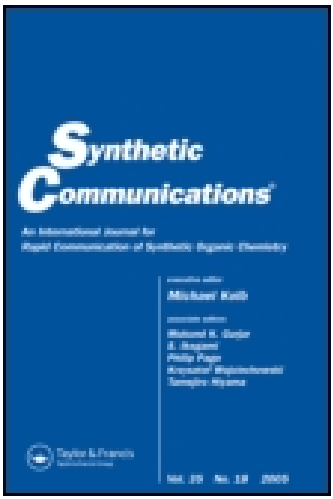

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1-(1-Alkenyl)benzotriazoles: Novel α-Hydroxyacyl Anion Equivalents for the Synthesis of α-Hydroxy Ketones

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1-(1-ALKENYL)BENZOTRIAZOLES: NOVEL α-HYDROXYACYL ANION EQUIVALENTS FOR THE SYNTHESIS OF α-HYDROXY KETONES

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ABSTRACT: α-Lithiated 1-(1-alkenyl)benzotriazoles, generated from the reactions of 1-(1-alkenyl)benzotriazoles with *n*-BuLi, react with a variety of electrophiles to afford α-substituted 1-(1-alkenyl)benzotriazoles which undergo epoxidation with *m*-CPBA followed by hydrolysis to give α-hydroxy ketones in good yields. Thus, 1-(1-alkenyl)benzotriazoles behave as α-hydroxyacyl anion equivalents.

INTRODUCTION

α-Hydroxy ketones are present in many biologically active compounds such as anti-tumor agents and drugs.[1,2] Currently available methods for the

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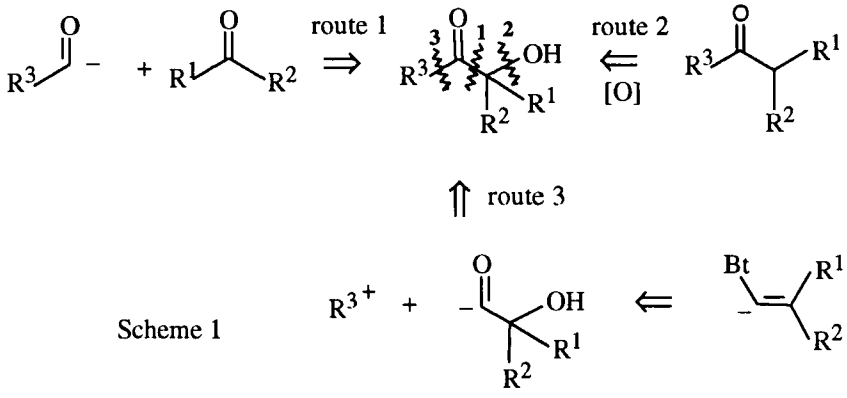
preparation of α-hydroxy ketones include the oxidation of ketones *via* their enol ethers[3] or enolate anions,[4,5] the acyloin[6] and benzoin[7] condensations, the partial reduction of 1,2-diketones,[8] the oxidations of epoxides[9] and alkenes,[10] the reactions of various acyl anion equivalents[11] and acyl lithiums with ketones and aldehydes,[12] and reductive coupling reactions of acid halides with ketones and aldehydes.[13] Among these, two general approaches have occupied a prominent position, the reaction of acyl anions with carbonyl compounds (route 1)[11,12] and the oxidation of ketones and their derivatives (route 2)[3-5] as illustrated in Scheme 1.



Scheme 1

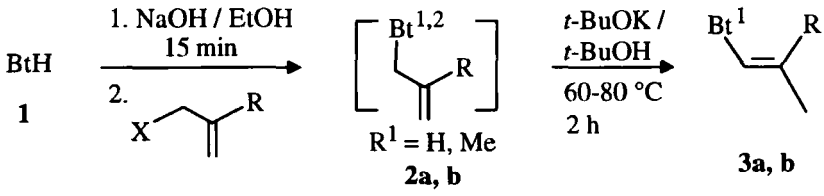
An alternative strategy for the construction of α-hydroxy ketones using α-hydroxyacyl anion equivalents, also shown in Scheme 1 (route 3), has received much less attention. An attractive feature of this route is that various functionalized groups R^1 could be introduced. However, to the best of our knowledge, only two types of synthetic precursors have been used as α-hydroxyacyl anion equivalents: lithium acetylide[1] and 1-chloroalkyl *p*-tolyl sulfoxides[14]. Moreover, the use of electrophiles other than simple ketones to produce α, α'-dihydroxy ketones has not been exploited.

We report here a general method for the preparation of a range of α-hydroxy ketones using 1-(1-alkenyl)benzotriazoles as α-hydroxyacyl anion equivalents (route 3 in Scheme 1).

RESULTS AND DISCUSSION

Preparation of 1-(1-Alkenyl)benzotriazoles 3a, b.

Synthetic routes to 1-(1-alkenyl)benzotriazoles are well established.[15,16] In this paper, we employed the base-assisted alkylation of benzotriazole with allyl halides and subsequent rearrangement as shown in Scheme 2. Alkylation of benzotriazole (**1**) with allyl bromide or 3-chloro-2-methylpropene in the presence of ethanolic sodium hydroxide gave a mixture of the



compound	R	yield (%)
3a	H	38
3b	Me	40

(Bt^1 = benzotriazol-1-yl)

Scheme 2

corresponding 1- and 2-substituted benzotriazoles **2a** or **2b.** Each mixture was isomerized without separation under strongly basic conditions to give a mixture of 1- and 2-(1-alkenyl)benzotriazoles. Recrystallization of these mixtures from diethyl ether/hexanes gave the 1-[*trans*-(1-alkenyl)]benzotriazole **3a** or **3b**, while

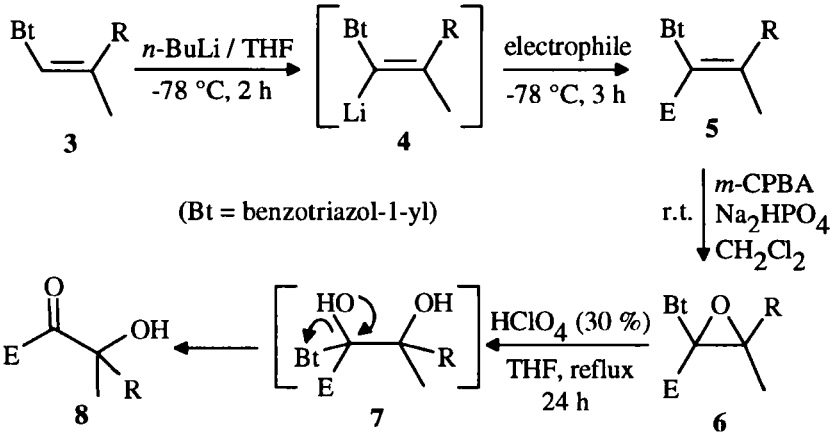
the other isomers remained in the solution. This method can be conveniently used for large scale preparation of **3a, b**; although the final yields (38% and 40%) are moderate, the required products are obtained free from the other isomers.[17]

α-Alkylation of 1-(1-Alkenyl)benzotriazoles 3a, b.

It is known that 1-(1-alkenyl)benzotriazoles can easily be lithiated at the carbon α to the benzotriazolyl group and that the resulting anion can react with a wide range of electrophiles.[16,17] In the current study, the range of both 1-(1-alkenyl)benzotriazole derivatives and the electrophiles has been further expanded (scheme 3). Thus, compounds **3** were treated with 1.1 equivalents of *n*-BuLi in THF at -78°C for 2 hours to generate the lithium anions **4** which reacted with various electrophiles such as octyl iodide, *p*-bromobenzyl bromide, benzophenone, cyclohexanone and benzaldehyde to afford the corresponding α-substituted 1-(1-alkenyl)benzotriazoles **5** generally in good yields. The intermediate alkenes **5** were either purified by recrystallization or column chromatography (see experimental section).

Formation of α-Hydroxy Ketones 8 via Epoxidation of α-Substituted 1-(1-Alkenyl)benzotriazoles 5 and Subsequent Hydrolysis.

Our initial attempts at the epoxidation of α-substituted 1-(1-alkenyl)-benzotriazoles **5** using *m*-CPBA in dichloromethane at room temperature gave complex mixtures. Presumably due to the strong acidic conditions, the epoxides formed from the reaction underwent either acid catalyzed nucleophilic addition with *m*-chlorobenzoic acid or polymerization. However, the reaction of the α-substituted 1-(1-alkenyl)benzotriazoles **5** with *m*-CPBA (2.0 eq) could be



compound	R	E	yield (%)
5a	Me	octyl	66
5b	Me	*p*-$BrC_6H_4CH_2$	41
5c	Me	Ph_2COH	80
5d	H	$(CH_2)_5COH$	58
5e	Me	PhCHOH	73
6a	Me	octyl	72
6b	Me	*p*-$BrC_6H_4CH_2$	61
6c	Me	Ph_2COH	43
6d	H	$(CH_2)_5COH$	80[a]
6e	Me	PhCHOH	53[b]
8a	Me	octyl	90
8b	Me	*p*-$BrC_6H_4CH_2$	70
8c	Me	Ph_2COH	65
8d	H	$(CH_2)_5COH$	60
8e	Me	PhCHOH	45

[a] Yield from ^1H NMR spectrum.

[b] Overall yield of two diastereomers.

Scheme 3

carried out in CH_2Cl_2 at room temperature with Na_2HPO_4 (2.5 eq) added to control the acidity of the solution. Under these reaction conditions, the expected epoxides **6** were obtained in good yields. The epoxides of type **6** are stable to weakly basic and acidic conditions, thus they can be washed with aqueous saturated Na_2CO_3 solution and purified by column chromatography using silica gel as the stationary phase. Compound **6d** was difficult to purify by column chromatography, so the crude epoxide **6d** (80% yield based on ^1H NMR spectrum) was used for further hydrolysis.

Hydrolysis of epoxides **6** took place in refluxing THF using 30% of aqueous perchloric acid as a catalyst. Presumably, the reaction initially provided the 1,2-dioles **7**, which rapidly eliminate the benzotriazolyl group to form the α-hydroxy ketones **8** in good yields.

Products **5**, **6** and **8** are all novel and were characterized by ^1H and ^{13}C NMR spectra and microanalysis (see experimental section).

In summary, a general synthetic method for the preparation of α-hydroxy ketones has been described. 1-(1-Alkenyl)benzotriazoles **3a, b** were readily deprotonated at the carbon α to the benzotriazolyl moiety and the resulting lithium anions reacted with a wide range of electrophiles to give α-substituted 1-(1-alkenyl)benzotriazoles **5** which underwent epoxidation followed by hydrolysis to afford various α-hydroxy ketones **8**. Thus, 1-(1-alkenyl)benzotriazoles **3a, b** act as α-hydroxyacyl anion equivalents.

EXPERIMENTAL

Melting points were determined on a Bristoline hot-stage microscope and are uncorrected. ^1H and ^{13}C NMR spectra were recorded on a 300 MHz

spectrometer. High resolution mass spectra and elemental analyses were carried out within the department. Column chromatography was conducted over silica gel (200-425 mesh, Kodak Co.). GC/MS analysis of the compound **8a** was performed on a Hewlett Packard 5890 series II gas chromatograph and a 5872 series MCD.

General Procedure for the Preparation of 1-(1-Alkenyl)benzotriazoles ***3a, b.***

Sodium hydroxide (20.0 g, 0.5 mol) was dissolved in the minimum amount of water and added to a stirred solution of benzotriazole (**1**) (59.57 g, 0.5 mol) dissolved in the minimum amount of ethanol. The resulting solution was placed in an ice bath and allowed to stir for 15 minutes. The appropriate allyl halide was added to the solution, and the reaction mixture was allowed to stir overnight while warming to room temperature. The solvent was removed under reduced pressure to give the crude products **2a** or **2b** to which were added *t*-BuOH (350 mL) and *t*-BuOK (52.31 g, 0.47 mol). The solution was heated at 65-80 ^{o}C for 3 hours, then poured into water (500 mL). After cooling, Et_2O (500 mL) was added and the organic layer was separated, washed with water (2 x 500 mL) and dried ($MgSO_4$). After removal of the solvent, the crude oil was crystallized from Et_2O to afford the pure product **3a** or **3b**.

*1-[trans-(1-Propenyl)]benzotriazole (**3a**).* 38% yield, white plates, mp 73-75 ^{o}C (lit.[17] mp 72-73 ^{o}C). ^{1}H NMR ($CDCl_3$): δ 8.06 (d, J = 8.3 Hz, 1H), 7.63 (d, J = 8.4 Hz, 1H), 7.48-7.53 (m, 1H), 7.35-7.40 (m, 1H), 7.30 (dq, J = 14.2 and 1.7 Hz, 1H), 6.51 (dq, J = 14.2 and 6.9 Hz, 1H), 1.98 (dd, J = 6.9 and 1.7 Hz, 3H); ^{13}C NMR ($CDCl_3$): δ 146.0, 131.3, 127.8, 124.1, 123.6, 120.0, 118.6, 109.9, 15.4.

*1-[1-(2-Methyl)propenyl]benzotriazole (**3b**).* 40% yield, white plates, mp 69-72 °C. ^{1}H NMR ($CDCl_3$): δ 8.07 (d, *J* = 8.3 Hz, 1H), 7.34-7.52 (m, 3H), 6.84-6.86 (m, 1H), 2.03 (d, *J* = 1.3 Hz, 3H), 1.77 (d, *J* = 1.4 Hz, 3H); ^{13}C NMR ($CDCl_3$): δ 145.1, 137.9, 133.2, 127.5, 123.8, 119.7, 117.0, 109.9, 22.7, 18.5. Anal. Calcd. for $C_{10}H_{11}N_3$: C 69.34, H 6.40, N 24.26. Found: C 69.03, H 6.39, N 24.53.

*General Procedure for the α-Lithiation and Alkylation of 1-(1-Alkenyl)benzotriazoles **3a, b**.*

The 1-(1-alkenyl)benzotriazole (20 mmol) in THF (100 ml) was cooled to -78 °C, and a solution of *n*-BuLi (22 mmol, 2.0 M in cyclohexane, 11 mL) was added dropwise. The solution was stirred at this temperature for 2 hours, at which point the electrophile (22 mmol) in THF (5 mL) was added. The mixture was stirred for an additional 3 hours at -78 °C, and then quenched with aqueous saturated NaCl (100 mL). Diethyl ether (100 mL) was added and the organic phase was separated and washed with additional aqueous saturated NaCl (3 x 100 mL) and dried over magnesium sulfate. After evaporating to dryness, the products **5** were purified by either recrystallization or column chromatography.

*1-[1-(1-Octyl-2-methyl)propenyl]benzotriazole (**5a**).* Purified by column chromatography using $CHCl_3$/hexane (9:1) as the eluent, 66% yield, oil. ^{1}H NMR ($CDCl_3$): δ 8.08 (d, *J* = 8.2 Hz, 1H), 7.45-7.48 (m, 1H), 7.28-7.39 (m, 2H), 2.58-2.65 (m, 2H), 2.01 (s, 3H), 1.38 (s, 3H), 1.18-1.26 (m, 12H), 0.84 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR ($CDCl_3$): δ 145.2, 133.6, 133.1, 130.0, 127.4, 123.6, 119.9, 110.1, 32.3, 31.7, 29.2, 29.1, 29.0, 27.4, 22.5, 20.0, 19.9, 14.0. Anal. Calcd. for $C_{18}H_{27}N_3$: C 75.74, H 9.53, N 14.72. Found: C 76.01, H 9.77, N 14.69.

*1-[1-(1-p-Bromobenzyl-2-methyl)propenyl]benzotriazole (**5b**).* Purified by column chromatography, 41% yield, oil. ^{1}H NMR ($CDCl_3$): δ 8.00 (d, J = 8.2 Hz, 1H), 7.26-7.37 (m, 2H), 7.21 (d, J = 8.5 Hz, 2H), 7.05 (d, J = 8.2 Hz, 1 H), 6.84 (d, J = 8.5 Hz, 2H), 3.95 (s, 2H), 2.14 (s, 3H), 1.45 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 144.9, 136.3, 134.5, 133.3, 131.3, 129.9, 128.2, 127.4, 123.5, 120.2, 119.6, 109.8, 37.8, 20.3, 20.1. Anal. Calcd. for $C_{17}H_{16}BrN_3$: C 59.81, H 4.72, N 12.32. Found: C 60.13, H 4.74, N 12.33.

*1-[1-(1-Hydroxy-diphenylmethyl-2-methyl)propenyl]benzotriazole (**5c**).* Recrystallized from Et_2O, 80% yield, white powder, mp 184-186 °C. ^{1}H NMR ($CDCl_3$): δ 7.89 (d, J = 8.3 Hz, 1H), 7.61-7.64 (m, 2H), 7.23-7.36 (m, 8H), 7.06-7.09 (m, 3H), 3.09 (s, 1H), 1.75 (s, 3H), 1.41 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 145.0, 144.8, 144.5, 142.4, 134.3, 134.1, 128.1, 127.5, 127.4, 127.2, 127.1, 127.0, 123.4, 119.4, 110.6, 81.9, 22.1. Anal. Calcd. for $C_{23}H_{21}N_3O$: C 77.72, H 5.96, N 11.82. Found: C 77.85, H 5.96, N 11.78.

*1-[1-(1-Hydroxycyclohexyl)propenyl]benzotriazole (**5d**).* Recrystallized from $CHCl_3$, 58% yield, white powder, mp 165-166 °C. ^{1}H NMR (DMSO-d_6): δ 8.05 (d, J = 8.3 Hz, 1H), 7.70 (d, J = 8.5 Hz, 1H), 7.54-7.60 (m, 1H), 7.38-7.43 (m, 1H), 5.79 (q, J = 7.4 Hz, 1H), 5.14 (s, 1H), 2.16 (d, J = 7.4 Hz, 3H), 1.46-1.75 (m, 5H), 1.15-1.34 (m, 4H), 0.89-0.99 (m, 1H); ^{13}C NMR (DMSO-d_6): δ 144.2, 142.1, 134.4, 130.3, 127.6, 123.7, 118.9, 111.1, 73.1, 35.2, 24.7, 20.7, 13.7. Anal. Calcd. for $C_{15}H_{19}N_3O$: C 70.01, H 7.44, N 16.33. Found: C 69.63, H 7.57, N 16.23.

*1-[1-(Hydroxyphenylmethyl)-2-methylpropenyl]benzotriazole (**5e**).* Recrystallized from a mixture of diethyl ether and hexane, 73% yield, white needles, mp 126-127 °C. ^{1}H NMR ($CDCl_3$): δ 7.93-7.96 (m, 1H), 6.95-7.30

(m, 8H), 6.45-6.85 (br.s, 1H), 6.18 (d, J = 6.6 Hz, 1H), 3.85 (br.s, 1H), 2.28 (s, 3H), 1.42 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 144.5, 140.6, 137.8, 134.3, 131.2, 128.0, 127.4, 127.3, 125.2, 123.5, 119.4, 110.1, 70.8, 20.4, 20.0. Anal. Calcd. for $C_{17}H_{17}N_3O$: C 73.10, H 6.13, N 15.04. Found: C 73.47, H 6.20, N 15.14.

General Procedure for the Epoxidation of α-Substituted 1-(1-Alkenyl)benzotriazoles 5.

A mixture of the α-substituted 1-(1-alkenyl)benzotriazole **5** (10 mmol), *m*-CPBA (20 mmol), and Na_2HPO_4 (25 mmol) in dichloromethane (250 mL), was vigorously stirred for 2 to 3 days. The reaction was followed by TLC and appropriate adjustments in reaction time were made. The reaction was quenched with aqueous saturated Na_2CO_3. The organic phase was separated and washed with additional aqueous saturated Na_2CO_3 (3 x 100 mL) followed by aqueous saturated NaCl (3 x 100 mL), and then dried over magnesium sulfate. After evaporating to dryness, the products **6** were purified by either recrystallization or column chromatography.

*2-Methyl-2,3-epoxy-3-(1-benzotriazolyl)undecane (**6a**).* Purified by column chromatography using $CHCl_3$ as the eluent, 72% yield, oil. ^1H NMR (DMSO-d_6): δ 8.04 (d, J = 8.5 Hz, 1H), 7.79 (d, J = 8.5 Hz, 1H), 7.49-7.54 (m, 1H), 7.35-7.40 (m, 1H), 2.22-2.30 (m, 1H), 2.02-2.10 (m, 1H), 1.56 (s, 3H), 0.95-1.26 (m, 12H), 0.91 (s, 3H), 0.71 (t, J = 7.8 Hz, 3H); ^{13}C NMR (DMSO-d_6): δ 144.5, 132.7, 127.8, 124.1, 119.3, 111.3, 77.9, 64.8, 32.1, 31.0, 28.5, 28.3, 28.2, 23.5, 21.9, 20.1, 19.6, 13.7. HRMS (FAB): $C_{18}H_{27}N_3O$ (M + H) requires: 302.2232. Found: 302.2217.

*1-(p-Bromophenyl)-2-(1-benzotriazolyl)-2,3-epoxy-3-methylbutane (**6b**).* Purified by column chromatography using hexane/EtOAc (1:8) as the eluent, 61% yield, oil. ^{1}H NMR ($CDCl_3$): δ 7.92-7.98 (m, 1H), 7.22-7.29 (m, 3H), 7.16 (d, *J* = 8.5 Hz, 2H), 6.76 (d, *J* = 8.5 Hz, 2H), 3.77 (d, *J* = 14.4 Hz, 1H), 3.30 (d, *J* = 14.4 Hz, 1H), 1.76 (s, 3H), 1.05 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 144.7, 133.7, 133.0, 131.3, 131.2, 127.6, 123.9, 121.2, 119.3, 111.3, 78.9, 66.0, 38.6, 20.6, 20.5. Anal. Calcd. for $C_{17}H_{16}BrN_3O$: C 57.14, H 4.52, N 11.77. Found: C 57.43, H 4.54, N 11.57.

*1-Hydroxy-1,1-diphenyl-2-(1-benzotriazolyl)-2,3-epoxy-3-methylbutane (**6c**).* Purified by column chromatography using hexane/EtOAc (3:1) as the eluent, 43% yield, white powder, mp 135-137 °C. ^{1}H NMR ($CDCl_3$): δ 7.95-7.98 (m, 2H), 7.77-7.80 (m, 1H), 7.07-7.37 (m, 8H), 6.79-6.86 (m, 3H), 4.38 (s, 1H), 1.49 (s, 3H), 1.10 (s, 3H). ^{13}C NMR ($CDCl_3$): δ 144.4, 143.2, 143.0, 133.4, 128.0, 127.6, 127.4, 127.1, 126.5, 123.7, 119.9, 111.9, 81.6, 80.0, 68.5, 22.5, 19.9. Anal. Calcd. for $C_{23}H_{21}N_3O_2$: C 74.37, H 5.70, N 11.31. Found: C 74.29, H 5.81, N 11.13.

*1-Hydroxy-1-phenyl-2-(1benzotriazolyl)-2,3-epoxy-3-methylbutane (**6e**).* Two diastereoisomers were obtained by column chromatography using a mixture of hexane/EtOAc (3:1) as the eluent. Isomer 1: 32% yield, yellow powder, mp 143-145 °C. ^{1}H NMR ($CDCl_3$): δ 7.94 (d, *J* = 7.6 Hz, 1H), 7.01-7.38 (m, 8H), 5.39 (s, 1H), 3.53 (br.s, 1H), 1.87 (s, 3H), 1.07 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 144.6, 137.5, 134.2, 128.4, 128.3, 127.4, 126.0, 123.8, 119.2, 112.2, 79.3, 74.7, 67.3, 21.8, 20.8. Anal. calcd. for $C_{17}H_{17}N_3O_2$: C 69.14, H 5.80, N 14.23. Found: C 69.43, H 5.84, N 14.16. Isomer 2: 21% yield, white powder, mp 152-153 °C. ^{1}H NMR ($CDCl_3$): δ 7.89 (d, *J* = 8.3 Hz, 1H), 6.85-

7.30 (m, 8H), 5.24 (d, J = 5.5 Hz, 1H), 4.42 (br.s, 1H), 1.89 (s, 3H), 1.04 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 144.3, 138.0, 134.0, 128.0, 127.9, 127.4, 125.7, 123.8, 119.1, 111.3, 79.8, 73.7, 67.2, 20.9, 19.8. Anal. Calcd. for $C_{17}H_{17}H_3O_2$: C 69.14, H 5.80, N 14.23. Found: C 68.75, H 5.86, N 14.17.

General Procedure for the Hydrolysis of epoxides ***6****.*

Epoxide **6** (5 mmol) was dissolved in THF (50 mL), and 30% aqueous perchloric acid (2 mL) was added to the mixture, which was then refluxed under nitrogen. The reaction was followed by GC or TLC. When the reaction was complete, the mixture was quenched and neutralized with 5% NaOH (50 mL). Diethyl ether (50 mL) was added and the organic phase was separated and washed with additional 5% NaOH (3 x 50 mL), followed by aqueous saturated NaCl (3 x 50 mL), and then dried over magnesium sulfate. After evaporating to dryness, the products **8** were purified by column chromatography.

2-Hydroxy-2-methyl-2'-heptylacetopropanone ***(8a)****.* Purified by column chromatography using hexane/EtOAc (3:1) as the eluent, 90% yield, oil. ^{1}H NMR ($CDCl_3$): δ 3.97 (s, 1H), 2.56 (t, J = 7.3 Hz, 2H), 1.55-1.70 (m, 2H), 1.36 (s, 6H), 1.20-1.35 (m, 10H), 0.88 (t, J = 7.2 Hz, 3H): ^{13}C NMR ($CDCl_3$): δ 214.4, 75.9, 35.3, 31.6, 29.1, 29.0, 28.9, 26.2, 23.5, 22.4, 13.8; *m/z* (M^+ + H, 1%), 183 (!), 141 (2), 102 (1), 59 (100), 43 (10).

2-Hydroxy-2-methyl-2'-(p-bromophenyl)acetopropanone ***(8b)****.* Purified by column chromatography using hexane/EtOAc (1:2) as the eluent, 70%, oil. ^{1}H NMR ($CDCl_3$): δ 7.45 (d, J = 8.4 Hz, 2H), 7.07 (d, J = 8.4 Hz, 2H), 3.84 (s, 2H), 3.60 (s, 1H), 1.43 (s, 6H); ^{13}C NMR ($CDCl_3$): δ 211.3, 132.6, 131.5, 131.2, 120.9, 76.6, 41.7, 26.4. Anal. Calcd. for $C_{11}H_{13}BrO_2$: C 51.56, H 5.12. Found: C 51.58, H 5.28.

*2,2'-Dihydroxy-2-methyl-2',2'-diphenylacetopropanone (**8c**).* Purified by column chromatography using hexane/EtOAc (3:1) as the eluent, 65%, yellow powder, mp 86-88 °C. ^{1}H NMR ($CDCl_3$): δ 7.24-7.38 (m, 10H), 5.23 (br.s, 1H), 2.93 (br.s, 1H), 1.45 (s, 6H); ^{13}C NMR ($CDCl_3$): δ 211.6, 141.9, 128.2, 127.9, 127.0, 87.3, 80.3, 28.2. Anal. Calcd. for $C_{17}H_{18}O_3$: C 75.53, H 6.71. Found: C 75.52, H 6.82.

*1-Hydroxycyclohexyl 1-hydroxyethyl ketone (**8d**).* Purified by column chromatography using hexane/EtOAc (4:1) as the eluent, 60% yield, yellow powder, mp 84-87 °C. ^{1}H NMR ($CDCl_3$): δ 4.75 (q, J = 6.7 Hz, 1H), 3.30 (br.s, 1H), 2.64 (br.s, 1H), 1.45-1.85 (m, 9H), 1.42 (d, J = 6.8 Hz, 3H), 1.15-1.35 (m, 1H); ^{13}C NMR ($CDCl_3$): δ 216.8, 78.6, 69.7, 34.3, 34.2, 24.9, 20.8, 20.6. Anal. Calcd. for $C_8H_{16}O_3$: C 62.77, H 9.36. Found: C 63.20, H 9.61.

*2,2'-Dihydroxy-2-methyl-2'-phenylacetopropanone (**8e**).* Purified by column chromatography using hexane/EtOAc (3:1) as the eluent, 45% yield, oil. ^{1}H NMR ($CDCl_3$): δ 7.20-7.40 (m, 5H), 5.63 (s, 1H), 4.20 (br.s, 1H), 2.50 (br.s, 1H), 1.24 (s, 3H), 1.19 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 214.3, 137.9, 128.9, 128.7, 127.9, 77.3, 75.9, 28.1, 27.5. HRMS (FAB): $C_{11}H_{14}O_3$ (M + H) requires: 195.1021. Found: 195.1001.

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