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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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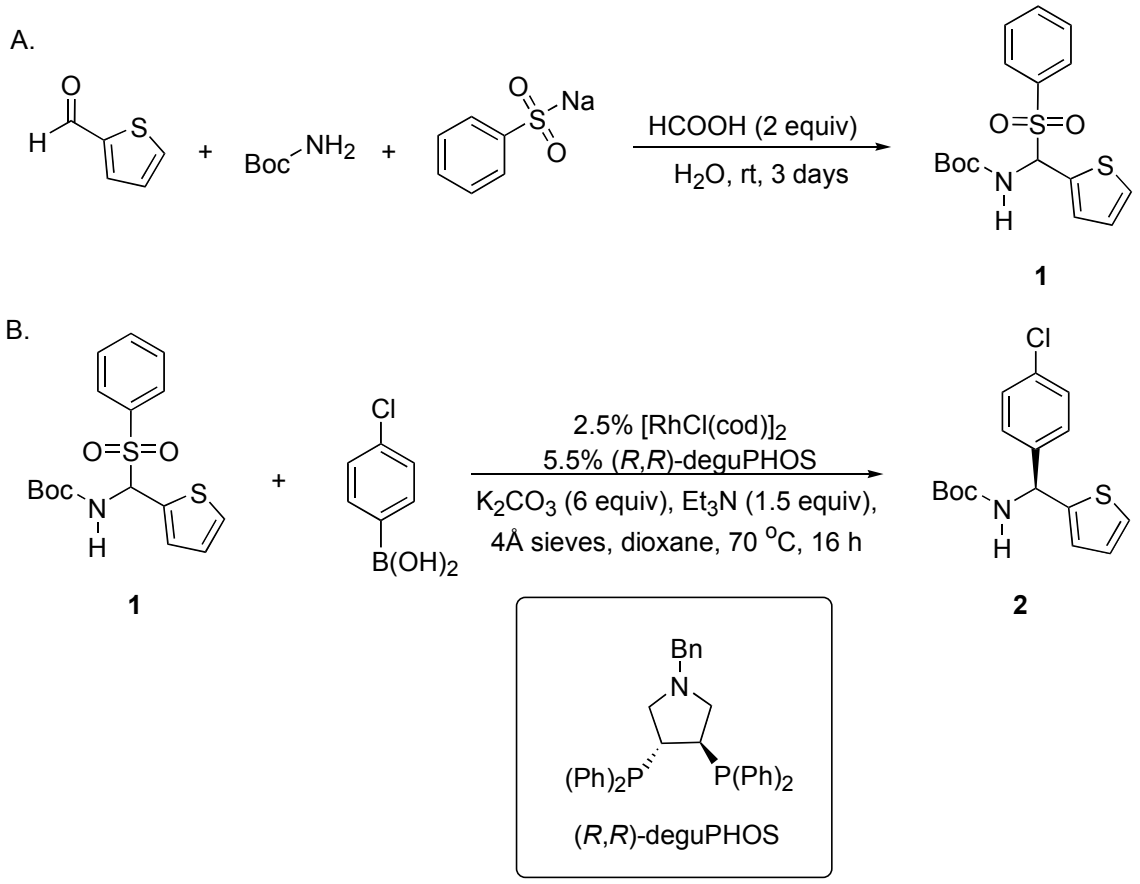
RHODIUM-CATALYZED ENANTIOSELECTIVE ADDITION OF ARYLBORONIC ACIDS TO *IN SITU* GENERATED *N*-BOC ARYLIMINES. PREPARATION OF (*S*)-*TERT*-BUTYL (4-CHLOROPHENYL)(THIOPHEN-2-YL)METHYLCARBAMATE



Submitted by Morten Storgaard and Jonathan A. Ellman.[1]
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1. Procedure

*A. tert-Butyl phenylsulfonyl(thiophen-2-yl)methylcarbamate (**1**).* In a 250-mL, round-bottomed flask benzenesulfinic acid sodium salt (13.13 g, 80.0 mmol, 2.0 equiv) (Note 1) is dissolved in H_2O (105 mL) (Note 2). *tert*-Butyl carbamate (4.69 g, 40.0 mmol, 1.0 equiv) (Note 3) is added, but does not dissolve. 2-Thiophene-carboxaldehyde (5.50 mL, 6.73 g, 60.0 mmol, 1.5 equiv) (Note 4) is added forming a yellow emulsion. Formic acid (3.10 mL, 3.68 g, 80.0 mmol, 2.0 equiv) (Note 5) is added. The flask is loosely fitted with a rubber septum and the white, opaque, biphasic mixture is stirred

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vigorously at room temperature (23 °C). After a couple of hours the water phase becomes clear. The product **1** is formed as yellow chunks, which become more dispersed in the water phase as the reaction proceeds. After 3 days (Note 6) of stirring the suspension is vacuum filtered (Note 7). The yellow chunks are crushed with a spatula, and the product is triturated with H_2O (2 × 10 mL) and Et_2O (2 × 10 mL) (Note 8). After each trituration the solvent is removed by vacuum filtration. Finally, it is dried for an hour under high vacuum (Note 9) to give the imine precursor **1** as a white solid (8.21 g, 58%) (Notes 10 and 11).

*B. (S)-tert-Butyl (4-chlorophenyl)(thiophen-2-yl)methylcarbamate (**2**).* An oven-dried (Note 12), 250-mL, three-necked round-bottomed flask with a magnetic stir bar is equipped with a vacuum adaptor in the middle neck and glass stoppers in the two other necks (one of which is loosely fitted to allow an outflow of nitrogen gas). The adaptor is connected to a nitrogen gas line (Note 13) and the flask is purged with nitrogen as it is allowed to cool to ambient temperature (23 °C). The flask is then charged with $[RhCl(cod)]_2$ (247 mg, 0.50 mmol, 0.025 equiv) (Note 14) and (*R*,*R*)-deguPHOS (583 mg, 1.1 mmol, 0.055 equiv) (Note 15) by removing one of the glass stoppers. A septum is used to seal the flask and the other glass stopper is exchanged with an adaptor equipped with a thermometer. The flask is then purged with nitrogen for 5 min and a positive nitrogen flow is thereafter maintained to ensure an oxygen-free atmosphere inside the flask (Note 16). Dry dioxane (80 mL) (Note 17) is added through the septum via a syringe and the flask is submerged into an oil bath (70 °C), and the mixture is stirred for 1 h (internal temperature: 65 °C, reached after 20 min). Initially, the precatalyst is not fully soluble in dioxane, but as the preincubation proceeds it completely dissolves. The solution of the active catalyst is clear and dark orange.

Meanwhile (Note 18), a 500-mL, oven-dried, three-necked round-bottomed flask (Note 19) with a magnetic stir bar is equipped with a vacuum adaptor in the middle neck and glass stoppers in the two other necks (one of which is loosely fitted to allow outflow of nitrogen gas). The adaptor is connected to a nitrogen gas line and the flask is purged with nitrogen as it is allowed to cool to ambient temperature (23 °C). The flask is then charged with *tert*-butyl phenylsulfonyl(thiophen-2-yl)methylcarbamate (**1**) (7.07 g, 20.0 mmol, 1.0 equiv), 4-chlorophenylboronic acid (6.26 g, 40.00 mmol, 2.0 equiv) (Notes 20 and 21), K_2CO_3 (16.58 g, 120.0 mmol, 6.0 equiv) (Note 22) and 4Å powdered molecular sieves (32 g) (Note 23) by removing one of the

glass stoppers. A septum is used to seal the flask, and the other glass stopper is exchanged with an adaptor equipped with a thermometer. The flask is then purged with nitrogen for 5 min, and a positive nitrogen inflow is maintained to ensure an oxygen-free atmosphere inside the flask. Dry dioxane (240 mL) is added through the septum via a syringe immediately before the preincubation is complete (described above). Additionally, dry triethylamine (4.20 mL, 3.04 g, 30.00 mmol, 1.5 equiv) (Note 24) is added via a syringe. The white suspension is stirred vigorously at room temperature (23 °C) while adding the preincubated solution of catalyst and ligand via cannula transfer (Note 25) resulting in a yellow suspension. The reaction flask is submerged into an oil bath (70 °C), and the yellow suspension is stirred vigorously for 16 h (internal temperature: 70 °C) (Note 26). The yellow suspension is allowed to cool to ambient temperature (23 °C) over the course of one hour and vacuum filtered through a plug of Celite™ (Note 27), which is rinsed with EtOAc (300 mL) (Note 28). The combined yellow filtrates are evaporated *in vacuo* (Note 29) to give a yellow solid (Note 30). The crude product is purified by flash chromatography (6.5 × 20 cm, 270 g silica gel) (Note 31) using a gradient of 5 to 15% EtOAc in hexanes and fractions of 50 mL. The column is eluted with 500 mL of 1:19 EtOAc:hexanes (Note 32), 500 mL of 1:12 EtOAc:hexanes, 1500 mL of 1:9 EtOAc:hexanes, 500 mL of 1:7 EtOAc:hexanes and finally with 500 mL of 1:5 EtOAc:hexanes. Fractions 32–65 (Note 33) are combined, evaporated *in vacuo* and dried overnight under high vacuum affording the title compound **2** as a white solid (4.92 g, 76%) (Notes 34 and 35) with 93% ee (Notes 36 and 37).

2. Notes

1. Benzenesulfinic acid sodium salt (98%) was purchased from Sigma-Aldrich and used without further purification.
2. Deionized water (H_2O) was used in all cases where the procedures call for water.
3. *tert*-Butyl carbamate (98%) was purchased from Sigma-Aldrich and was used without further purification.
4. 2-Thiophene-carboxaldehyde (98%) was purchased from Sigma-Aldrich and was used without further purification.
5. Formic acid (HCOOH) (reagent grade, >95%) was purchased from Sigma-Aldrich and was used without further purification.

6. This reaction was originally published by Wenzel and Jacobsen[2] giving only a 44% yield of product **1** when MeOH:H_2O (1:2) was used as the solvent and with a 3 day reaction time. We attempted to increase the yield by heating the reaction mixture to 50 °C, but this resulted in product decomposition. Increasing the reaction concentration resulted in only a slight increase in the yield of **1**. Reducing the amount of MeOH resulted in the most significant increase in yield. Ultimately, running the reaction in pure H_2O gave the reported yield. Lower yields were achieved with a reaction time of only 1 day (44%), while a further increase in the yield can be achieved after 5 days (74%).

7. Wilmad Labglass sintered glass funnel, 60 mL, size M, was used.

8. Diethyl ether (Et_2O), anhydrous HPLC grade, stabilized, was purchased from Fisher Scientific Chemicals and was used without further purification.

9. High vacuum refers to 0.025 mmHg at 23 °C.

10. *tert*-Butyl phenylsulfonyl(thiophen-2-yl)methylcarbamate (**1**) exhibits the following properties: mp 160–162 °C (decomp.). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.26 (s, 9 H), 5.62 (d, J = 10.0 Hz, 1 H), 6.18 (d, J = 10.8 Hz, 1 H), 7.05–7.09 (m, 1 H), 7.26–7.28 (m, 1 H), 7.41–7.43 (m, 1 H), 7.52–7.57 (m, 2 H), 7.63–7.65 (m, 1 H), 7.90–7.94 (m, 2 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 28.2, 70.4, 81.7, 127.6, 128.0, 129.3, 129.6, 129.8, 131.7, 134.3, 136.7, 153.4. IR (neat) 3347, 2955, 1699, 1510, 1306, 1150 cm^{-1}. Anal. calcd for $C_{16}H_{19}NO_4S_2$: C, 54.37; H, 5.42; N, 3.96; found: C, 54.39; H, 5.40; N, 3.87.

11. A second run by the checkers provided 10.57 g (75%) of **1** with a melting point range of 159–161 °C. The submitters reported a yield of 8.46 g (60%) with a melting point range of 162–164 °C.

12. Oven-dried refers to drying of flasks, glass stoppers, adaptors and magnetic stir bars in an oven (150 °C) overnight before use. The glassware was assembled while still hot and cooled to ambient temperature (23 °C) under high vacuum. The submitters cooled the glassware under high vacuum.

13. The nitrogen gas line was a standard dual manifold with multiple ports with stopcocks that allow vacuum or nitrogen to be selected without the need for placing the flask on a separate line. One manifold was connected to a source of nitrogen dried through a tube of Drierite® (>98% $CaSO_4$, >2% $CoCl_2$), while the other was connected to a high-vacuum Fisher Scientific Maxima® C Plus Model M8C pump (0.025 mm Hg). The nitrogen

gas line was vented through an oil bubbler that was connected to the manifold through a valve (making it possible to disconnect the bubbler during cannula transfer), while solvent vapors were prevented from contaminating the pump through a dry ice/isopropanol cold trap.

14. $[RhCl(cod)]_2$ (chloro(1,5-cyclooctadiene)rhodium(I) dimer), 98%, which is air stable, was purchased from Strem and was used without further purification.

15. (*R*,*R*)-deguPHOS ((3*R*,4*R*)-1-benzyl-3,4-bis-diphenylphosphanyl-pyrrolidine), 98%, was purchased from Strem and was used without further purification.

16. The active catalyst is very sensitive to air. It is important to introduce a nitrogen atmosphere to the flask and maintain a positive pressure of nitrogen throughout the preincubation and the reaction to prevent catalyst decomposition.

17. 1,4-Dioxane, HPLC grade, was purchased from Fisher Scientific Chemicals and passed through a column of dry, activated, basic alumina under a nitrogen atmosphere. The solvent is transferred to the flask via a syringe without exposure to air.

18. This part of the procedure can be performed while stirring the precatalyst and ligand, but the dioxane and Et_3N should not be added until just immediately before the active catalyst is ready (1 h at 70 °C). This is to avoid premature hydrolysis of the *in situ* generated imine, which results in a decreased yield of the title compound **2**.

19. A 500-mL flask was used instead of a 1000-mL to reduce the risk of catalyst decomposition – minimizing unoccupied volume reduces the risk of oxygen contamination.

20. 4-Chlorophenylboronic acid (95%) was purchased from Sigma-Aldrich and recrystallized from H_2O before use as described in Note 21.

21. Commercially available arylboronic acids contain boroximes (anhydride trimers) that do not add efficiently to the *in situ* generated imine. Therefore, to maximize formation of the title compound **2**, we found it very important to recrystallize and dry the arylboronic acid before use. This was carried out as follows: in a 1000-mL conical flask was added 4-chlorophenylboronic acid (10 g) (Note 20) and H_2O (400 mL) and the flask was covered with a watch glass. The suspension was heated to boiling over the course of 25 minutes on a heating plate (115 °C) under vigorous stirring with a magnetic stir bar. The boiling point was maintained for 5 minutes to fully dissolve the boronic acid. The hot solution was filtered through filter

paper using gravity filtration to remove insoluble particles. The colorless solution was cooled to ambient temperature (23 °C) overnight and then was cooled in an ice bath for 1 hour (internal temperature: 5 °C). During the cooling process the aryboronic acid precipitated and was isolated by vacuum filtration and dried by continuing the vacuum filtration for an additional 15 minutes. To remove further amounts of water the boronic acid was dried in high vacuum at room temperature (23 °C) until ^{1}H NMR analysis in DMSO-d_6 showed a composition of no more than approx. 5% boroxime and 30% H_2O, at which point the mass of product was 8.0–8.6 g of white microplates. The drying procedure is important because reaction of pure boroxime will cause a reduction in the yield of the title compound **2** down to 52%. Depending on the initial amount of water in the recrystallized batch and the vacuum pump capacity, the time of drying may vary. Usually we were able to obtain the above-mentioned composition requirements within 5–15 minutes of drying in high vacuum. It is highly recommended to dry the arylboronic stepwise, e.g. 5 minutes at a time and then analyze the arylboronic by NMR. In DMSO-d_6 (dried prior to use over 4Å molecular sieves, 3.2 mm pellets) 4-chlorophenylboronic acid exhibits the following chemical shifts (300 MHz): δ 8.16 (s, broad), 7.79 (d, J = 8.3, 2H), 7.39 (d, J = 8.3, 2H), while the corresponding boroxime exhibits these shifts: δ 7.86 (d, J = 8.1, 2H), 7.42 (d, J = 8.1, 2H). The composition can be determined using the integrals directly if the DMSO is water-free. Occasionally, we found it difficult to remove the excess of water without increasing the amount of boroxime to strictly more than 5%. In such cases the batch should be recrystallized again.

22. Potassium carbonate (K_2CO_3), anhydrous, was purchased from EM Science (an affiliate of Merck KGaA) and was dried overnight before use under high vacuum at 100 °C in a thermostatically controlled oil bath.

23. Molecular sieves, 4Å, <5 microns, powdered, were purchased from Sigma-Aldrich and activated under high vacuum at 230–260 °C overnight. Heating was achieved by a Glas-Col® heating mantle, 2/3 filled with sand and connected to a Powerstat® variable autotransformer (in: 120 V, 50/60, ~1 PH, out: 0–140 V, 10 A, 1.4 KVA). The transformer was adjusted to approx. 250 °C as measured with a thermometer placed directly into the sand.

24. Triethylamine was purchased from Fisher Scientific Chemicals and was freshly distilled from CaH_2 under a nitrogen atmosphere before use.

25. Cannulation technique (Figure 1) was used to conveniently transfer the active catalyst solution (A) to the mixture of starting materials, bases and molecular sieves (B) through a cannula (C) without exposure to air. Before inserting the cannula into the flasks, an extra oil bubbler (D) was attached to flask B via a needle through the septum. The cannula (C) was then inserted into flask A and after a minute the other end of C was inserted into flask B. To cannulate the catalyst solution (A), the nitrogen inlet to flask B (E) and the Schlenk line oil bubbler (F) were both closed making the extra oil bubbler (D) the only outlet from the system. After complete cannulation E and F were both opened again, and the extra bubbler (D) and cannula (C) were removed.

26. It is not convenient to monitor the progress of the reaction by TLC because the diagnostic compound (the imine formed *in situ* from **1**) is unstable and does not elute without decomposition on TLC. Therefore, we ran a number of reactions on small scale (0.250 mmol) at different reaction times. We found that the amount of the title product **2** reaches a 65–67% NMR yield after 10 hours. Neither product decomposition nor an increase in yield are observed with prolonged reaction times, e.g., 40 hours at 70 °C. For convenience we chose a 16 h reaction time.

27. Celite™ powder, 545 filter aid, not acid washed, was purchased from Fisher Scientific and was used without further purification. The filter plug was prepared by mixing Celite™ (20 g) with EtOAc (80 mL) and filtered through a Kimax® sintered glass funnel, 150 mL – 60F.

28. Ethyl acetate (EtOAc), HPLC grade, was purchased from Fisher Chemicals and was used without further purification.

29. Evaporation *in vacuo* was carried out on a Büchi Rotavapor R-114 at 45 mmHg with a Büchi Waterbath B-480 at 35 °C, unless otherwise stated.

30. The ^{1}H NMR ($CDCl_3$) spectrum of the crude product was recorded to determine if the reaction proceeded as expected. Besides EtOAc, dioxane and the peaks corresponding to the title compound **2** (Note 34), the crude product also contains 2-thiophene-carboxyaldehyde (9.68 ppm), and other decomposition compounds: δ 7.86, 7.75, 4.57 and 1.28 ppm. If the reaction has been performed correctly there should be only trace amounts of the the *in situ* generated imine (9.05 and 1.57 ppm) in the crude product, and the crude product should be a yellow solid rather than an oil.

31. Silica gel 60 (0.040–0.063 mm), 230–400 mesh ASTM, was purchased from Merck KGaA and used without further purification.

32. Hexanes, HPLC grade, was purchased from Fisher Scientific and used without further purification.

33. TLC of fractions is performed using Dynamic Adsorbents, Inc. glass plates coated with 250 mm F-254 silica gel. 15% EtOAc in hexanes is used as the eluent. Visualization is achieved with UV (Spectroline®, Model EF-140C, short wave ultraviolet 254 nm) and subsequently with PMA staining (10 g phosphomolybdic acid + 100 mL absolute EtOH) by immersion and heating with a heat gun. The title compound **2** is visible by UV and stains dark brown with PMA at an $R_f = 0.41$. Trace amounts of 2-thiophene-carboxaldehyde, which is generated by decomposition of *tert*-butyl phenylsulfonyl(thiophen-2-yl)methylcarbamate (**1**), elutes at $R_f = 0.35$. This aldehyde is only visible by UV and does not stain with PMA. Fractions containing both thiophene-carboxaldehyde and **2** are collected because this aldehyde is easy to remove under vacuum (boils at 75 – 77 °C at 11 mmHg). Fractions containing an impurity with $R_f = 0.22$ (visible by UV and stains brown with PMA) were not collected.

34. The title compound (**2**) exhibits the following properties: mp 138–140 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 1.43 (s, 9 H), 5.20 (broad s, 1 H), 6.10 (broad s, 1 H), 6.77–6.80 (m, 1 H), 6.90–6.94 (m, 1 H), 7.22–7.34 (m, 5 H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 28.6, 54.2, 80.5, 125.5, 125.9, 127.1, 128.5, 129.0, 133.7, 140.6, 145.9, 154.9. IR (neat) 3347, 2979, 2921, 2361, 1686, 1515, 1233, 1169 cm^{-1}. $[\alpha]_D^{20}$ +11.0 (*c* = 0.5, EtOH). MS (ESI+) *m*/*z* 346 (M^+ + Na, 100%), 347 (17%), 348 (40%). Anal. calcd. for $C_{16}H_{18}ClNO_2S$: C, 59.34; H, 5.60; N, 4.33; found: C, 59.50; H, 5.63; N, 4.23.

35. The checkers also performed the reaction at half-scale and isolated pure product in a 65% yield at 96% ee. The submitters report a full-scale reaction to provide product in 65% yield at 95-99% ee.

36. The absolute configuration was shown by anomalous dispersion to be (*S*) using X-ray crystallography. This configuration is consistent with prior additions of this type [see Reference 13].

37. Enantiomeric excess is determined by chiral HPLC using an Agilent 1100 series instrument and a Chiralpak® AS-H column (amylose tris[(*S*)-α-methylbenzyl-carbamate] coated on 5 mm silica gel), L = 250 mm, I.D. = 4.6 mm, from Danicel Technologies, LTD. 1% EtOH in hexanes is used as the eluent (isochratic) with a flow rate of 1.00 mL/min (max. 70 bar) for 25 minutes. For optimal performance the column is equilibrated with the solvent system for at least 45 minutes before running the sample. A sample

is prepared by dissolving approx. 1 mg compound in 1 mL of 1% EtOH in hexanes and filtering through a 4 mm nylon syringe filter (0.45 mm) purchased from National Scientific. 5.0 mL of this solution is used for injection. To determine the retention times for both enantiomers, a racemate of **2** (synthesized with dppBenz as ligand) can be analyzed: (*R*)-enantiomer (minor): 11.1 minutes and (*S*)-enantiomer (major): 13.5 minutes. Samples are analyzed at the following wavelengths: 222, 230, 250 and 254 nm each of which gave similar %ee.

Waste Disposal Information

All hazardous materials should be handled and disposed of in accordance with "Prudent Practices in the Laboratory"; National Academy Press; Washington, DC, 1995.

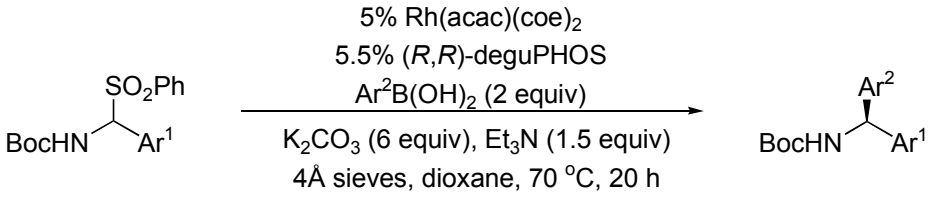
3. Discussion

Synthesis of enantiomerically pure functionalized amines is of great importance because such compounds are widely used in drugs. The rhodium-catalyzed enantioselective addition of arylboronic acids to *in situ* generated *N*-Boc aromatic imines is a general and easy method for the preparation of *N*-Boc protected diaryl methanamines. The first reported example of addition of arylboronic acids to an imine was the addition to *N*-sulfonyl aldimines published in 2000 by Miyaura and co-workers.[3] A number of enantioselective variants were later developed using chiral ligands, such as *N*-Boc-L-valine amidomonophosphanes,[4] (1*R*,4*R*)-bicyclo[2.2.2]-octadienes,[5] (*S*)-ShiP,[6] monodentate phosphoramidites,[7,8] binaphtholic phosphites,[8] tetrahydropentalenes,[9] and (*R*,*R*)-deguPHOS.[10] Most of the methods are limited to aromatic imines, but more recently enantioselective catalytic additions to aliphatic imines have also been reported.[11,12]

However, these methods suffer from a number of drawbacks. For example, all of the methods utilize unstable imine substrates, and many of the methods necessitate the use of very harsh conditions to remove the *N*-substituent present in the addition products. Some of these problems were previously solved by the Ellman group using *N*-Boc aromatic imines generated *in situ* from easily prepared and stable α-carbamoyl sulfones in an enantioselective addition with arylboronic acids (Table 1).[13] Commercially

available (*R*,*R*)-deguPHOS was used as the chiral ligand to obtain enantiomeric excesses up to 99%. However, Rh(acac)(coe)$_2$ was used as the precatalyst, and it is currently not commercially available. Moreover, Rh(acac)(coe)$_2$ is highly air-sensitive necessitating that the reactions be set up in a nitrogen-filled glovebox,[13] which is inconvenient for most research laboratories.

Table 1. Synthesis of various *N*-Boc amines.[13]



Entry	*Ar*^{1}	*Ar*^{2}	*Yield (%)*[a]	*ee (%)*[b]
1	Ph	4-ClC_6H_4	76	98[c]
2	Ph	4-MeC_6H_4	70	96
3	Ph	4-MeOC_6H_4	76	93[c]
4	Ph	4-$CF_3C_6H_4$	51	95[c]
5	Ph	3-ClC_6H_4	55	99
6	Ph	3-MeC_6H_4	66	95
7	Ph	3-AcC_6H_4	52	94
8	Ph	2-MeC_6H_4	62	93
9	4-MeC_6H_4	Ph	71	90
10	3-MeC_6H_4	Ph	70	95
11	2-MeC_6H_4	Ph	63	97
12	4-BrC_6H_4	Ph	59	90
13	2-thienyl	Ph	71	96
14	4-MeOC_6H_4	Ph	76	96[c]
15	4-$CF_3C_6H_4$	Ph	69	79[c]

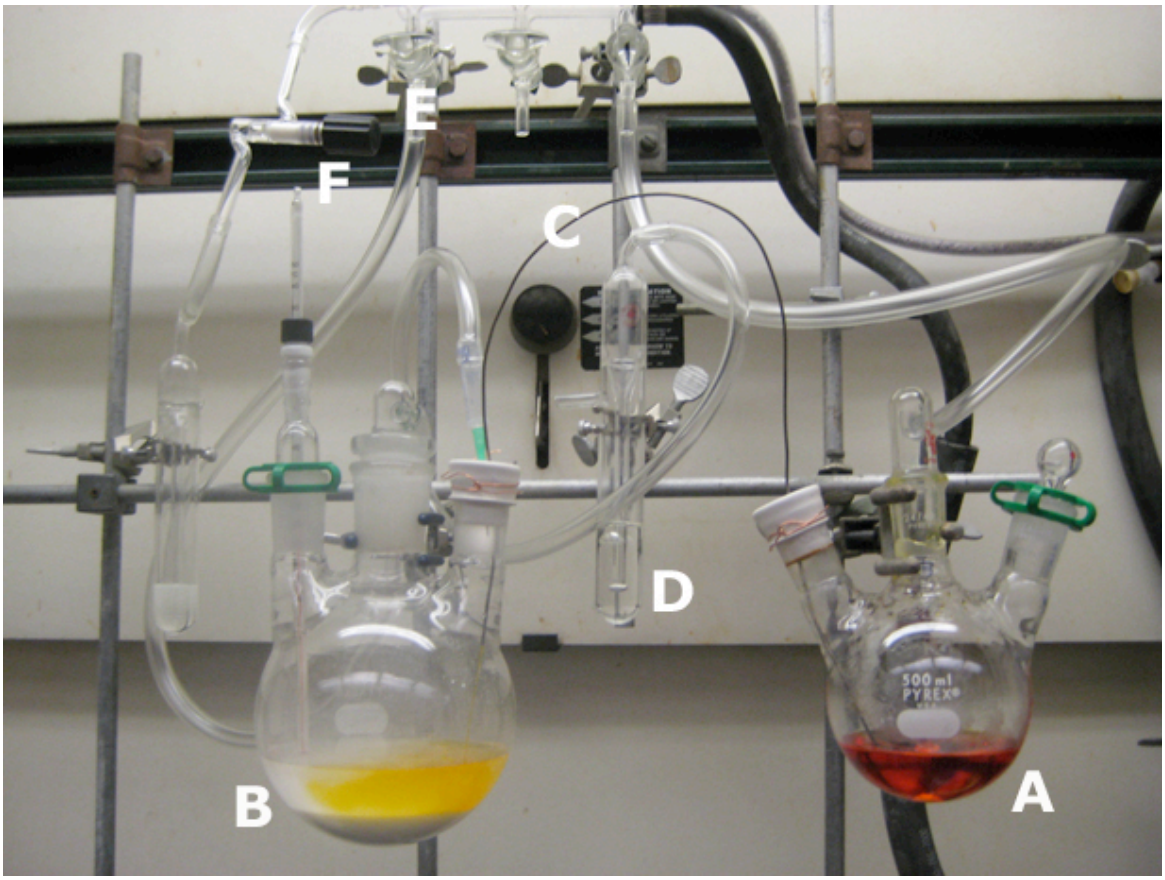
[a] Isolated yields after chromatography. [b] Determined by chiral HPLC analysis. [c] Absolute configuration established by comparison of the optical rotation of amine obtained upon Boc cleavage to literature values.[14]

Optimization of this chemistry was therefore revisited. We found that the inexpensive and air-stable precatalyst, [RhCl(cod)]$_2$, performed equally well to Rh(acac)(coe)$_2$. Unfortunately, an enantiomeric excess of only 40% was achieved with this precatalyst. To improve the enantiomeric excess, we

therefore performed a series of preincubation experiments whereby $[RhCl(cod)]_2$ and (*R,R*)-deguPHOS were stirred at 70 ^{o}C in dioxane prior to adding the starting materials, bases and molecular sieves. We found that one hour of preincubation resulted in a dramatic improvement in the enantiomeric excess to at least 95% ee. Shorter preincubations gave lower enantiomeric excess, whereas longer incubations were not beneficial.

Furthermore, we discovered that the presence of significant quantities of the boroxime (cyclic anhydride) in the boronic acid resulted in a decreased yield of the title compound **2**. Decreased yields may occur because the boroxime adds only slowly to the *in situ* generated imine, which competitively hydrolyzes under the reaction conditions. Commercially available boronic acids contain varying amounts of boroxime and therefore should be recrystallized from water before use. To avoid too much water in the reaction mixture, the boronic acid should also be dried prior to use. Boronic acids should not contain more than 5% boroxime and preferentially no more than 30% water as determined by ^{1}H NMR in dry DMSO-d_6.

Figure 1: Cannulation technique



To expand the usability of the chemistry and to make it easier to perform on larger scale the reaction was set up using Schlenk techniques. This reaction set up provides for efficient reactions on both small and large scale, but it is important to transfer the active catalyst solution by cannulation technique to completely avoid exposure to air.

In conclusion, the title product **2** has been prepared in good yield and with high enantioselectivity. We believe that these optimized conditions should be compatible with the same range of different α-carbamoyl sulfones and arylboronic acids reported previously (Table 1).[13] This method, which utilizes the commercially available (*R*,*R*)-deguPHOS chiral ligand and the commercially available and air stable $[RhCl(cod)]_2$ precatalyst, does not require the use of a glovebox and represents a straightforward and general method for the enantioselective synthesis of *N*-protected diaryl methanamines.

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Appendix
Chemical Abstracts Nomenclature; (Registry Number)

tert-Butyl phenylsulfonyl(thiophen-2-yl)methylcarbamate: Carbamic acid, *N*-[(phenylsulfonyl)-2-thienylmethyl]-, 1,1-dimethylethyl ester; (479423-34-2)

tert-Butyl carbamate: Carbamic acid, 1,1-dimethylethyl ester; (4248-19-5)

2-Thiophene-carboxaldehyde; (98-03-3)

Benzenesulfinic acid sodium salt; (873-55-2)

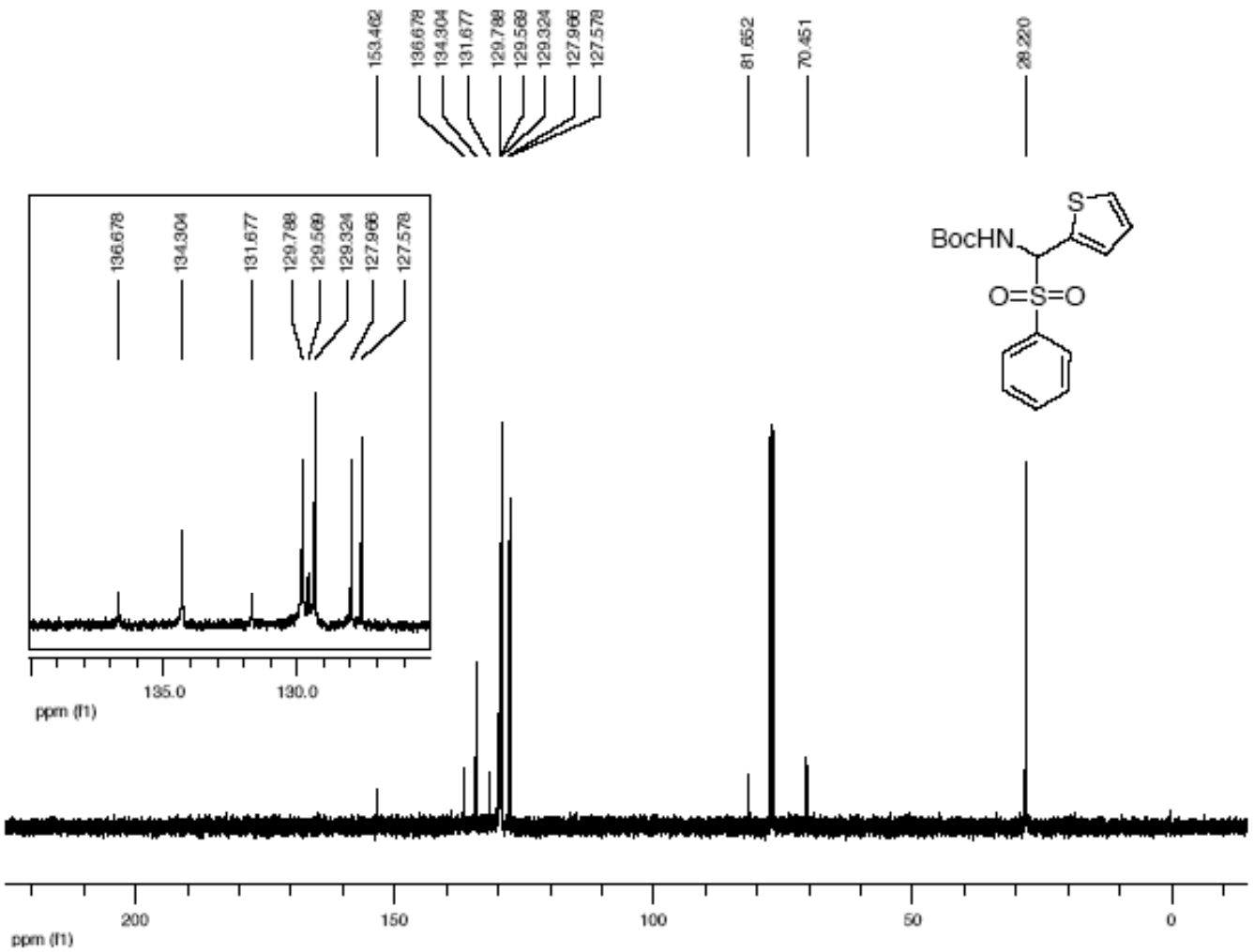
$[RhCl(cod)]_2$; (12092-47-6)

(*R*,*R*)-deguPHOS: Pyrrolidine, 3,4-bis(diphenylphosphino)-1-(phenylmethyl)-, (3*R*,4*R*)-; (99135-95-2)

4-Chlorophenylboronic acid: Boronic acid, B-(4-chlorophenyl)-; (1679-18-1)

Morten Storgaard was born in Denmark in 1980. He graduated from Technical University of Denmark in 2006 with a M.Sc. degree in chemistry and in 2007 he continued as a Ph.D. student under the supervision of professor David Tanner and Dr. Bernd Peschke from Novo Nordisk. His research has mainly been focusing on palladium catalyzed coupling reactions towards the synthesis of biologically active compounds. In the summer and fall of 2008 he visited the group of Jonathan A. Ellman at University of California at Berkeley and carried out research on the rhodium-catalyzed enantioselective synthesis of amines.

Jason Bexrud received his B.Sc. from Simon Fraser University in 2003. After which, he began doctoral work at the University of British Columbia with Laurel Schafer. His thesis focused on the development of titanium and zirconium-catalyzed hydroamination and C-H functionalization reactions.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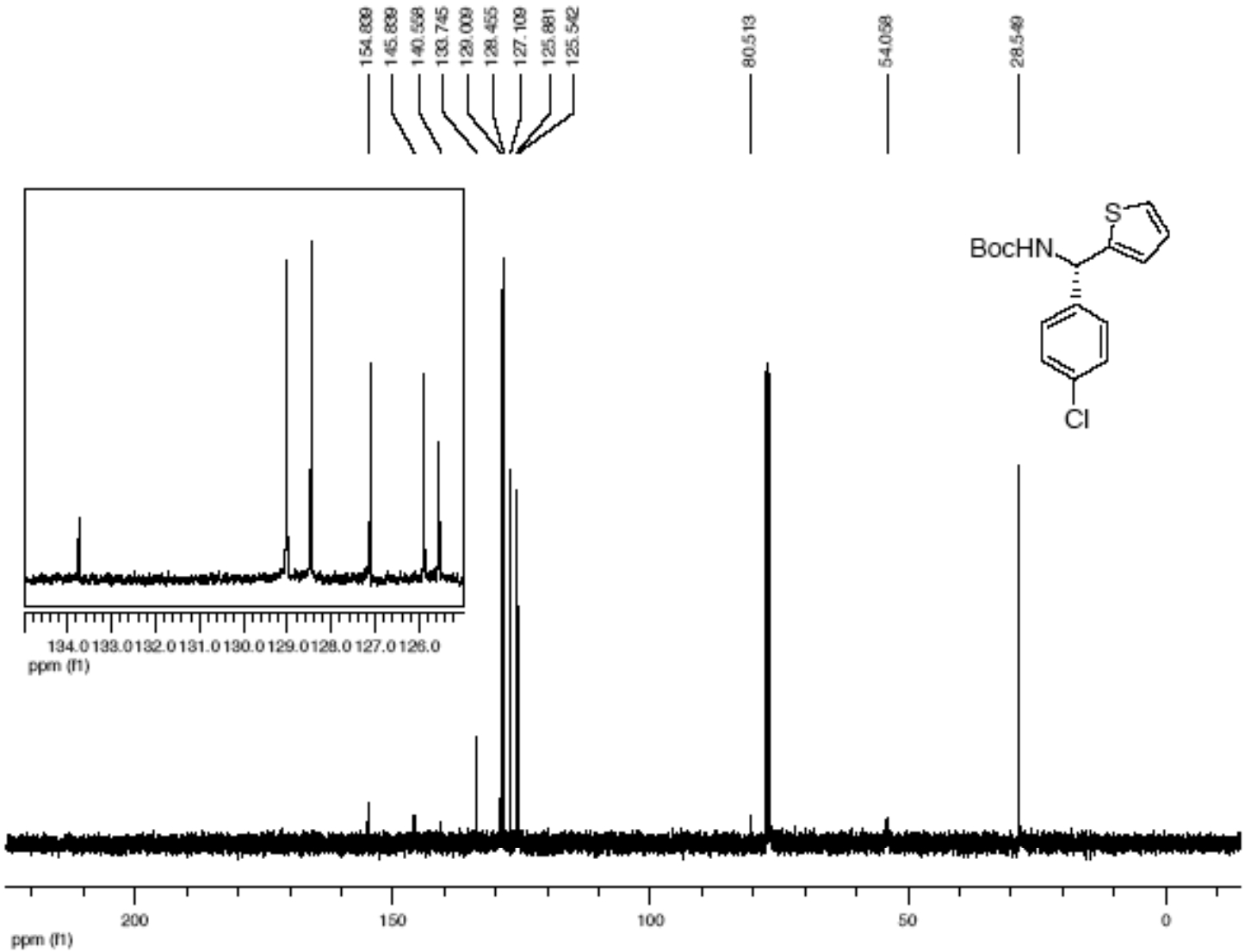
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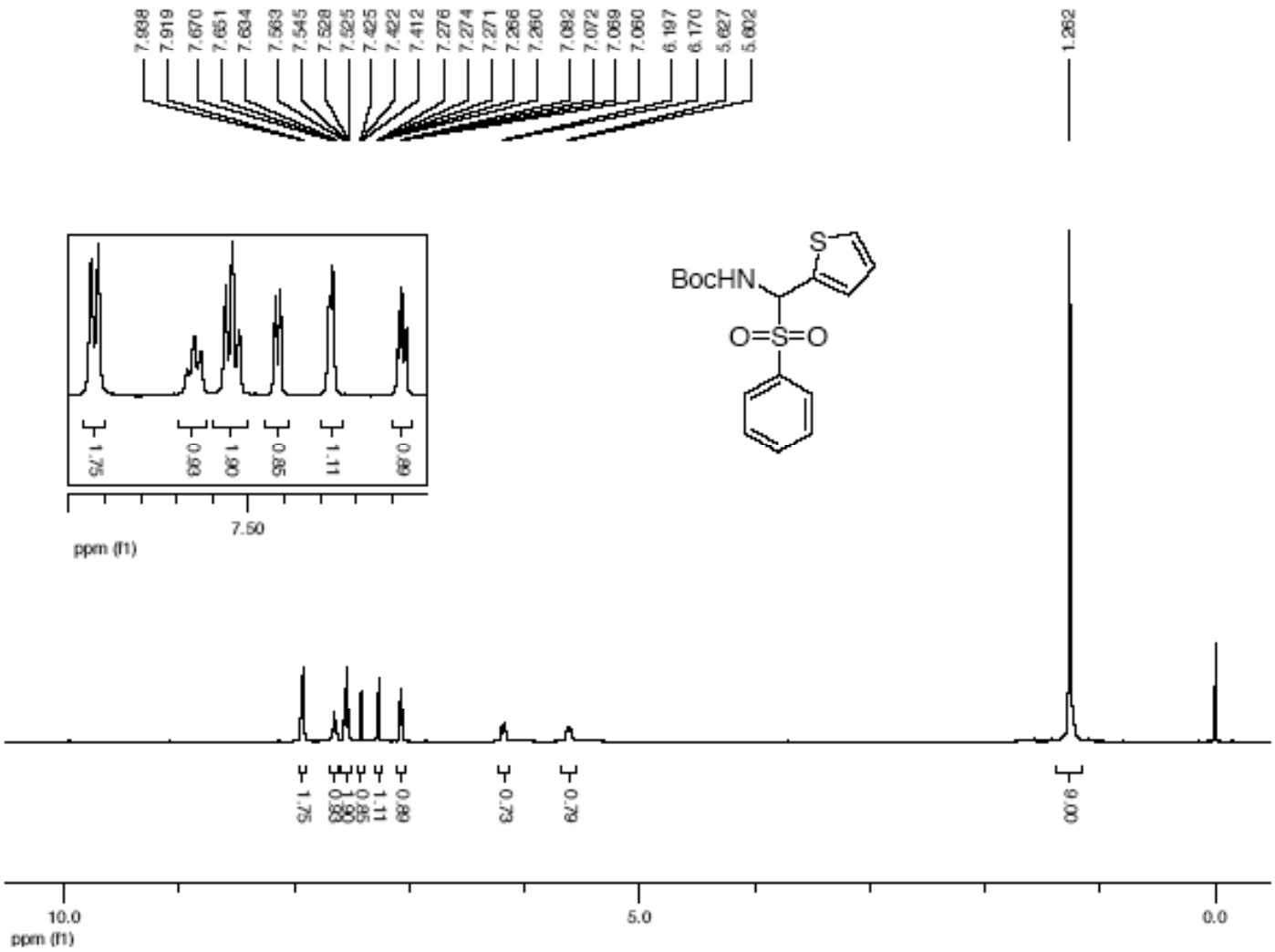
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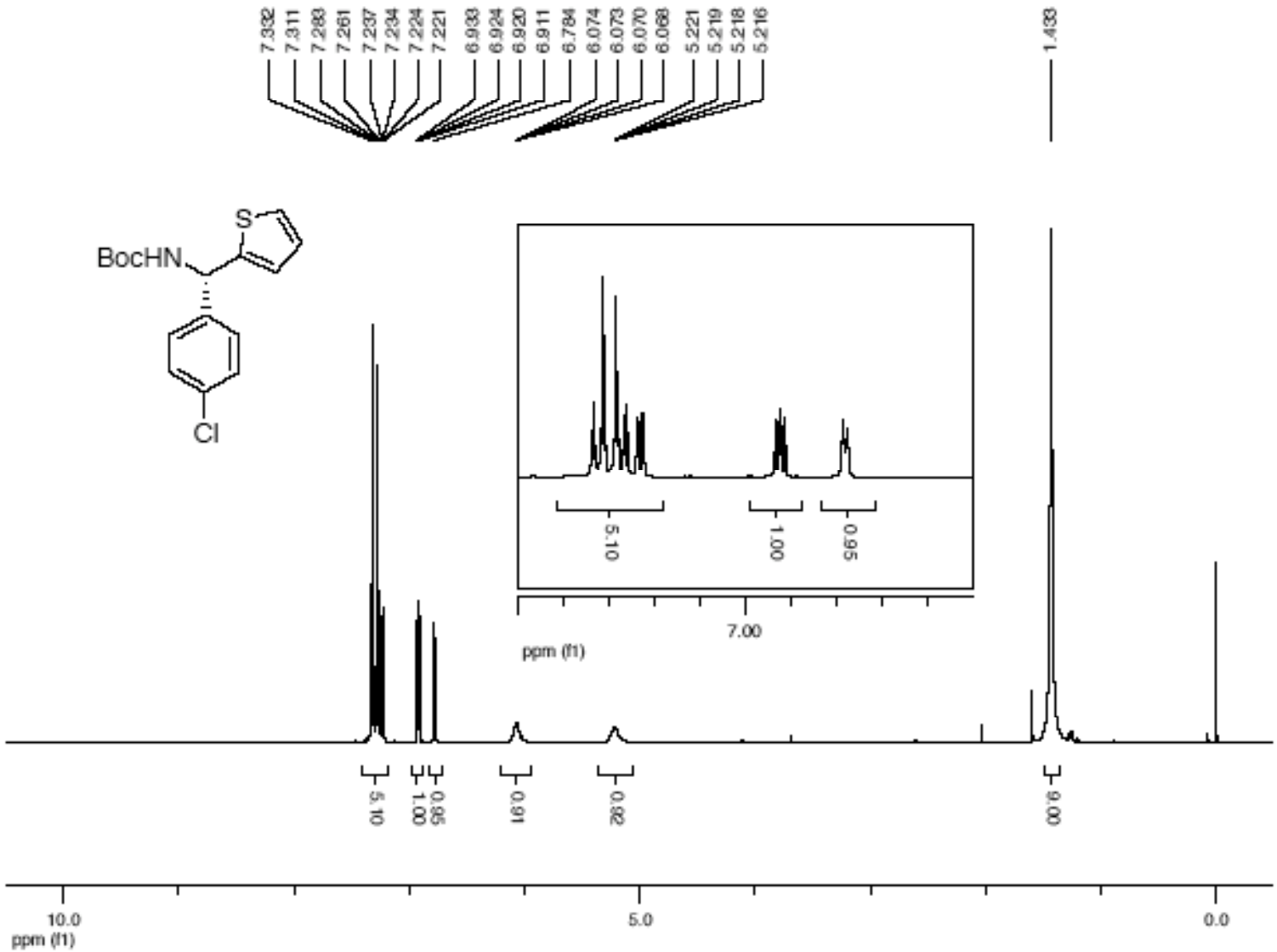
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S
Cl
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