Table I. Second-Order Rate Constants for the Hydrogen Ion Catalyzed Hydrolysis of Selected Acetals[a]

acetal	k_{H^+}, M^{-1} s^{-1}	acetal	k_{H^+}, M^{-1} s^{-1}
PhCH=CHCH(OEt)$_2$	1.3×10^3	PhCH(OEt)$_2$[b]	1.7×10^2
PhC≡CCH(OEt)$_2$	0.13	$CH_3CH_2CH(OEt)_2$[c]	3.0
CH_2=CHCH(OEt)$_2$	56		

[a] 25 °C in aqueous solution, ionic strength <0.1 and not held constant. [b] Reference 2a, ionic strength 0.5 (KCl). [c] Reference 6, ionic strength 0.5 (KCl).

finding that it is the leaving group that plays the more dominant role in producing observable general acid catalysis, and thus it is not at all suprising that the natural substrates of enzymes are hydrolyzed by employing a general acid catalyst, because the leaving group in these cases is comparable in oxxgen basicity to trifluoroethanol. Previous work has shown that even the less reactive acetals containing the trifluoroethoxy group exhibit pronounced general acid catalysis.[2b]

In reviewing structural features that might lead to increased reactivity and hence be suitable candidates for demonstrating the ubiquity of general acid catalysis in the hydrolysis of acetals, we measured the kinetics of hydrolysis of the diethyl acetals of cinnamaldehyde (**1**), phenylpropiolaldehyde (**2**), and acrolein (**3**).

PhCH=CHCH(OEt)$_2$ (**1**) PhC≡CCH(OEt)$_2$ (**2**)

CH_2=CHCH(OEt)$_2$ (**3**)

In addition to evaluating the activating effect of conjugation, we were intrigued by the prospect of products or intermediates resulting from "unexpected" reaction at carbons other than at the *pro*-carbonyl. In all cases, however, spectral evidence indicated the presence of the expected aldehyde as the only observable product of hydrolysis. Repetitive scans of the UV spectrum during the course of hydrolysis showed that the entire spectrum changed from that of reactant to that of product in a smooth first-order manner. The rate constants measured were not a function of the wavelength chosen for measurement. Therefore, if attack by water occurs at a carbon other than the *pro*-carbonyl during hydrolysis, it must produce an intermediate that is not observable (either because of a weakly absorbing UV spectrum or because of low concentration) *and* must ultimately lead to the expected aldehyde product. The most likely event is that the intermediate ions **1a** and **2a** simply react like the analogous oxycarbocations, which cannot lose their structural integrity during nucleophilic attack.

PhCH=$\overset{+}{C}$HCHOEt (**1a**) PhC≡$\overset{+}{C}$CHOEt (**2a**)

Thus the reactivities tabulated in Table I simply reflect the energy barrier to formation of the oxycarbocations, as opposed to being complicated by mechanistic differences. It appears that direct conjugation of a double bond with the reaction center increases the rate of hydrolysis by 1 order of magnitude; conjugation of a triple bond decreases the rate of hydrolysis by about 3 orders of magnitude. The deactivating effect of a conjugated triple bond is consistent with results (admittedly somewhat scattered) from solvolysis experiments.[3]

The reactivities contained in Table I suggest that acetals **1** and **3** will show the same sort of marginal general acid catalysis observed in the hydrolysis of benzaldehyde diethyl acetals. Acetal **2** reacts too slowly to allow the suitable experiments to be conducted.

The absence of attack by water at a carbon other than the *pro*-carbonyl carbon simply reflects the directing effect of the aromatic ring conjugated with the multiple bond, i.e., the potential loss of conjugative stabilization requires that the solvent attack the *pro*-carbonyl carbon. This is somewhat unexpected, since the conjugative stabilization can be estimated from heats of hydrogenation data to be about 1-2 kcal/mol for **1** and a negative 1 kcal/mol for **2**.[4] These relatively small energies imply that loss of conjugation of the multiple bond with the aromatic group should not direct the nucleophilic attack as strongly as it apparently does. Perhaps this implies some sort of solvent participation prior to the complete loss of EtOH from the acetal moiety. Such participation is required in order to explain adequately the acid-catalyzed methanolysis/anomerization of glucopyranosides.[5]

Experimental Section

Solutions. Acidic solutions were made with standardized reagent grade hydrochloric acid or reagent grade standard buffers and distilled water. The pH of all solutions was measured experimentally and was consistent with the value calculated from the concentration of the reagents.

Materials. Acetals **2** and **3** were purchased from Aldrich Chemical Co.; acetal **1** was synthesized by using standard procedures.[2a]

Kinetic Method. The general methodology was as reported previously.[2c] Rate constants were measured at two or more wavelengths for each acetal, usually for increasing and decreasing absorbance changes. Absorbance versus time data were recorded with a Beckman Model 25 kinetic system.[2c] Conventional pseudo-first-order rate plot were prepared to calculate k_{obsd} values; k_{H^+} values were obtained from the slope of k_{obsd} versus $[H^+]$ plots (a log-log plot yielded unit slope).

Acknowledgment. The support of the National Science Foundation (Grant CHE-8421082) is gratefully acknowledged. R.S. thanks Edgington Oil Co. for support in this work.

Registry No. 1, 7148-78-9; 2, 6142-95-6; 3, 3054-95-3.

(3) Streitwieser, A. *Solvolytic Displacement Reactions*; McGraw-Hill: New York, 1962.
(4) Jensen, J. L. *Prog. Phys. Org. Chem.* **1976**, *12*, 189-228.
(5) Jensen, J. L.; Tsuang, S.-C.; Uslan, A. H. *J. Org. Chem.* **1986** *51*, 816-819.
(6) Cannon, K. A. M.S. Thesis, California State University, Long Beach, 1980.

Synthesis of 2,3-Norbornadienonaphthacene

Harish K. Patney

Department of Chemistry, School of Physical Sciences, University of Technology, Sydney, P.O. Box 123, Broadway, NSW 2007, Australia

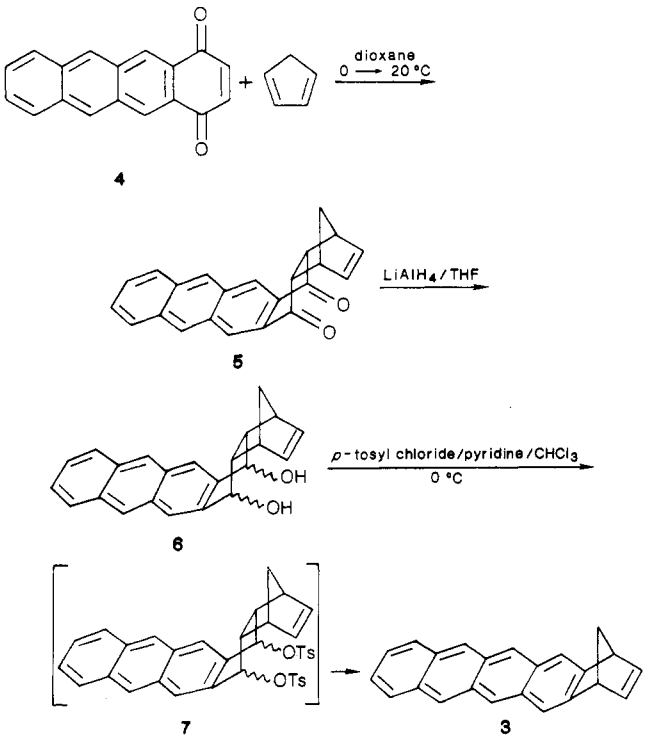
Received April 26, 1988

Norbornenyl-fused aromatic systems such as compounds **1** and **2** have recently claimed a special interest because of π-facial stereoselectivity.[1] We recently reported an improved synthesis of 2,3-norbornadienoanthracene (**2**)[2] and its application to the synthesis of anthracene annellated norbornenylogues. We now report here the synthesis of the next homologue in this series, the previously un-

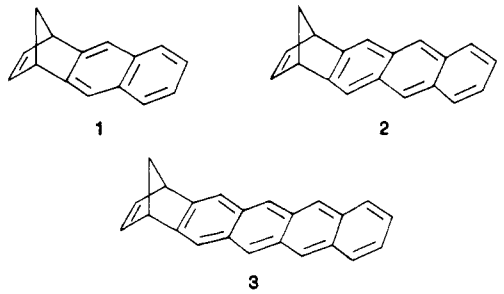
(1) Hayes, P. C.; Paquette, L. A. *J. Org. Chem.* **1983**, *48*, 1257.
(2) Patney, H. K.; Paddon-Row, M. N. *Synthesis* **1986**, 326.

0022-3263/88/1953-6106$01.50/0

Scheme I



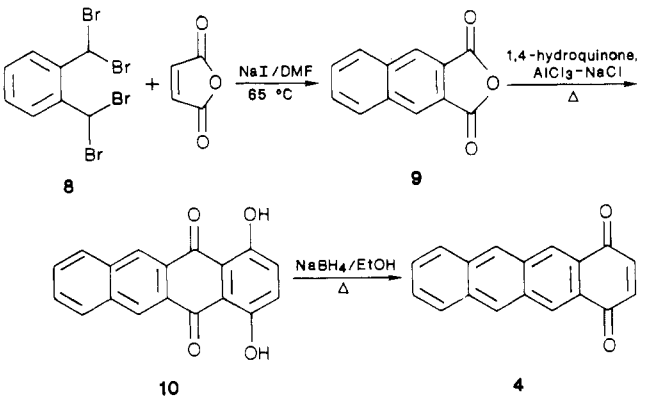
known 2,3-norbornadienonaphthacene (**3**) and study some of its Diels–Alder reactions with various dienophiles.



The synthetic strategy (Scheme I) is similar to the one employed by us in the synthesis of compound **2**[2] and simply involves Diels–Alder cycloaddition of cyclopentadiene to 1,4-naphthacenequinone (**4**). The adduct **5** was reduced with lithium aluminum hydride, giving rise to a mixture of diastereomeric diols **6**. This mixture when treated with *p*-toluenesulfonyl chloride and pyridine at 0 °C led directly to the formation of **3**. The intermediate **7** formed under these conditions underwent spontaneous dehydrotosylation. Overall yield of the reaction starting from 1,4-naphthacenequinone (**4**) was 22.5%.

1,4-Naphthacenequinone (**4**) was prepared according to the Scheme II. The precursor 2,3-naphthalic anhydride (**9**) was prepared in 84% yield from tetrabromo-*o*-xylene (**8**)[3,4] and maleic anhydride by treatment with sodium iodide in dimethylformamide. The same precursor can also be prepared by sodium dichromate oxidation of 2,3-dimethylnaphthalene to naphthalene-2,3-dicarboxylic acid, followed by its conversion to anhydride by treatment with acetic anhydride.[5] But the former method was preferred in this work due to its simplicity. An aluminum chloride catalyzed Friedel–Crafts acylation of 1,4-hydroquinone

Scheme II



with naphthalic anhydride (**9**) afforded an 66% yield of 1,4-dihydroxy-5,12-naphthacenequinone (**10**).[6] Reduction of **10** with sodium borohydride gave 1,4-naphthacenequinone (**4**) in almost quantitative yield.[2,7]

The naphthacene portion in **3** proved to be a very reactive diene component in Diels–Alder cycloaddition reactions. For example, it reacted with maleic anhydride (boiling xylene) within 30 min to yield a white crystalline solid in 88% yield. The ^{1}H NMR spectrum of this solid showed it to be a mixture of a number of compounds to which we assign the eight possible structures (**12a–15a**, syn/anti mixtures) (Scheme III), based upon the similar assignments given to the products of 2,3-norbornadienoanthracene (**2**) on maleic anhydride,[1] as well as reaction of naphthacene with various dienophiles.[8] Similarly **4** reacted with (*E*)-1,2-bis(phenylsulfonyl)ethylene (**11b**)[9] within 30 min (boiling cumene), giving rise to a product mixture, to which we assign the structures (**12b–15b**). The phenylsulfonyl substituents were converted to their respective olefins (**16–19**) by reduction with buffered sodium amalgam.[9] The presence of four compounds (**16–19**) was confirmed by subjecting the above mixture to GC–MS analysis, which showed the presence of four isomeric components in the approximate ratio of 2:1:2:7, all having a m/e (M^+) value of 318.

Experimental Section

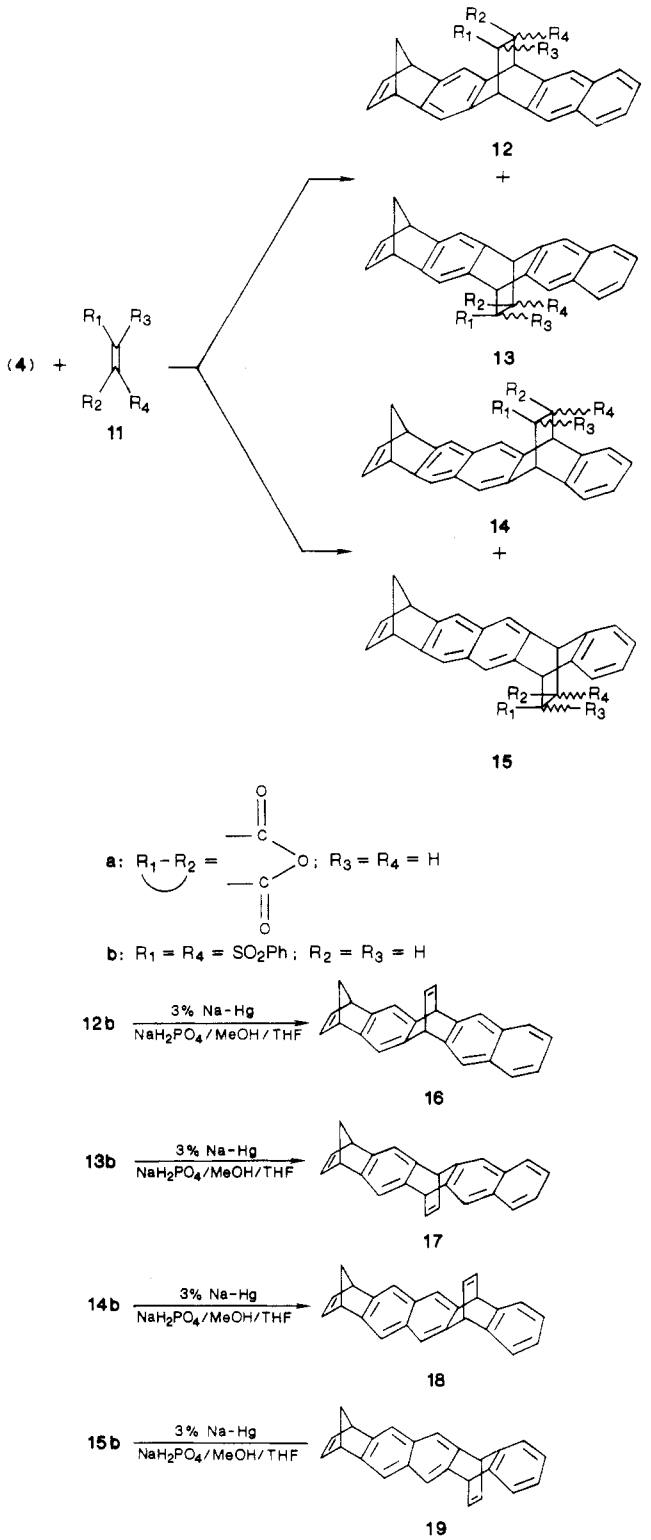
Melting points are uncorrected and were recorded on an electrothermal melting point apparatus. The ^{1}H NMR spectra were recorded on a JEOL PMX-60 (60 MHz) spectrometer with tetramethylsilane as an internal standard. Infrared spectra were recorded on a Hitachi Model 270-30 spectrophotometer. The ultraviolet spectra were recorded on a Shimadzu UV-240 spectrophotometer. Mass spectra were measured on an AEI MS 902-Pye 105 GLC–MS system.

Naphthalic Anhydride (9). A mixture of tetrabromide **8** (36.0 g, 85 mmol), maleic anhydride (4.9 g, 50 mmol), sodium iodide (80 g, 0.53 mol), and dry dimethylformamide (200 mL) was stirred at 65 °C for 16 h. The cooled reaction mixture was poured onto ice water (500 mL), and the brown color due to iodine was discharged by the gradual addition of aqueous sodium hydrogen sulfite. Filtration gave the yellow precipitate, which was recrystallized from acetone–petroleum ether (bp 40–60 °C) to give **9** (8.7 g, 87.6%) as light yellow crystals, mp 248 °C (lit.[5] mp 250–251 °C).

1,4-Dihydroxy-5,12-naphthacenequinone (10). To a fused mixture of sodium chloride (6.5 g) and anhydrous aluminum chloride (32.5 g) at 180–200 °C was added a mixture of **9** (6.5 g,

(3) Cava, M. P., Deana A. A.; Muth, K. *J. Am. Chem. Soc.* **1959**, *81*, 6458.
(4) Paddon-Row, M. N.; Patney, H. K. *Synthesis* **1986**, 328.
(5) Cava, M. P.; Van Meter, J. P. *J. Org. Chem.* **1969**, *34*, 538.
(6) Waldmann, H.; Mathiowetz, H. *Ber. Dtsch. Chem. Ges.* **1931**, 1713.
(7) Deschamps, A.; Cohen, A.; Abboud, J. *Bull. Soc. Chim. Fr.* **1965**, 2694.
(8) Meek, J. S.; Dewey, F. M.; Hanna, M. W. *J. Org. Chem.* **1967**, *32*, 69.
(9) Lucchi, O. De.; Lucchini, V.; Pasquato, L.; Modena, G. *J. Org. Chem.* **1984**, *49*, 596.

Scheme III



32.8 mmol) and hydroquinone (4.5 g, 41 mmol) in small portions. The temperature of the reaction mixture was raised to 210–220 °C, and the mixture was stirred mechanically for 3.5 h. During this time the whole reaction mixture turned into a solid mass that was difficult to stir. The solid mass was extracted with 50% aqueous hydrochloric acid (4 × 75 mL), and the precipitates were collected by filtration and dried under vacuum. The dried material was extracted in a soxhlet apparatus for 16 h, with xylene as the solvent. Upon cooling, the xylene solution deposited orange crystals of **10** (6.3 g, 66.2%), mp 308 °C (lit.[6] mp 304 °C).

1,4-Naphthacenequinone (4). To a stirred mixture of compound **10** (5.1 g, 17.6 mmol) and ethanol (250 mL) was added sodium borohydride (4.0 g, 0.11 mol) portionwise, and then the mixture was heated under reflux for 45 min. The cold blue violet solution was acidified with 2 M HCl, and the brown precipitate collected by filtration was washed with water (acid free) and dried under vacuum. The compound **4**, obtained in nearly quantitative yield, was pure enough to be used for the next step. However, an analytically pure sample of **4** was obtained by recrystallization from hot ethanol, mp 280–282 °C (lit.[7] mp 282–283 °C): ^{1}H NMR ($CDCl_3$) δ 7.00 (s, 2 H), 7.31–7.67 (m, 2 H), 7.77–8.13 (m, 2 H), 8.55 (s, 2 H), 8.70 (s, 2 H).

Cycloadduct 5 of 1,4-Naphthacenequinone (4) with Cyclopentadiene. Cyclopentadiene (0.66 g, 10 mmol) was added dropwise to a stirred mixture of **4** (1.13 g, 4 mmol) and dioxane (100 mL) at 0 °C, and stirring was continued for 90 min at the same temperature. The reaction mixture was allowed to warm to room temperature and stirred further for 16 h. The product mixture was concentrated on the rotary evaporator and diluted with petroleum ether (bp 40–60 °C). The adduct **5**, as dark yellow crystals, was collected by filtration (yield: 1.19 g, 91.8%): mp 262–264 °C dec; IR (film, NaCl plate) 3037, 3000, 2960, 2932, 2860, 1676, 1600, 1562, 1453, 1418, 1360, 1336, 1300, 1282, 1238, 960, 922, 910, 870, 742 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.58 (unresolved AB, 2 H), 3.54 (m, 2 H), 3.72 (m, 2 H), 6.00 (t, J = 1.5 Hz, 2 H), 7.40–7.60 (m, 2 H), 7.87–8.18 (m, 2 H), 8.58 (s, 2 H), 8.71 (s, 2 H); MS, m/e (M^+) calcd 324.1146, obsd 324.1141.

2,3-Norbornadienonaphthacene (3). To a stirred slurry of lithium aluminum hydride (250 mg, 6.6 mmol) in dry tetrahydrofuran was added dropwise a solution of **5** (780 mg, 2.4 mmol) in tetrahydrofuran (80 mL) at room temperature, and the mixture was stirred for 16 h. The reaction mixture was taken in ether (100 mL) and treated with wet sodium sulfate to destroy the excess hydride reagent. The ether–tetrahydrofuran layer was decanted off from the solids, and the latter was extracted with fresh ether–tetrahydrofuran (1:1, 3 × 20 mL) mixture. The combined organic extracts were evaporated to dryness on a rotary evaporator, and the crude product was recrystallized from acetone–ether to give diastereomeric mixture of diols **6** (680 mg, 86%): mp 214–216 °C; IR (film, NaCl plate) 3320, 3052, 2922, 2833, 1640, 1453, 1425, 1326, 1075, 1023, 920, 906, 743 cm^{-1}; ^{1}H NMR ($CDCl_3$ + DMSO-d_6) δ 1.27 (unresolved AB, 2 H), 2.93 (s, OH, D_2O exch), 3.10 (m, 4 H), 4.95 (s, OH, D_2O exch), 5.03 (m, 2 H), 5.14 (m, 2 H), 7.27–7.63 (m, 2 H), 7.73–8.13 (m, 2 H), 7.85 (s, 2 H), 8.28 (s, 2 H).

To a stirred mixture of diols **6** (1.10 g, 3.35 mmol), pyridine (3.3 mL), and chloroform (16 mL) was added at 0 °C *p*-toluenesulfonyl chloride (2.56 g, 13.4 mmol) in small portions. The reaction mixture was stirred at the same temperature for 7 h and then left in the freezer for 40 h, after which time it was poured onto crushed ice. The aqueous phase was extracted with dichloromethane (8 × 20 mL), and the combined dichloromethane extracts were washed with ice–cold 1 M hydrochloric acid (30 mL), ice–cold water (30 mL), 10% aqueous sodium hydrogen carbonate (30 mL), and brine (20 mL) and passed through a short column of neutral alumina. Evaporation of solvent, followed by recrystallization from hot toluene gave pure 2,3-norbornadienonaphthacene (**3**) (280 mg, 28.6%) as golden yellow plates: mp > 360 °C; IR (KBr) 3052, 2968, 2920, 2848, 1466, 1450, 1430, 1365, 1311, 1295, 1232, 1124, 958, 912, 860, 822, 735, 705, 462 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.27 (unresolved AB, 2 H), 3.97 (m, 2 H), 6.66 (br s, 2 H), 7.13–7.53 (m, 2 H), 7.63 (s, 2 H), 7.77–8.10 (m, 2 H), 8.40 (s, 2 H), 8.55 (s, 2 H); UV max (benzene) 460 (log ϵ 3.65), 433 (log ϵ 3.68), 408 (log ϵ 3.63), 402 (log ϵ 3.52), 387 (log ϵ 3.61), 368 nm (log ϵ 3.32); MS, m/e (M^+) calcd 292.1248, obsd 292.1241. Anal. Calcd for $C_{23}H_{16}$: C, 94.48; H, 5.52. Found: C, 94.22; H, 5.26.

Reaction of 3 with Maleic Anhydride. A mixture of **3** (34.6 mg, 0.12 mmol) and maleic anhydride (11.6 mg, 11.8 mmol) in xylene (1 mL) was heated under reflux for 30 min. The cooled solution was diluted with ether, and the precipitated white adduct, a mixture of **12a–15a** (39 mg, 84.8%), was collected by filtration: IR (film, NaCl plate) 3054, 2958, 2923, 2860, 1867, 1780, 1743, 1460, 1380, 1284, 1226, 1200, 1075, 924, 755 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.00–2.47 (m, 2 H), 3.52 (m, 2 H), 3.70–4.07 (m, 2 H), 4.85 (m, 2 H), 6.67 (m, 2 H), 7.00–7.90 (m, 8 H); MS, m/e (M^+) calcd 390.1251, obsd 390.1243.

Reaction of 3 with (*E*)-1,2-Bis(phenylsulfonyl)ethylene (11b). A mixture of **3** (146 mg, 0.5 mmol) and (*E*)-1,2-bis(phe-

nylsulfonyl)ethylene[9] (**11b**) (191 mg, 0.6 mmol) in xylene (5 mL) was heated under reflux for 30 min. The cooled solution was diluted with ether, and the white adduct **12b–15b** (277 mg, 92.5%) was collected by filtration: ^{1}H NMR ($CDCl_3$) δ 2.27 (m, 2 H), 3.68–4.05 (m, 2 H), 4.10 (m, 2 H), 4.90 (m, 2 H), 6.65 (m, 2 H), 7.00–8.05 (m, 18 H).

Sodium Amalgam Reduction of Adducts 12b–15b. A mixture of adducts **12b–15b** (272 mg, 0.45 mmol) was taken up in dry tetrahydrofuran (5 mL) and methanol (10 mL), containing sodium dihydrogen phosphate (1.2 g), and purged with nitrogen. With efficient stirring, 3% sodium amalgam (ca. 2.5 g) was added in small portions. After 16 h, the mixture was filtered through a Celite pad and poured onto brine (20 mL). The solvent was evaporated off on the rotary evaporator, and the aqueous residues were extracted with dichloromethane (4 × 20 mL). The combined organic layer was washed with water (2 × 20 mL) and brine (20 mL), dried (Na_2SO_4), and evaporated to give **16–19** as a light yellow solid (140 mg, 97.8%). GC–MS analysis of this mixture showed it to be an isomeric mixture of four components, in the approximate ratio of 2:1:2:7 (column used: 12 m × 0.32 mm (i.d.), packed with fused silica–BP_1 type, column temperature 250 °C, isothermal conditions), all with the m/e (M^+) of 318: IR (film, NaCl plate) 3054, 3000, 2960, 2930, 1460, 1448, 1322, 1305, 1283, 1264, 1225, 1181, 1145, 1133, 1098, 1082, 903, 879, 838, 817, 746, 738, 704, 681 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 2.20 (m, 2 H), 3.50–3.95 (m, 2 H), 5.02 (m, 2 H), 6.57 (m, 2 H), 6.70–7.75 (m, 10 H); MS, m/e (M^+) calcd 318.1404, obsd 318.1396.

Acknowledgment. I wish to thank J. Keegan for running the mass spectra and L. Ambrose for some technical assistance. I also wish to thank L. Green for the drawings.

Registry No. **3**, 117202-21-8; **4**, 15098-01-8; **5**, 117202-22-9; **6**, 117202-23-0; **8**, 13209-15-9; **9**, 716-39-2; **10**, 18071-92-6; **11b**, 963-16-6; **12a**, 117202-24-1; **12b**, 117202-26-3; **13a**, 117305-58-5; **13b**, 117305-60-9; **14a**, 117202-25-2; **14b**, 117202-27-4; **15a**, 117305-59-6; **15b**, 117305-61-0; **16**, 117202-28-5; **17**, 117305-62-1; **18**, 117202-29-6; **19**, 117305-63-2; maleic anhydride, 108-31-6; 1,4-hydroquinone, 123-31-9; cyclopentadiene, 542-92-7.

A Convenient Stereoselective Synthesis of 1,2,3-Aminodiols from α-Amino Acids

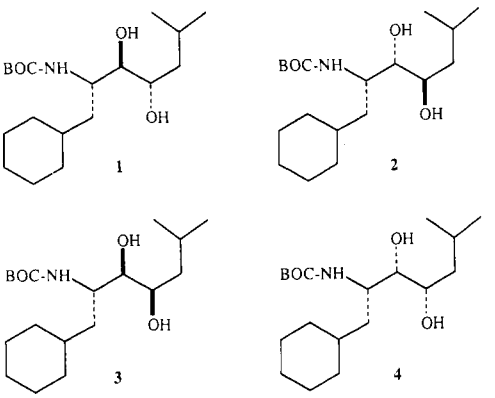
Jay R. Luly,* Chi-Nung Hsiao, Nwe BaMaung, and Jacob J. Plattner

Abbott Laboratories, Pharmaceutical Products Division, Abbott Park, Illinois 60064

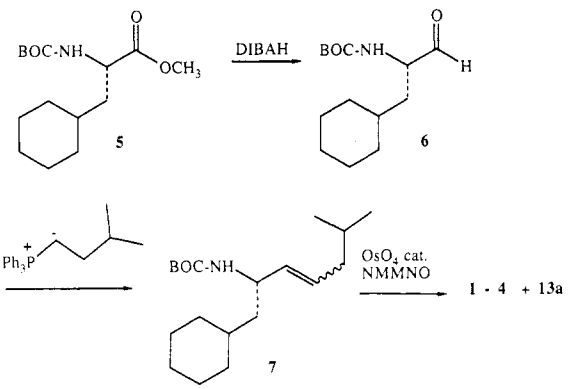
Received May 23, 1988

Recently, we reported that dipeptides attached to appropriately substituted amino diols **1–4** (Chart I) are potent inhibitors of the aspartic proteinase renin.[1] If the diol were mimicking the transition state for hydrolysis of the Leu[10]–Val[11] amide bond of the enzyme substrate, angiotensinogen, then one might expect a stereochemical bias for the diol geometry in the active site. Therefore, we initially sought a synthesis which, from naturally occurring L-amino acids, would provide a synthesis of all four diastereomeric diols, realizing that after definition of the most active isomer, a highly diastereoselective route would be necessary.

Chart I



Scheme I



In this paper, we describe routes that proceed with low and high diastereoselectivity. Using an extension of our methylide olefination procedure of Boc-protected α-amino aldehydes,[2] we were able to olefinate Boc-(cyclohexyl)-alaninal **6**, derived from ester **5**[3], to give a cis/trans mixture of olefins **7**[1a,c] (Scheme I). This one-flask manipulation provided **7** in 50–60% yield (from **5**) and in 99% ee as was determined by conversion to the (+)- and (−)-MTPA amides.[1c] Diols **1–4**, as well as trace and variable amounts of hydroxy ketone **13a**, were then obtained by catalytic osmylation with little olefin facial selectivity. Although all four diol isomers were readily separable by silica gel chromatography, anti isomers **1** and **2** were obtained in higher yield due to slight preferential formation of *cis*-**7** over *trans*-**7** in the olefination step.[4]

Simultaneously, we explored an epoxidation route that would be expected to favor the formation of syn isomers **3** and **4**. Allylic alcohol **8** (*R*:*S*, 1:1), prepared by Swern oxidation of alcohol **10a** followed by vinyl Grignard addition, was chosen for initial study. Treatment of **8** with MCPBA for 14 h in dichloromethane provided a mixture of epoxides **9**. Since attempted purification of the isomers of **9** by silica gel chromatography led to severely reduced yields, crude **9** was used in the copper-catalyzed reaction[5] with isopropylmagnesium chloride. Assuming preferential

(1) (a) Luly, J. R.; Fung, A. K. L.; Plattner, J. J.; Marcotte, P.; BaMaung, N.; Soderquist, J. L.; Stein, H. In *Peptides: Chemistry and Biology*; Marshall, G. R., Ed.; ESCOM Science Publishers B.V.: Leiden, The Netherlands, 1988; p 487. (b) Kleinert, H. D.; Luly, J. R.; Marcotte, P. A.; Perun, T. J.; Plattner, J. J.; Stein, H. *FEBS Lett.* **1988**, *230*, 38. (c) Luly, J. R.; BaMaung, N.; Soderquist, J.; Fung, A. K. L.; Stein, H.; Kleinert, H. D.; Marcotte, P. A.; Egan, D. A.; Bopp, B.; Merits, I.; Bolis, G.; Greer, J.; Perun, T.; Plattner, J. J. *J. Med. Chem.*, in press.

(2) Luly, J. R.; Dellaria, J. F.; Plattner, J. J.; Soderquist, J. L.; Yi, N. *J. Org. Chem.* **1987**, *52*, 1487.

(3) Boger, J.; Payne, L. S.; Perlow, D. S.; Lohr, N. S.; Poe, M.; Blaine, E. H.; Ulm, E. H.; Schorn, T. W.; LaMont, B. I.; Lin, T.-Y.; Kawai, M.; Rich, D. H.; Veber, D. F. *J. Med. Chem.* **1985**, *28*, 1779.

(4) Syn diols **3** and **4** are formed by osmylation of *trans*-**7** while anti diols **1** and **2** are derived from *cis*-**7**. The relative stereochemistry of the adjacent carbons bearing the amino and hydroxyl groups was established by cyclization to the oxazolidinones and measurement of the chemical shifts of the ring hydrogens.[1c]

(5) (a) Huynh, C.; Derguini-Boumechal, F.; Linstrumelle, G. *Tetrahedron Lett.* **1979**, 1503. (b) Brockway, C.; Kocienski, P.; Pant, C. *J. Chem. Soc., Perkin Trans. 1* **1984**, 875.

0022-3263/88/1953-6109$01.50/0