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September 2014: The paragraphs above replace the section "Handling and Disposal of Hazardous Chemicals" in the originally published version of this article. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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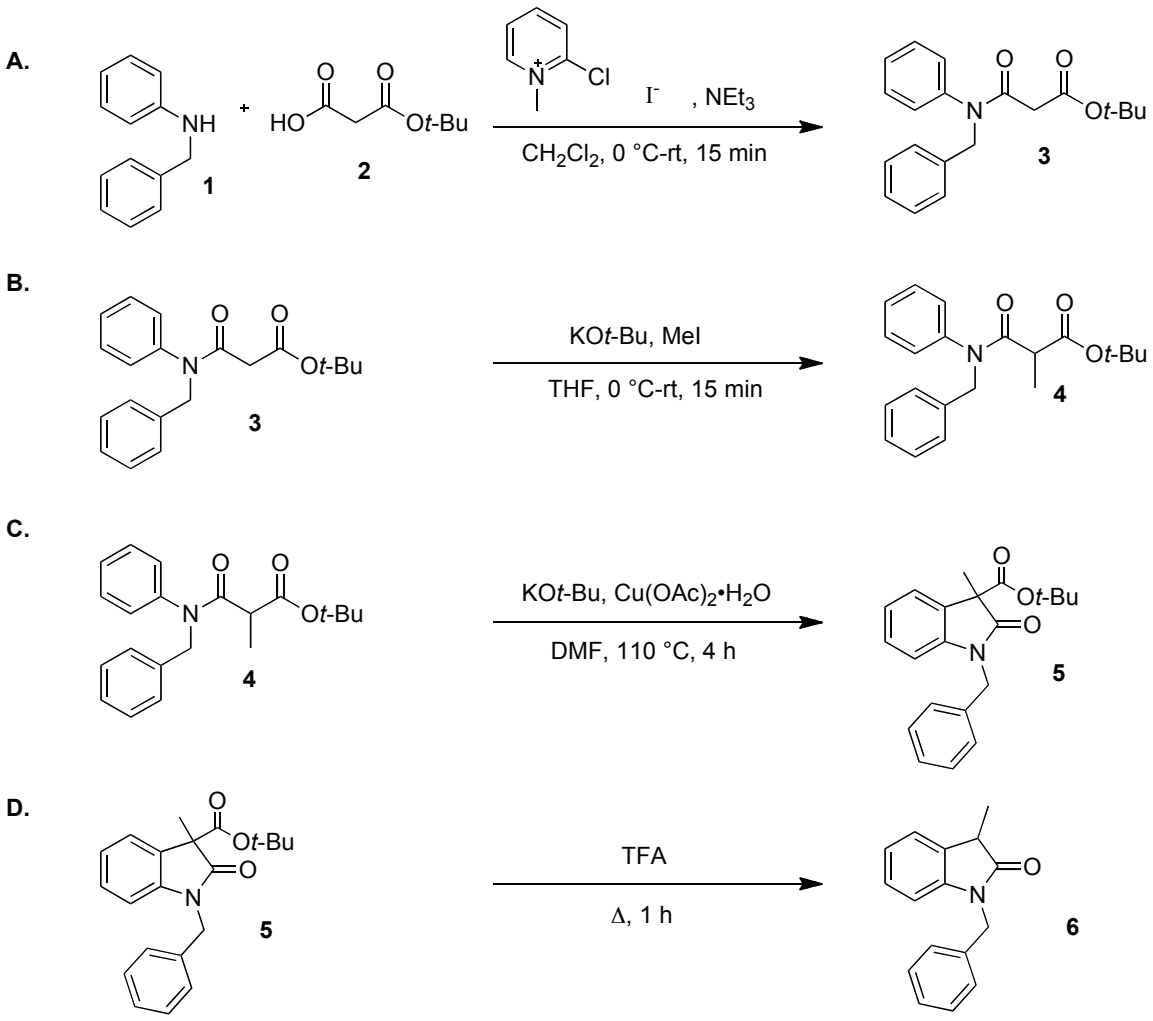
Preparation of 3-Alkylated Oxindoles from *N*-Benzyl Aniline via a Cu(II)-Mediated Anilide Cyclization Process



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Checked by Joshua S. Alford and Huw M. L. Davies.

1. Procedure

A. *tert-Butyl 3-(benzyl(phenyl)amino)-3-oxopropanoate* (**3**). A 250-mL, 2-necked, round-bottomed flask (B24 open neck; B14 with thermometer adaptor and −10-60 °C thermometer fitted) with a stir bar (oval, 1.25 in x 0.625 in) is charged with *N*-benzylaniline (10.96 g, 60.0 mmol, 1.0 equiv) (Note 1), dichloromethane (120 mL) (Note 2) and *tert*-butyl malonate (10.56 g, 66.0 mmol, 1.1 equiv) (Note 3) to give a pale yellow solution. The flask is placed in an ice-water bath to give an internal temperature of 4 °C. 2-

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Chloro-1-methylpyridinium iodide (Mukaiyama's reagent, 16.82 g, 66.0 mmol, 1.1 equiv) (Note 4) is added in a single portion to give a yellow suspension and an exotherm to 10 °C. The mixture is stirred for 5 min until the temperature has returned to 3 °C, before addition of triethylamine (33.3 mL, 24.29 g, 240.0 mmol, 4.0 equiv) (Note 5) *via* syringe maintaining the temperature below 10 °C (ca. 10 min) to give a yellow solution. On complete addition, the ice bath is removed and the reaction allowed to warm to room temperature. The reaction progress is monitored by TLC analysis on silica gel (Note 6). After 15 min, the yellow solution is quenched by the addition of an aqueous 3 M HCl solution (60 mL) to give a biphasic solution which is stirred for 5 min before transferring to a 500-mL separating funnel, and washing the flask with an additional 50 mL dichloromethane. The combined organic layers are separated and washed with 60 mL saturated aqueous solution of sodium bicarbonate and 120 mL saturated NaCl solution, dried over Na_2SO_4 (20 g), filtered (sinter, 60 mL, porosity 3) into a 500-mL round-bottomed flask and concentrated by rotary evaporation (38 °C water-bath, 15 to 10 mmHg) to afford 18.19 g of a yellow oil. Flash chromatography (SiO_2, 3:1 to 1:1 petroleum ether/Et_2O) (Note 7) gave 17.39 g (89%) of the product as a colorless oil (Note 8), which is utilized in the next step.

B. *tert-Butyl 3-(benzyl(phenyl)amino)-2-methyl-3-oxopropanoate* (**4**). A 250-mL, two-necked, round-bottomed flask (B24 septum and argon balloon; B14 with thermometer adaptor and −10-60 °C thermometer fitted) with a stir bar (oval, 1.25 in x 0.625 in) is charged with *tert*-butyl 3-(benzyl(phenyl)amino)-3-oxopropanoate (16.28 g, 50.0 mmol, 1.0 equiv) and tetrahydrofuran (100 mL) (Note 9) to give a pale yellow solution. The flask is placed in an ice-water bath to give an internal temperature of 3 °C. Potassium *tert*-butoxide (6.18 g, 55.0 mmol, 1.1 equiv) (Note 10) is added to give an orange suspension and an exotherm to 10 °C. The reaction is stirred until the temperature had returned to 3 °C (ca. 5 min), before addition of methyl iodide (3.4 mL, 7.61 g, 52.5 mmol, 1.05 equiv) (Note 11) *via* syringe over 30 min, maintaining the temperature below 10 °C to give a cream suspension. On complete addition, the ice bath is removed and the mixture stirred for 15 min. The reaction progress is monitored by TLC analysis on silica gel (Note 12). After this time the cream suspension is quenched by the addition of 50 mL saturated aqueous ammonium chloride solution and transferred to a 250-mL separating funnel. The washings are transferred with 20 mL of water and 100 mL Et_2O (Note 13). The organic layer is separated

and washed with 100 mL saturated NaCl solution, dried over $MgSO_4$ (20 g), filtered (sinter, 60 mL, porosity 3) into a 250-mL round-bottomed flask and concentrated by rotary evaporation (32 °C water-bath, 15 to 10 mmHg) to afford 17.96 g of an orange oil. Flash chromatography (SiO_2, 7:3 petroleum ether/Et_2O) (Note 14) gave 15.61 g (92%) of the product as a colorless sticky oil (Note 15), which is utilized in the next step.

C. *tert-Butyl 1-benzyl-3-methyl-2-oxoindoline-3-carboxylate* (**5**). A 2-L 2-necked, round-bottomed flask (B24 septum and argon balloon; B19 with thermometer adaptor and 0-300 °C thermometer fitted) with a stir bar (oval, 1.25 in x 0.625 in) is charged with *tert*-butyl 3-(benzyl(phenyl)amino)-2-methyl-3-oxopropanoate (16.55 g, 48.8 mmol, 1.0 equiv) and *N,N*-dimethylformamide (800 mL) (Note 16) to give a colorless solution. Potassium *tert*-butoxide (6.02 g, 53.7 mmol, 1.1 equiv) (Note 10) is added to give a yellow solution. The mixture is stirred for 5 min before addition of copper(II) acetate monohydrate (9.78 g, 48.8 mmol, 1.00 equiv) (Note 17) in a single portion to give a green-blue suspension, which is placed in a 110 °C oil-bath. The reaction progress is monitored by TLC analysis on silica gel (Note 18). After 4 h, the brown suspension is cooled to room temperature and concentrated by rotary evaporation (78 °C water-bath, 15 to 10 mmHg) to approximately $1/10^{th}$ volume. The brown suspension is poured into a 1-L separating funnel, and washed with 400 mL of water, 100 mL of 3 M HCl and 200 mL of Et_2O to give a brown organic and green aqueous layers. The layers are separated and the aqueous layer further extracted with of Et_2O (2 × 200 mL). The combined organic layers are washed with 200 mL of saturated sodium bicarbonate solution and 2 × 200 mL of a saturated NaCl solution, dried over $MgSO_4$ (20 g), filtered (sinter, 60 mL, porosity 3) into a 1-L round-bottomed flask and concentrated by rotary evaporation (32 °C water-bath, 15 to 10 mmHg) to afford 15.30 g of a brown oil. Flash chromatography (SiO_2, 4:1 petroleum ether/ Et_2O) (Note 19), followed by collection of the product on a sinter (60 mL, porosity 3), using portions of hexane (3 × 50 mL) (Note 20) gave 8.32 g (51%) of the product as a colorless solid (Note 21), which is utilized in the next step.

D. *1-Benzyl-3-methylindolin-2-one* (**6**). A 100-mL 1-necked round-bottomed flask (B14 with condenser fitted) with a stir bar (oval, 1.25 in x 0.625 in) is charged with *tert*-butyl 1-benzyl-3-methyl-2-oxoindoline-3-carboxylate (7.42 g, 22.0 mmol, 1.0 equiv) and trifluoroacetic acid (11 mL) (Note 22) to give a yellow solution which is placed in an oil-bath held at 75 °C. The reaction progress is monitored by TLC analysis on silica gel (Note

23). After 1 h, the brown solution is cooled to room temperature, transferred to a 250-mL round-bottomed flask using 3 × 20 mL of dichloromethane and concentrated by rotary evaporation (38 °C water-bath, 15 to 10 mmHg) to yield an oil. Ethanol (50 mL) (Note 24) is added to dissolve the oil and then removed by rotary evaporation (40 °C water-bath, 12 mmHg) to give a colorless solid (4.88 g). Purification by recrystallization (ethanol) (Note 25) gave 4.14 g (80%) of the product as colorless shards (Note 26).

2. Notes

1. *N*-Benzyl aniline (99%) was purchased from Aldrich Chemical Company, Inc.

2. Dichloromethane (HPLC grade) was purchased from Fisher Scientific Company and used as received.

3. *tert*-Butyl malonate (97%) was purchased from Alfa Aesar. The supplied material contained 5–10% *tert*-butyl ethyl malonate as an impurity, but was used as received.

4. 2-Chloro-1-methylpyridinium iodide (Mukaiyama's reagent; 97%) was purchased from Aldrich Chemical Company, Inc.

5. Triethylamine was purchased from Aldrich Chemical Company, Inc.

6. TLC analysis was carried out using silica gel plates (Note 28) with petroleum ether-Et_2O (1:1) as eluent and visualisation with UV (254 nm) and *p*-anisaldehyde. *N*-Benzyl aniline **1** has R_f = 0.77 (white) and the product **3** has R_f = 0.42 (purple).

7. The crude material was purified by column chromatography. A 60-mm diameter column was wet-packed with a silica gel slurry made from petroleum ether/Et_2O (3:1) (180 g) (Note 30) to give a 160-mm column depth. Sand (1 cm) was layered onto the silica and the crude oil suspended in the eluent (25 mL) and poured onto the sand. Washings are also loaded with further portions of the eluent (2 x 25 mL) and 400 mL of eluent was collected. Fractions (16 x 150 mm test tubes) are collected from 600 mL of petroleum ether/Et_2O (3:1) and 1.5 L of petroleum ether/Et_2O (1:1) to give 55 fractions. The product was identified by thin layer chromatography (petroleum ether/Et_2O (1:1); R_f = 0.42) and fractions 15-53 are collected and concentrated by rotary evaporation (35 °C water-bath, 15 to 10 mmHg). The material was then dried overnight under high vacuum (0.08 mmHg) with an oval stir-bar to yield the product.

8. The checkers report an 88% yield when the reaction was performed at half-scale. Compound **3** exhibits the following physical and spectroscopic properties: ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.42 (s, 9 H), 3.14 (s, 2 H), 4.91 (s, 2 H), 7.01–7.03 (m, 2 H), 7.23–7.26 (m, 5 H), 7.29–7.31 (m, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 28.1, 43.1, 53.1, 81.6, 127.6, 128.5, 128.9, 129.8, 137.3, 142.1, 166.4, 167.0; IR (neat): 3063, 2978, 1731, 1660, 1495, 1392, 1367, 1326, 1142, 697 cm^{-1}; HRMS (ESI) *m/z* 326.1749 [326.1751 calcd for $C_{20}H_{24}NO_3$ (M+H)]. Anal. Calcd for: C, 73.82, H, 7.12, N, 4.30. Found: C, 73.59, H, 7.13, N, 4.41.

9. Tetrahydrofuran (HPLC grade) was purchased from Fisher and purified using a Innovative Technology Inc. Pure Solv™ solvent purification system.

10. Potassium *tert*-butoxide was purchased from Aldrich Chemical Company, Inc.

11. Methyl iodide was purchased from Aldrich Chemical Company, Inc.

12. TLC analysis was carried out using silica gel plates (Note 28) with petroleum ether-Et_2O (1:1) as eluent and visualisation with UV (254 nm) and *p*-anisaldehyde. *tert*-Butyl 3-(benzyl(phenyl)amino)-3-oxopropanoate **3** has R_f = 0.38 (purple) and the product **4** has R_f = 0.48 (blue).

13. Diethyl ether (Lab reagent grade) was supplied by Fisher Scientific.

14. A 60-mm diameter column was wet-packed with silica gel (220 g) (Note 30) to give a 140 mm column depth. Sand (1 cm) was layered onto the silica and the crude oil suspended in the eluent (25 mL) and poured onto the sand. Washings are also loaded in a further portion of eluent (25 mL). Fractions (45 mL) are collected from 4 L of petroleum ether/Et_2O (7:3). The 49 fractions were analyzed by TLC (petroleum ether/Et_2O :7:3) and the product (R_f = 0.27) identified in fractions 11-35, which were collected and concentrated by rotary evaporation (32 °C water-bath, 15 to 10 mmHg). The residual material was dried overnight under high vacuum (0.1 mbar) with an oval stir bar to yield the product **4**.

15. The checkers report a 91% yield when the reaction was performed at half-scale. Compound **4** exhibits the following physical and spectroscopic properties: ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.28 (d, *J* = 7 Hz, 3 H), 1.41 (s, 9 H), 3.27 (q, *J* = 7.2, 1 H), 4.57 (d, *J* = 14.4 Hz, 1 H), 5.22 (d, *J* = 14.4 Hz, 1 H), 7.01–7.04 (m, 2 H), 7.22–7.27 (m, 5 H), 7.30–7.34 (m, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 14.2, 28.1, 44.6, 53.2, 81.3, 127.6, 128.5, 128.7,

128.9, 129.8, 137.6, 142.2, 169.9, 170.5; IR (neat): 3063, 2978, 2935, 1738, 1656, 1595, 1495, 1454, 1393, 1367, 1325, 1245, 1147, 848, 735, 697 cm^{-1}; HRMS (ESI) *m/z* 340.1906 [340.1907 calcd for $C_{21}H_{26}NO_3$ (M+H)]. Anal. Calcd for: C, 74.31; H, 7.42, N, 4.13. Found: C, 73.49; H, 7.29, N, 4.15.

16. *N,N*-Dimethylformamide (anhydrous, 99.8%) was purchased from Sigma-Aldrich and used as received. Submitters purchased *N,N*-dimethylformamide from Fisher Scientific and purified using a Innovative Technology Inc. Pure Solv™ solvent purification system.

17. Copper(II) acetate monohydrate was purchased from Aldrich Chemical Company, Inc.

18. TLC analysis was carried out using silica gel plates (Note 28) with petroleum ether-Et_2O (1:1) as eluent and visualisation with UV (254 nm) and *p*-anisaldehyde. *tert*-Butyl 3-(benzyl(phenyl)amino)-2-methyl-3-oxopropanoate **4** has R_f = 0.50 (blue) and the product **5** has R_f = 0.68 (purple).

19. A 60-mm diameter column was wet-packed with silica gel (120 g) (Note 30) to give a 110-mm column depth. Sand (1 cm) was layered onto the silica and the crude oil suspended in dichloromethane (10 mL) and poured onto the sand. Washings were also loaded in a further portion of dichloromethane (5 mL). Fractions (16 x 150 mm tubes) were collected from 1.5 L of petroleum ether/Et_2O (4:1). The 90 fractions were evaluated by thin layer chromatography (petroleum ether/Et_2O; 4:1) product R_f = 0.26) and fractions 37-81 were collected and concentrated (Rotary evaporation (32 °C water-bath, 15 to 10 mmHg)) to yield the product.

20. The colorless solid was suspended in hexane (50 mL) and filtered, collecting the solid on a sinter (60 mL, porosity 3) and washing with three additional portions of 100 mL portions of hexane (Note 27). The colorless solid obtained was transferred to a 50-mL round-bottomed flask and dried overnight under high vacuum (0.08 mmHg).

21. The checkers report a 50% yield when the reaction was performed at half-scale. Compound **5** exhibits the following physical and spectroscopic properties: mp 106–107 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.36 (s, 9 H), 4.66 (d, *J* = 16 Hz, 1 H), 5.22 (d, *J* = 16 Hz, 1 H), 6.68 (d, *J* = 7.6 Hz, 1 H), 7.02 (ddd, *J* = 1.2, 7.6, 7.6 Hz, 1 H), 7.17 (ddd, *J* = 1.2, 7.6, 7.6 Hz), 7.23–7.33 (m, 6 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 20.1, 28.0, 43.9, 56.1, 82.6, 109.6, 122.8, 123.0, 127.3, 127.8, 128.9, 130.9, 135.9, 142.9, 168.9, 175.8; IR (film): 3061, 2979, 2932, 1732, 1713, 1609, 1488, 1466, 1368, 1252, 1152, 1115, 1108, 748, 697 cm^{-1}; HRMS (ESI) *m/z* 338.1749 [338.1751

calcd for $C_{21}H_{24}NO_3$ (M+H)]. Anal. Calcd for: C, 74.75, H, 6.87, N, 4.15. Found: C, 74.56, H, 6.94, N, 4.19.

22. Trifluoroacetic acid, 98% was purchased from Aldrich Chemical Company Inc.

23. TLC analysis was carried out using silica gel plates (Note 28) with petroleum ether-Et_2O (1:1) as eluent and visualisation with UV (254 nm) and *p*-anisaldehyde. *tert*-Butyl 1-benzyl-3-methyl-2-oxoindoline-3-carboxylate **5** has R_f = 0.68 (purple) and the product **6** has R_f = 0.46 (pink).

24. Ethanol (analytical reagent grade) was purchased from Fisher Scientific and used as received.

25. The colorless solid was dissolved in the minimum amount of boiling ethanol (ca. 15 mL) and allowed to cool to room temperature. The crystals were broken up with a spatula and collected *via* filtration in a sinter (60 mL, porosity 3) washing with three 50 mL portions of hexane (Note 27). The crystals were transferred to a 50-mL round-bottomed flask and dried overnight under high vacuum (0.08 mmHg).

26. The checkers report an 81% yield when the reaction was performed at half-scale. Compound **6** exhibits the following physical and spectroscopic properties: mp 119–120 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.54 (d, *J* = 8 Hz, 3 H), 3.54 (q, *J* = 7.6 Hz, 1 H), 4.92 (s, 2 H), 6.72 (d, *J* = 8 Hz, 1 H), 7.02 (ddd, *J* = 1.2, 7.6, 7.6 Hz), 7.16 (dt, *J* = 1.2, 2, 8 Hz, 1 H), 7.24–7.34 (m, 6 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 15.9, 40.8, 43.9, 109.2, 122.7, 123.8, 127.5, 127.8, 128.0, 129.0, 130.9, 136.2, 143.3, 179.0 ppm; IR (film): 3057, 3031, 2930, 1704, 1613, 1487, 1466, 1454, 1348, 1202, 1169, 972, 749, 687 cm^{-1}; HRMS (ESI) *m/z* 238.1224 [238.1226 calcd. for $C_{16}H_{16}NO$ (M+H)]. Anal. Calcd. for: C, 80.98; H, 6.37, N, 5.90. Found: C, 80.70; H, 6.24, N, 5.91. The physical and spectroscopic data matches those previously reported.[2]

27. *n*-Hexane (HPLC grade) was purchased from Fisher Scientific and used as received.

28. TLC plates were supplied by Merck, aluminium backed silica gel 60 (F_{254}).

29. Petroleum ether (lab reagent grade) supplied by Fisher Scientific. Diethyl ether (anhydrous) was supplied by Fisher Scientific.

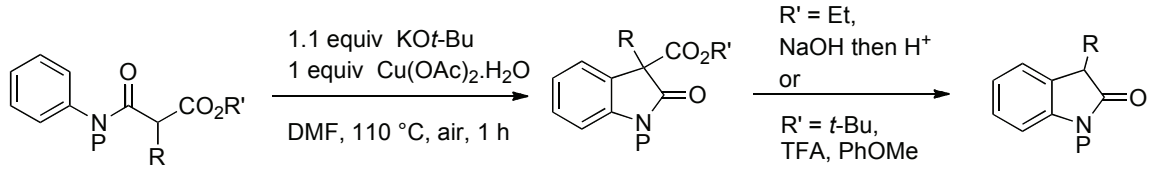
30. Silica Gel (60) was purchased from Sorbent Technologies. Submitters purchased silica gel (60) from Fluka.

Safety and Waste Disposal Information

All hazardous materials should be handled and disposed of in accordance with "Prudent Practices in the Laboratory"; National Academies Press; Washington, DC, 2011.

3. Discussion

3-Substituted oxindoles form the cornerstone of numerous natural products and bioactive lead compounds.[3] We recently reported an efficient new route to 3,3-disubstituted oxindoles such as esters **5** from anilides **4** using potassium *tert*-butoxide as base and stoichiometric $Cu(OAc)_2.H_2O$ in DMF (Scheme 1).[4,5] This procedure is operationally straightforward, employs inexpensive reagents and does not require anhydrous conditions or the use of an inert atmosphere (other electron-withdrawing groups, such as nitrile and phosphonate, could also be employed).[4-6] Cyclization to generate the quaternary all-carbon-center occurs *via* a formal C-H, Ar-H coupling, but preliminary mechanistic studies are consistent with a sequence involving deprotonation, copper(II)-mediated radical generation and then homolytic aromatic substitution.[4,6] A related procedure was developed which utilizes catalytic $Cu(OAc)_2 \bullet H_2O$, but this has yet to be applied to multi-gram transformations.[7]



4, R = Alkyl, Arylalkyl, Hetarylalkyl,
R ' = Et, *t*-Bu
P = Me, Bn, PMB

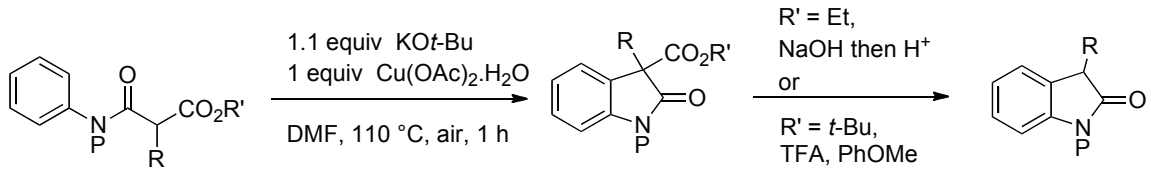
5

6

The stoichiometric $Cu(OAc)_2.H_2O$ methodology was also extended to prepare 3-monosubstituted oxindoles **6** by subsequent decarboxyalkylation (Scheme 1). 3-Alkylated oxindoles are valuable as synthetic building blocks[8] and as drug candidates.[9] A base-mediated saponification/decarboxylation sequence using ethyl esters (**5**, R' = Et) was not widely applicable, but the use of neat TFA (with anisole as a cation trap) at room temperature on the corresponding *t*-butyl esters (**5**, R' = *t*-Bu) proved extremely efficient and versatile.[5] The scope of this process is shown in Table 1. As can be seen, this decarboxyalkylation sequence was used to prepare a range of 3-substituted oxindoles including those with

saturated alkyl substituents, allyl, benzyl, phenethyl and naphthylmethyl substituents, as well as the benzyloxypropyl and 4-pyridylmethyl examples. The *N*-protecting group could be benzyl, methyl or *p*-methoxybenzyl (PMB). With *N*-PMB protection, the use of a higher temperature and a longer reaction time gave both decarboxyalkylation and *N*-deprotection.

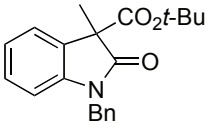
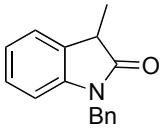
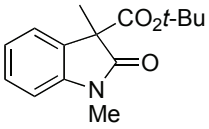
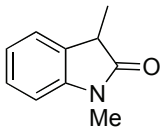
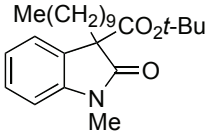
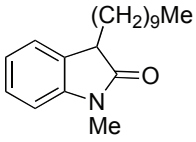
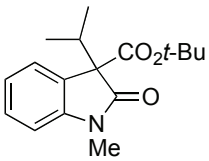
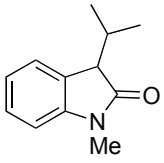
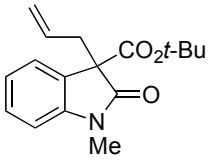
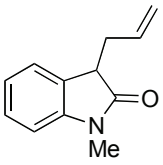
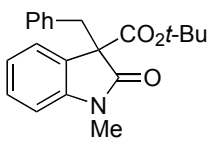
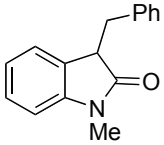
Table 1 Scope of the copper(II)-mediated cyclisation and TFA-mediated decarboxyalkylation procedure



4, R = Alkyl, Arylalkyl, Hetarylalkyl,
R ' = Et, *t*-Bu
P = Me, Bn, PMB

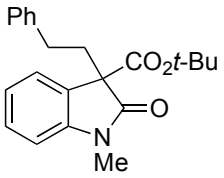
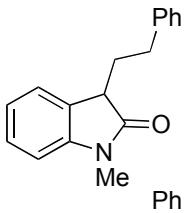
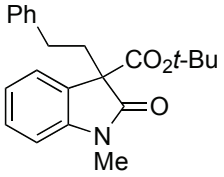
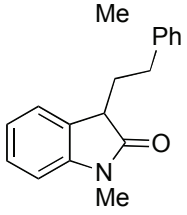
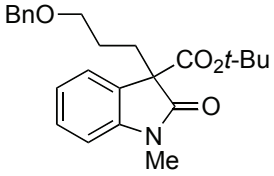
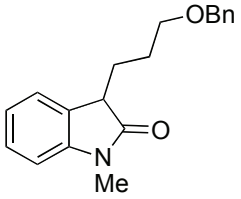
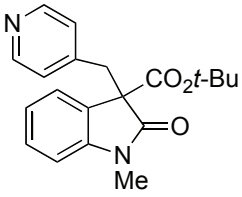
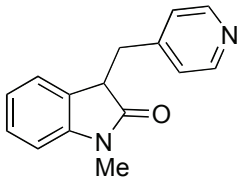
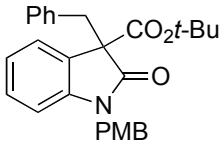
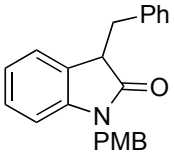
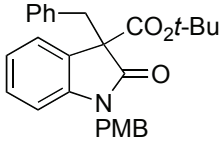
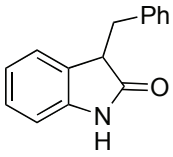
5

6

Entry	Oxindole 5	Yield 5 (%)	Alkyoxindole 6	Yield 6 (%)
i		55		77
ii		82		78
iii		76		90
iv		46[a]		68
v		59		92
vi		93		98

[a] Heat for 3 days

Table 1 (continued)

Entry	Oxindole 5	Yield 5 (%)	Alkyoxindole 6	Yield 6 (%)
vii		71		62
viii		73		93
ix		65		86
x		66		92
xi		69		84
xii		69		87

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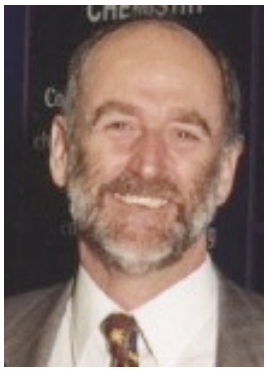
Appendix
Chemical Abstracts Nomenclature; (Registry Number)

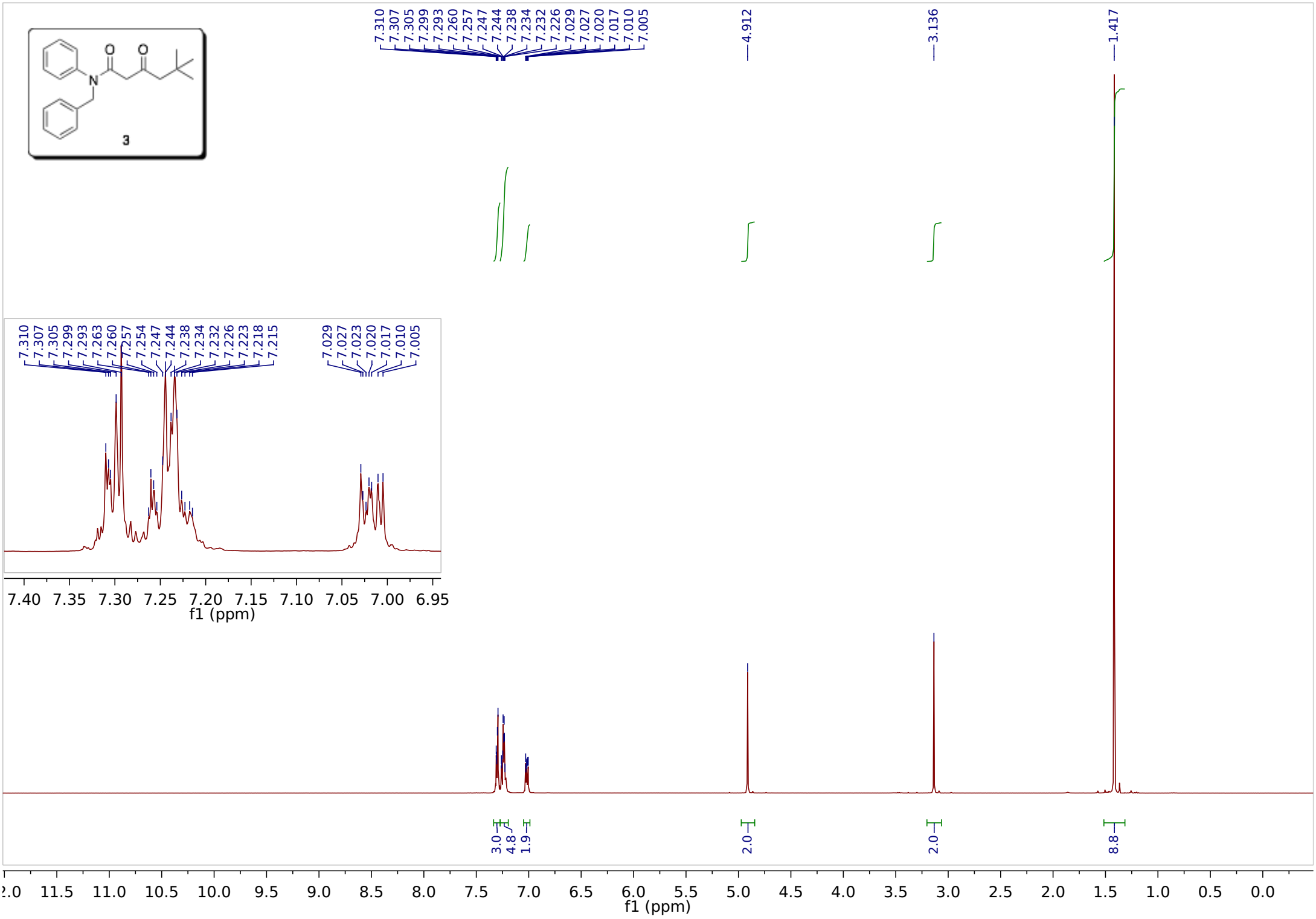
tert-Butyl 3-(benzyl(phenyl)amino)-3-oxopropanoate;
N-Benzylaniline; (103-32-2)
2-Chloro-1-methylpyridinium iodide; (14338-32-0)
tert-Butyl malonate; (40052-13-9)
tert-Butyl 3-(benzyl(phenyl)amino)-2-methyl-3-oxopropanoate;
Methyl iodide; (74-88-4)
Potassium tert-butoxide; (865-47-4)
Copper(II) acetate monohydrate; (6046-93-1)
Trifluoroacetic acid; (76-05-1)
tert-Butyl 1-benzyl-3-methyl-2-oxoindoline-3-carboxylate;
1-Benzyl-3-methylindolin-2-one; (34943-91-4)



Richard Taylor obtained his B.Sc. and Ph.D. (Dr. D. Neville Jones) from the University of Sheffield. Postdoctoral periods with Dr. Ian Harrison and Professor Franz Sondheimer were followed by lectureships at the Open University and then UEA, Norwich. In 1993 he moved to the Chair of Organic Chemistry at the University of York. Taylor's research interests centre on the synthesis of bioactive natural products and the development of new synthetic methodology. His awards include the Royal Society of Chemistry's Pedler Lectureship (2007). Taylor is the current President of the International Society of Heterocyclic Chemistry, a past-President of the RSC Organic Division and an Editor of Tetrahedron.

David Pugh was born in Harrogate, North Yorkshire in 1985. He carried out his undergraduate studies and obtained an M. Chem. (Hons) at the University of York in 2007, carrying out a final year project under the supervision of Prof. Richard Taylor. He remained in the group to undertake a Ph.D. and is investigating new methodology for the synthesis of cyclopropanes and oxindoles.

Joshua S. Alford received both his B.S. and M.S. in chemistry from Missouri State University under the supervision of Dr. Chad Stearman. He later joined the Davies research group at Emory University to pursue a PhD degree. His current projects include the synthesis of pharmaceutical agents utilizing rhodium carbenoid chemistry and the development of a new type of donor/acceptor carbenoid.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7.027
7.020
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7.010
7.005
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1.417
O
O
N
3
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7.307
7.305
7.299
7.293
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7.257
7.254
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7.238
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7.232
7.226
7.223
7.218
7.215
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7.027
7.023
7.020
7.017
7.010
7.005
7.40 7.35 7.30 7.25 7.20 7.15 7.10 7.05 7.00 6.95
f1 (ppm)
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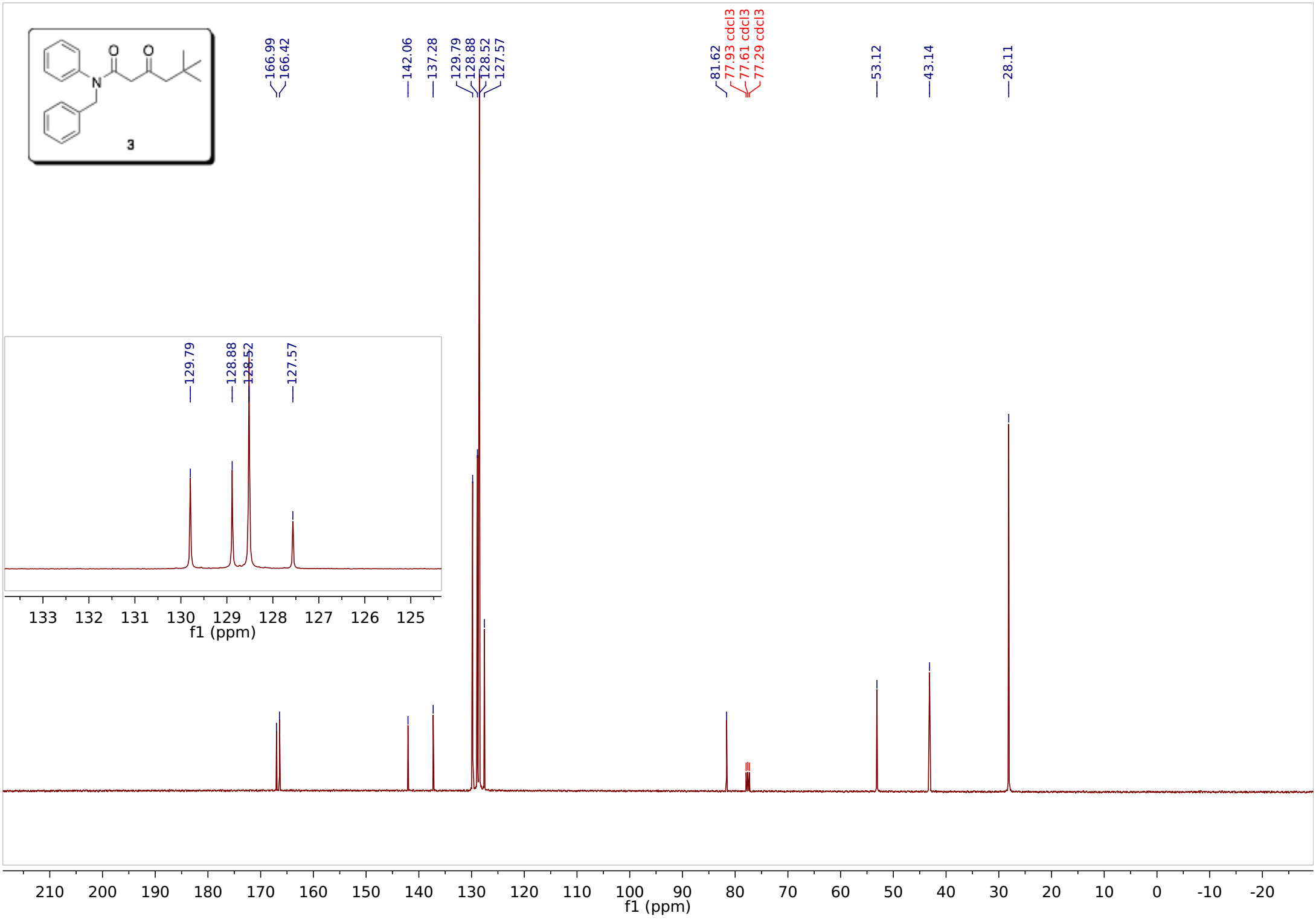
4.8
1.9
2.0
2.0
8.8
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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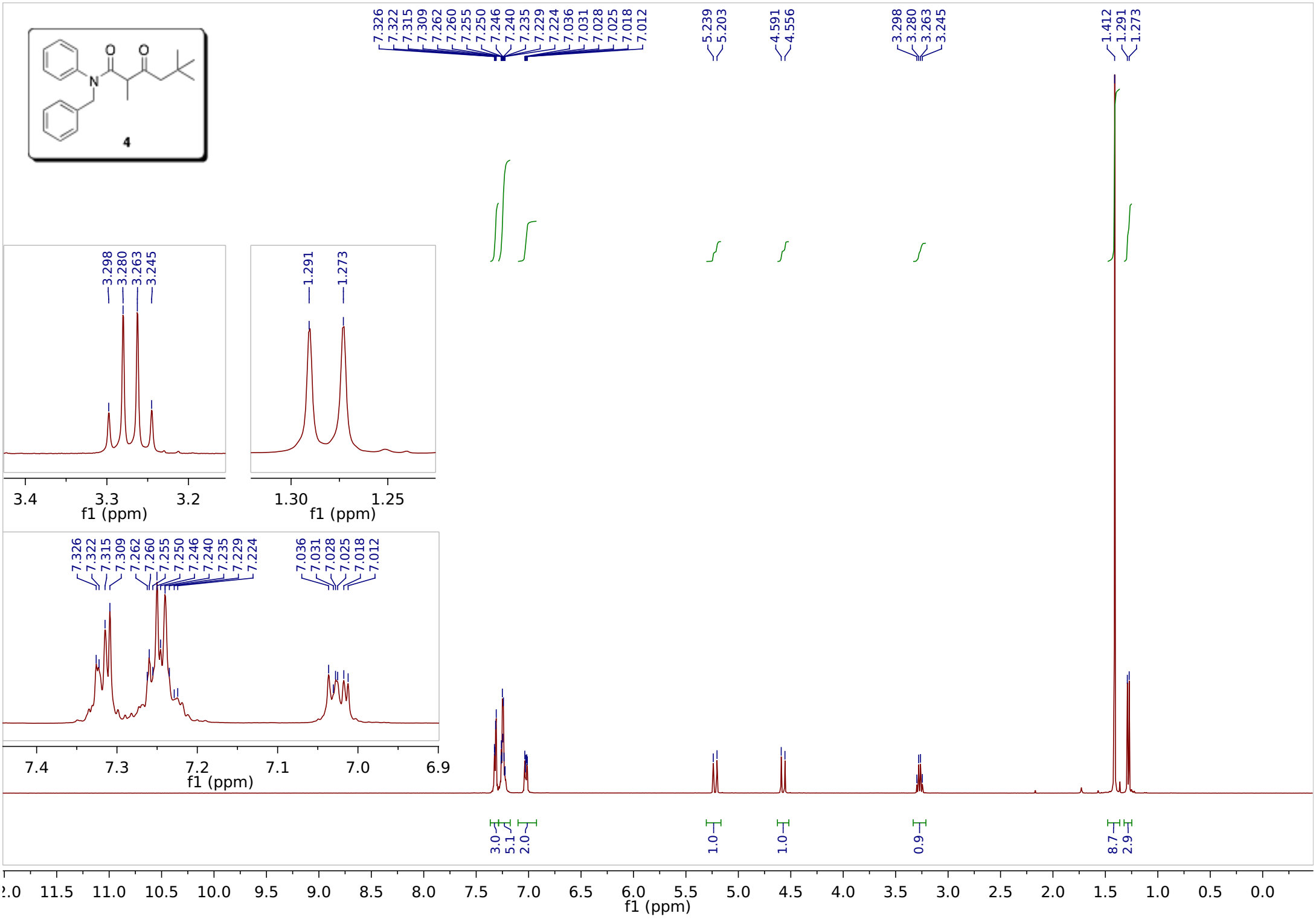
28.11
f1 (ppm)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7.036
7.031
7.028
7.025
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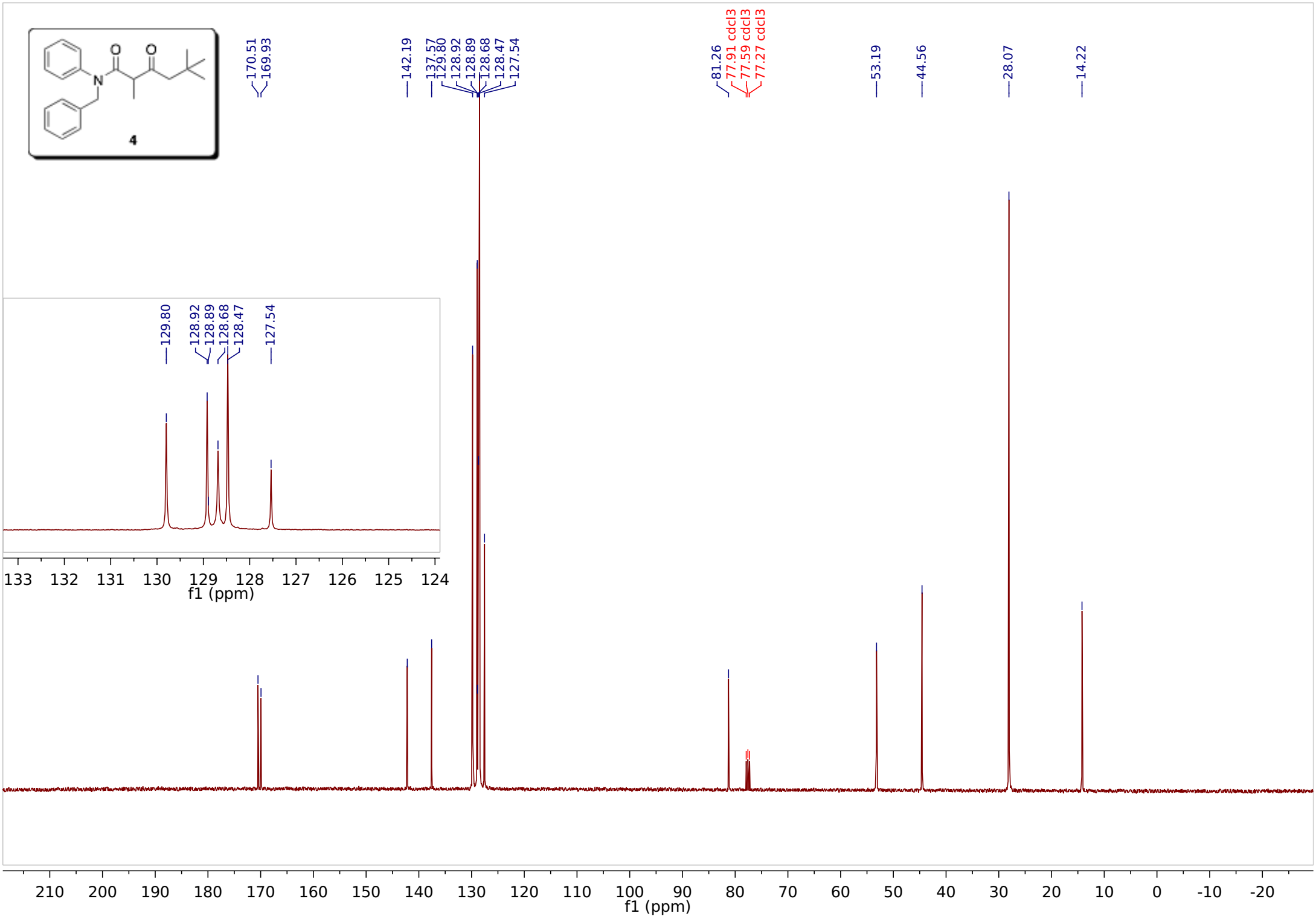
1.273
f1 (ppm)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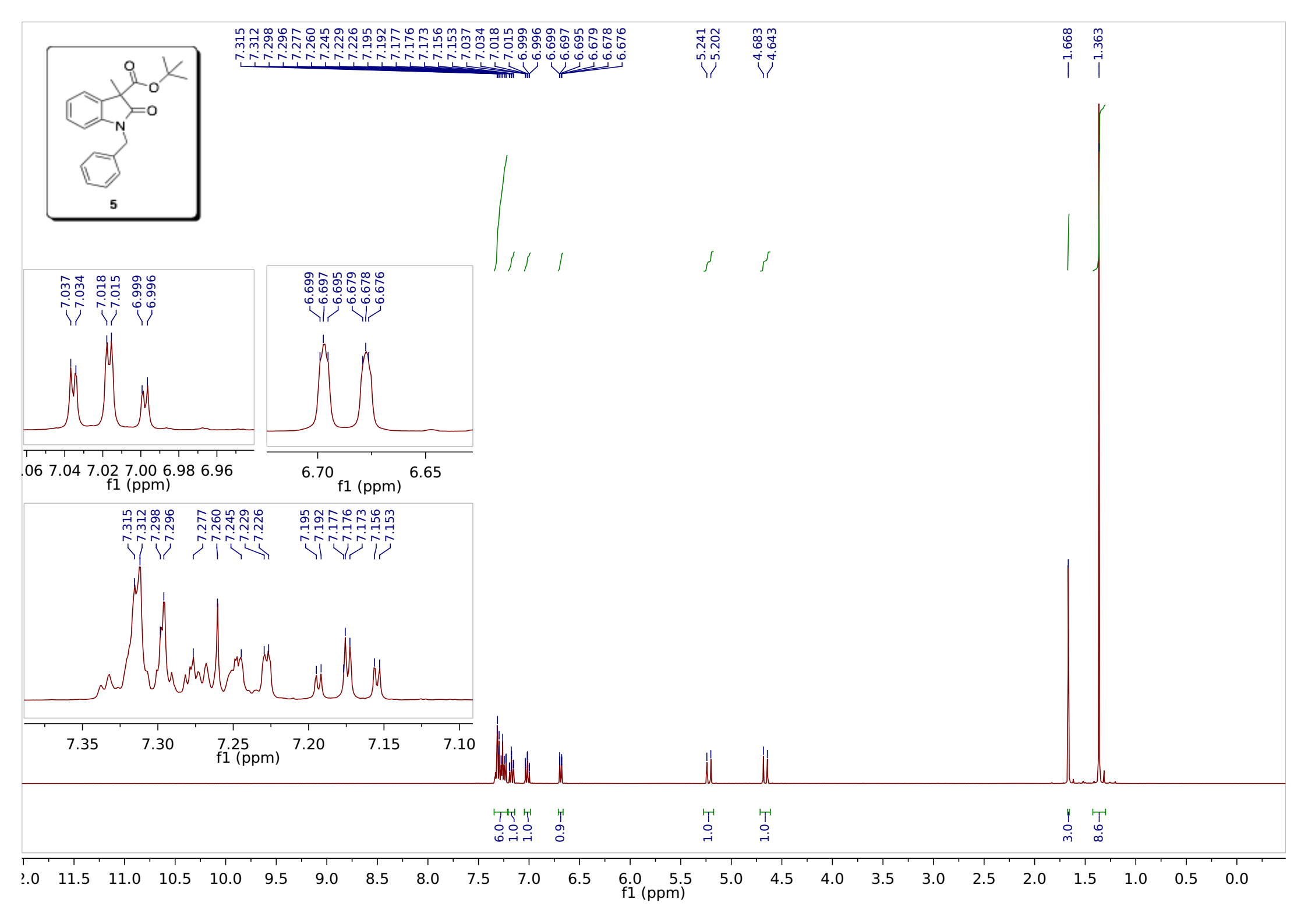
f1 (ppm)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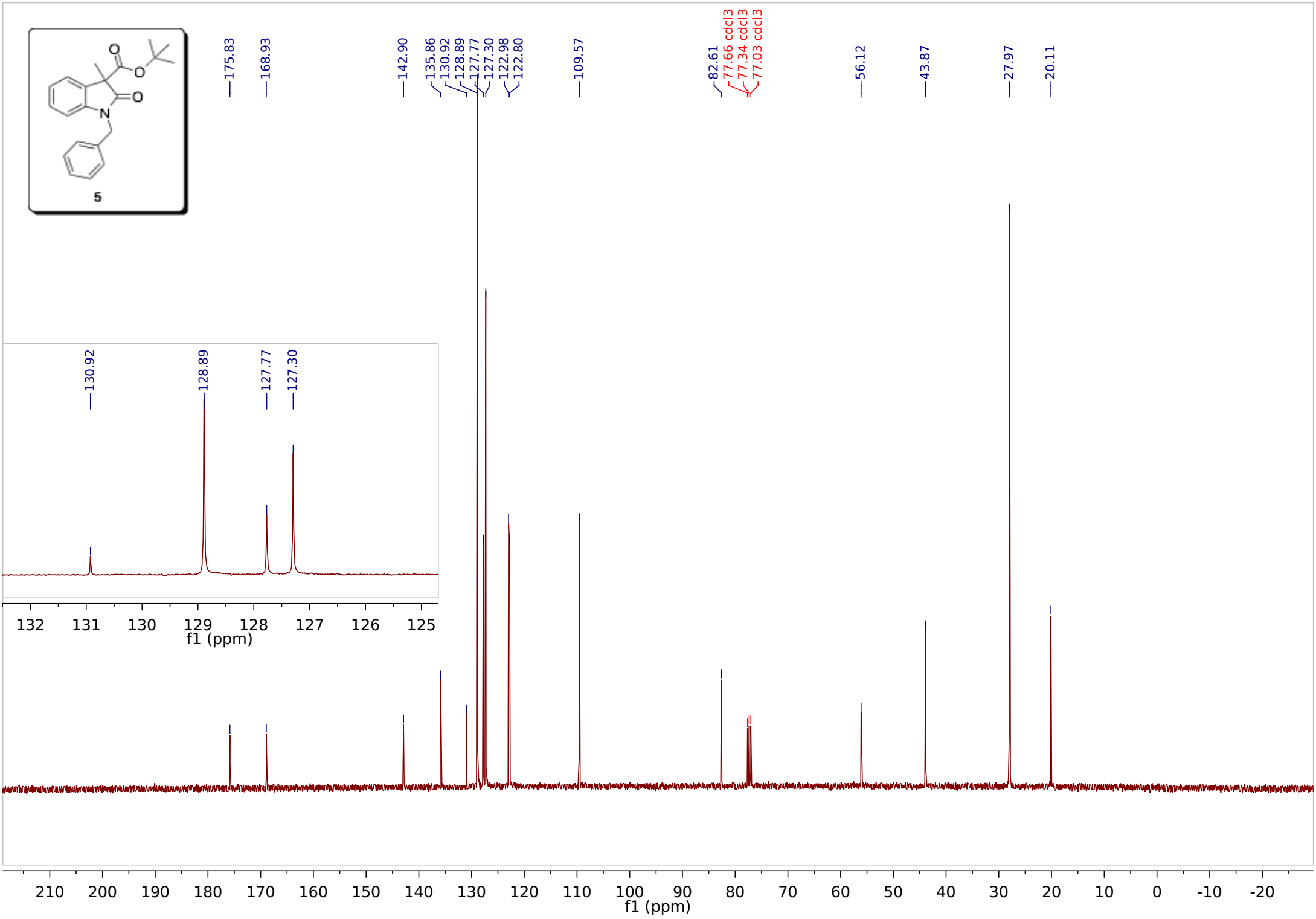
f1 (ppm)
f1 (ppm)
f1 (ppm)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20.11
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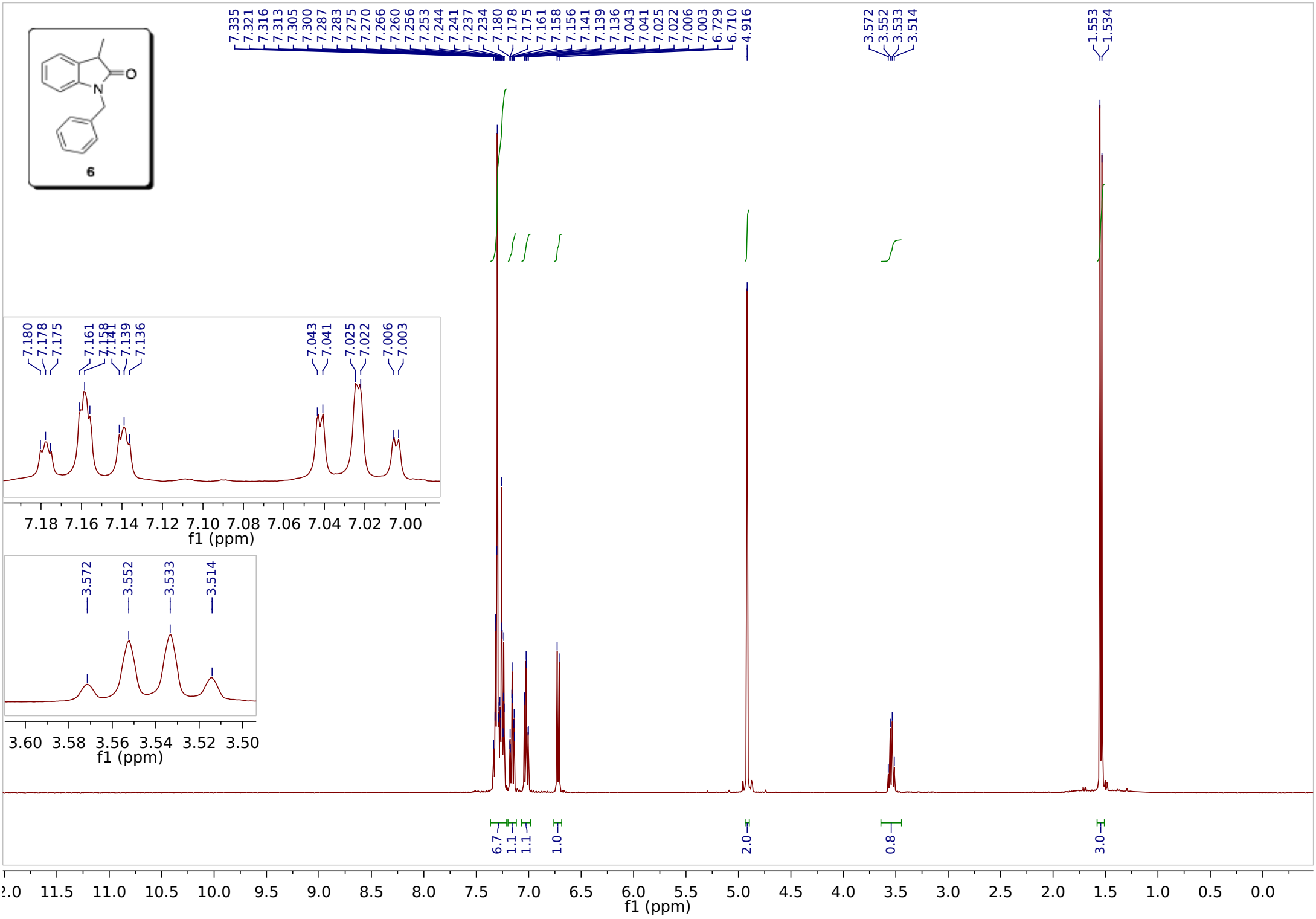
f1 (ppm)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f1 (ppm)
3.60 3.58 3.56 3.54 3.52 3.50
f1 (ppm)
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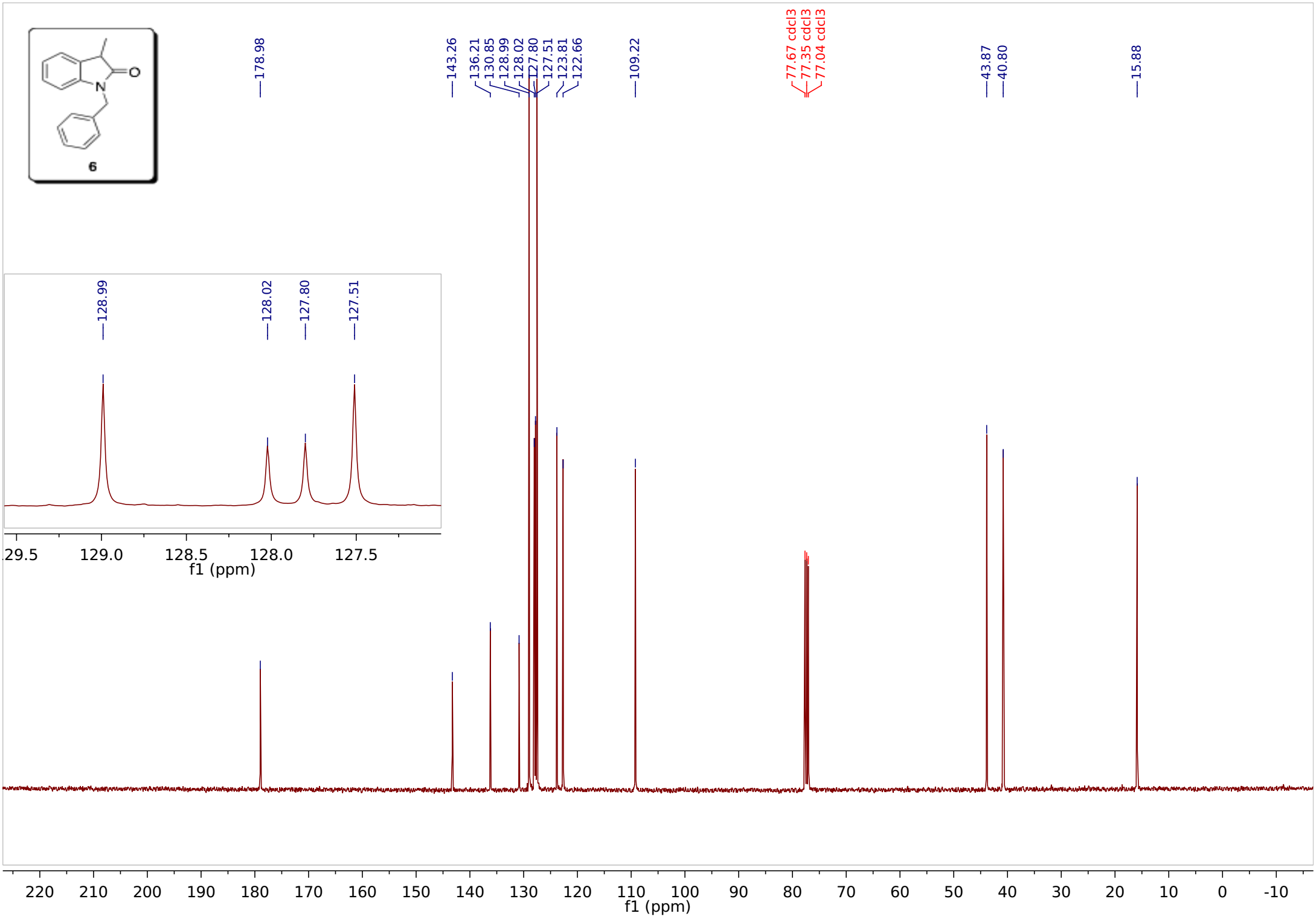
1.1
1.0
2.0
0.8
3.0
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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143.26
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123.81
122.66
109.22
77.67 cdcl3
77.35 cdcl3
77.04 cdcl3
43.87
40.80
15.88
128.99
128.02
127.80
127.51
29.5
129.0
128.5
128.0
127.5
f1 (ppm)
220
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)