

SYNTHESIS OF A NOVEL CARBOHYDRATE
TOWARD DOUBLE-HEADED NUCLEOSIDES:
VIA GRIGNARD REAGENT

By

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requirements for the Honors Program
and Departmental Honors
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CERTIFICATE OF APPROVAL

HONORS THESIS

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“For I know the plans I have for you”, declares the Lord,
“plans to prosper you and not to harm you, plans to give
you hope and a future. Then you will call upon me and
come and pray to me, and I will listen to you.”

- Jeremiah 29: 11-12

In honor of my family.

To Dad, for tirelessly editing each paper and checking each math problem,

To Mom, for your advice, encouragement, and love,

To Diane, for your admiration and friendship.

Grateful acknowledgement is also made to

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LIST OF ABBREVIATIONS

AIDS	Acquired immunodeficiency syndrome
BF ₃	Boron trifluoride
B(OMe) ₃	Trimethoxyborane
bp	Boiling point
CbzCl	Benzyl chloroformate
CDCl ₃	Chloroform-d
CH ₂ Cl ₂	Dichloromethane
ddB	2',3'-Dideoxynucleosides
DHN	Double-Headed Nucleoside
DMF	Dimethylformamide
2,2-DMP/DMP	2,2-dimethoxypropane
DNA	Deoxyribonucleic acid
Et ₃ N	Triethylamine
Et ₂ O	Diethyl ether
HCl	Hydrochloric acid
HIV RT	Human immunodeficiency virus reverse transcriptase
H ₂ O	Water
I ₂	Iodine
Iso-ddB	iso-Dideoxynucleosides
KIO ₄	Potassium periodate
LiBH ₄	Lithium borohydride

MeOH	Methanol
Mg	Magnesium
MgSO ₄	Magnesium sulfate
MsCl	Methanesulfonyl chloride
Na ₂ CO ₃	Sodium carbonate
NaHCO ₃	Sodium hydrogen carbonate
NaI	Sodium iodide
NMR	Nuclear Magnetic Resonance
PMA	Phosphomolybdic acid hydrate
PPh ₃	Triphenylphosphine
RBF	Round bottom flask
RNA	Ribonucleic acid
Rxn	Reaction
SOCl ₂	Thionyl chloride
TLC	Thin layer chromatography
TsOH	p-toluenesulfonyl chloride
Zn	Zinc

LIST OF COMPOUNDS

- 1** L-serine [(S)-2-Amino-3-hydroxypropanoic acid]
- 2** N-Cbz-L-serine
- 3** N-Cbz-L-serine methyl ester
- 4** 3-Benzyl-2,2,4-trimethyl-(4S)-3,4-oxazolidinedicarboxylate
- 5** 3-Benzyl-2,2-dimethyl-4-hydroxymethyl-(4R)-3-oxazolidinecarboxylate
- 6** 3-Benzyl-2,2-dimethyl-4-iodomethyl-(4S)-3,4-oxazolidinecarboxylate
- 7** 2-Amino-2-hydroxymethylpropane-1,3-diol
- 8** 5-Amino-2,2-dimethyl-5-hydroxymethyl-1,3-dioxane
- 9** 2,2-Dimethyl-1,3-dioxane-5-one
- 10** 5-Hydroxy-5-[3-benzylcarbamate-(4R)-2,2,4-trimethyl-1,3-oxazolidine-4-yl]-2,2-dimethyl-1,3-dioxane
- 11** L-serine methyl ester hydrochloride
- 12** Methyl (2S)-2-methoxycarbonylamino-3-hydroxypropanoate
- 13** 2,2,3,4-tetramethyl-(4S)-3,4-oxazolidinedicarboxylate
- 14** 2,2,3-trimethyl-(4R)-4-hydroxymethyl-3-oxazolidinecarboxylate
- 15** 2,2,3-trimethyl-(4S)-4-methanesulfonyloxymethyl-3-oxazolidinecarboxylate
- 16** 2,2,3-trimethyl-(4R)-4-iodomethyl-3-oxazolidinecarboxylate
- 17** 5-Hydroxy-5-[3-methylcarbamate-(4R)-2,2,4-trimethyl-1,3-oxazolidine-4-yl]-2,2-dimethyl-1,3-dioxane

I. PURPOSE

The human immunodeficiency virus reverse transcriptase (HIV RT) enzyme is the solitary enzyme required for the development of proviral DNA from viral RNA and is therefore the target for most antiviral AIDS medications¹. Nucleoside analogues of the 2',3'-dideoxynucleosides (ddB) (**Figure 1**) and isomeric dideoxynucleosides (iso-ddB) (**Figure 1**) have been assessed for their abilities to inhibit the replication of HIV RT². Many of these analogues lack the 2'- and 3'-hydroxyl groups and have been shown to be potent and selective inhibitors of HIV replication in human CD4-bearing cell lines *in vitro*³.

2',3'-Dideoxynucleosides (ddB) are among a class of HIV RT enzyme inhibitors. Though ddB is active against HIV RT at the chain terminal position, it is limited by rapid degradation via hydrolysis of the glycosidic bond. To overcome this instability, a more stable dideoxynucleoside, iso-ddB, was created⁴.

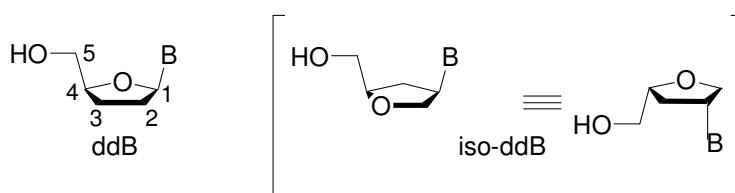
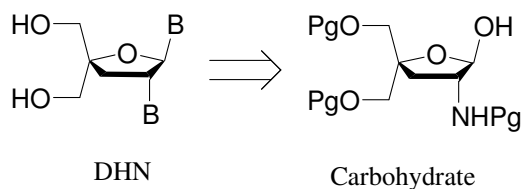


FIGURE 1. Structures of ddB and iso-ddB, where B is equivalent to a type of DNA base.

The design of a novel double-headed nucleoside (DHN) which incorporates both ddB and iso-ddB into one molecule would provide an interesting test case for antiviral activity. The electronegative heterocycle at the 2'-position should stabilize the glycosidic bond and the incorporation of the second hydroxymethyl at the 4'-position should provide two potential sites for phosphorylation (**Figure 2**). The DHN may have a hypothetical

advantage due to reduced incorporation into human bone marrow tissues, reducing toxicity.



Retro Synthetic Analysis

FIGURE 2. The synthesis of the carbohydrate is the goal of this project, while DHN is the ultimate target of the entire project. In this scheme, DHN is derived from the carbohydrate in multiple steps. Pg is a protecting group.

The goal of this work was to design a method to produce large quantities of the desired carbohydrate. This carbohydrate may theoretically be used to generate multiple heterocyclic base combinations for the DHN molecule.

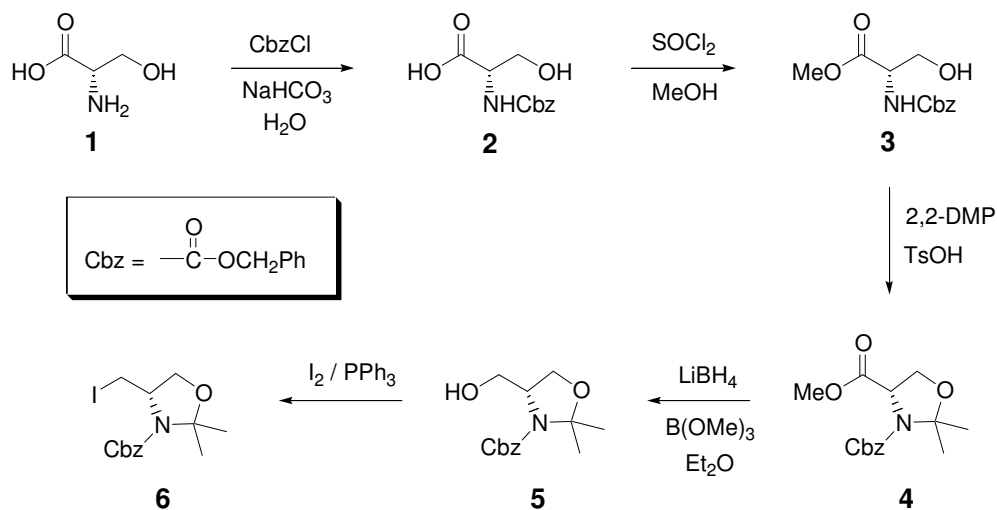
Various methods of synthesis may be pursued to create the DHN. While starting materials of nucleosides and carbohydrates were considered, a synthetic route from an amino acid was chosen. Obtaining the DHN from the nucleoside would be expensive, produce poor yields, and have a limited scope. Use of carbohydrate starting materials would require destruction of several chiral centers, which would also be expensive and give poor yields.

The amino acid, L-serine, has multiple functions in the synthesis. Beginning with this amino acid allows serine's multifunctionality to provide the required chiral center of either DHN enantiomer. Its condensation with a ketone in a convergent synthesis provides the desired carbohydrate backbone necessary for the attachment of the desired heterocycles for nucleoside development.

II. RESULTS AND DISCUSSION

The overall goal of the carbohydrate synthesis is to combine a nucleophilic amino acid with an electrophilic ketone. All reactions involved simple protection or deprotection, and nucleophilic addition utilizing Reformatski or Grignard coupling. Each of the reactions was consistent with literature. The protection of the amine can be performed with benzyl or methyl carbamate, but the choice of starting with the benzyl carbamate allowed the reactions to be monitored by thin layer chromatography (TLC) under ultraviolet light. **Scheme 1** illustrates the synthesis of the desired iodide, **6**, for the nucleophilic addition with the ketone.

Scheme 1: Benzyl carbamate protection of L-serine and its conversion to the iodide



Benzyl chloroformate was added to protect the amine in L-serine, **1**, to produce a white solid. The reaction was monitored by carbon dioxide evolution. The purification involved removing the excess CbzCl in an organic wash (ether) while the conjugate base of **2** remained in the water. The addition of acid to the water converted the conjugate

base into the acid, which was less soluble in the water and precipitated the bulk product to allow filtration. The product was collected as a white solid at a 90% yield.

The carboxylic acid was converted to a methyl ester with thionyl chloride in methanol. This procedure was used instead of the Fischer esterification because it is faster and instead of removing water the byproducts are sulfur dioxide and hydrochloric acid; two gas byproducts that drive the reaction to completion. This reaction was improved when the RBF was filled with argon to eliminate moisture or oxygen from entering the flask. The product, **3**, of the high yielding reaction was collected as a clear oil.

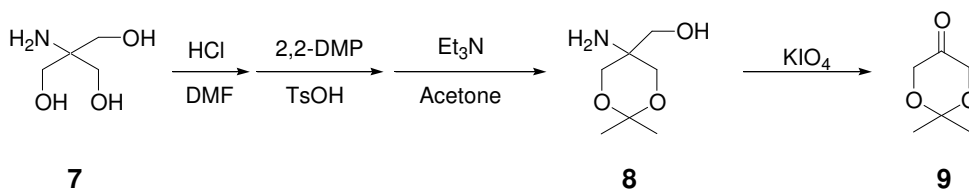
An oxazolidine ring was formed to remove the acidic protons from the alcohol and amine during the nucleophilic addition. The reaction was controlled by careful distillation of methanol. Two methanol molecules are removed per each formation of oxazolidine **4** by azeotropic distillation with chloroform. A color change from an initial orangish-brown to a reddish-brown signified that the chloroform-methanol azeotrope was removed. The product was purified under vacuum (0.9 torr) at 150°C to afford a clear golden oil in 58.5 % yield.

The methyl ester was treated with LiBH_4 in the presence of $\text{B}(\text{OMe})_3$ in Et_2O to form the reduced alcohol, **5**. The RBF was then filled with argon to eliminate any moisture or oxygen from entering the flask. The methoxide was formed as hydrogen gas was released. The trimethoxyborane azeotrope (bp 53-58°C) was distilled by adding methanol. Acidity was increased with HCl to promote the alkoxide of **5**. The product of the high yielding reaction was a light golden oil with a slight brown impurity that was removed by column filtration.

The alcohol **5** was converted to the iodide **6** to form a better leaving group for metal insertion. The pure, unstable product was covered with aluminum foil to prevent it from reacting with light. The formation of the iodide was simple, but the iodide was difficult to separate from the alcohol. Column chromatography was not required for the previous steps, but was necessary here to separate the starting material **5** from the product **6**. The purification of the iodide **6** was difficult due to column cracking and required several days for its purification.

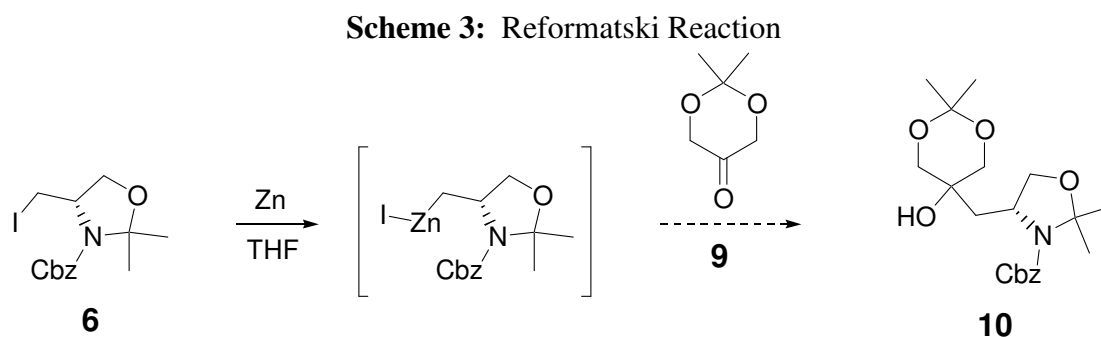
The goal of **Scheme 2** was to obtain the ketone, 2,2-dimethyl-1,3-dioxane-5-one, **9**, to react with 3-benzyl-2,2-dimethyl-4-iodomethyl-(4S)-3,4-oxazolidinonecarboxylate, **6**, in the Reformatski reaction. 2-Amino-2-hydroxymethylpropane-1,3-diol, **7**, was chosen as the starting material because it appeared to provide a suitable pathway and was on hand.

Scheme 2: Ketone Synthesis



The amine was protected with hydrochloric acid, preventing the nitrogen from reacting with 2,2-DMP. 2,2-DMP was used to protect two of the alcohols, forming the 1,3-dioxane. Et₃N removed the HCl, providing the amine **8**. The oxidative cleavage reaction at the 5-position was accomplished with KIO₄. The product was purified by extraction into dichloromethane and concentrated to afford a white solid **9** in high yields.

Zinc insertion into **6** (**Scheme 3**) was tested to determine if the Reformatski reaction would be possible. The iodide **6** was heated in the presence of zinc to achieve metal insertion. A loss of starting material was not observed, signifying that zinc was not active enough to perform the reaction. Magnesium was not used because it would react with the benzyl carbamate protecting group⁵.

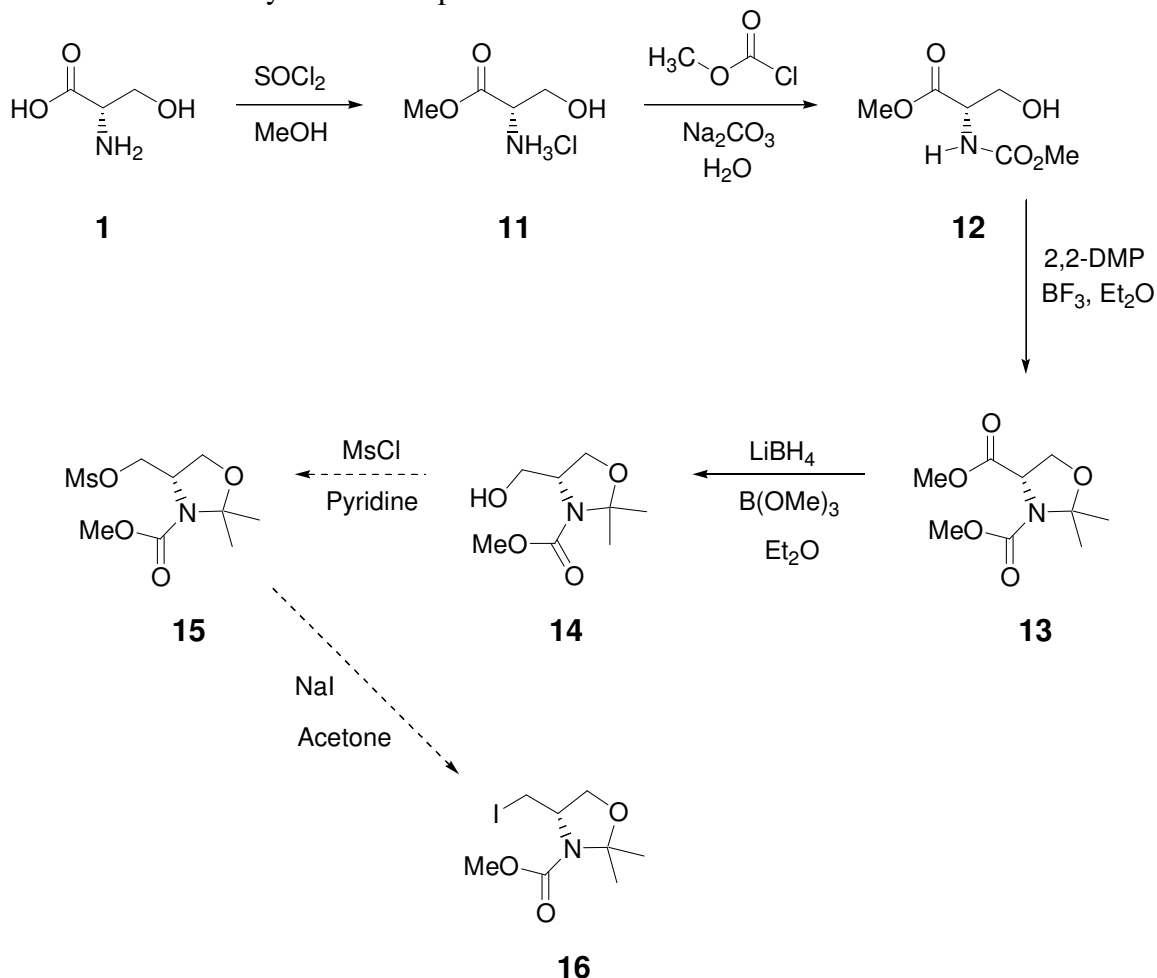


The protecting group, methyl carbamate, was chosen to replace the benzyl carbamate protecting group due to its stability under Grignard conditions. The use of methyl carbamate, due to its similar functionality, enabled the development of a similar strategy used in **Scheme 1**. An alternate route (**Scheme 4**) which protects the amine with methyl carbamate will produce a more stable compound toward Grignard reagents for the coupling with the ketone **9** (**Scheme 2**).

The disadvantage of using the methyl carbamate protecting group was its lack of UV-activity used to monitor reaction progress. Instead, phosphomolybdic acid hydrate (PMA), an expensive and toxic stain, was utilized to view spots on TLC plates. After the TLC plate had been spotted and eluted with a solvent, the TLC plate was dipped in a

dilute PMA solution before heat was applied to the TLC plate. The heat developed the stain and created a spot where the product previously existed on the plate.

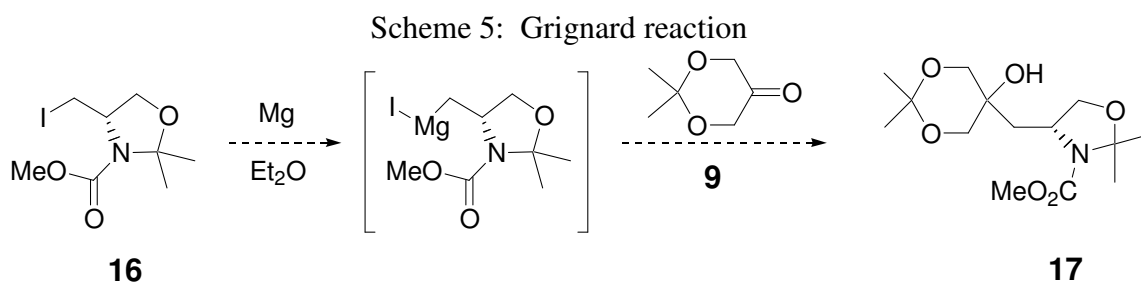
Scheme 4: Methyl carbamate protection of L-serine and its conversion to the iodide



In **Scheme 4**, L-serine, **1**, was converted to L-serine methyl ester hydrochloride, **11**, before the methyl carbamate was formed. Product **11** was not isolated but was directly converted to **12**. The alcohol **12** was converted to the oxazolidine **13** using the same procedures as in **Scheme 1**. The methyl carbamate **13** was distilled (102 °C at 1.6 torr) at a lower boiling point than the benzyl carbamate **4** due to its lower molecular weight.

The methyl ester was treated with LiBH_4 in the presence of $\text{B}(\text{OMe})_3$ in Et_2O to form the reduced alcohol **14**. The RBF was filled with argon to eliminate any moisture or oxygen from entering the flask. The product was collected as a clear oil in quantitative yields.

Future work involving the formation of the iodide **16** followed by the Grignard reaction, **Scheme 5**, should produce the carbohydrate **17** that directly precedes the formation of the desired carbohydrate.



III. CONCLUSION

The success of achieving the carbohydrate is probable because the Grignard reaction is well-established. This formation of the carbohydrate is significant because the product differs significantly from other natural or synthesized carbohydrates. The advantage to this synthetic pathway is the simplistic nature of only using protection or condensation reactions. The high yielding and universal steps toward the construction of the heterocycles on the carbohydrate will lead to the DHN. Biological testing will examine the hypothesis of combining two carbohydrates to form an effective antiviral compound.

IV. EXPERIMENTAL

N-Cbz-L-serine (2).

L-serine (**1**) (2.50 g, 19.5 mmol) was dissolved in 20 mL water and cooled in an ice bath as sodium bicarbonate (3.43 g, 40.8 mmol) was added over 15 minutes. The cool solution was treated with benzylchloroformate (CbzCl; 3 mL, 21 mmol) and stirred until CO₂ evolution stopped. The aqueous solution was washed with ether (4 x 20 mL) and acidified (pH=2) with concentrated hydrochloric acid in an ice bath. The milky-white solution was filtered to collect pure product. The aqueous layer was extracted with ethyl acetate, dried over MgSO₄, filtered and concentrated to collect additional product (3.83 g total, 90% yield) as a white solid. ¹H NMR (DMSO) δ 7.3 (s, 5H), 5.1 (s, 2H), 4.1 (m, 1H), 3.8 (d, 2H).

N-Cbz-L-serine methyl ester (3).

A sample of compound **2** (10.0 g, 41.8 mmol) was placed in methanol (200 mL) and stirred under argon as SOCl₂ (3.0 mL, 41.8 mmol) was added dropwise. The resulting clear yellowish solution was stirred for 24 hours at room temperature. Methanol was removed by distillation, the product was extracted with dichloromethane, and a base was added to neutralize excess acid. The analytically pure product was collected as a clear oil (7.38 g total, 70% yield). ¹H NMR (CDCl₃) δ 7.3 (s, 3H), 5.3 (s, 1H), 5.1 (s, 1H), 3.9 (d, 1H), 3.7 (s, 2H), 1.5 (s, 1H).

3-Benzyl-2,2,4-trimethyl-(4S)-3,4-oxazolidinedicarboxylate (4).

A solution of compound **3** (7.38 g, 30.84 mmol) in CHCl₃ was treated with 2,2-DMP (5.0 mL, 40.66 mmol) as TsOH (0.30 g, 1.56 mmol) was added. The solution was

heated to reflux for 5 hours and the red/yellowish mixture separated into a clear, reddish-brown solution with yellow salts. During the distillation, the first fraction was collected at 0.9 torr from 70 – 110 °C. This clear yellowish fraction was the undesired impurities. The desired product was a viscous, clear, golden liquid that was collected around 0.9 torr at 150 °C. The residue was distilled, providing an analytically pure sample (5.29 g total, 58.5% yield). ^1H NMR (CDCl_3) δ 7.35 (s, 5H), 5.2-5.1 (m, 2H), 4.6-4.3 (m, 1H), 4.1-4.05 (m, 2H), 3.8 and 3.6 (two singlets, 3H), 1.8-1.5 (m, 6H). ^{13}C -NMR δ 71.0, 151.5, 136.1, 128.2, 127.7, 127.5, 95.2, 66.5 (CH_2), 66.6 (CH_2), 59.3, 52.1, 24.7, 23.8.

3-Benzyl-2,2-dimethyl-4-hydroxymethyl-(4R)-3-oxazolidinecarboxylate (5).

A solution of compound **4** (10.04 g, 34.1 mmol) in Et_2O (100 mL, 955.2 mmol) was treated with $\text{B}(\text{OMe})_3$ (0.32 mL, 2.8 mmol) and stirred under nitrogen. LiBH_4 (0.836 g, 38.4 mmol) was added. The addition of MeOH (35 mL) at room temperature over a 24 hour period caused an off-white sticky crust to develop as the solution remained clear. Additional MeOH redissolved the glue-like crust while the solution remained clear and colorless. The catalyst was removed by distillation and the alkoxide was protonated by the addition of aqueous hydrochloric acid. The product was extracted with dichloromethane and concentrated, yielding a clear oil (8.57 g total, 95.4% yield): ^1H NMR (CDCl_3) δ 7.4 (s, 5H), 5.2 (s, 2H), 3.8 (d, 5H), 2.2 (m, 1H), 1.8 (d, 6); ^{13}C NMR δ 127.6, 93.8, 76.6, 64.8, 59.2, 24.1, 22.6.

3-Benzyl-2,2-dimethyl-4-iodomethyl-(4S)-3,4-oxazolidinecarboxylate (6).

A solution of PPh_3 (2.38 g, 9.0 mmol) in CH_2Cl_2 (30 mL) was slowly treated with iodine (2.290 g, 9.02 mmol). Imidazole (0.78 g, 11.5 mmol) was added and the solution

was diluted with additional CH₂Cl₂ (20 mL). Compound **5** (2.08 g, 7.8 mmol) was added slowly at 0°C. The reaction was covered with aluminum foil, allowed to react at room temperature for 72 hours, and concentrated *in vacuo*. The solution was washed with 50 mL aqueous NaHCO₃, 100 mL aqueous Na₂SO₃, and 50 mL aqueous NaCl, dried over Na₂SO₄, filtered, and concentrated *in vacuo*. The oil was purified on a short silica column with the eluent CH₂Cl₂ to obtain the desired product (1.72 g total, 58.4% yield): ¹H NMR (CDCl₃) δ 7.4 (s, 5H), 5.2, (s, 2H), 4.3 (m, 3H), 3.3 (m, 2H), 1.5 (d, 6H); ¹³C NMR δ 151.5, 136.0, 127.9, 94.5, 77.0, 67.2, 58.9, 26.8, 24.3, 6.4.

5-Amino-2,2-dimethyl-5-hydroxymethyl-1,3-dioxane (8).

2-Amino-2-hydroxymethylpropane-1,3-diol, **7**, (26.659 g, 220 mmol) in 70mL DMF was cooled in an ice bath and slowly treated with HCl (20 mL, 240 mmol) and stirred for one hour at room temperature. The suspension was concentrated *in vacuo* to afford a crude white salt. The salt was suspended in 70 mL DMF, treated with TsOH (1.9 g, 10 mmol) and 2,2-DMP (30 mL, 244 mmol) and stirred overnight. The solution was warmed to 50°C. The solutes dissolved into a clear solution, which was treated with triethylamine (5 mL), and concentrated *in vacuo*. The viscous oil was diluted in DMF (60 mL) and added with vigorous stirring to a solution of triethylamine (50 mL) in ethyl acetate (800 mL). A white precipitate was removed by filtration and the solution was concentrated *in vacuo* to afford a thick oil **8** (23.725 g, 67% yield), that solidified over time. ¹H NMR (CDCl₃) δ 3.95-3.20 (m, 9H), 1.40 (s, 6H); ¹³C NMR (CDCl₃) δ 98.2, 66.5, 63.9, 50.2, 24.6, 22.0.

2,2-Dimethyl-1,3-dioxane-5-one (9).

A solution of **8** (7.505 g, 46.6 mmol) in MeOH (20 mL) was treated with KIO₄ (13.386 g, 58.2 mmol) in H₂O (92.8 mL) and stirred at 0°C for several days until the white solution became clear. The reaction was purified by extraction only. The solution was concentrated *in vacuo* and the desired product was obtained (4.6 g, 76% yield).

¹H NMR (CDCl₃) δ 7.1 (d, 1H), 6.7 (s, 1H), 5.4 (s, 4H), 4.2 (s, 4H), 2.2 (s, 3H), 1.4, (s, 8H).

5-Hydroxy-5-[3-benzylcarbamate-(4R)-2,2,4-trimethyl-1,3-oxazolidine-4-yl]-2,2-dimethyl-1,3-dioxane (10).

Two equivalents of zinc (nanosize activated powder in hexanes) were added to **6** (0.1 g) and heated to reflux in THF. Zinc insertion was not observed by TLC, thus failing to provide evidence of a Reformatski reaction. This prompted the Grignard approach (Scheme 5) with magnesium, a more active metal.

Methyl (2S)-2-methoxycarbonylamino-3-hydroxypropanoate (12).

A solution of **1** (89.664 g, 853 mmol) in 1100 mL methanol was cooled to 0°C in a 2 L 3-necked RBF and slowly treated with thionyl chloride (65 mL added dropwise, 1 drop/3 sec). The cooled solution was stirred overnight under argon and allowed to warm to room temperature. The solution was concentrated *in vacuo* to provide the white solid L-serine methyl ester hydrochloride **11**, which was used directly in the next step. The solid was dissolved in 150 mL water, cooled in an ice bath, and treated with sodium carbonate (121.66 g, 981 mmol.) followed by methylchloroformate (95 mL, 970 mmol). The mixture was stirred for four hours and allowed to warm to room temperature. The

aqueous solution was extracted with chloroform (4 x 200 mL), dried over MgSO₄, filtered and concentrated *in vacuo* to afford a clear oil (146.1 g) in 96.6% yield over the two steps. ¹H NMR (CDCl₃) δ 6.18 (bd, 1H), 4.41 (m, 1H), 3.85 (m, 2H), 3.80 (s, 3H), 3.70 (s, 3H); ¹³C NMR (CDCl₃) δ 171.1, 156.8, 62.5, 55.9, 52.3, 52.2.

2,2,3,4-tetramethyl-(4S)-3,4-oxazolidenedicarboxylate (13).

A solution of **12** (14.238 g, 80 mmol) and 2,2-dimethoxypropane (10 mL, 81.3 mmol) in 100mL chloroform was treated with 0.4mL BF₃·OEt₂ and stirred under argon for 24 hours. A distillation head was added and the methanol-chloroform azeotrope (53°C) was removed slowly. Additional chloroform was added until the methanol was removed. The chloroform layer was washed with saturated sodium bicarbonate (3 x 50mL), dried over MgSO₄, filtered and concentrated *in vacuo* to afford a light yellow oil (16.768 g, 96% yield). ¹H NMR (CDCl₃) δ 4.43 (m, 1H), 4.14 (m, 2H), 3.76 (s, 3H), 3.67 (s, 3H), 1.66 (s, 3H), 1.52 (s, 3H); ¹³C NMR (CDCl₃) δ 170.7, 151.9, 94.8, 66.1, 58.3, 51.9, 51.7, 24.4, 23.4.

2,2,3-trimethyl-(4R)-4-hydroxymethyl-3-oxazolidenecarboxylate (14).

A solution of **13** (29.017 g, 133.5 mmol) in 200 mL diethyl ether and trimethylborate (1.5 mL) was cooled in an ice bath and treated with lithium borohydride (1.65 g, 75.8 mmol) in four portions and stirred for 48-hours at ambient temperature under argon. The solution mixture (white solid in ether) was quenched with methanol (12 mL) and the cloudy solution was concentrated *in vacuo* (to remove ether). The clear oil was diluted with chloroform (250 mL) and water (50 mL) and the basic solution (pH~12) was neutralized with HCl in an ice bath. The organics were separated and the

aqueous layer was extracted with additional chloroform (3 x 75 mL). The combined chloroform was dried over MgSO₄, filtered, and concentrated *in vacuo* to provide a clear oil in quantitative yield. ¹H NMR (CDCl₃) δ 4.00 (bs, 3H), 3.70 (bs, 6H), 1.54 (s, 3H), 1.48 (s, 3H); ¹³C NMR (CDCl₃) δ 153.7, 94.2, 66.4, 62.2, 59.3, 52.4, 26.7, 23.0.

APPENDIX
SELECTED NMR SPECTRA

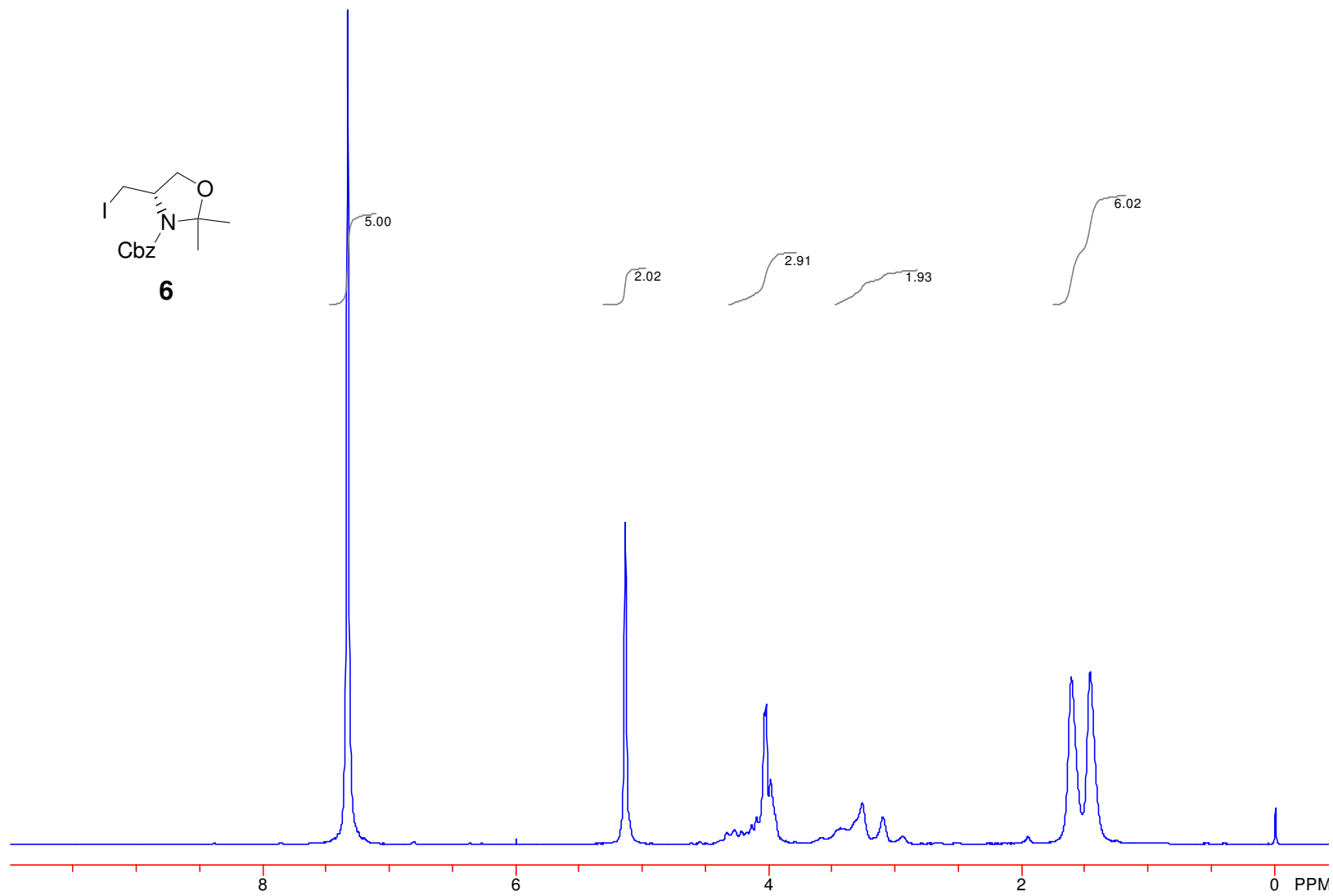


Figure 3: ¹H NMR spectrum of compound 6.

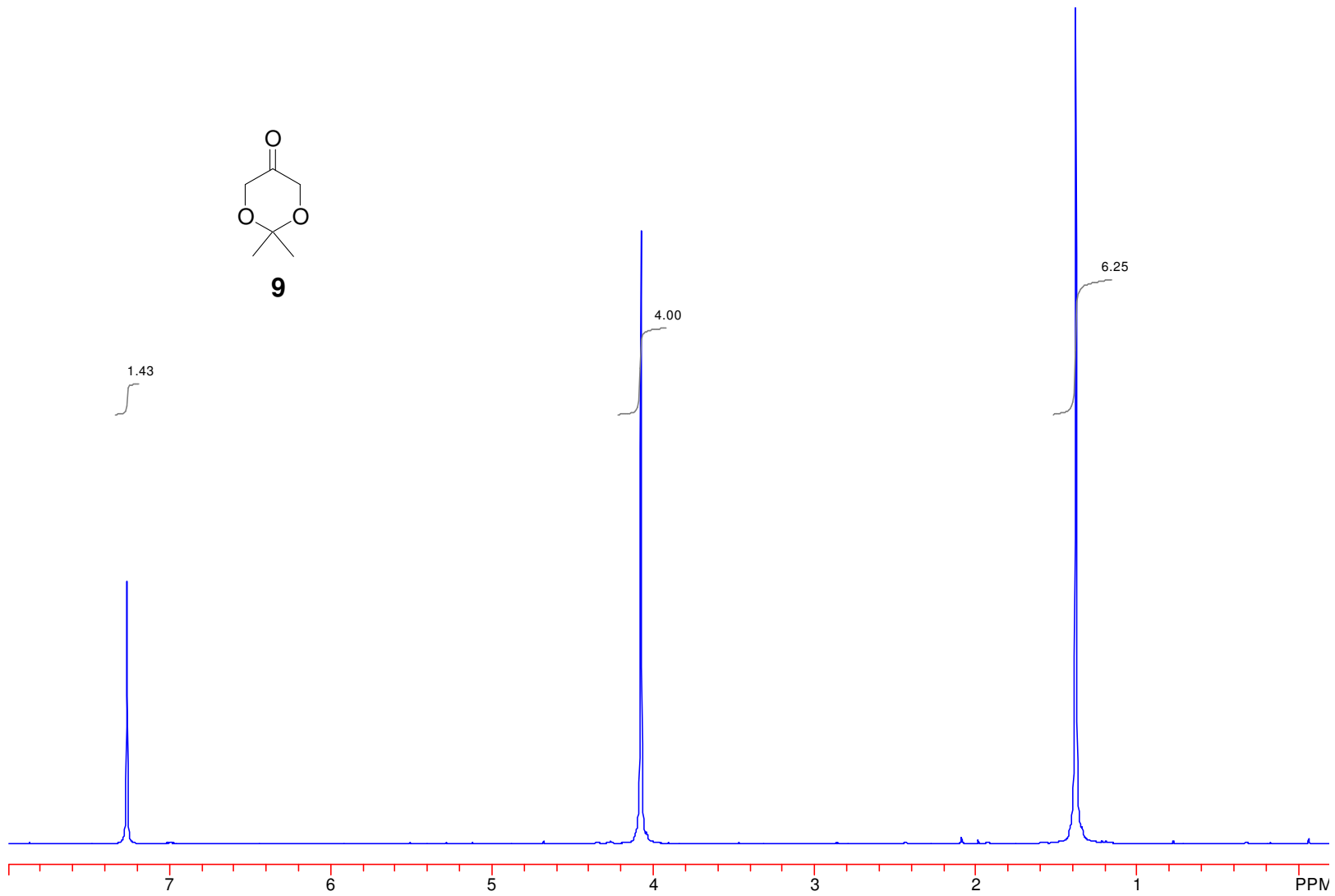


Figure 4: ^1H NMR spectrum of compound **9**.

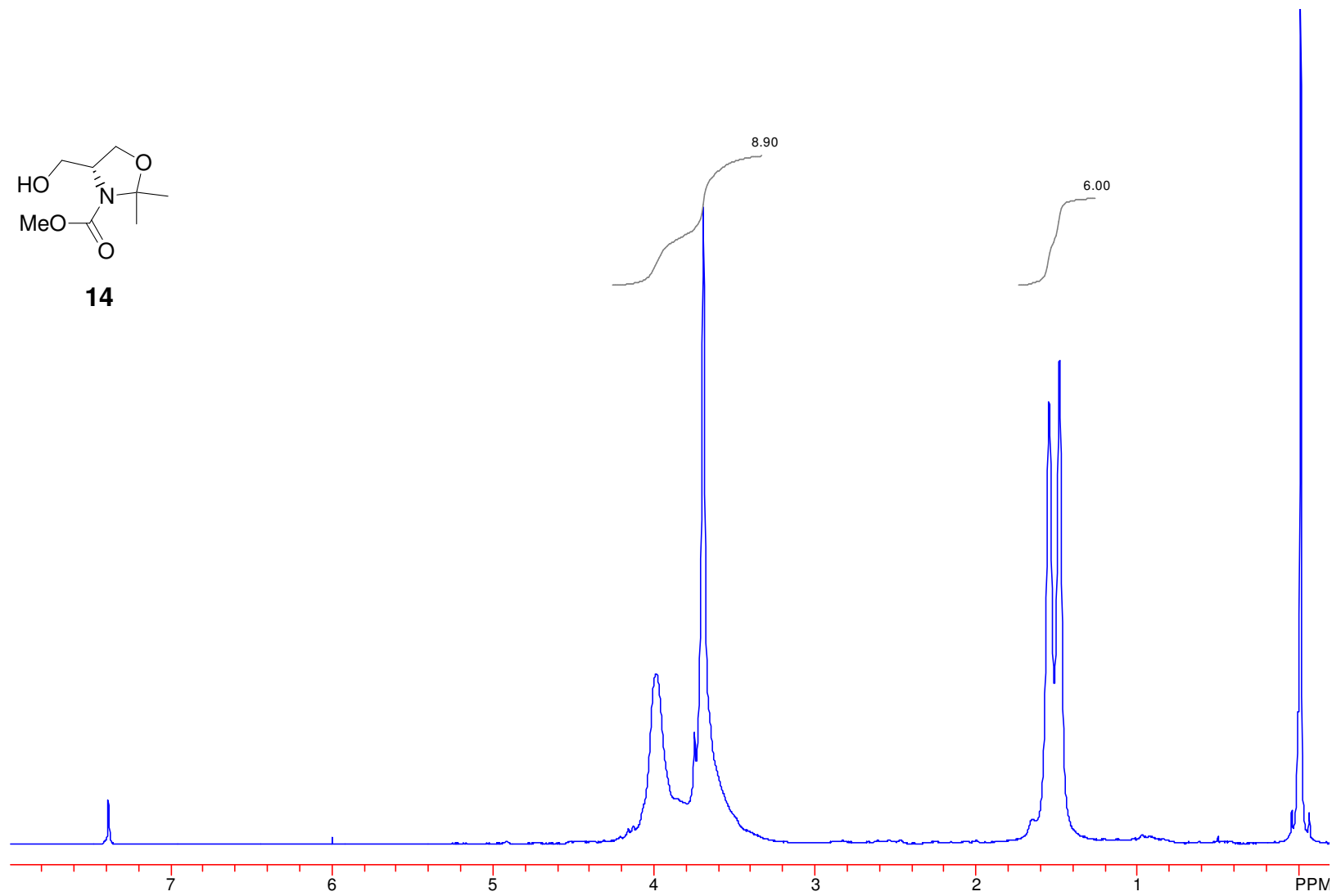
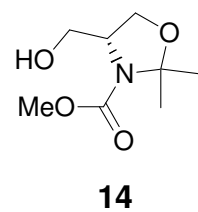


Figure 5: ^1H NMR spectrum of compound **14**.

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VITA

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EDUCATION

BS, Biochemistry, with Honors; minor concentration: Religion
McMurry University, Abilene TX (GPA 3.84/4.00), 2006

Honors thesis: Synthesis of a Novel Carbohydrate Toward Double-Headed Nucleosides: via Grignard Reagent
Advisor: Arlen Jeffery, Ph.D.

Artesia High School, Artesia NM (GPA 4.22/4.23; top 1% of class), 2002

EXPERIENCE

Intern, Oak Ridge National Lab, Oak Ridge TN; Mentor: Wei Wang, Ph.D., Fall Semester, 2005.

- Synthesized monodispersed silica nanoparticles by forced hydrolysis; size and distribution verified by Dynamic Light Scattering.
- Studied alcohols, alcohol/water ratios, temperature, and pH to develop best technique to synthesize specific sized nanoparticles.
- Determined emission and intensity of Rhodamine B, Rhodamine 6G, and Fluorescein isothiocyanate using fluorescence spectrometry.

Researcher, McMurry University, Abilene TX; Advisor: Arlen Jeffery, Ph.D., Summer 2004, 2005.

- Synthesized organic molecules, on large and small scales, under inert gases.
- Characterized products with ^1H NMR, ^{13}C NMR, DEPT, and HETCOR as well as TLC and medium pressure column chromatography.
- Studied the rate enhancement and efficiency of microwave heating.

Teaching Assistant for McMurry 101, McMurry University, Abilene TX; Fall Semester 2004.

- Planned and led programs and activities for biology and chemistry students.
- Monitored student progress and discussed options for individual improvement.
- Counseled students on majors, careers, and campus involvement.

PRESENTATIONS

- Honors Thesis Presentation, organic synthesis research, Abilene, TX; May 2006
- Poster presentation, nanoparticle research, Oak Ridge National Lab, Oak Ridge TN; December 2005
- Poster presentation, organic synthesis research, ACS Southwest Regional Meeting Dallas TX; October 2004

AFFILIATIONS

- American Chemical Society
- ACS Student Affiliate Chapter, Vice President.

AWARDS

- Who's Who Among Students in American Universities & Colleges, 2005.
- Outstanding McMurry 101 Peer Leader, 2005.
- Outstanding Freshman Math Award, 2003.
- National Dean's List, 2006/Dean's List, December 2002—2006.
- Kappa Mu Epsilon Honor Mathematics Society, President.
- Alpha Lambda Delta Honor Leadership Society.
- Alpha Chi National Honor Scholarship Society.
- Honors Program, Departmental Honors.

VOLUNTEER WORK

December 2002 - Present (2 hours/week): Big Brothers Big Sisters, Epi Silva, Abilene TX

- Tutor and work on organizational skills.
- Teach right from wrong and work to improve manners.
- Talk about strengths and problems and help to set goals.

Summer 2004 - Summer 2005: Youth Intern at St. Paul United Methodist Church, Abilene TX

- Lead bible studies and small group discussions.
- Talk with students about choices and future.

2004, 2005: Tribe Guide, McMurry University, Abilene TX

- Lead group activities, small groups, and ropes courses.
- Taught McMurry traditions and values to students.
- Talked with parents and students about the transition to college.