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Electronic Supplementary Information for

# Electrochemical deoxygenative reduction of ketones

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# Contents

## 1. General information

Reagents were purchased at the highest commercial quality grade and used without further purification, unless otherwise stated. Yields refer to chromatographically and spectroscopically ($^1$H NMR) homogeneous material, unless otherwise stated. Reactions were monitored by thin layer chromatography (TLC) carried out on 0.25 mm E. Merck silica plates (60F-254), using UV light (254 nm) and TLC stain with 2,4-dinitrophenylhydrazine-sulfuric acid for visualization. Flash chromatography columns were packed with 200-300 mesh silica gel in petroleum (bp. 60-90 ℃). $^1$H, $^{13}$C and $^{19}$F NMR data were recorded with Bruker (400 MHz) or Jeol (400 MHz) spectrometers with tetramethylsilane as an internal standard. All chemical shifts ($\delta$) are reported in ppm and coupling constants ($J$) in Hz. All chemical shifts were reported relative to tetramethylsilane (0 ppm for $^1$H), $CDCl_3$ (77.0 ppm for $^{13}$C) and DMSO-d6 (2.5 ppm for $^1$H, 40.0 ppm for $^{13}$C).

## 2. Experimental procedures

### 2.1 Electrode materials and dimensions

The instrument for undivided electrolysis is IKA® ElectraSyn 2.0 with carousel. The electrodes used in IKA® ElectraSyn 2.0 were purchased from IKA Company. The anodic electrode was the carbon electrode (3.0 cm × 0.8 cm × 0.2 cm) (3.0 cm is the height of the electrode immersed in the solution) and the cathodic electrode was the nickel plate (3.0 cm × 0.8 cm × 0.2 cm).

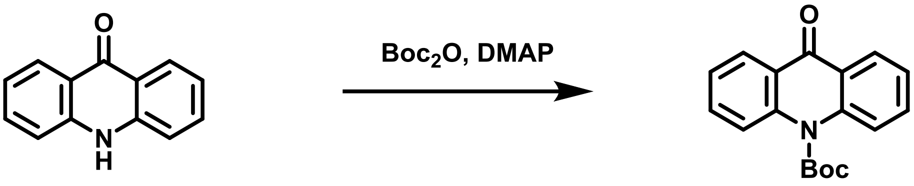
IKA ElectraSyn 2.0

IKA Carousel complete

Cyclic voltammograms were recorded on an electrochemical workstation CS150H (CorrTest®). A steady glassy carbon disk electrode (3 mm in diameter) was used as the working electrode; a platinum plate was used as the counter electrode; the reference was an Ag/$AgNO_3$ electrode with (0.01 M) $AgNO_3$ in acetonitrile.

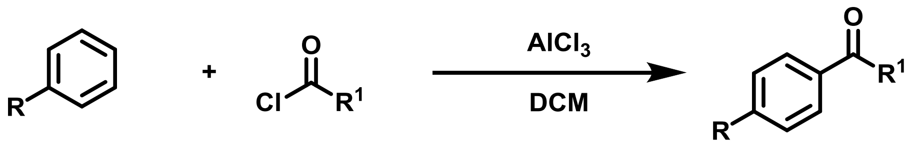
## 2.2 General procedure for the preparation of ketones

**General procedure A[1]:**



To a solution of acridone (500 mg, 2.56 mmol, 1 equiv.) and $Boc_2O$ (837 mg, 3.84 mmol, 1.5 equiv.) in MeCN (8 mL) at room temperature, DMAP (468 mg, 3.84 mmol, 1.5 equiv.) was added. The reaction mixture was stired at rt for 8 h followed by 3 h at 60 ℃. The solvent was removed under vacuum, the crude was dissolved in $Et_2O$. The resulting solution was washed with a diluted solution of HCl (0.1 M), brine and dried over $MgSO_4$. After evaporation of the solvent the crude product purified by column chromatography (pentane/$Et_2O$ 2:1) to obtain the compound **1e** as a white solid.

**General procedure B[2]:**



Acetyl chloride (0.46 mL) was added in a dropwise manner to a mixture of aluminium chloride (0.86 g, 21 mmol) in anhydrous DCM (100 mL). The slurry was left to stir for 30 min after which, biphenyl (0.50 g, 10.6 mmol) was added. The reaction mixture was then left to stir for 14 h. The reaction was quenched using a mixture of ice and water (150 mL) and the organic layer washed with aqueous hydrochloric acid solution (HCl) (0.5 M, 2 × 50 mL), water (100 mL), saturated sodium bicarbonate solution ($NaHCO_3$) (50 mL) and water (2 × 100 mL). The combined organic layer was dried over anhydrous magnesium sulfate ($MgSO_4$) filtered and the solvent was removed under vacuum to give the substrates **1m**, **1w and 1x.**

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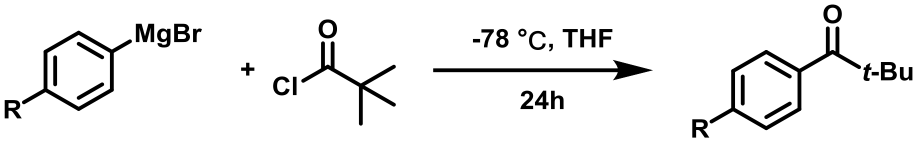
[1] T. Stopka, L. Marzo, M. Zurro, S. Janich, E. Würthwein, C. G. Daniliuc, J. Alemán,and O. G. Mancheño, *Angew. Chem. Int. Ed.*, 2015, **54**, 5049–5053.

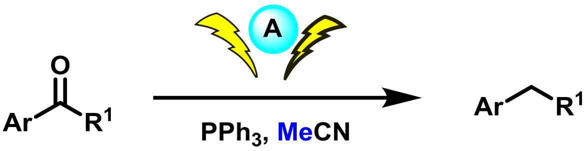
[2] R. K. Lota, S. Dhanani, C. P. Owen and S. Ahmed, *Letters in Drug Design & Discovery*, 2007, **4**, 180–184.

**General procedure C[3]:**



To a cooled (-78 ℃) solution of pivaloyl chloride (3 mL) in THF (20 mL) was added a solution of freshly prepared arylmagnesium bromide (1.2 mmol in THF, 20 mL) under $N_2$ atmosphere. The solution was stirred for 24 h at the same temperature, then was allowed to warm to room temperature. The mixture was diluted with saturated aqueous $NH_4Cl$ solution (30 mL) and extracted with DCM (30 mL × 3). The extract was filtered and concentrated under reduced pressure and the crude mixture was purified by silica gel column chromatography to obtain the substrate **1y**.

## 3. General procedure for the electrochemical reduction of ketone



The electrolysis was carried out in the electrolysis cell of IKA® ElectraSyn 2.0. The anodic electrode was the carbon electrode (3.0 cm × 0.8 cm × 0.2 cm) and the cathodic electrode was the nickel plate (3.0 cm × 0.8 cm × 0.2 cm). Aryl ketones (0.5 mmol), $Et_4NBr$ (105.0 mg, 0.5 mmol), $PPh_3$ (655.0 mg, 2.5 mmol), MeCN (4 mL) were added to an oven-dried undivided cell (6 mL) equipped with a stirring bar (the order of the addition did not affect the result). Then the reaction mixture was stirred and electrolyzed at a constant current of 20 mA at room temperature for 8 h. When the reaction was finished, the solvent was evaporated under vacuum and the crude material was purified by column chromatography or preparative TLC to furnish the desired product.

## 4. Procedure for gram-scale synthesis

The electrolysis was carried out in the electrolysis cell of IKA® ElectraSyn 2.0. The anodic electrode was the carbon electrode (3.0 cm × 0.8 cm × 0.2 cm) and the cathodic electrode was the nickel plate (3.0 cm × 0.8 cm × 0.2 cm). According to General Procedure, starting 9H-fluoren-9-one (1.4 g, 8.0 mmol) was reacted with $PPh_3$ (10.5 g, 40 mmol) were added to an oven-dried undivided cell with MeCN (25 mL) equipped with a stirring bar. The reaction mixture was stirred and electrolyzed at a constant current of 40 mA at room

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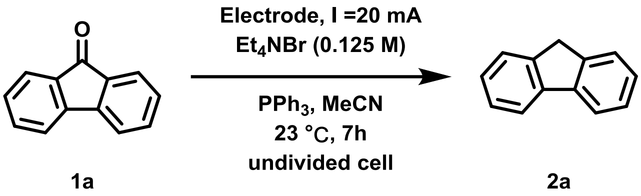
[3] J. Chen, Z. Zhang, B. Li, F. Li, Y. Wang, M. Zhao, I. D. Gridnev, T. Imamoto and W. Zhang, *Nat. Commun.*, 2018, **9**, 5000–5009.

temperature for 48 h. Solvent was evaporated under vacuum and the crude material was purified by column chromatography (petroleum ether) to afford the title compound as a white solid in 60% yield (0.8 g).

## 5. Optimization of the reaction conditions

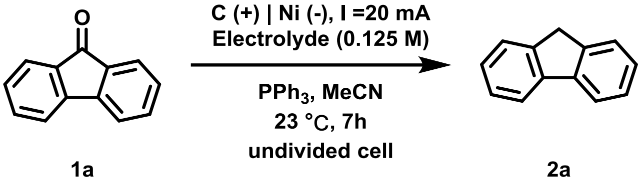
### Table S1. Optimization of the electrode material



| Entry | Electrode | Yield[a] |
|---|---|---|
| 1 | C (+)\|Ni (-) | **72%** |
| 2 | C (+)\|Pt (-) | <5% |
| 3 | C (+)\|C (-) | 50% |

[a] Isolated yields after chromatography were reported.

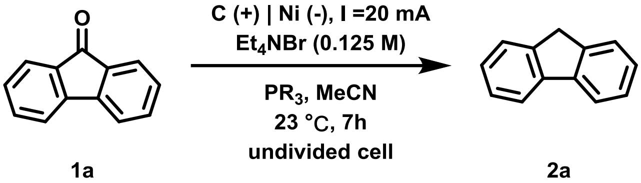
### Table S2. Optimization of the electrolyde.



| Entry | Electrolde | Yield[a] |
|---|---|---|
| 1 | $^{n}Bu_4NBr$ | 45% |
| 2 | $Et_4NI$ | 35% |
| 3 | $Et_4NPF_6$ | 54% |
| 4 | $Et_4NClO_4$ | 36% |

[a] Isolated yields after chromatography were reported.

### Table S3. Optimization of the $PR_3$.



| Entry | $PR_3$ | Yield[a] |
|---|---|---|
| 1 | $^{n}Bu_3P$ | 45% |
| 2 | $Cy_3P$ | 14% |
| 3 | $[N(Me)_2]_3P$ | 29% |
| 4 | $(PhO)_3P$ | 54% |

[a] Isolated yields after chromatography were reported.

## 6. Procedure for cyclic voltammetry (CV)

Cyclic voltammetry was performed in a three-electrode cell under air at room temperature. A steady glassy carbon disk electrode (3 mm in diameter) was used as the working electrode; a platinum plate was used as the counter electrode; the reference was an $Ag/AgNO_3$ electrode with (0.01 M) $AgNO_3$ in acetonitrile. 8 mL acetonitrile solvent containing (0.025 M) $Et_4NBr$ was used as the blank. The spectrums were recorded with the scan rate of 100 mV $s^{-1}$ (starting from 0 V). The CV of Background, $PPh_3$ and Benzophenone were conducted respectively.

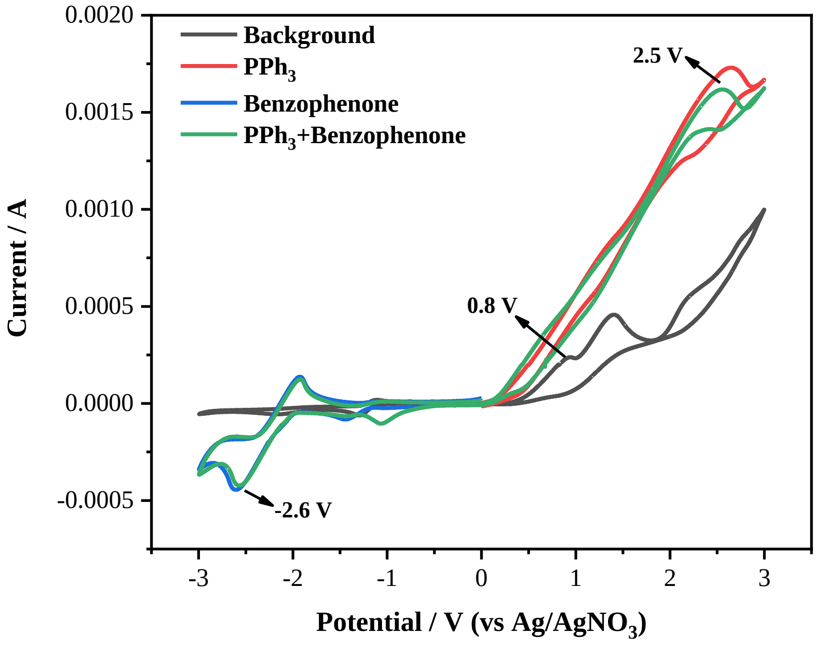
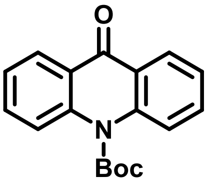


**Fig 1**. Cyclic voltammograms recorded in (0.025 M) $Et_4NBr$-MeCN solution: scan rate: 100 mV $s^{-1}$; starting potential: 0 V; glass carbon (3 mm diameter, Working Electrode); platinum plate (Counter Electrode); $Ag/AgNO_3$ (0.01 M) $AgNO_3$ in MeCN (Reference Electrode); Concentrations: $PPh_3$ (0.2 mmol / 8 ml MeCN), Benzophenone (0.2 mmol / 8 ml MeCN), $PPh_3$ + Benzophenone (0.2 mmol $PPh_3$ + 0.2 mmol Benzophenone / 8 ml MeCN).

## 7. Characterization data of the starting materials

**tert-butyl 9-oxoacridine-10(9H)-carboxylate (1e)**

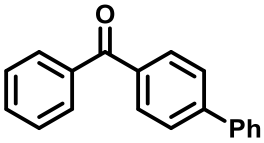


**1e**

Prepared according to general procedure A from acridin-9(10H)-one on a 2.6 mmol scale. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 75% yield (566.3 mg).

$R_f$ (petroleum ether/ethyl acetate = 20:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 8.45 – 8.43 (dd, *J* = 8.0, 1.6 Hz, 2H), 7.69 – 7.65 (ddd, *J* = 8.6, 7.0, 1.7 Hz, 2H), 7.57 (dd, *J* = 8.6, 1.0 Hz, 2H), 7.39 – 7.29 (m, 2H), 1.69 (s, 9H). **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 178.84, 152.09, 139.70, 133.66, 127.49, 123.48, 123.07, 117.76, 86.61, 28.01. Spectroscopic data were in good agreement with literature[4]

**[1,1'-biphenyl]-4-yl(phenyl)methanone (1m)**

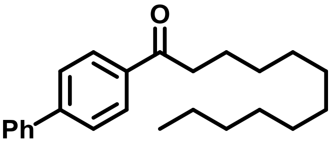


**1m**

Prepared according to general procedure B from 1,1'-biphenyl (2 mmol) and benzoyl chloride (2.2 mmol). The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 50% yield (258.8 mg).

Rf (petroleum ether/ethyl acetate = 20:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.95 – 7.88 (m, 2H), 7.89 – 7.81 (m, 2H), 7.76 – 7.69 (m, 2H), 7.69 – 7.64 (m, 2H), 7.64 – 7.58 (m, 1H), 7.55 – 7.47 (m, 4H), 7.45 – 7.38 (m, 1H). **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 196.63, 145.50, 140.23, 138.02, 136.50, 132.67, 131.02, 130.29, 129.26, 128.60, 128.48, 127.58, 127.25. Spectroscopic data were in good agreement with literature[5]

**1-([1,1'-biphenyl]-4-yl)dodecan-1-one (1w)**



**1w**

Prepared according to general procedure B from 1,1'-biphenyl (2 mmol) and dodecanoyl chloride (2.2 mmol). The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 90% yield (601.9 mg).

Rf (petroleum ether/ethyl acetate = 20:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 8.04 (d, *J* = 8.5 Hz, 2H), 7.68 (d, *J* = 8.5 Hz, 2H), 7.64 – 7.61 (m, 2H), 7.50 – 7.44 (m, 2H), 7.43 – 7.37 (m, 1H), 2.99 (t, *J* = 7.4, 2H), 1.87 – 1.70 (m, 2H), 1.26 (s, 16H), 0.93 – 0.82 (m, 3H). **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 200.60, 145.86, 140.27, 136.11, 129.27, 129.00, 128.50, 127.58, 127.53, 39.04, 32.26, 29.98, 29.85, 29.76, 29.69, 29.58, 24.83, 23.03, 14.47. Spectroscopic data were in good agreement with literature[6]

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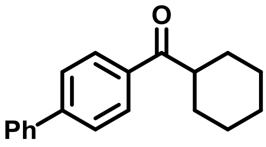
[4] A. A. Kulago, E. M. Mes, M. Klok, A. Meetsma, A. M. Brouwer and B. L. Feringa, *J. Org. Chem.*, 2010, **75**, 666–679.

[5] I. Sapountzis, W. Lin, C. C. Kofink, C. Despotopolou and P. Knochel, *Angew. Chem. Int. Ed.*, 2005, **44**, 1654–1657.

[6] J. Boivin and V. T. Nguyen, *Beilstein Journal of Organic Chemistry* 2007, **3**, No. 45. DOI:10.1186/1860-5397-3-45.

### [1,1'-biphenyl]-4-yl(cyclohexyl)methanone (1x)

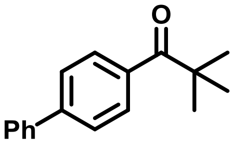


1x

Prepared according to general procedure B from 1,1'-biphenyl (2 mmol) and cyclohexanecarbonyl chloride (2.2 mmol). The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 86% (456.2 mg).

Rf (petroleum ether/ethyl acetate = 20:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 8.07 – 8.00 (m, 2H), 7.71 – 7.66 (m, 2H), 7.65 – 7.61 (m, 2H), 7.52 – 7.44 (m, 2H), 7.43 – 7.35 (m, 1H), 3.30 (tt, *J* = 11.4, 3.3 Hz, 1H), 1.97 – 1.83 (m, 4H), 1.66 – 1.22 (m, 6H). **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 203.72, 145.69, 140.25, 135.28, 129.23, 129.16, 128.44, 127.54, 127.53, 45.97, 29.77, 26.29, 26.19. **HRMS** m/z (ESI) calcd for $C_{19}H_{21}O$ ([M+H]$^+$) 265.1592, found 265.1592.

### 1-([1,1'-biphenyl]-4-yl)-2,2-dimethylpropan-1-one (1y)



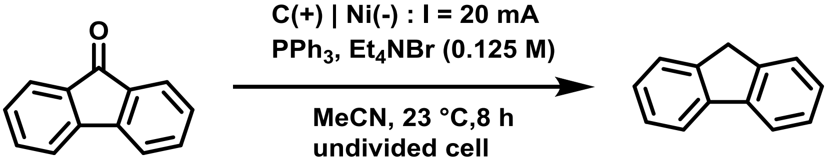
1y

Prepared according to general procedure C from [1,1'-biphenyl]-4-ylmagnesium bromide (3 mmol) and pivaloyl chloride (2 mmol). The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 94% (446.9 mg).

Rf (petroleum ether/ethyl acetate = 20:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.88 – 7.81 (m, 2H), 7.66 – 7.60 (m, 4H), 7.47 (t, *J* = 7.5 Hz, 2H), 7.42 – 7.37 (m, 1H), 1.41 (s, 9H). **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 208.65, 144.01, 140.36, 137.20, 129.21, 129.05, 128.26, 127.48, 127.01, 44.51, 28.44. **HRMS** m/z (ESI) calcd for $C_{17}H_{19}O$ ([M+H]$^+$) 239.1436, found 239.1436.

## 8. Detail descriptions for products

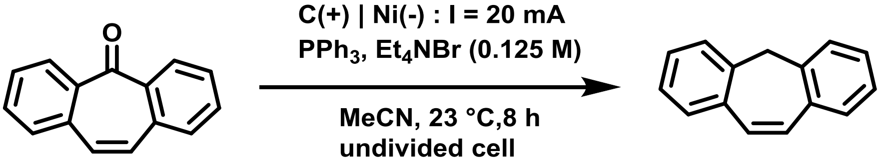
### 9H-fluorene (2a)



The starting 9H-fluoren-9-one (90.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 72% yield (59.8 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.84 (d, *J* = 7.5 Hz, 2H), 7.59 (d, *J* = 7.4 Hz, 2H), 7.43 (t, *J* = 7.4 Hz, 2H), 7.36 (td, *J* = 7.4, 1.2 Hz, 2H), 3.94 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 143.52, 142.01, 127.03, 127.00, 125.33, 120.18, 37.24. Spectroscopic data were in good agreement with literature[7]

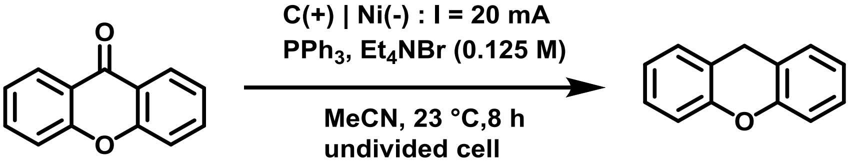
**5H-dibenzo[a,d][7]annulene (2b)**



The starting 5H-dibenzo[a,d][7]annulen-5-one (103.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 82% yield (79.0 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.42 – 7.35 (m, 6H), 7.32 – 7.27 (m, 2H), 7.11 (s, 2H), 3.83 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 138.42, 135.48, 131.83, 128.72, 128.41, 128.18, 126.37, 41.94. **HRMS** m/z (ESI) calcd for $C_{17}H_{13}$ ([M+H]$^+$) 193.1017, found 193.1014.

**9H-xanthene (2c)**



The starting 9H-xanthen-9-one (98.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 61% yield (55.5 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.27 – 7.18 (m, 4H), 7.11 – 7.04 (m, 4H), 4.08 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 152.26, 129.23, 127.95, 123.26, 120.88, 116.77, 28.19. Spectroscopic data were in good agreement with literature[8]

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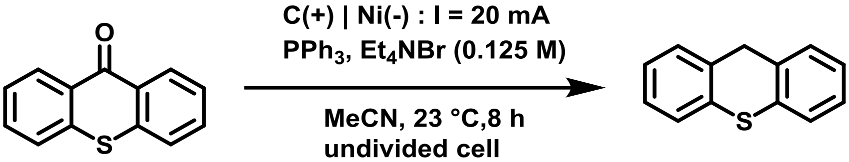
[7] D. L. J. Clive and R. Sunasee, *Org. Chem.*, 2007, **9**, 2677–2688.

[8] E. Böβ, T. Hillringhaus, J. Nitsch and M. Klussmann, *Org. Biomol. Chem.*, 2011, **9**, 1744–1748.

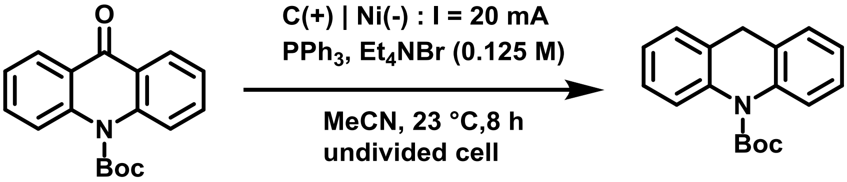
**9H-thioxanthene (2d)**



The starting 9H-thioxanthen-9-one (106.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 65% yield (64.4 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.52 – 7.41 (m, 2H), 7.35 – 7.31 (m, 2H), 7.26 – 7.19 (m, 4H), 3.88 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 136.51, 134.16, 128.25, 127.17, 126.92, 126.84, 39.53. Spectroscopic data were in good agreement with literature[9]

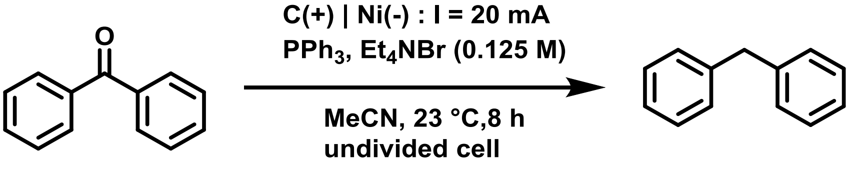
**tert-butyl acridine-10(9H)-carboxylate (2e)**



The starting tert-butyl 9-oxoacridine-10(9H)-carboxylate (147.6 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 49% yield (137.2 mg).

Rf (petroleum ether/ethyl acetate = 50:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.54 (d, $J$ = 8.0 Hz, 2H), 7.14 – 7.08 (m, 4H), 7.01 (t, $J$ = 7.4 Hz, 2H), 3.69 (s, 2H), 1.44 (s, 9H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 152.79, 139.07, 133.30, 127.26, 126.17, 125.35, 125.25, 82.07, 34.13, 28.53. Spectroscopic data were in good agreement with literature[10]

**diphenylmethane (2f)**



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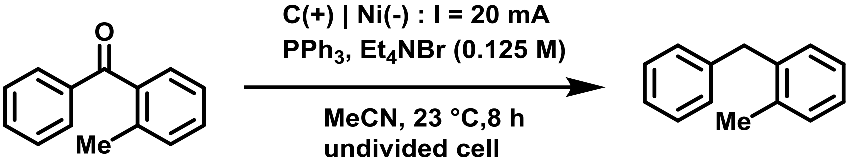
[9] X.-Q Zhu, Z. Dai, A. Yu, S. Wu and J.-P. Cheng, *J. Phys. Chem. B*, 2008, **112**, 11694–11707.

[10] T. Stopka, L. Marzo, M. Zurro, S. Janich, E.-U. Würthwein, C. G. Daniliuc, J. Alemán and O. G. Mancheño, *Angew. Chem. Int. Ed.*, 2015, **54**, 5049 –5053.

The starting benzophenone (91.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 92% yield (77.3 mg).

Rf (petroleum ether): 0.6; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.34 – 7.28 (m, 4H), 7.25 – 7.19 (m, 6H), 4.01 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 141.44, 129.27, 128.79, 126.39, 42.28. Spectroscopic data were in good agreement with literature[11]

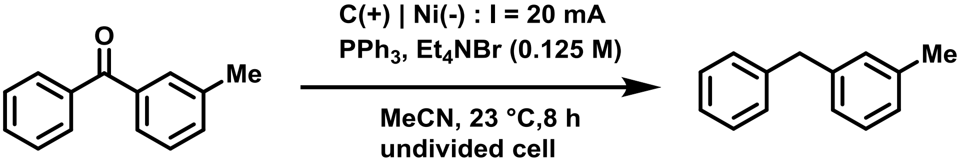
**1-benzyl-2-methylbenzene (2g)**



The starting phenyl(o-tolyl)methanone (98.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 36% yield (32.8 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.35 – 7.29(m, 2H), 7.27 – 7.12 (m, 7H), 4.04 (s, 2H), 2.29 (s, 3H).; **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 140.70, 139.24, 136.96, 130.60, 130.26, 129.06, 128.71, 126.77, 126.31, 126.24, 39.78, 20.02. Spectroscopic data were in good agreement with literature[12]

**1-benzyl-3-methylbenzene (2h)**



The starting phenyl(m-tolyl)methanone (98.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 53% yield (48.2 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.41 – 7.36 (m, 2H), 7.32 – 7.28 (m, 4H), 7.17 – 7.05 (m, 3H), 4.05 (s, 2H), 2.42 (s, 3H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 141.56, 141.34, 138.33,

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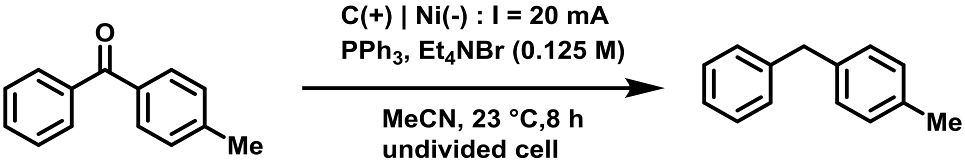
[11] M. Peña-López, M. Ayán-Varela, L. A. Sarandeses and J. P. Sestelo, *Chem. Eur. J.*, 2010, **16**, 9905–9909.

[12] C.-R. Chen, S. Zhou, D. B. Biradar and H.-M. Gau, *Adv. Synth. Catal.*, 2010, **352**, 1718–1727.

130.03, 129.23, 128.75, 128.66, 127.14, 126.33, 126.30, 42.21, 21.74. Spectroscopic data were in good agreement with literature[12]

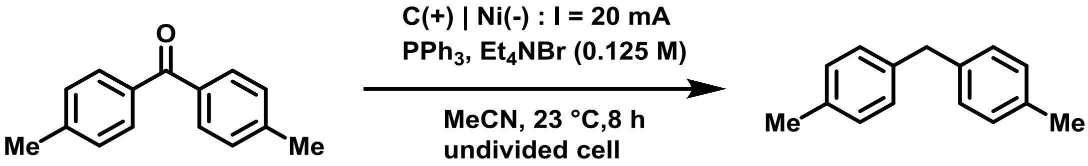
**1-benzyl-4-methylbenzene (2i)**



The starting phenyl(p-tolyl)methanone (98.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 50% yield (45.5 mg).

Rf (petroleum ether): 0.5; $^1$**H NMR** (400 MHz, Chloroform-d) δ 7.43 – 7.34 (m, 2H), 7.31 –7.27 (m, 3H), 7.22 – 7.17 (m, 4H), 4.05 (s, 2H), 2.42 (s, 3H); $^{13}$**C NMR** (400 MHz, Chloroform-d) δ 141.72, 138.39, 135.84, 129.47, 129.19, 129.13, 128.75, 126.29, 41.83, 21.35. Spectroscopic data were in good agreement with literature[13]

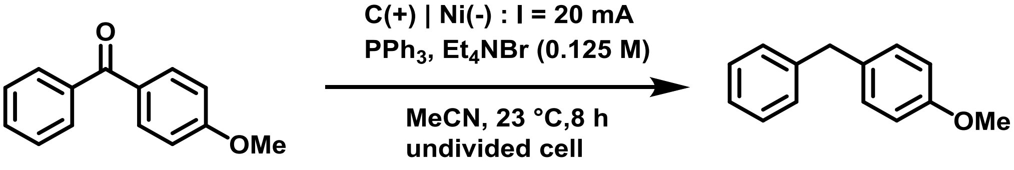
**di-p-tolylmethane (2j)**



The starting di-p-tolylmethanone (105.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 61% yield (59.8 mg).

Rf (petroleum ether): 0.5; $^1$**H NMR** (400 MHz, Chloroform-d) δ 7.29 – 7.23 (m, 8H), 4.08 (s, 2H), 2.49 (s, 6H); $^{13}$**C NMR** (400 MHz, Chloroform-d) δ 138.69, 135.73, 129.43, 129.07, 41.41, 21.33. Spectroscopic data were in good agreement with literature[14]

**1-benzyl-4-methoxybenzene (2k)**



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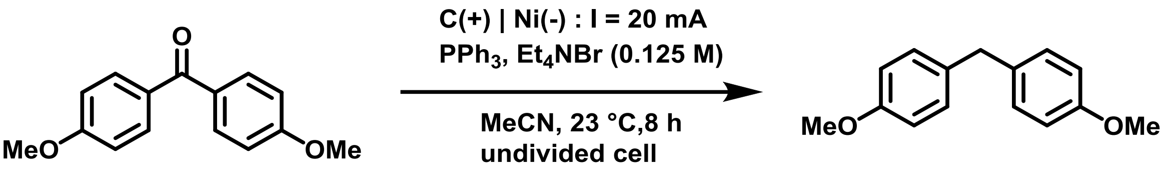
[13] G. Sun and Z. Wang, *Tetrahedron Letters*, 2008, **49**, 4929–4932.

[14] R. B. Bedford, M. Huwe and M. C. Wilkinson, *Chem. Commun.*, 2009, 600–602.

The starting (4-methoxyphenyl)(phenyl)methanone (106.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 50:1) to afford the title compound as a colorless oil in 70% yield (69.3 mg).

Rf (petroleum ether/ethyl acetate = 100:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.36 (t, *J* = 7.5 Hz, 2H), 7.27 (t, *J* = 7.3 Hz, 3H), 7.19 (d, *J* = 8.5 Hz, 2H), 6.92 (d, *J* = 8.5 Hz, 2H), 4.01 (s, 2H), 3.85 (s, 3H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 158.23, 141.88, 133.53, 130.16, 129.11, 128.73, 126.28, 114.15, 55.53, 41.33. Spectroscopic data were in good agreement with literature[13]

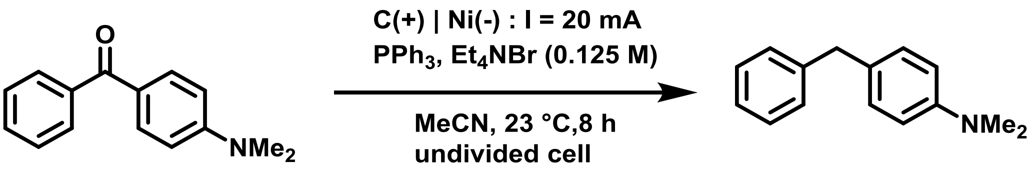
**bis(4-methoxyphenyl)methane (2l)**



The starting bis(4-methoxyphenyl)methanone (121.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 56% yield (63.9 mg).

Rf (petroleum ether/ethyl acetate = 100:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.14 (d, *J* = 8.5 Hz, 4H), 6.88 (d, *J* = 8.5 Hz, 4H), 3.92 (s, 2H), 3.82 (s, 6H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 158.15, 133.99, 130.01, 114.10, 55.51, 40.40. Spectroscopic data were in good agreement with literature[13]

**4-benzyl-N,N-dimethylaniline (2m)**

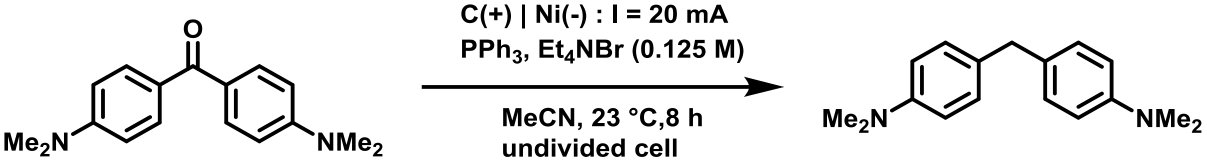


The starting (4-(dimethylamino)phenyl)(phenyl)methanone (112.5 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 20:1) to afford the title compound as a white solid in 76% yield (80.2 mg).

Rf (petroleum ether/ethyl acetate = 50:1): 0.2; **$^1$H NMR** (400 MHz, Chloroform-d) δ7.29 – 7.22 (m, 2H), 7.20 – 7.13 (m, 2H), 7.05 (d, *J* = 8.6 Hz, 2H), 6.68 (d, *J* = 8.6 Hz, 2H), 3.88 (s, 2H), 2.89 (s, 6H); **$^{13}$C NMR** (400

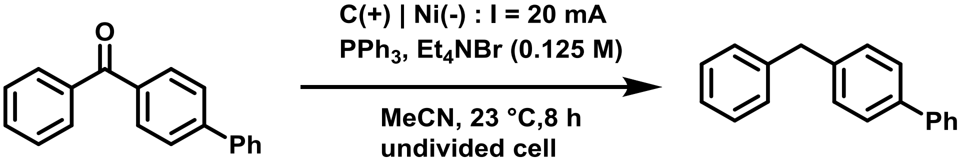
MHz, Chloroform-d) δ 149.44, 142.38, 129.85, 129.56, 129.11, 128.65, 126.09, 113.26, 41.23. Spectroscopic data were in good agreement with literature[15]

**4,4'-methylenebis(N,N-dimethylaniline) (2n)**



The starting bis(4-(dimethylamino)phenyl)methanone (134.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 10:1) to afford the title compound as a white solid in 65% yield (82.6 mg). Rf (petroleum ether/ethyl acetate = 10:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.13 (d, *J* = 8.4 Hz, 4H), 6.75 (d, *J* = 8.5 Hz, 4H), 3.88 (s, 2H), 2.96 (s, 12H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 149.29, 130.58, 129.68, 113.30, 41.23, 40.15. Spectroscopic data were in good agreement with literature[16]

**4-benzyl-1,1'-biphenyl (2o)**



The starting [1,1'-biphenyl]-4-yl(phenyl)methanone (129.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 70% yield (84.5 mg). Rf (petroleum ether): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.71 – 7.67 (m, 2H), 7.65 – 7.60 (m, 2H), 7.55 – 7.50 (m, 2H), 7.46 – 7.39 (m, 3H), 7.39 – 7.28 (m, 5H), 4.13 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 141.31, 141.28, 140.55, 139.32, 129.64, 129.28, 129.04, 128.83, 127.52, 127.39, 127.31, 126.46, 41.89. Spectroscopic data were in good agreement with literature[17]

**2-benzyl-1,1'-biphenyl (2p)**

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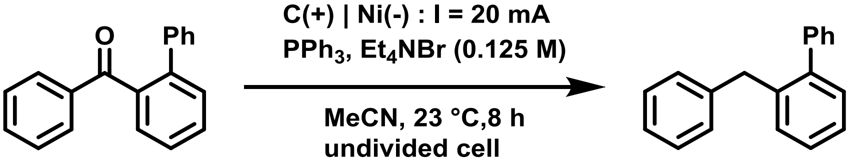
[15] M. Amatore and C. Gosmini, *Chem. Commun.*, 2008, 5019–5021.

[16] Y.-Y. Lai, N.-T. Lin Y.-H. Liu, Y. Wang and T.-Y. Luh, *Tetrahedron*, 2007, **63**, 6051–6055

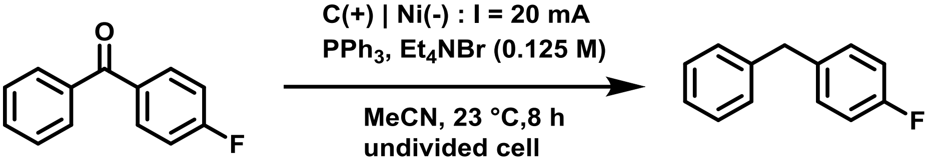
[17] N. Sakai, K. Kawana, R. Ikeda, Y. Nakaike and T. Konakahara, *Eur. J. Org. Chem.*, 2011, 3178–3183.



The starting [1,1'-biphenyl]-2-yl(phenyl)methanone (129.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 70% yield (84.5 mg).

Rf (petroleum ether): 0.3; $^1$H NMR (400 MHz, Chloroform-d) δ 7.49 – 7.40 (m, 3H), 7.41 – 7.34 (m, 5H), 7.34 – 7.27 (m, 3H), 7.26 – 7.21 (m, 1H), 7.09 (d, *J* = 7.5 Hz, 2H), 4.07 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 142.57, 141.96, 141.76, 138.54, 130.63, 130.44, 129.61, 129.17, 128.55, 128.35, 127.78, 127.21, 126.49, 126.09, 39.36. Spectroscopic data were in good agreement with literature[18]

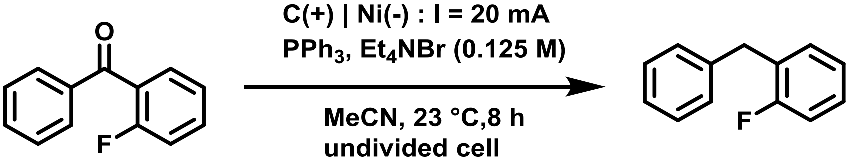
**1-benzyl-4-fluorobenzene (2q)**



The starting (4-fluorophenyl)(phenyl)methanone (100.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 71% yield (66.2 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.28 (t, *J* = 7.5 Hz, 2H), 7.22 – 7.09 (m, 5H), 6.95 (t, *J* = 8.7 Hz, 2H), 3.93 (s, 2H).; **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 161.72 (d, *J* = 243.9 Hz), 141.26, 137.08 (d, *J* = 3.2 Hz), 130.60 (d, *J* = 7.8 Hz), 129.15, 128.86, 126.53, 115.53 (d, *J* = 21.2 Hz), 41.39; **$^{19}$F NMR** (376 MHz, Chloroform-d) δ -117.30. Spectroscopic data were in good agreement with literature[19]

**1-benzyl-2-fluorobenzene (2r)**



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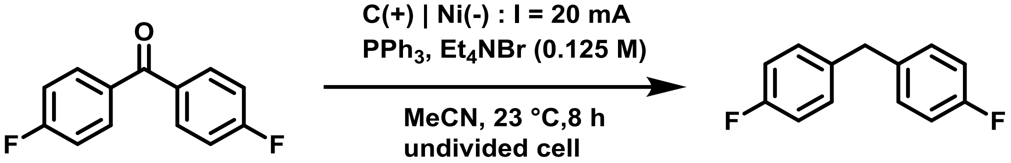
[18] R. Kuwano and M. Yokogi, *Org. Lett.*, 2005, **7**, 945–947.

[19] D. Srimani, A. Bej and A. Sarkar, *J. Org. Chem.*, 2010, **75**, 4296–4299.

The starting (2-fluorophenyl)(phenyl)methanone (100.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 65% yield (60.5 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.38 – 7.33 (m, 2H), 7.31 – 7.16 (m, 5H), 7.16 – 7.02 (m, 2H), 4.07 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 161.26 (d, $J$ = 245.4 Hz), 140.17, 131.35 (d, $J$ = 4.6 Hz), 128.97 (d, $J$ = 29.3 Hz), 128.46 , 128.26 (d, $J$ = 8.0 Hz), 126.55, 124.38 (d, $J$ = 3.6 Hz), 115.64 (d, $J$ = 22.0 Hz), 35.13 (d, $J$ = 3.0 Hz); **$^{19}$F NMR** (376 MHz, Chloroform-d) δ -117.80. Spectroscopic data were in good agreement with literature[20]

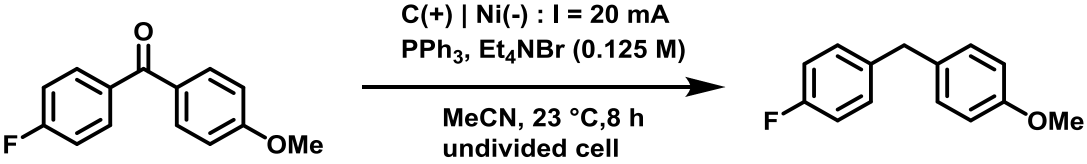
**bis(4-fluorophenyl)methane (2s)**



The starting bis(4-fluorophenyl)methanone (109.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a colorless oil in 87% yield (88.7 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.14 (dd, $J$ = 8.3, 5.6 Hz, 4H), 7.04 – 6.97 (m, 4H), 3.94 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 161.77 (d, $J$ = 244.2 Hz), 136.92 (d, $J$ = 3.0 Hz), 130.52 (d, $J$ = 7.8 Hz), 115.62 (d, $J$ = 21.2 Hz), 40.53; **$^{19}$F NMR** (376 MHz, Chloroform-d) δ -117.06. Spectroscopic data were in good agreement with literature[21]

**1-fluoro-4-(4-methoxybenzyl)benzene (2t)**



The starting (4-fluorophenyl)(4-methoxyphenyl)methanone (115.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 30:1) to afford the title compound as a colorless oil in 61% yield (66.1 mg).

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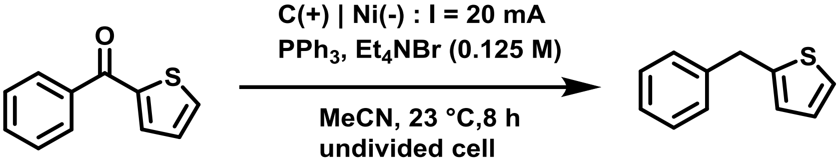
[20] S. K. Yen, L. L. Koh, H. V. Huynh and T. S. A. Hor, *Eur. J. Inorg. Chem.*, 2009, 4288–4297.

[21] X. Qian and C. M. Kozak, *Synlett*, 2011, 6, 852–856.

Rf (petroleum ether/ethyl acetate = 50:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.21 – 7.11 (m, 4H), 7.06 – 6.97 (m, 2H), 6.93 – 6.86 (m, 2H), 3.94 (s, 2H), 3.82 (s, 3H); **$^{13}$C NMR** (100 MHz, Chloroform-d) δ 161.64 (d, *J* = 243.7 Hz), 158.33, 137.55 (d, *J* = 3.2 Hz), 133.34, 130.44 (d, *J* = 7.8 Hz), 130.07, 115.45 (d, *J* = 21.1 Hz), 114.22, 55.50, 40.46; **$^{19}$F NMR** (376 MHz, Chloroform-d) δ -117.42. Spectroscopic data were in good agreement with literature[22]

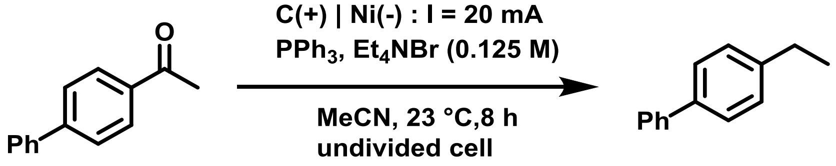
**2-benzylthiophene (2u)**



The starting phenyl(thiophen-2-yl)methanone (94.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a yellow oil in 26% yield (22.6 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.40 – 7.24 (m, 5H), 7.19 (d, *J* = 5.1 Hz, 1H), 7.00 – 6.94 (m, 1H), 6.85 (d, *J* = 3.3 Hz, 1H), 4.21 (s, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 144.35, 140.71, 128.91, 128.86, 127.14, 126.80, 125.47, 124.27, 36.35. Spectroscopic data were in good agreement with literature[23]

**4-ethyl-1,1'-biphenyl (2v)**



The starting 1-([1,1'-biphenyl]-4-yl)ethan-1-one (98.0 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 62% yield (56.5 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.68 (d, *J* = 7.5 Hz, 2H), 7.62 (d, *J* = 8.1 Hz, 2H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.37 (d, *J* = 8.0 Hz, 2H), 2.78 (q, *J* = 7.6 Hz, 2H), 1.37 (t, *J* = 7.6 Hz, 3H).; **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 143.68, 141.48, 138.91, 129.03, 128.61, 127.40, 127.32, 127.28, 28.85, 15.96. Spectroscopic data were in good agreement with literature[24]

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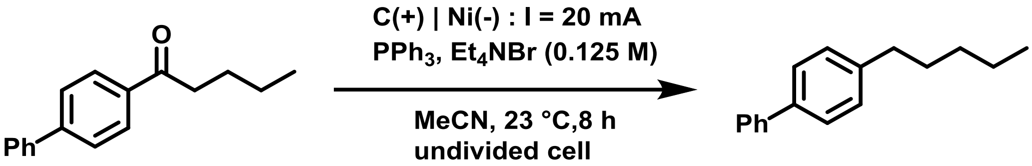
[22] M.-B. Li, X.-L. Tang and S.-K. Tian, *Adv. Synth. Catal.*, 2011, **353**, 1980–1984.

[23] N. Henry, C. Enguehard-Gueiffier, I. Thery and A. Gueiffier, *Eur. J. Org. Chem.*, 2008, 4824–4827.

[24] B. Karimi, D. Elhamifar, J. H. Clark and A. J. Hunt, *Chem. Eur. J.*, 2010, **16**, 8047 – 8053.

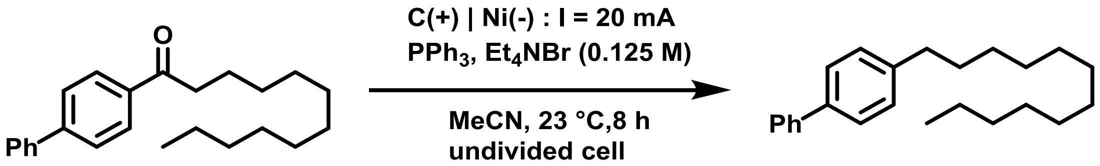
**4-pentyl-1,1'-biphenyl (2w)**



The starting 1-([1,1'-biphenyl]-4-yl)pentan-1-one (109.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 100:1) to afford the title compound as a white solid in 45% yield (50.4 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.61 (d, *J* = 8.3, Hz, 2H), 7.53 (d, *J* = 8.2 Hz, 2H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.36 – 7.32 (m, 1H), 7.28 (d, *J* = 8.1 Hz, 2H), 2.66 (t, *J* = 7.8, 2H), 1.72 – 1.63 (m, 2H), 1.41 – 1.34 (m, 4H), 0.92 (t, *J* = 7.2, 3H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 142.44, 141.51, 138.86, 129.15, 129.03, 127.32, 127.31, 127.28, 35.93, 31.92, 31.55, 22.92, 14.41. Spectroscopic data were in good agreement with literature[25]

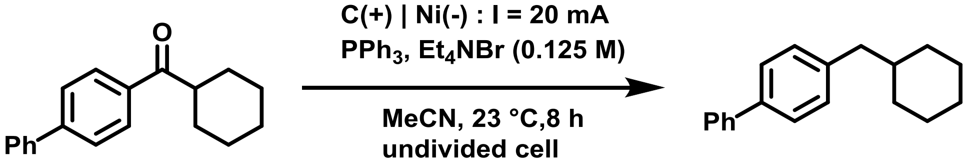
**4-dodecyl-1,1'-biphenyl (2x)**



The starting 1-([1,1'-biphenyl]-4-yl)dodecan-1-one (168.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a white solid in 50% yield (80.6 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.64 – 7.59 (m, 2H), δ 7.54 (d, *J* = 8.2 Hz, 2H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.37 – 7.32 (m, 1H), 7.28 (d, *J* = 8.3 Hz, 2H), 2.78 – 2.55 (m, 2H), 1.68 (p, *J* = 7.6 Hz, 2H), 1.39 – 1.24 (m, 18H), 0.94 – 0.89 (m, 3H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 142.45, 141.53, 138.86, 129.15, 129.02, 127.32, 127.31, 127.27, 35.98, 32.29, 31.88, 30.04, 30.02, 29.97, 29.90, 29.75, 29.73, 23.06, 14.49. **HRMS** m/z (ESI) calcd for $C_{24}H_{35}$ ($[M+H]^+$) 323.2739, found 323.2737.

**4-(cyclohexylmethyl)-1,1'-biphenyl (2y)**



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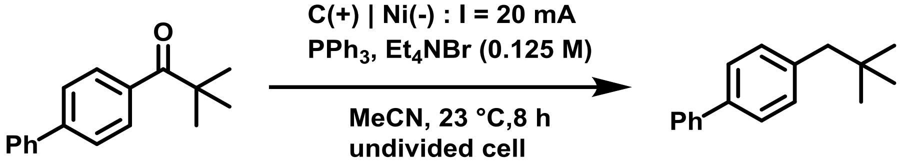
[25] Z. Dai, W. Zhang, Z. Zhang and B. Wei, *Advanced Materials Research Vols.*, 233-235 (2011) pp 1119-1122.

The starting [1,1'-biphenyl]-4-yl(cyclohexyl)methanone (132.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a white solid in 60% yield (60.0 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.64 – 7.59 (m, 2H), 7.55 – 7.51 (m, 2H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.38 – 7.31 (m, 1H), 7.24 (d, *J* = 8.2 Hz, 2H), 2.55 (d, *J* = 7.1 Hz, 2H), 1.79 – 1.65 (m, 5H), 1.61 – 1.53 (m, 1H), 1.30 – 1.18 (m, 3H), 1.06 – 0.95 (m, 2H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 141.51, 140.86, 138.82, 129.92, 129.02, 127.31, 127.26, 127.10, 44.10, 40.13, 33.53, 26.92, 26.68. **HRMS** m/z (ESI) calcd for $C_{19}H_{23}$ ([M+H]$^+$) 251.2800, found 251.1798.

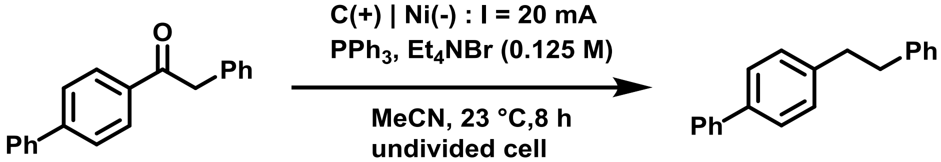
**4-neopentyl-1,1'-biphenyl (2z)**



The starting 1-([1,1'-biphenyl]-4-yl)-2,2-dimethylpropan-1-one (119.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a white solid in 50% yield (56.0 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.66 – 7.62 (m, 2H), 7.57 – 7.52 (m, 2H), 7.45 (t, *J* = 7.5 Hz, 2H), 7.39 – 7.34 (m, 1H), 7.27 – 7.23 (m, 2H), 2.58 (s, 2H), 0.99 (s, 9H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 141.47, 139.24, 138.91, 131.22, 129.03, 127.31, 126.66, 50.21, 32.19, 29.77. Spectroscopic data were in good agreement with literature[26]

**4-phenethyl-1,1'-biphenyl (2aa)**



The starting 1-([1,1'-biphenyl]-4-yl)-2-phenylethan-1-one (136.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether) to afford the title compound as a white solid in 56% yield (72.3 mg).

Rf (petroleum ether): 0.5; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.63 – 7.57 (m, 2H), 7.56 – 7.51 (m, 2H), 7.48 – 7.41 (m, 2H), 7.37 – 7.33 (m, 1H), 7.32 – 7.26 (m, 4H), 7.25 – 7.19 (m, 3H), 2.98 (s, 4H); **$^{13}$C NMR**

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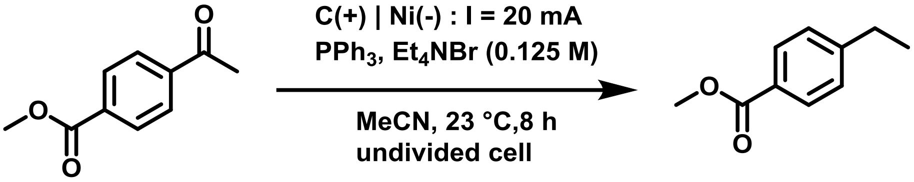
[26] C.-H. Cho, M. Sun, Y.-S. Seo, C.-B. Kim and K. Park, *J. Org. Chem.*, 2005, **70**, 1482-1485.

(400 MHz, Chloroform-d) δ 142.06, 141.38, 141.24, 139.19, 129.20, 129.06, 128.80, 128.70, 127.40, 127.37, 127.33, 126.29, 38.24, 37.91. **HRMS** m/z (ESI) calcd for $C_{20}H_{19}$ ($[M+H]^+$) 259.1487, found 259.1487.

**methyl 4-ethylbenzoate (2ab)**



The starting methyl 4-acetylbenzoate (89.1 mg, 0.5 mmol) was reacted with $PPh_3$ (655.0 mg, 2.5 mmol) according to general procedure. The crude product was purified by column chromatography (petroleum ether/ethyl acetate = 70:1) to afford the title compound as a colorless oil in 53% yield (43.1 mg).

Rf (petroleum ether/ethyl acetate = 100:1): 0.3; **$^1$H NMR** (400 MHz, Chloroform-d) δ 7.96 (d, $J$ = 8.3 Hz, 2H), 7.26 (d, $J$ = 8.4 Hz, 2H), 3.90 (s, 3H), 2.70 (q, $J$ = 7.6 Hz, 2H), 1.25 (t, $J$ = 7.6 Hz, 3H); **$^{13}$C NMR** (400 MHz, Chloroform-d) δ 167.52, 150.06, 130.02, 128.21, 52.29, 29.27, 15.56, 1.36. Spectroscopic data were in good agreement with literature[27]

## 9. Procedure for divided-cell electrolysis

Ketone (2.0 mmol) and $PPh_3$ (10 mmol) were added into the anodic chamber, while the cathodic chamber was added with the same substances, ketone (2.0 mmol) and $PPh_3$ (10.0 mmol). Subsequently, MeCN (16 ml) containing $Et_4NBr$ (2.0 mmol) was added to the anodic chamber and the cathodic chamber, respectively. Then the solution was stirred and electrolysed at a constant current of 20 mA at room temperature (23 ℃) for 8 h. When the reaction was finished, the solution was treated by the standard procedure.

## 10. Procedure for Deuterium experiment

The electrolysis was carried out in the electrolysis cell of IKA® ElectraSyn 2.0. The anodic electrode was the carbon electrode (3.0 cm × 0.8 cm × 0.2 cm) and the cathodic electrode was the nickel plate (3.0 cm × 0.8 cm × 0.2 cm). Benzophenone (0.5 mmol), $Et_4NBr$ (105.0 mg, 0.5 mmol), $PPh_3$ (655.0 mg, 2.5 mmol), $CD_3CN$ (4 mL) were added to an oven-dried undivided cell (6 mL) equipped with a stirring bar (the order of the addition did not affect the result). Then the reaction mixture was stirred and electrolyzed at a constant current of 20 mA at room temperature for 8 h. When the reaction was finished, the solution was treated by the standard

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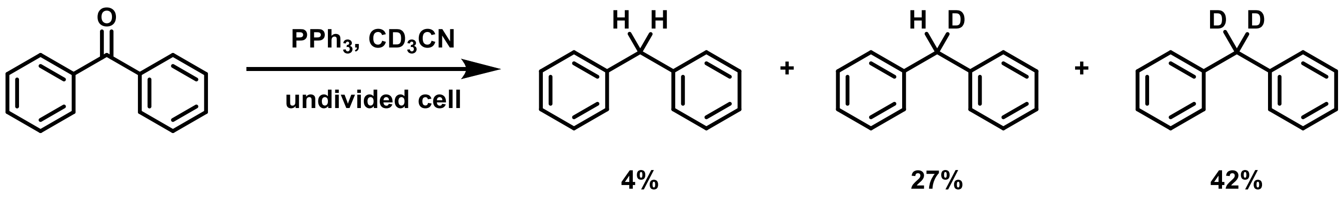
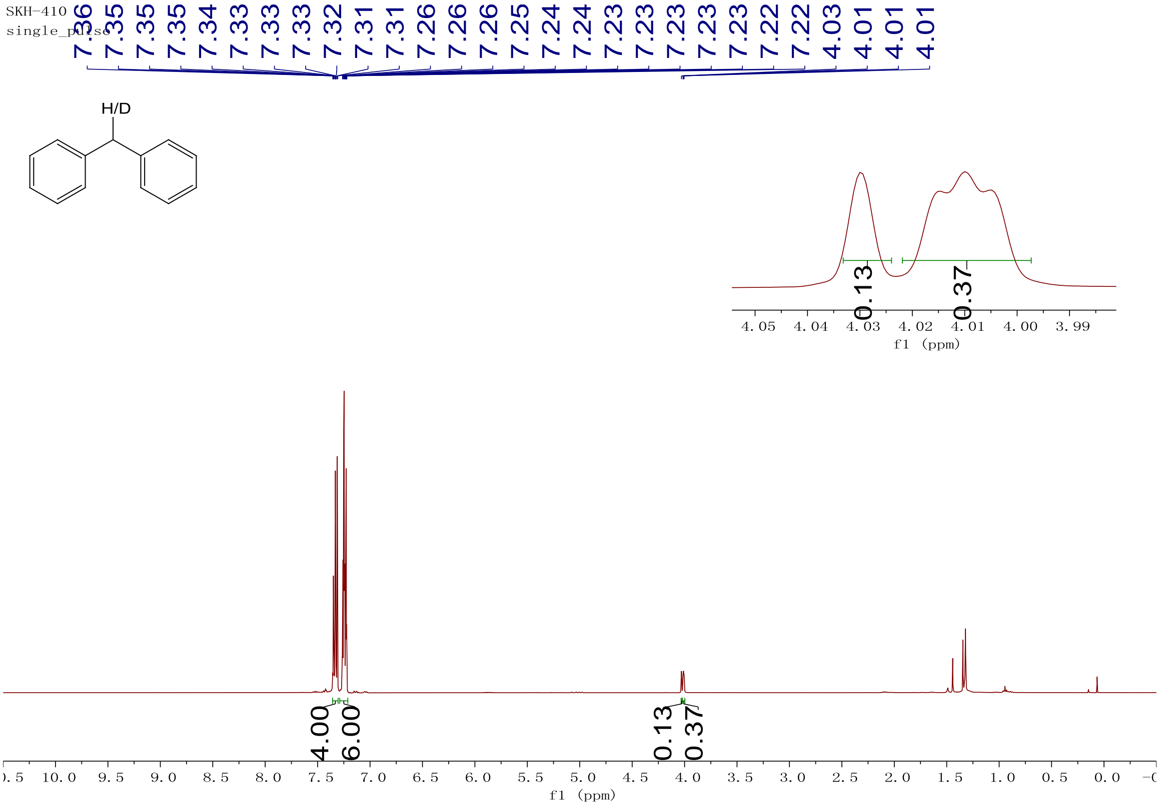
[27] I. Kondolff, H. Doucet and M. Santelli, *Organometallics,* 2006, **25**, 5219-5222.

procedure. It got the deuterated product with 73% yield, where H,H : H,D : D,D = 4% : 27% : 42%. **$^{1}$H NMR** (400 MHz, Chloroform-d) δ 7.36 – 7.30 (m, 4H), 7.29 – 7.21 (m, 6H), 4.04– 4.00 (m, 0.5H).

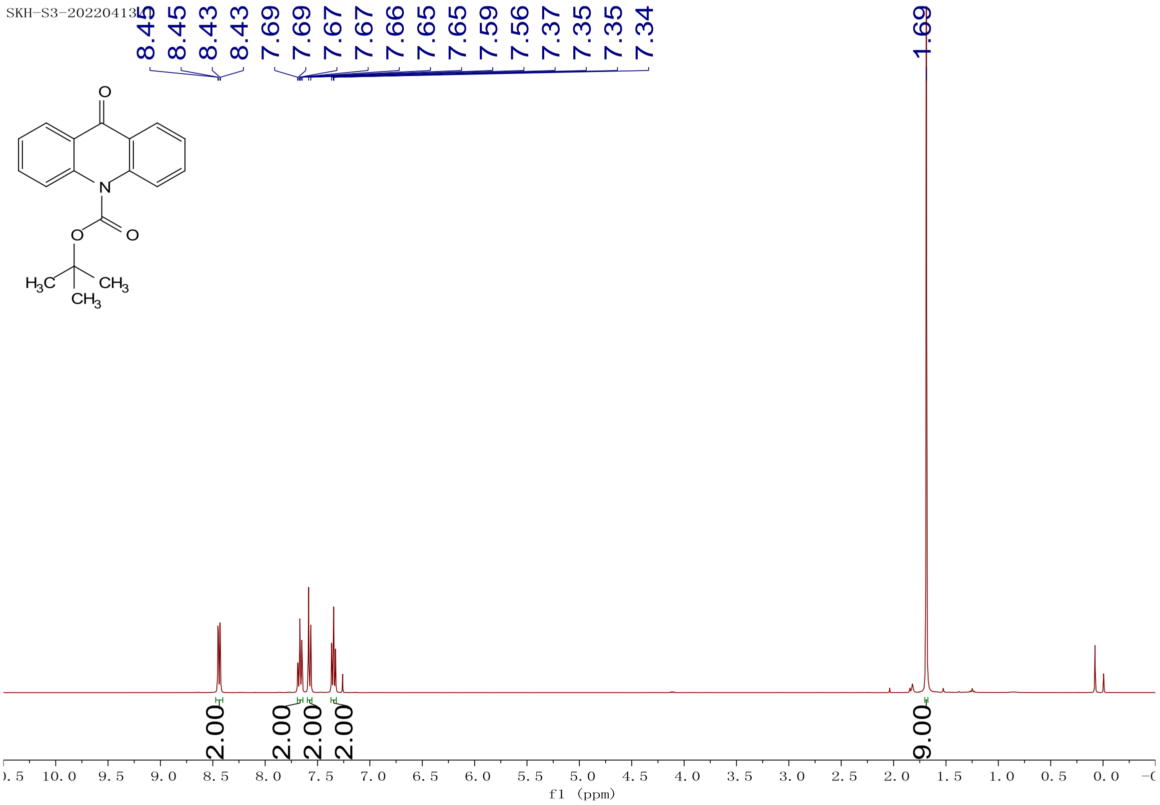


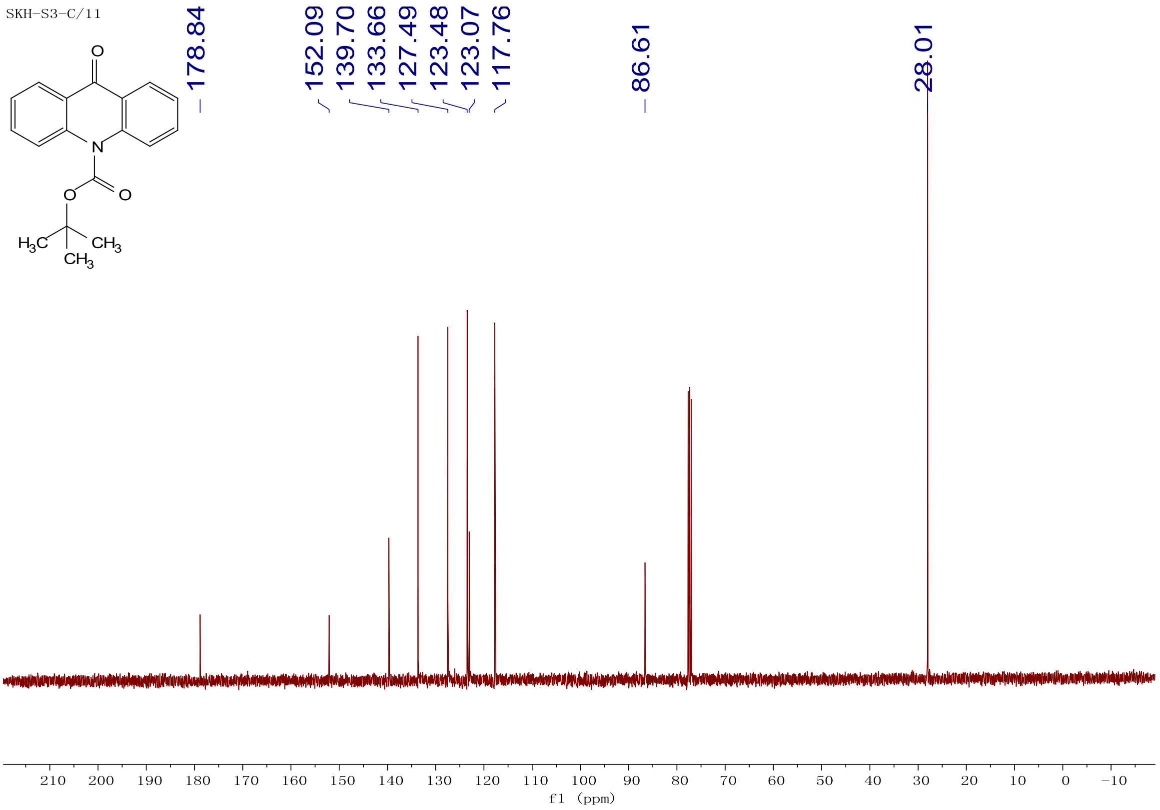
**$^{1}$H NMR** (400 MHz, CDCl$_3$)



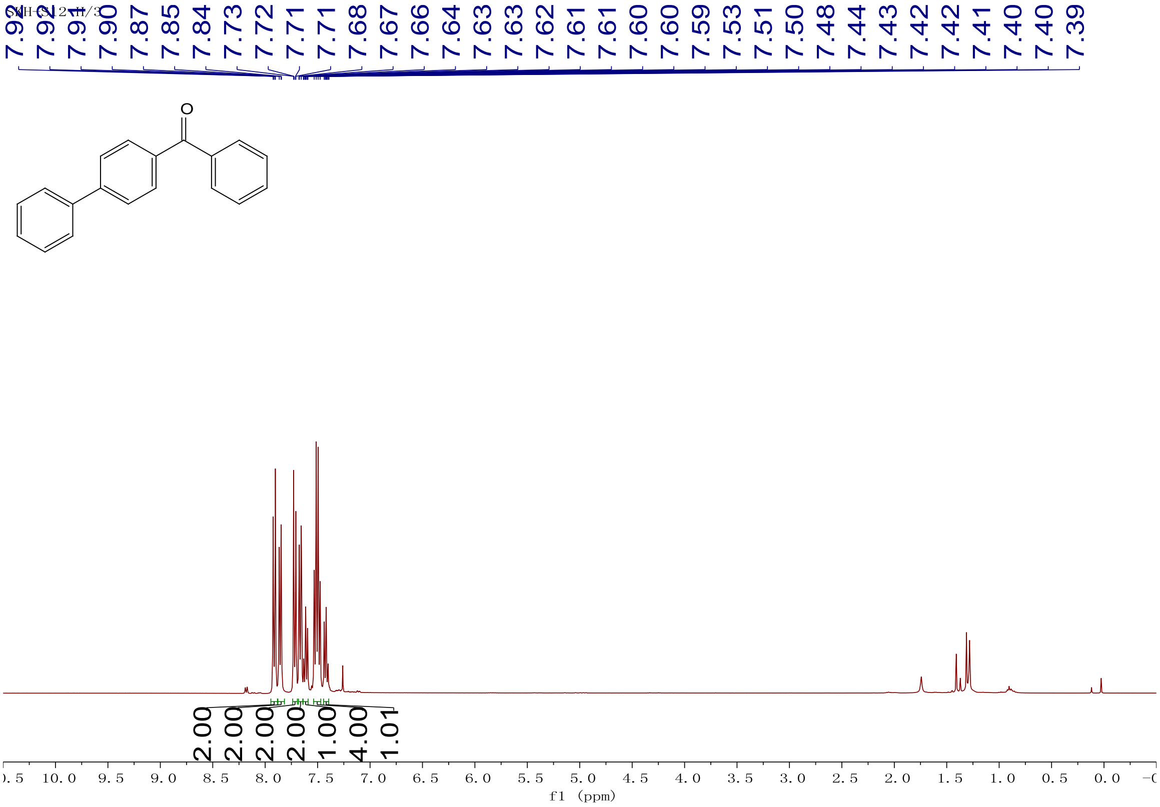
# 11. $^1$H, $^{13}$C and $^{19}$F NMR spectra

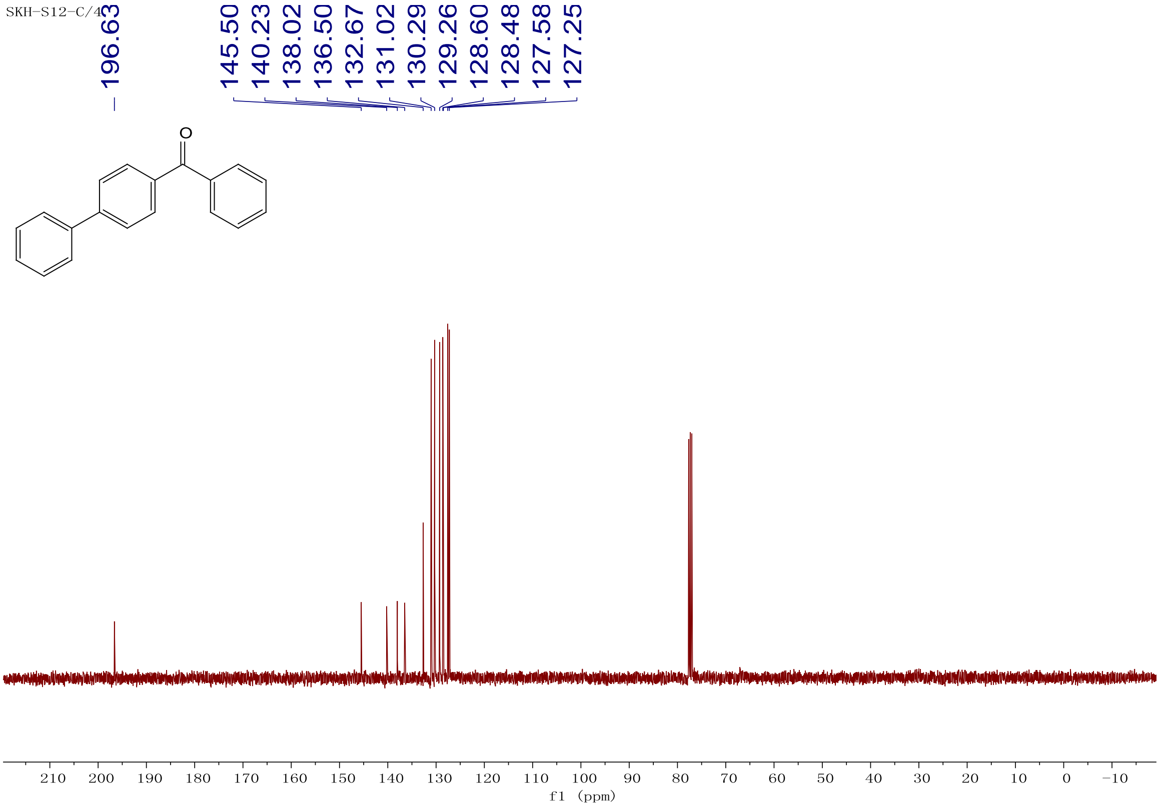
**1e**



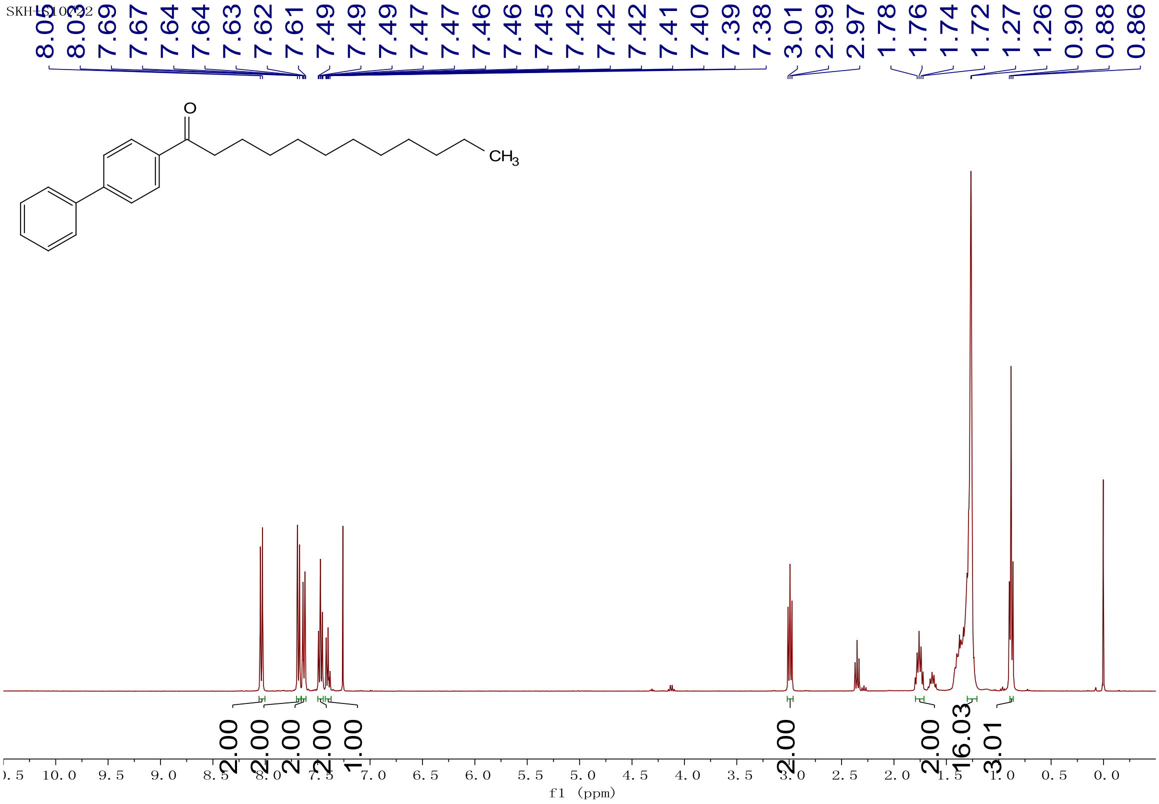


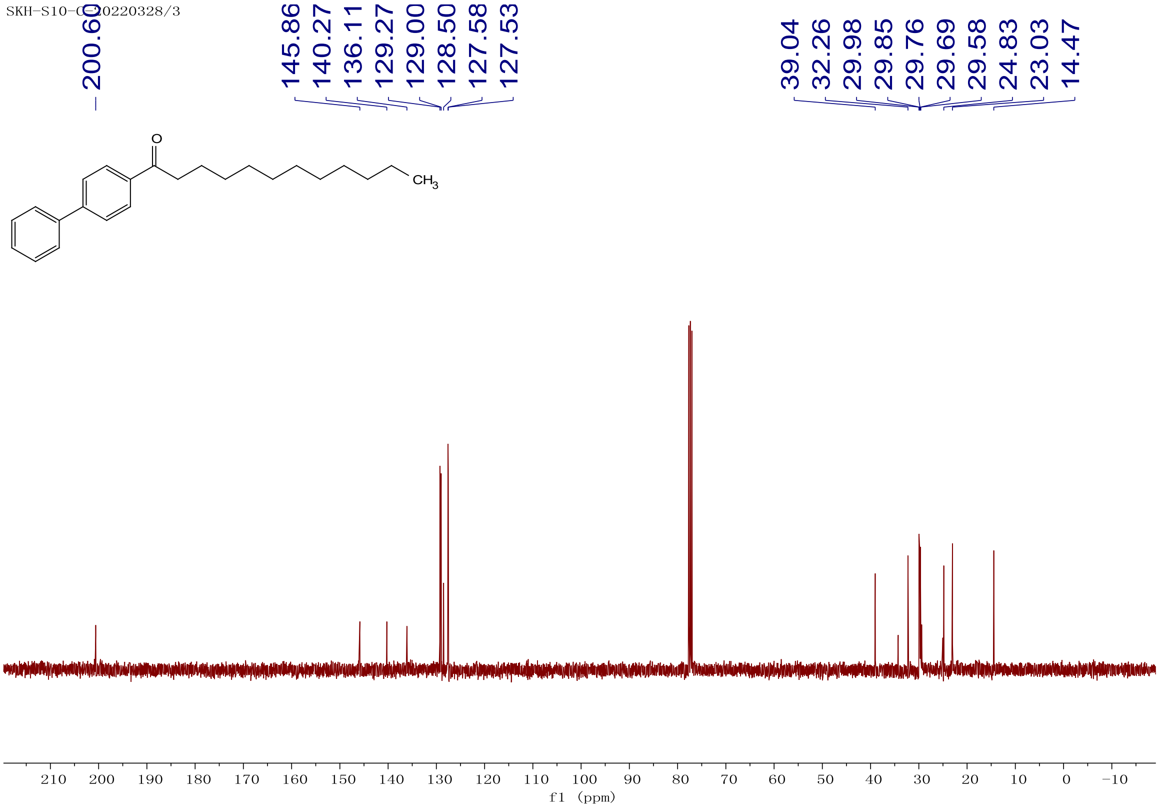
# 1m


SKH-S12-H/3
7.92 7.92 7.91 7.90 7.87 7.85 7.84 7.73 7.72 7.71 7.71 7.68 7.67 7.66 7.64 7.63 7.63 7.62 7.61 7.61 7.60 7.60 7.59 7.53 7.51 7.50 7.48 7.44 7.43 7.42 7.42 7.41 7.40 7.40 7.39
O
2.00 2.00 2.00 2.00 1.00 4.00 1.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

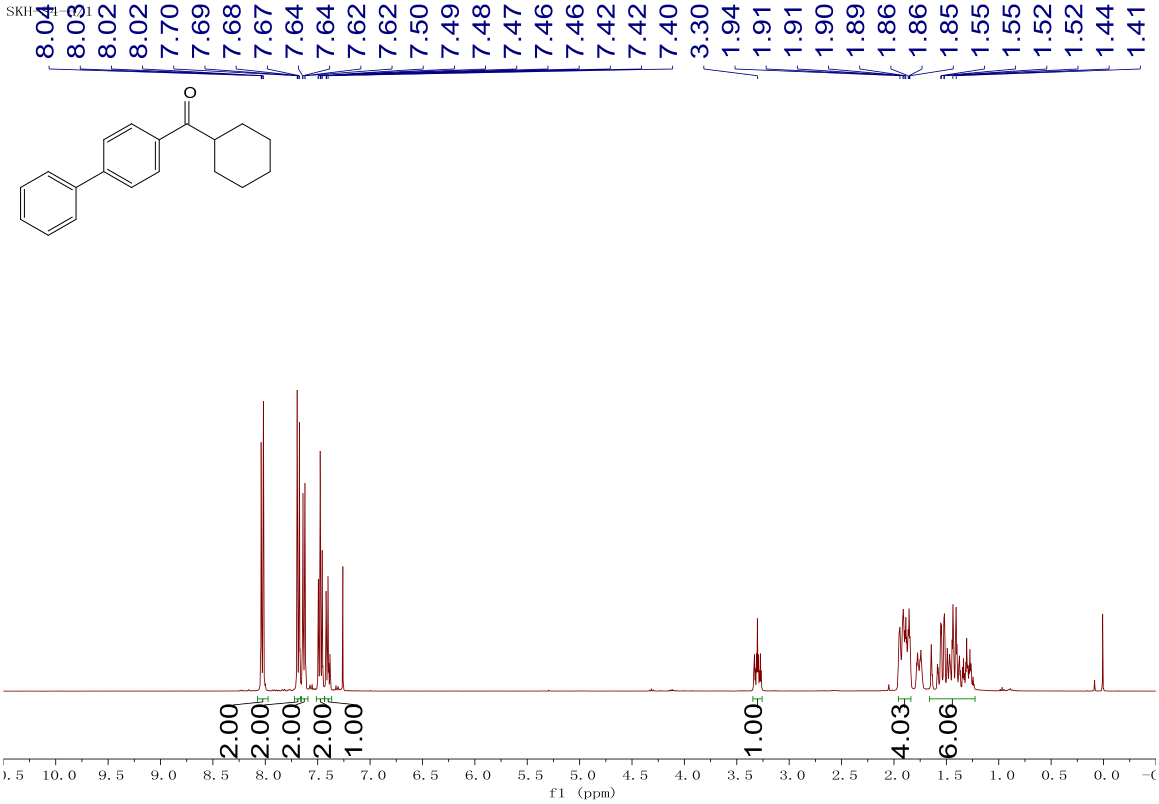

SKH-S12-C/4
196.63
145.50 140.23 138.02 136.50 132.67 131.02 130.29 129.26 128.60 128.48 127.58 127.25
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

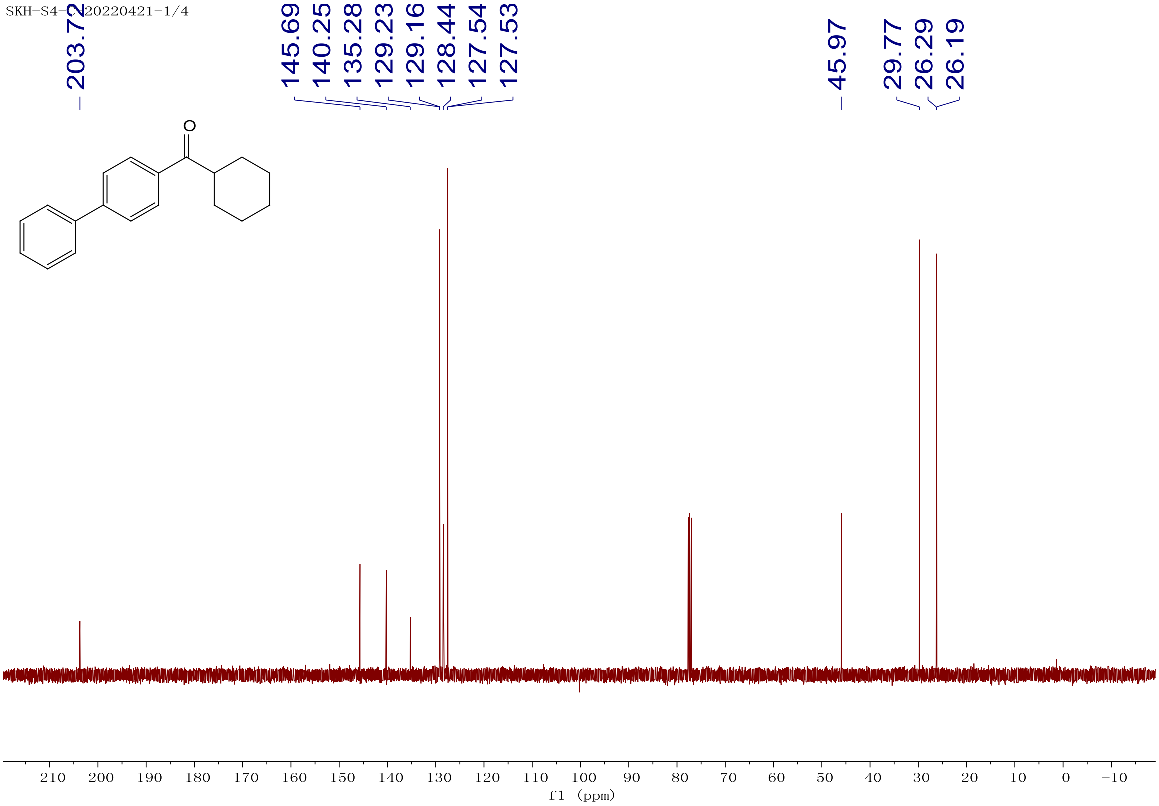
**1w**


SKH-S10/22
8.05
8.03
7.69
7.67
7.64
7.64
7.63
7.62
7.61
7.49
7.49
7.49
7.47
7.47
7.46
7.46
7.45
7.42
7.42
7.42
7.41
7.40
7.39
7.38
3.01
2.99
2.97
1.78
1.76
1.74
1.72
1.27
1.26
0.90
0.88
0.86
O
CH3
2.00
2.00
2.00
2.00
1.00
2.00
2.00
16.03
3.01
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

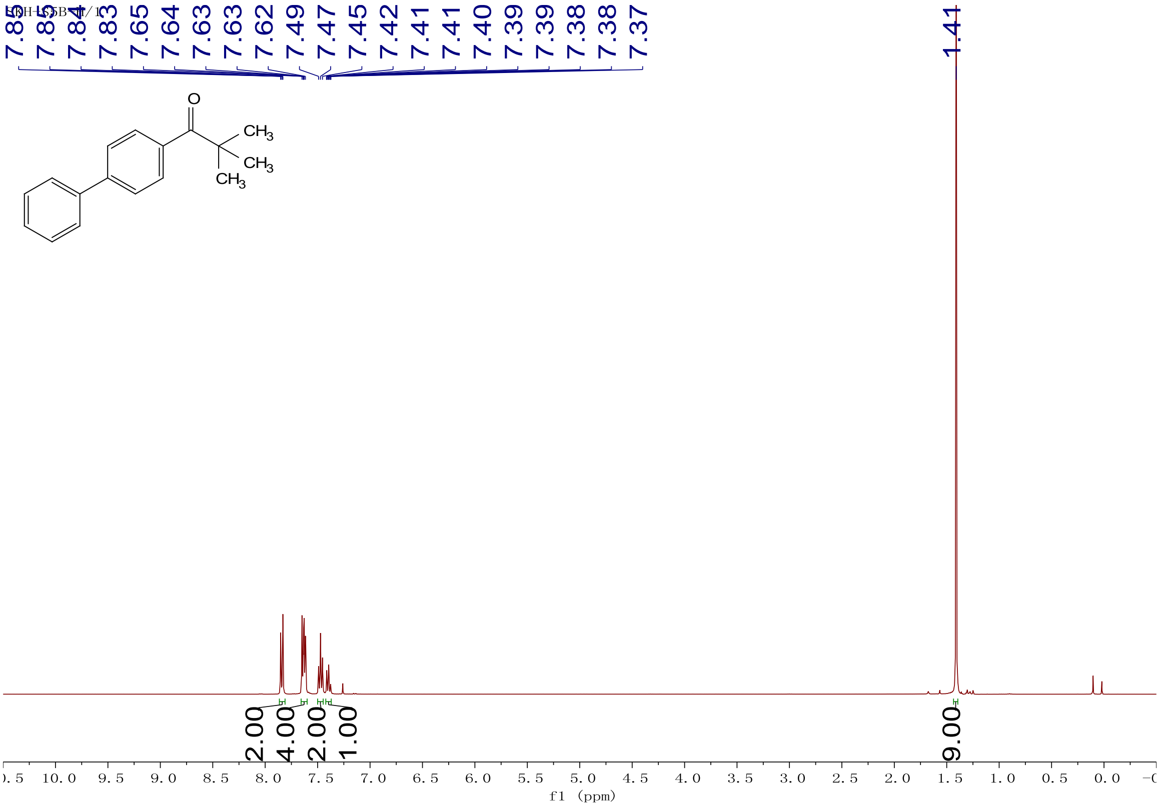

SKH-S10-C-20220328/3
200.60
145.86
140.27
136.11
129.27
129.00
128.50
127.58
127.53
39.04
32.26
29.98
29.85
29.76
29.69
29.58
24.83
23.03
14.47
O
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

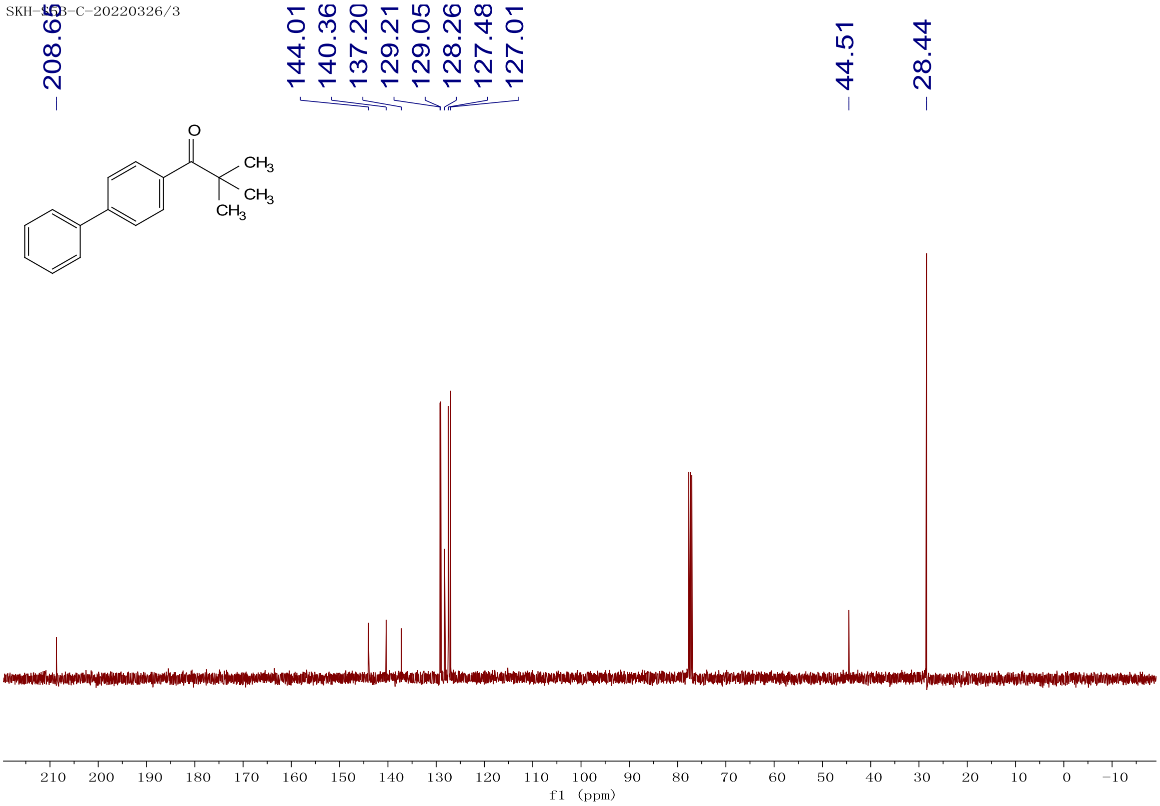
# 1x


SKH-S4-1/1
8.04
8.03
8.02
8.02
7.70
7.69
7.68
7.67
7.64
7.64
7.62
7.62
7.50
7.49
7.48
7.47
7.46
7.46
7.42
7.42
7.40
3.30
1.94
1.91
1.91
1.90
1.89
1.86
1.86
1.85
1.55
1.55
1.52
1.52
1.44
1.41
O
2.00
2.00
2.00
2.00
1.00
1.00
4.03
6.06
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

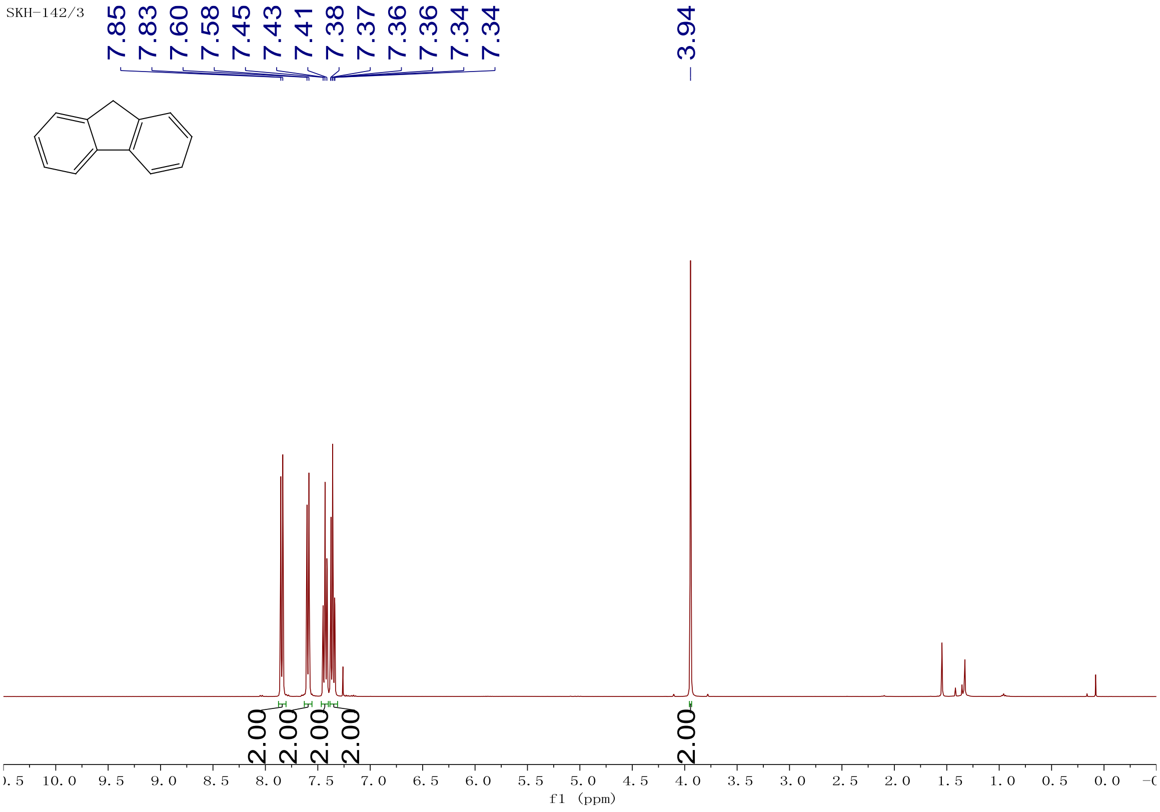

SKH-S4-120220421-1/4
203.72
145.69
140.25
135.28
129.23
129.16
128.44
127.54
127.53
45.97
29.77
26.29
26.19
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

# 1y


SKH-S5B-H/1
7.85
7.85
7.84
7.83
7.65
7.64
7.63
7.63
7.62
7.49
7.47
7.45
7.42
7.41
7.41
7.40
7.39
7.39
7.38
7.38
7.37
1.41
O
CH3
CH3
CH3
2.00
4.00
2.00
1.00
9.00
0.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0
f1 (ppm)


SKH-S5B-C-20220326/3
208.65
144.01
140.36
137.20
129.21
129.05
128.26
127.48
127.01
44.51
28.44
O
CH3
CH3
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

**2a**


SKH-142/3
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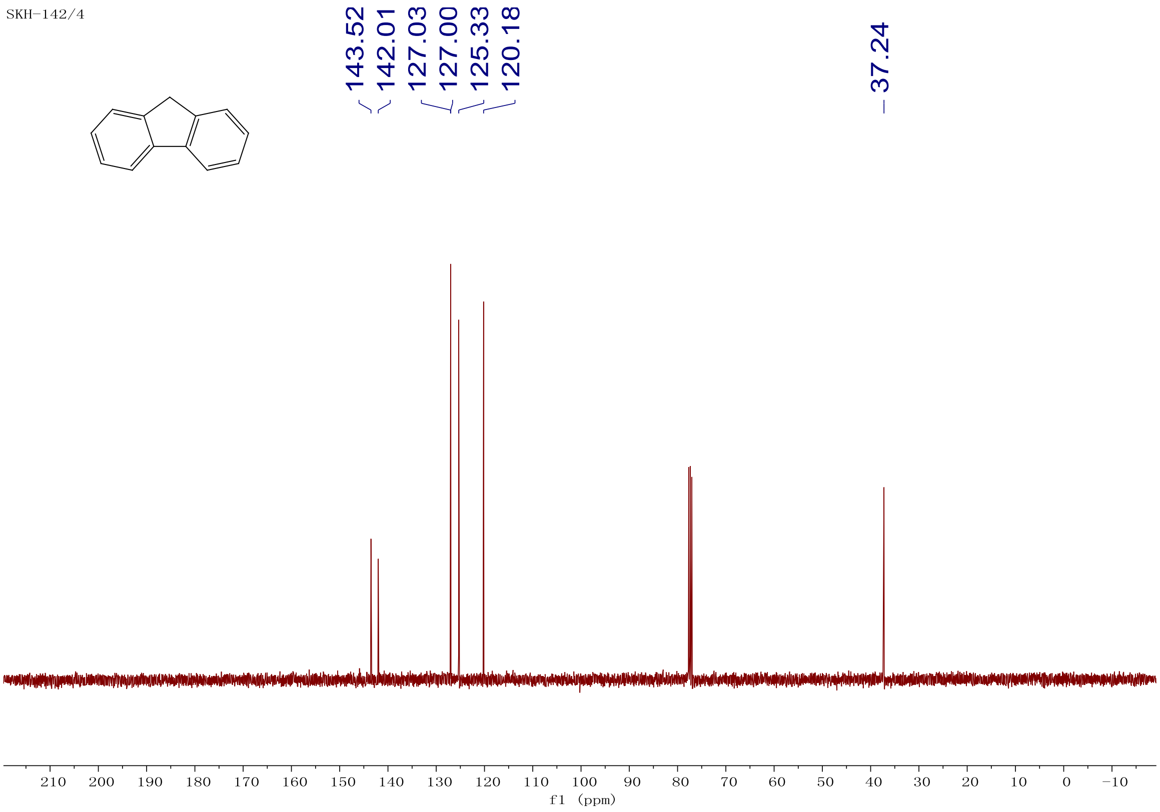
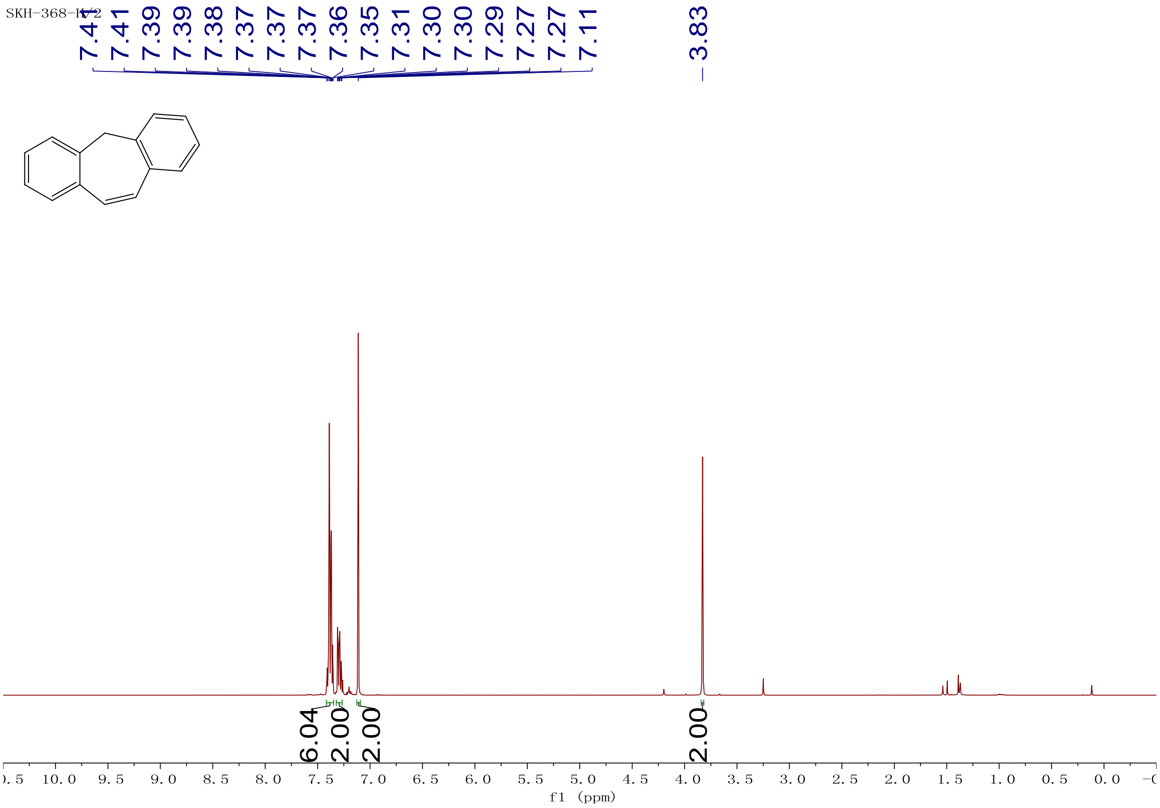
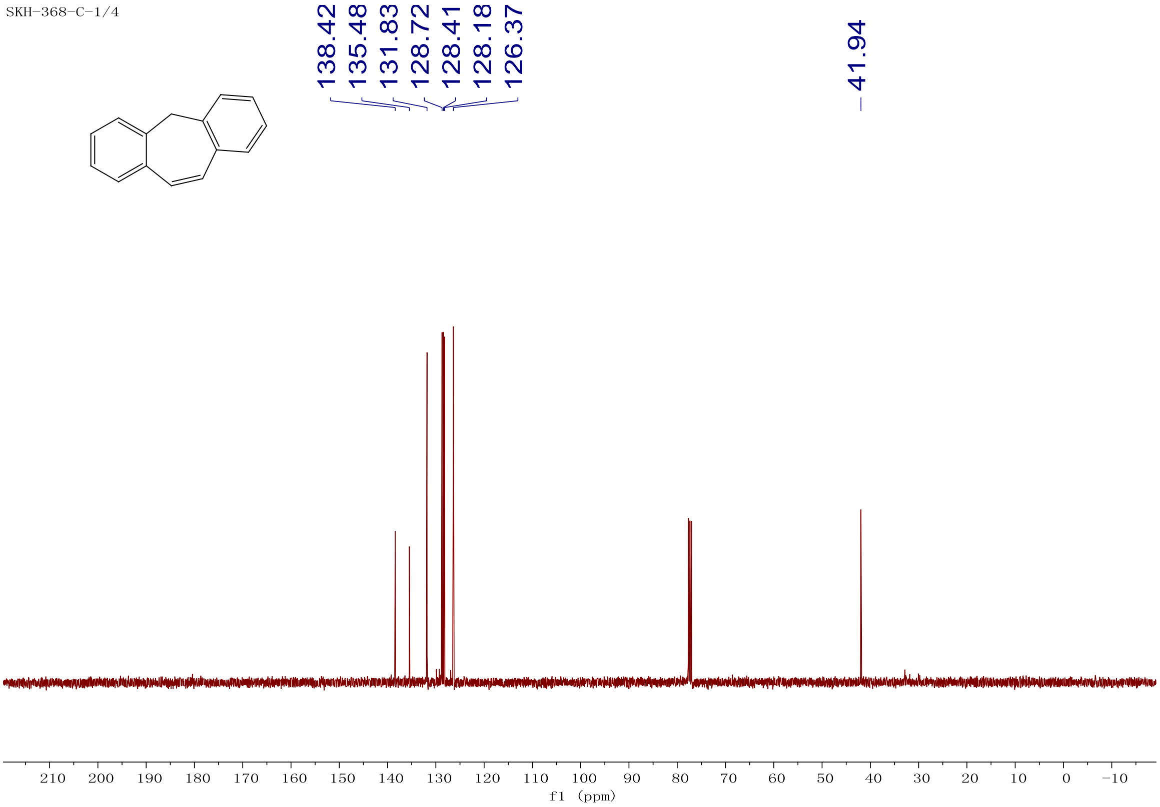
7.83
7.60
7.58
7.45
7.43
7.41
7.38
7.37
7.36
7.36
7.34
7.34
3.94
2.00
2.00
2.00
2.00
2.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

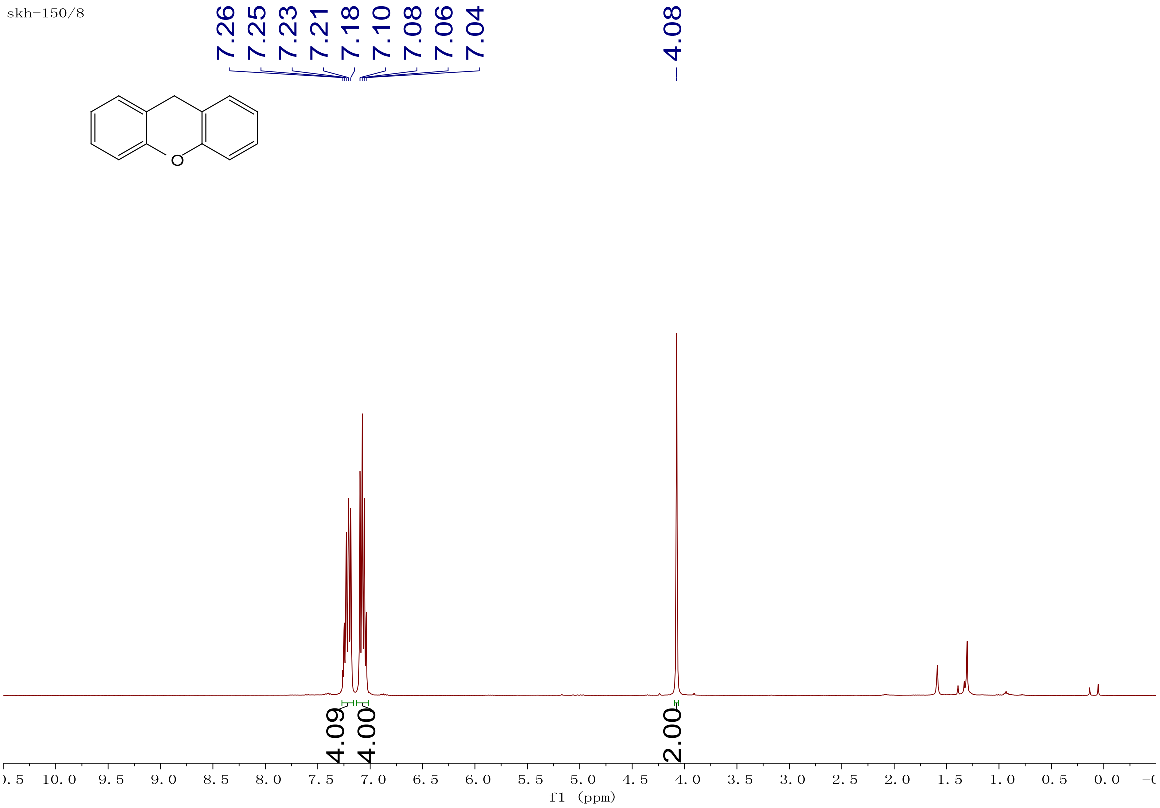

SKH-142/4
143.52
142.01
127.03
127.00
125.33
120.18
37.24
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

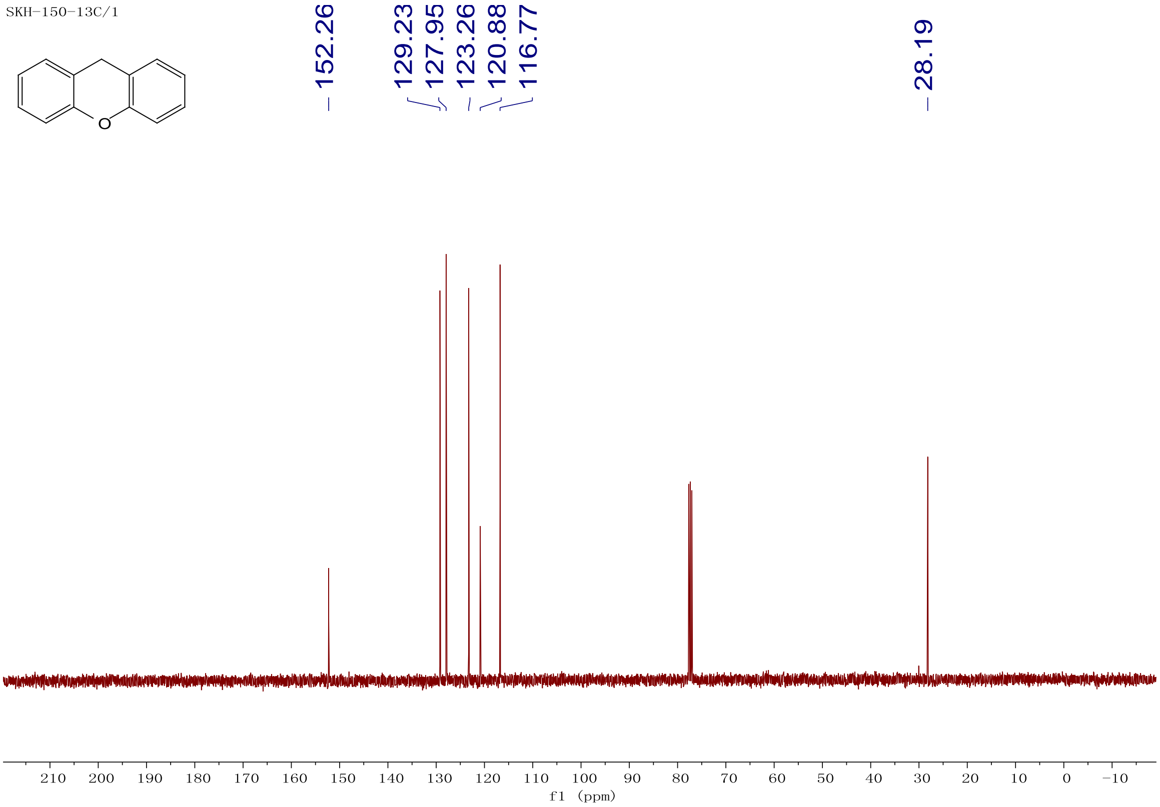
**2b**


SKH-368-H/2
7.41
7.41
7.39
7.39
7.38
7.37
7.37
7.37
7.36
7.35
7.31
7.30
7.30
7.29
7.27
7.27
7.11
3.83
6.04
2.00
2.00
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

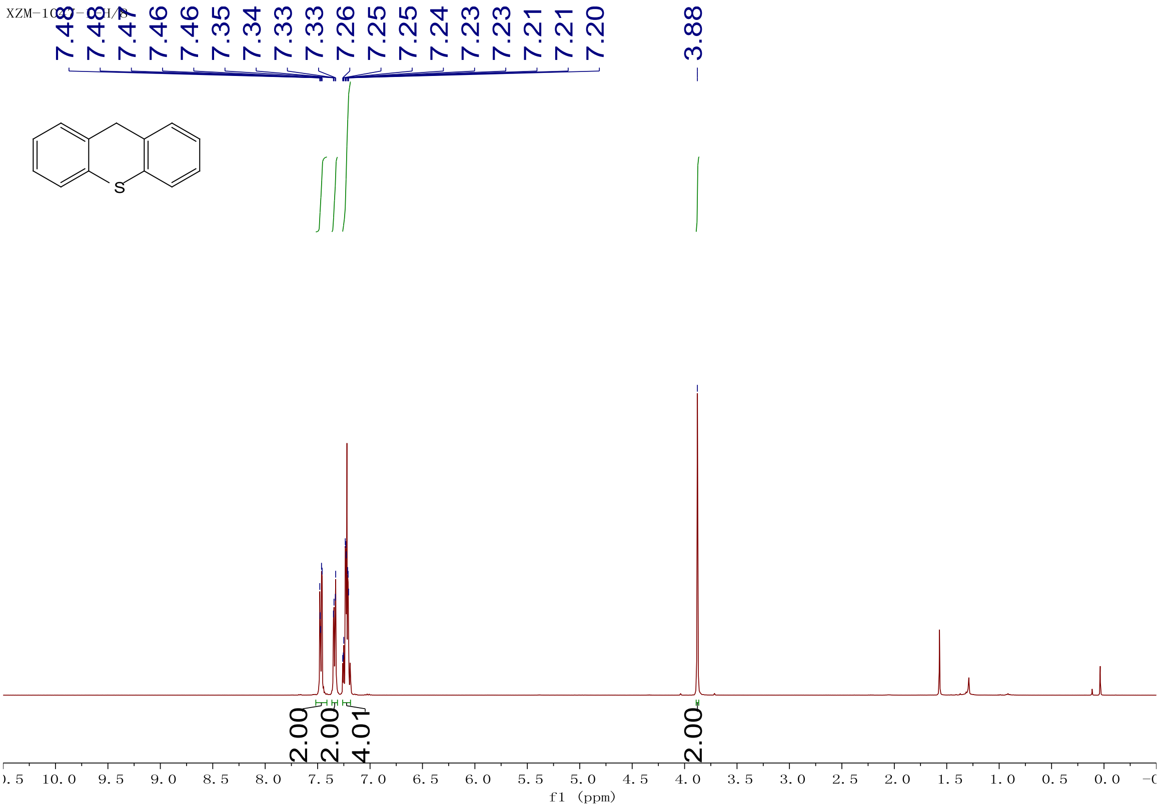

SKH-368-C-1/4
138.42
135.48
131.83
128.72
128.41
128.18
126.37
41.94
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

# 2c

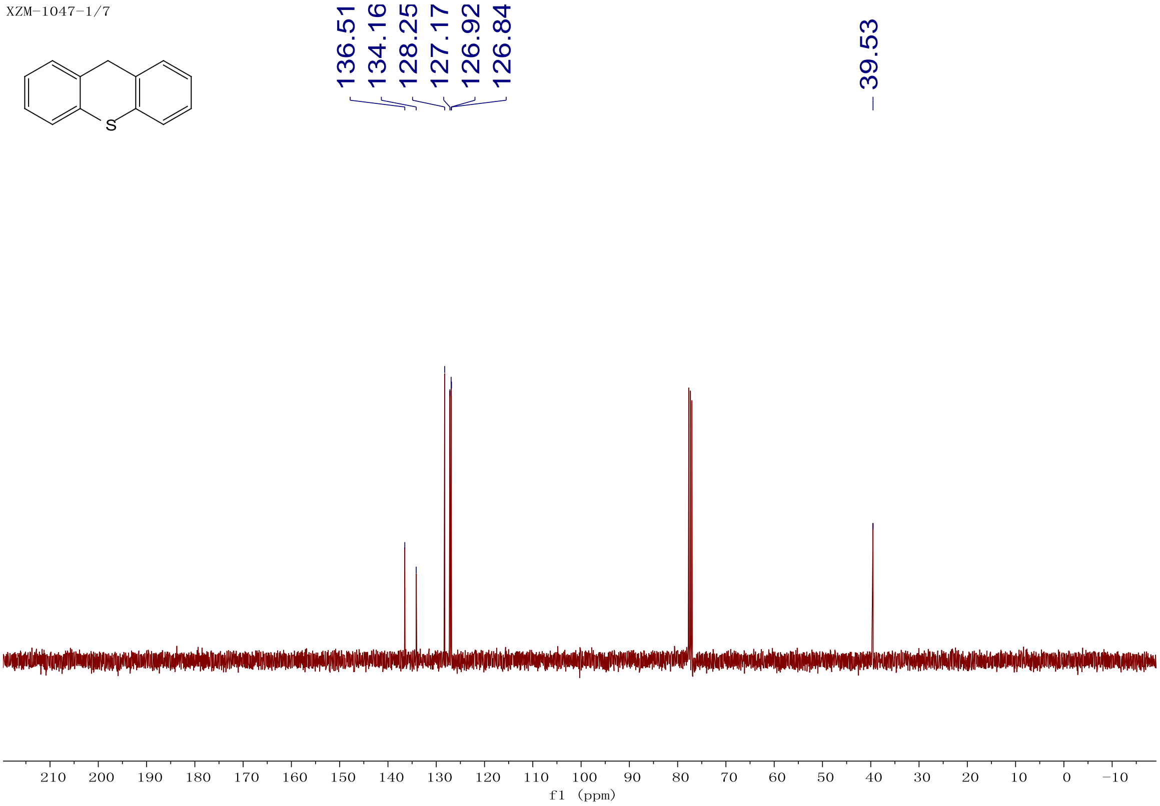

skh-150/8
7.26
7.25
7.23
7.21
7.18
7.10
7.08
7.06
7.04
4.08
O
4.09
4.00
2.00
0.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


SKH-150-13C/1
152.26
129.23
127.95
123.26
120.88
116.77
28.19
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

# 2d

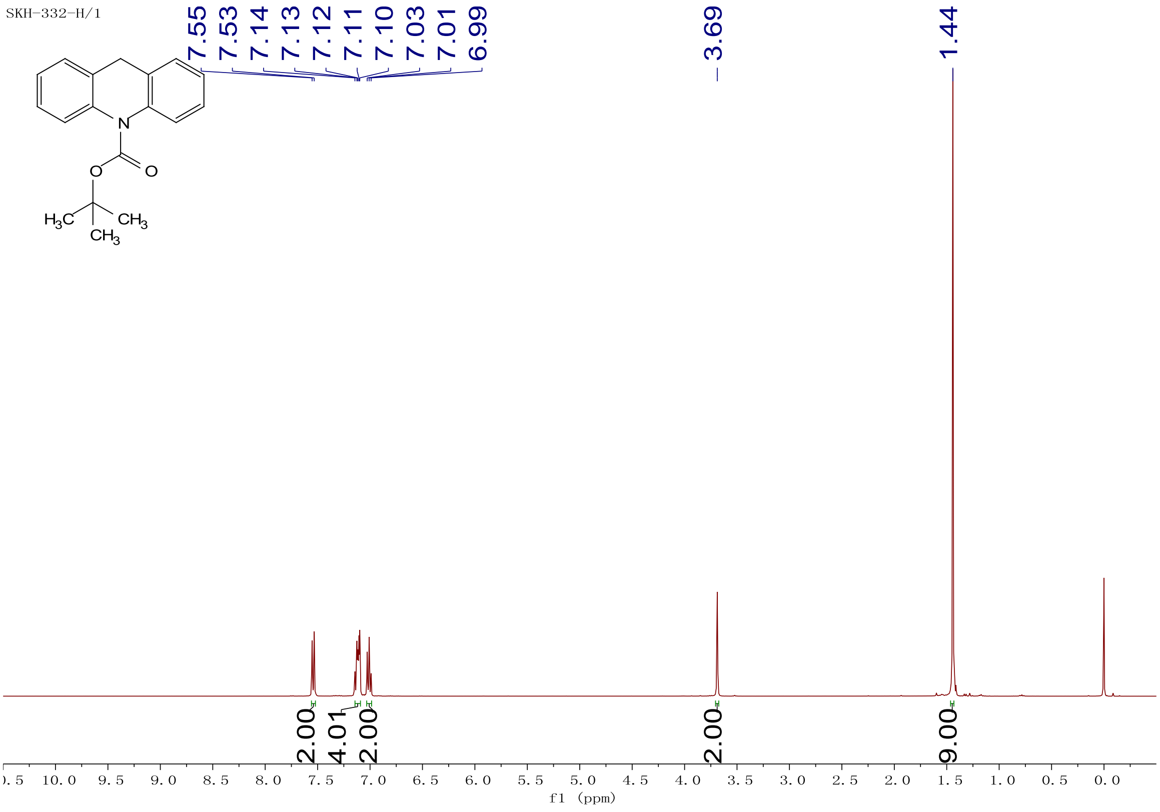


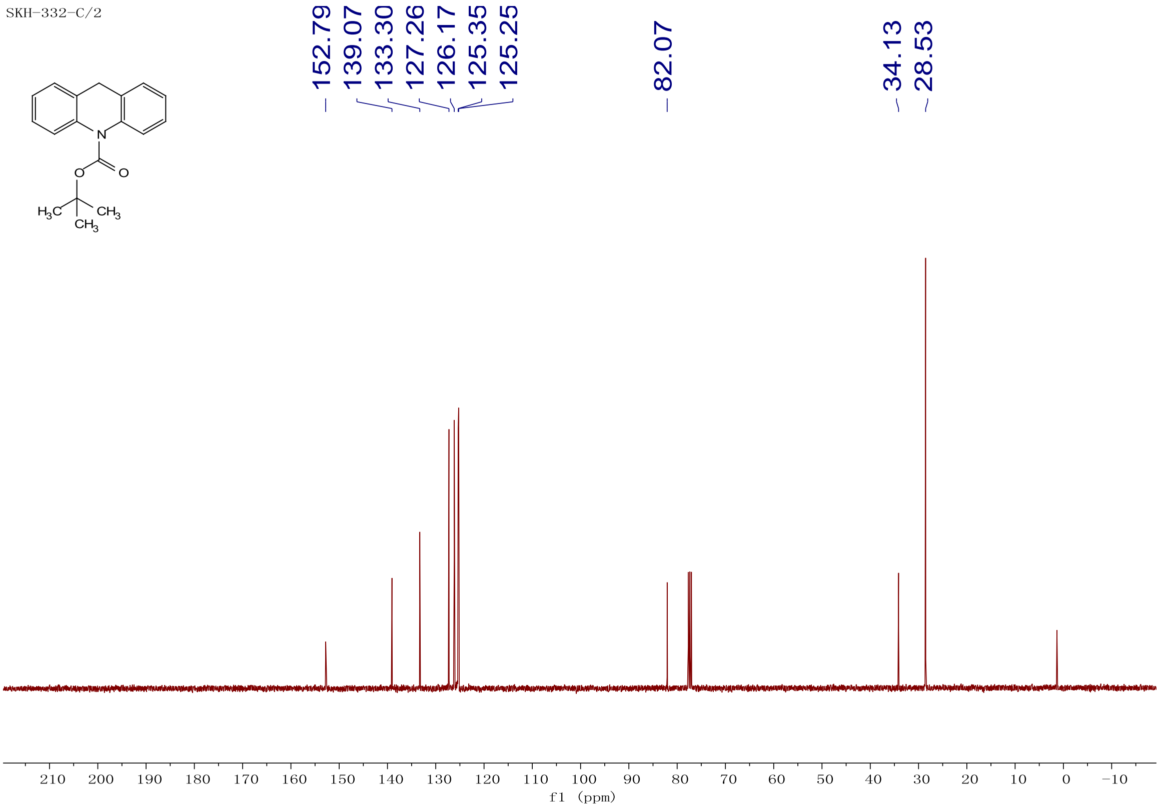
XZM-10
7.48
7.48
7.47
7.46
7.46
7.35
7.34
7.33
7.33
7.26
7.25
7.25
7.24
7.23
7.23
7.21
7.21
7.20
3.88
S
2.00
2.00
4.01
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



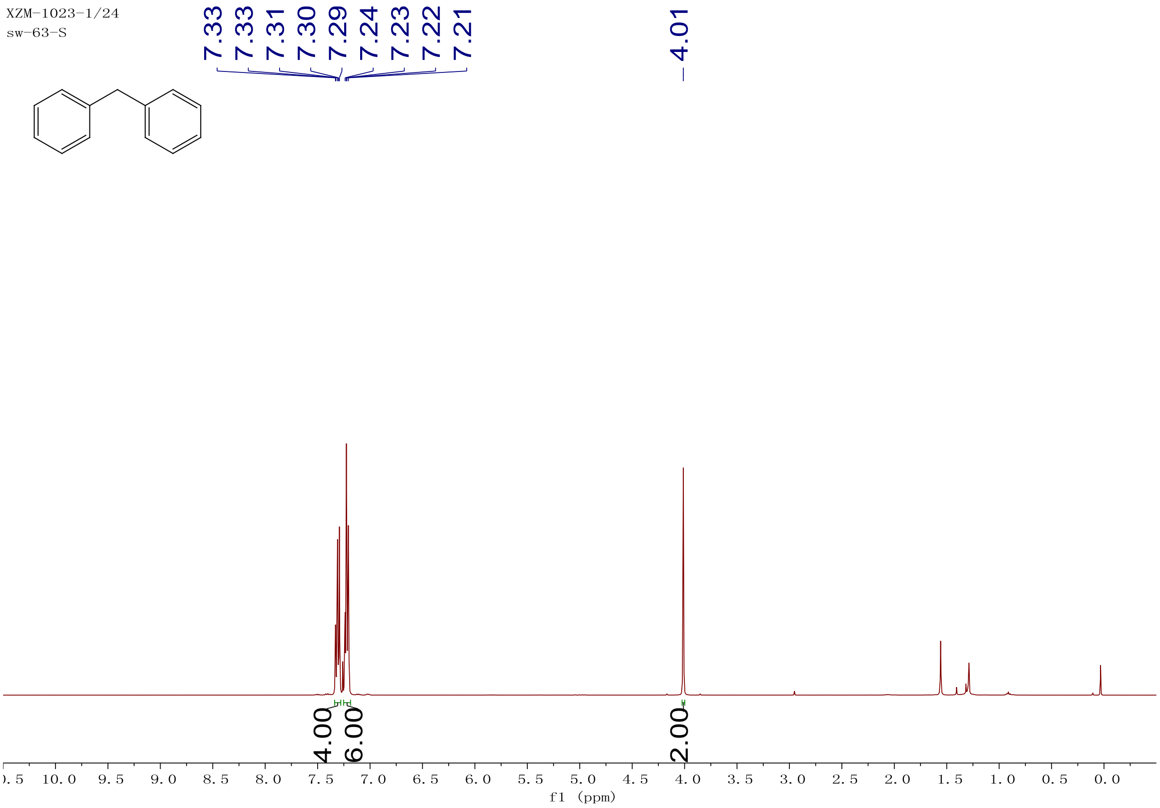
XZM-1047-1/7
S
136.51
134.16
128.25
127.17
126.92
126.84
39.53
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

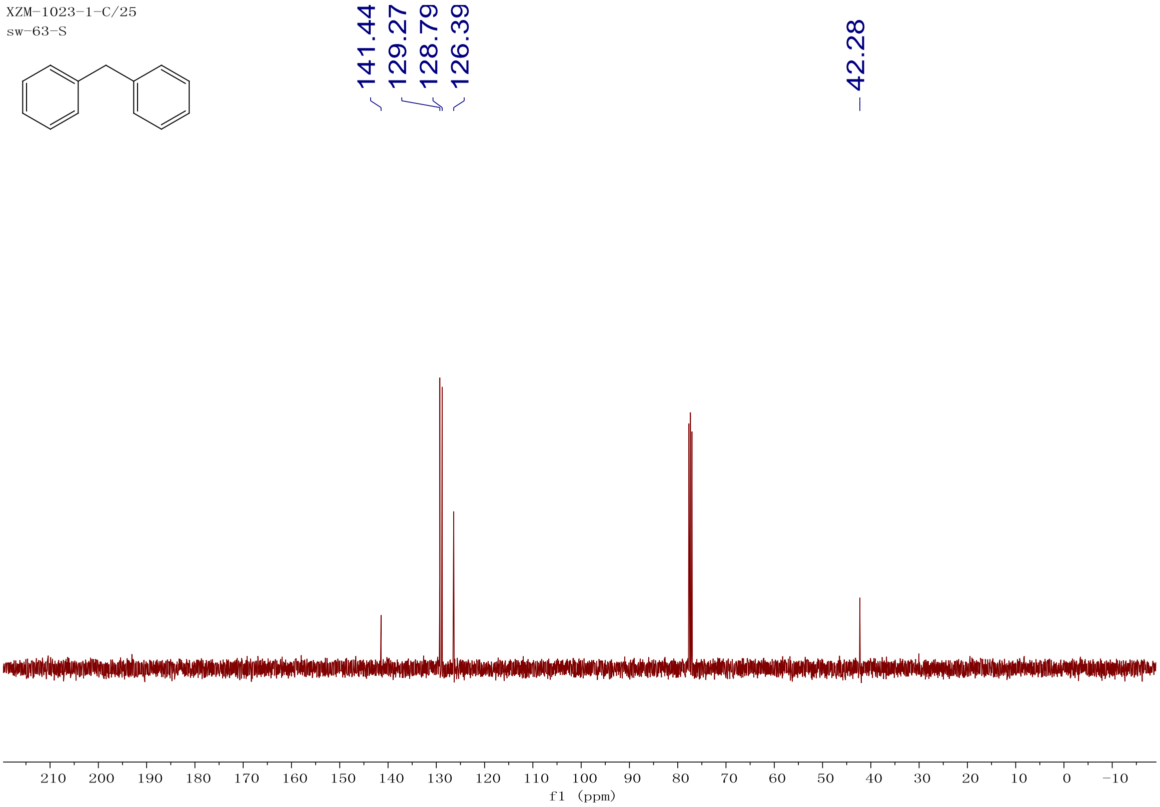
# 2e


SKH-332-H/1
N
O
O
H3C
CH3
CH3
7.55
7.53
7.14
7.13
7.12
7.11
7.10
7.03
7.01
6.99
3.69
1.44
2.00
4.01
2.00
2.00
9.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

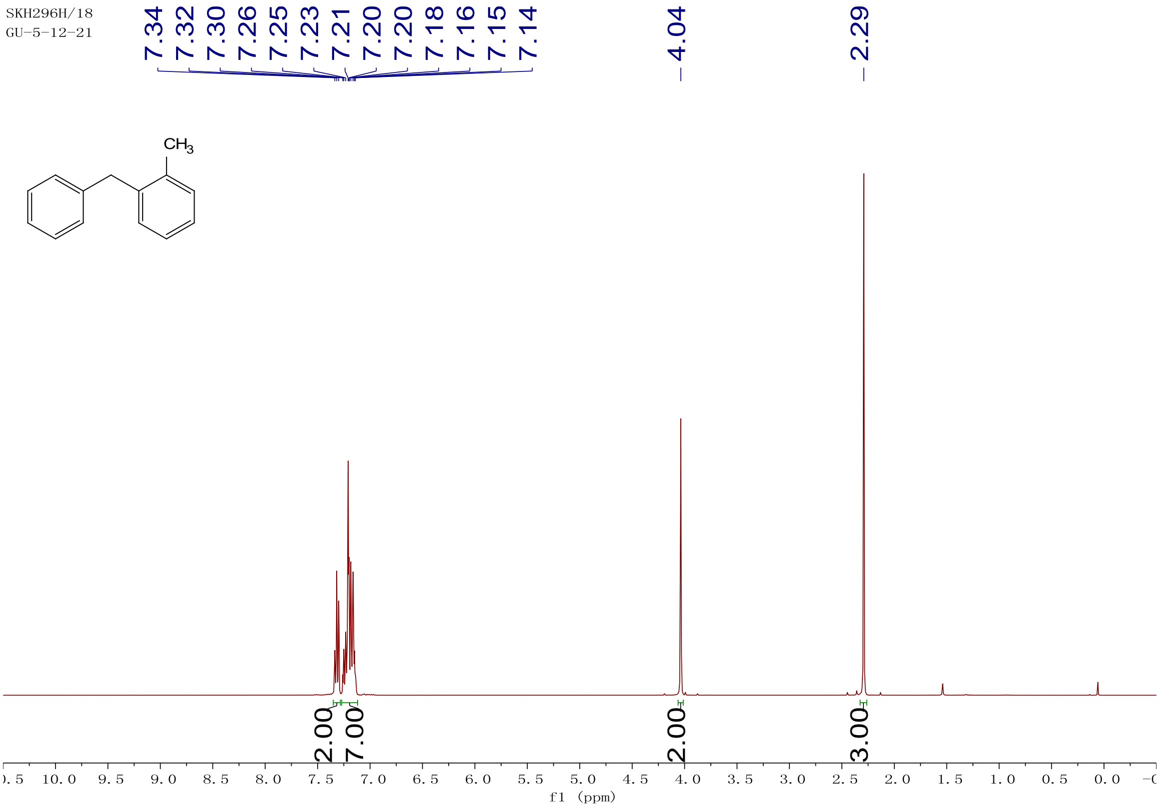

SKH-332-C/2
N
O
O
H3C
CH3
CH3
152.79
139.07
133.30
127.26
126.17
125.35
125.25
82.07
34.13
28.53
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

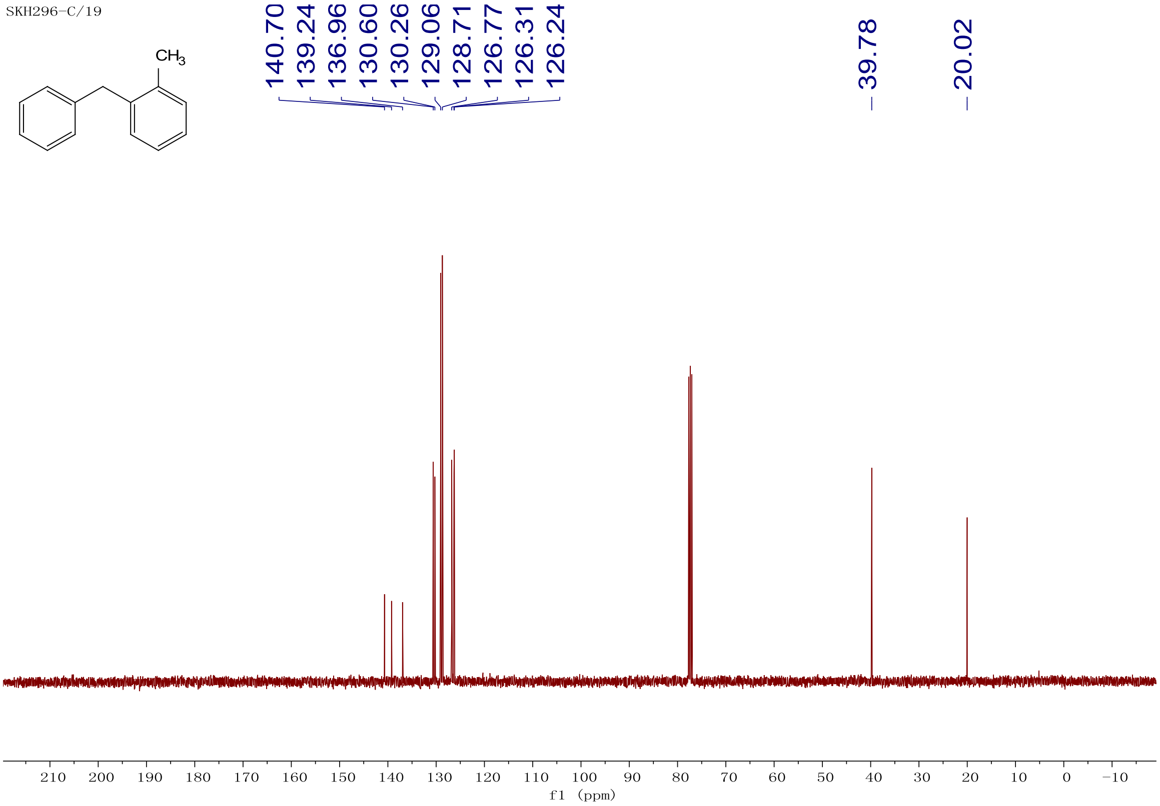
# 2f


XZM-1023-1/24
sw-63-S
7.33
7.33
7.31
7.30
7.29
7.24
7.23
7.22
7.21
4.01
4.00
6.00
2.00
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

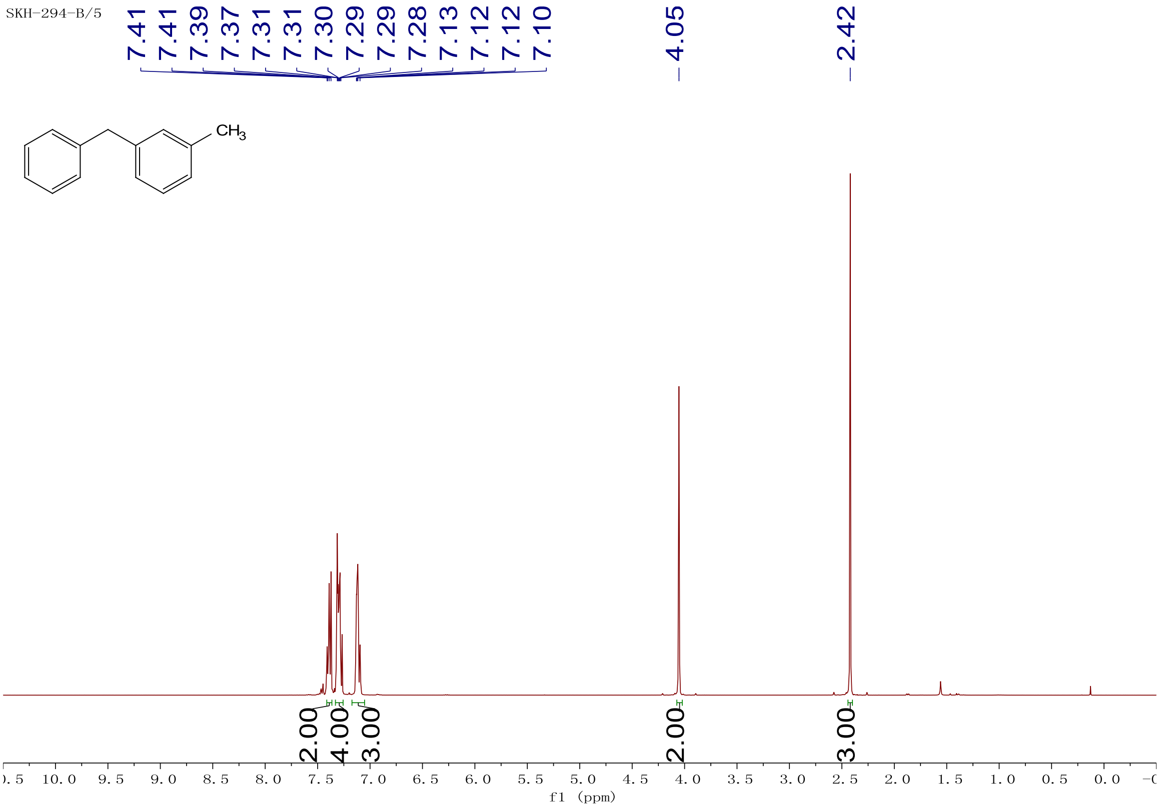

XZM-1023-1-C/25
sw-63-S
141.44
129.27
128.79
126.39
42.28
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

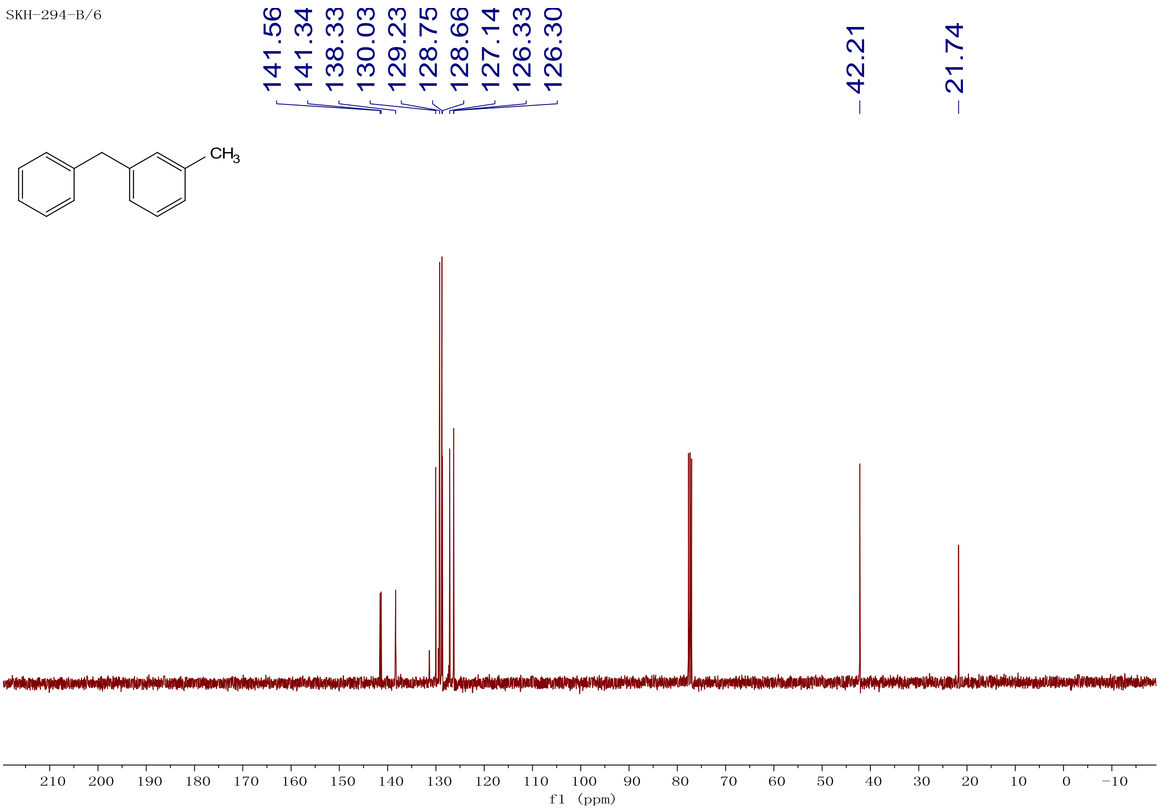
**2g**


SKH296H/18
GU-5-12-21
7.34
7.32
7.30
7.26
7.25
7.23
7.21
7.20
7.20
7.18
7.16
7.15
7.14
4.04
2.29
CH3
2.00
7.00
2.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

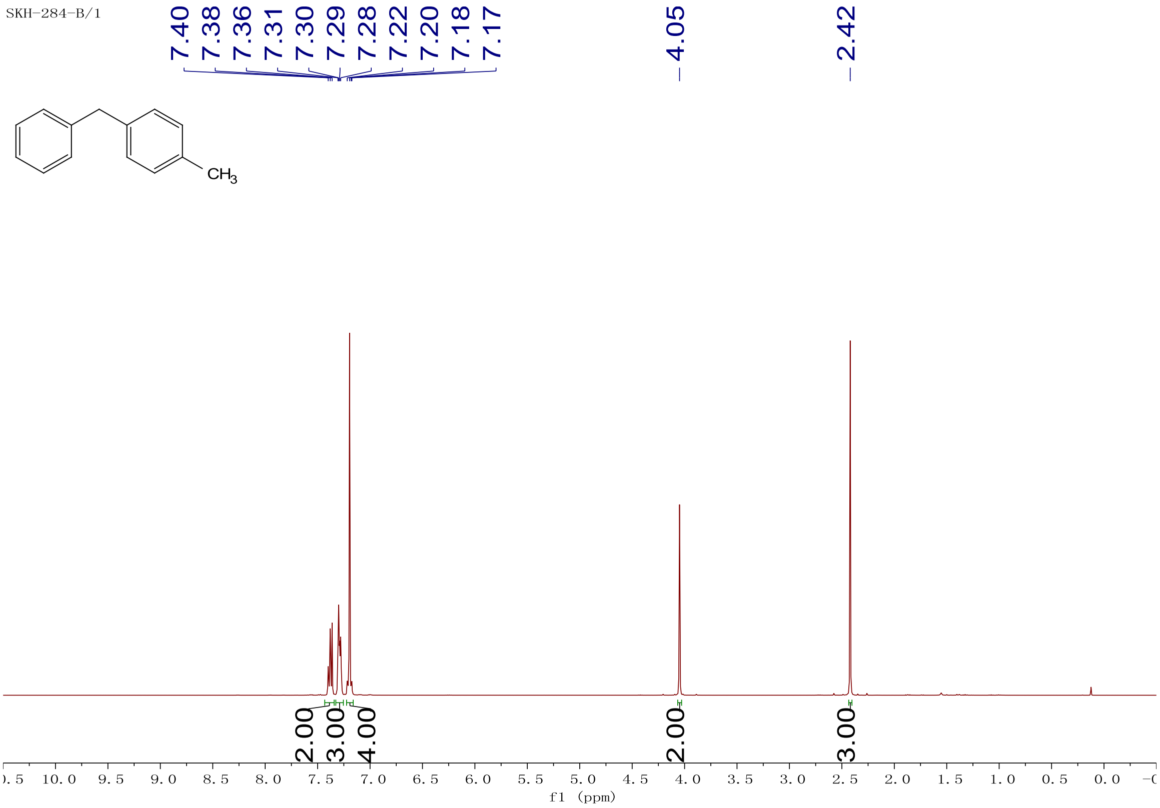

SKH296-C/19
140.70
139.24
136.96
130.60
130.26
129.06
128.71
126.77
126.31
126.24
39.78
20.02
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

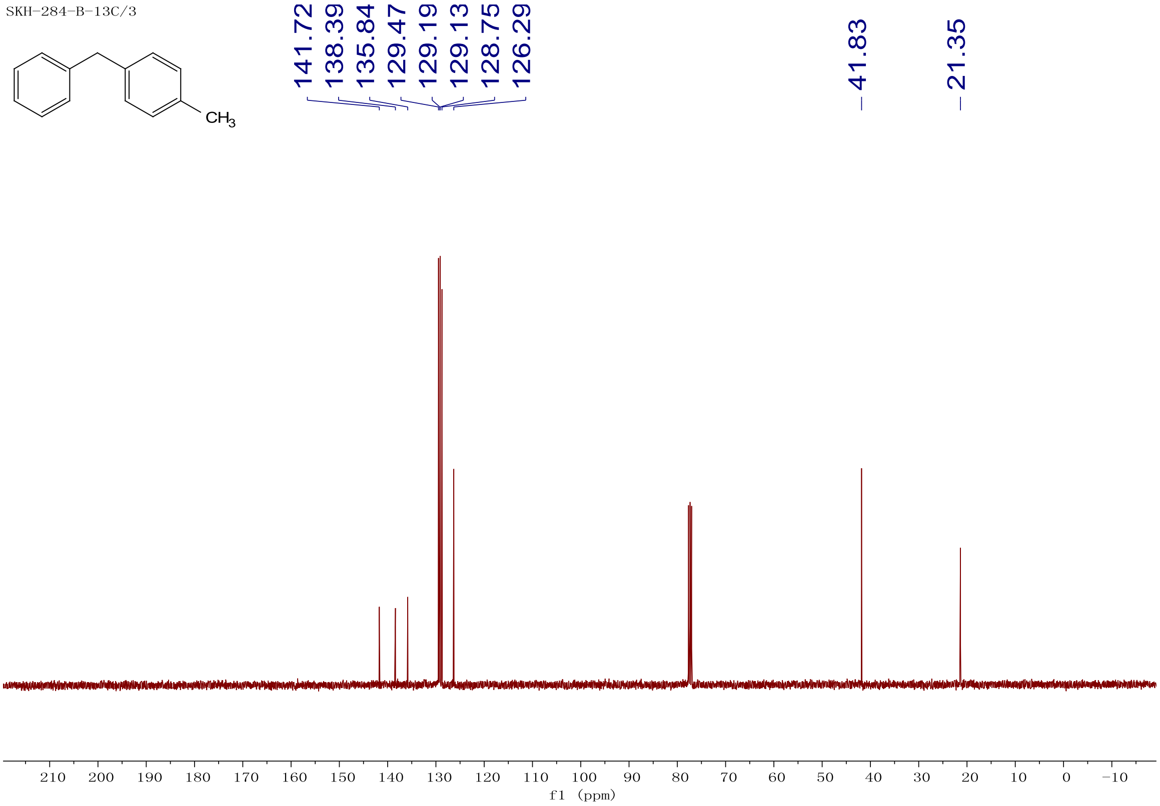
# 2h


SKH-294-B/5
7.41
7.41
7.39
7.37
7.31
7.31
7.30
7.29
7.29
7.28
7.13
7.12
7.12
7.10
4.05
2.42
CH3
2.00
4.00
3.00
2.00
3.00
0.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

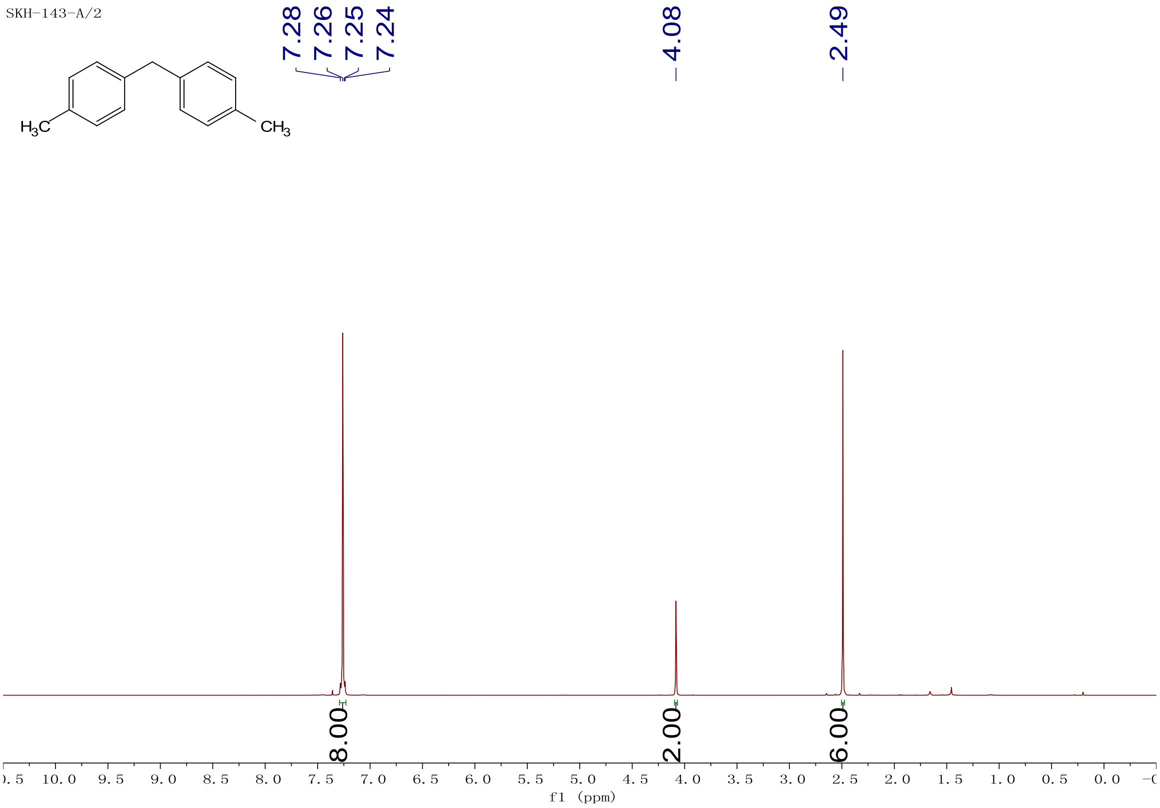

SKH-294-B/6
141.56
141.34
138.33
130.03
129.23
128.75
128.66
127.14
126.33
126.30
42.21
21.74
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

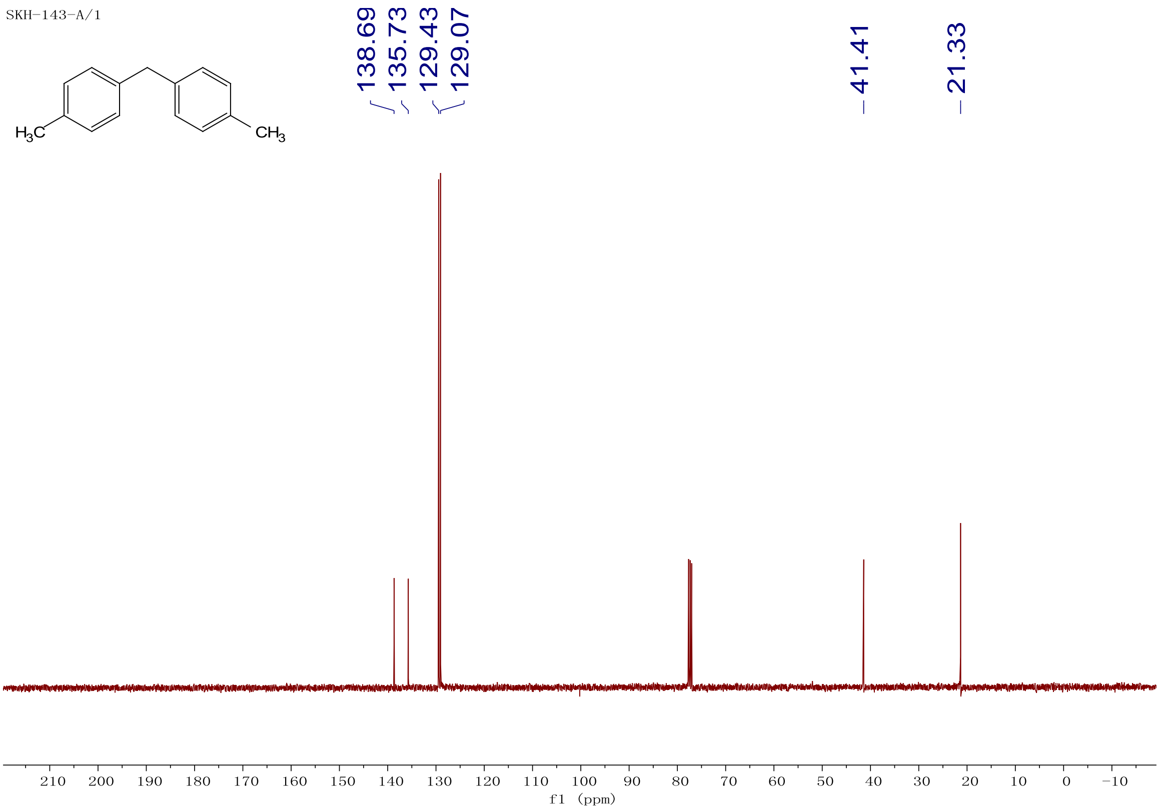
# 2i


SKH-284-B/1
7.40
7.38
7.36
7.31
7.30
7.29
7.28
7.22
7.20
7.18
7.17
4.05
2.42
CH3
2.00
3.00
4.00
2.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

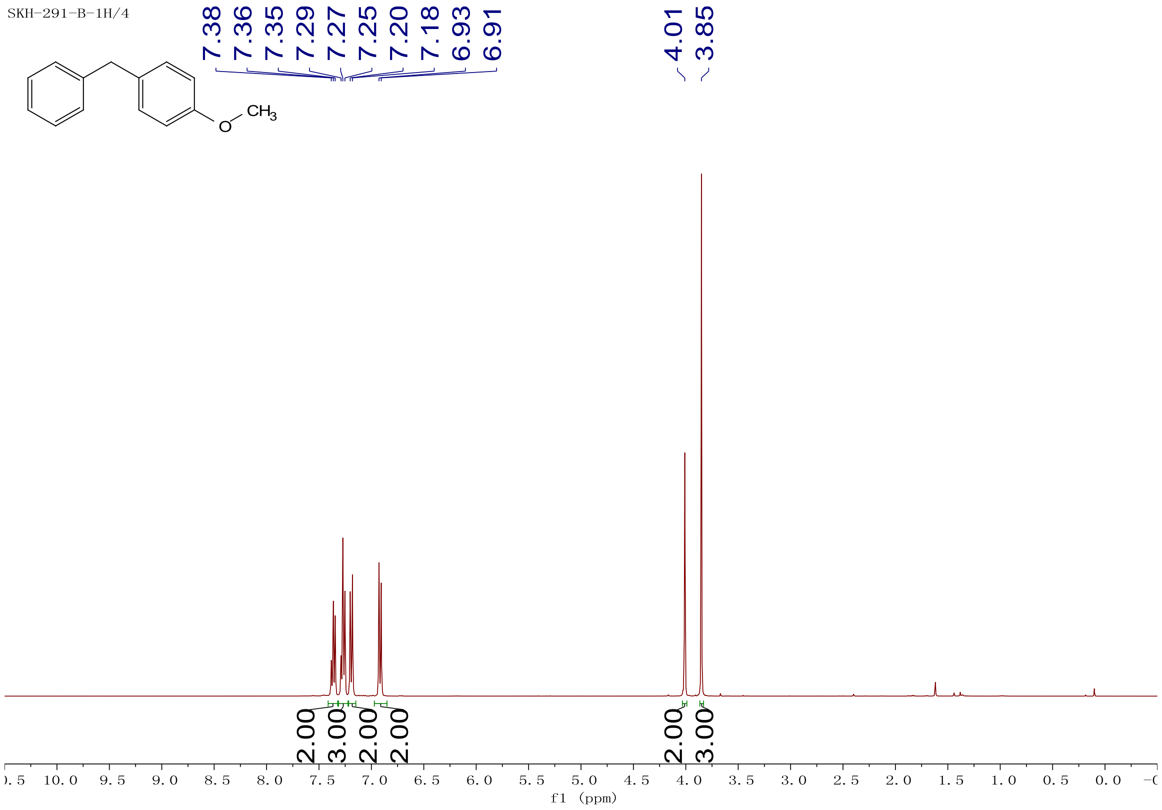

SKH-284-B-13C/3
141.72
138.39
135.84
129.47
129.19
129.13
128.75
126.29
41.83
21.35
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

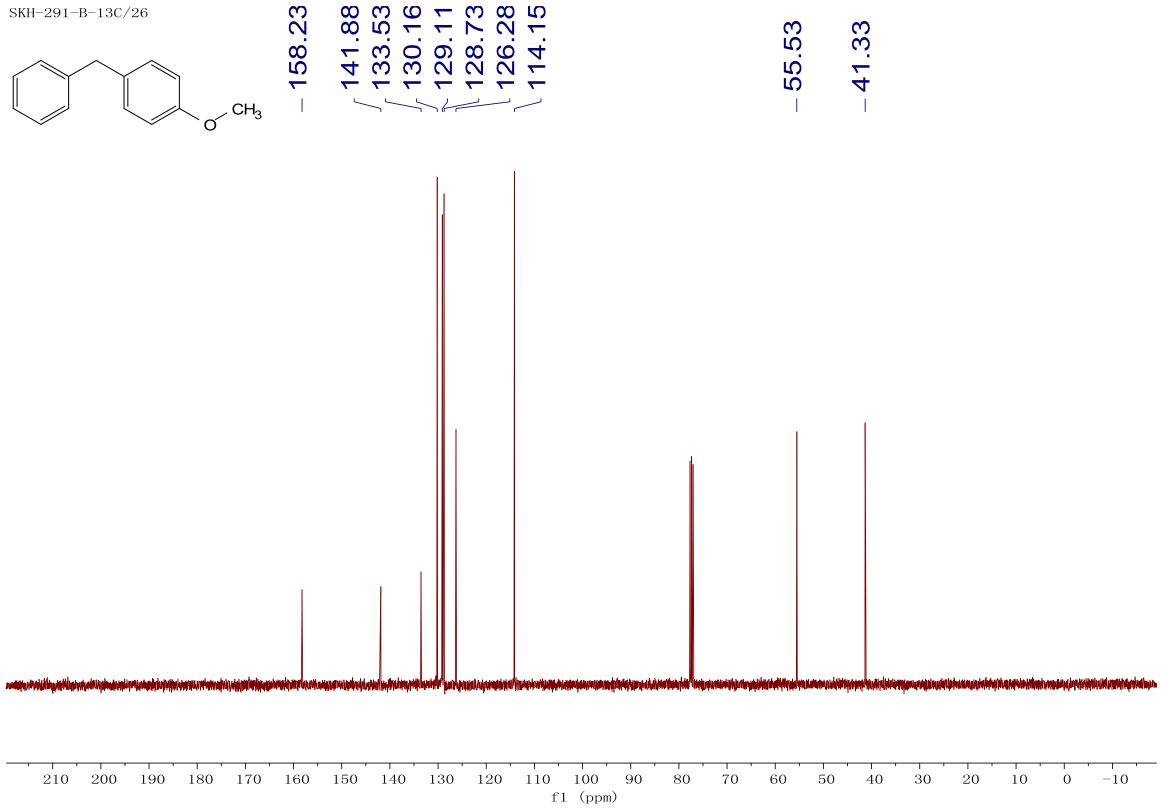
## 2j


SKH-143-A/2
H3C
CH3
7.28
7.26
7.25
7.24
4.08
2.49
8.00
2.00
6.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

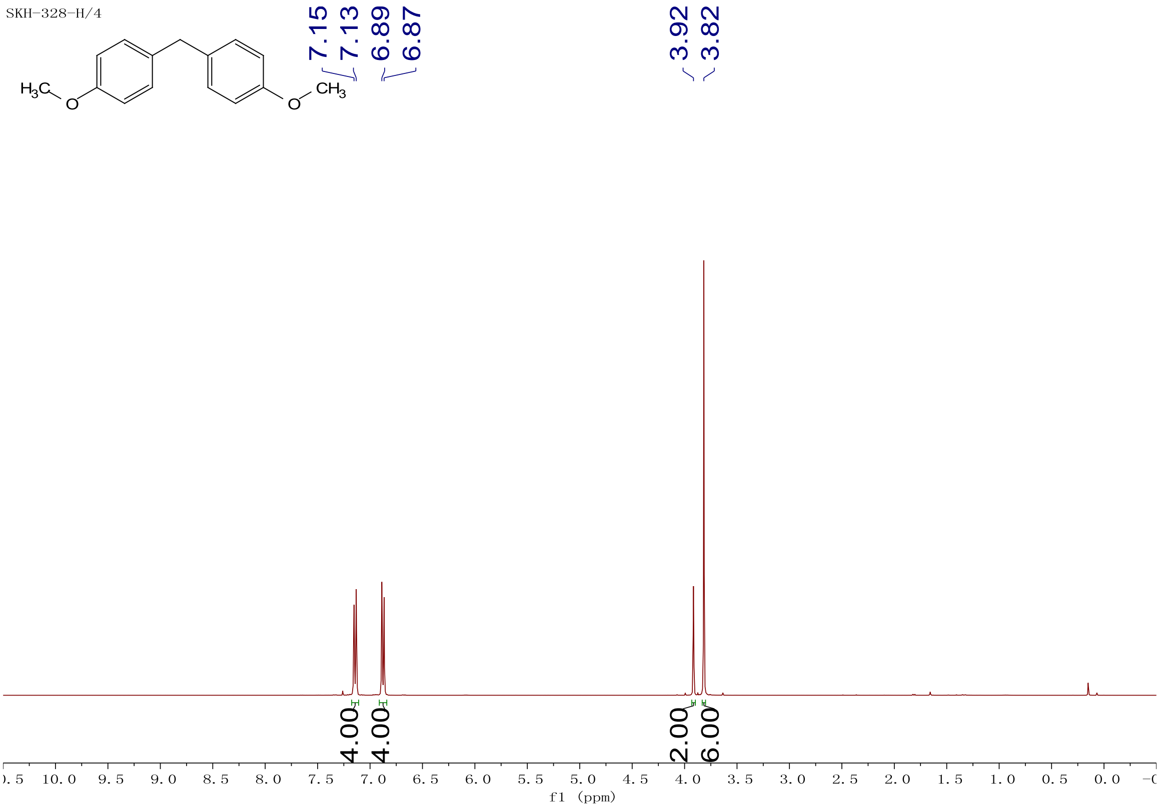

SKH-143-A/1
H3C
CH3
138.69
135.73
129.43
129.07
41.41
21.33
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

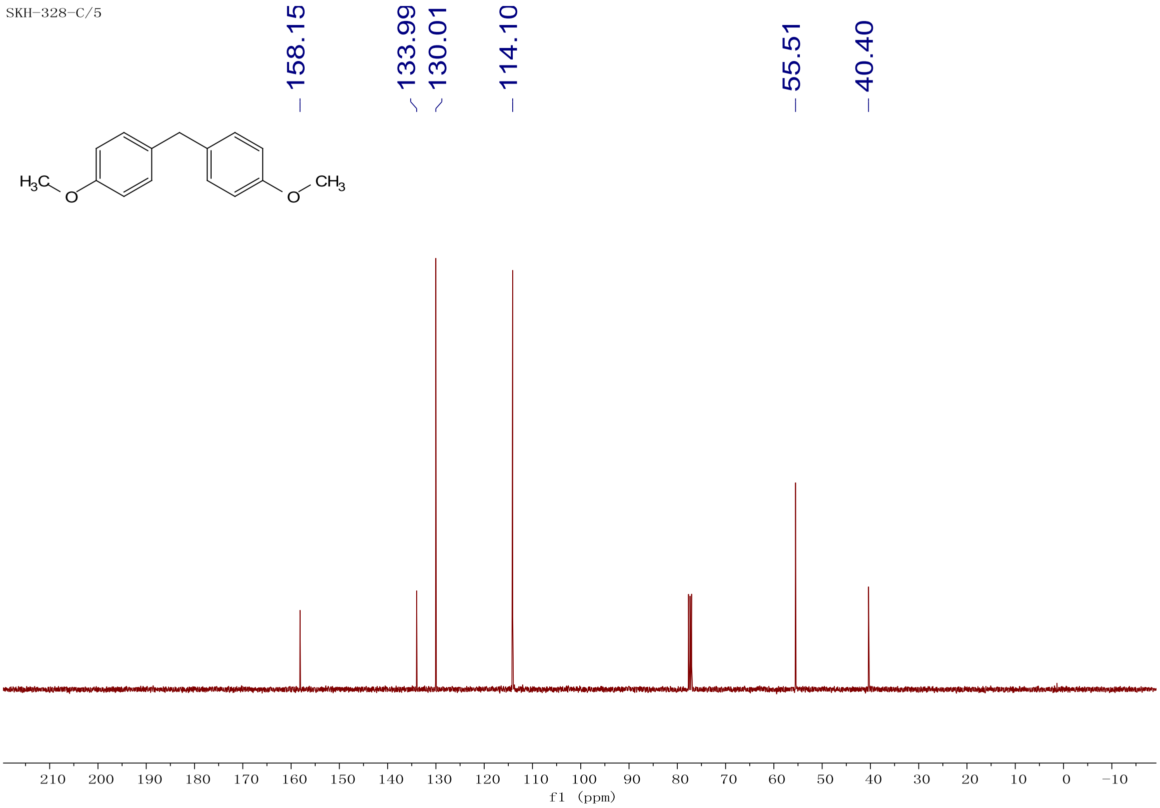
## 2k


SKH-291-B-1H/4
CH3
O
7.38
7.36
7.35
7.29
7.27
7.25
7.20
7.18
6.93
6.91
4.01
3.85
2.00
3.00
2.00
2.00
2.00
3.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

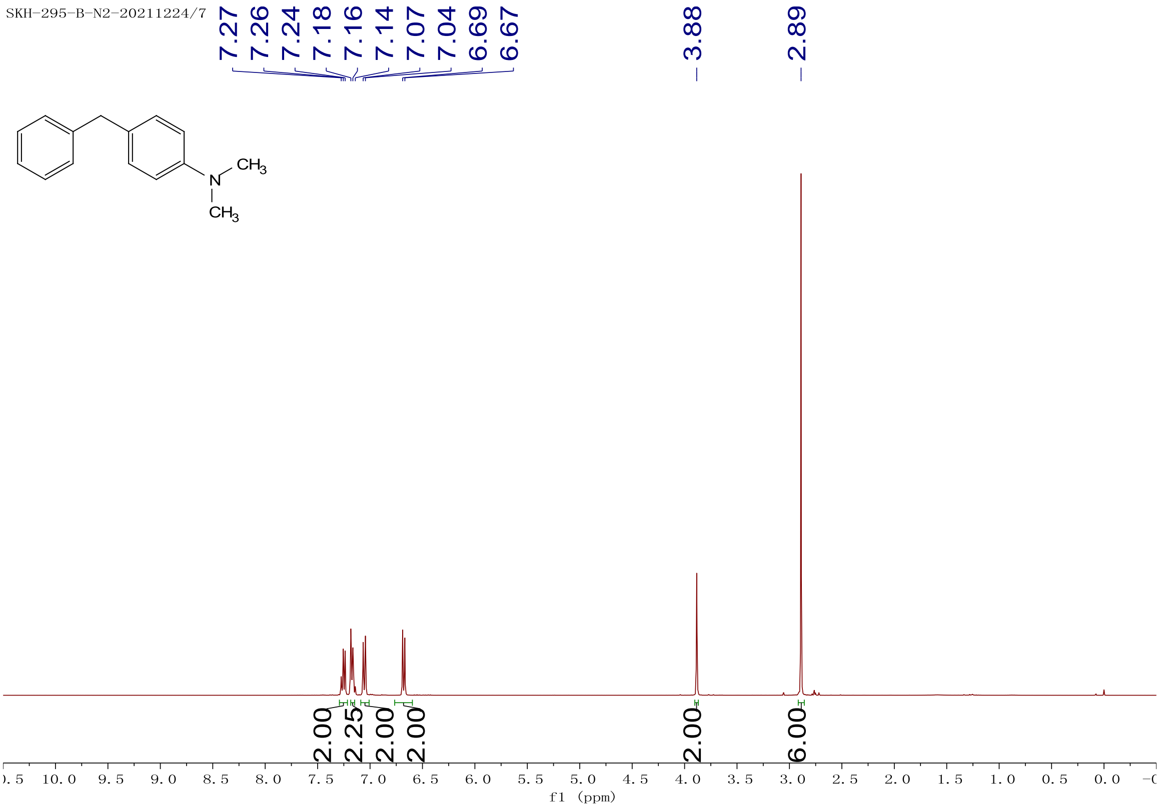

SKH-291-B-13C/26
CH3
O
158.23
141.88
133.53
130.16
129.11
128.73
126.28
114.15
55.53
41.33
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

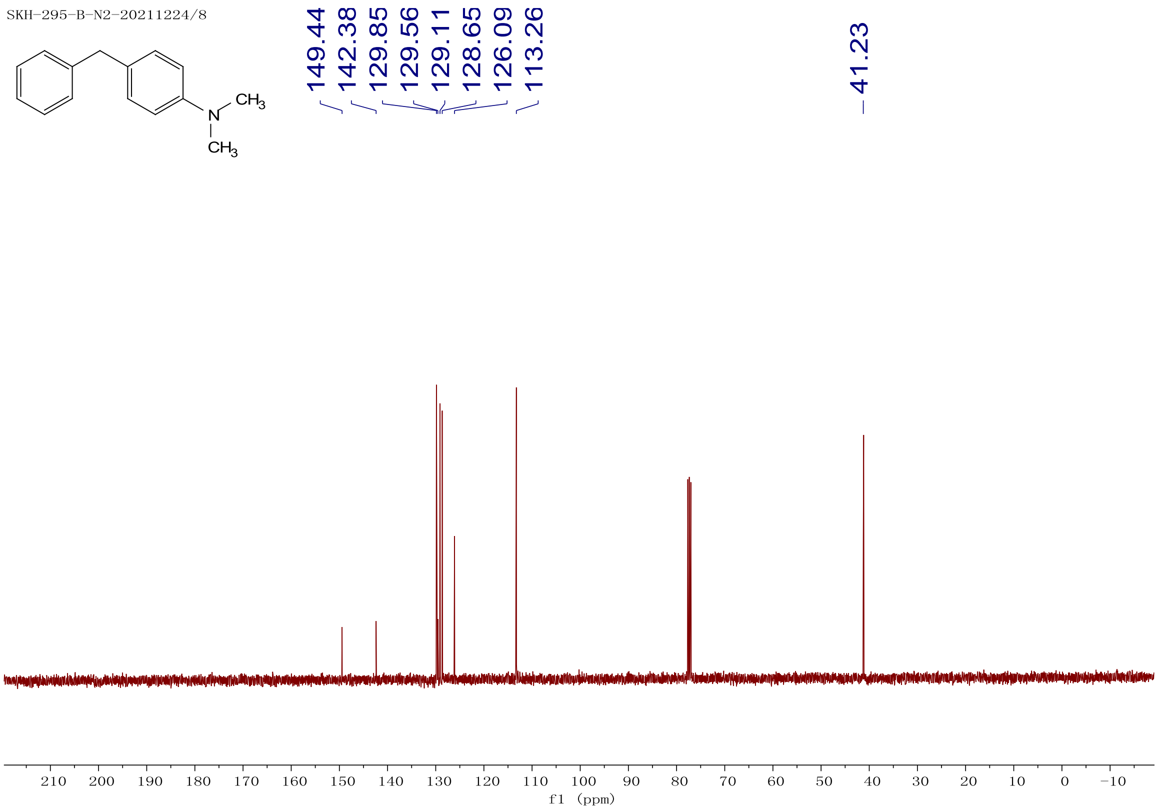
# 2l


SKH-328-H/4
H3C
O
O
CH3
7.15
7.13
6.89
6.87
3.92
3.82
4.00
4.00
2.00
6.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

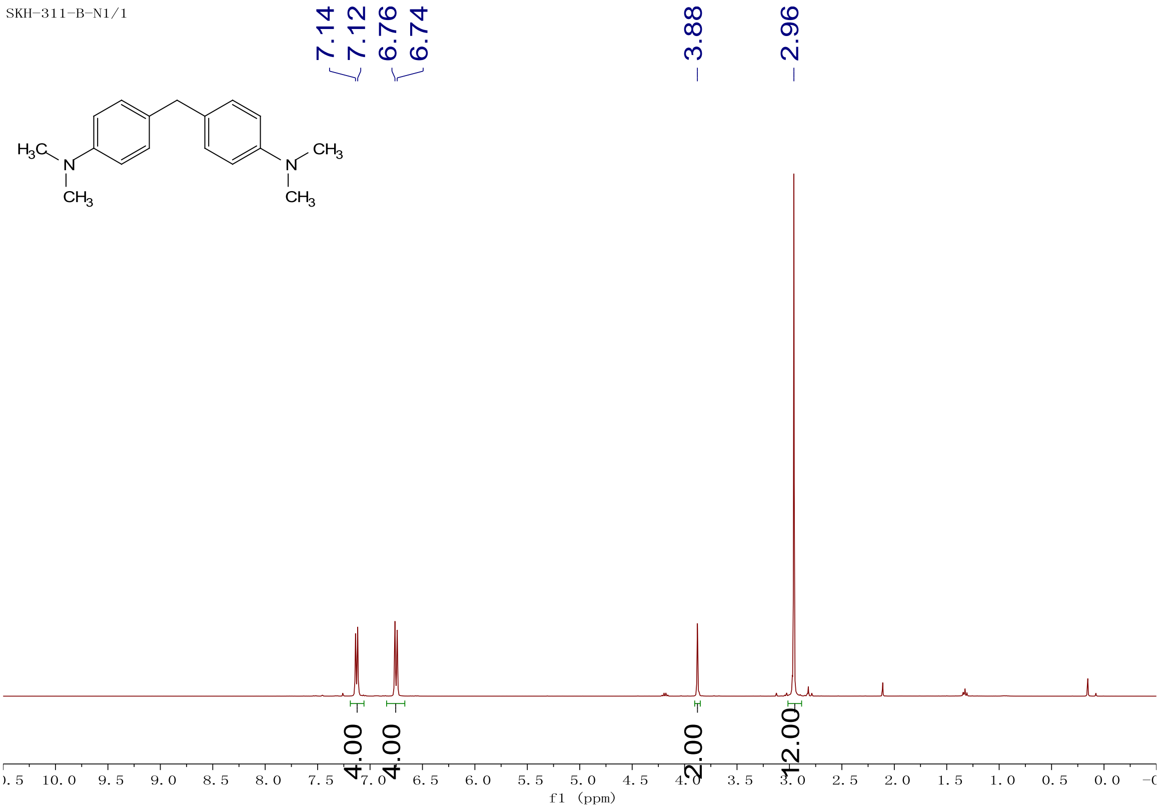

SKH-328-C/5
158.15
133.99
130.01
114.10
55.51
40.40
H3C
O
O
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

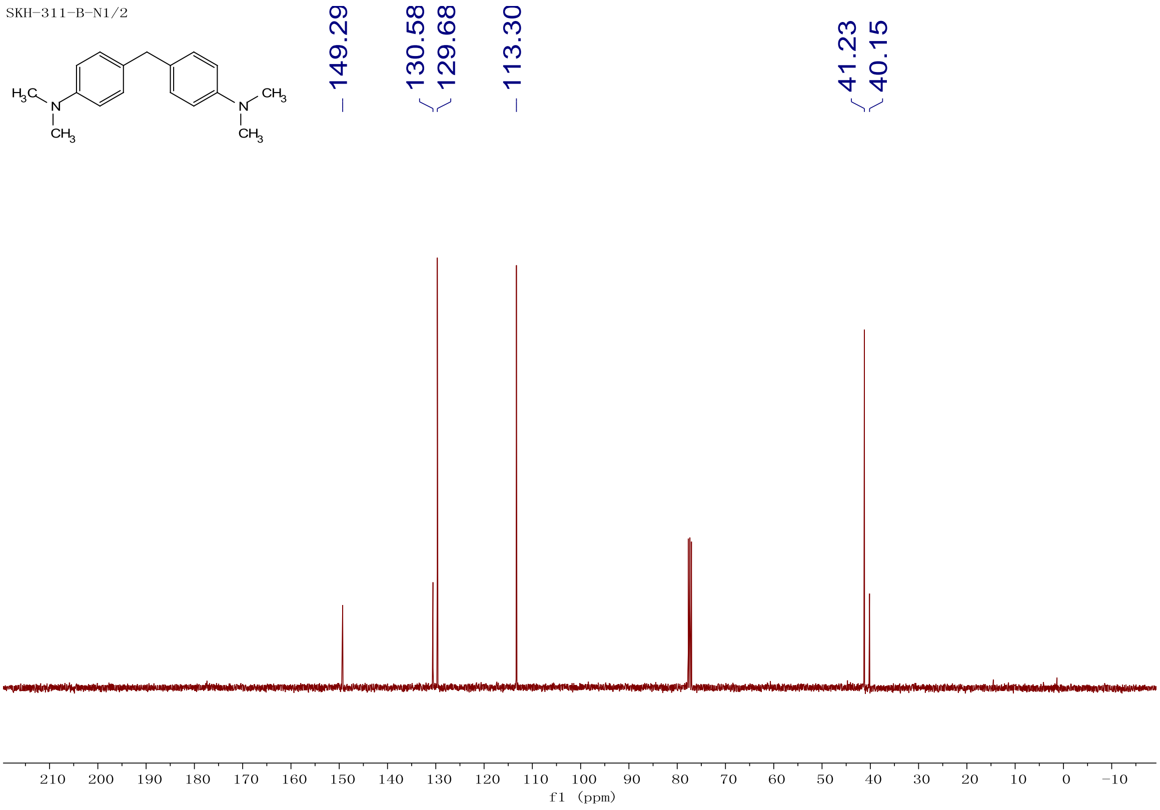
# 2m


SKH-295-B-N2-20211224/7
7.27
7.26
7.24
7.18
7.16
7.14
7.07
7.04
6.69
6.67
3.88
2.89
CH3
N
CH3
2.00
2.25
2.00
2.00
2.00
6.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

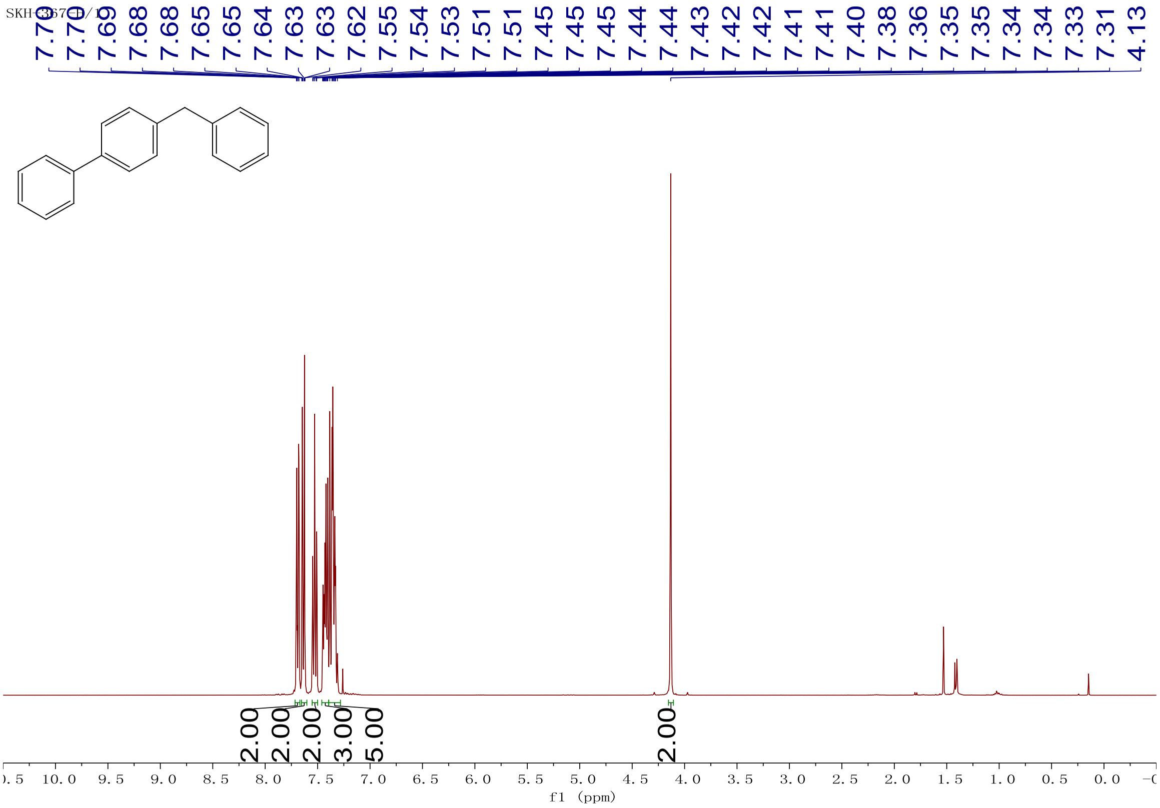

SKH-295-B-N2-20211224/8
149.44
142.38
129.85
129.56
129.11
128.65
126.09
113.26
41.23
CH3
N
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

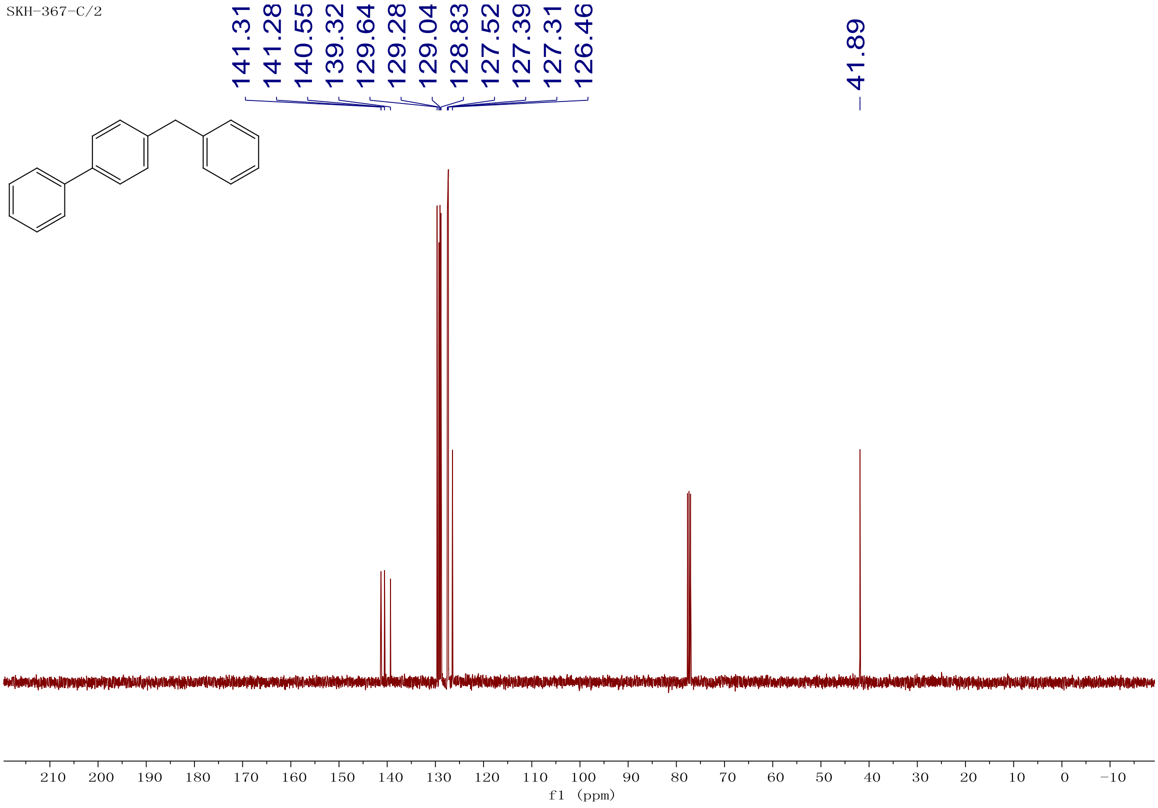
**2n**


SKH-311-B-N1/1
7.14
7.12
6.76
6.74
3.88
2.96
H3C
N
CH3
CH3
N
CH3
4.00
4.00
2.00
12.00
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

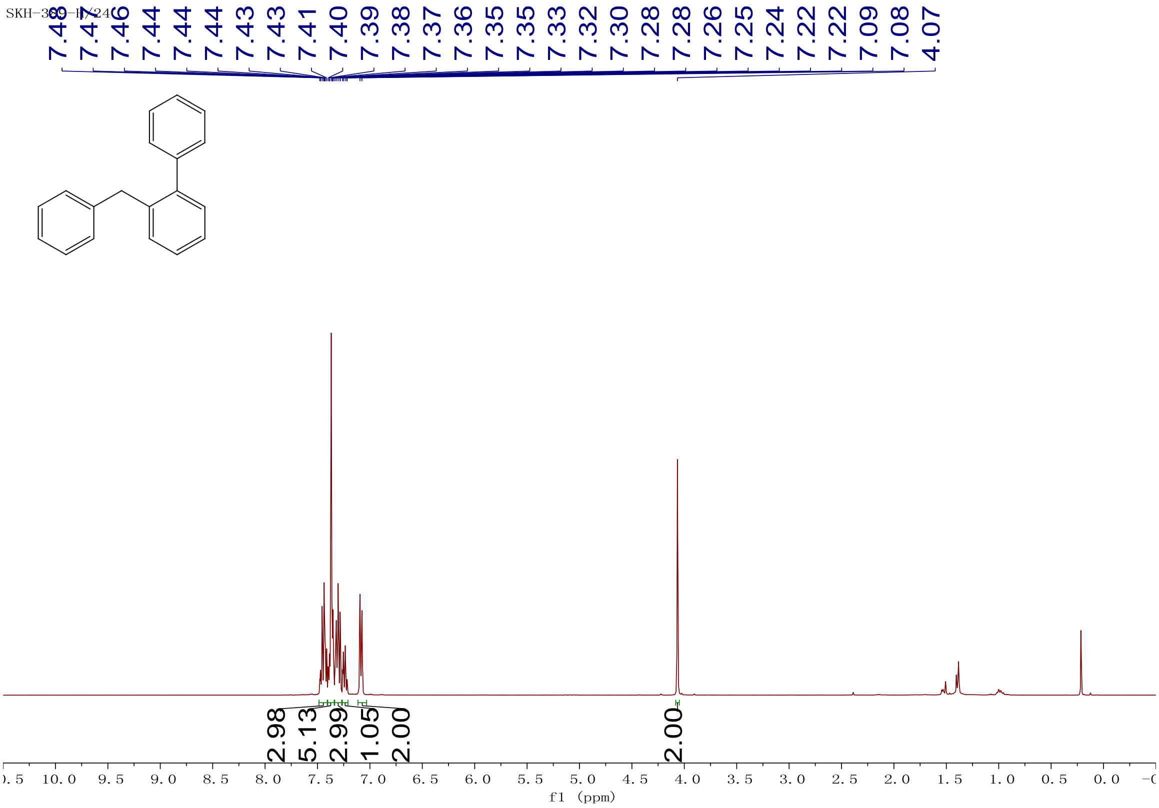

SKH-311-B-N1/2
149.29
130.58
129.68
113.30
41.23
40.15
H3C
N
CH3
CH3
N
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

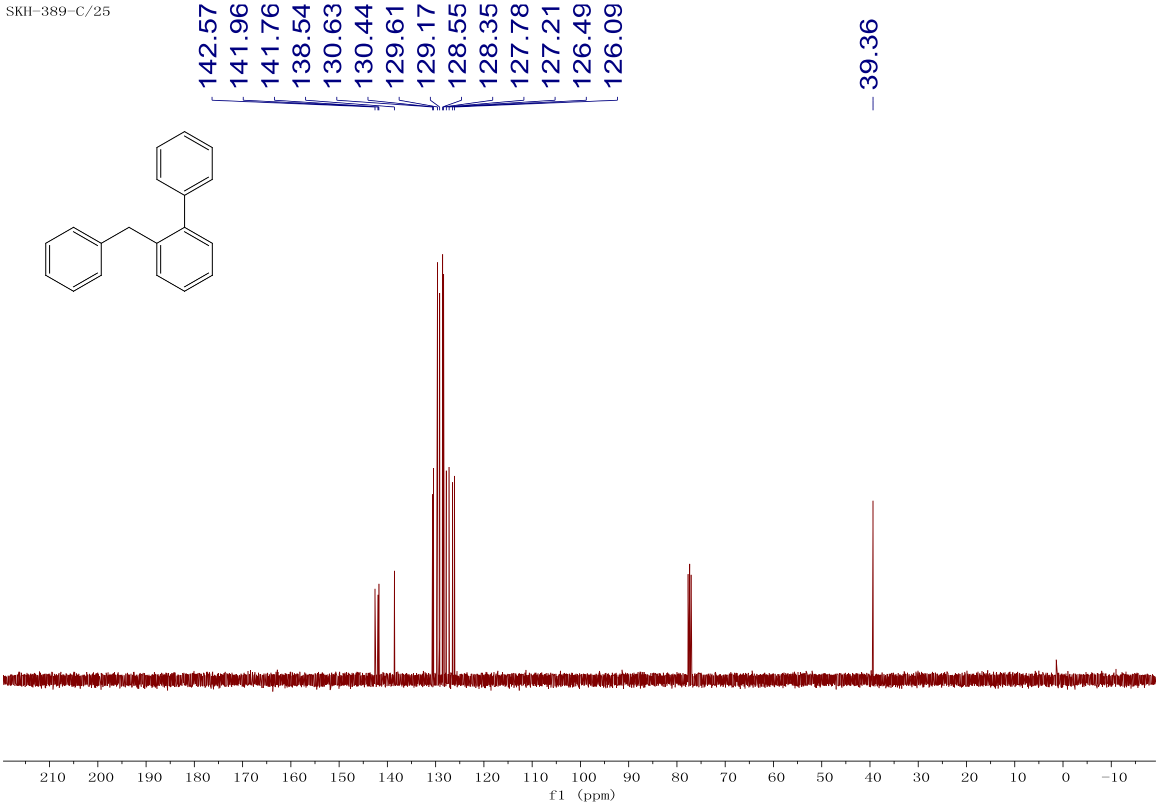
# 2o


SKH-367-H/1
7.70
7.70
7.69
7.68
7.68
7.65
7.65
7.64
7.63
7.63
7.62
7.55
7.54
7.53
7.51
7.51
7.45
7.45
7.45
7.44
7.44
7.43
7.42
7.42
7.41
7.41
7.40
7.38
7.36
7.35
7.35
7.34
7.34
7.33
7.31
4.13
2.00
2.00
2.00
3.00
5.00
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

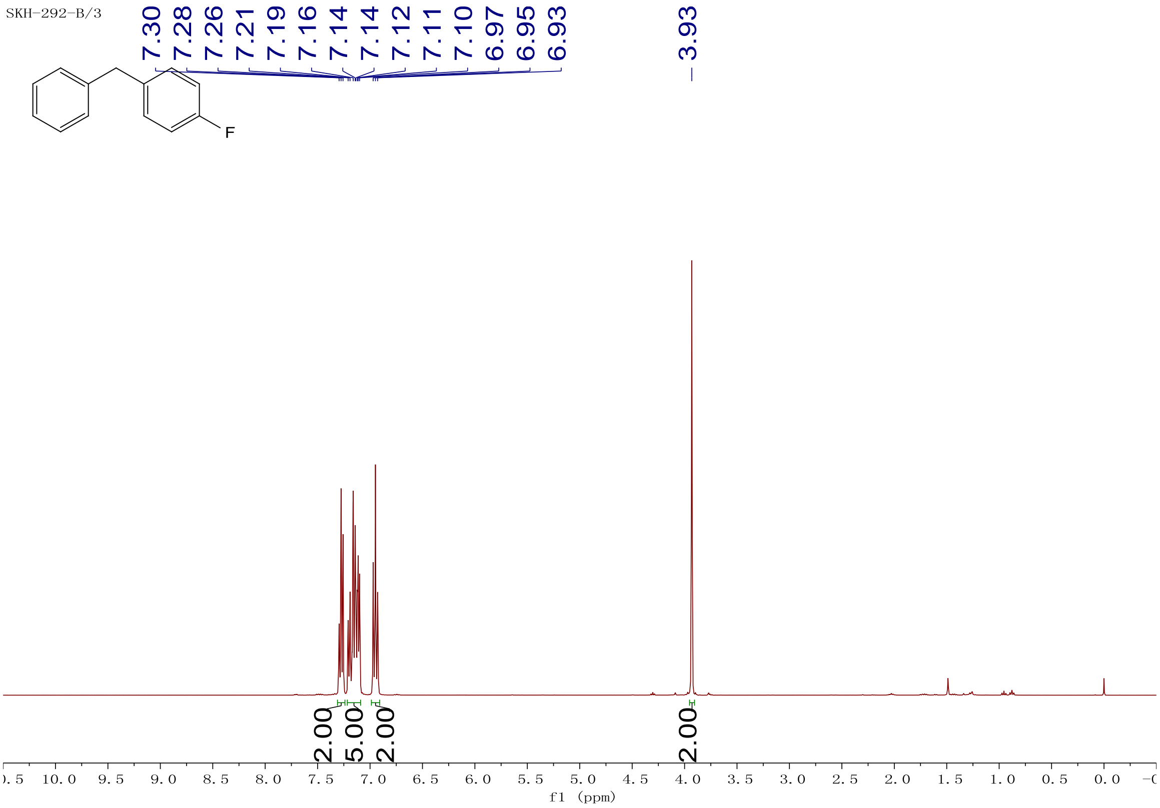

SKH-367-C/2
141.31
141.28
140.55
139.32
129.64
129.28
129.04
128.83
127.52
127.39
127.31
126.46
41.89
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

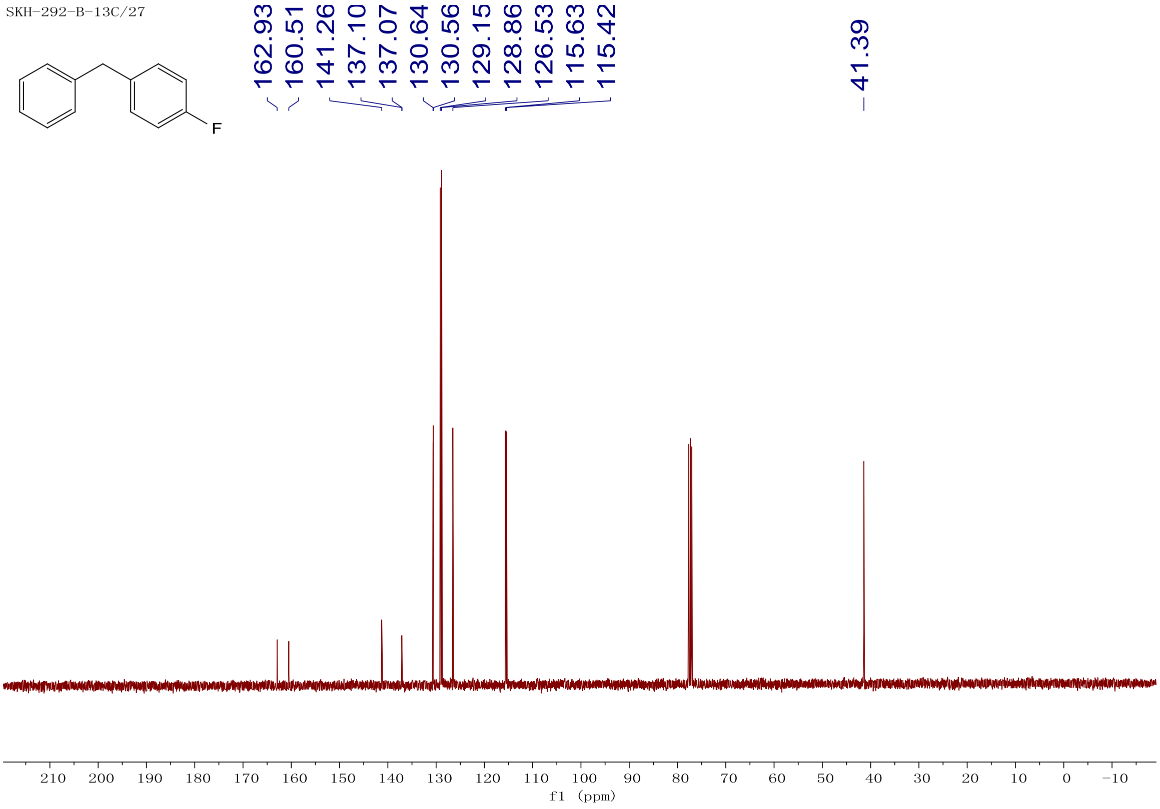
# 2p

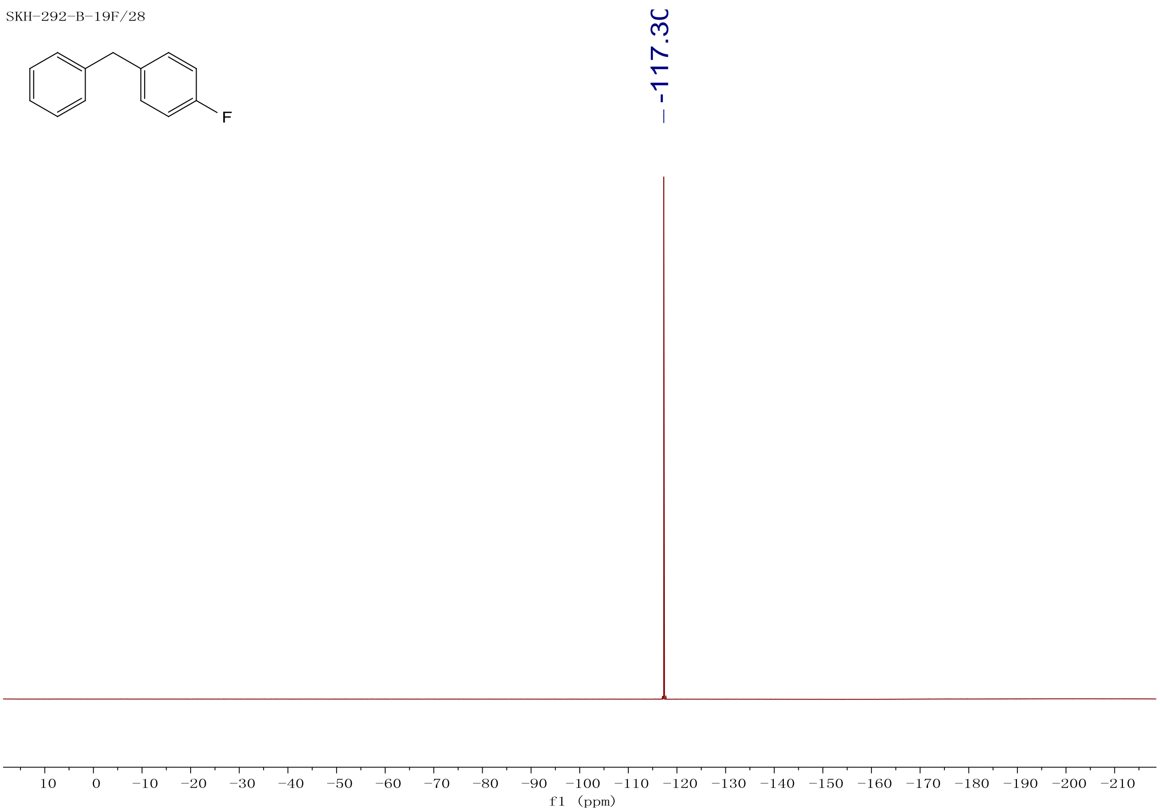

SKH-389-H/24
7.48 7.47 7.46 7.44 7.44 7.44 7.43 7.43 7.41 7.40 7.39 7.38 7.37 7.36 7.35 7.35 7.33 7.32 7.30 7.28 7.28 7.26 7.25 7.24 7.22 7.22 7.09 7.08 4.07
2.98 5.13 2.99 1.05 2.00
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


SKH-389-C/25
142.57 141.96 141.76 138.54 130.63 130.44 129.61 129.17 128.55 128.35 127.78 127.21 126.49 126.09
39.36
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

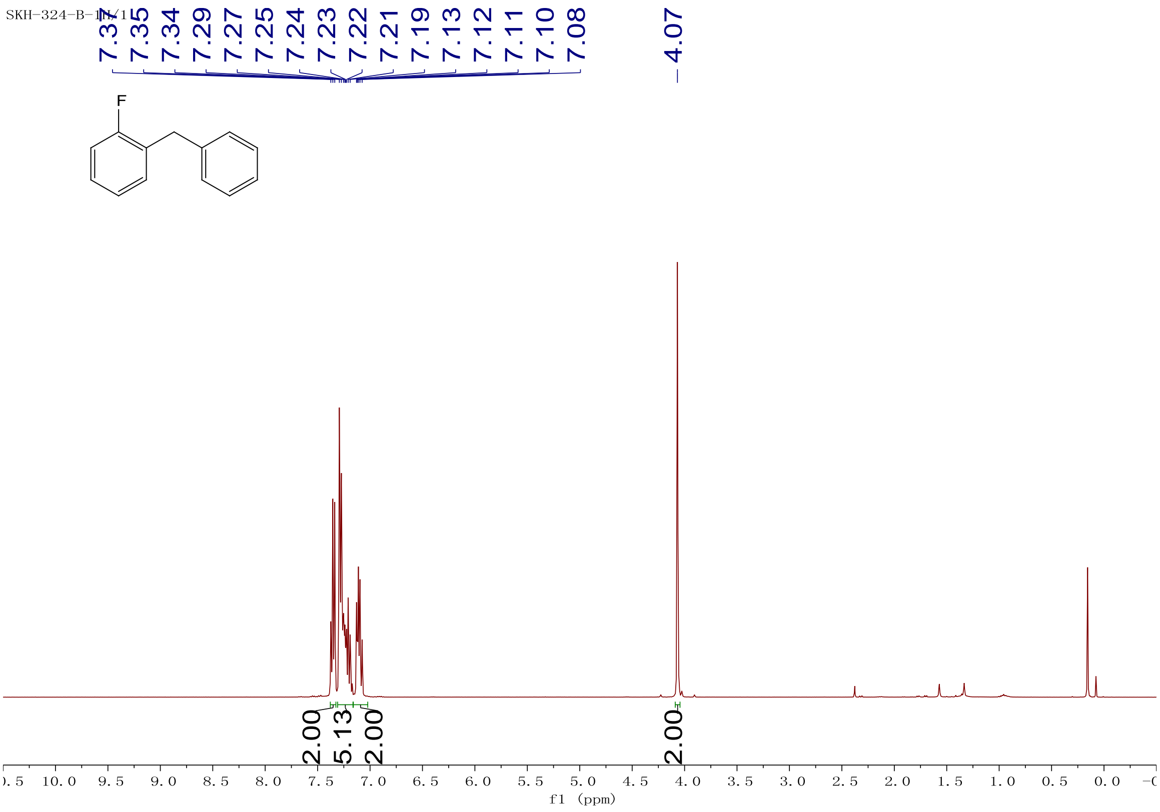
**2q**

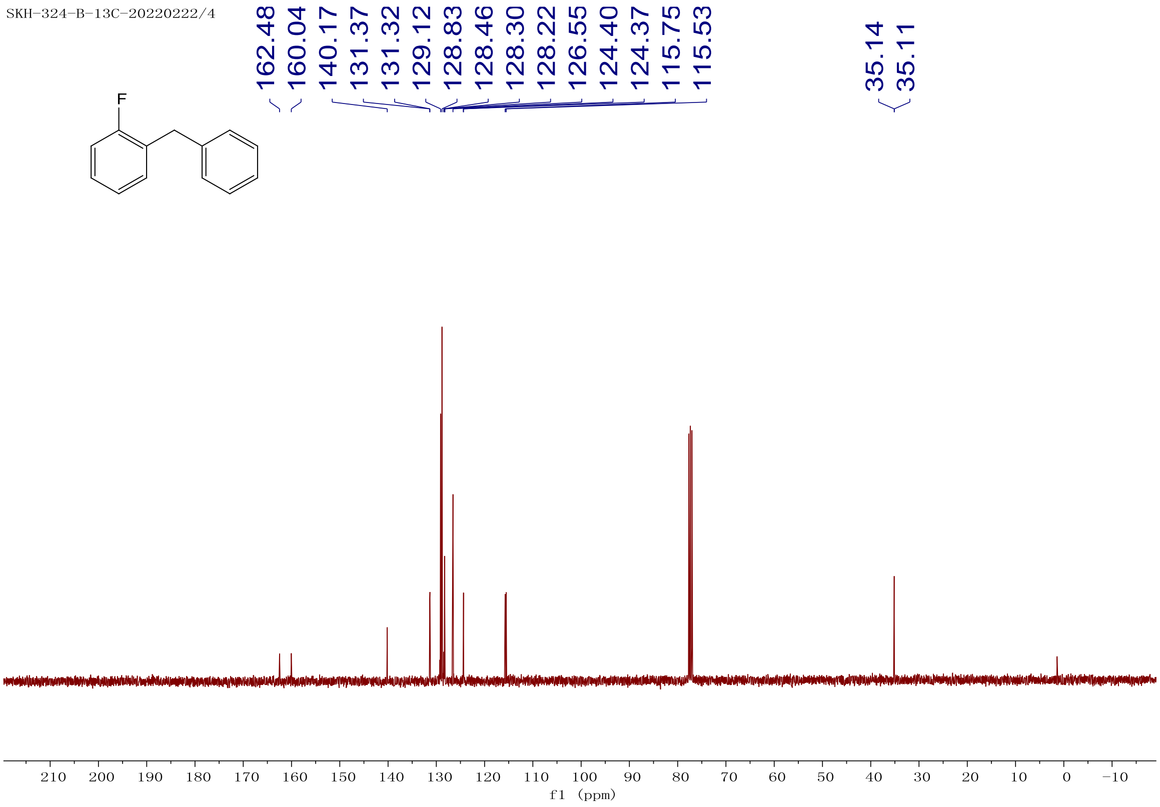

SKH-292-B/3
7.30
7.28
7.26
7.21
7.19
7.16
7.14
7.14
7.12
7.11
7.10
6.97
6.95
6.93
3.93
F
2.00
5.00
2.00
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

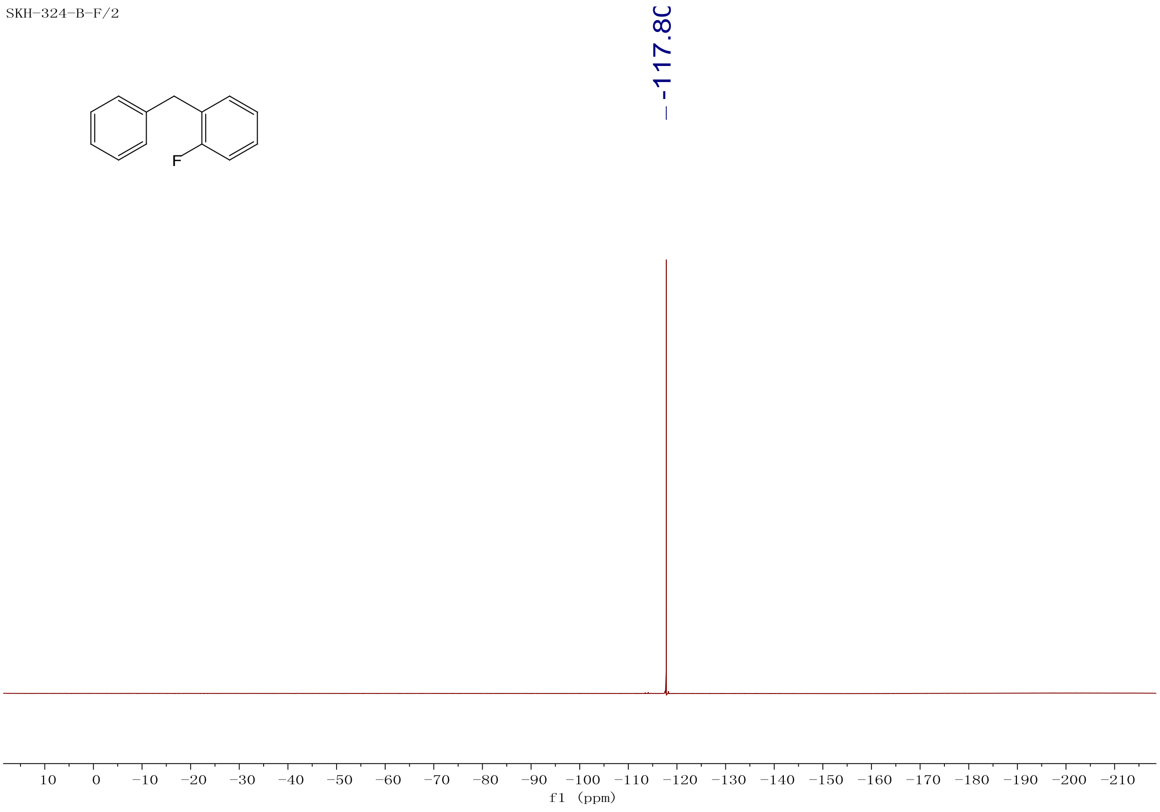

SKH-292-B-13C/27
162.93
160.51
141.26
137.10
137.07
130.64
130.56
129.15
128.86
126.53
115.63
115.42
41.39
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


SKH-292-B-19F/28
F
-117.30
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)

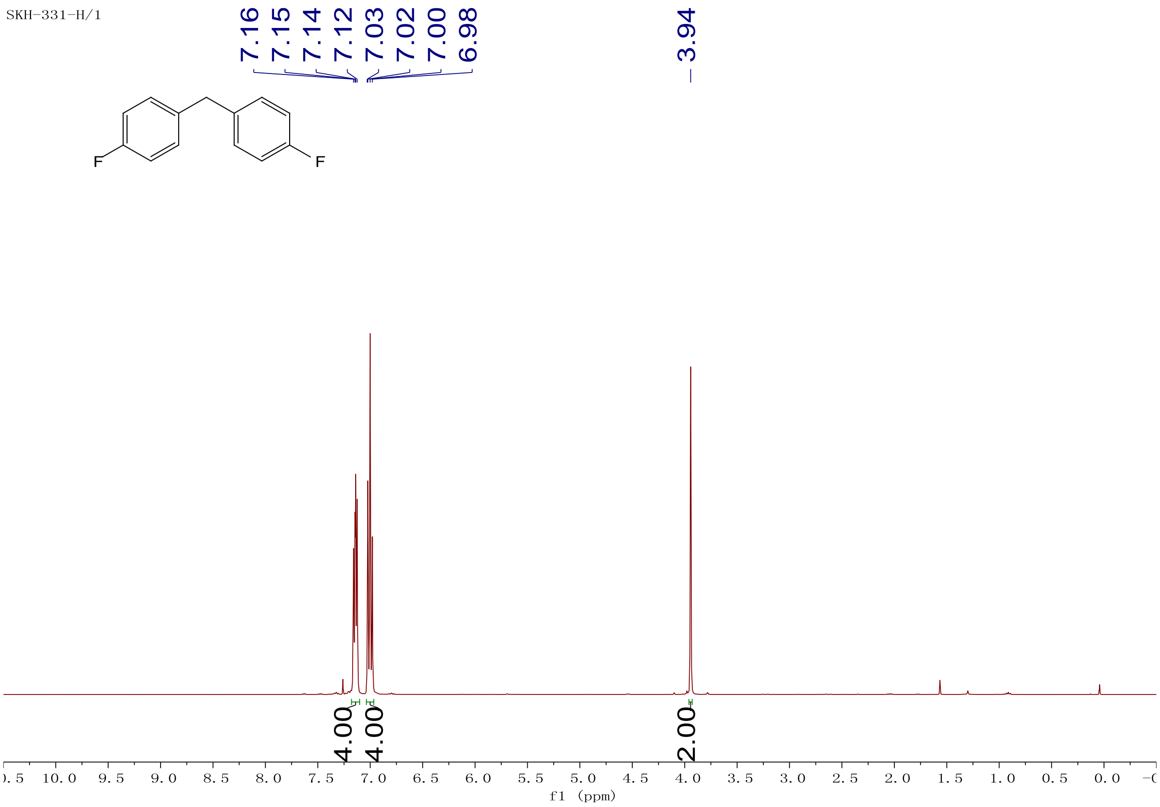
**2r**

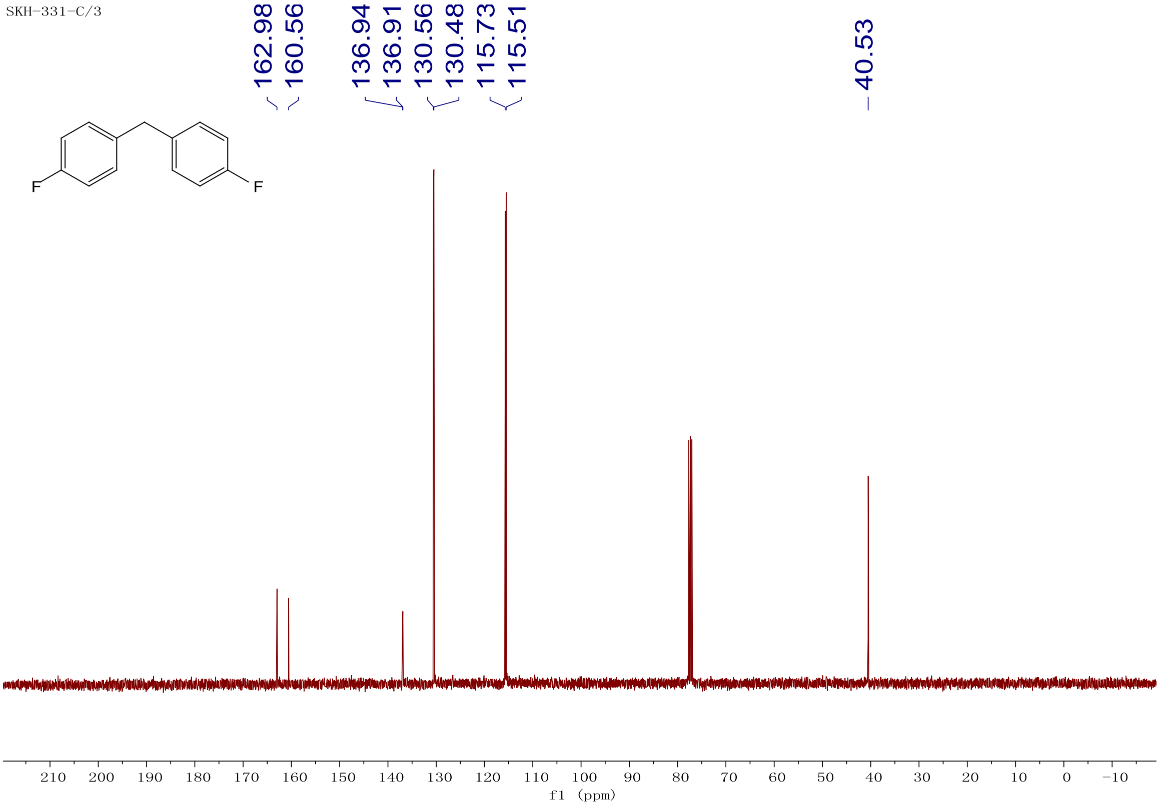

SKH-324-B-1H/1
7.37
7.35
7.34
7.29
7.27
7.25
7.24
7.23
7.22
7.21
7.19
7.13
7.12
7.11
7.10
7.08
4.07
F
2.00
5.13
2.00
2.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

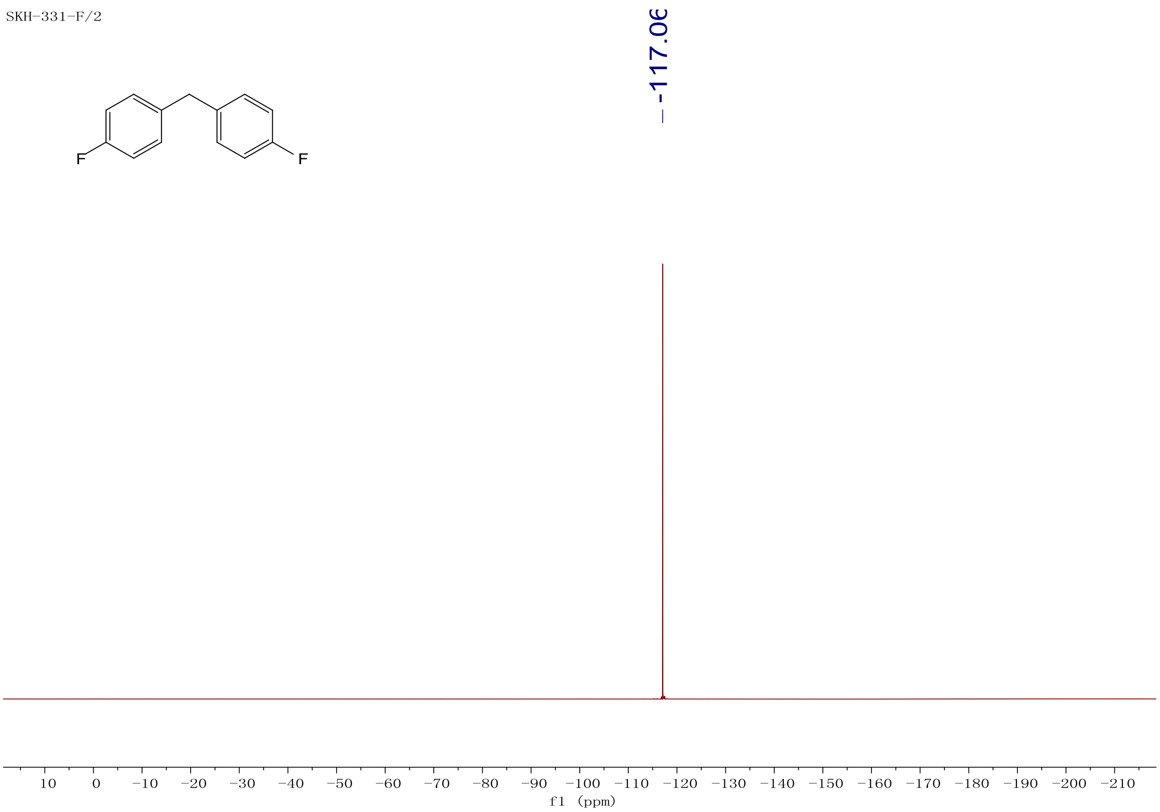

SKH-324-B-13C-20220222/4
F
162.48
160.04
140.17
131.37
131.32
129.12
128.83
128.46
128.30
128.22
126.55
124.40
124.37
115.75
115.53
35.14
35.11
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)


SKH-324-B-F/2
F
−117.80
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)

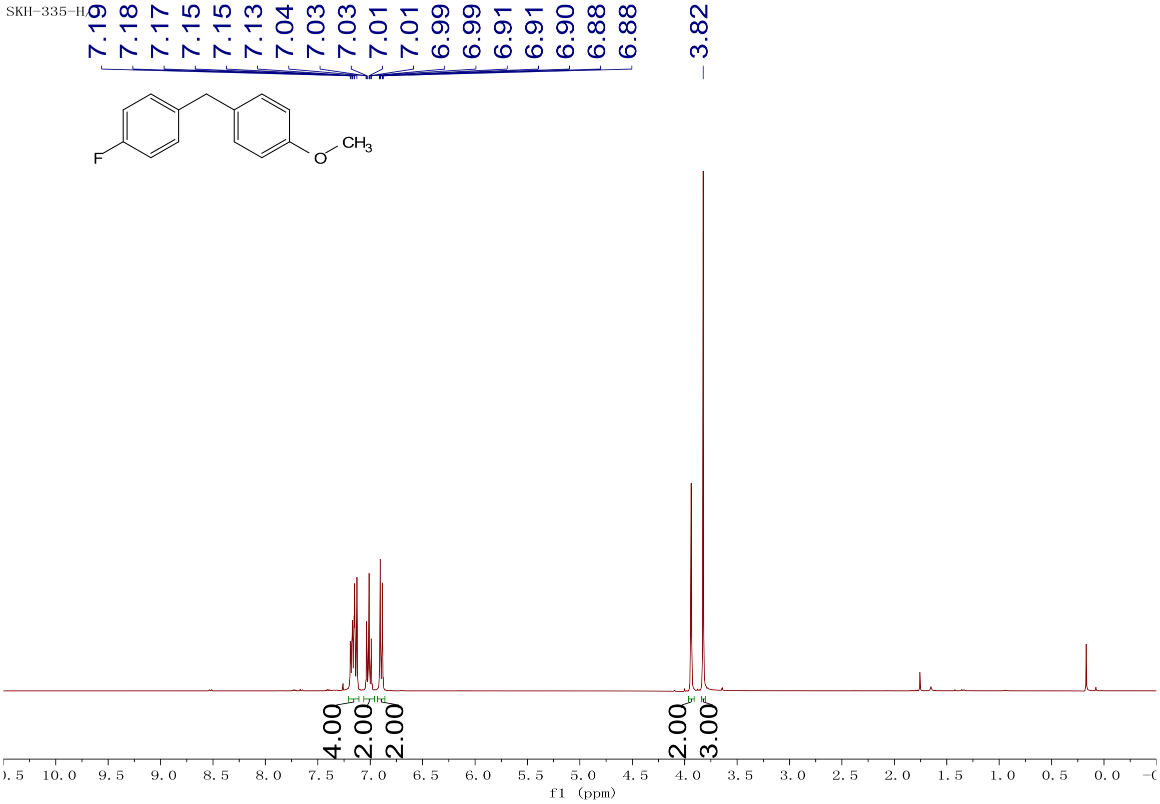
**2s**

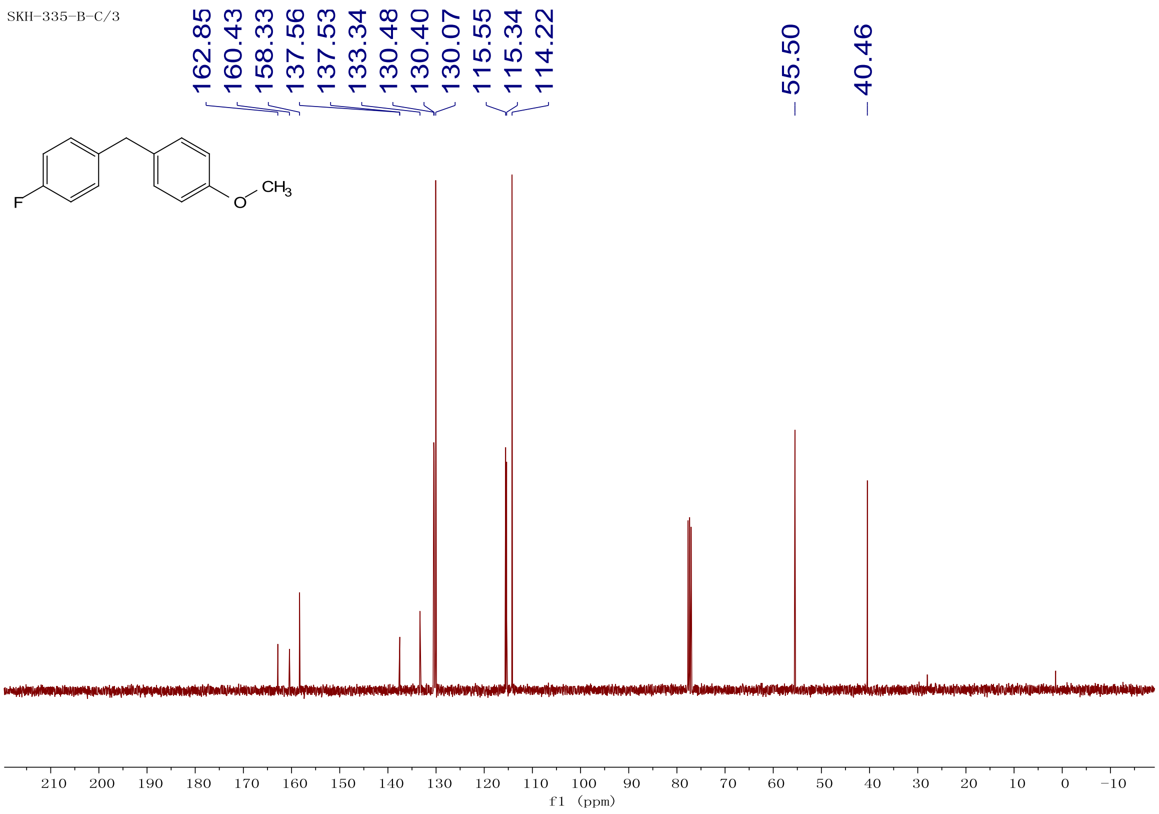

SKH-331-H/1
7.16
7.15
7.14
7.12
7.03
7.02
7.00
6.98
3.94
F
F
4.00
4.00
2.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

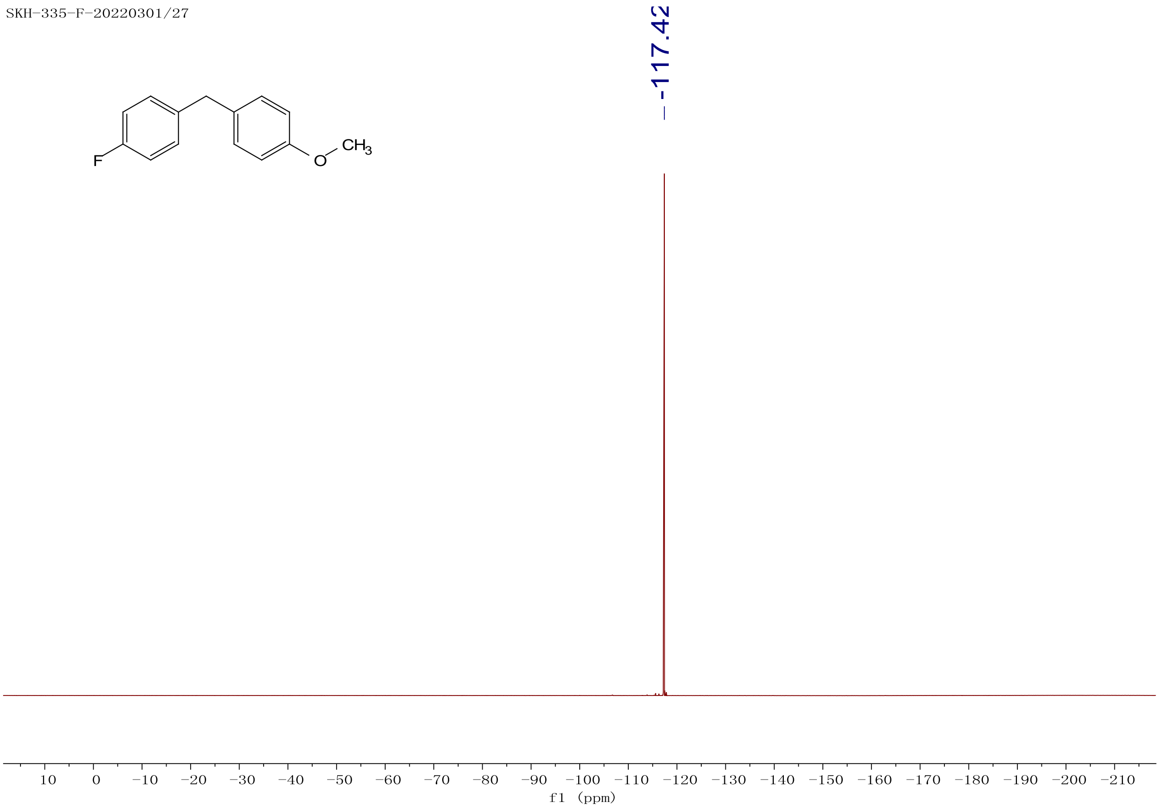

SKH-331-C/3
162.98
160.56
136.94
136.91
130.56
130.48
115.73
115.51
40.53
F
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


SKH-331-F/2
-117.06
F
F
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)

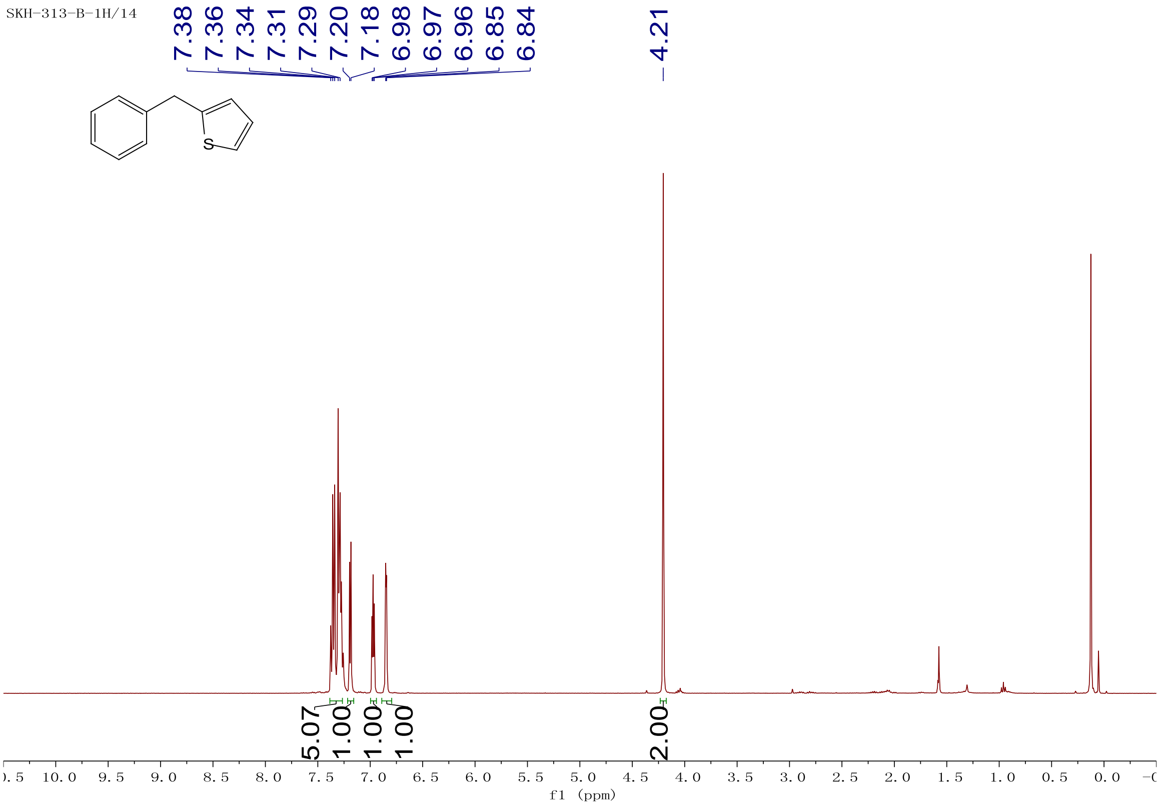
**2t**

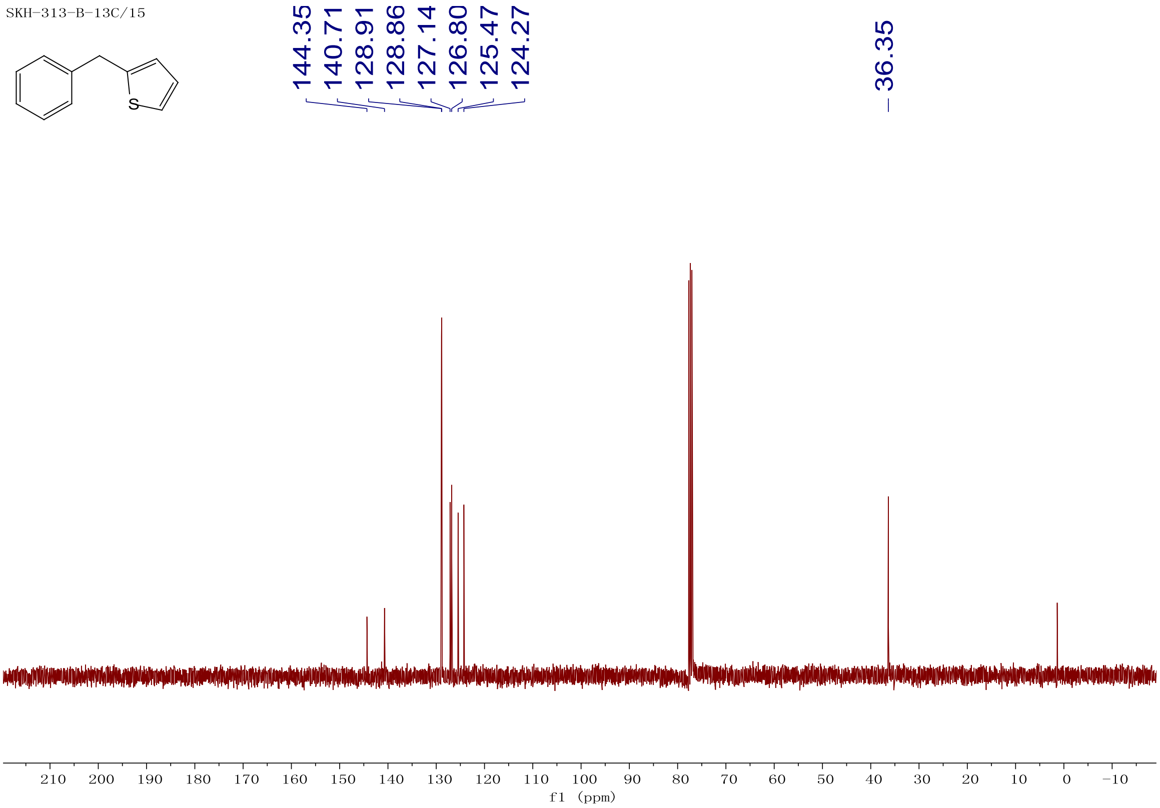

SKH-335-H
7.19
7.18
7.17
7.15
7.15
7.13
7.04
7.03
7.03
7.01
7.01
6.99
6.99
6.91
6.91
6.90
6.88
6.88
3.82
F
O
CH3
4.00
2.00
2.00
2.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


SKH-335-B-C/3
162.85
160.43
158.33
137.56
137.53
133.34
130.48
130.40
130.07
115.55
115.34
114.22
55.50
40.46
F
O
CH$_3$
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

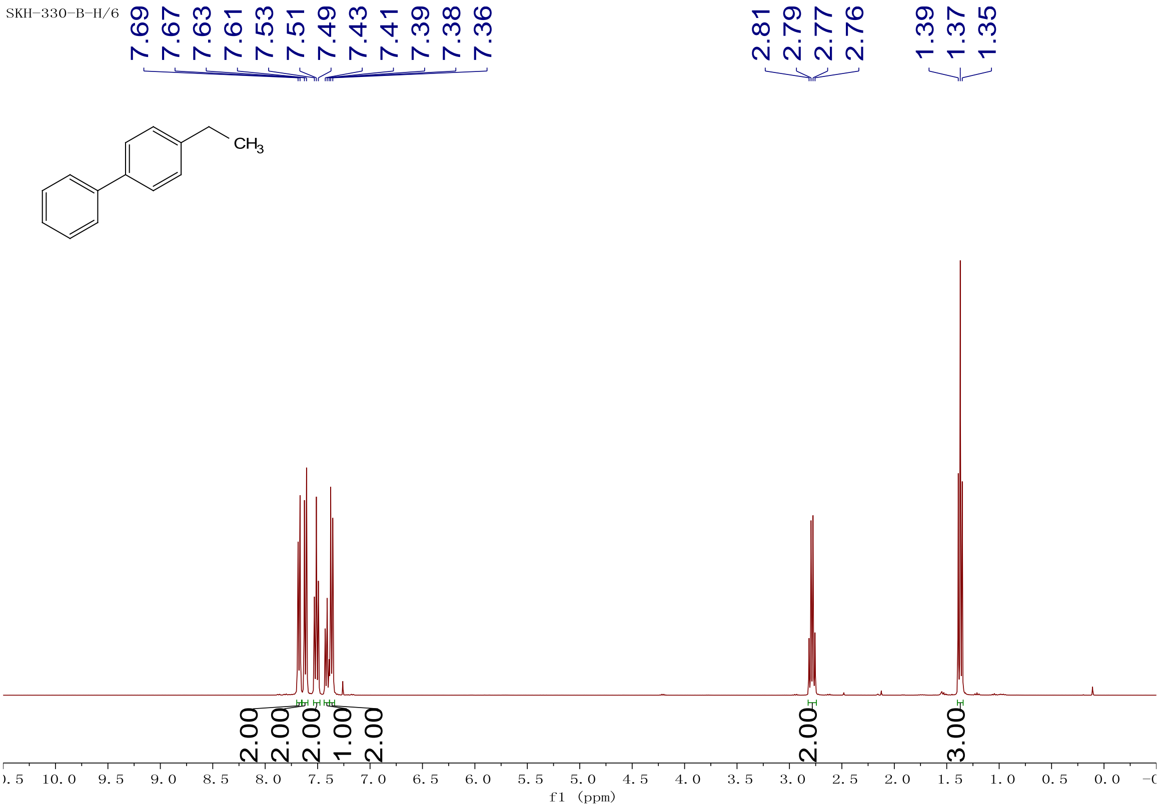

SKH-335-F-20220301/27
-117.42
F
O
CH$_3$
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
−190
−200
−210
f1 (ppm)

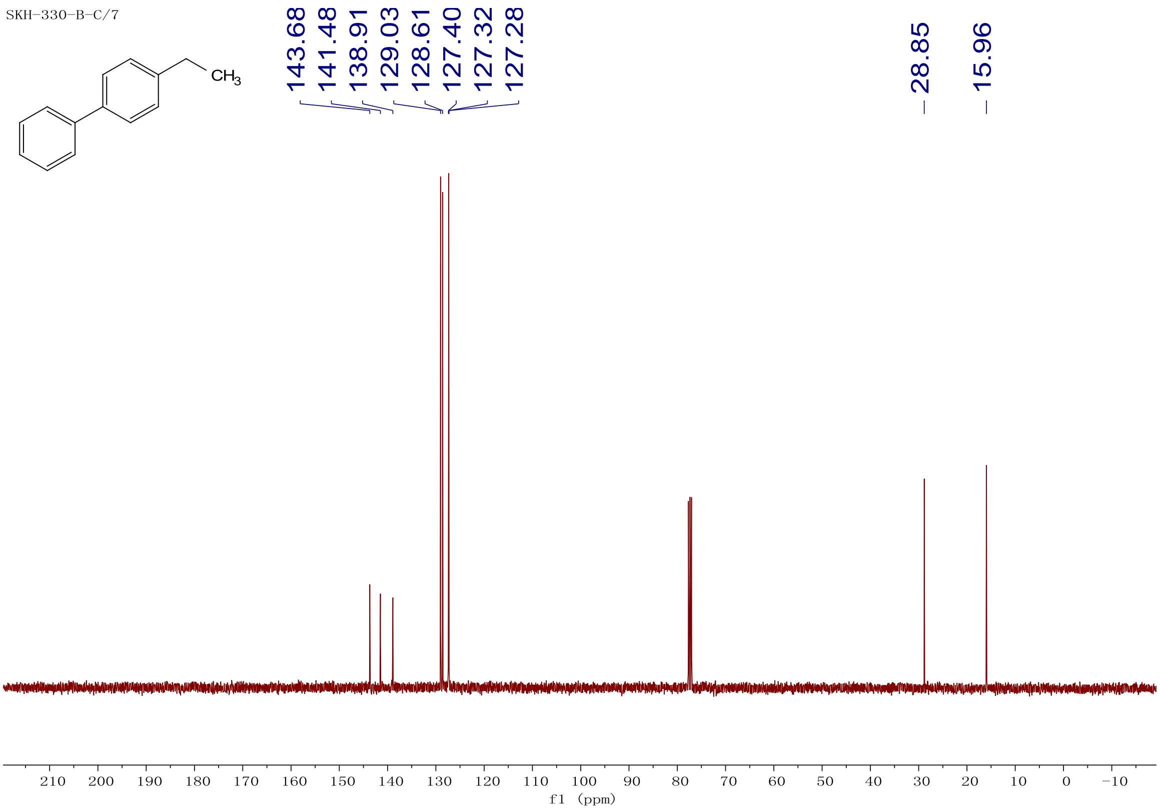
**2u**


SKH-313-B-1H/14
7.38
7.36
7.34
7.31
7.29
7.20
7.18
6.98
6.97
6.96
6.85
6.84
4.21
S
5.07
1.00
1.00
1.00
2.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

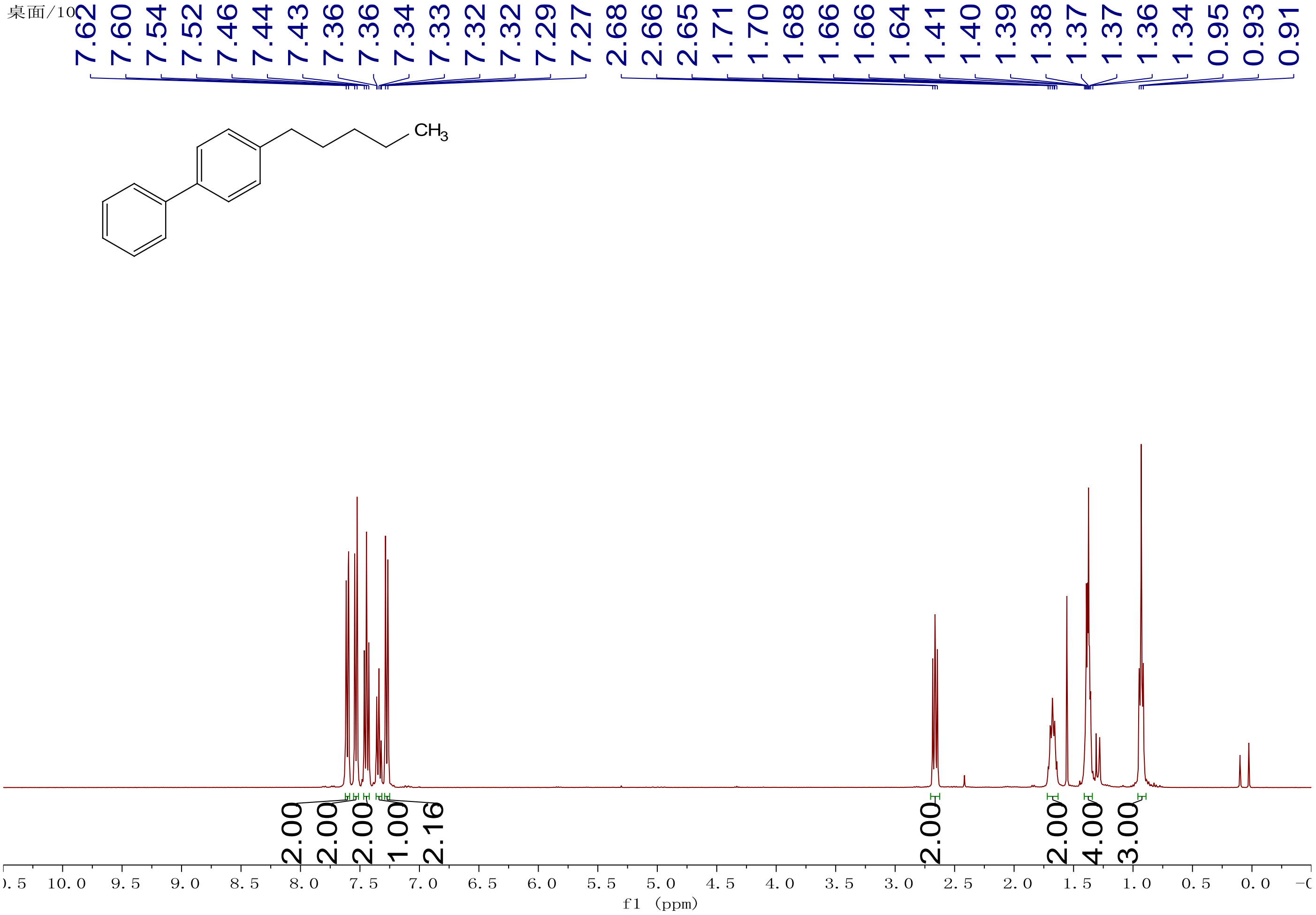

SKH-313-B-13C/15
144.35
140.71
128.91
128.86
127.14
126.80
125.47
124.27
36.35
S
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

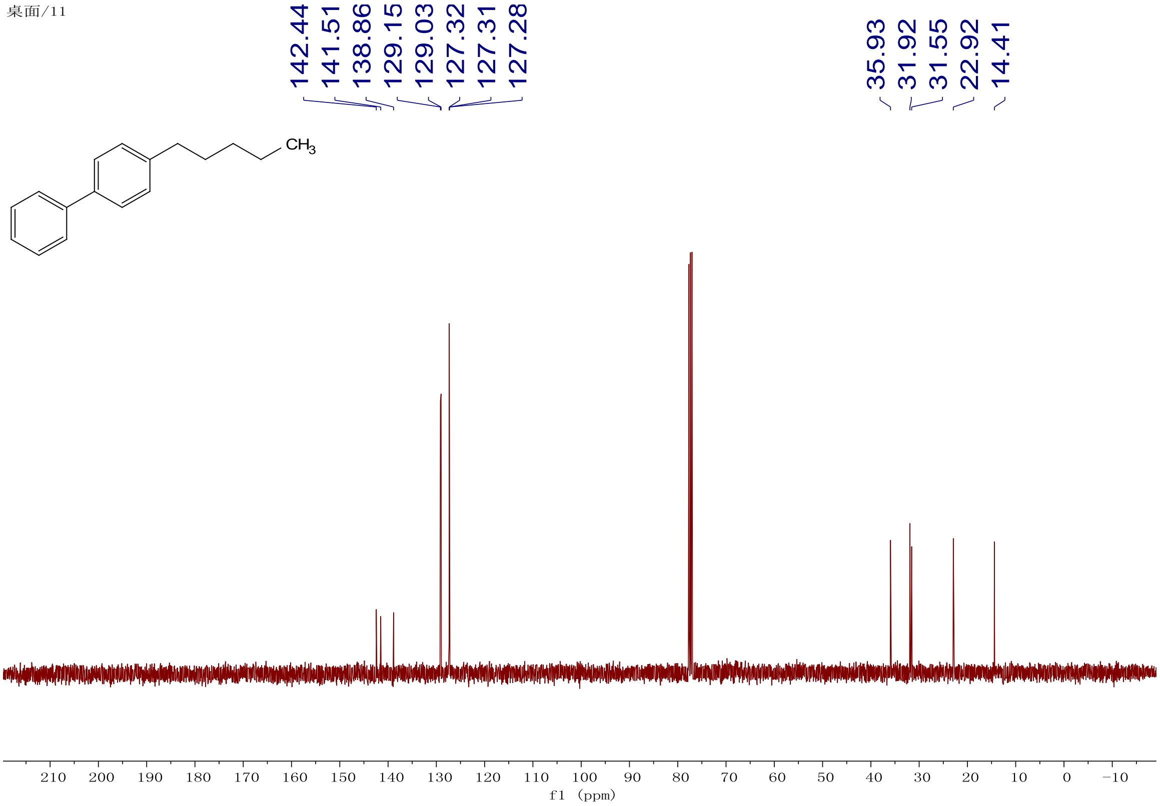
# 2v


SKH-330-B-H/6
7.69
7.67
7.63
7.61
7.53
7.51
7.49
7.43
7.41
7.39
7.38
7.36
2.81
2.79
2.77
2.76
1.39
1.37
1.35
CH3
2.00
2.00
2.00
1.00
2.00
2.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

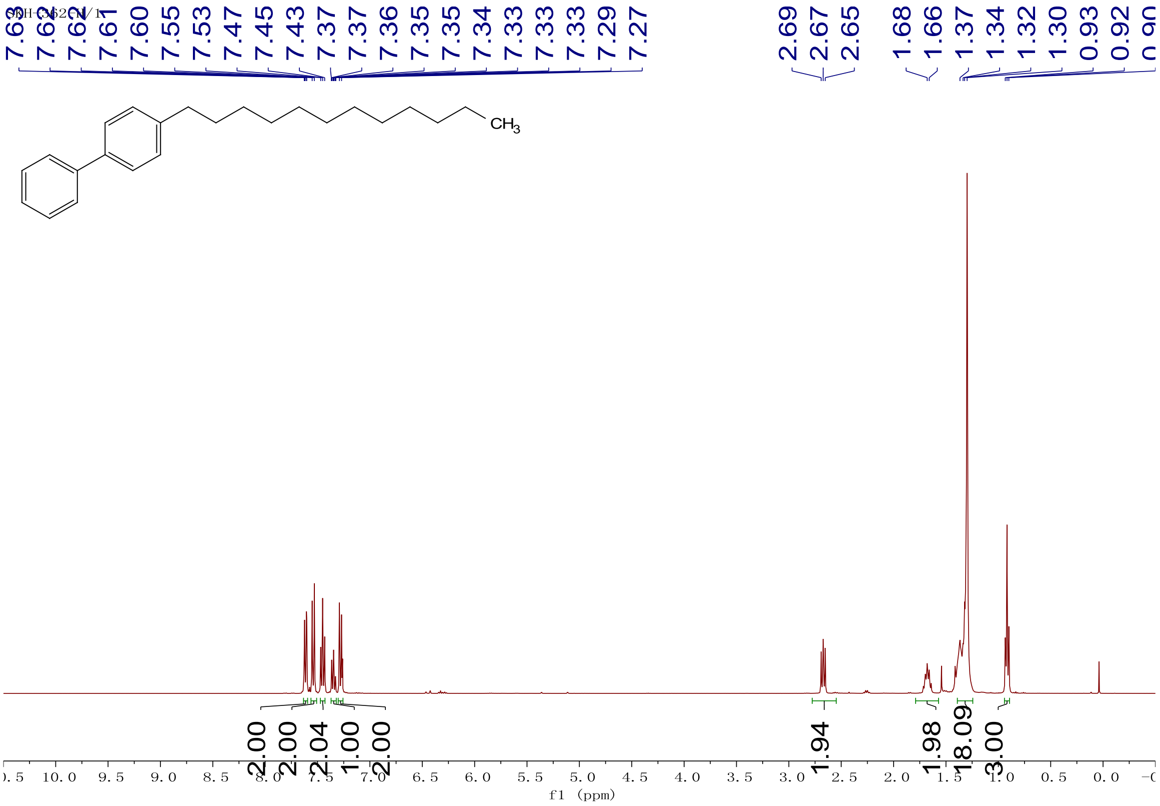

SKH-330-B-C/7
143.68
141.48
138.91
129.03
128.61
127.40
127.32
127.28
28.85
15.96
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

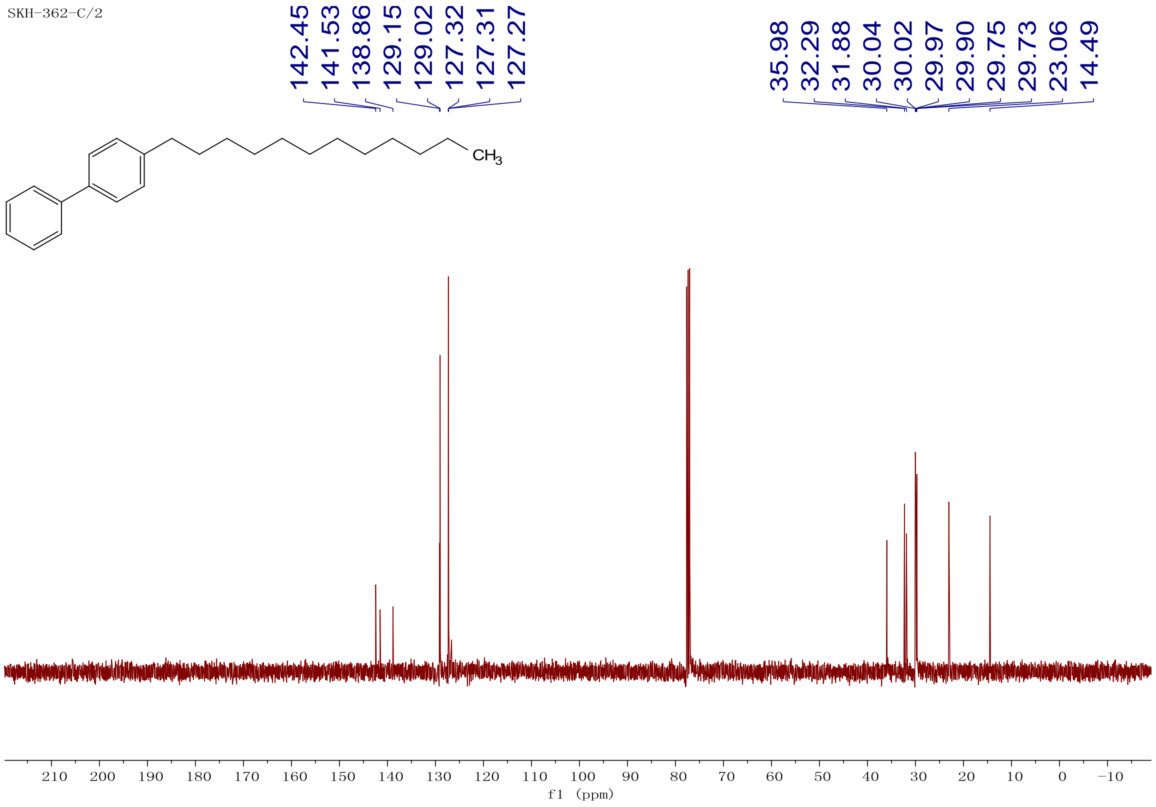
# 2w


桌面/10
7.62
7.60
7.54
7.52
7.46
7.44
7.43
7.36
7.36
7.34
7.33
7.32
7.32
7.29
7.27
2.68
2.66
2.65
1.71
1.70
1.68
1.66
1.66
1.64
1.41
1.40
1.39
1.38
1.37
1.37
1.36
1.34
0.95
0.93
0.91
CH3
2.00
2.00
2.00
1.00
2.16
2.00
2.00
4.00
3.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

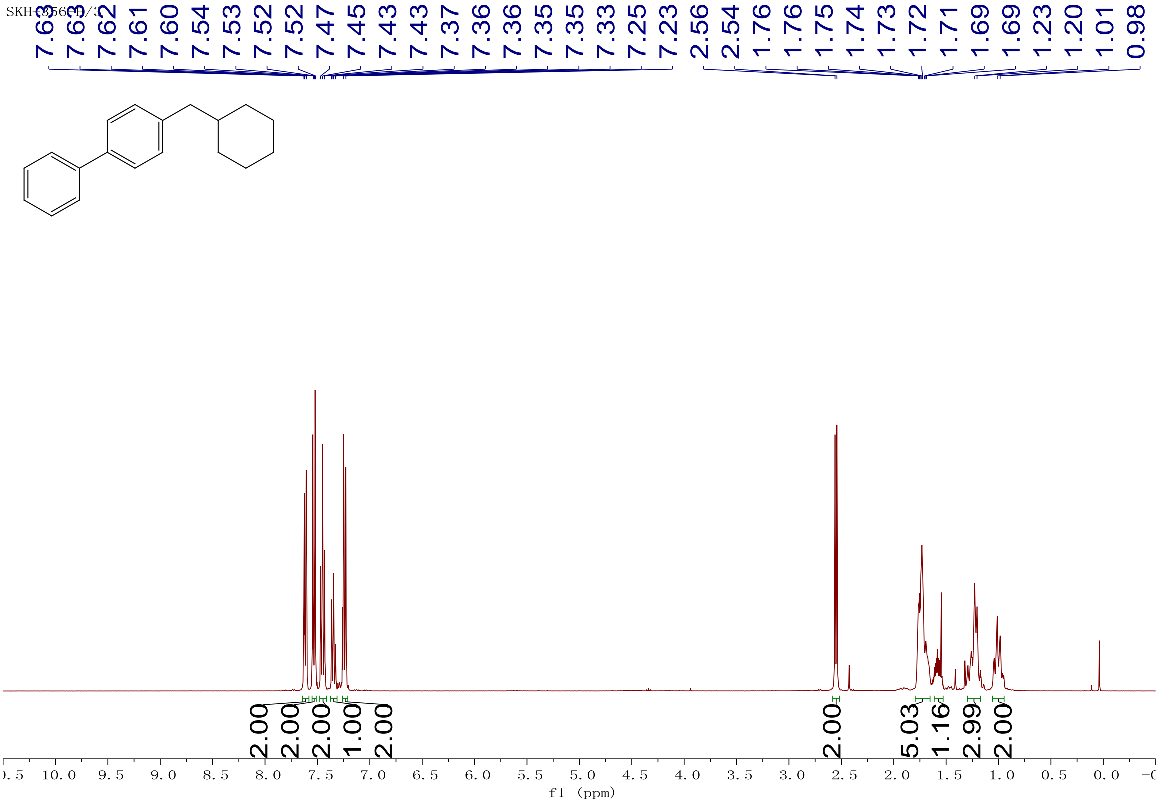

桌面/11
142.44
141.51
138.86
129.15
129.03
127.32
127.31
127.28
35.93
31.92
31.55
22.92
14.41
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

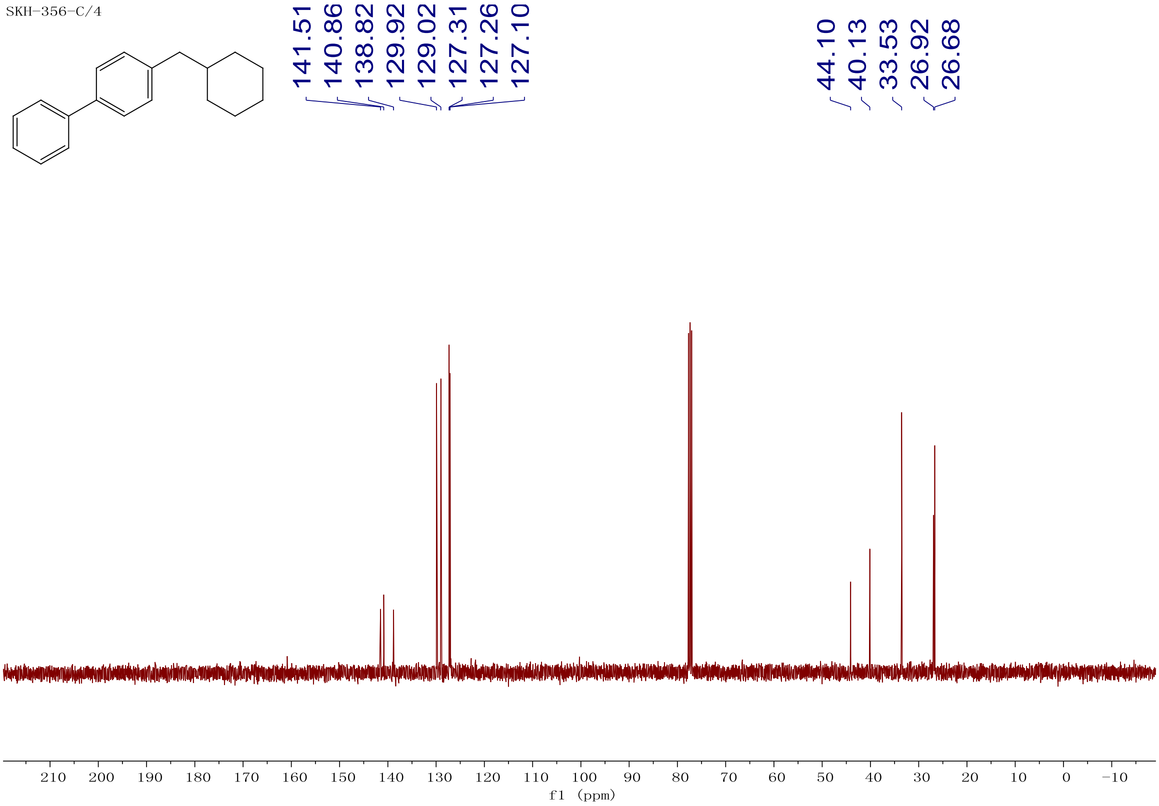
**2x**


SKH-362-H/1
7.63
7.62
7.62
7.61
7.60
7.55
7.53
7.47
7.45
7.43
7.37
7.37
7.36
7.35
7.35
7.34
7.33
7.33
7.33
7.29
7.27
2.69
2.67
2.65
1.68
1.66
1.37
1.34
1.32
1.30
0.93
0.92
CH3
2.00
2.00
2.04
1.00
2.00
1.94
1.98
18.09
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

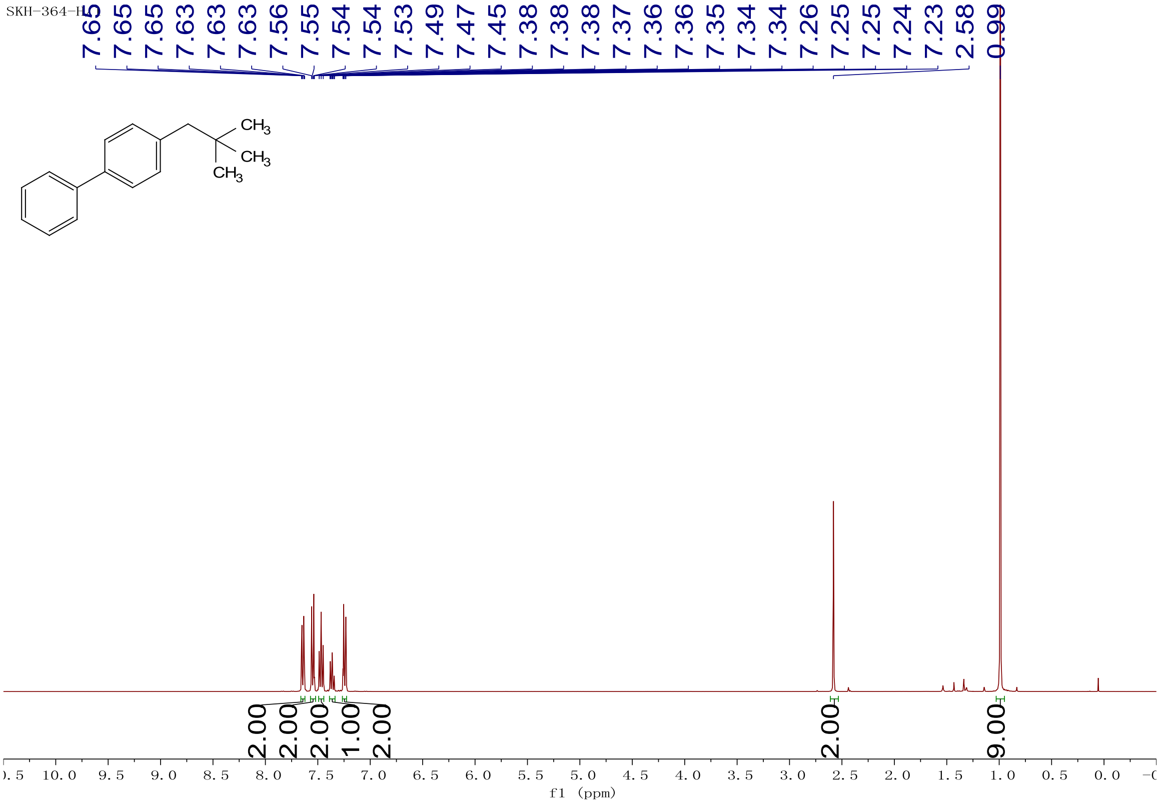

SKH-362-C/2
142.45
141.53
138.86
129.15
129.02
127.32
127.31
127.27
35.98
32.29
31.88
30.04
30.02
29.97
29.90
29.75
29.73
23.06
14.49
CH3
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

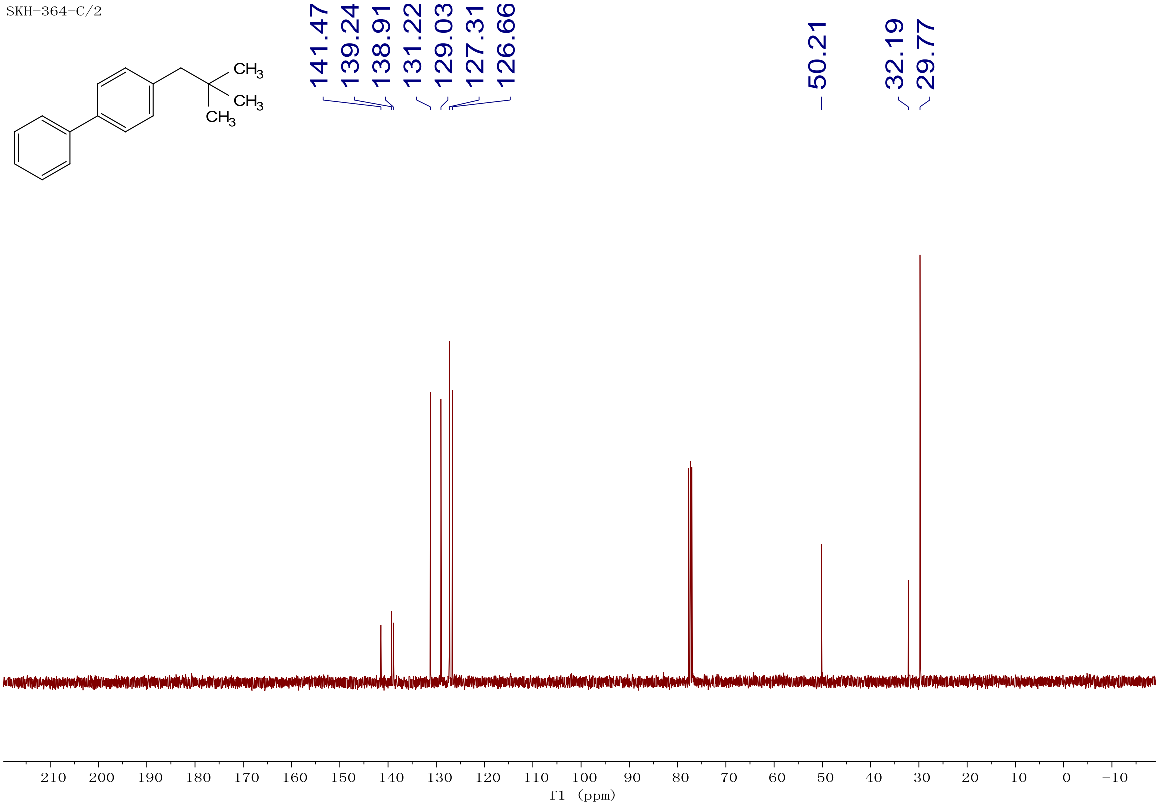
# 2y


SKH-356-H/3
7.63
7.63
7.62
7.61
7.60
7.54
7.53
7.52
7.52
7.47
7.45
7.43
7.43
7.37
7.36
7.36
7.35
7.35
7.33
7.25
7.23
2.56
2.54
1.76
1.76
1.75
1.74
1.73
1.72
1.71
1.69
1.69
1.23
1.20
1.01
0.98
2.00
2.00
2.00
1.00
2.00
2.00
5.03
1.16
2.99
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

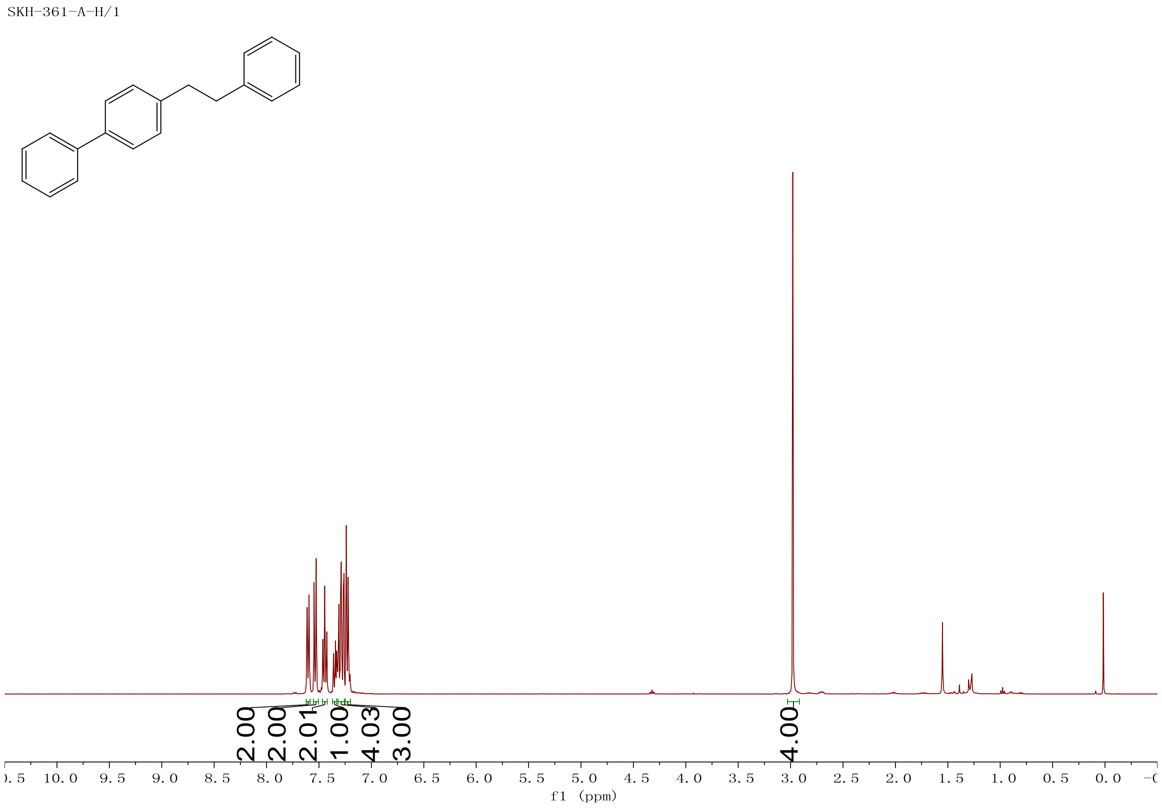

SKH-356-C/4
141.51
140.86
138.82
129.92
129.02
127.31
127.26
127.10
44.10
40.13
33.53
26.92
26.68
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

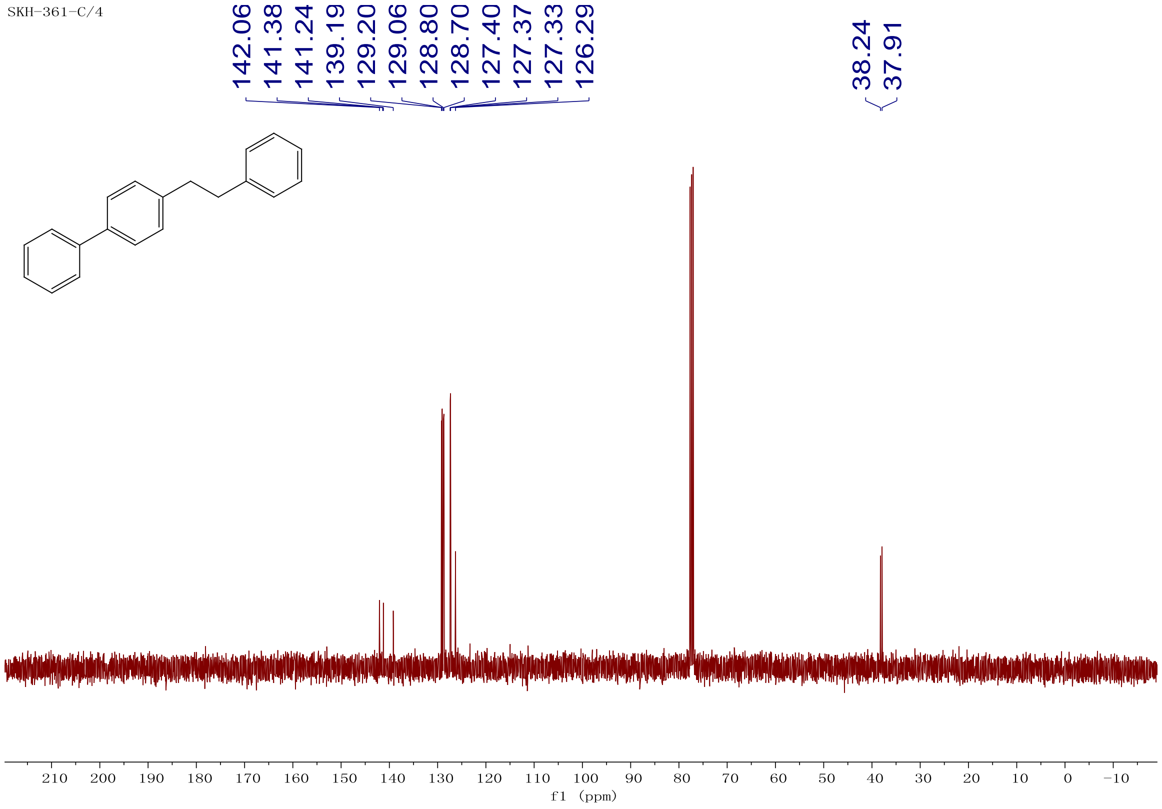
**2z**


SKH-364-H
7.65 7.65 7.65 7.63 7.63 7.63 7.56 7.55 7.54 7.54 7.53 7.49 7.47 7.45 7.38 7.38 7.38 7.37 7.36 7.36 7.35 7.34 7.34 7.26 7.25 7.25 7.24 7.23 2.58 0.99
CH3
CH3
CH3
2.00
2.00
2.00
1.00
2.00
2.00
9.00
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

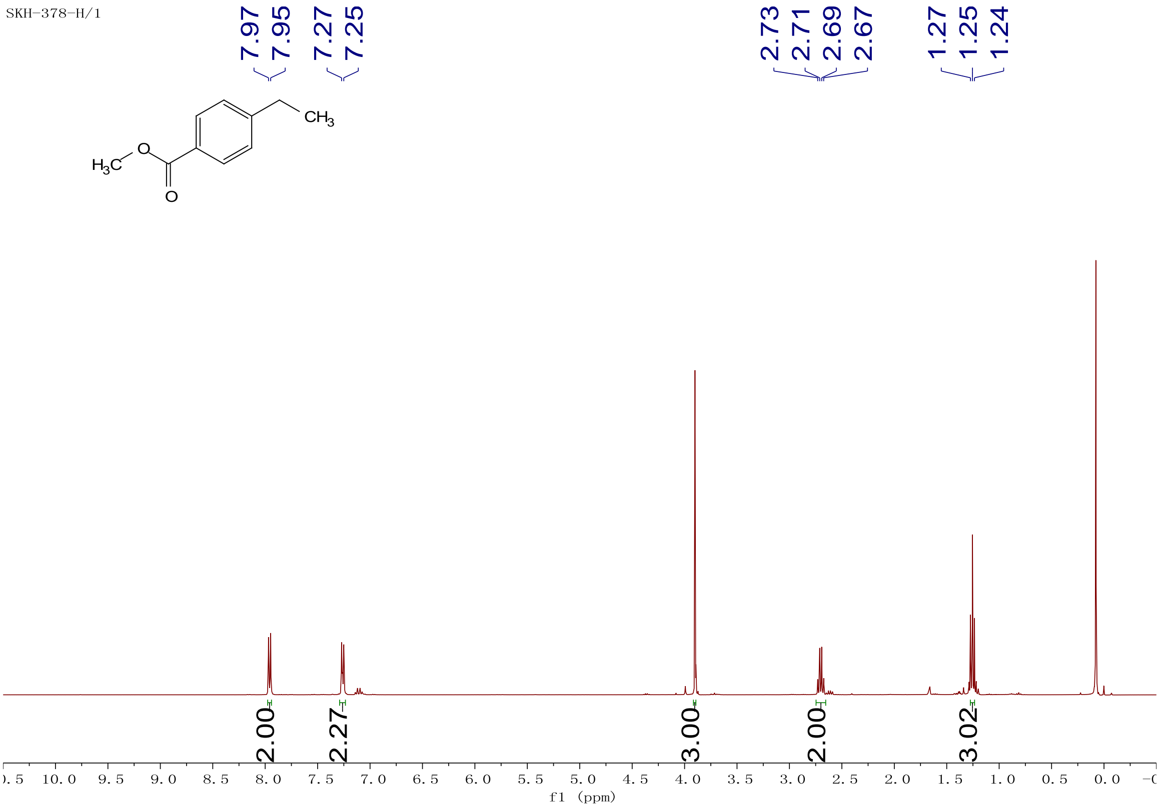

SKH-364-C/2
141.47 139.24 138.91 131.22 129.03 127.31 126.66
50.21
32.19 29.77
CH3
CH3
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

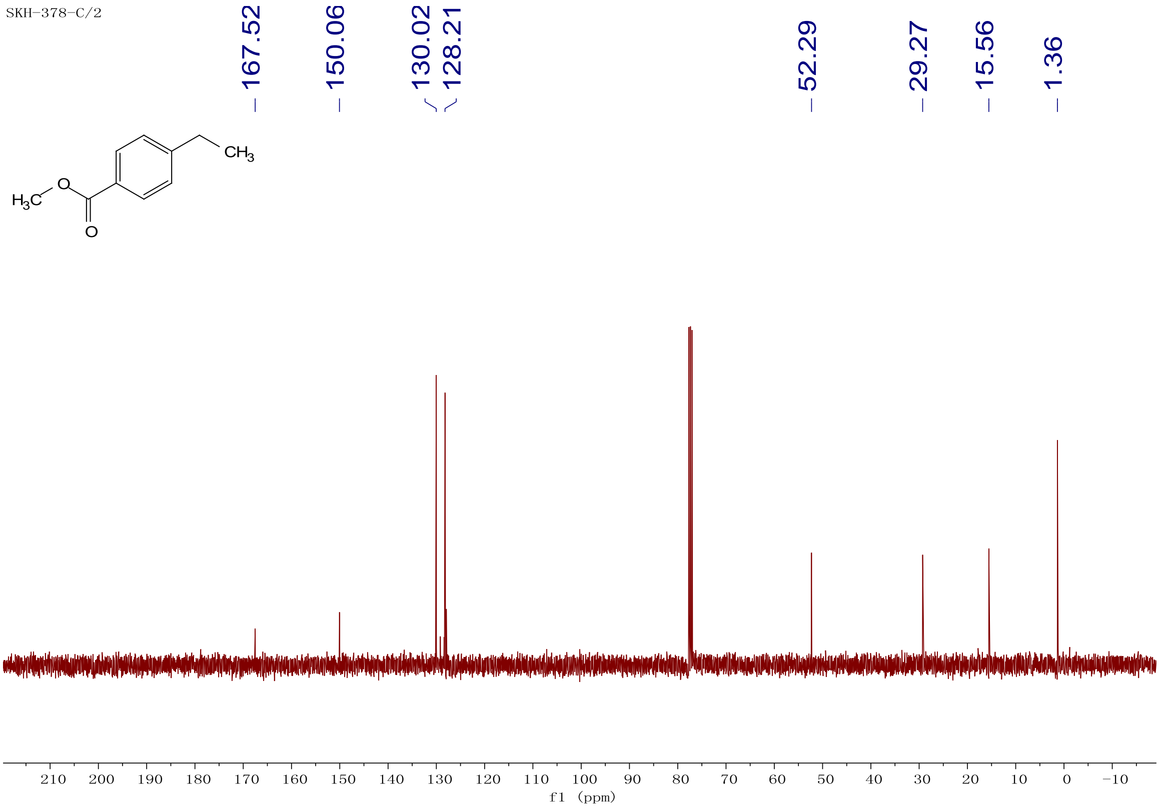
# 2aa


SKH-361-A-H/1
2.00
2.00
2.01
1.00
4.03
3.00
4.00
). 5
10. 0
9. 5
9. 0
8. 5
8. 0
7. 5
7. 0
6. 5
6. 0
5. 5
5. 0
4. 5
4. 0
3. 5
3. 0
2. 5
2. 0
1. 5
1. 0
0. 5
0. 0
−(
f1 (ppm)


SKH-361-C/4
142.06
141.38
141.24
139.19
129.20
129.06
128.80
128.70
127.40
127.37
127.33
126.29
38.24
37.91
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

# 2ab


SKH-378-H/1
7.97
7.95
7.27
7.25
2.73
2.71
2.69
2.67
1.27
1.25
1.24
CH3
H3C
O
O
2.00
2.27
3.00
2.00
3.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


SKH-378-C/2
167.52
150.06
130.02
128.21
52.29
29.27
15.56
1.36
CH3
H3C
O
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)