, *J* = 7.7, 1.4, 0.7 Hz, 1H), 7.73 (s, 1H), 7.68 (d, *J* = 8.4 Hz, 2H), 7.44 – 7.39 (m, 1H), 7.31 (dd, *J* = 7.6, 1.0 Hz, 1H), 7.12 – 7.09 (m, 2H), 4.05 (d, *J* = 6.6 Hz, 1H), 3.75 (s, 3H), 3.16 – 3.08 (m, 2H), 2.49 – 2.45 (m, 1H), 2.27 (s, 3H), 2.18 – 2.14 (m, 1H), 2.02 – 1.98 (m, 1H), 1.95 – 1.91 (m, 1H), 1.84 (dd, *J* = 12.0, 2.9 Hz, 1H), 1.75 – 1.71 (m, 1H), 1.53 – 1.48 (m, 1H), 1.28 (s, 3H), 1.26 – 1.25 (m, 3H).

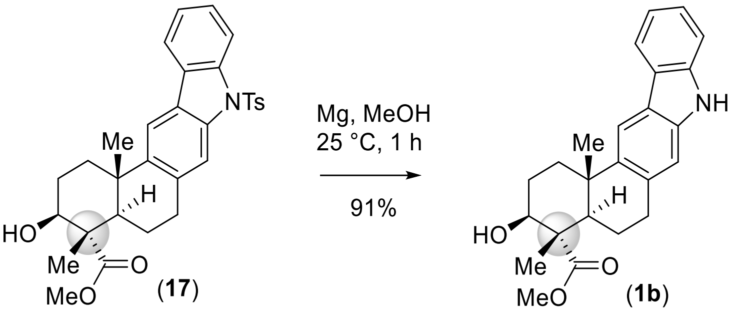
**$^{13}$C {$^{1}$H} NMR** (126 MHz, CDCl$_3$): δ 177.8, 145.2, 144.7, 138.5, 136.8, 135.2, 135.1, 129.7, 129.7, 126.9, 126.6, 126.5, 124.5, 123.7, 123.0, 119.5, 115.4, 115.1, 114.7, 75.2, 53.7, 52.4, 45.5, 37.3, 37.0, 30.9, 27.3, 25.6, 21.5, 21.4, 10.7.

**IR** (neat) $\upsilon_{max}$ 3389, 2930, 2866, 1710, 1602, 1455, 1243, 915, 788, 540 cm$^{-1}$

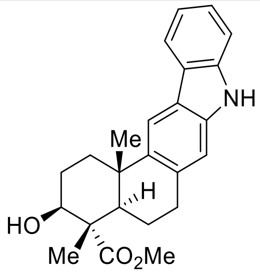
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd for $[C_{31}H_{33}NO_5S + H]^+$ 532.2158, found: 532.2150.

$[\alpha]^{25}_{589} = +120.67$ (*c* = 0.1, CHCl$_3$).

**Total Synthesis of Xiamycin A Methyl Ester (1b):**



In an oven-dried round-bottom flask, the compound **17** (67 mg, 0.126 mmol, 1.0 equiv.) was taken in MeOH (4 mL). Then Mg (15 mg, 0.630 mmol, 5.0 equiv.) was added and the reaction mixture was sonicated at 25 ºC temperature for 1 h. After complete consumption of starting material (monitored by TLC analysis), it was quenched with saturated NH$_4$Cl (2 mL) and extracted with EtOAc (4 mL X 2). The organic layers were dried over Na$_2$SO$_4$ and concentrated on a rotary evaporator under reduced pressure. The crude product was purified by flash column chromatography with a solvent gradient of 50% EtOAc in *n*-hexane to afford xiamycin A methyl ester [(+)-**1b**] as a white foam.



xiamycin A
methyl ester [(+)-**1b**]

**Methyl** (3*S*,4*S*,4*aR*,13*bS*)-**3-hydroxy-4,13*b*-dimethyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*] carbazole-4-carboxylate** [(+)-**1b**]**:** [(+)-**1b**] was obtained as a white foam (0.126 mmol scale, 0.043 g, 91% yield). R$_f$ = 0.2 (30% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, CDCl$_3$): δ 7.97 (dt, *J* = 7.7, 0.9 Hz, 1H), 7.90 (s, 1H), 7.83 (s, 1H), 7.33 (dd, *J* = 3.8, 1.0 Hz, 1H), 7.32 – 7.31 (m, 1H), 7.18 – 7.14 (m, 1H), 7.01 (d, *J* = 1.4 Hz, 1H), 4.09 – 4.05 (m, 1H), 3.71 (s, 3H), 3.08 – 3.03 (m, 2H), 2.57 – 2.52 (m, 1H), 2.19 (dd, *J* = 12.5, 2.4 Hz, 1H), 2.01 – 1.96 (m, 1H), 1.95 – 1.91 (m, 1H), 1.84 (ddd, *J* = 11.1, 2.9, 1.7 Hz, 1H), 1.78 (d, *J* = 10.0 Hz, 1H), 1.49 – 1.43 (m, 1H), 1.27 (s, 3H), 1.27 (s, 3H).

**$^{13}$C {$^1$H} NMR** (101 MHz, CDCl$_3$): δ 178.9, 142.0, 141.0, 139.1, 134.3, 126.4, 124.5, 122.9, 120.8, 120.1, 116.6, 111.4, 110.8, 76.3, 54.8, 53.2, 46.8, 38.3, 38.2, 31.7, 28.4, 26.8, 22.4, 11.7.

**IR** (neat) $\upsilon_{max}$ 3389, 2930, 2866, 1710, 1602, 1455, 1243, 915, 788, 540 cm$^{-1}$

**HRMS** (ESI) *m/z*: [M + H]$^+$ calcd. for [C$_{24}$H$_{27}$NO$_3$ + H]$^+$ 378.2069, found: 378.2070.

$[\alpha]^{25}_{589}$ = +112.6° (*c* = 0.2, CH$_3$OH); {Lit.[1] $[\alpha]_D^{21}$ = +162.4° (*c* = 1.3, CH$_3$OH)}.

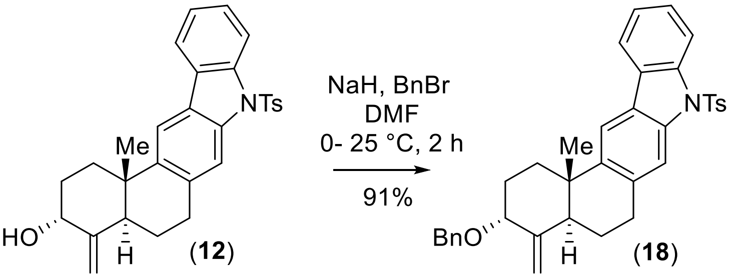
**Comparison of $^1$H-NMR Data** of Xiamycin A methyl ester [(+)-**1b**] of this report with isolation of [(+)-**1b**] by Hertweck:[1]

| Hertweck's isolation report of Xiamycin A methyl ester [(+)-**1b**]<br>($^1$H-NMR, 3**00** MHz, $CD_3OD$) [1] | This report: Xiamycin A methyl ester [(+)-**1b**]<br>($^1$H-NMR, 400 MHz, $CDCl_3$) |
|---|---|
| 7.96 (dd, *J* = 7.7, 1.1 Hz, 1H) | 7.97 (dt, *J* = 7.7, 0.9 Hz, 1H) |
| 7.92 (s, 1H) | 7.90 (s, 1H) |
| - | 7.83 (s, 1H) |
| 7.34 (dd, *J* = 8.0, 1.1 Hz, 1H) | 7.33 (dd, *J* = 3.8, 1.0 Hz, 1H) |
| 7.27 (ddd, *J* = 8.0, 7.4, 1.1 Hz, 1H) | 7.32 – 7.31 (m, 1H) |
| 7.08 (ddd, *J* = 8.1, 7.3, 1.1 Hz, 1H) | 7.18 – 7.14 (m, 1H) |
| 7.05 (s, 1H) | 7.01 (d, *J* = 1.4 Hz, 1H) |
| 4.05 (dd, *J* = 9.1, 7.1 Hz, 1H) | 4.09 – 4.05 (m, 1H) |
| 3.71 (s, 3H) | 3.71 (s, 3H) |
| 3.09 (dd, *J* = 16.7, 6.1 Hz, 1H) | 3.08 – 3.03 (m, 2H) |
| 2.98 (m, 1H) | 2.57 – 2.52 (m, 1H) |
| 2.61 (td, *J* = 13.1, 3.0 Hz, 1H) | 2.19 (dd, *J* = 12.5, 2.4 Hz, 1H) |
| 2.13 (dd, *J* = 12.5, 2.0 Hz, 1H) | 2.01 – 1.96 (m, 1H) |
| 2.00 (ddd, *J* = 13.4, 12.8, 7.0 Hz, 1H) | 1.95 – 1.91 (m, 1H) |
| 1.88 (m, 1H) | 1.84 (ddd, *J* = 11.1, 2.9, 1.7 Hz, 1H) |
| 1.74 (m, 1H) | 1.78 (d, *J* = 10.0 Hz, 1H) |
| 1.38 (m, 1H) | 1.49 – 1.43 (m, 1H) |
| 1.29 (s, 3H) | 1.27 (s, 3H) |
| 1.23 (s, 3H) | 1.27 (s, 3H) |

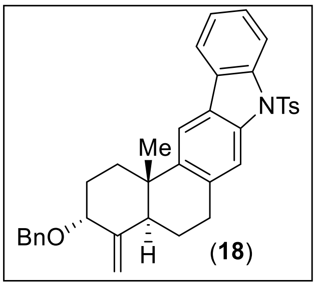
**Comparison of $^1$H-NMR Data** of Xiamycin A methyl ester [(+)-**1b**] of this report with isolation of [(+)-**1b**] by Hertweck:[1]

| Hertweck's Isolation of Xiamycin A methyl ester [(+)-**1b**] ($^{13}$C-NMR, 125.76 MHz, $CD_3OD$)[1] | This synthesis: Xiamycin A methyl ester [(+)-**1b**] ($^{13}$C-NMR, 101 MHz, $CDCl_3$) |
|---|---|
| 179.8 | 178.9 |
| 142.0 | 142.0 |
| 141.8 | 141.0 |
| 140.2 | 139.1 |
| 133.9 | 134.3 |
| 126.1 | 126.4 |
| 124.6 | 124.5 |
| 123.1 | 122.9 |
| 120.5 | 120.8 |
| 119.4 | 120.1 |
| 116.3 | 116.6 |
| 111.5 | 111.4 |
| 110.8 | 110.8 |
| 76.3 | 76.3 |
| 55.4 | 54.8 |
| 52.6 | 53.2 |
| 48.1 | 46.8 |
| 39.0 | 38.3 |
| 38.4 | 38.2 |
| 31.9 | 31.7 |
| 28.5 | 28.4 |
| 26.3 | 26.8 |
| 22.6 | 22.4 |
| 11.3 | 11.7 |

**Synthesis of compound (+)-18:**



In an oven dried round bottom flask compound **12** (200 mg, 0.424 mmol, 1.0 equiv.) was dissolved in anhydrous DMF (5 ml) maintaining $N_2$ inertness and set on an ice bath. Sodium hydride (0.37 mg, 0.933 mmol, 2.2 equiv.) was added in portion-wise manner to the reaction vessel and stirred for 15 min at 0 °C. Then benzyl bromide (0.110 mL, 0.933 mmol, 2.2 equiv.) was directly added to the solution and the reaction mixture was allowed to stir at 25 $^{o}$C for 1.5 h until the full consumption of starting material (monitored by TLC). The reaction was quenched with excess of saturated aqueous $Na_2S_2O_3$ solution. Then the solution was extracted with EtOAc and water. The aqueous phase was extracted with EtOAc (6 mL X 3). The combined organic layers were dried over anhydrous $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum. The crude product was purified by flash chromatography with 10% EtOAc in *n*-hexane to afford (+)-**18** as yellowish liquid.



**(3*R*,4*aR*,13*bS*)-3-(benzyloxy)-13*b*-methyl-4-methylene-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole** [(+)-**18**]**:** [(+)-**18**] was obtained as a yellow liquid. $R_f$ = 0.7 (20% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.24 (dt, *J* = 8.4, 0.9 Hz, 1H), 8.00 (s, 1H), 7.83 (ddd, *J* = 7.7, 1.4, 0.7 Hz, 1H), 7.80 (s, 1H), 7.72 – 7.68 (m, 2H), 7.43 – 7.38 (m, 1H), 7.34 – 7.26 (m, 6H), 7.25 (s, 1H), 7.13 – 7.08 (m, 2H), 5.09 (t, *J* = 1.5 Hz, 1H), 4.93 (t, *J* = 1.7 Hz, 1H), 4.48 (d, *J* = 12.1 Hz, 1H), 4.30 (d, *J* = 12.1 Hz, 1H), 3.97 (t, *J* = 2.7 Hz, 1H), 3.21 – 3.10 (m, 2H), 2.74 – 2.68 (m, 1H), 2.26 (d, *J* = 3.5 Hz, 3H), 2.22 – 2.16 (m, 1H), 2.14 – 2.04 (m, 2H), 1.98 – 1.91 (m, 1H), 1.91 – 1.84 (m, 2H), 1.05 (s, 3H).

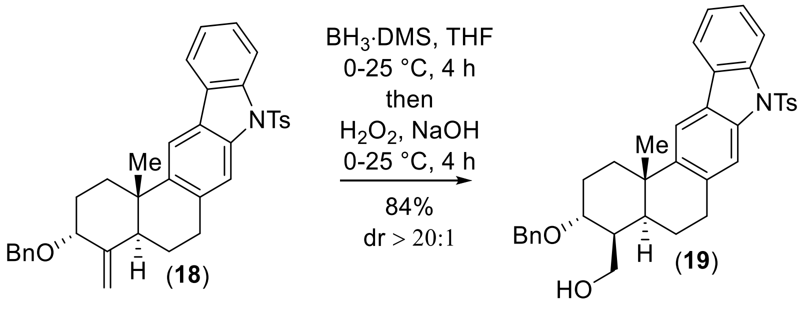
**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 149.0, 144.7, 143.4, 139.0, 138.5, 136.7, 135.4, 135.2, 129.7, 129.7, 128.3, 127.5, 127.5, 127.3, 126.8, 126.7, 126.5, 124.5, 123.7, 119.6, 116.5, 115.0, 115.0, 111.7, 79.1, 69.1, 41.9, 39.4, 33.5, 30.9, 29.3, 22.9, 21.5, 21.0.

**IR** (neat) $\upsilon_{max}$ 2930, 2866, 1812, 1602, 1455, 1243, 915, 788, 540 $cm^{-1}$

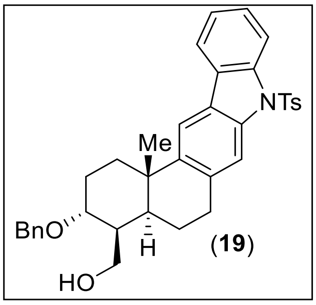
**HRMS** (ESI) *m/z*: $[M + Na]^+$ calcd. for $[C_{36}H_{35}NO_3S + Na]^+$ 584.2235, found: 584.2227.

$[\alpha]^{25}_{589}$ = +22.43° (*c* = 0.1, $CHCl_3$).

**Hydroboration-oxidation of olefin 18:**



In an oven dried round-bottom flask the compound (**18**, 0.430 g, 0.765 mmol, 1.0 equiv.) was dissolved in anhydrous THF (10 mL). Then $Me_2S{\cdot}BH_3$ (0.956 mL, 0.765 mmol, 1.0 equiv.) was added dropwise under an $N_2$ atmosphere at 0 °C. The mixture was then stirred at 25 °C for 4 h. Then 4 (*M*) NaOH (4 mL), and 30% $H_2O_2$ (4 mL) were added at 0 °C and the mixture was stirred at 25 °C for 4 h. After completion of the reaction (confirmed by TLC analysis), the reaction mixture was then extracted with 40% EtOAc in *n*-hexane (20 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. It was purified by flash chromatography using 20% EtOAc in *n*-hexane to afford (+)-[**19**] as white foam.



((3*R*,4*S*,4*aS*,13*bS*)-3**-(benzyloxy)-13*b*-methyl-8-tosyl-2,3,4,4a,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazol-4-yl)methanol** [(+)**-19**]**:** [(+)**-19**] was obtained as a yellowish liquid (0.765 mmol, 0.372 g, 84% yield). $R_f$ = 0.5 (40% EtOAc in *n*-hexane).

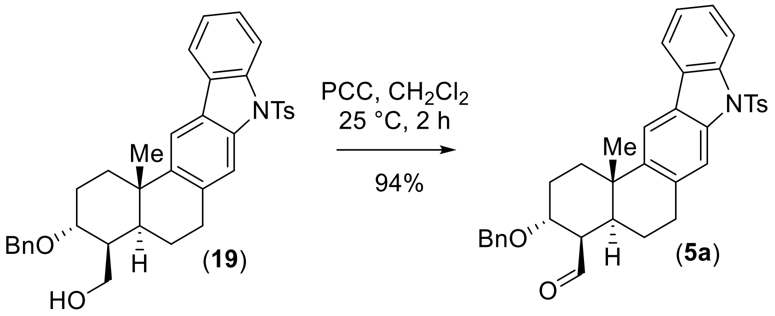
**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.26 – 8.22 (m, 1H), 7.94 (s, 1H), 7.84 – 7.80 (m, 1H), 7.74 (s, 1H), 7.69 – 7.65 (m, 2H), 7.42 – 7.38 (m, 1H), 7.33 – 7.27 (m, 5H), 7.25 (s, 1H), 7.11 – 7.08 (m, 2H), 4.56 (d, *J* = 11.9 Hz, 1H), 4.52 (d, *J* = 12.0 Hz, 1H), 3.88 – 3.82 (m, 2H), 3.64 (t, *J* = 10.6 Hz, 1H), 3.17 – 3.09 (m, 2H), 2.33 (ddd, *J* = 13.1, 5.3, 2.2 Hz, 1H), 2.25 (s, 3H), 2.13 (d, *J* = 8.9 Hz, 1H), 2.01 (d, *J* = 4.3 Hz, 1H), 1.95 (dd, *J* = 12.6, 3.8 Hz, 1H), 1.67 – 1.61 (m, 1H), 1.08 (s, 3H).

**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 145.0, 144.7, 139.1, 138.6, 136.7, 135.6, 135.2, 129.8, 128.4, 127.5, 127.5, 126.8, 126.6, 124.5, 123.7, 119.6, 115.8, 115.1, 114.9, 74.5, 70.3, 61.5, 49.0, 38.2, 37.1, 32.8, 31.4, 25.3, 23.7, 22.5, 21.6.

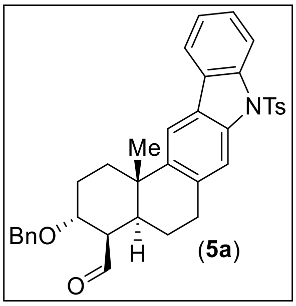
**IR** (neat) $\upsilon_{max}$ 3375, 2930, 2866, 1812, 1602, 1455, 1243, 915, 540 $cm^{-1}$

$[\alpha]^{25}_{589}$ = +42.06° (*c* = 0.1, $CHCl_3$)

**Synthesis of Compound (+)-5a:**



In an oven dried round-bottom flask the alcohol **19** (330 mg, 0.569 mmol, 1.0 equiv.) was charged in $CH_2Cl_2$ under $N_2$ atmosphere. Pyridinium chlorochromate (147 mg, 0.682 mmol, 1.2 equiv.) was added to the reaction mixture and then it was stirred at 25 ºC for 2 h. After completion of the reaction (monitored by TLC) the crude product was purified by flash chromatography with 20% EtOAc in *n*-hexane to afford **5a** as white foam.



(3*R*,4*R*,4*aS*,13*bS*)**-3-(benzyloxy)-13*b*-methyl-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carbaldehyde** [(+)-**5a**]**:** [(+)-**5a**] was obtained as a yellow liquid (0.569 mmol scale, 309 mg, 94% yield). $R_f$ = 0.7 (40% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 10.00 (s, 1H), 8.24 (d, *J* = 8.4 Hz, 1H), 7.98 (s, 1H), 7.84 – 7.80 (m, 1H), 7.75 (s, 1H), 7.68 (d, *J* = 8.4 Hz, 2H), 7.43 – 7.39 (m, 1H), 7.33 – 7.26 (m, 6H), 7.12 – 7.09 (m, 2H), 4.56 (d, *J* = 11.8 Hz, 1H), 4.44 (d, *J* = 11.7 Hz, 1H), 4.25 – 4.22 (m, 1H), 3.26 – 3.18 (m, 2H), 2.73 (dt, *J* = 5.7, 1.9 Hz, 1H), 2.59 (ddd, *J* = 13.4, 5.7, 2.1 Hz, 1H), 2.38 – 2.31 (m, 1H), 2.26 (s, 3H), 2.20 – 2.15 (m, 1H), 2.09 – 2.04 (m, 1H), 1.99 – 1.93 (m, 1H), 1.90 – 1.83 (m, 2H), 1.08 (s, 3H).

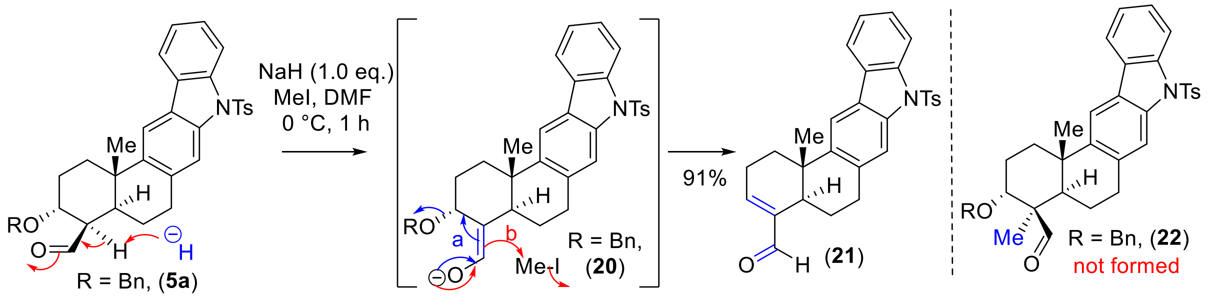
**$^{13}$C {$^{1}$H} NMR** (126 MHz, $CDCl_3$): δ 203.6, 144.8, 143.5, 138.6, 138.6, 136.9, 135.2, 135.1, 129.8, 128.5, 127.7, 127.6, 127.0, 126.6, 126.6, 124.7, 123.8, 119.7, 116.1, 115.1, 115.1, 77.3, 71.6, 70.6, 57.3, 39.1, 37.7, 32.7, 31.7, 29.8, 23.7, 23.6, 23.1, 21.6.

**IR** (neat) $\upsilon_{max}$ 2930, 2866, 1812, 1785, 1455, 1243, 915, 788 $cm^{-1}$.

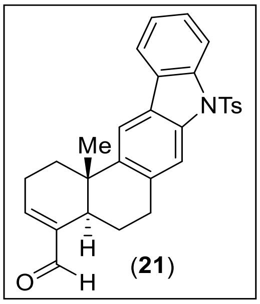
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd. for $[C_{36}H_{35}NO_4S + H]^+$ 578.2365, found: 578.2367.

$[\alpha]^{25}_{589}$ = +56.73° (*c* = 0.1, $CHCl_3$).

**Attempt of diastereoselective methylation of [(+)-5a]:**



In an oven dried round-bottom flask compound **5a** (250 mg, 0.433 mmol, 1.0 equiv.) was taken in DMF (5 mL) at 0 °C under an argon atmosphere. To this solution NaH (17 mg, 0.432 mmol, 1.0 equiv.) at 0 ᵒC and methyl iodide (0.032 mL, 0.519 mmol, 1.2 equiv.) was added and stirred for an additional 1 h. After completion of the reaction (confirmed by TLC analysis), it was quenched with saturated aqueous $Na_2S_2O_3$ solution (5 mL). The reaction mixture was then extracted with EtOAc (5 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. The crude products were purified by flash chromatography with 20% EtOAc in *n*-hexane to afford compound **21** as yellow liquid.



(**21**)

**(**4*aR*,13*bS***)-13*b*-methyl-8-tosyl-2,4*a*,5,6,8,13*b*-hexahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carbaldehyde** [(+)-**21**]: (+)-**21** was obtained as yellow liquid. (0.433 mmol scale; 0.185 g, 91% yield). $R_f$ = 0.6 (20% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 9.51 (s, 1H), 8.26 (dt, *J* = 8.3, 0.9 Hz, 1H), 8.04 (t, *J* = 0.7 Hz, 1H), 7.84 (ddd, *J* = 7.7, 1.4, 0.7 Hz, 1H), 7.78 (s, 1H), 7.72 – 7.69 (m, 2H), 7.44 – 7.40 (m, 1H), 7.33 – 7.29 (m, 1H), 7.12 – 7.10 (m, 2H), 6.86 (d, *J* = 3.1 Hz, 1H), 3.26 – 3.19 (m, 2H), 3.09 – 3.02 (m, 1H), 2.62 – 2.56 (m, 3H), 2.52 (d, *J* = 12.4 Hz, 1H), 2.26 (s, 3H), 1.69 – 1.63 (m, 2H), 1.08 (s, 3H).

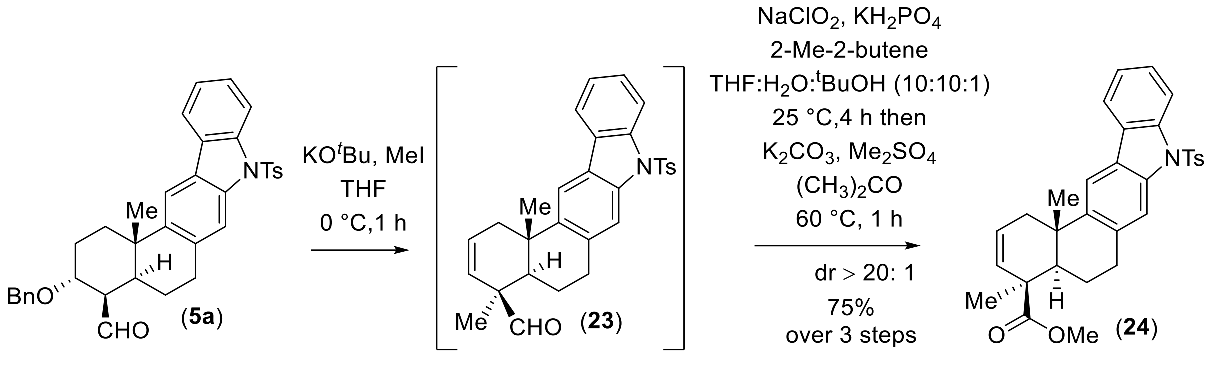
**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 194.8, 152.3, 144.8, 142.8, 142.7, 138.5, 137.0, 136.1, 135.3, 129.8, 126.9, 126.9, 126.7, 126.6, 124.0, 123.8, 119.5, 115.4, 115.1, 114.6, 77.31, 40.3, 36.0, 32.3, 29.4, 24.7, 22.4, 21.6, 19.1.

**IR** (neat) $\nu_{max}$ 3135, 2840, 1782, 1662, 1480, 1114, 981 $cm^{-1}$.

**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd. for $[C_{29}H_{27}NO_3S + H]^+$ 470.1790, found: 470.1758.

$[\alpha]^{25}_{589}$ = +25.0 (*c* = 0.1, $CHCl_3$).

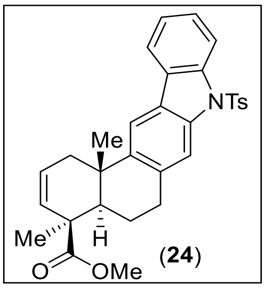
**Synthesis of *α*, *β*-unsaturated ester (24):**



In an oven dried round-bottom flask compound **5a** (320 mg, 0.553 mmol, 1.0 equiv.) was taken in THF (10 mL) at 25 °C under an argon atmosphere. To this solution KO$^t$Bu (186 mg, 1.659 mmol, 3.0 equiv.) at 0 $^{\upsilon}$C and methyl iodide (0.041 mL, 0.663 mmol, 1.2 equiv.) was added and stirred for an additional 1 h. After completion of the reaction (confirmed by TLC analysis), it was quenched with saturated aqueous $Na_2S_2O_3$ solution (10 mL). The reaction mixture was then extracted with EtOAc (10 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. Next the crude **23** was charged for the next step.

In an oven dried round-bottom flask to a solution of the aldehyde compound **23** (0.553 mmol, 1.00 equiv.) in 10 ml of mixed solvent system of THF: $H_2O$: $^t$BuOH (10:10:1). Next, 2-methyl 2-butene (0.587 mL, 5.530 mmol, 10.0 equiv.) was added. Then a mixture of $NaClO_2$ (0.150 g, 1.659 mmol, 3.00 equiv.) and $KH_2PO_4$ (0.376 g, 2.765 mmol, 5.0 equiv.) at 0 °C. The mixture was warmed to room temperature and stirred for 4 h and 10 ml of water was added. Then it was extracted three times with EtOAc and dried over $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum to afford the corresponding acid compound as colourless foam. The crude product was charged for the next step without further purification.

In an oven-dried round-bottom flask crude acid was taken and dissolved in acetone solvent then $K_2CO_3$ (152 mg, 1.106 mmol, 2.0 equiv.) and $Me_2SO_4$ (0.180 mL, 1.106 mmol, 2.0 equiv.) were added simultaneously and stirred for 1 h at 60 ºC. Finally work up was done by $CH_2Cl_2/H_2O$. The organic filtrate was dried over anhydrous $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum. The crude products were purified by flash chromatography with 20% EtOAc in *n*-hexane to afford compound **24** as yellow gel.



(**24**)

**Methyl** (4*S*,4*aR*,13*bS*)**-4,13*b*-dimethyl-8-tosyl-4,4*a*,5,6,8,13*b*-hexahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carboxylate** [(+)-**24**]: (+)-**24** was obtained as yellow liquid. (0.553 mmol scale; 0.213 g, 75% yield over 3 steps). $R_f = 0.5$ (20% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.24 (dd, $J = 8.4, 0.8$ Hz, 1H), 7.95 (s, 1H), 7.85 – 7.81 (m, 1H), 7.74 (s, 1H), 7.70 (d, $J = 8.3$ Hz, 2H), 7.43 – 7.39 (m, 1H), 7.30 (tt, $J = 7.5, 0.8$ Hz, 1H), 7.25 (d, $J = 0.6$ Hz, 1H), 7.12 – 7.08 (m, 2H), 5.79 – 5.75 (m, 2H), 3.66 (d, $J = 0.6$ Hz, 3H), 3.18 – 3.09 (m, 1H), 3.02 – 2.93 (m, 1H), 2.68 (dd, $J = 17.5, 4.2$ Hz, 1H), 2.37 – 2.28 (m, 1H), 2.26 (s, 3H), 2.19 (d, $J = 17.2$ Hz, 1H), 1.96 (dd, $J = 13.1, 4.8$ Hz, 1H), 1.81 (dd, $J = 12.7, 1.9$ Hz, 1H), 1.41 (s, 3H), 1.20 (s, 3H).

**$^{13}$C {$^1$H} NMR** (101 MHz, $CDCl_3$): δ 176.3, 144.8, 143.3, 138.6, 136.7, 135.8, 135.3, 131.7, 129.7, 127.0, 126.6, 126.6, 124.9, 124.7, 123.8, 119.7, 117.6, 115.1, 114.5, 53.5, 51.8, 50.4, 45.4, 41.2, 37.3, 32.9, 27.8, 24.4, 21.6.

**IR** (neat) $\nu_{max}$ 3135, 2840, 1887, 1692, 1480, 1112, 986 $cm^{-1}$.

**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd. for $[C_{31}H_{31}NO_4S + H]^+$ 514.2052, found: 514.2059.

$[\alpha]^{25}_{589} = +92.6$ ($c = 0.2$, $CHCl_3$).

A plausible mechanism of *α*-methylation of **5a** is depicted in Figure 1. The diastereoselective methylation could undergo *via* two ways (see, Scheme 7 in manuscript). In the path **A**, base could facilitate the -OBn elimination product **21** followed by an abstraction of proton from *γ*-H position (vinylogous position; see, **21**) to form enolate intermediate **21a** which upon methylation afforded **23** as sole diastereomer. Whereas, in path **B**, 2.0 equivalent of bases simultaneously abstract the $\alpha$-H as well as $\gamma$-H leading to the formation of enolate intermediate **21a**. However, the formation of $\alpha,\beta$-unsaturated aldehyde **21** (see, Scheme 6 in manuscript) in case of NaH as a base, probably suggests the pathway **A** is the preferred one.

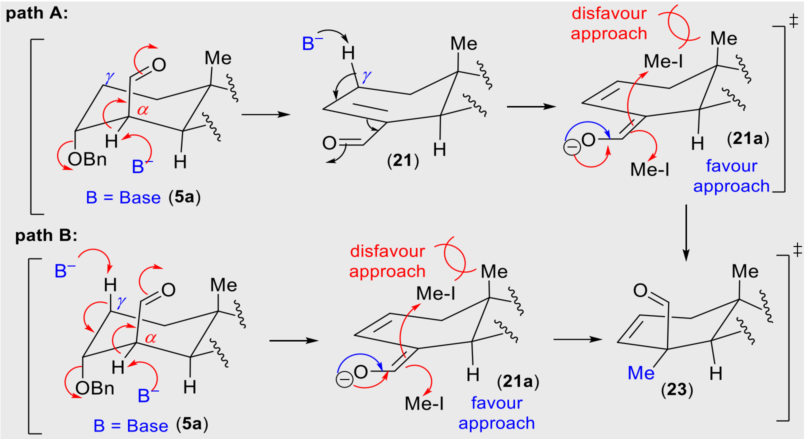
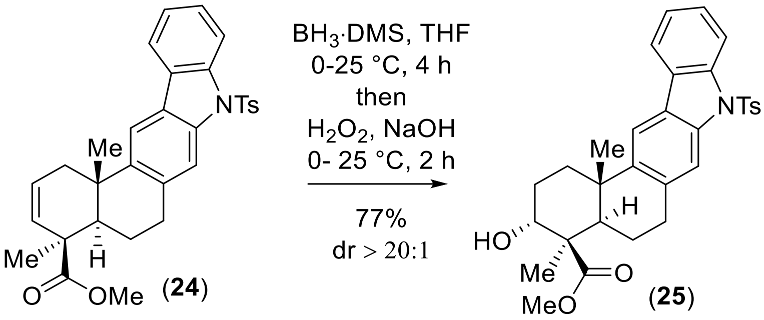
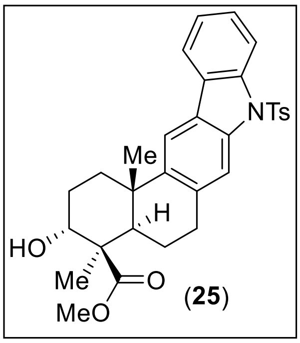


**Fig. 1**. Plausible mechanism of $\alpha$-methylation of **5a**.

### Hydroboration-oxidation of ester (24):



In an oven dried round-bottom flask the ester (**24**, 0.210 g, 0.408 mmol, 1.0 equiv.) was dissolved in anhydrous THF (6 mL). Then $Me_2S.BH_3$ (0.810 mL, 0.765 mmol, 1.0 equiv.) was added dropwise under an $N_2$ atmosphere at 0 °C. The mixture was then stirred at 25 °C for 4 h. Then 4(*M*) NaOH (1 mL), and 30% $H_2O_2$ (1 mL) were added at 0 °C and the mixture was stirred at 25 °C for 2 h. After completion of the reaction (confirmed by TLC analysis), the reaction mixture was then extracted with 40% EtOAc in *n*-hexane (5 mL X 2). The organic layers were collected, dried over $Na_2SO_4$ and concentrated in a rotary evaporator under reduced pressure. It was purified by flash chromatography using 30% EtOAc in *n*-hexane to afford (+)-[**25**] as yellowish foam.



(**25**)

**Methyl (3*R*,4*R*,4*aR*,13*bS*)-3-hydroxy-4,13*b*-dimethyl-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carboxylate** [(+)-**25**]: (+)-**25** was obtained as yellow liquid. (0.408 mmol scale; 0.349 g, 77% yield). $R_f = 0.6$ (40% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.27 (d, *J* = 8.4 Hz, 1H), 7.99 (s, 1H), 7.86 – 7.84 (m, 1H), 7.79 (s, 1H), 7.73 (d, *J* = 1.6 Hz, 1H), 7.71 (s, 1H), 7.45 – 7.43 (m, 1H), 7.35 – 7.32 (m, 1H), 7.14 (s, 1H), 7.13 – 7.12 (m, 1H), 5.17 – 5.12 (m, 1H), 3.73 (s, 4H), 3.56 (t, *J* = 11.3 Hz, 1H), 3.24 – 3.14 (m, 2H), 3.04 (ddd, *J* = 17.5, 12.8, 6.1 Hz, 1H), 2.48 (dt, *J* = 13.2, 3.6 Hz, 1H), 2.30 (s, 3H), 2.05 – 2.01 (m, 3H), 1.70 (s, 2H), 1.56 (s, 3H), 1.15 (s, 3H).

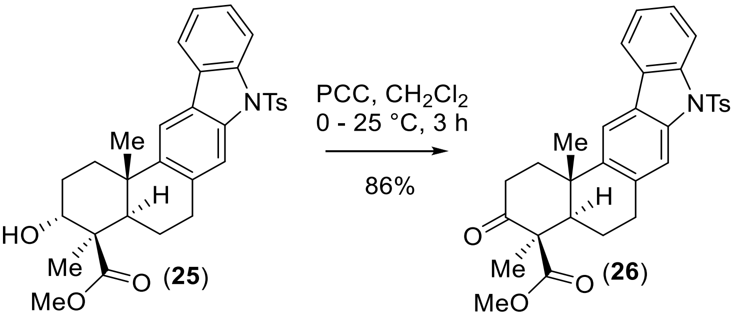
**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 178.5, 144.7, 143.7, 138.5, 136.7, 135.3, 135.2, 129.7, 126.9, 126.6, 126.5, 125.0, 124.7, 123.7, 119.6, 116.9, 115.0, 114.6, 52.4, 51.4, 49.0, 38.6, 38.4, 33.2, 32.2, 31.9, 29.7, 29.7, 29.4, 29.1, 26.4, 23.6, 23.5, 23.4, 22.7, 21.5, 21.2, 14.1.

**IR** (neat) $\nu_{max}$ 3420, 2910, 2840, 1887, 1692, 1480, 1111, 981 $cm^{-1}$.

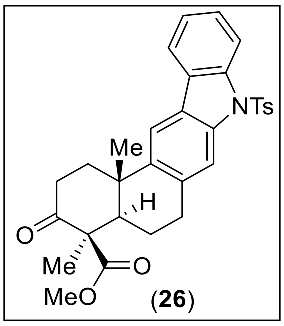
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd. for $[C_{31}H_{33}NO_5S + H]^+$ 532.2158, found: 532.2137.

$[\alpha]^{25}_{589} = +76.22$ (*c* = 0.1, $CHCl_3$).

**PCC-Oxidation of compound 25:**



In an oven dried round-bottom flask the alcohol **25** (190 mg, 0.357 mmol, 1.0 equiv.) was charged in $CH_2Cl_2$ under $N_2$ atmosphere. Pyridinium chlorochromate (92 mg, 0.428 mmol, 1.2 equiv.) was added to the reaction mixture and then it was stirred at 25 ºC for 3 h. After completion of the reaction (monitored by TLC) the crude product was purified by flash chromatography with 20% EtOAc in *n*-hexane to afford **26** as white foam.



(**26**)

**Methyl** (4*R*,4*aR*,13*bS*)**-4,13*b*-dimethyl-3-oxo-8-tosyl-2,3,4,4a,5,6,8,13*b*-octahydro-1*H*-naphtho**[**2,1-*b*]**carbazole-4-carboxylate** [(+)-**26**]: (+)-**26** was obtained as yellow liquid. (0.357 mmol scale; 162 mg, 86% yield). $R_f$ = 0.6 (40% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.24 (dt, *J* = 8.3, 0.8 Hz, 1H), 7.99 (s, 1H), 7.82 (ddd, *J* = 7.7, 1.4, 0.7 Hz, 1H), 7.78 (s, 1H), 7.70 – 7.69 (m, 1H), 7.68 (d, *J* = 1.8 Hz, 1H), 7.45 – 7.40 (m, 1H), 7.33 – 7.29 (m, 1H), 7.12 (dd, *J* = 1.3, 0.7 Hz, 1H), 7.10 (t, *J* = 1.0 Hz, 1H), 3.72 (s, 3H), 3.24 – 3.18 (m, 1H), 3.14 (dd, *J* = 14.8, 6.2 Hz, 1H), 3.04 (dt, *J* = 17.7, 9.6 Hz, 1H), 2.70 (ddd, *J* = 13.2, 6.2, 2.5 Hz, 1H), 2.63 – 2.57 (m, 1H), 2.27 (s, 3H), 2.24 – 2.21 (m, 1H), 1.89 – 1.82 (m, 2H), 1.48 (s, 3H), 1.37 (s, 3H).

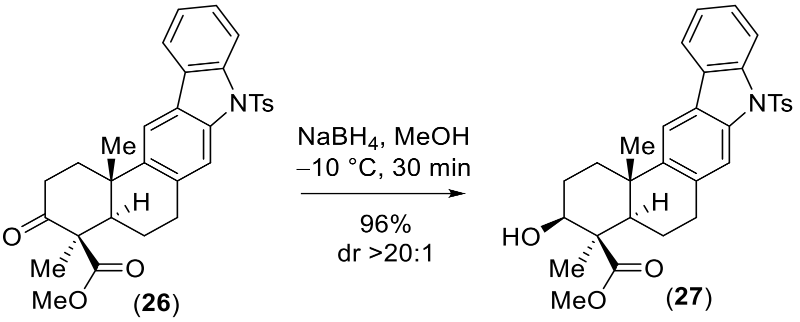
**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 207.8, 174.0, 144.8, 142.4, 138.6, 137.0, 135.2, 129.7, 127.1, 126.5, 126.4, 124.8, 123.8, 119.6, 116.6, 115.0, 114.8, 57.5, 53.9, 52.2, 39.5, 38.3, 37.4, 32.7, 29.7, 23.2, 21.5, 20.9.

**IR** (neat) $\upsilon_{max}$ 2931, 2866, 1716, 1680, 1602, 1455, 1243, 915, 788, 541 $cm^{-1}$.

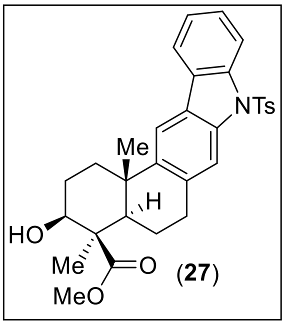
**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd for $[C_{31}H_{31}NO_5S + H]^+$ 530.2001, found: 530.2010.

$[\alpha]^{25}_{589}$ = +36.0 (*c* = 0.1, $CHCl_3$).

**NaBH4 Reduction of compound 26:**



In an oven dried round-bottom flask the keto compound **26** (156 mg, 0.295 mmol, 1.0 equiv.) was taken in MeOH (2 mL). Next, $NaBH_4$ (12 mg, 0.295 mmol, 1.0 equiv.) was added at −10 °C and stirred for 30 min. After completion of the reaction (monitored by TLC), the reaction was quenched with saturated aqueous $NH_4Cl$ (3 mL) and the aqueous mixture was extracted with EtOAc and water. The aqueous layer was then extracted three times with EtOAc and dried over $Na_2SO_4$ and concentrated in a rotary evaporator under vacuum. The crude product was purified by column chromatography with 40% EtOAc in *n*-hexane to afford **27** as colorless liquid.



**Methyl** (3*S*,4*R*,4*aR*,13*bS*)**-3-hydroxy-4,13*b*-dimethyl-8-tosyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*]carbazole-4-carboxylate** [(+)-**27**]: (+)-**27** was obtained as yellow liquid. (0.295 mmol scale, 150 mg, 96% yield). $R_f = 0.6$ (40% EtOAc in *n*-hexane).

**$^1$H NMR** (400 MHz, $CDCl_3$): δ 8.23 (d, $J = 8.4$ Hz, 1H), 7.96 (s, 1H), 7.81 (ddd, $J = 7.7$, 1.3, 0.7 Hz, 1H), 7.76 (s, 1H), 7.69 (d, $J = 1.9$ Hz, 1H), 7.68 (d, $J = 2.2$ Hz, 1H), 7.43 – 7.39 (m, 1H), 7.32 – 7.28 (m, 1H), 7.11 (dd, $J = 1.9$, 1.1 Hz, 1H), 7.09 (d, $J = 0.8$ Hz, 1H), 3.70 (s, 3H), 3.52 (d, $J = 11.2$ Hz, 1H), 3.18 (d, $J = 6.1$ Hz, 1H), 3.15 – 3.12 (m, 1H), 3.05 – 2.95 (m, 1H), 2.44 (dt, $J = 13.3$, 3.6 Hz, 1H), 2.26 (s, 3H), 2.24 – 2.20 (m, 1H), 2.02 (d, $J = 3.3$ Hz, 1H), 1.58 (s, 2H), 1.52 (s, 3H), 1.50 (d, $J = 1.8$ Hz, 1H), 1.11 (s, 3H).

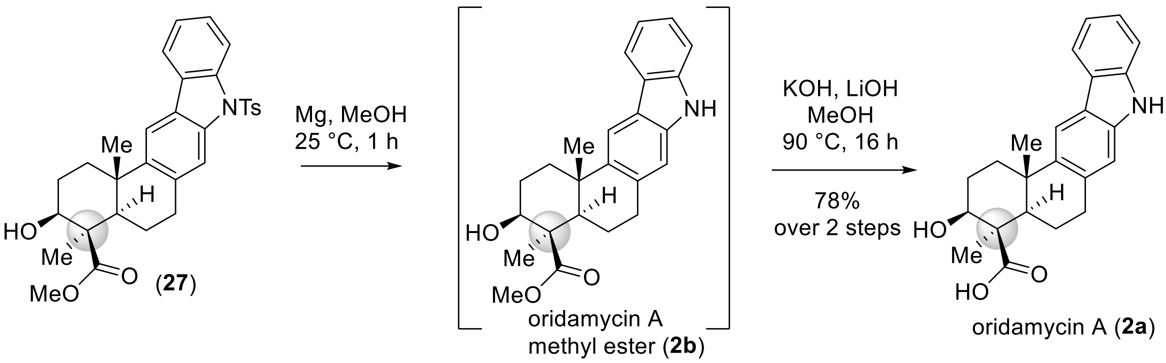
**$^{13}$C {$^1$H} NMR** (126 MHz, $CDCl_3$): δ 178.5, 144.7, 143.7, 138.5, 136.7, 135.3, 135.2, 129.7, 126.9, 126.5, 124.7, 123.7, 119.6, 116.9, 115.0, 114.6, 78.1, 52.4, 51.4, 49.0, 38.6, 38.5, 33.17, 29.3, 29.1, 23.6, 23.5, 21.5.

**IR** (neat) $\nu_{max}$ 3410, 2920, 2840, 1887, 1692, 1480, 1121, 982 $cm^{-1}$.

**HRMS** (ESI) *m/z*: $[M + H]^+$ calcd. for $[C_{31}H_{33}NO_5S + H]^+$ 532.2158, found: 532.2156.

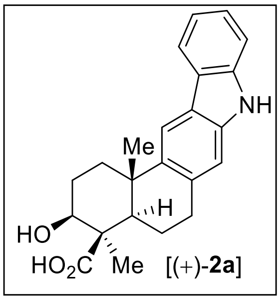
$[\alpha]^{25}_{589} = +54.20$ ($c = 0.1$, $CHCl_3$).

**Total synthesis of Oridamycin A (2a):**



In an oven-dried round-bottom flask, the compound **27** (60 mg, 0.113 mmol, 1.0 equiv.) was taken in MeOH (4 mL). Then Mg (14 mg, 0.565 mmol, 5.0 equiv.) was added and the reaction mixture was sonicated at 25 ºC temperature for 1 h. After complete consumption of starting material (monitored by TLC analysis), it was quenched with saturated $NH_4Cl$ (2 mL) and extracted with EtOAc (4 mL X 2). The organic layers were dried over $Na_2SO_4$ and concentrated on a rotary evaporator under reduced pressure. The combined organic layers were collected, dried over $Na_2SO_4$, and concentrated under reduced pressure. The crude product was charged for the next steps.

In an oven dried round-bottom flask, crude **2b** (0.113 mmol, 1.0 equiv.) was taken in methanol (3 mL) at 25 °C. Next, KOH (63 mg, 1.128 mmol, 10.0 equiv.) and LiOH (27 mg, 1.128 mmol, 10.0 equiv.) were added sequentially and the reaction mixture was refluxed at 80 ºC. After 16 h the reaction mixture was quenched with 2(*N*) HCl at 0 ºC and the *pH* of the reaction mixture was adjusted to 2. Then the reaction mixture was extracted with EtOAc (5 mL X 2). The combined organic layers were collected, dried over $Na_2SO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography with 60% EtOAc in *n*-hexane to afford **2a** as colorless liquid.



**(3*S*,4*R*,4a*R*,13b*S*)-3-hydroxy-4,13*b*-dimethyl-2,3,4,4*a*,5,6,8,13*b*-octahydro-1*H*-naphtho[2,1-*b*] carbazole-4-carboxylic acid** [(+)-**2a**]**:** Oridamycin A [(+)-**2a**] was obtained as white foam (0.113 mmol, 32 mg, 78% yield over 2 steps). $R_f$ = 0.20 (70% EtOAc in *n*-hexane).

**$^1$H NMR** (500 MHz, $CD_3OD$): δ 7.97 (d, *J* = 8.3 Hz, 2H), 7.37 (d, *J* = 8.2 Hz, 1H), 7.30 (d, *J* = 7.7 Hz, 1H), 7.11 (d, *J* = 7.4 Hz, 1H), 7.08 (s, 1H), 3.26 (dd, *J* = 12.2, 4.7 Hz, 1H), 3.09 (dd, *J* = 16.6, 5.2 Hz, 1H), 2.97 (ddd, *J* = 16.8, 12.4, 6.2 Hz, 1H), 2.62 – 2.57 (m, 1H), 2.44 (dt, *J* = 14.6, 5.4 Hz, 1H), 2.34 – 2.29 (m, 1H), 2.26 – 2.22 (m, 1H), 1.96 – 1.92 (m, 1H), 1.60 (d, *J* = 4.0 Hz, 1H), 1.53 (s, 1H), 1.51 (s, 3H), 1.29 (s, 3H).

**$^{13}$C {$^1$H} NMR** (126 MHz, $CD_3OD$): δ 180.1, 142.0, 140.3, 140.1, 134.4, 126.0, 124.5, 123.2, 120.5, 119.3, 117.4, 111.4, 110.6, 79.0, 54.0, 49.8, 40.0, 39.6, 34.0, 30.2, 24.7, 24.5, 22.4.

**IR** (neat) $\upsilon_{max}$ 3368, 2939, 2216, 1655, 1439, 1033, 931, 870 cm$^{-1}$.

**HRMS** (ESI) *m/z*: $[M + H]^+$calcd for $[C_{23}H_{25}O_3N + H]^+$ 364.1913, found: 364.1900.

$[\alpha]^{20}_{589}$ = +67.3 (*c* = 0.2, MeOH); Isolation $[\alpha]^{22.4}_{D}$ = +73.3 (c = 0.07, MeOH)[2]

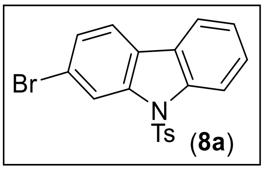
**Comparison of $^1$H-NMR Data** of oridamycin A [(+)-**2a**] of this report with natural [(+)-**2a**] by Takada[2]:

| Takada's isolation report of oridamycin A [(+)-**2a**] ($^1$H-NMR, 3**00** MHz, CD$_3$OD) [2] | This report of oridamycin A [(+)-**2a**] ($^1$H-NMR, 500 MHz, CD$_3$OD) |
|---|---|
| 7.93 (d, *J* = 8.0 Hz, 1H) | 7.97 (d, *J* = 8.3 Hz, 2H) |
| 7.93 (s, 1H) | |
| 7.32 (d, *J* = 8.0 Hz, 1H) | 7.37 (d, *J* = 8.2 Hz, 1H) |
| 7.25 (dt, *J* = 8.1, 1.4 Hz, 1H) | 7.30 (d, *J* = 7.7 Hz, 1H) |
| 7.05 (dt, *J* = 8.1, 1.4 Hz, 1H) | 7.11 (d, *J* = 7.4 Hz, 1H) |
| 7.03 (s, 1H) | 7.08 (s, 1H) |
| 3.22 (dd, *J* = 12.2, 4.6 Hz, 1H) | 3.26 (dd, *J* = 12.2, 4.7 Hz, 1H) |
| 3.06 (ddd, *J* = 16.3, 5.4, 2.3 Hz, 1H) | 3.09 (dd, *J* = 16.6, 5.2 Hz, 1H) |
| 2.94 (ddd, *J* = 16.3, 5.4, 2.3 Hz, 1H) | 2.97 (ddd, *J* = 16.8, 12.4, 6.2 Hz, 1H) |
| 2.57 (dt, *J* = 13.6, 3.6 Hz, 1H) | 2.62 – 2.57 (m, 1H) |
| 2.30 (dq, *J* = 12.6, 2.3 Hz, 1H) | 2.44 (dt, *J* = 14.6, 5.4 Hz, 1H) |
| 2.23 (m, 1H) | 2.34 – 2.29 (m, 1H) |
| 2.09 (dt, *J* = 12.7, 5.4 Hz, 1H) | 2.26 – 2.22 (m, 1H) |
| 1.90 (qd, *J* = 13.6, 3.6 Hz ,1H) | 1.96 – 1.92 (m, 1H) |
| 1.58 (dt, *J* = 13.6, 4.1 Hz, 1H) | 1.60 (d, *J* = 4.0 Hz, 1H), |
| 1.56 (m, 1H) | 1.53 (s, 1H) |
| 1.48 (s, 3H) | 1.51 (s, 3H) |
| 1.26 (s, 3H) | 1.29 (s, 3H) |

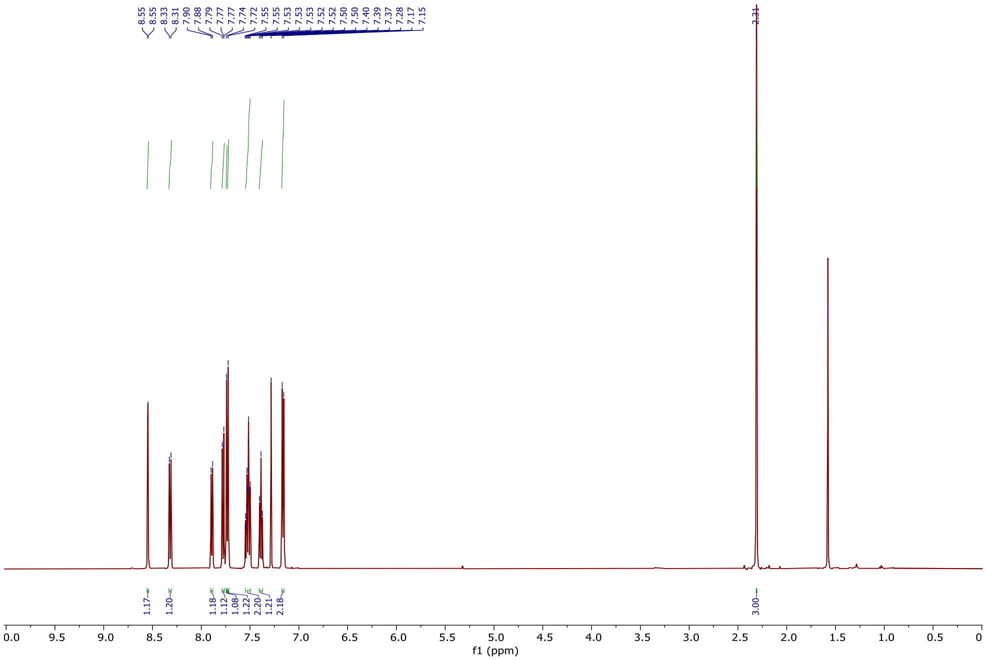
**Comparison of $^{1}$H-NMR Data** of oridamycin A [(+)-**2a**] of this report with natural [(+)-**2a**] by Takada:[2]

| Takada's Isolation of oridamycin A [(+)-**2a**] ($^{13}$C-NMR, 151 MHz, $CD_3OD$)[2] | This Synthesis: oridamycin A [(+)-**2a**] ($^{13}$C-NMR, 126 MHz, $CD_3OD$) |
|---|---|
| 181.0 | 180.1 |
| 142.0 | 142.0 |
| 140.3 | 140.3 |
| 140.1 | 140.0 |
| 134.5 | 134.4 |
| 126.1 | 126.0 |
| 124.6 | 124.5 |
| 123.2 | 123.2 |
| 120.5 | 120.5 |
| 119.3 | 119.2 |
| 117.5 | 117.5 |
| 111.4 | 111.4 |
| 110.7 | 110.7 |
| 79.1 | 79.0 |
| 54.1 | 54.0 |
| 49.8 | 49.8 |
| 40.0 | 40.0 |
| 39.6 | 39.6 |
| 34.0 | 34.0 |
| 30.3 | 30.2 |
| 24.8 | 24.7 |
| 24.6 | 24.5 |
| 22.5 | 22.4 |

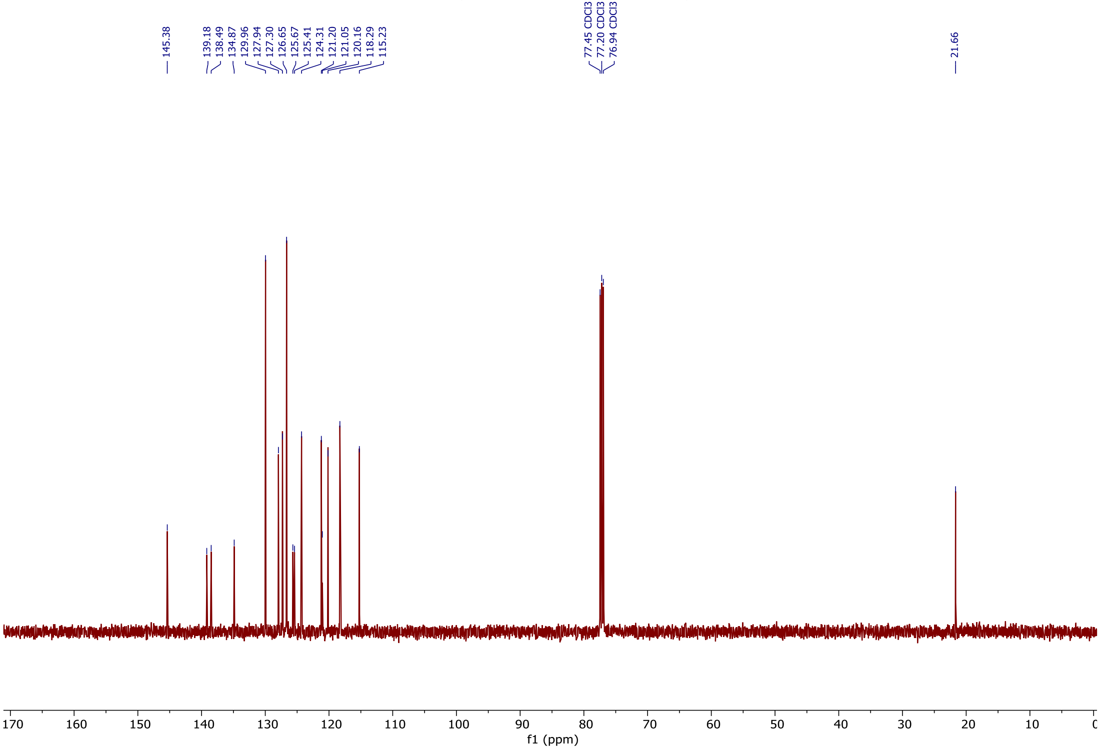
# Spectral Data



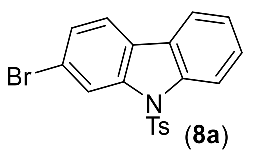
(**8a**)



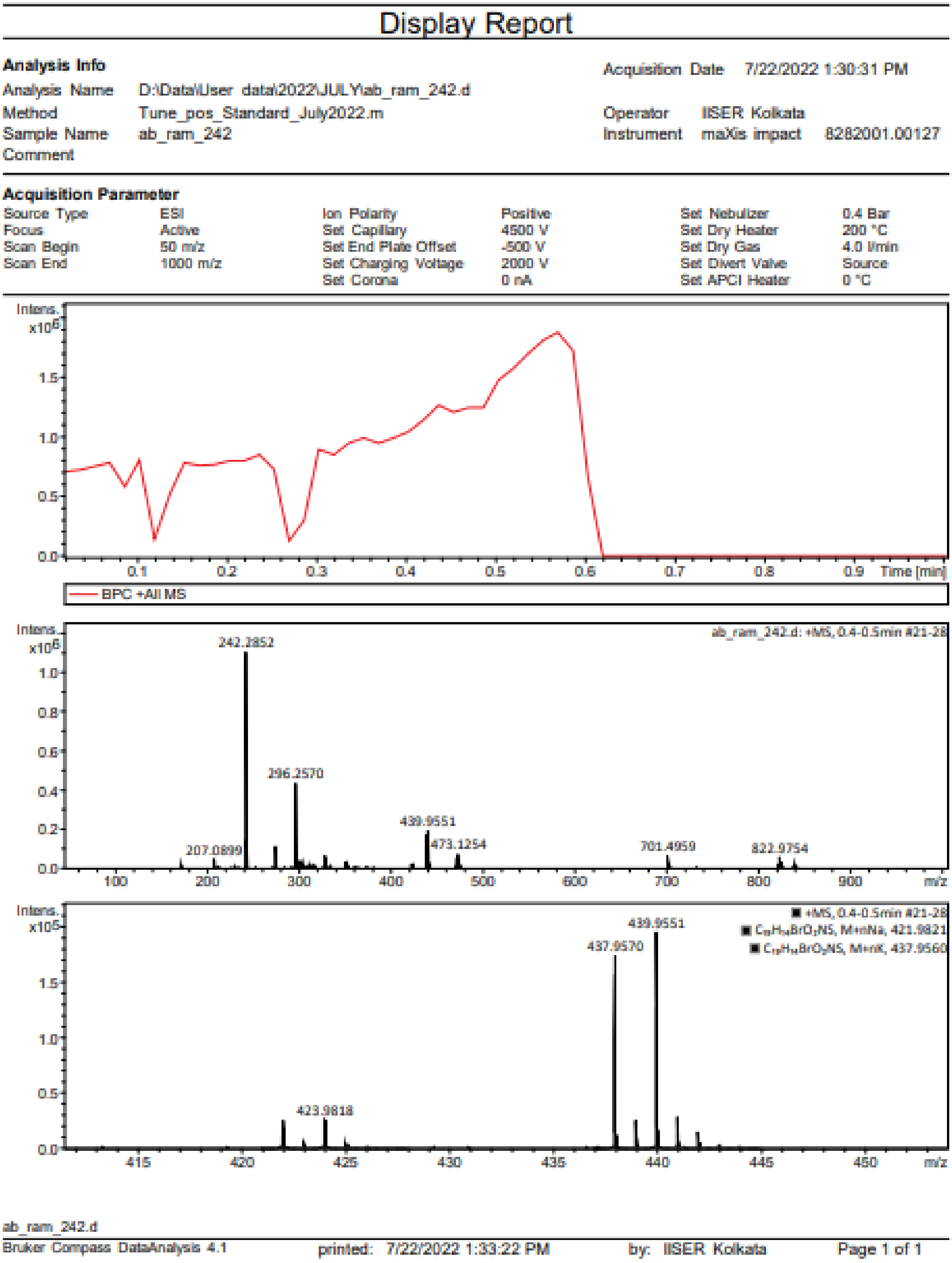
$^1$H NMR (500 MHz, $CDCl_3$) of **8a**



$^{13}$C {$^1$H} NMR (125 MHz, $CDCl_3$) of **8a**



(8a)



# Display Report

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Method Tune_pos_Standard_July2022.m
Sample Name ab_ram_242
Comment

Acquisition Date 7/22/2022 1:30:31 PM

Operator IISER Kolkata
Instrument maXis impact 8282001.00127

**Acquisition Parameter**

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|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
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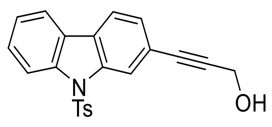
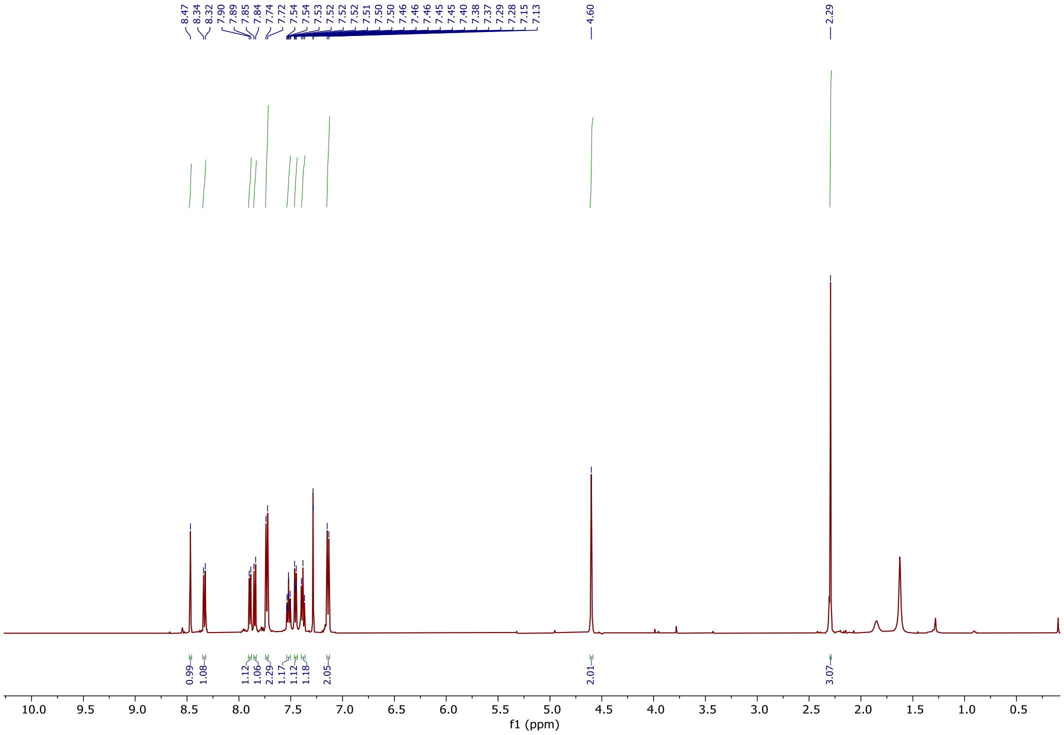
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |

ab_ram_242.d
Bruker Compass DataAnalysis 4.1 printed: 7/22/2022 1:33:22 PM by: IISER Kolkata Page 1 of 1

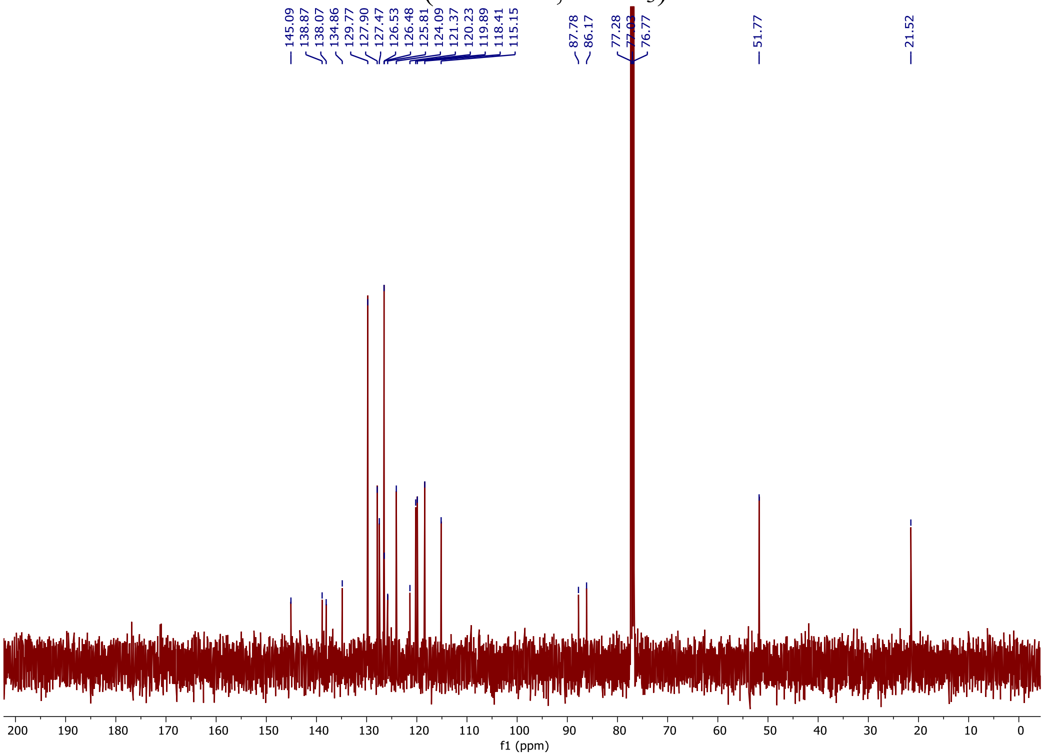
HRMS data of **8a**



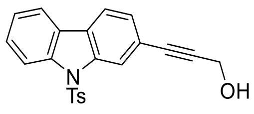
(**8b**)



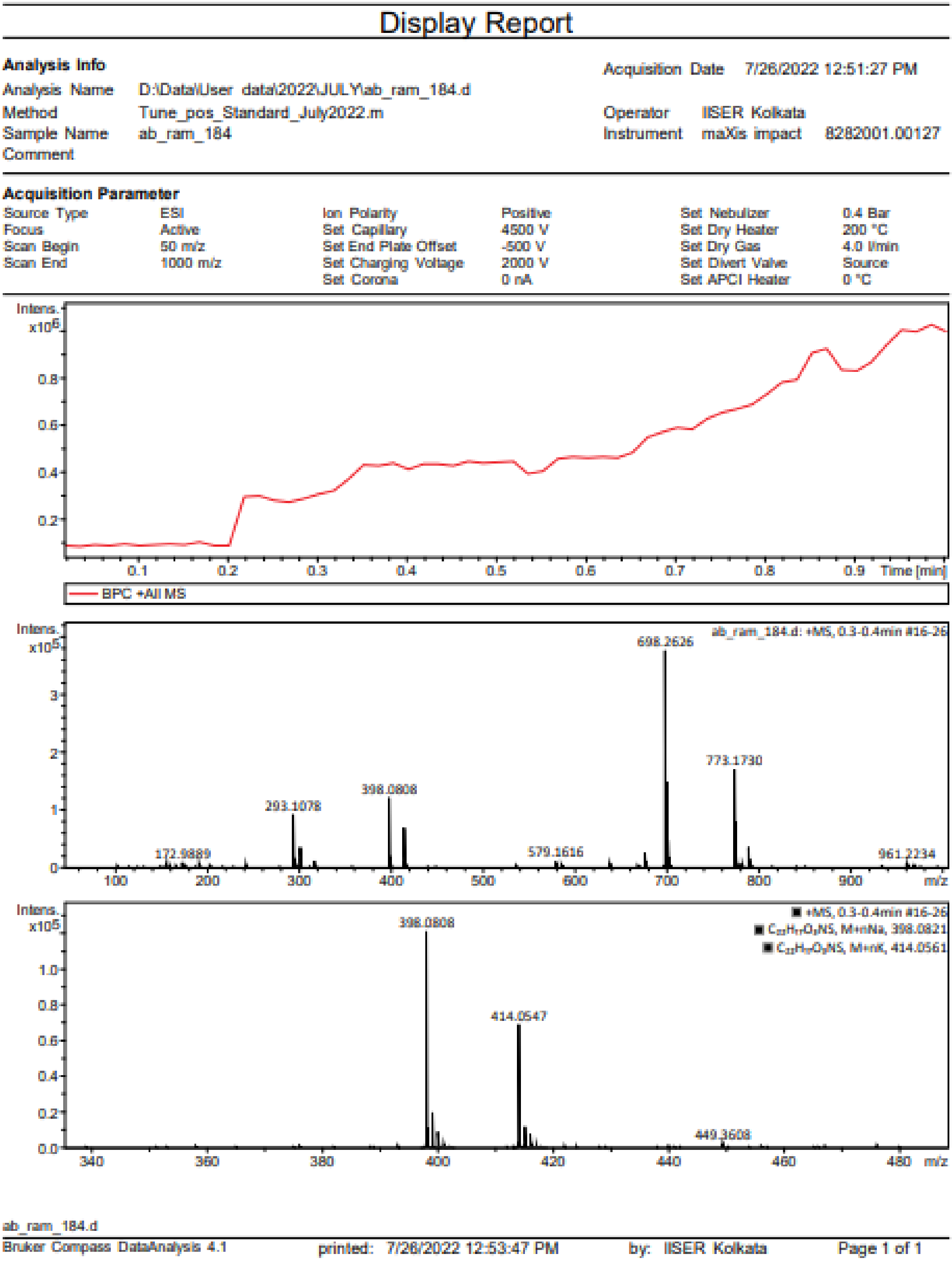
$^{1}$H NMR (500 MHz, CDCl$_3$) of **8b**



$^{13}$C {$^{1}$H} NMR (125 MHz, CDCl$_3$) of **8b**



(**8b**)



Display Report

**Analysis Info**

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Method Tune_pos_Standard_July2022.m
Sample Name ab_ram_184
Comment

Acquisition Date 7/26/2022 12:51:27 PM
Operator IISER Kolkata
Instrument maXis impact 8282001.00127

**Acquisition Parameter**

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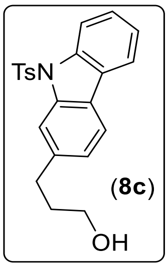
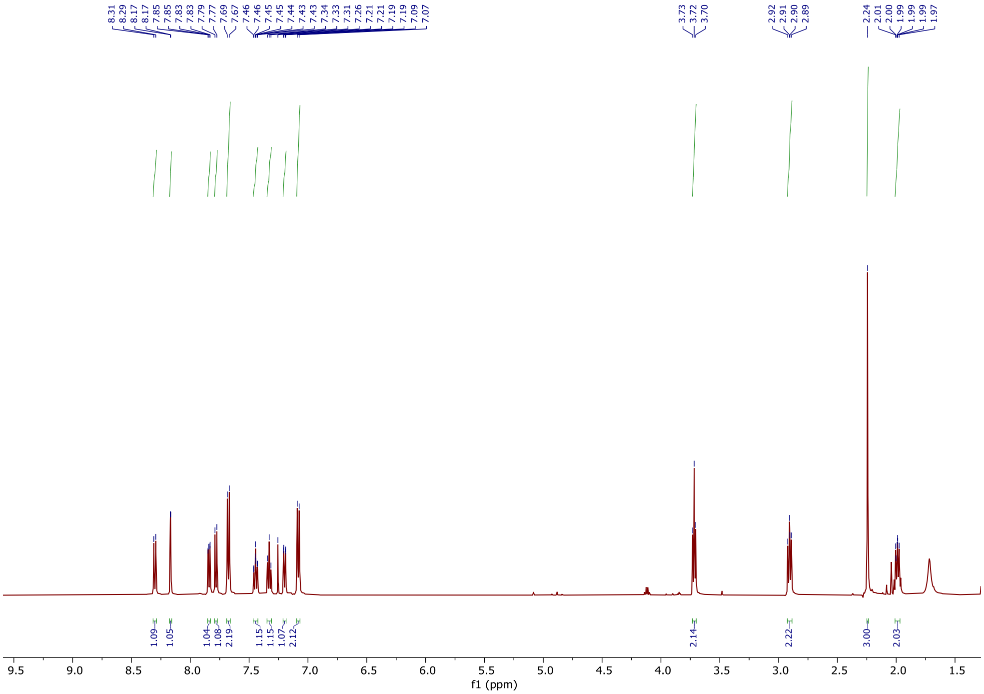
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |

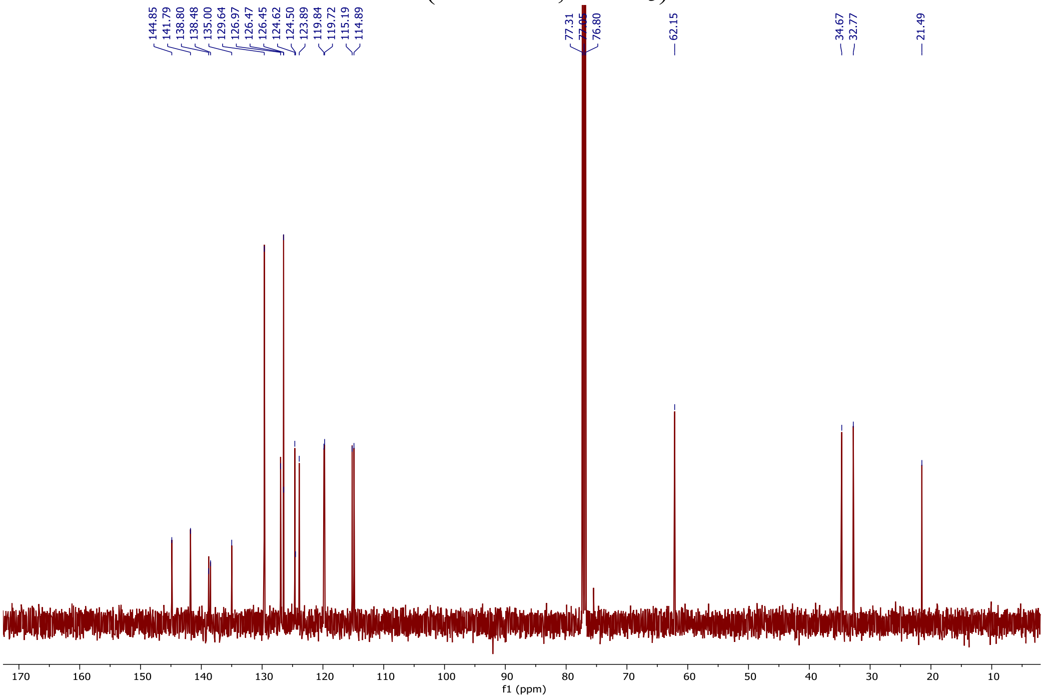
ab_ram_184.d
Bruker Compass DataAnalysis 4.1 printed: 7/26/2022 12:53:47 PM by: IISER Kolkata Page 1 of 1

HRMS data of **8b**

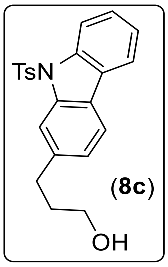




$^1$H NMR (500 MHz, CDCl$_3$) of **8c**



$^{13}$C {$^1$H} NMR (125 MHz, CDCl$_3$) of **8c**



(**8c**)

## Display Report

**Analysis Info**

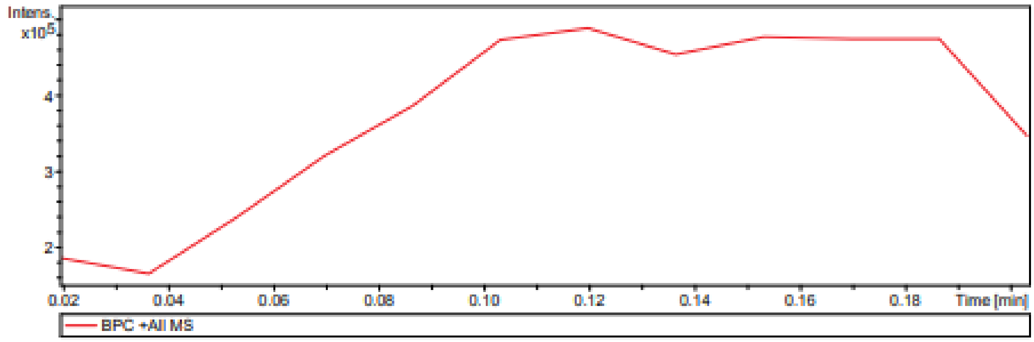
Acquisition Date 8/8/2022 7:19:31 PM

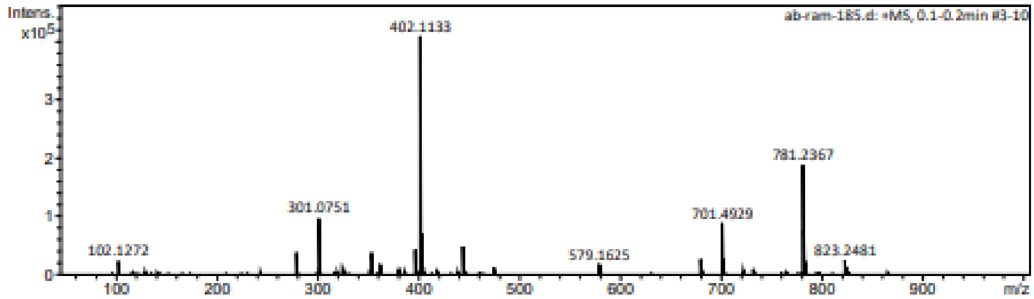
Analysis Name D:\Data\User data\2022\AUGUST\ab-ram-185.d
Method Tune_pos_Standard_July2022.m
Sample Name ab-ram-185
Comment

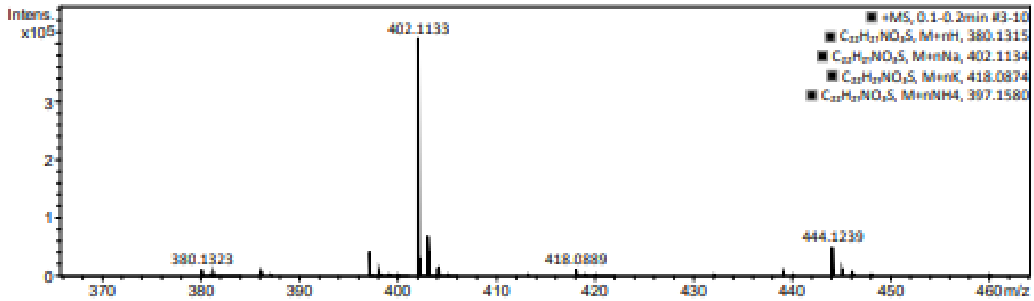
Operator IISER Kolkata
Instrument maXis impact 8282001.00127

**Acquisition Parameter**

| | | | | | |
|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |



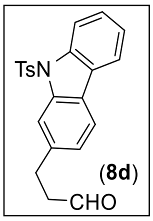


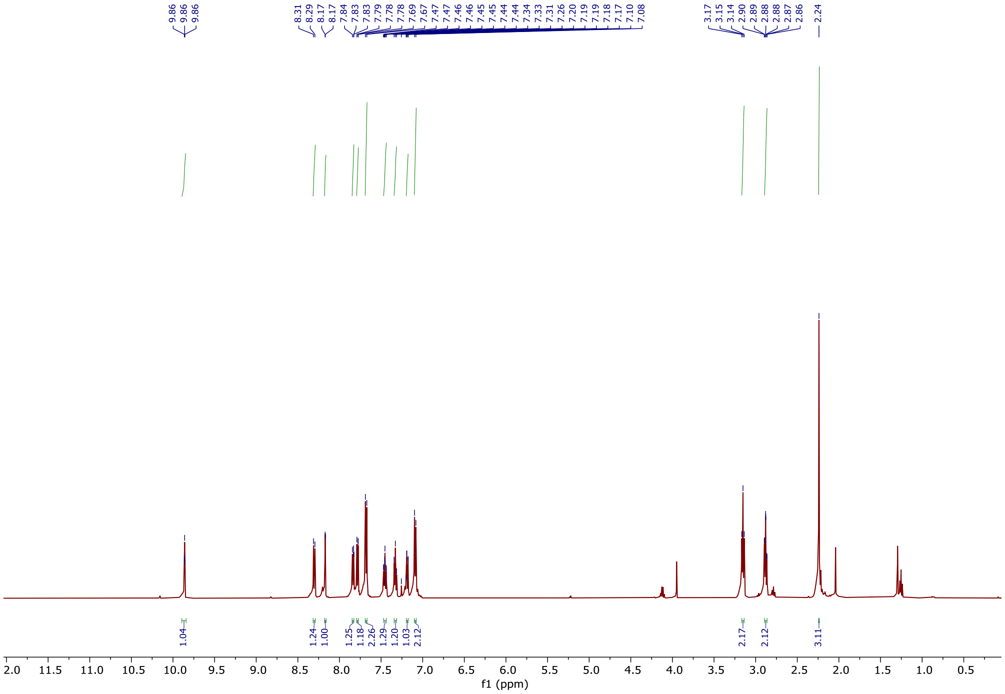


■ +MS, 0.1-0.2min #3-10
■ $C_{22}H_{21}NO_3S$, M+nH, 380.1315
■ $C_{22}H_{21}NO_3S$, M+nNa, 402.1134
■ $C_{22}H_{21}NO_3S$, M+nK, 418.0874
■ $C_{22}H_{21}NO_3S$, M+nNH4, 397.1580

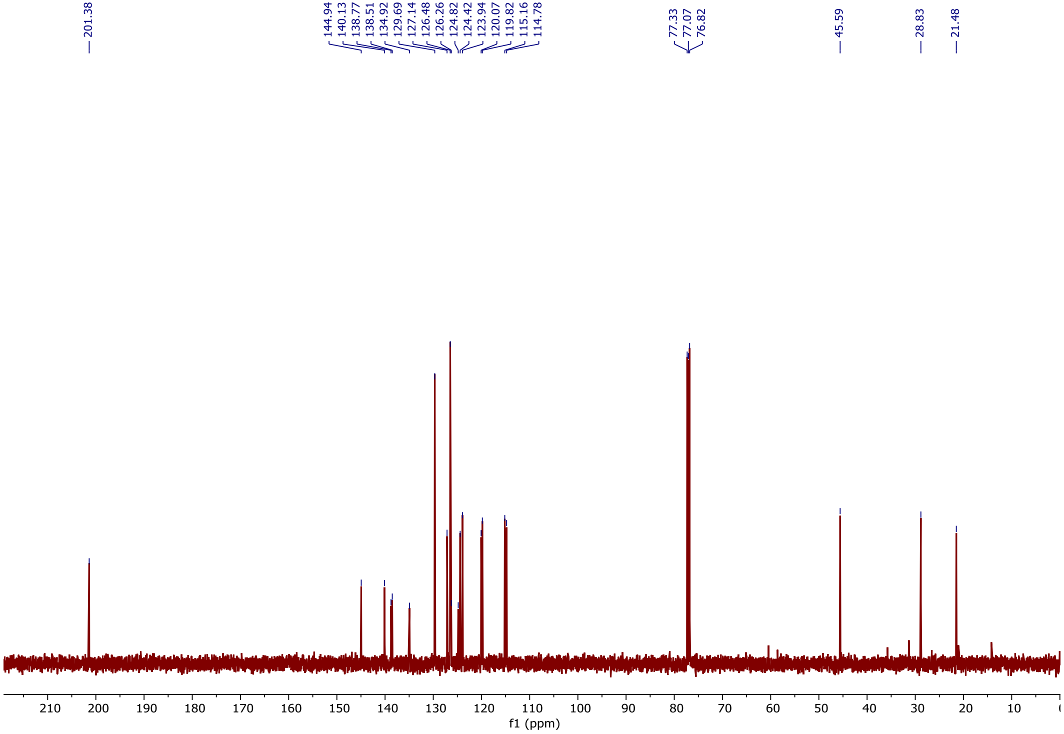
ab-ram-185.d
Bruker Compass DataAnalysis 4.1 printed: 8/8/2022 7:22:17 PM by: IISER Kolkata Page 1 of 1

HRMS data of **8c**

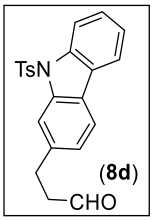




$^1$H NMR (500 MHz, CDCl$_3$) of **8d**



$^{13}$C {$^1$H} NMR (125 MHz, CDCl$_3$) of **8d**



(**8d**)

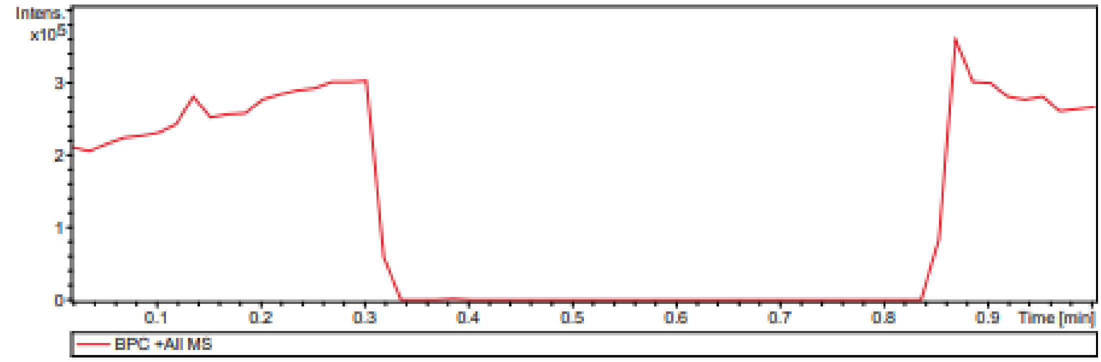
# Display Report

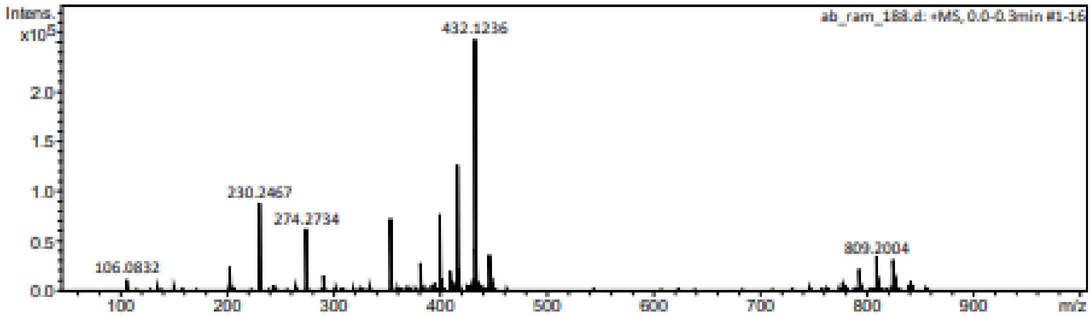
**Analysis Info**

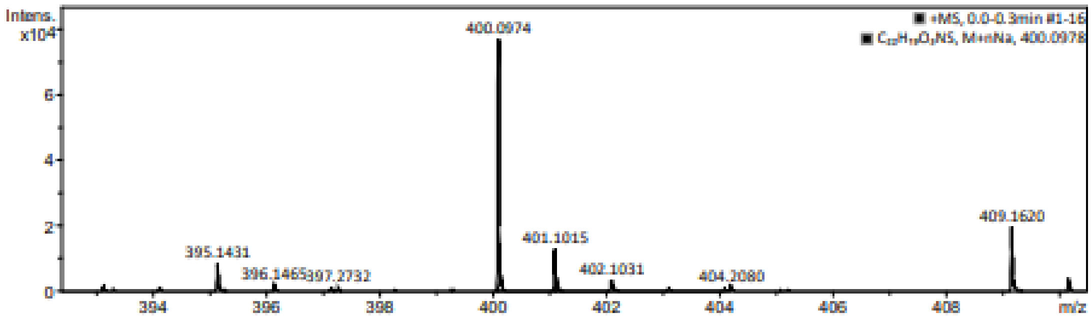
| | | | |
|---|---|---|---|
| Analysis Name | D:\Data\User data\2022\AUGUST\ab_ram_188.d | Acquisition Date | 8/8/2022 12:16:45 PM |
| Method | Tune_pos_Standard_July2022.m | Operator | IISER Kolkata |
| Sample Name | ab_ram_188 | Instrument | maXis impact 8282001.00127 |
| Comment | | | |

**Acquisition Parameter**

| | | | | | |
|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |



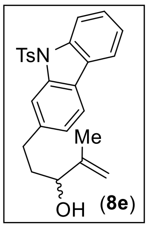




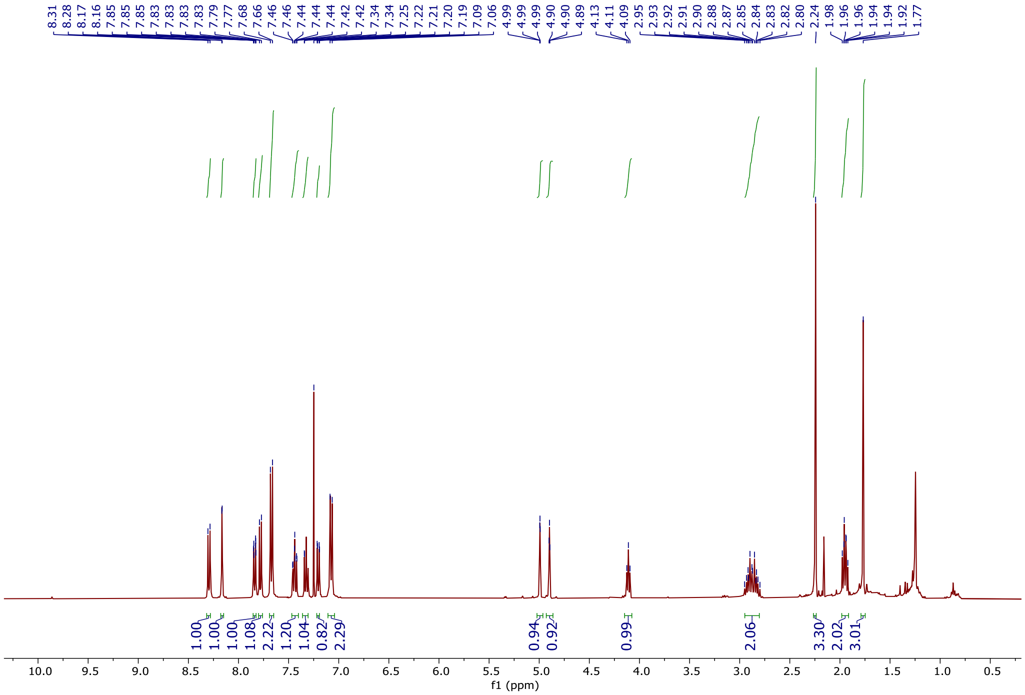
ab_ram_188.d

Bruker Compass DataAnalysis 4.1 printed: 8/8/2022 12:21:07 PM by: IISER Kolkata Page 1 of 1

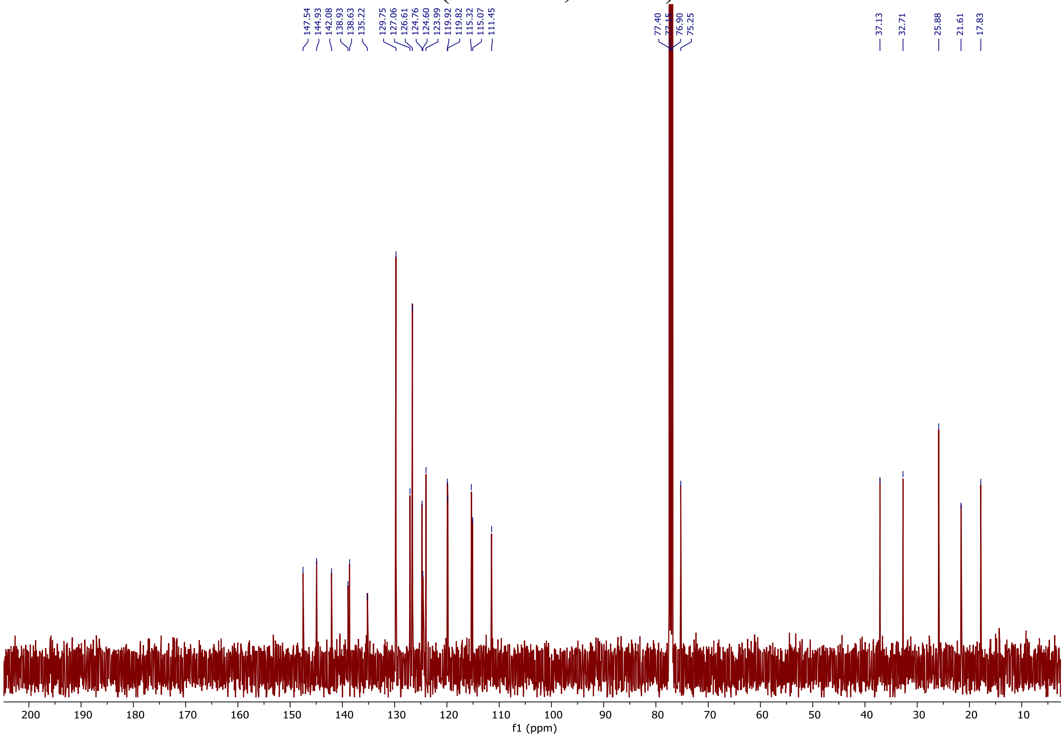
HRMS data of **8d**



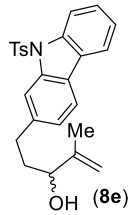
(**8e**)



$^{1}$H NMR (400MHz, $CDCl_3$) of **8e**



$^{13}$C {$^{1}$H} NMR (125 MHz, $CDCl_3$) of **8e**



(**8e**)

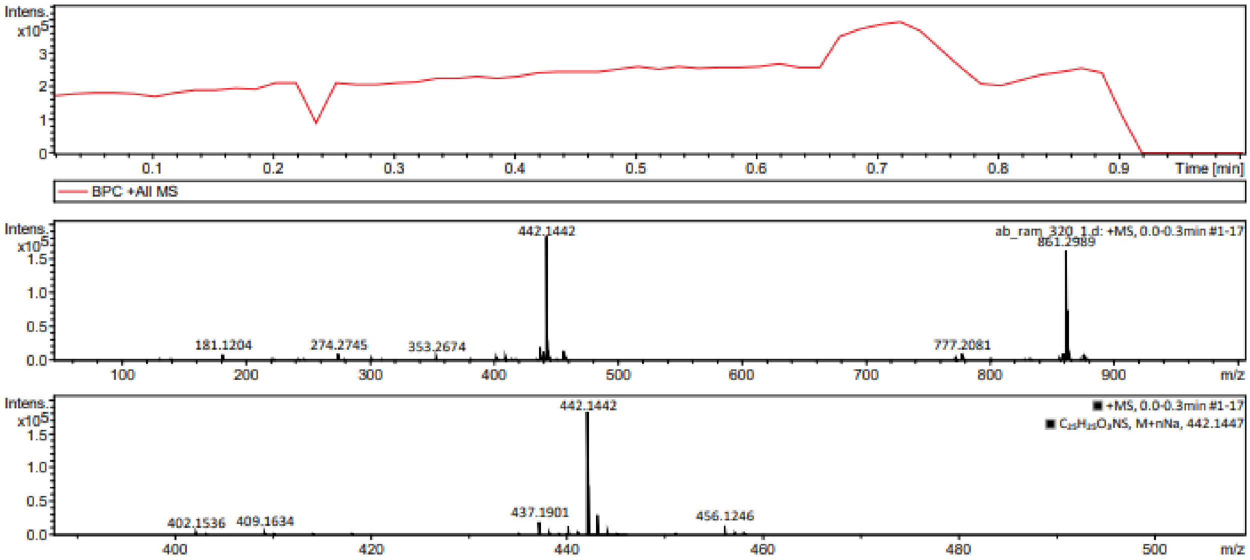
# Display Report

**Analysis Info**

| | | | |
|---|---|---|---|
| Analysis Name | D:\Data\User data\2022\SEPT\ab_ram_320_1.d | Acquisition Date | 9/21/2022 10:23:22 AM |
| Method | Tune_pos_Standard_July2022.m | Operator | IISER Kolkata |
| Sample Name | ab_ram_320_1 | Instrument | maXis impact 8282001.00127 |
| Comment | | | |

**Acquisition Parameter**

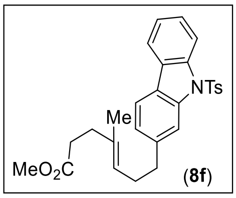
| | | | | | |
|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |



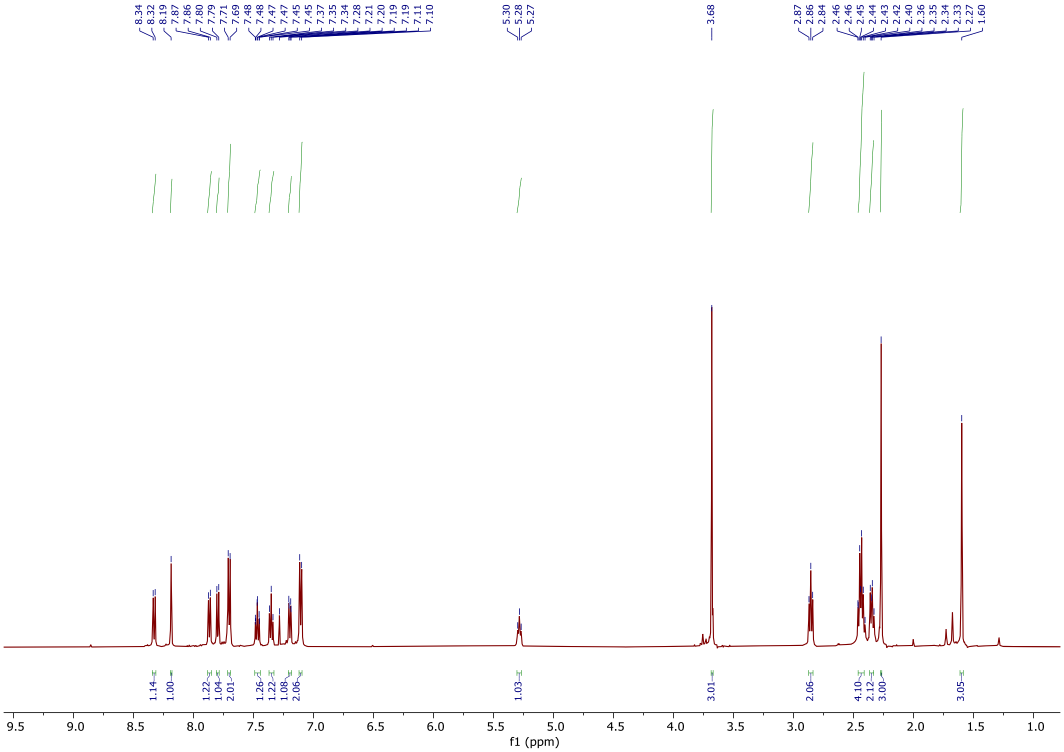
ab_ram_320_1.d

Bruker Compass DataAnalysis 4.1 printed: 9/21/2022 10:25:20 AM by: IISER Kolkata Page 1 of 1

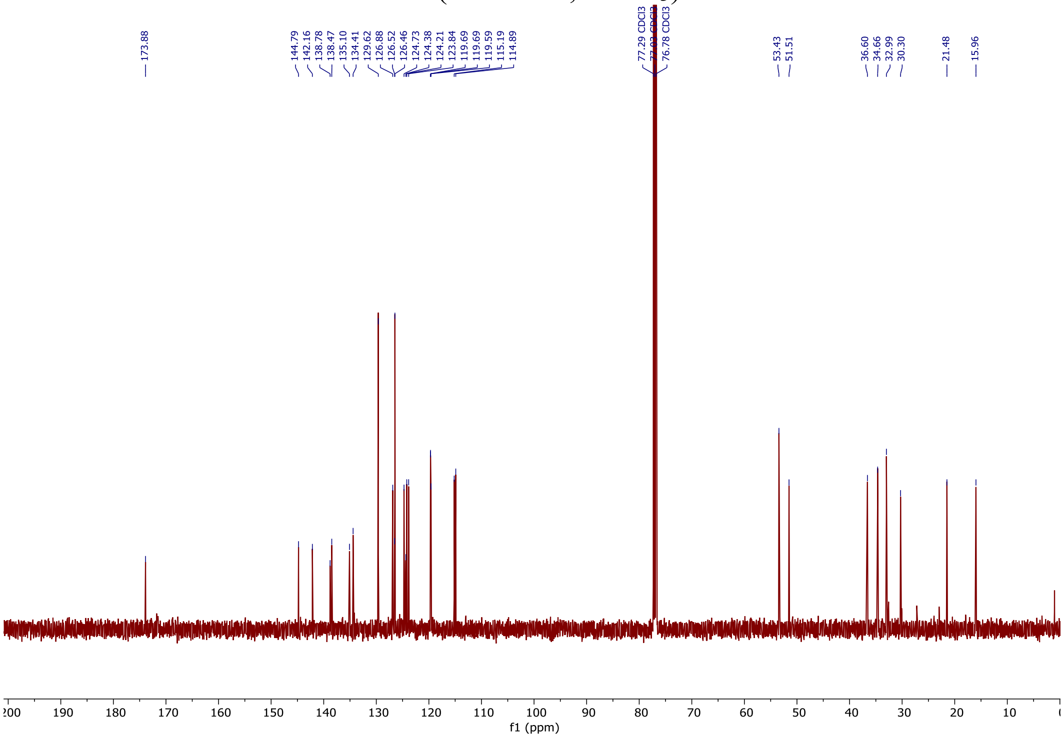
HRMS data of **8e**



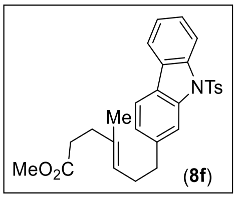
(**8f**)



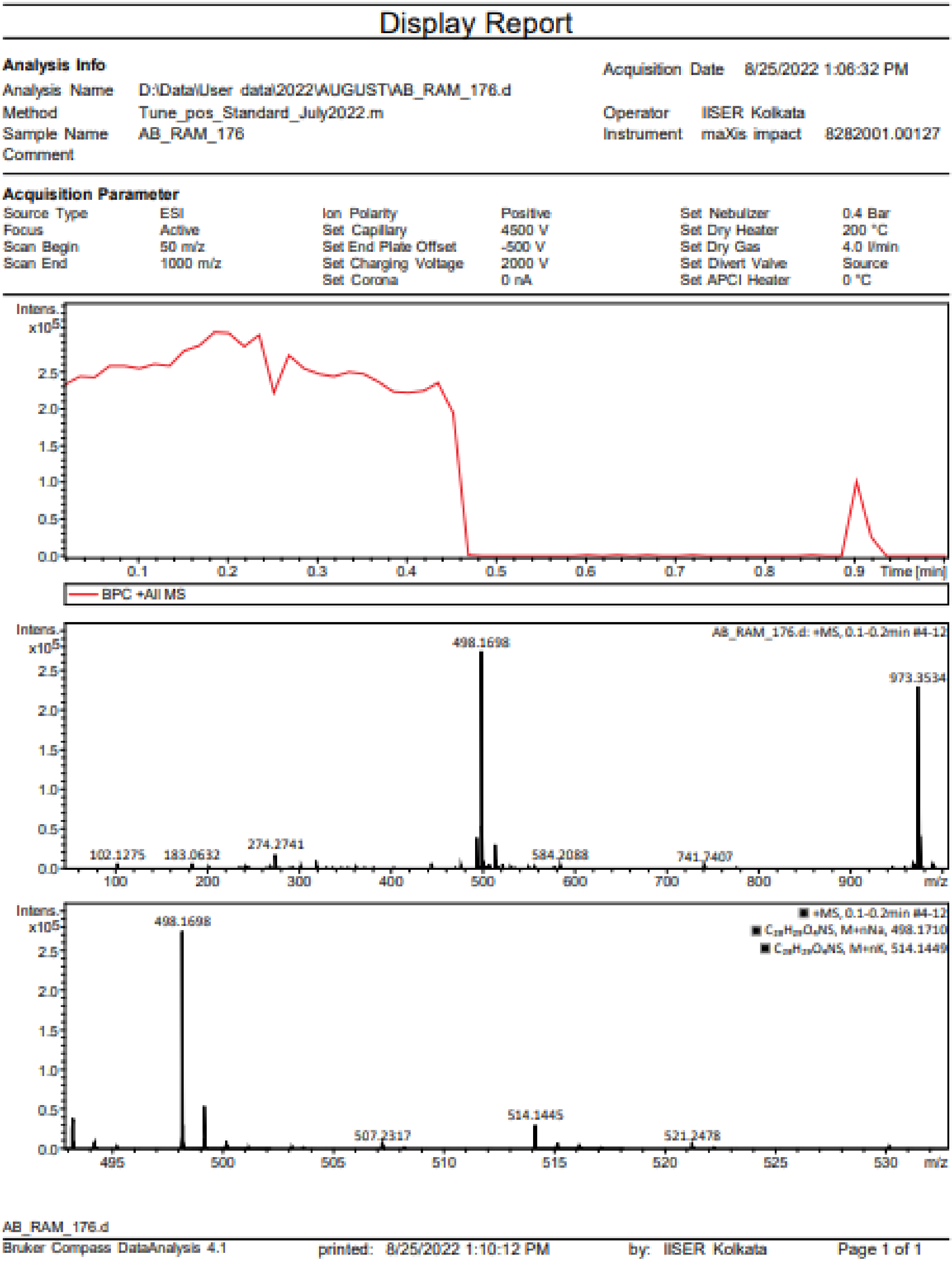
$^1$H NMR (500 MHz, CDCl$_3$) of **8f**



$^{13}$C {$^1$H} NMR (125 MHz, CDCl$_3$) of **8f**



(8f)



# Display Report

**Analysis Info**

| | | | |
|---|---|---|---|
| Analysis Name | D:\Data\User data\2022\AUGUST\AB_RAM_176.d | Acquisition Date | 8/25/2022 1:06:32 PM |
| Method | Tune_pos_Standard_July2022.m | Operator | IISER Kolkata |
| Sample Name | AB_RAM_176 | Instrument | maXis impact 8282001.00127 |
| Comment | | | |

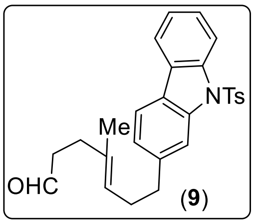
**Acquisition Parameter**

| | | | | | |
|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |

AB_RAM_176.d

Bruker Compass DataAnalysis 4.1 printed: 8/25/2022 1:10:12 PM by: IISER Kolkata Page 1 of 1

HRMS data of **8f**



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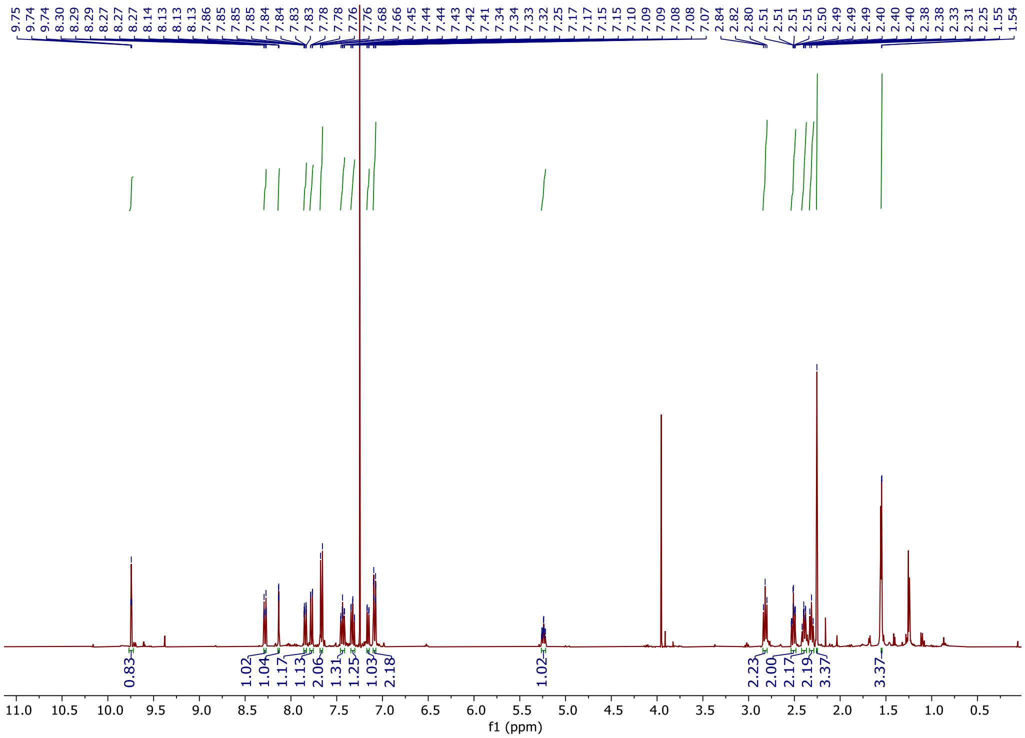
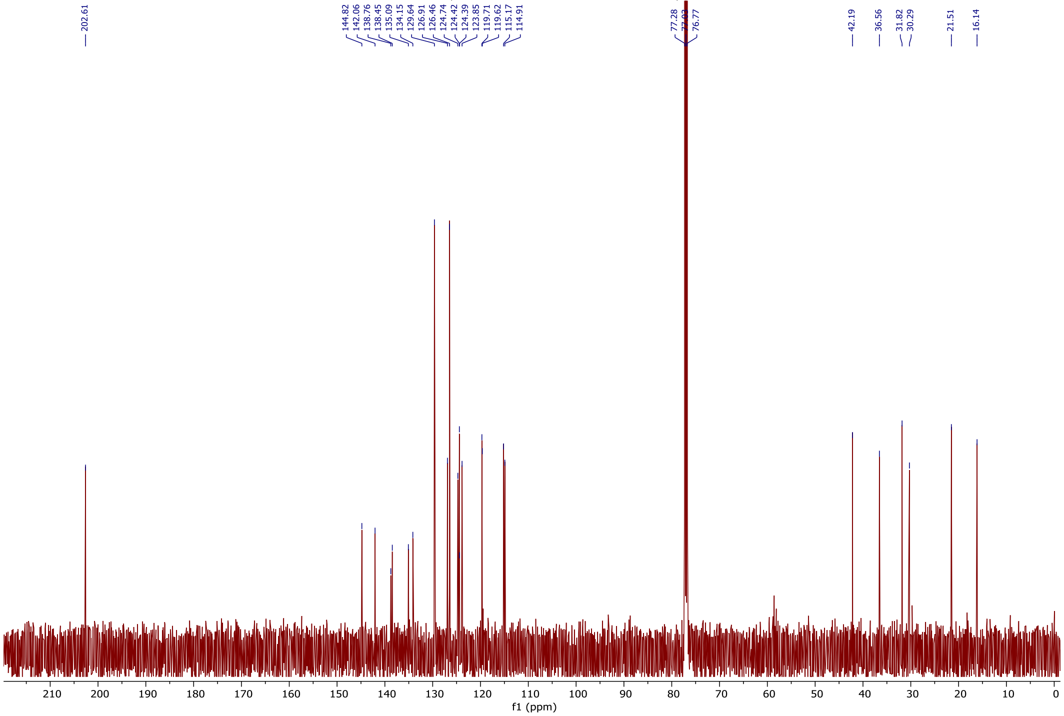
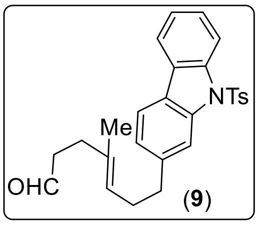


$^1$H NMR (400 MHz, CDCl$_3$) of **9**



$^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$) of **9**



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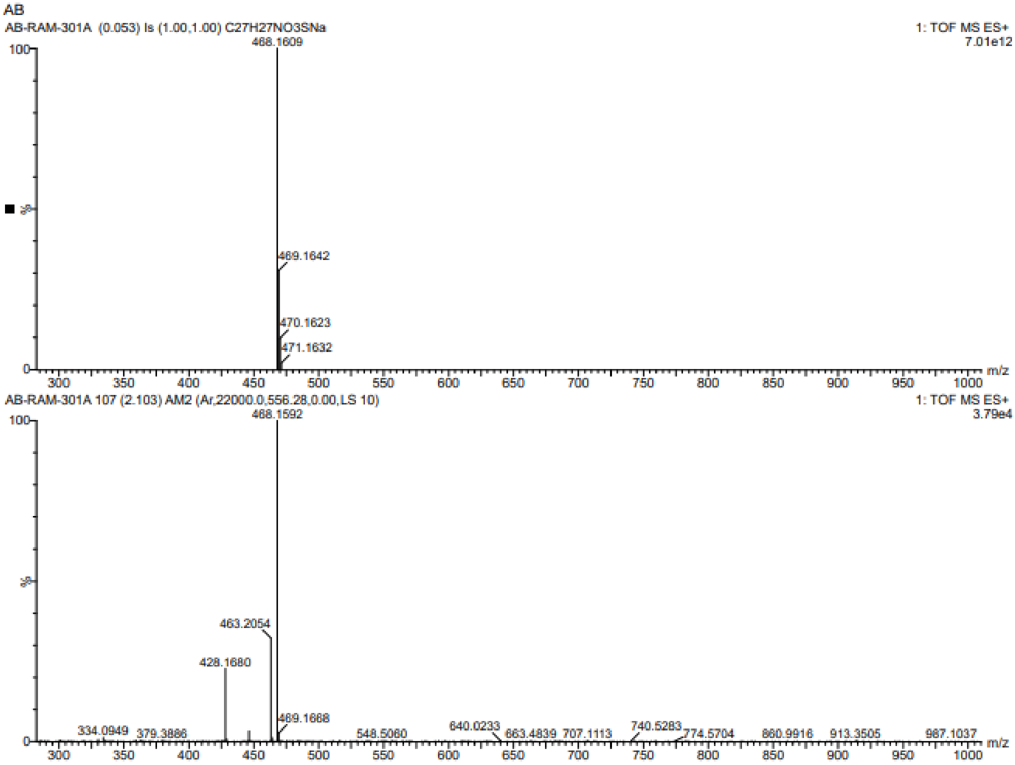
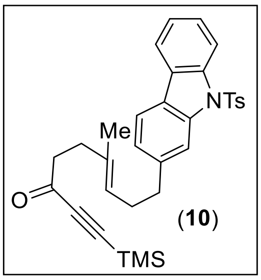


HRMS data of **9**



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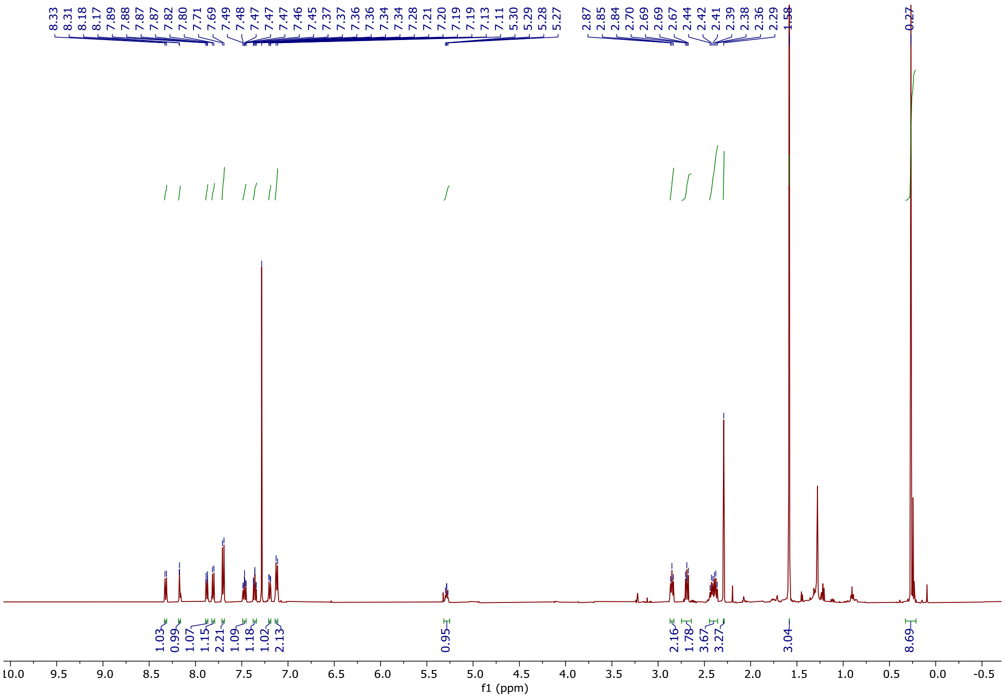
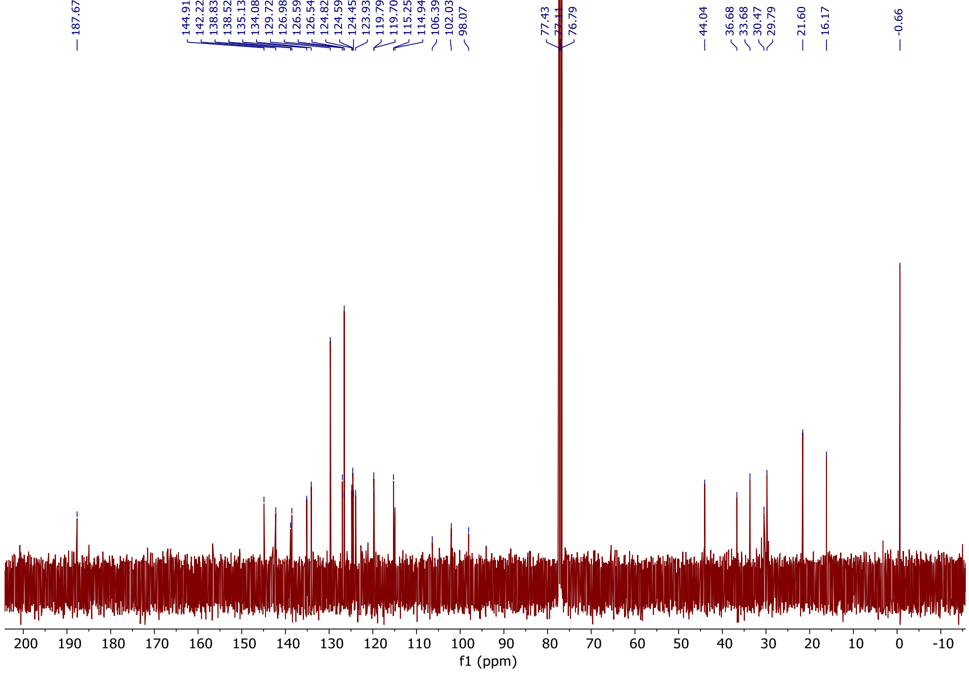
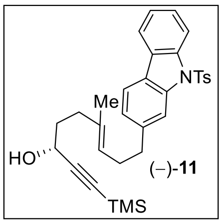


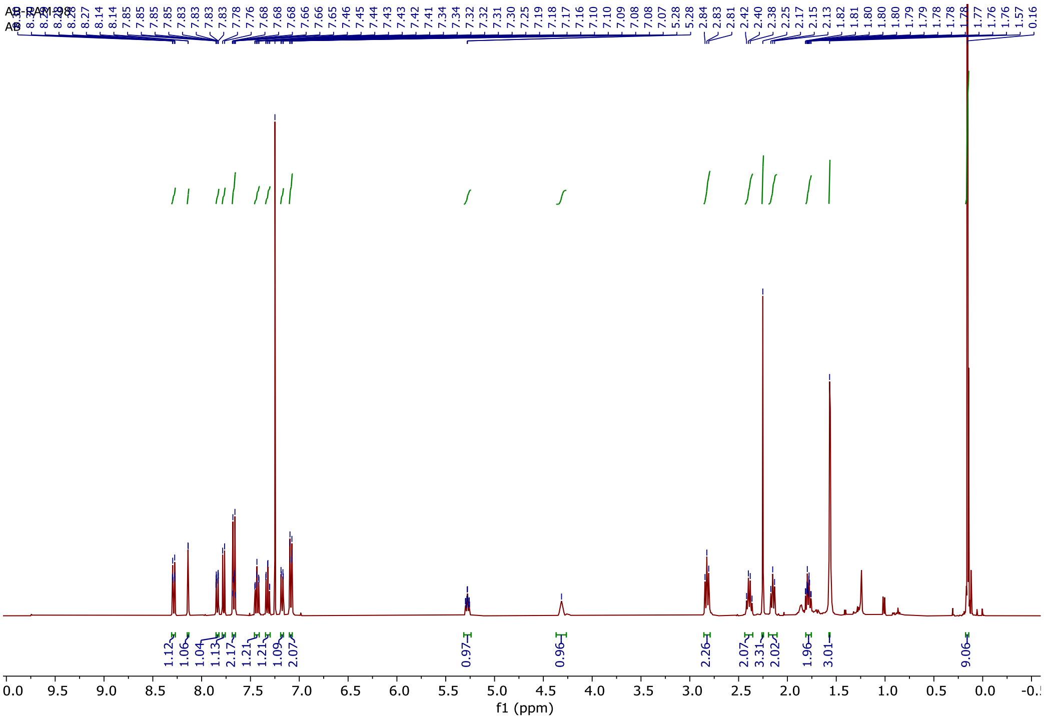
$^1$H NMR (500 MHz, CDCl$_3$) of **10**



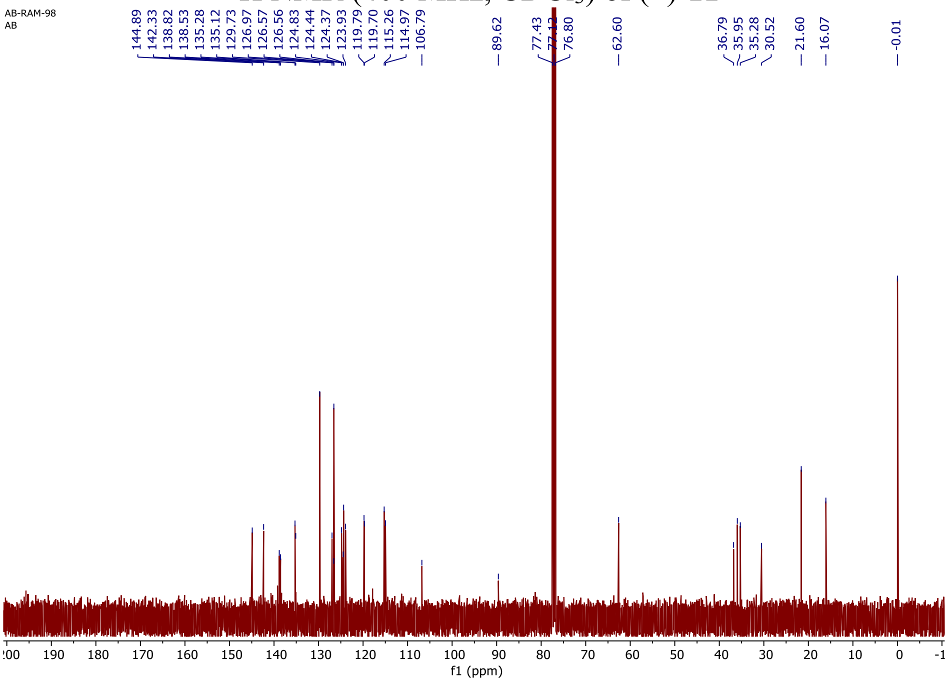
$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of **10**



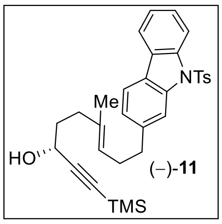
(−)-**11**



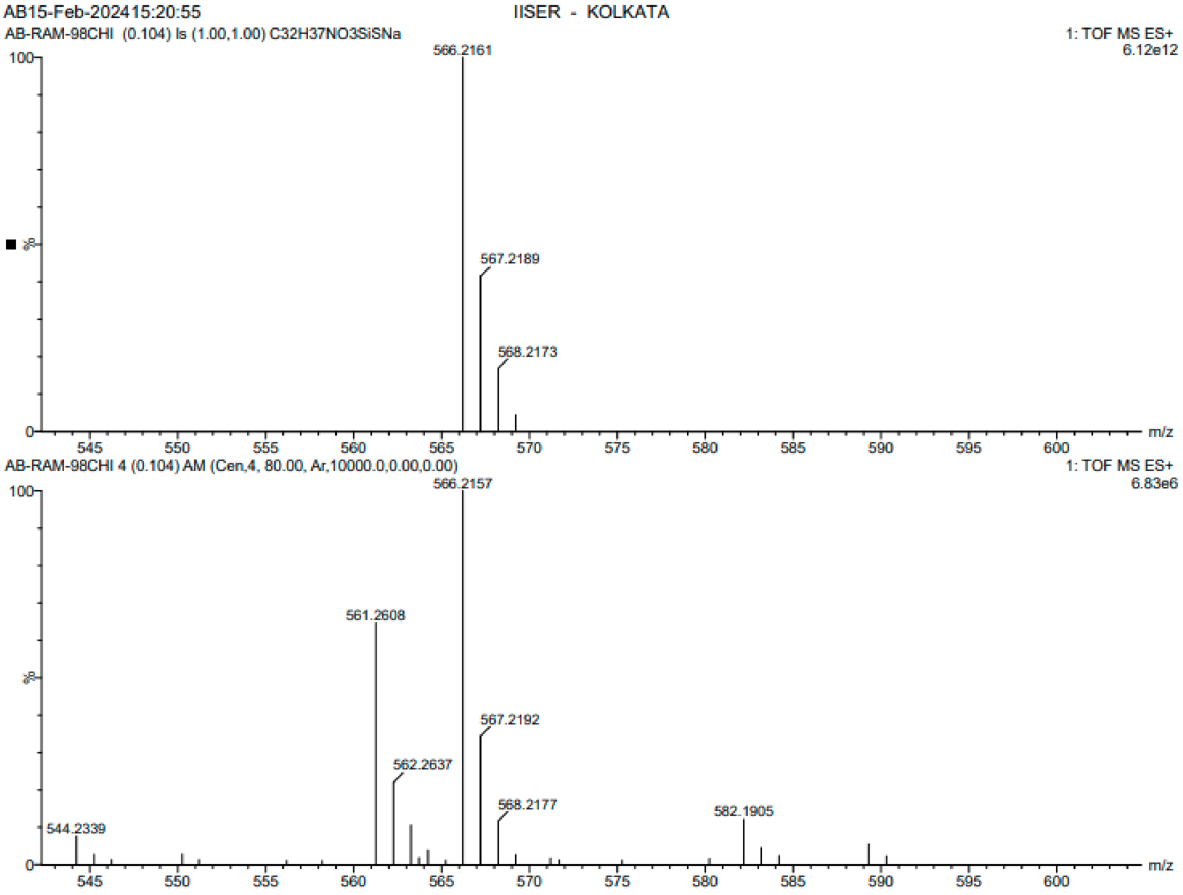
$^{1}$H NMR (400 MHz, CDCl$_3$) of (−)-**11**



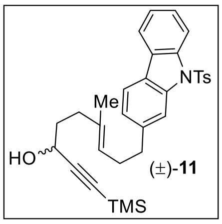
$^{13}$C {$^{1}$H} NMR (101 MHz, CDCl$_3$) of (−)-**11**



(−)-**11**



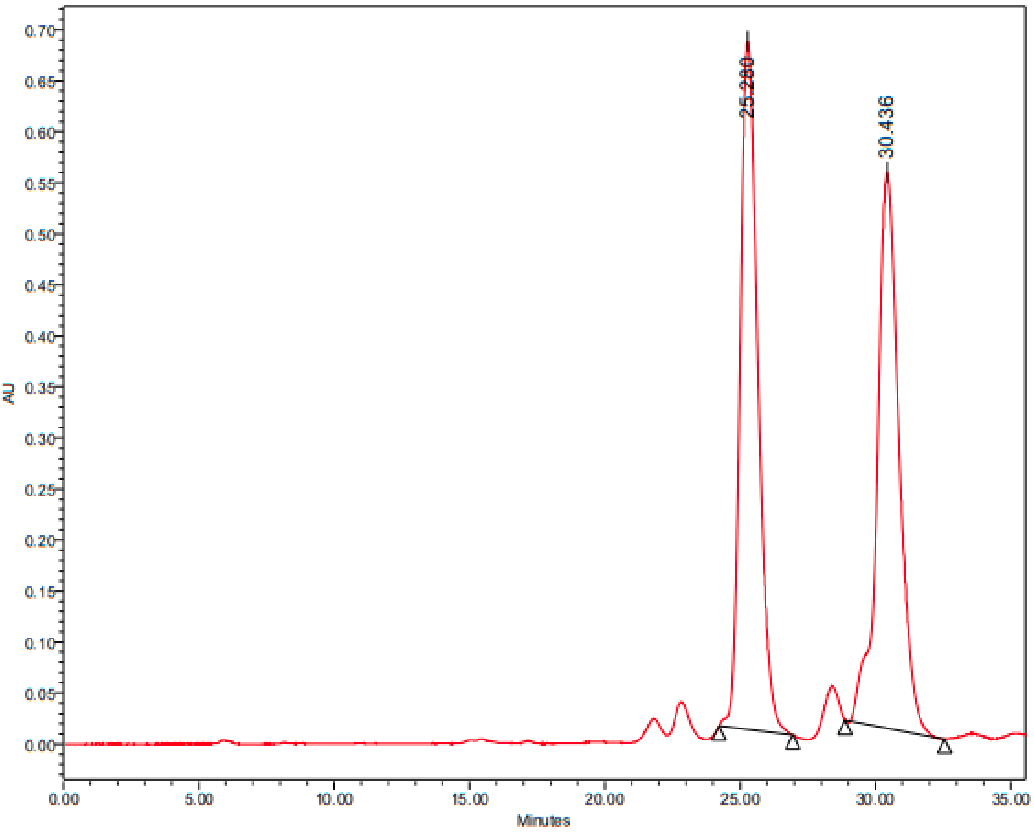
HRMS data of (−)-**11**



(±)-**11**

Empower™ 3 SOFTWARE

## Peak Summary Report



Sample Name: AB_RAM_AD-H_01_10_RAC_F0P5; Date Acquired: 03-02-2024 18:53:48 IST; Vial: 1 Injection: 1

### Peak Summary with Statistics

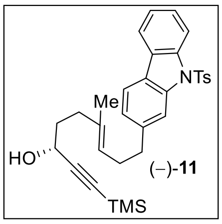
### Name:

| | Sample Name | Vial | Inj | Retention Time (min) | Area | % Area | Height |
|---|---|---|---|---|---|---|---|
| 1 | AB_RAM_AD-H_01_10_RAC_F0P5 | 1 | 1 | 30.436 | 30510805 | 49.81 | 544453 |
| 2 | AB_RAM_AD-H_01_10_RAC_F0P5 | 1 | 1 | 25.280 | 30737967 | 50.19 | 673924 |
| Mean | | | | 27.858 | | | |
| Std. Dev. | | | | 3.646 | | | |

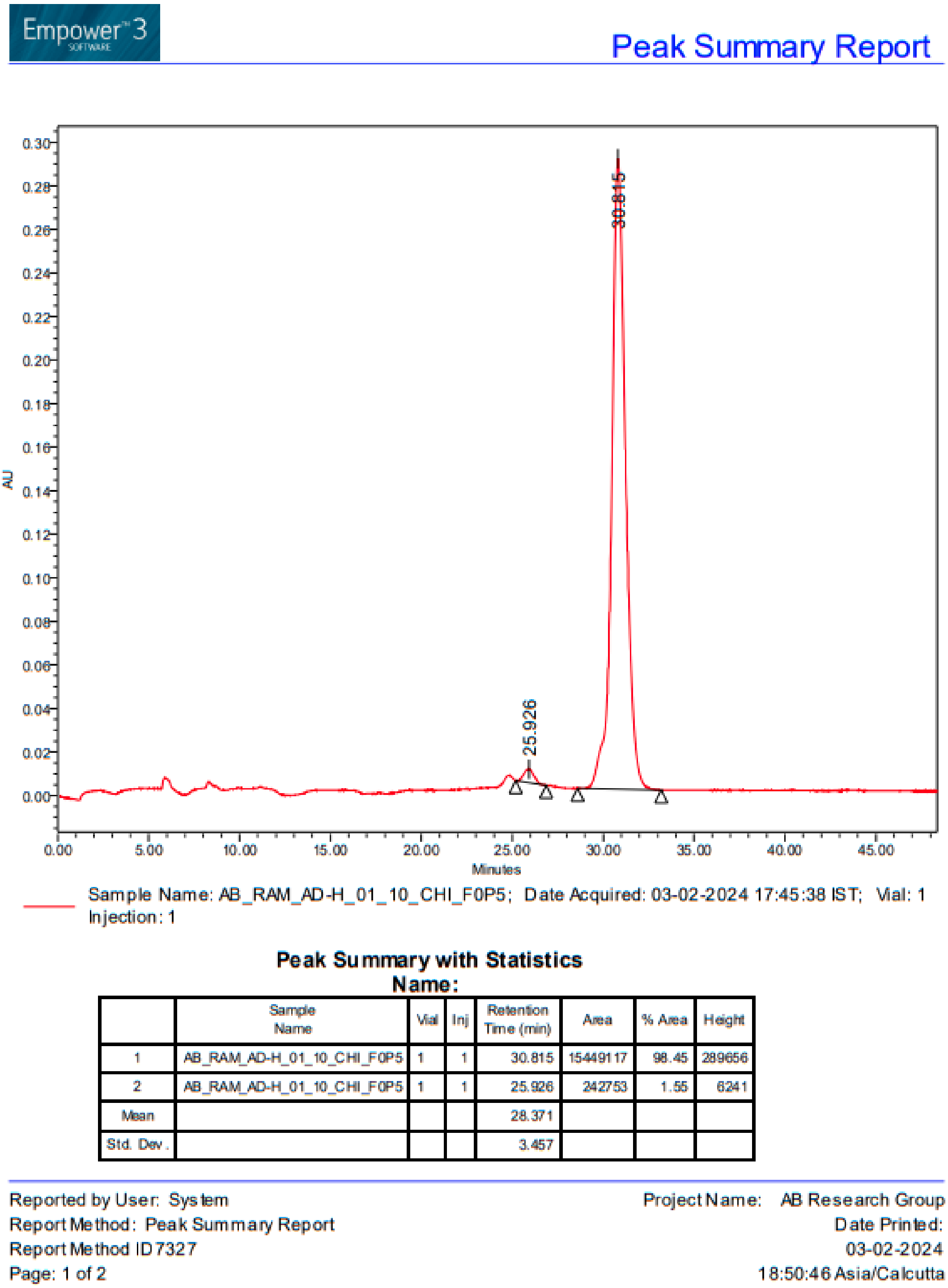
Reported by User: System
Report Method: Peak Summary Report
Report Method ID 7327
Page: 1 of 2

Project Name: AB Research Group
Date Printed:
07-02-2024
14:42:44 Asia/Calcutta

HPLC traces of [(±)-**11**]-AD-*H* column



(–)-**11**



Peak Summary Report

Sample Name: AB_RAM_AD-H_01_10_CHI_F0P5; Date Acquired: 03-02-2024 17:45:38 IST; Vial: 1 Injection: 1

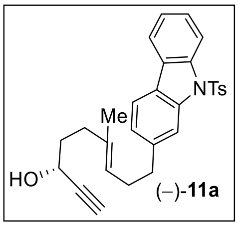
**Peak Summary with Statistics**
**Name:**

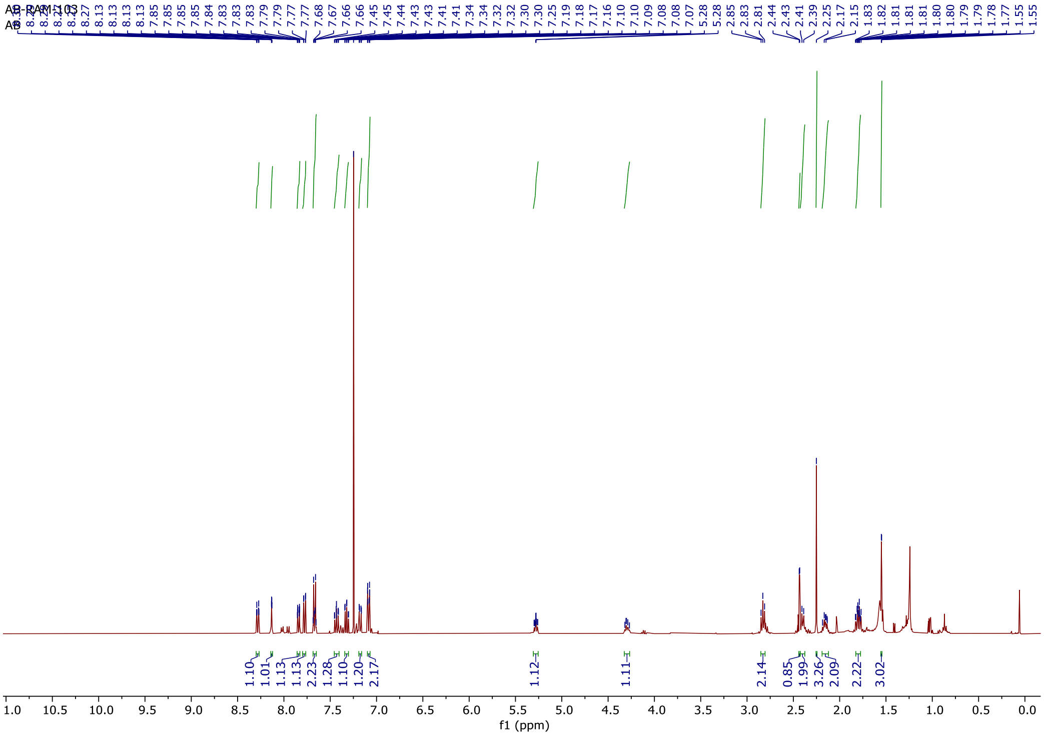
| | Sample Name | Vial | Inj | Retention Time (min) | Area | % Area | Height |
|---|---|---|---|---|---|---|---|
| 1 | AB_RAM_AD-H_01_10_CHI_F0P5 | 1 | 1 | 30.815 | 15449117 | 98.45 | 289656 |
| 2 | AB_RAM_AD-H_01_10_CHI_F0P5 | 1 | 1 | 25.926 | 242753 | 1.55 | 6241 |
| Mean | | | | 28.371 | | | |
| Std. Dev. | | | | 3.457 | | | |

Reported by User: System
Report Method: Peak Summary Report
Report Method ID 7327
Page: 1 of 2

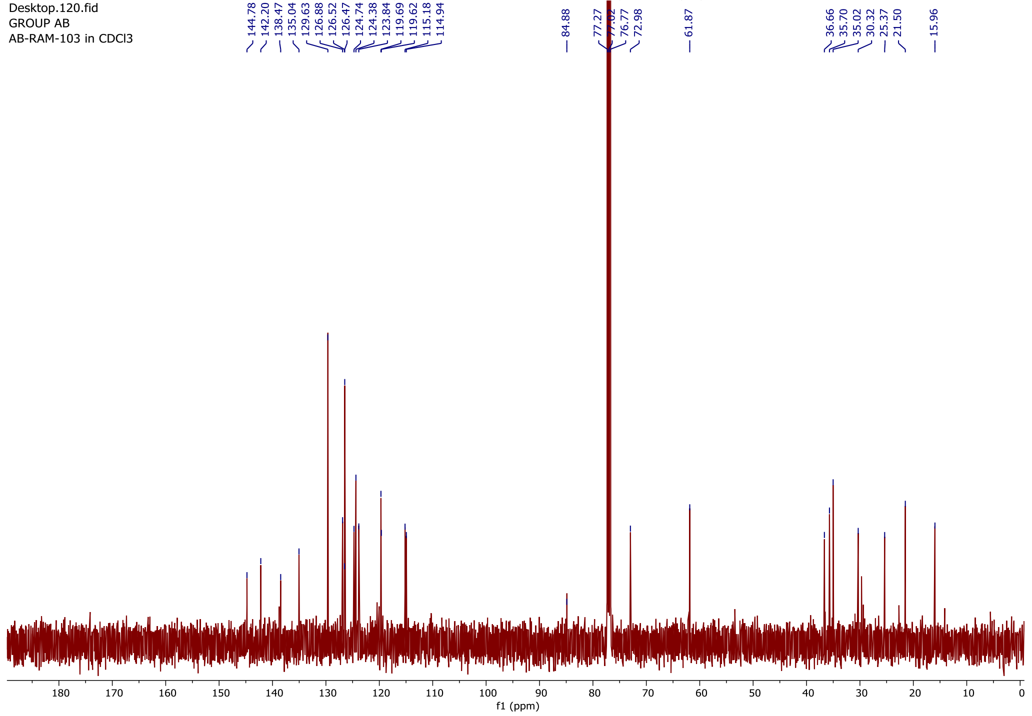
Project Name: AB Research Group
Date Printed:
03-02-2024
18:50:46 Asia/Calcutta

HPLC traces of [(–)-**11**]-AD-*H* column

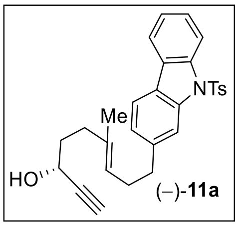




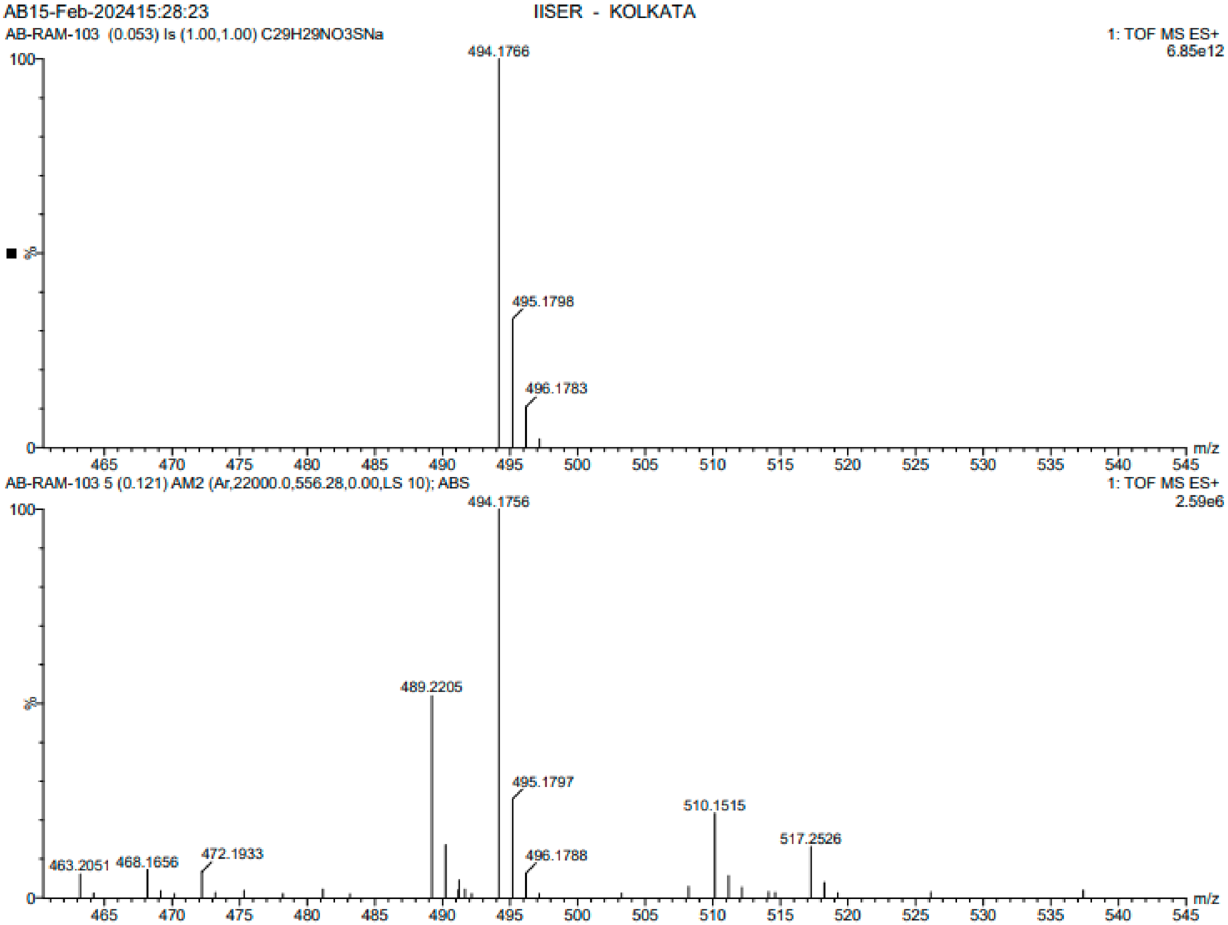
$^1$H NMR (400 MHz, CDCl$_3$) of (–)-**11a**



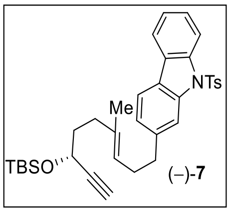
$^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$) of (–)-**11a**



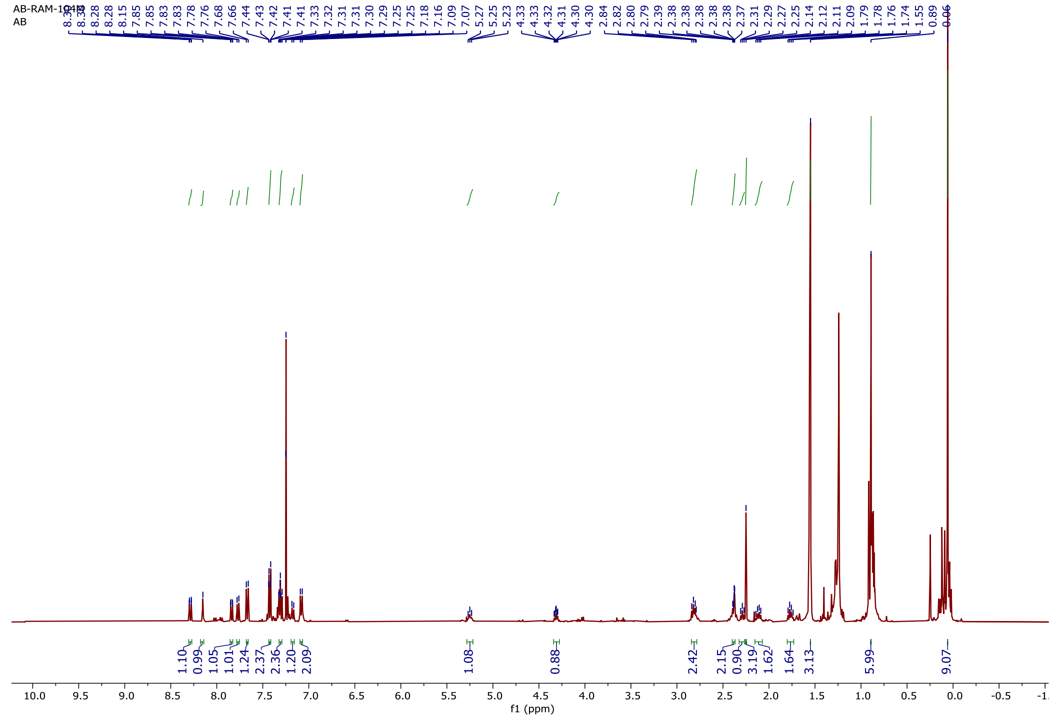
(−)-**11a**



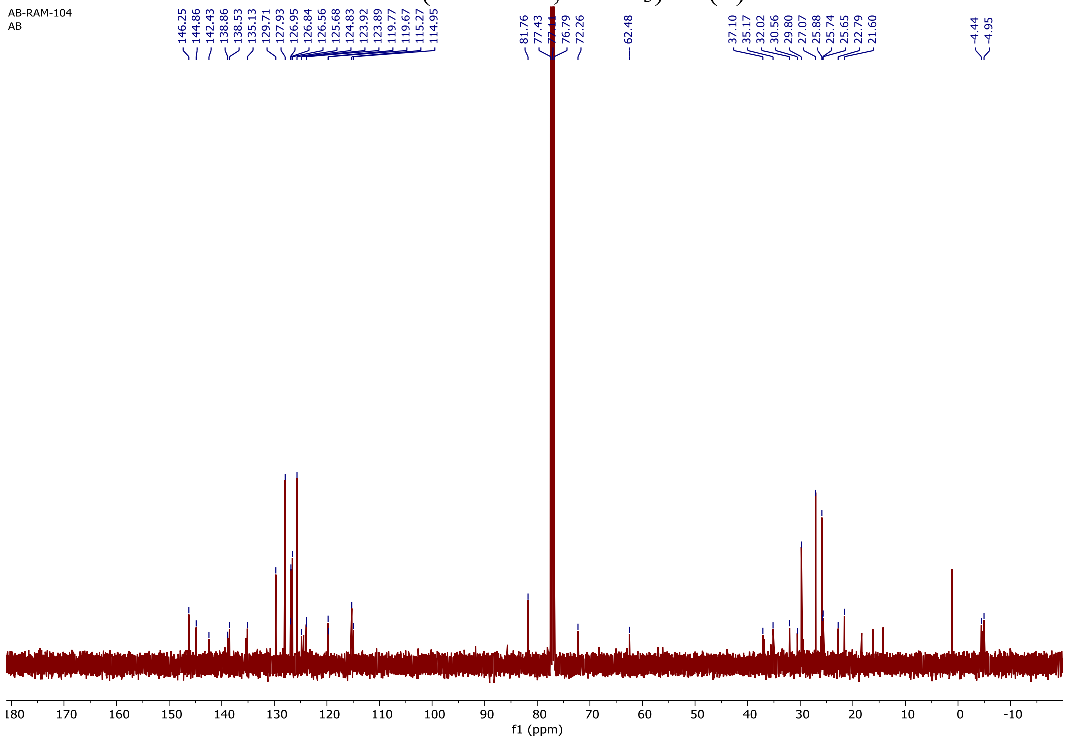
HRMS data of (−)-**11a**



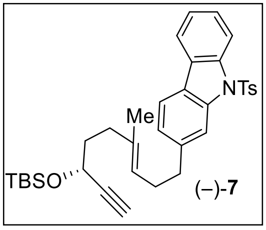
(–)-**7**



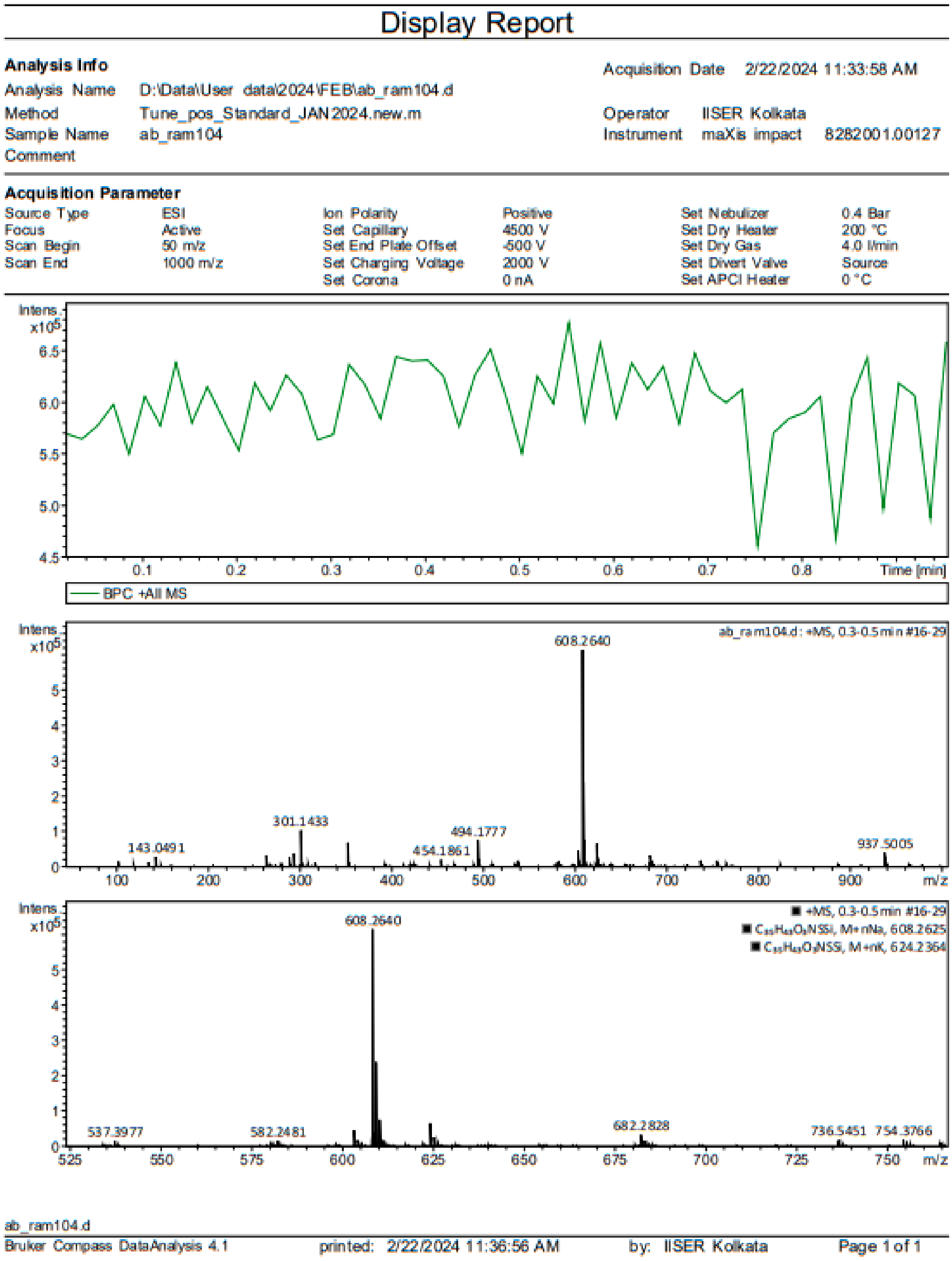
$^{1}$H NMR (400 MHz, CDCl$_3$) of (–)-**7**



$^{13}$C {$^{1}$H} NMR (101 MHz, CDCl$_3$) of (–)-**7**



(–)-**7**



Display Report

**Analysis Info**

Analysis Name D:\Data\User data\2024\FEB\ab_ram104.d

Method Tune_pos_Standard_JAN2024.new.m

Sample Name ab_ram104

Comment

Acquisition Date 2/22/2024 11:33:58 AM

Operator IISER Kolkata

Instrument maXis impact 8282001.00127

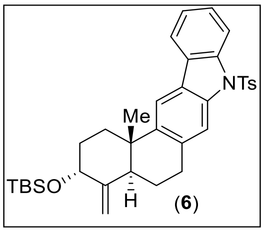
**Acquisition Parameter**

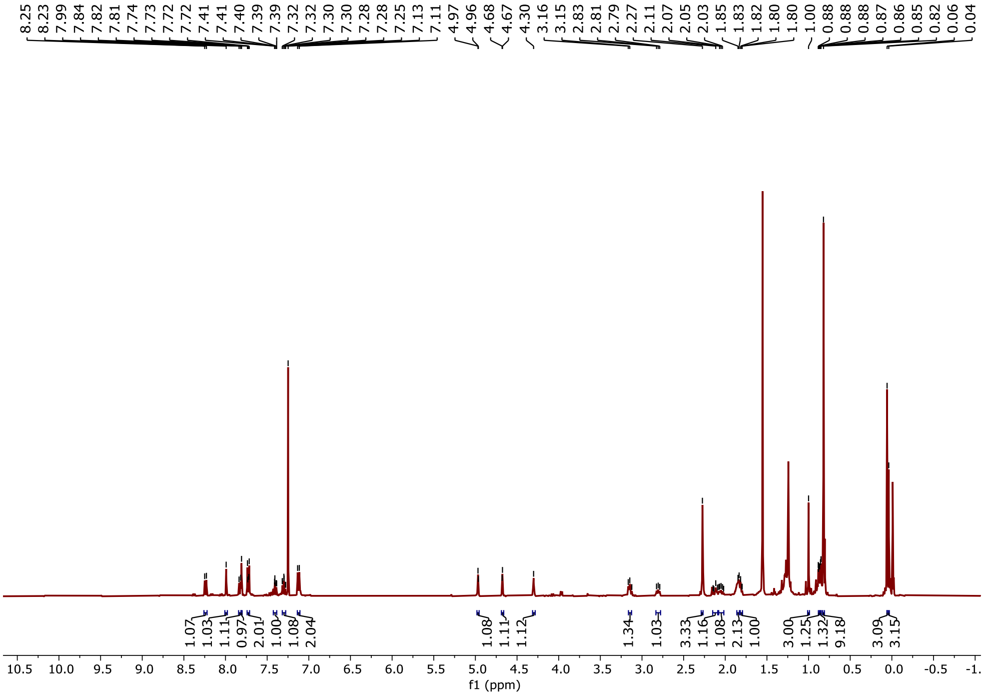
| | | | | | |
|---|---|---|---|---|---|
| Source Type | ESI | Ion Polarity | Positive | Set Nebulizer | 0.4 Bar |
| Focus | Active | Set Capillary | 4500 V | Set Dry Heater | 200 °C |
| Scan Begin | 50 m/z | Set End Plate Offset | -500 V | Set Dry Gas | 4.0 l/min |
| Scan End | 1000 m/z | Set Charging Voltage | 2000 V | Set Divert Valve | Source |
| | | Set Corona | 0 nA | Set APCI Heater | 0 °C |

ab_ram104.d

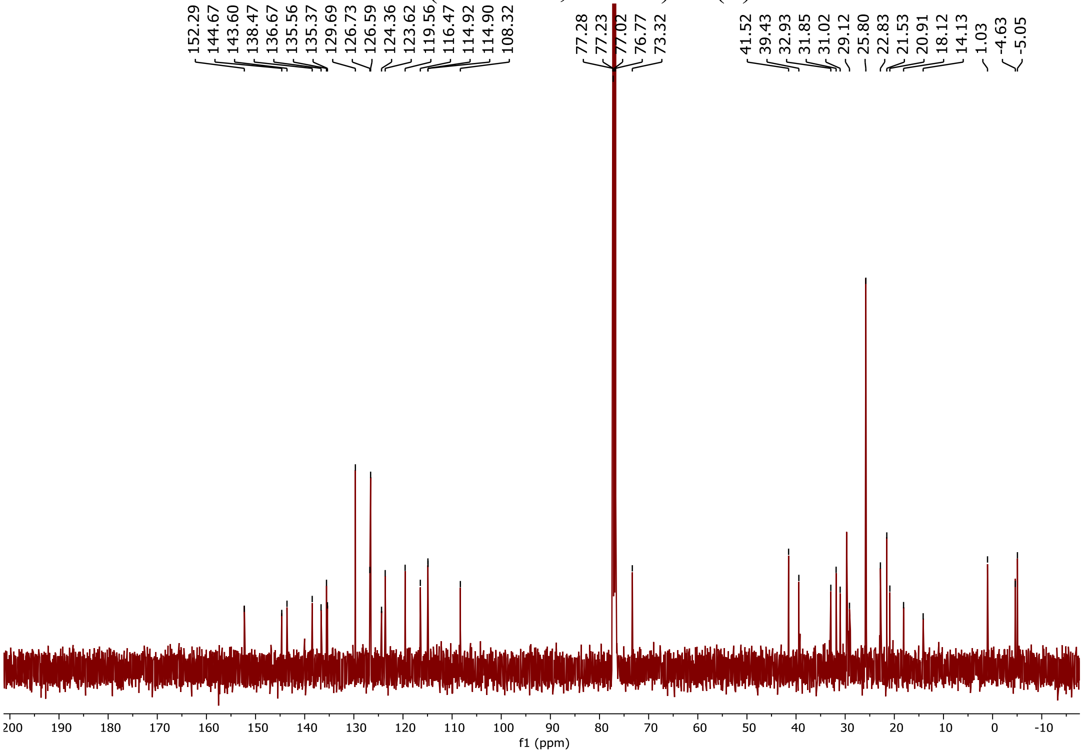
Bruker Compass DataAnalysis 4.1 printed: 2/22/2024 11:36:56 AM by: IISER Kolkata Page 1 of 1

HRMS data of (–)-**7**

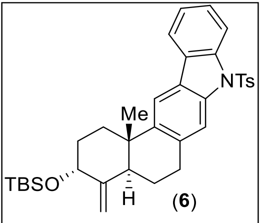




$^{1}$H NMR (400 MHz, CDCl$_3$) of (–)-**6**



$^{13}$C {$^{1}$H} NMR (126 MHz, CDCl$_3$) of (–)-**6**



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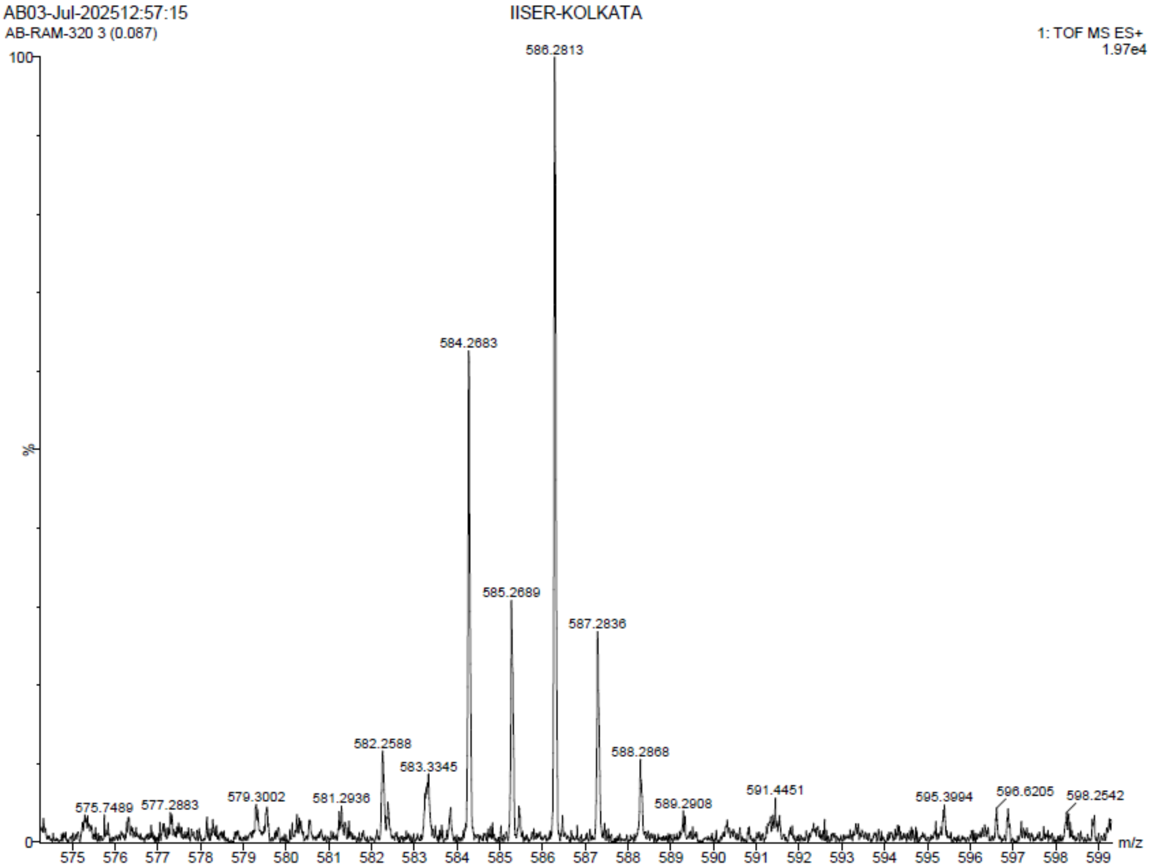
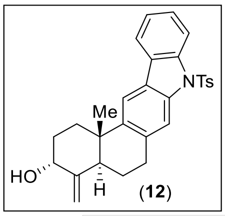


HRMS data of (−)-**6**



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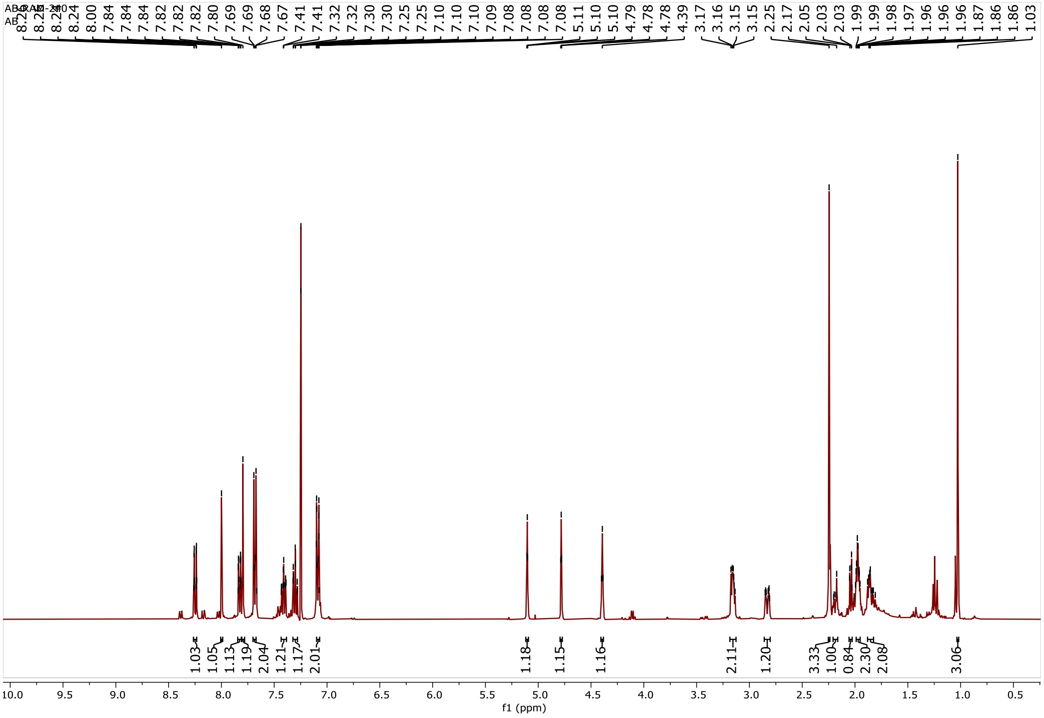
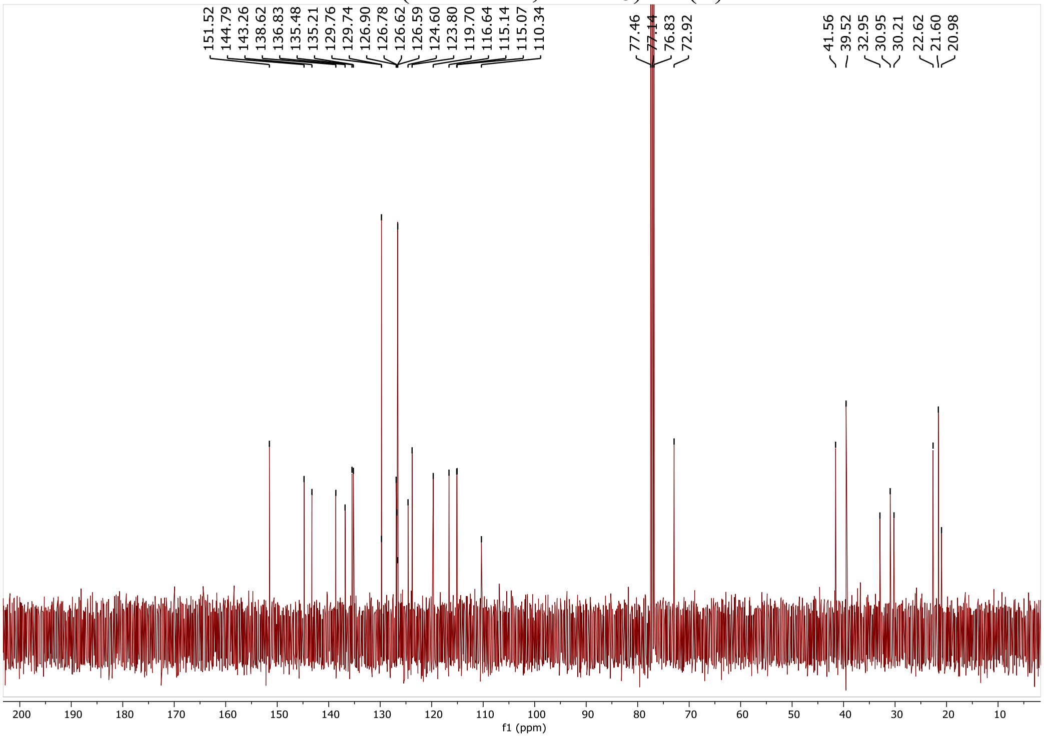
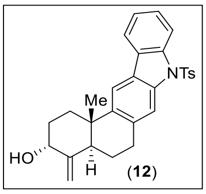


$^{1}$H NMR (400 MHz, CDCl$_3$) of (–)-**12**



$^{13}$C {$^{1}$H} NMR (101 MHz, CDCl$_3$) of (–)-**12**



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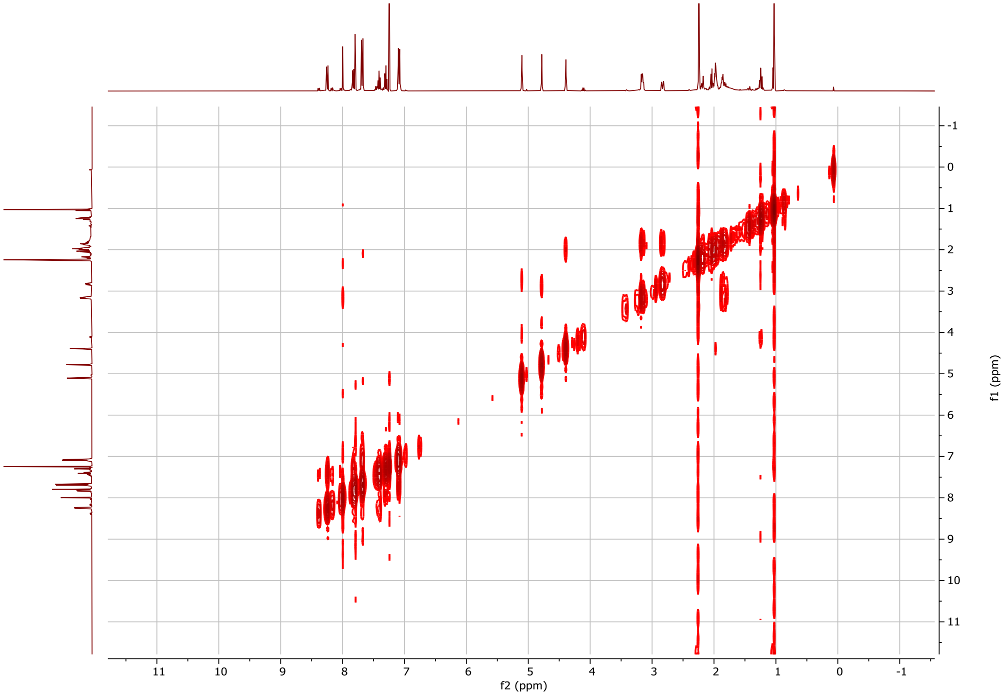
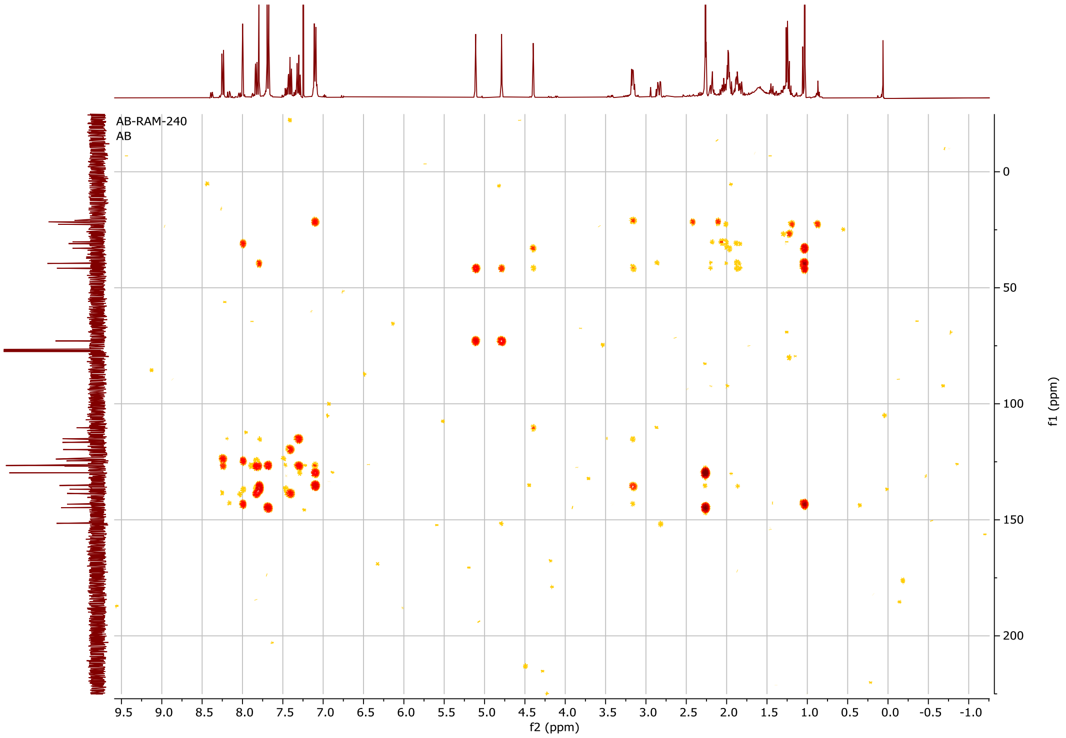


$^1$H-$^1$H COSY Data of (–)-**12**



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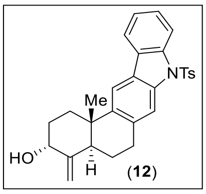

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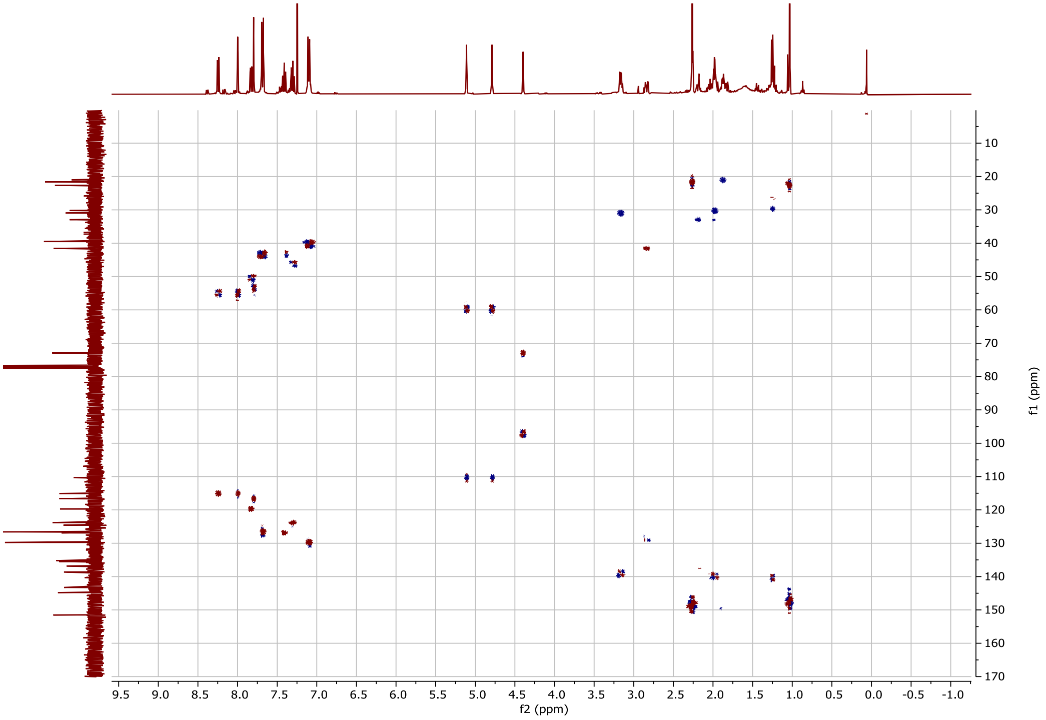

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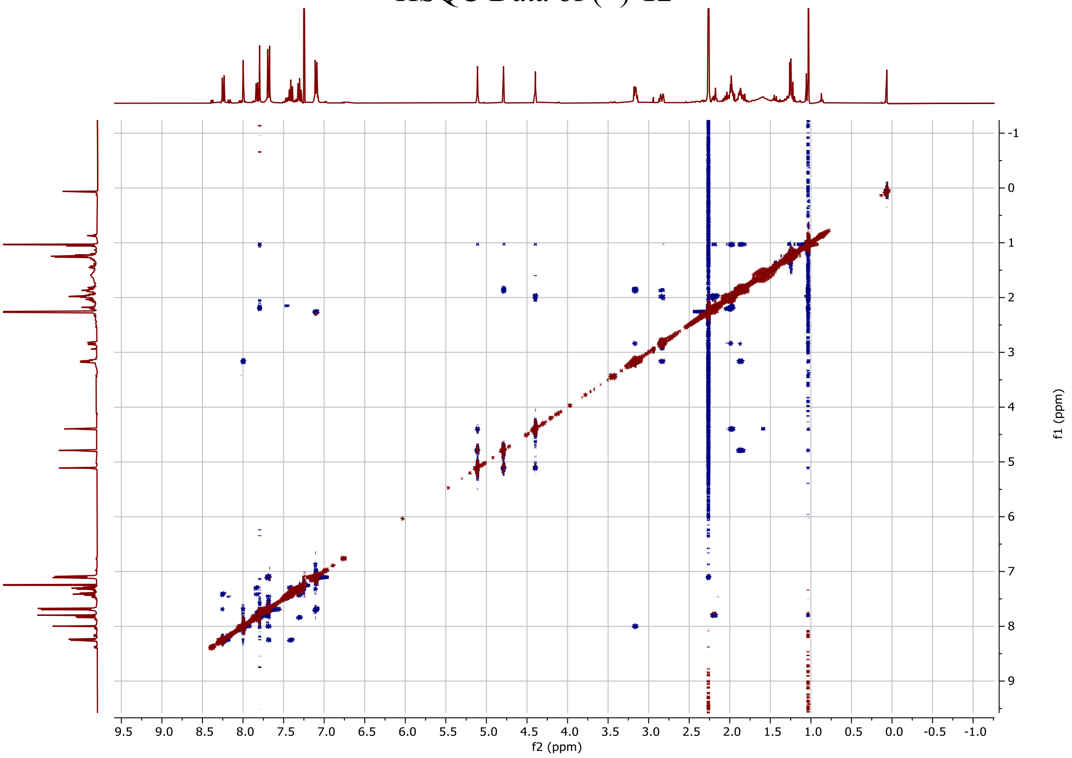

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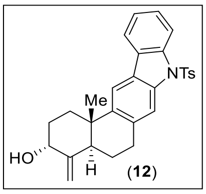
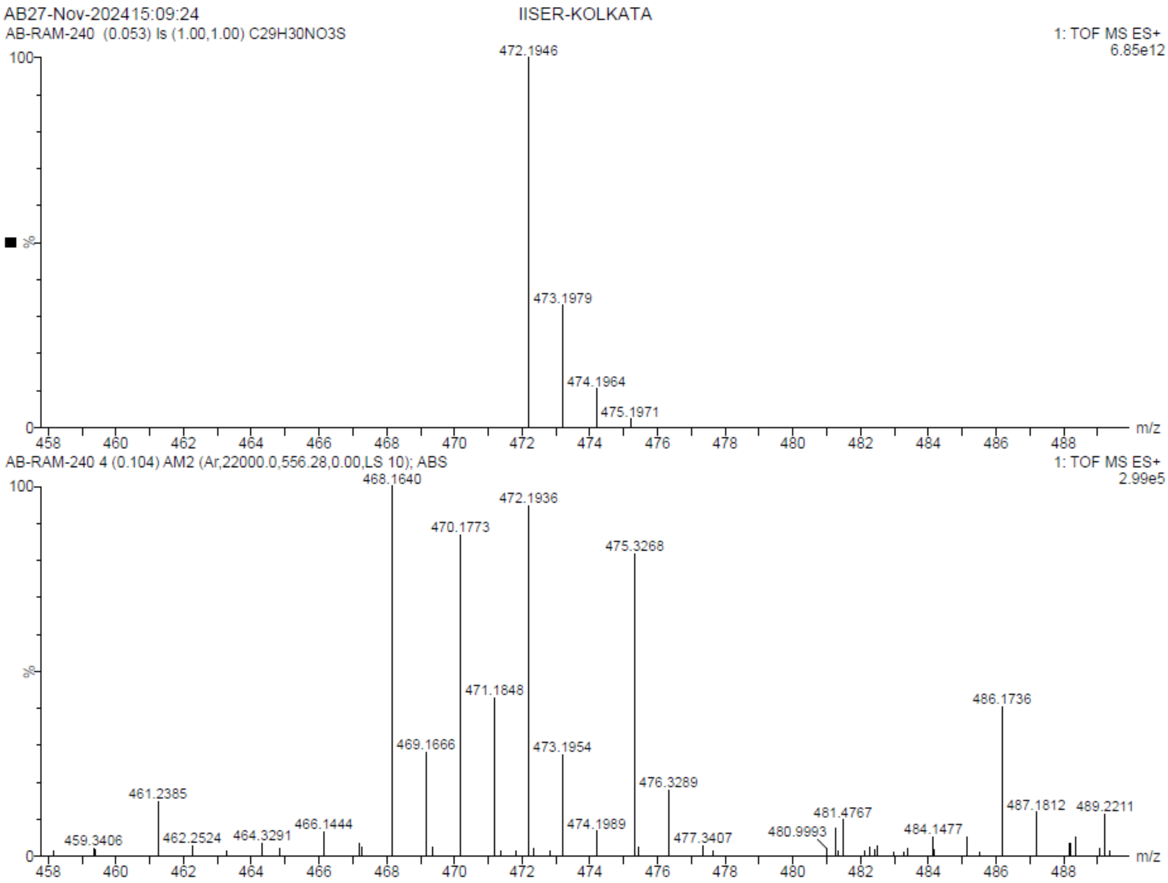
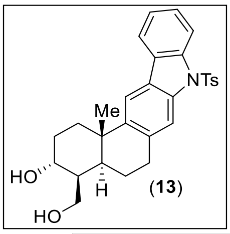
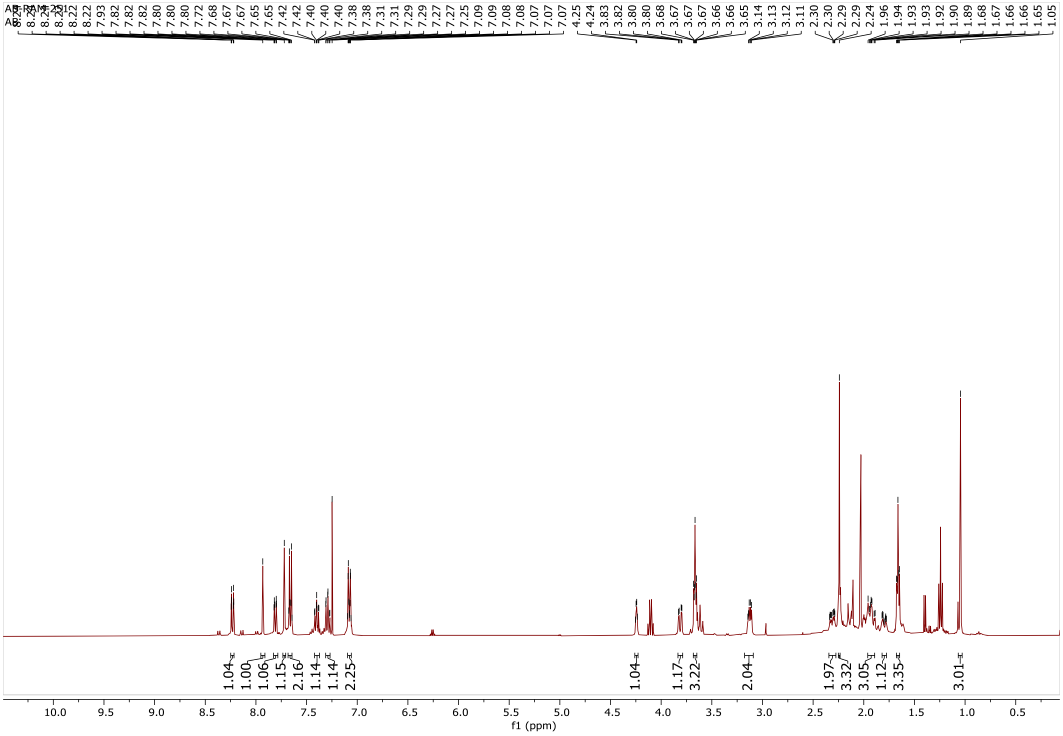


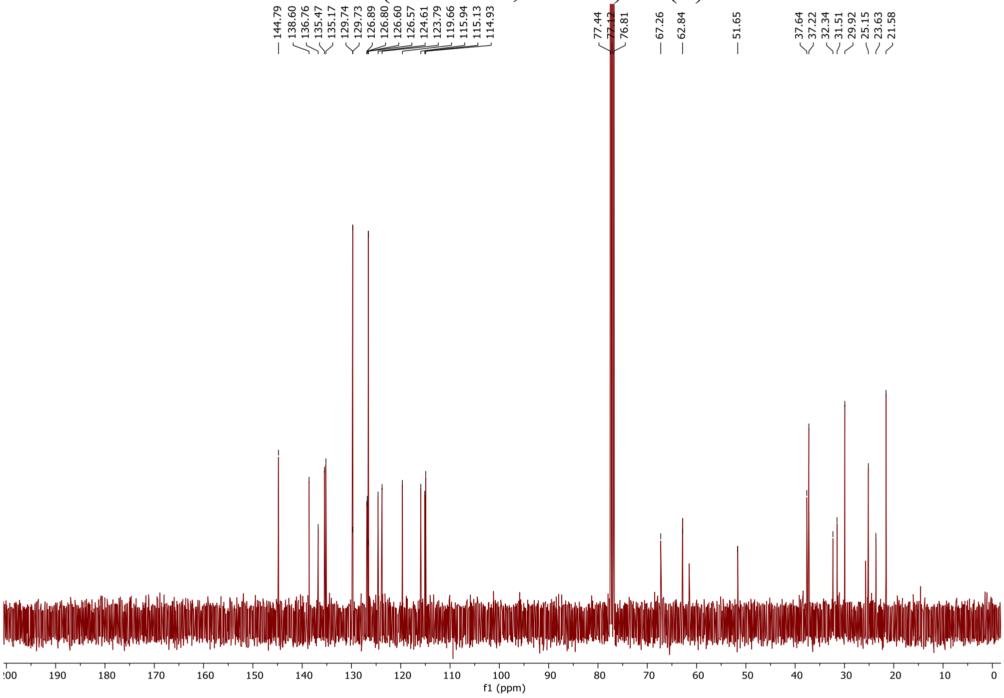


HRMS data of (−)-**12**

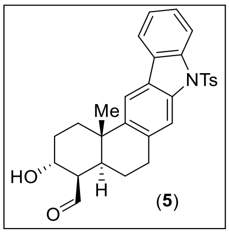




$^1$H NMR (400 MHz, CDCl$_3$) of (−)-**13**



$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of (−)-**13**



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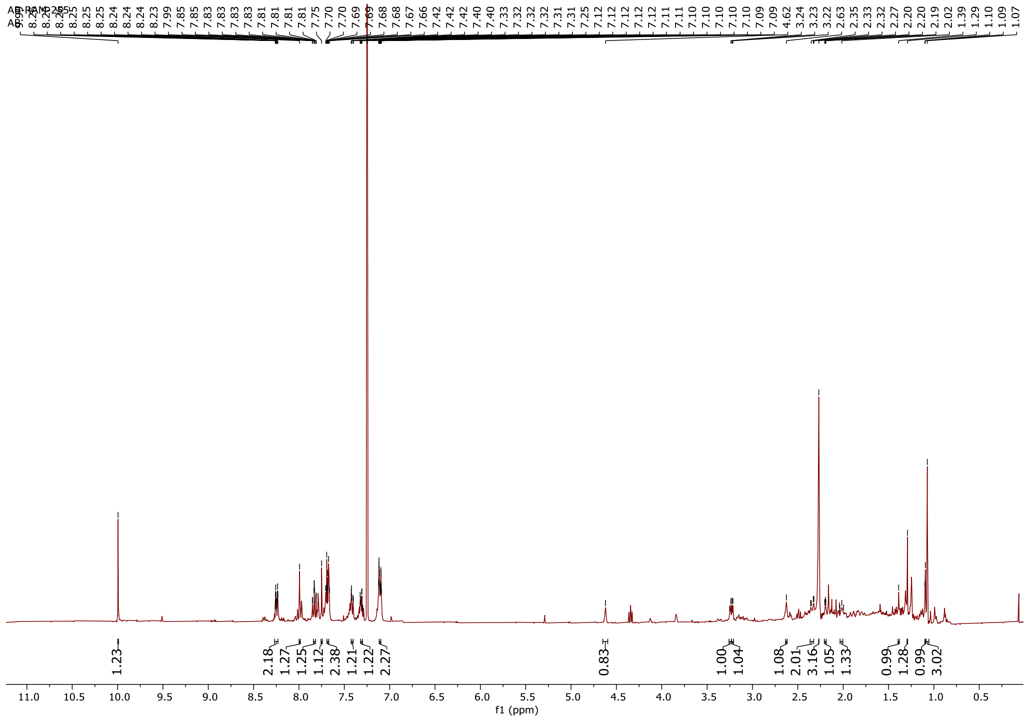
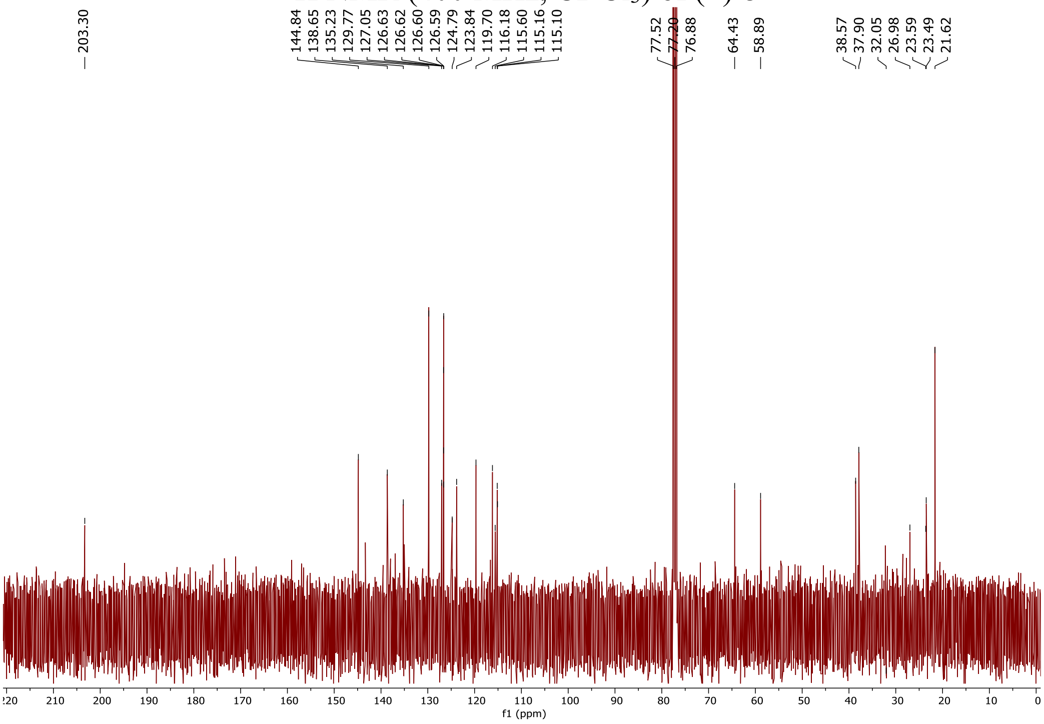
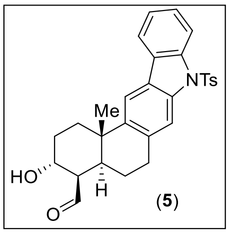


$^1$H NMR (400 MHz, CDCl$_3$) of (–)-**5**



$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of (–)-**5**



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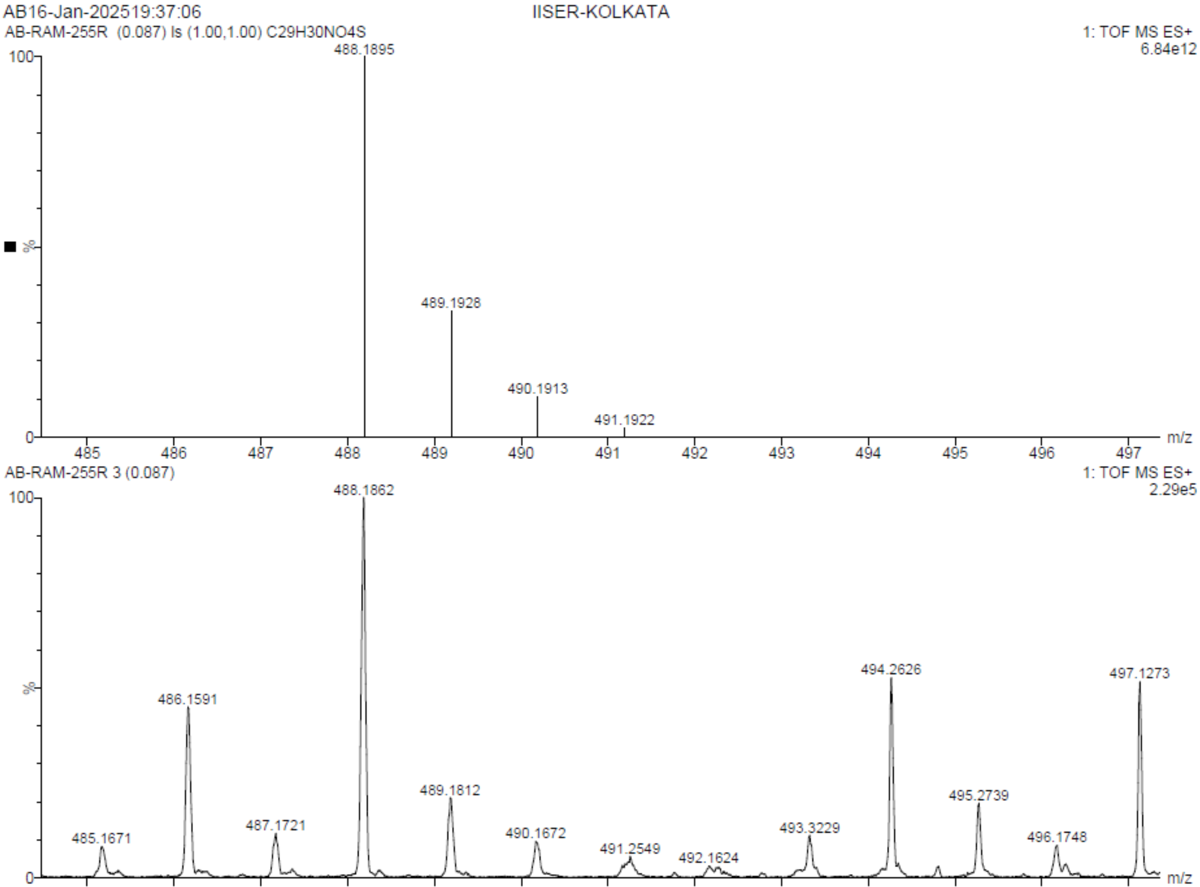
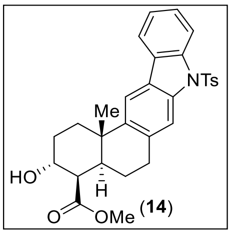


HRMS data of (–)-**5**



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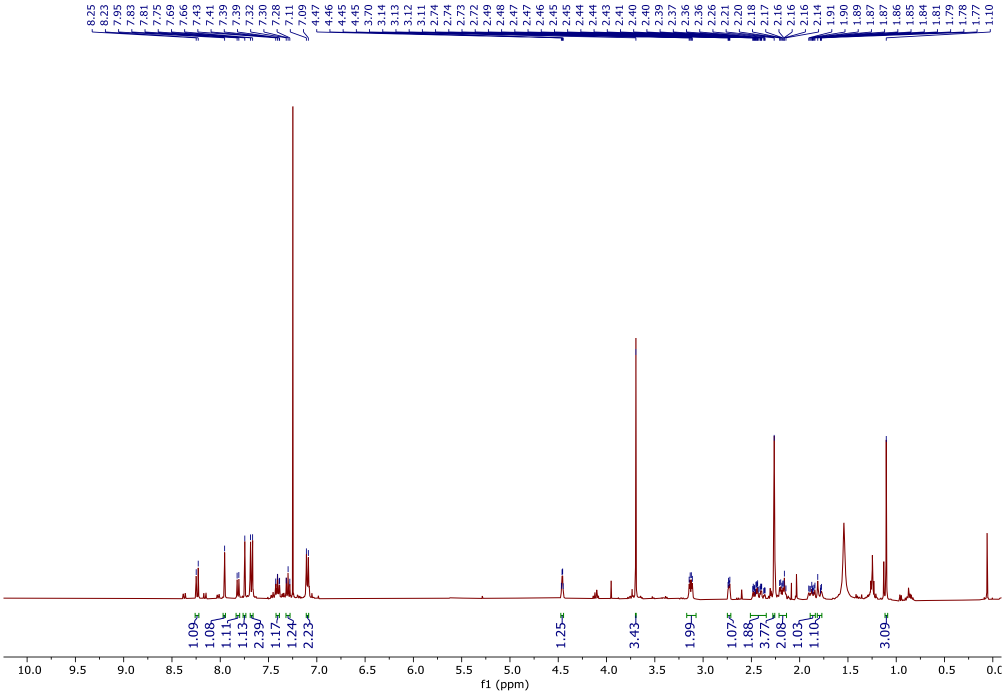
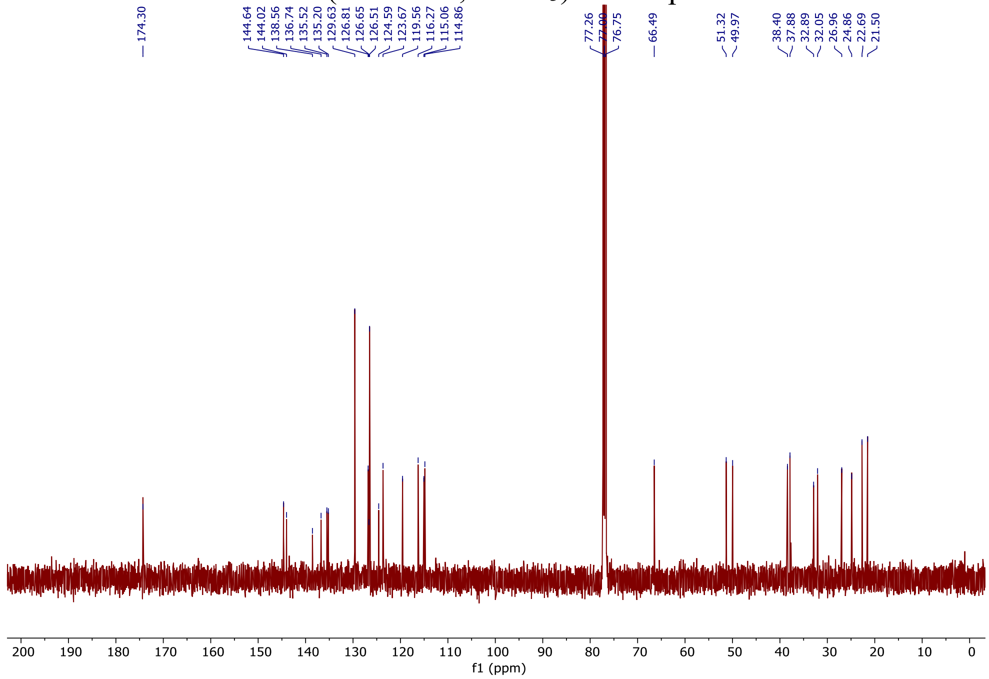
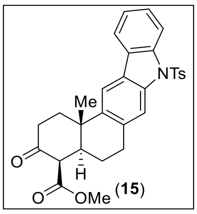


$^{1}$H NMR (400 MHz, $CDCl_3$) of compound **14**



$^{13}$C {$^{1}$H} NMR (125 MHz, $CDCl_3$) of compound **14**



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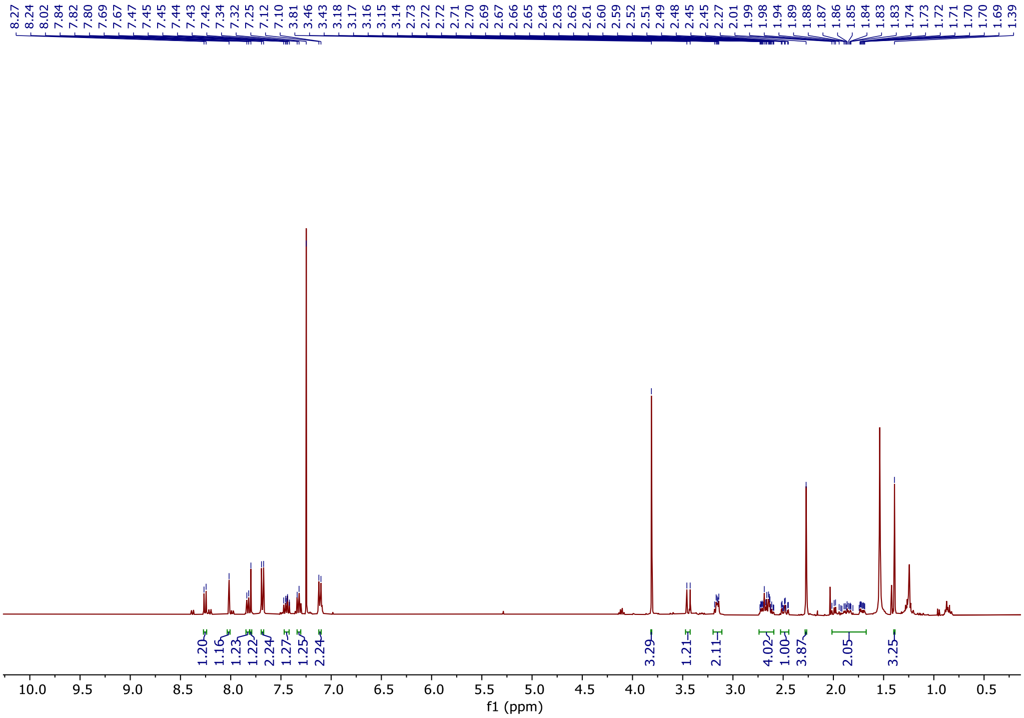
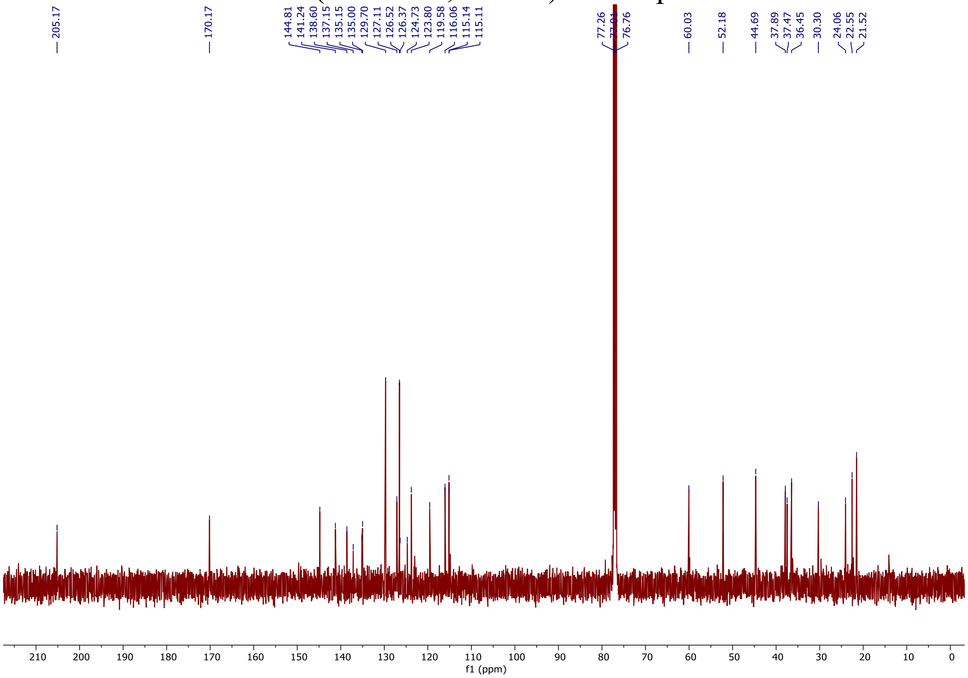
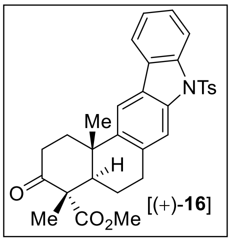


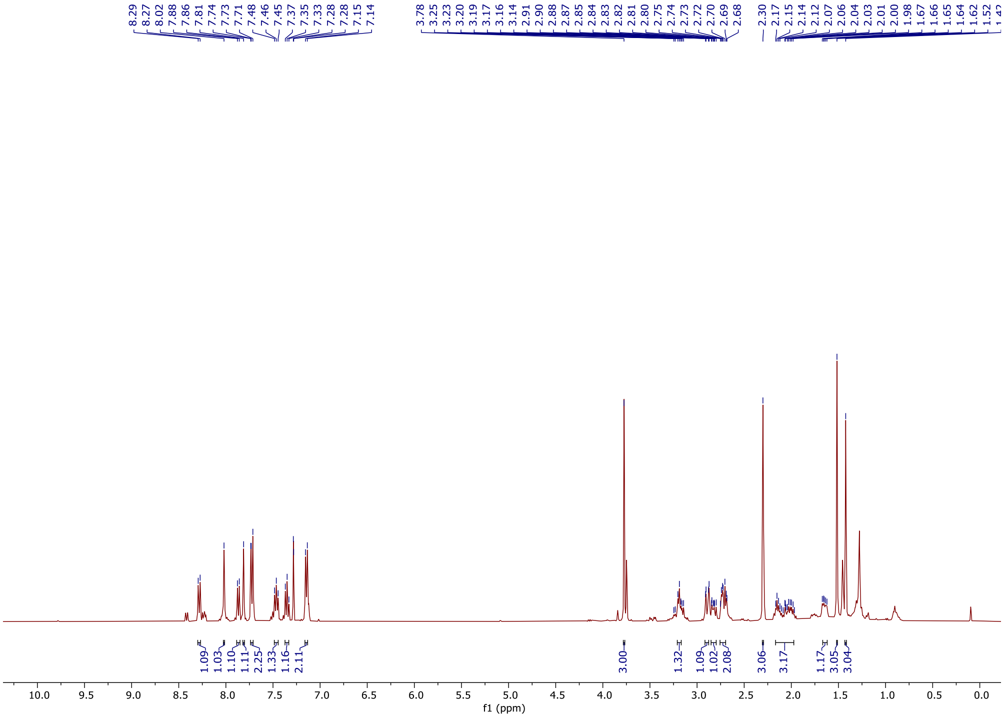
$^1$H NMR (500 MHz, CDCl$_3$) of compound **15**



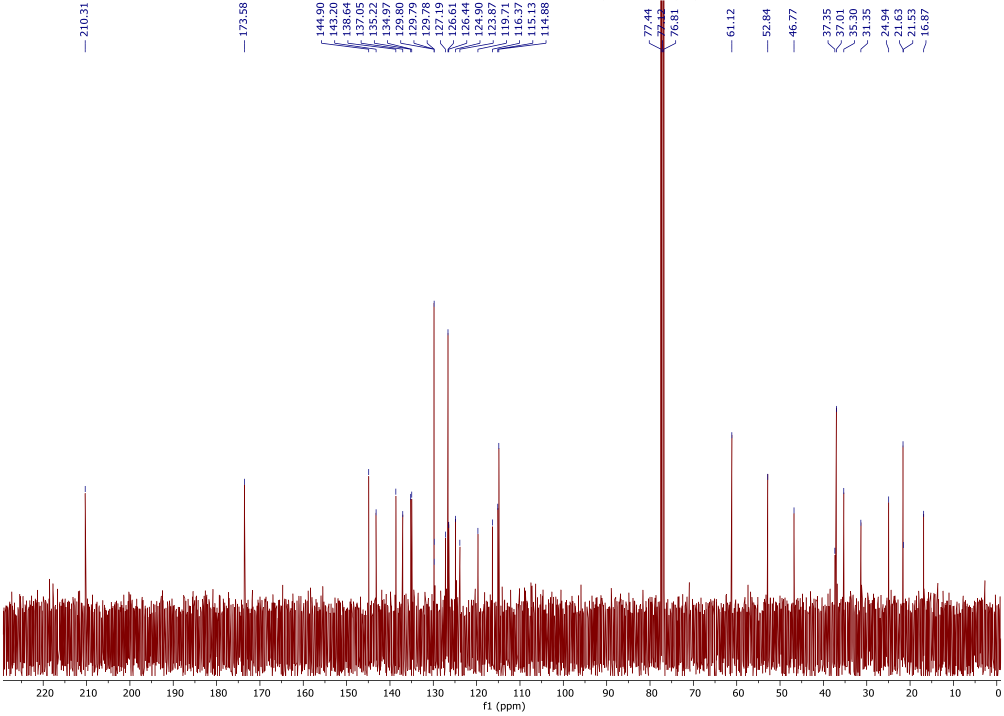
$^{13}$C {$^1$H} NMR (125 MHz, CDCl$_3$) of compound **15**



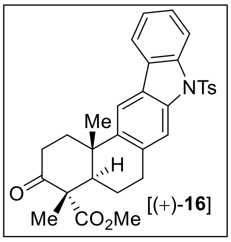
[(+)-**16**]



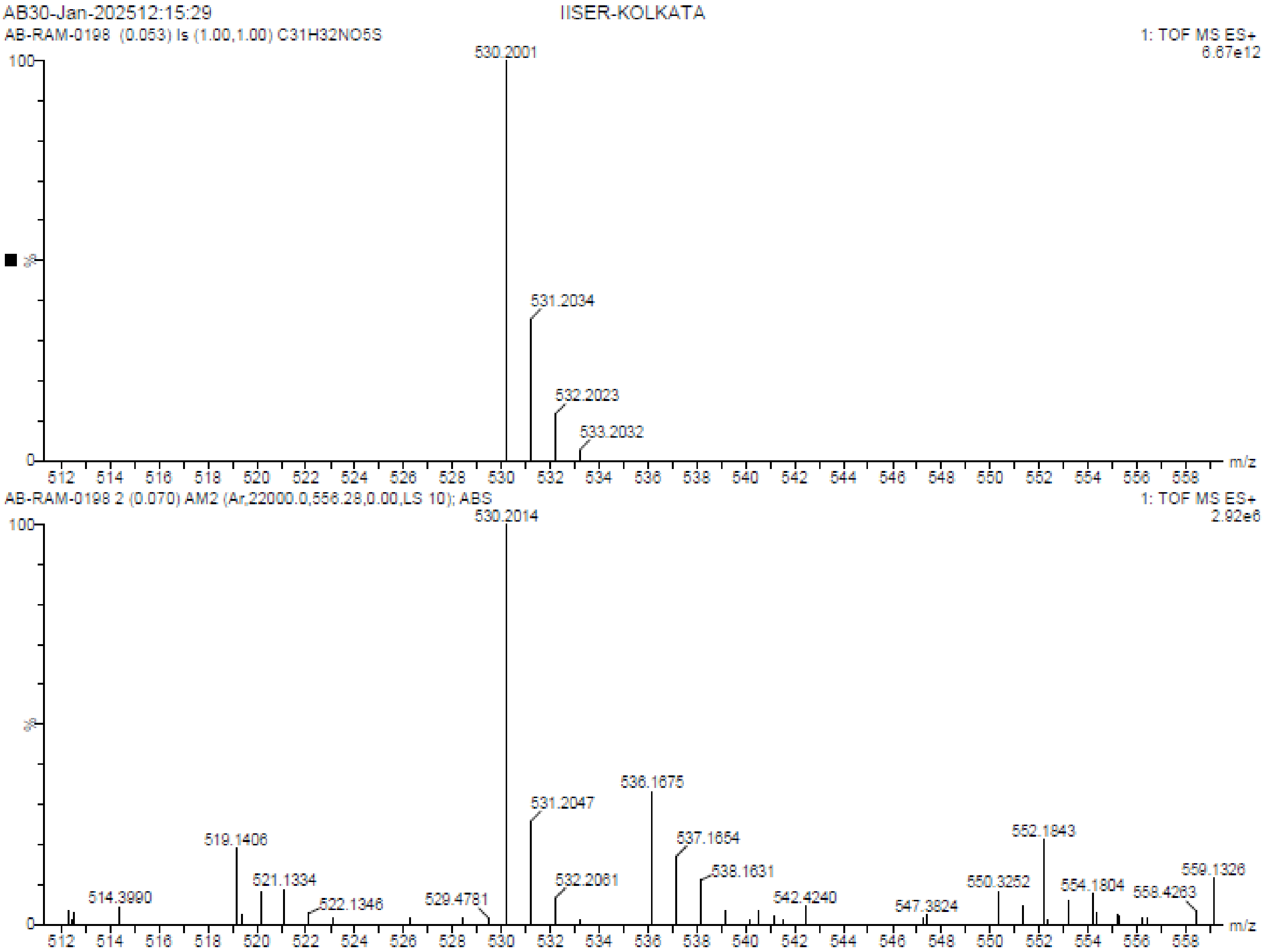
$^{1}$H NMR (400 MHz, CDCl$_3$) of [(+)-**16**]



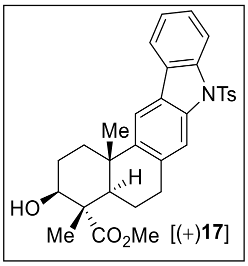
$^{13}$C {$^{1}$H} NMR (101 MHz, CDCl$_3$) of [(+)-**16**]



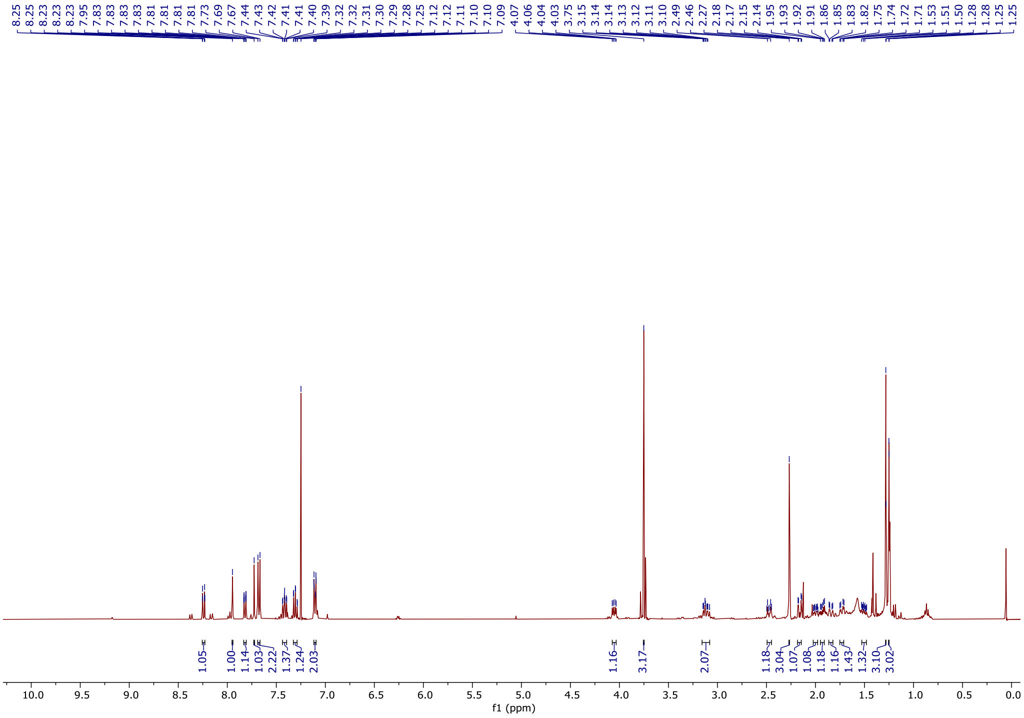
[(+)-**16**]



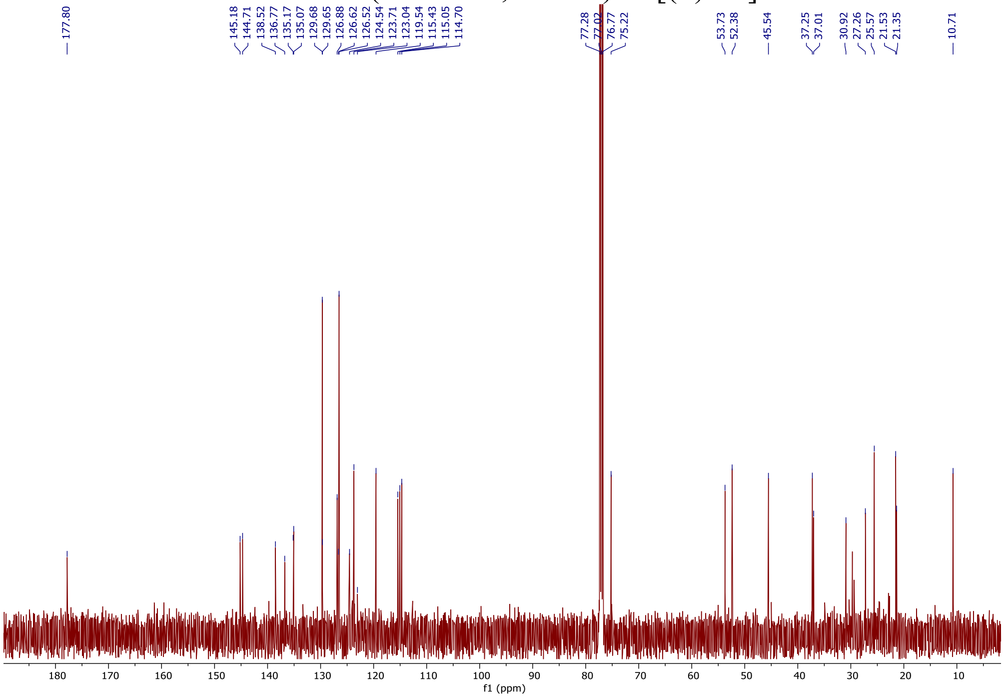
HRMS Data of Compound [(+)-**16**]



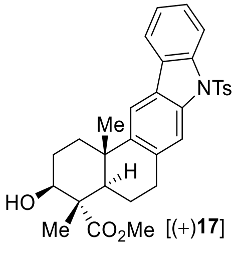
[(+)**17**]



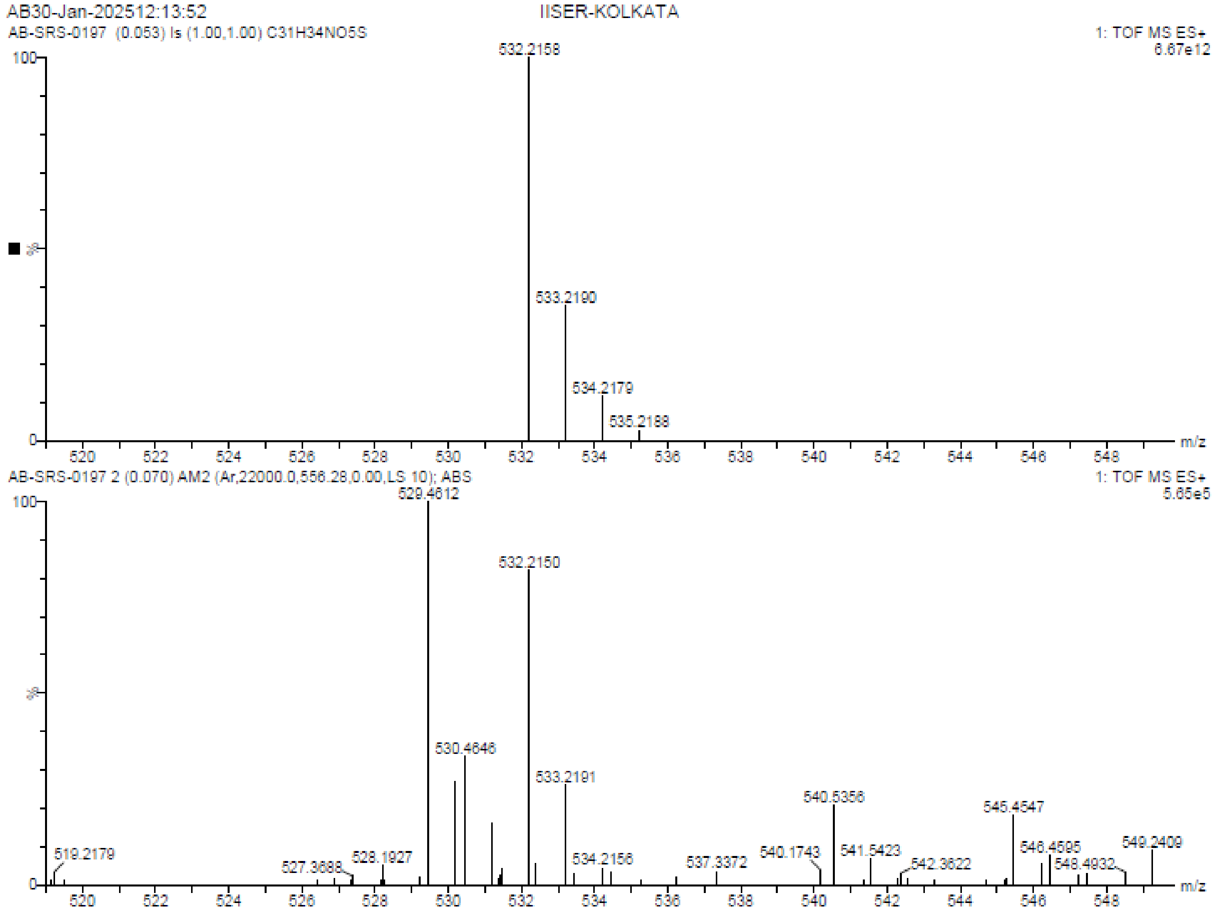
$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**17**]



$^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$) of [(+)-**17**]



[(+)**17**]



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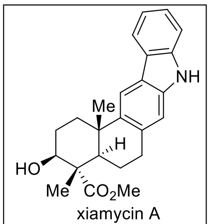
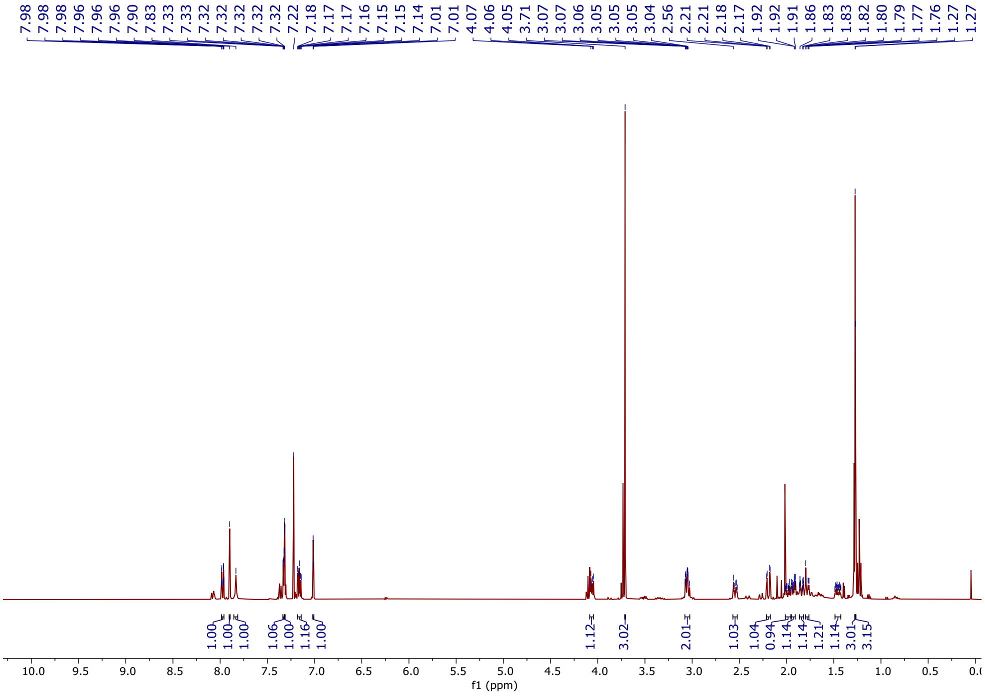
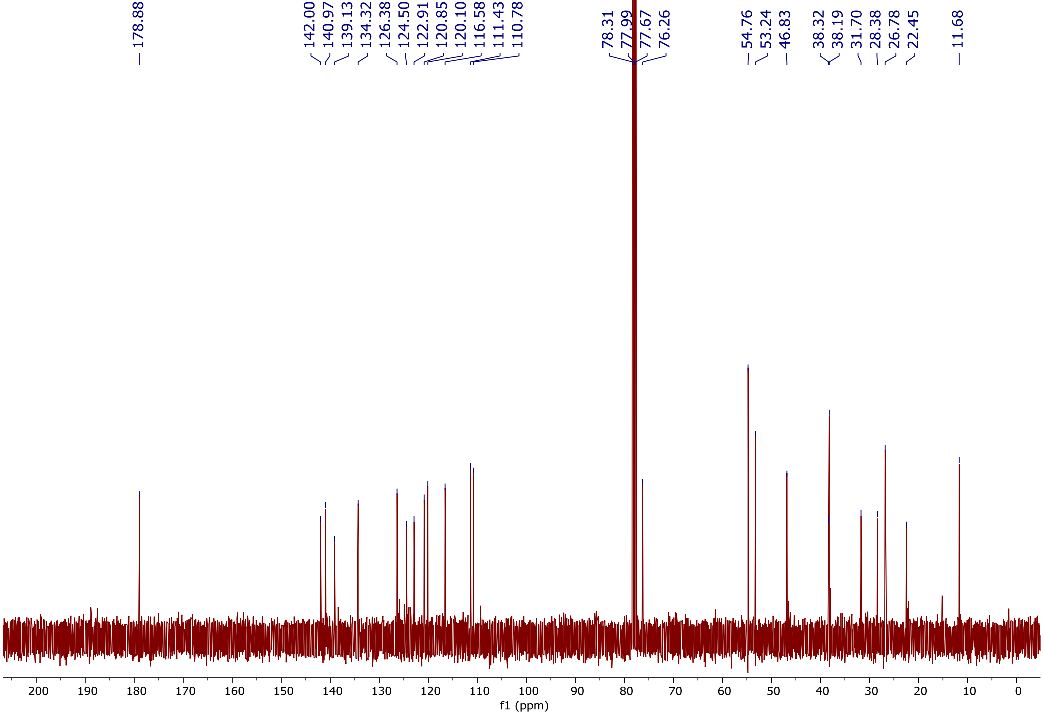


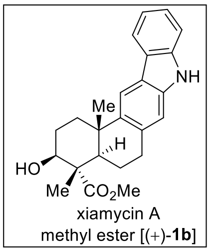
xiamycin A methyl ester [(+)-**1b**]



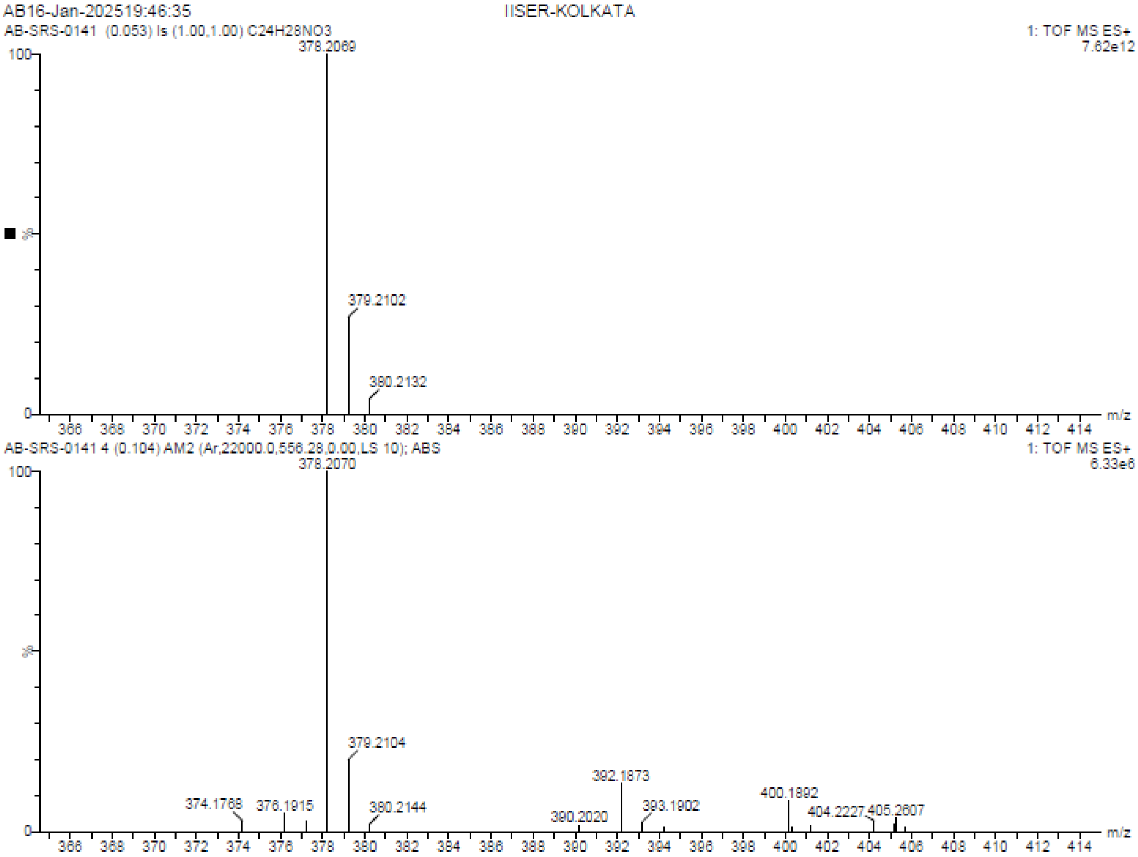
$^{1}$H NMR (400 MHz, CDCl$_3$) of [(+)-**1b**]



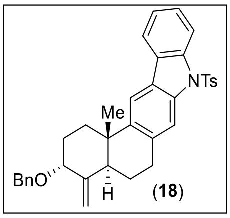
$^{13}$C {$^{1}$H} NMR (101 MHz, CDCl$_3$) of [(+)-**1b**]

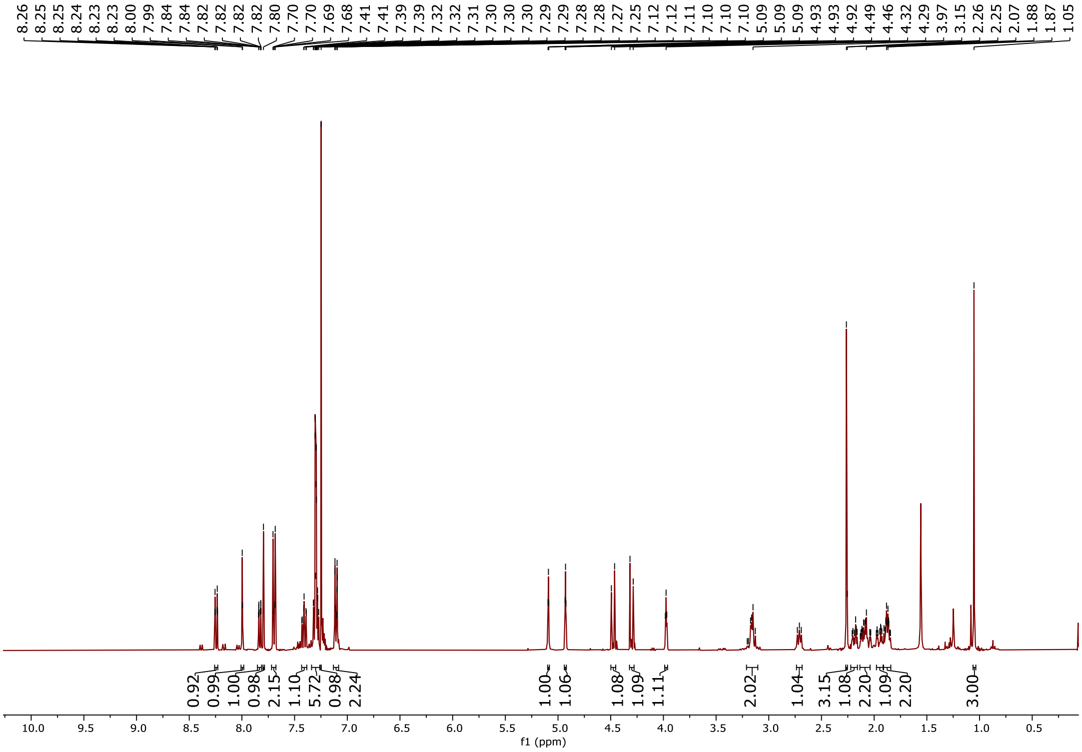


xiamycin A
methyl ester [(+)-**1b**]

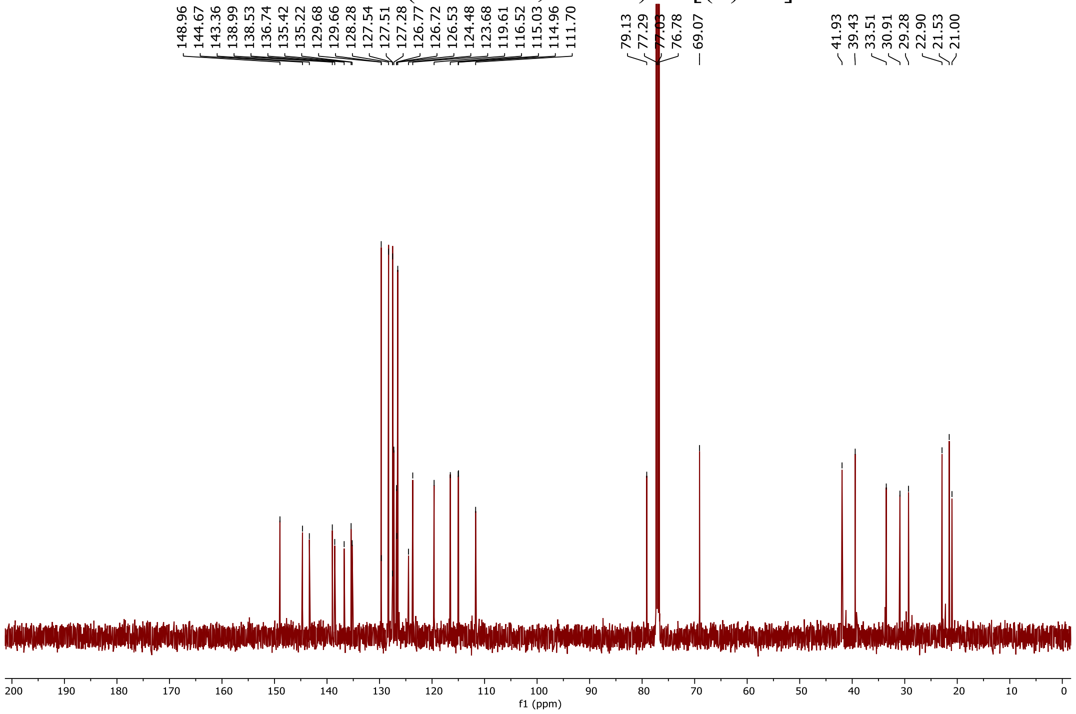


HRMS Data of Compound [(+)-**1b**]

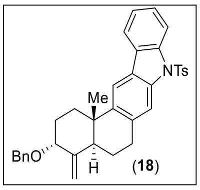


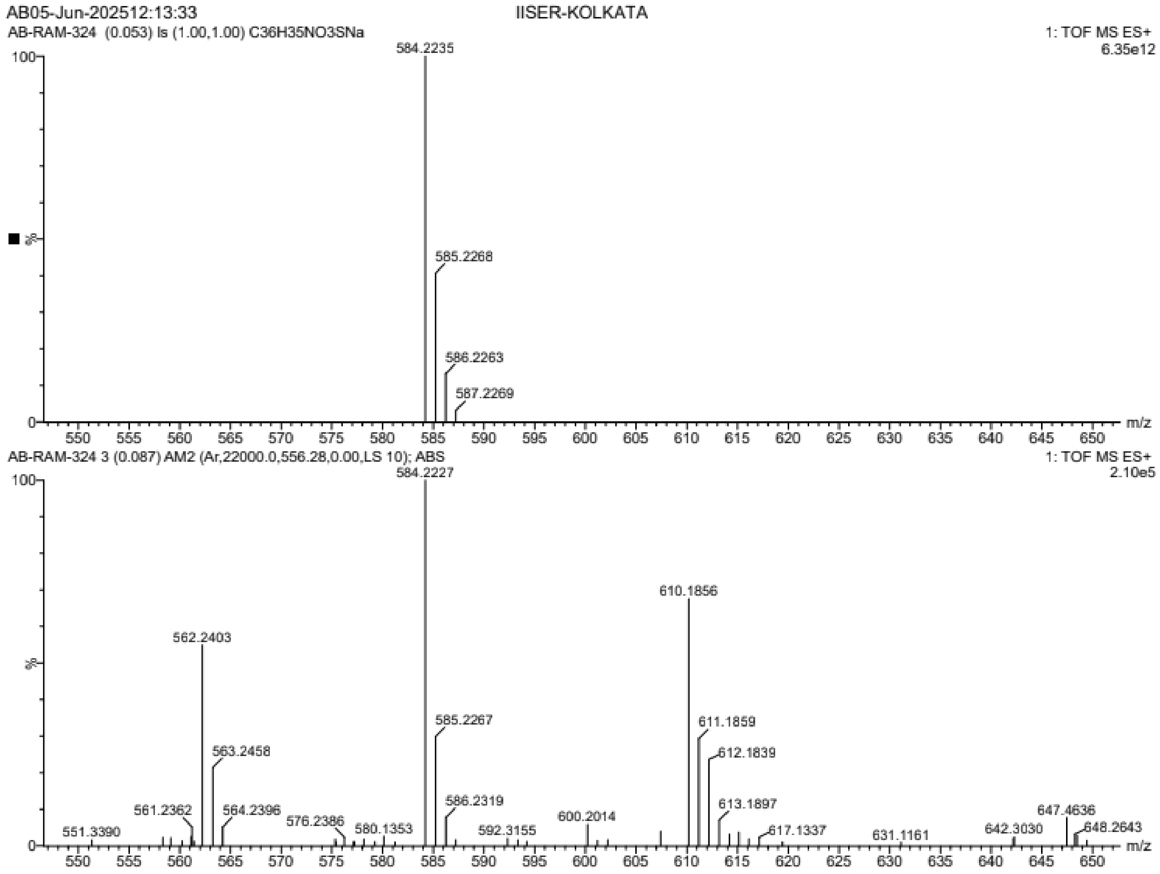


$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**18**]

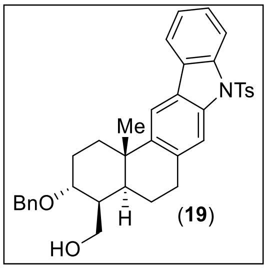


$^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$) of [(+)-**18**]





HRMS Data of Compound [(+)-**18**]



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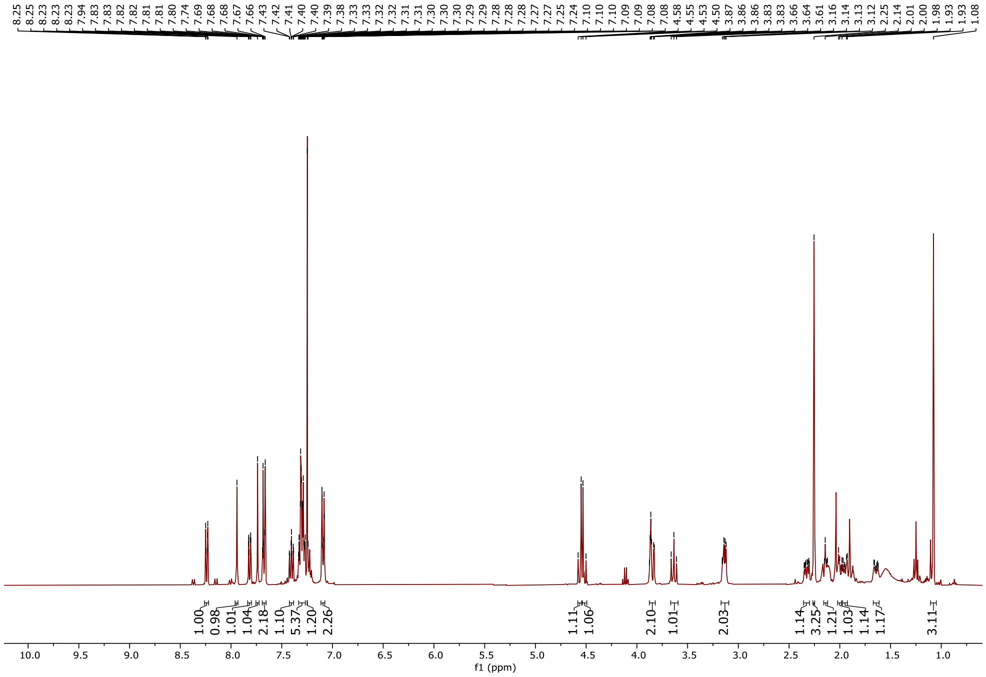
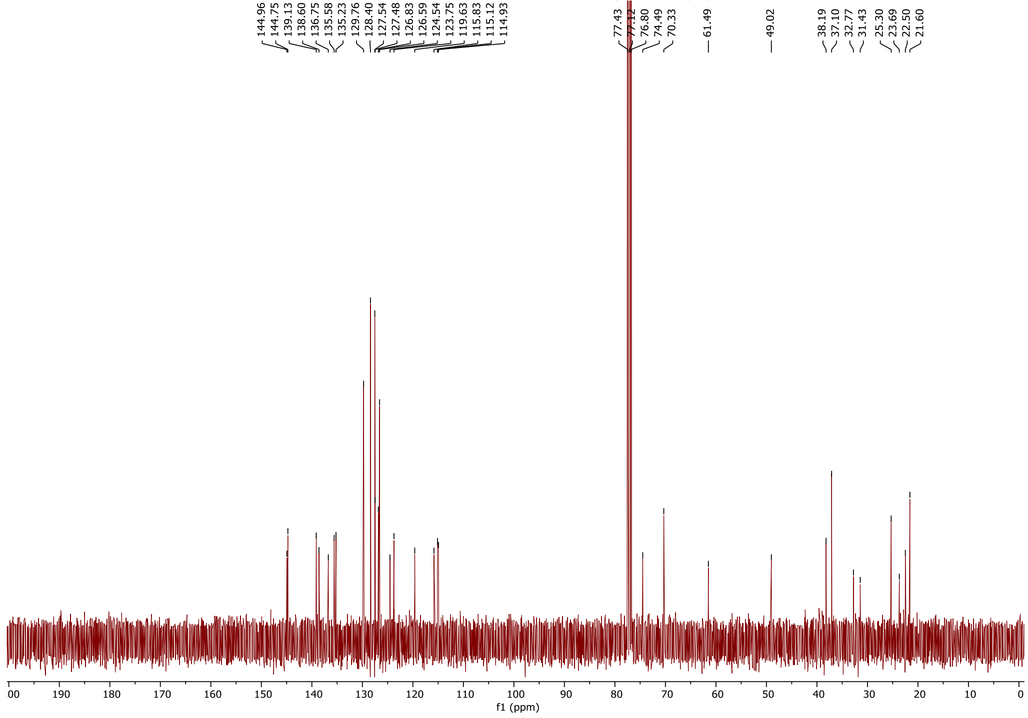
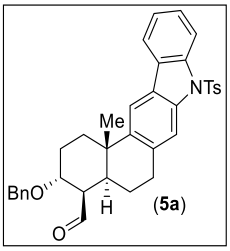
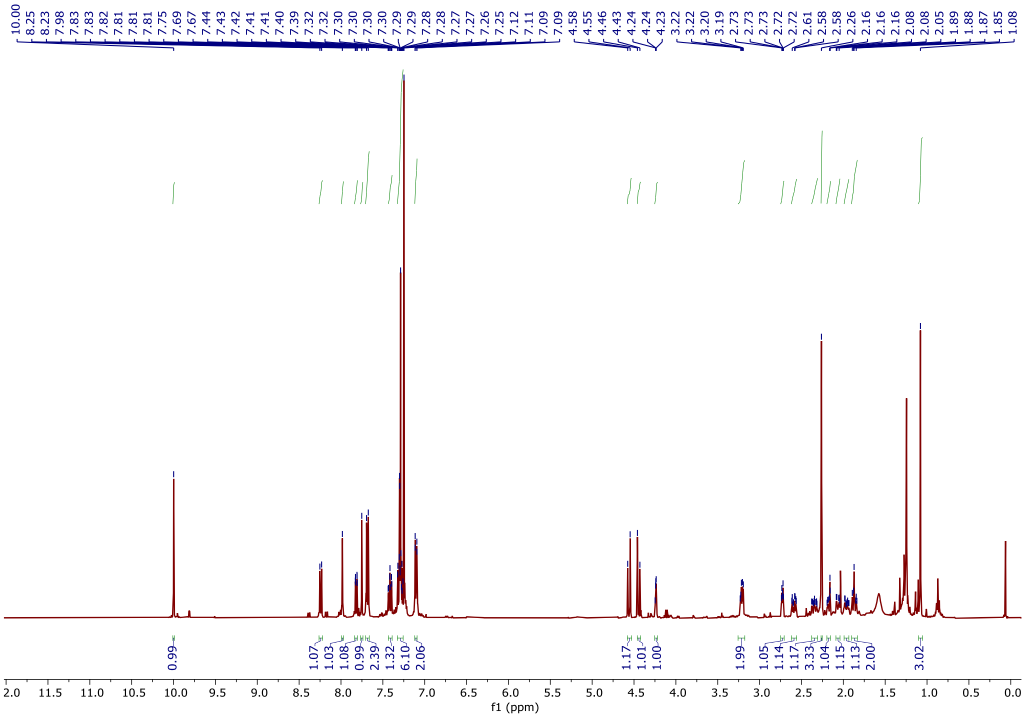


$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**19**]

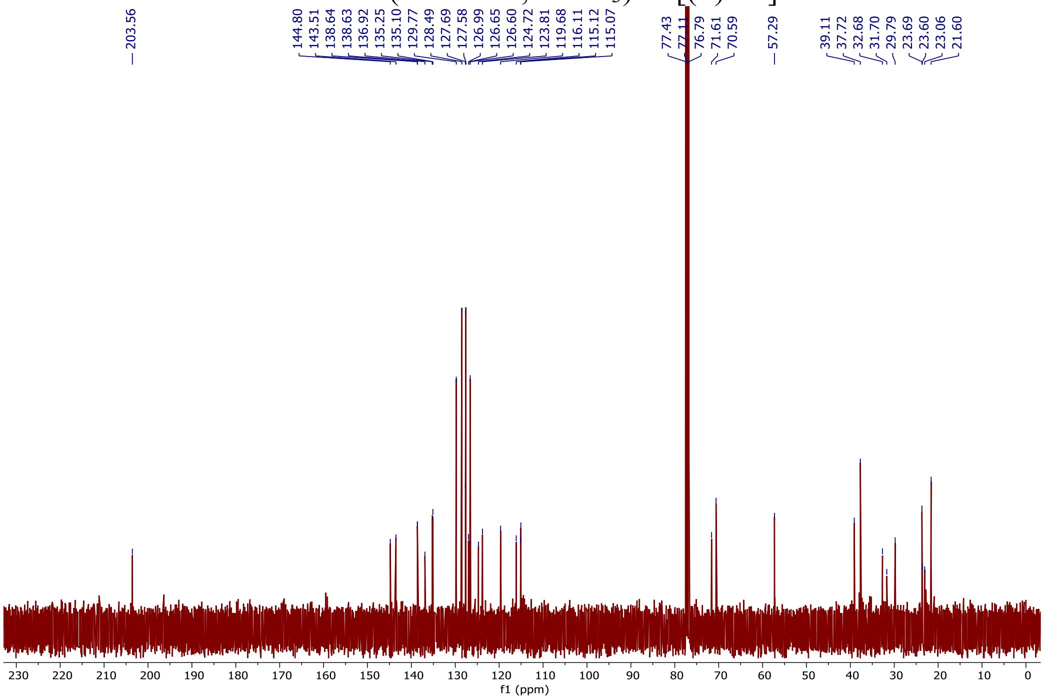


$^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$) of [(+)-**19**]

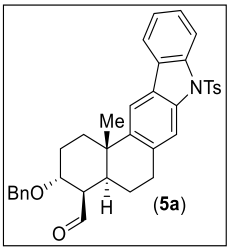




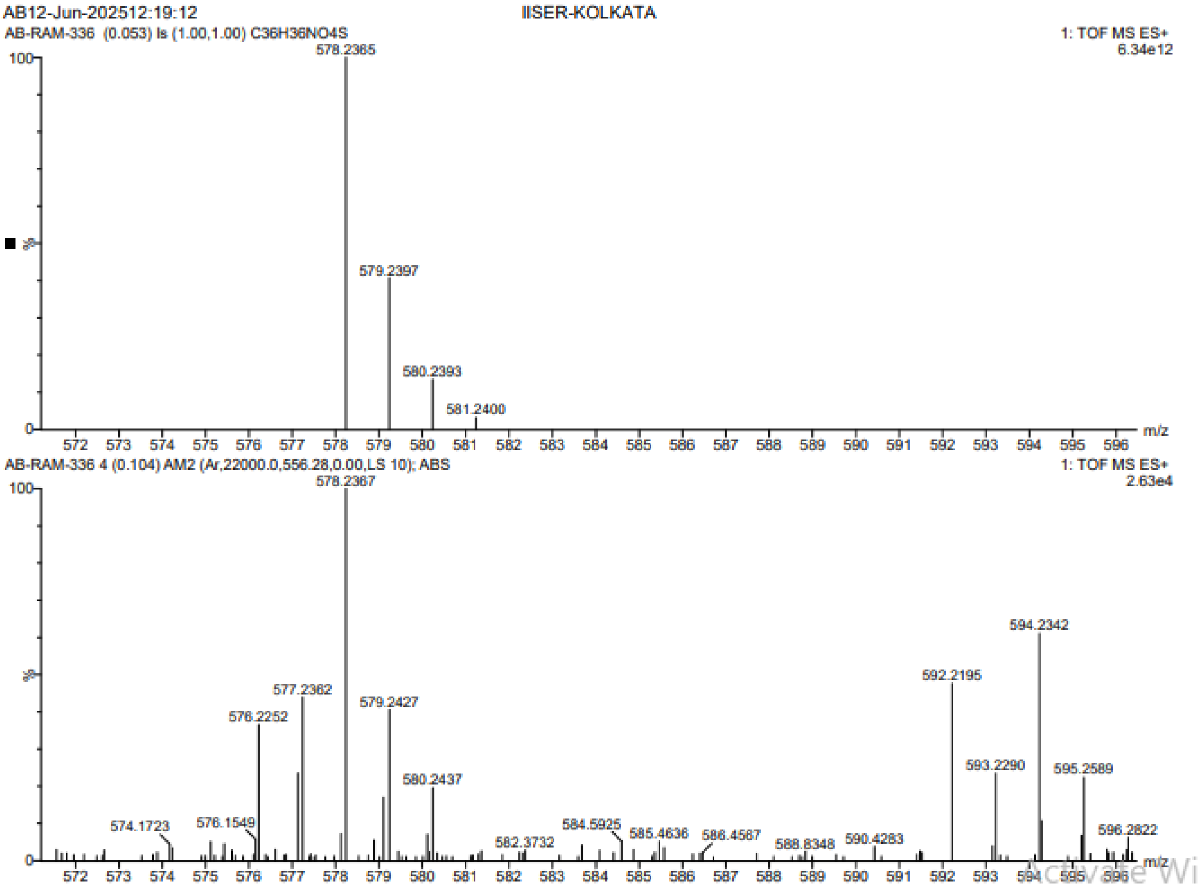
$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**5a**]



$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of [(+)-**5a**]



(5a)



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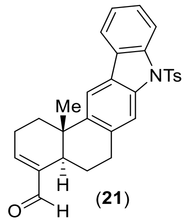

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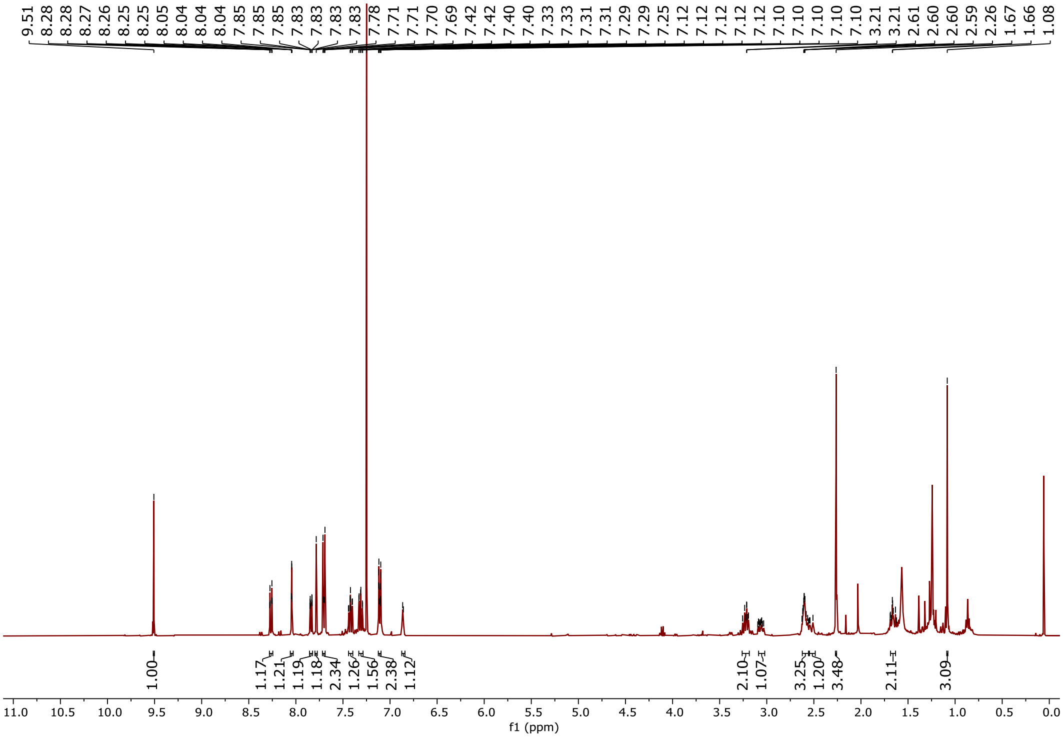
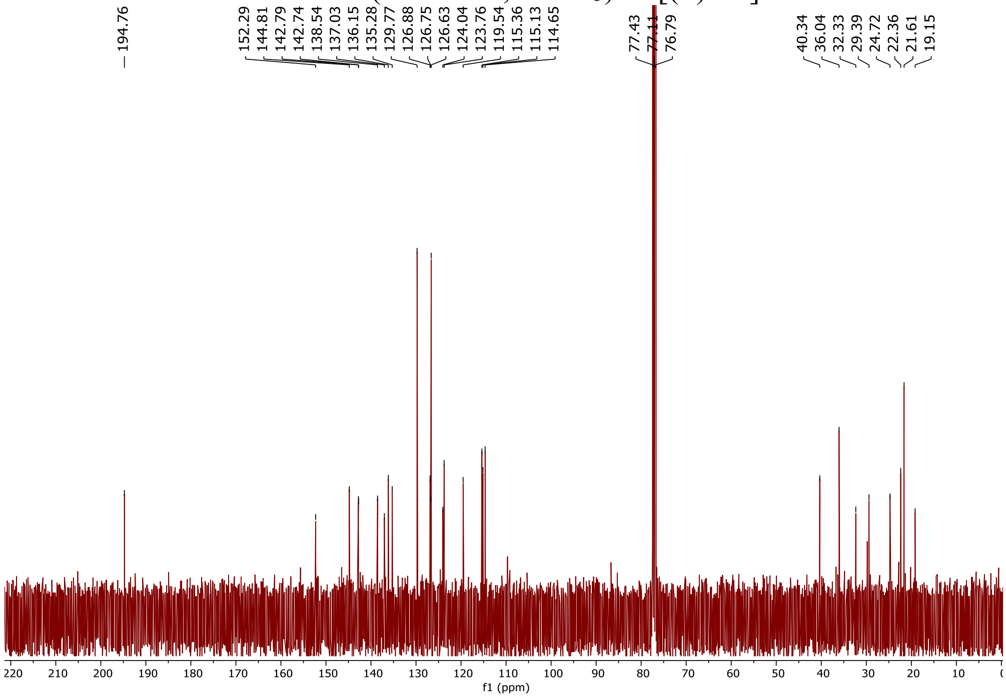
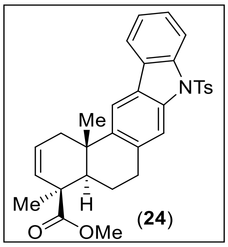
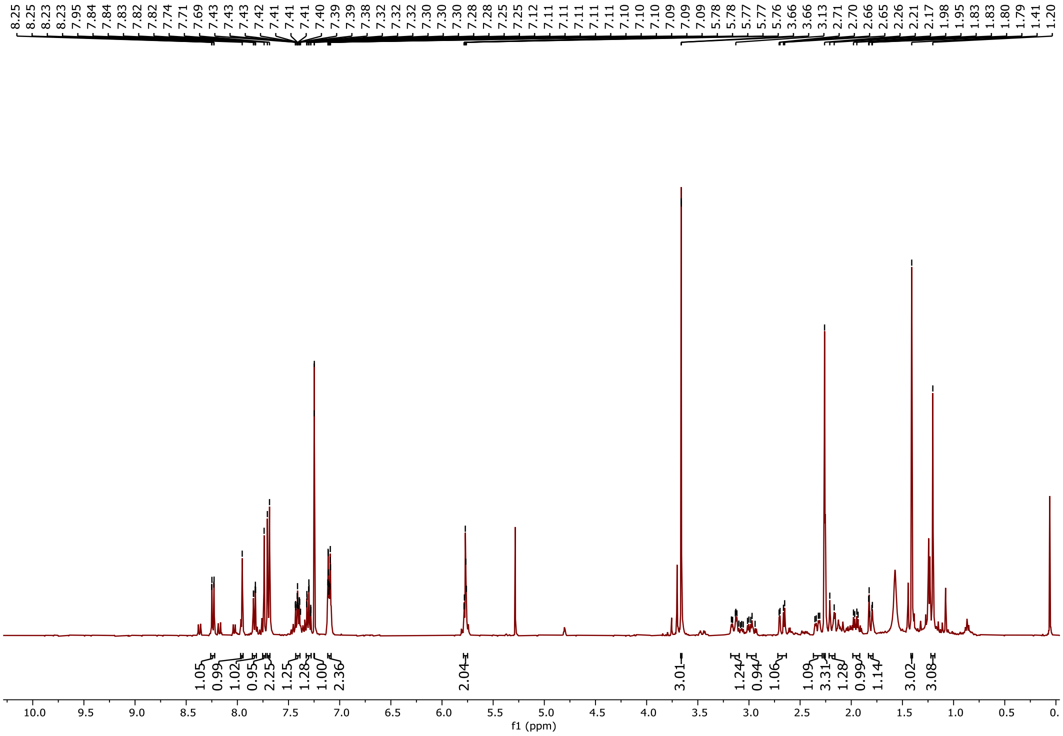


$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**21**]

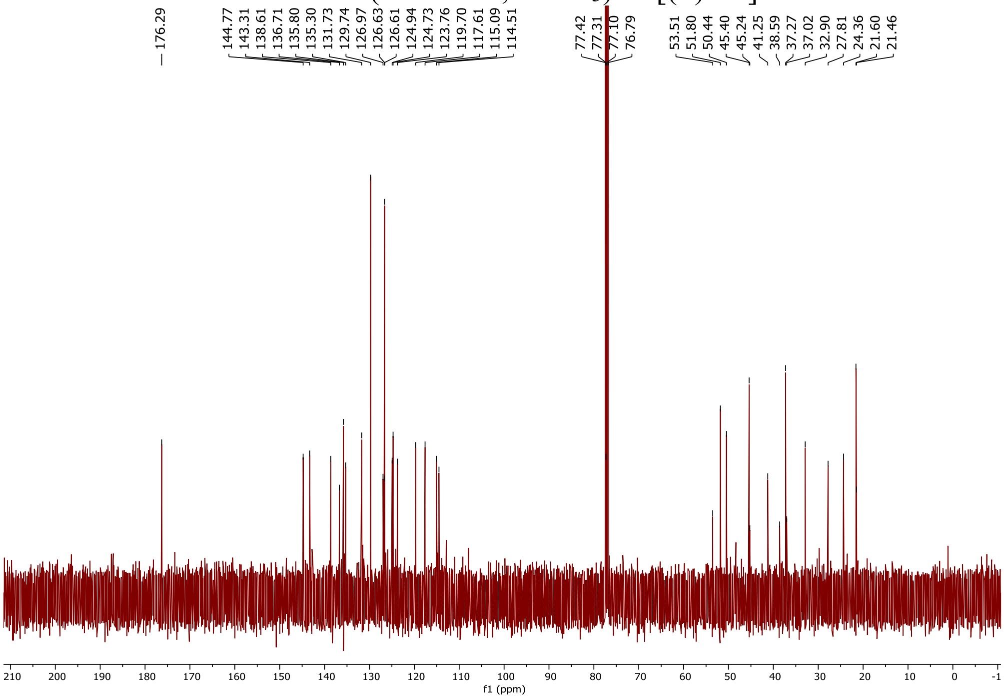


$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of [(+)-**21**]

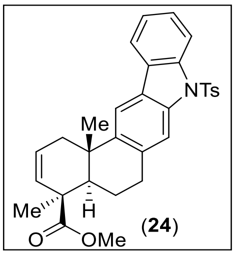




$^1$H NMR (400 MHz, CDCl$_3$) of [(+)-**24**]



$^{13}$C {$^1$H} NMR (101 MHz, CDCl$_3$) of [(+)-**24**]



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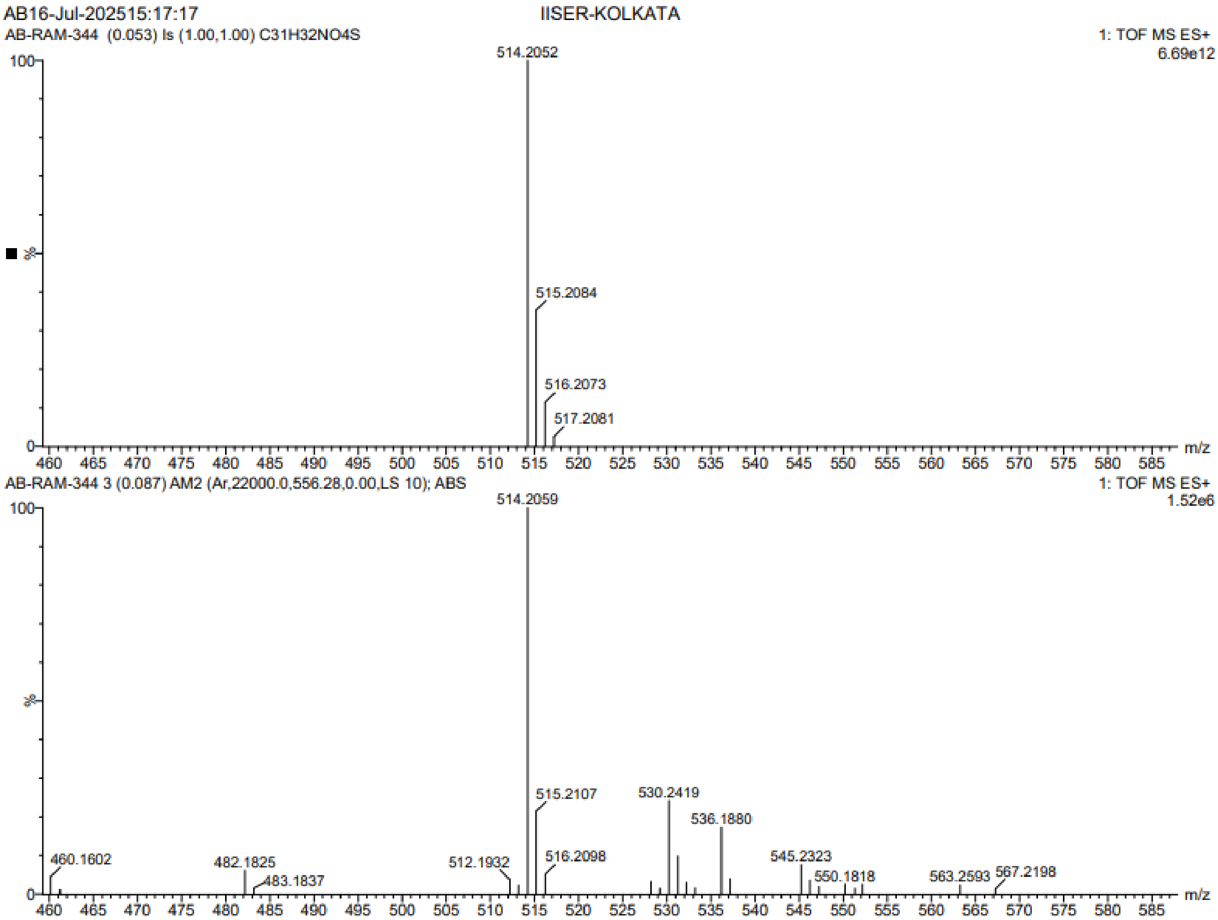
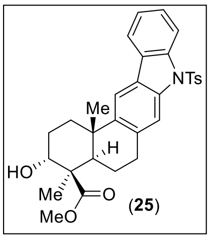
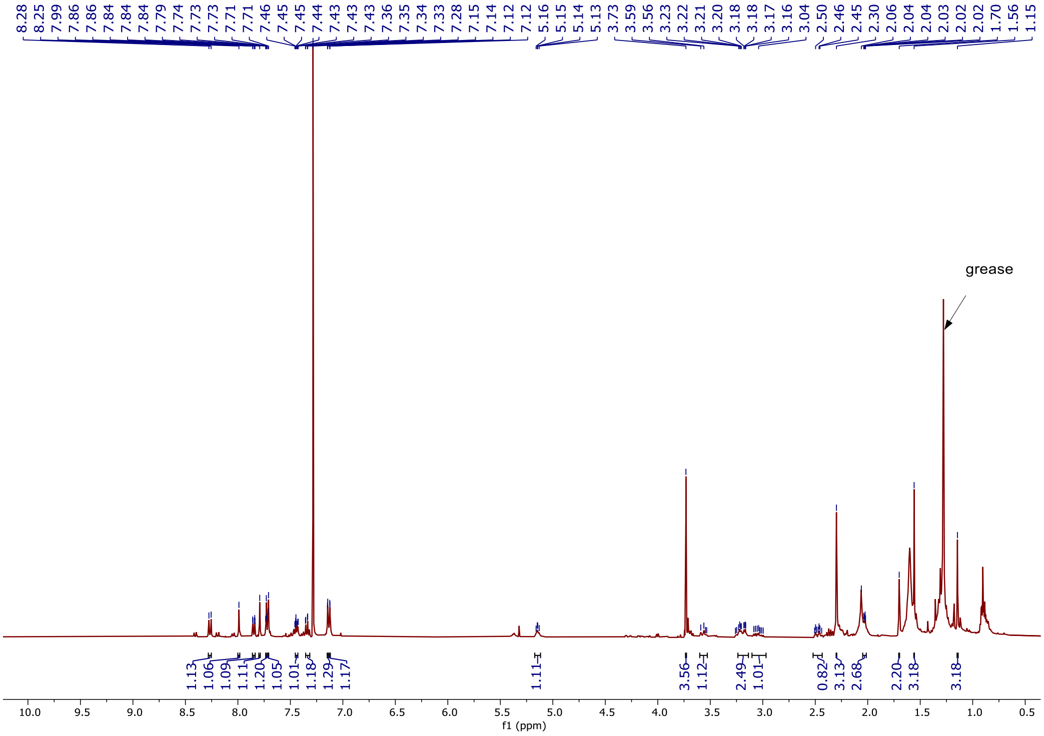


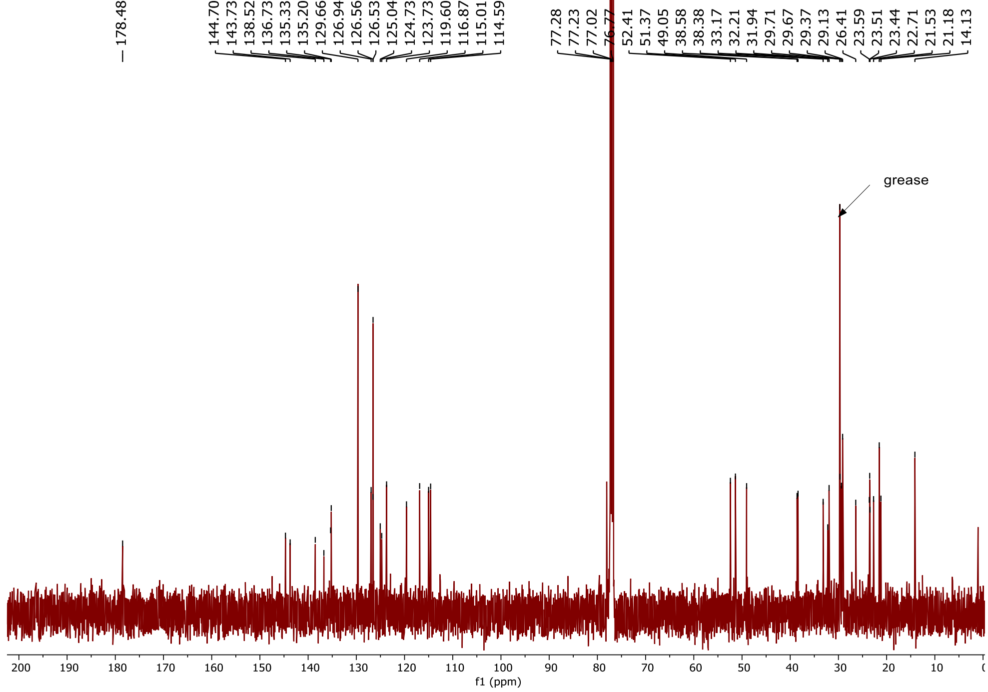
HRMS Data of Compound [(+)-**24**]



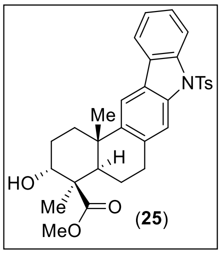
(**25**)



$^1$H NMR (400 MHz, $CDCl_3$) of [(+)-**25**]



$^{13}$C {$^1$H} NMR (126 MHz, $CDCl_3$) of [(+)-**25**]



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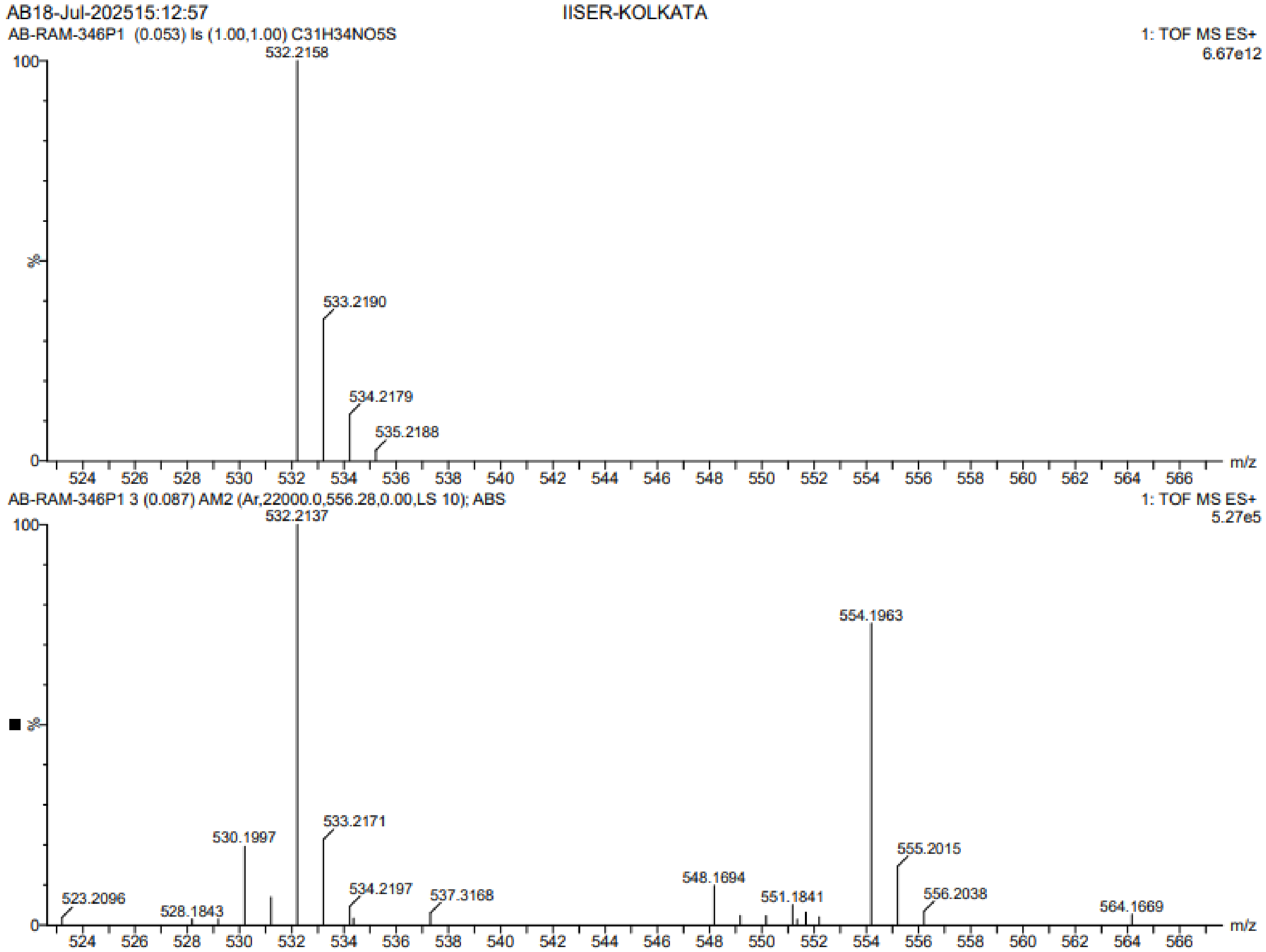
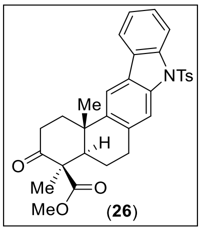
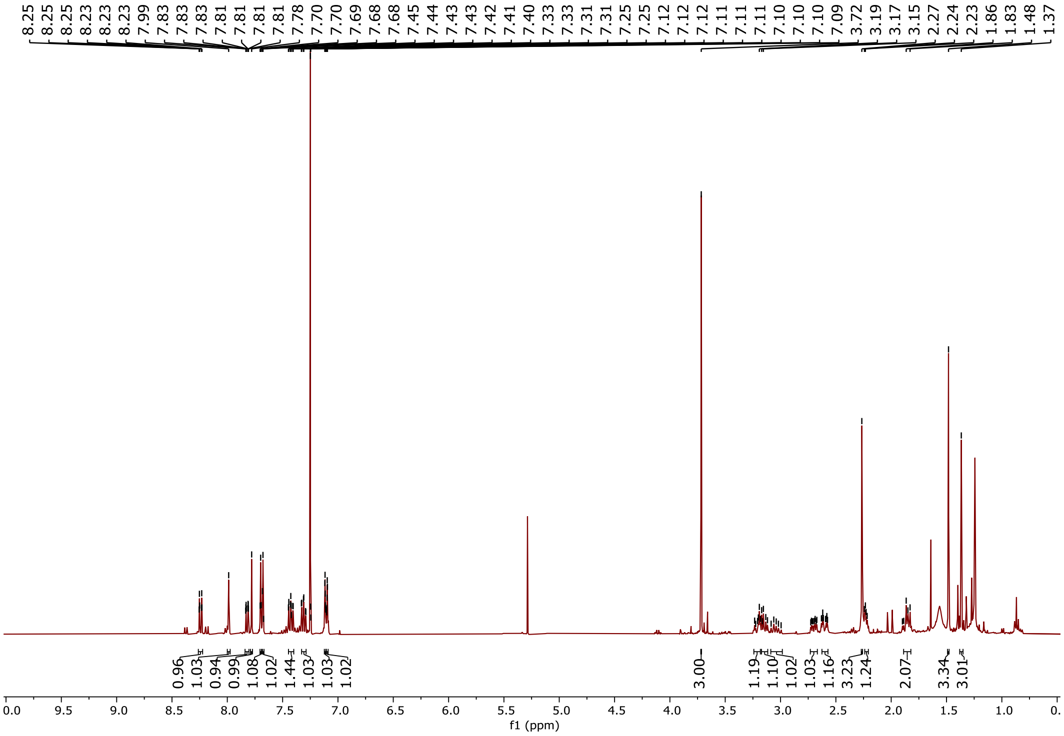


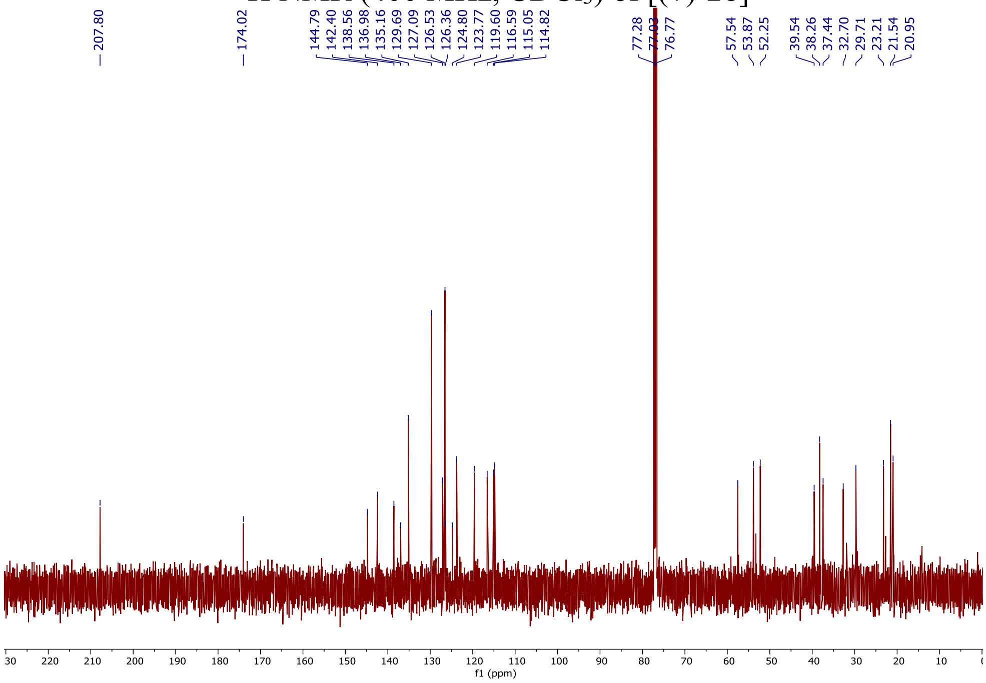
HRMS Data of Compound [(+)-**25**]



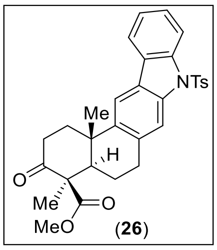
(**26**)

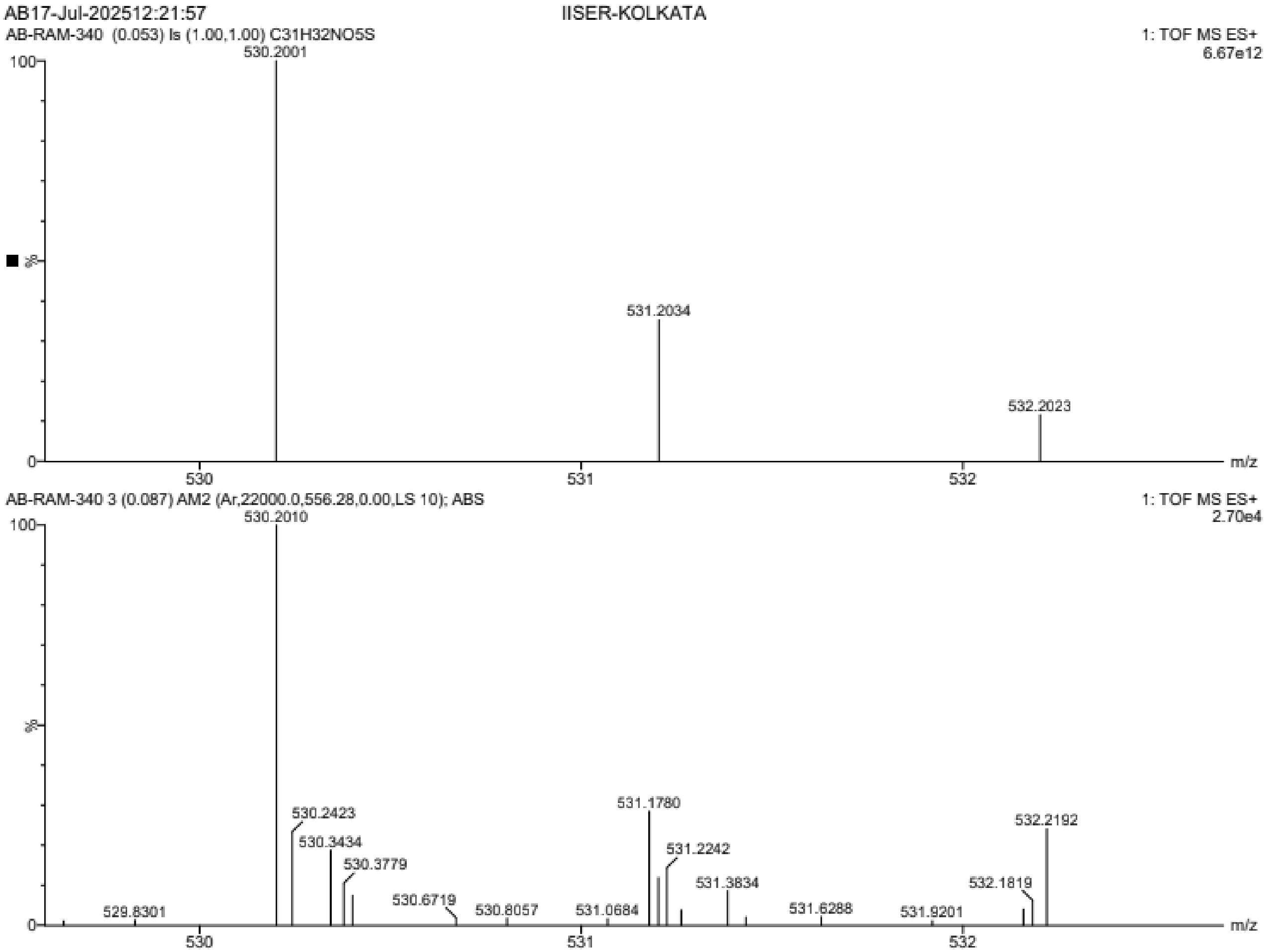


$^{1}$H NMR (400 MHz, CDCl$_3$) of [(+)-**26**]

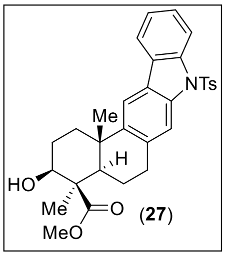


$^{13}$C {$^{1}$H} NMR (126 MHz, CDCl$_3$) of [(+)-**26**]





HRMS Data of Compound [(+)-**26**]



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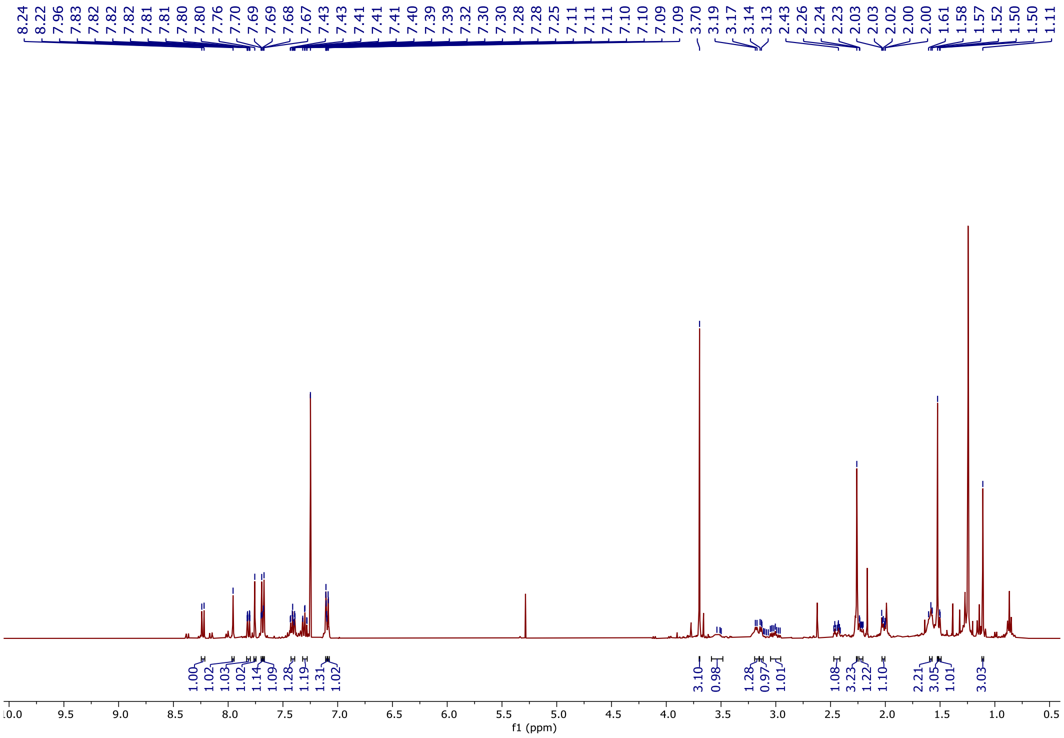
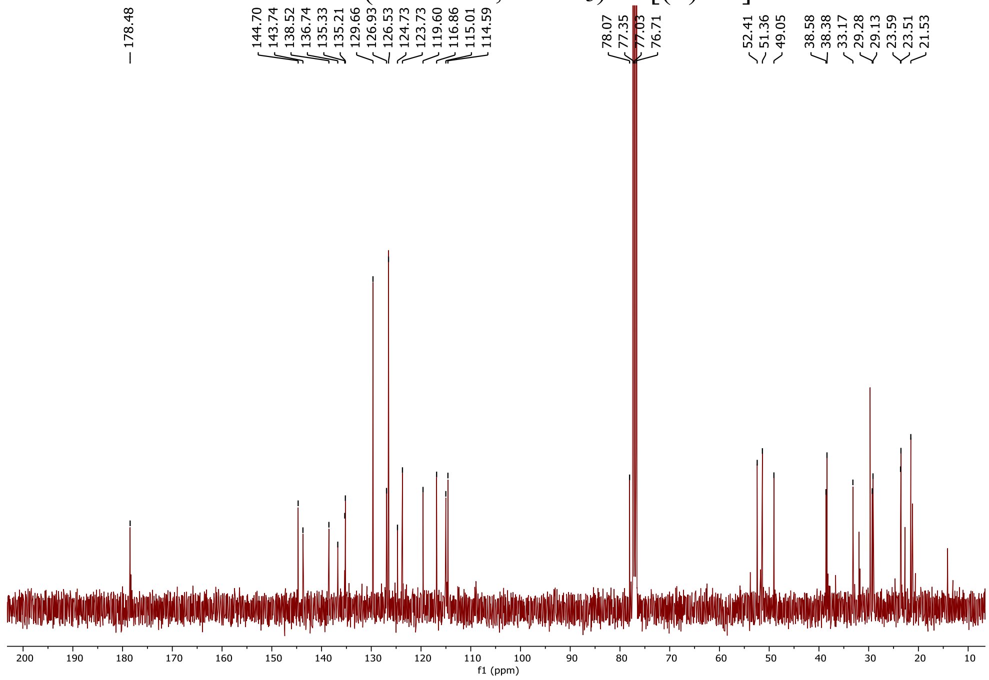
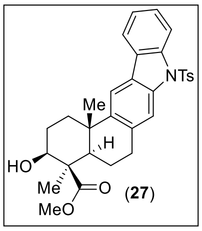


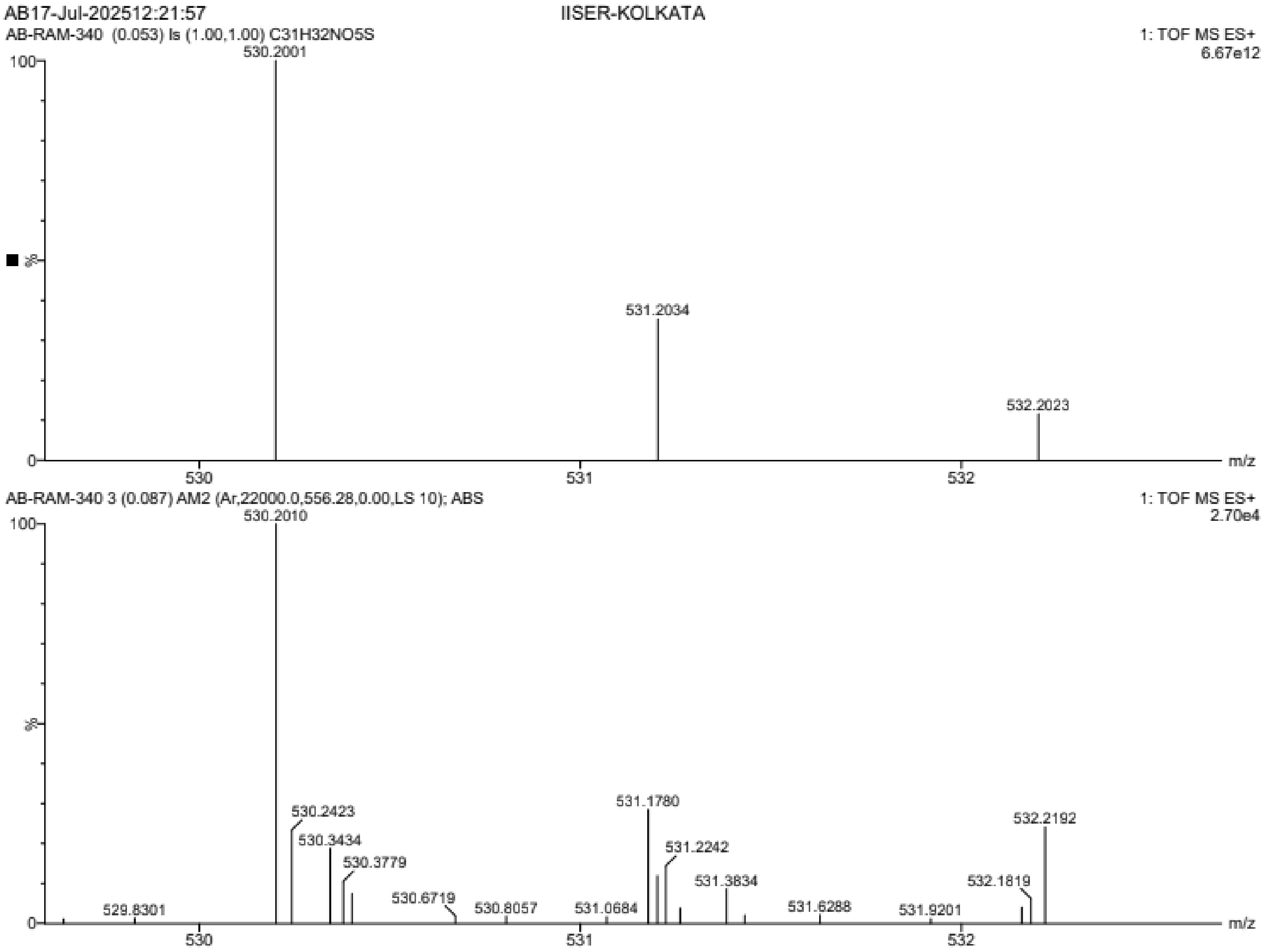
$^{1}$H NMR (400 MHz, CDCl$_3$) of [(+)-**27**]



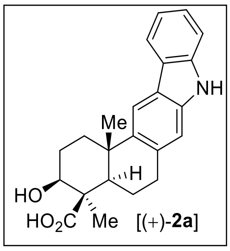
$^{13}$C {$^{1}$H} NMR (126 MHz, CDCl$_3$) of [(+)-**27**]

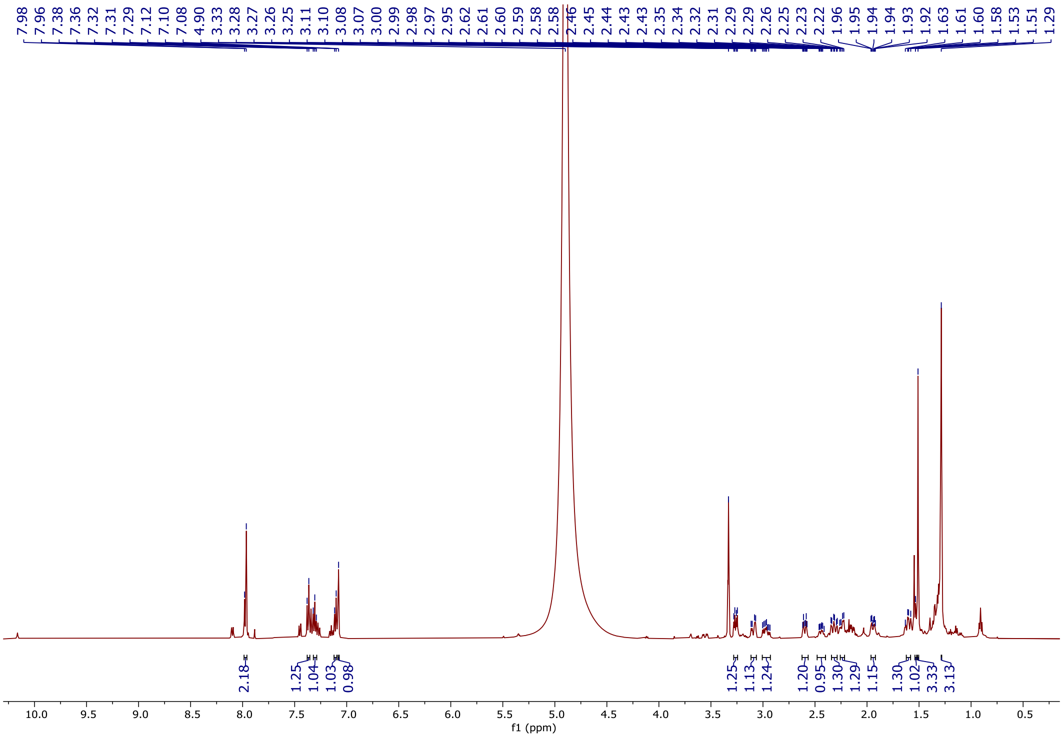


(**27**)

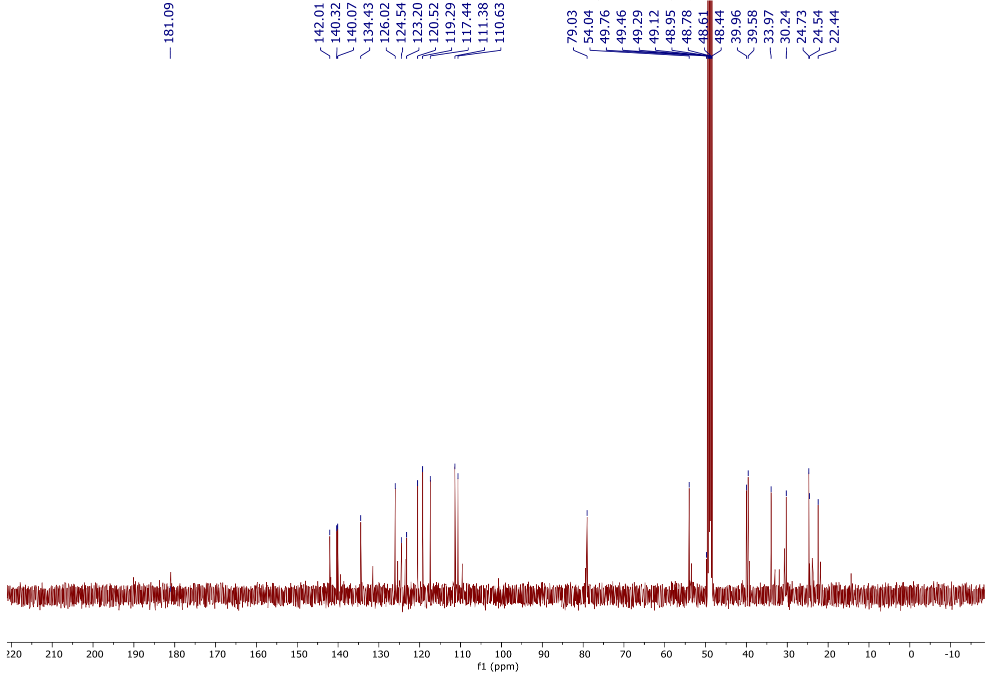


HRMS Data of Compound [(+)-**27**]

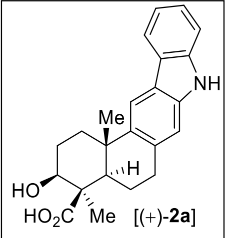




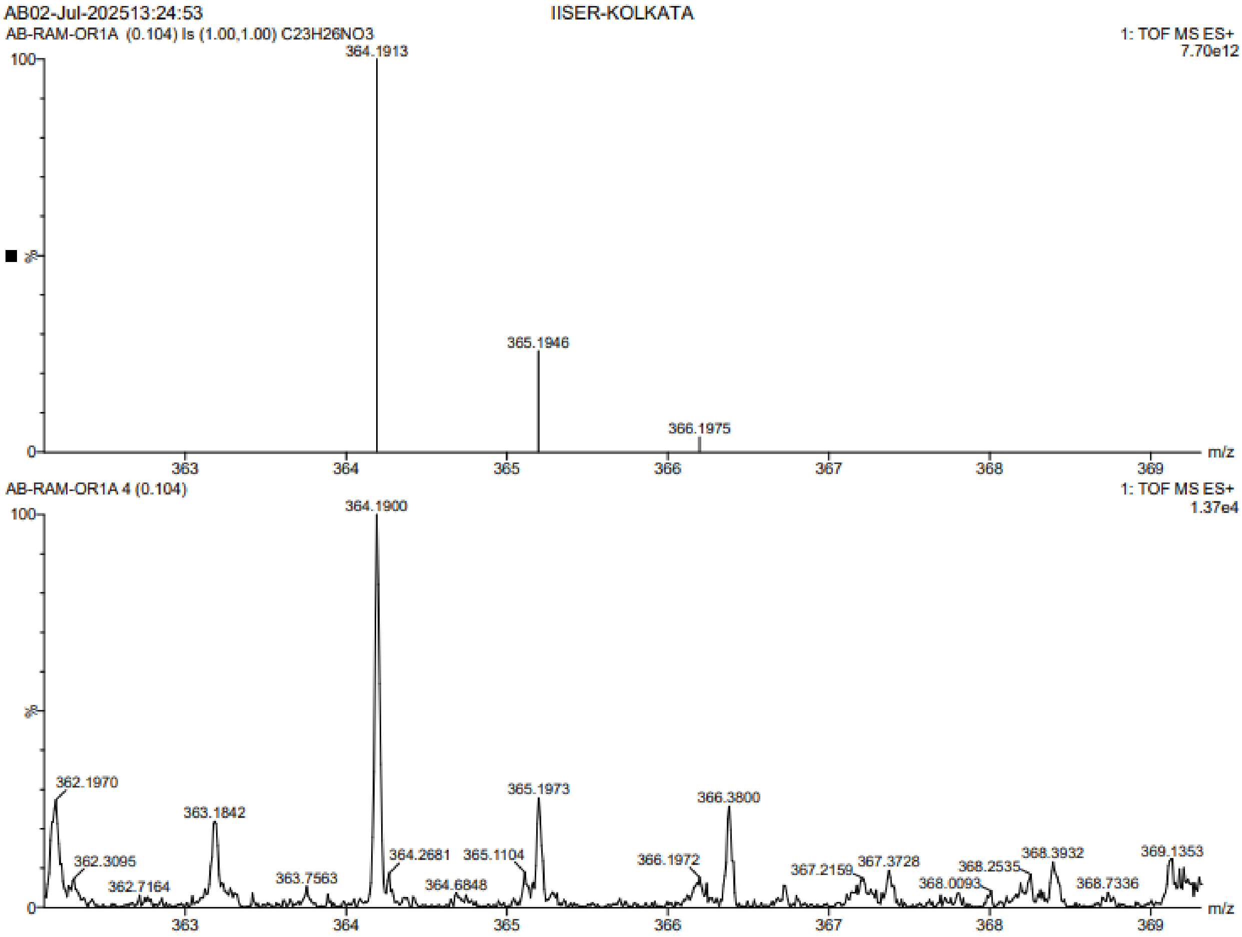
$^1$H NMR (500 MHz, MeOD) of [(+)-**2a**]



$^{13}$C {$^1$H} NMR (126 MHz, MeOD) of [(+)-**2a**]



[(+)-**2a**]



HRMS Data of Compound [(+)-**2a**]

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