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Diastereoselective Addition of α-Hydroxyalkyl and α-Alkoxyalkyl Radicals to Chiral 4-Methyleneoxazolidin-5-ones

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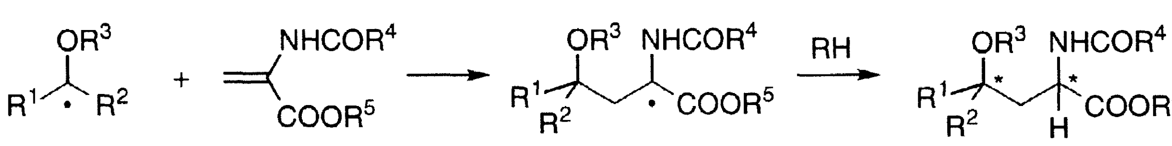
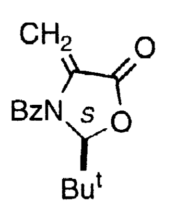
Abstract: A method for preparing optically active homoserine derivatives via the photoinduced radical additions of alcohols and ethers to the chiral 4-methyleneoxazolidin-5-ones **1** and **2** has been achieved. These photoadducts, however, are readily prone to epimerization under the conditions required for their deprotection. © 1998 Elsevier Science Ltd. All rights reserved.

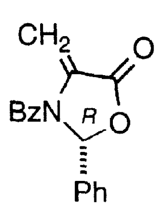
L-Homoserine and its derivatives are useful building blocks for the synthesis of unnatural amino acids, including γ-seleno-, γ-thio- and γ-phosphono-derivatives.[1,2] Some of these compounds have interesting biological activities.[3] In principle, homoserines can be obtained from the addition of α-hydroxyalkyl and α-alkoxyalkyl radicals to α,β-didehydroamino acids (eq 1). Optically active versions of these target compounds could, in principle, be obtained if either the α-hydroxyalkyl and α-alkoxyalkyl radical were chiral or the α,β-didehydroamino acid was chiral. Indeed, a readily available chiral auxiliary for α-hydroxyalkyl radicals has been recently developed by Garner.[4] In this paper we report our studies aimed at preparing optically active homoserine derivatives from the photoinduced radical additions of alcohols and ethers to the chiral, cyclic α,β-didehydroamino acid derivatives, the (2*S*)[5] and (2*R*)[6] 4-methyleneoxazolidin-5-ones **1** and **2**, respectively.

(eq 1)





1



2

While the photochemical induced addition of alcohols to α,β–unsaturated carbonyl[7] and sulfur[8] compounds has been well documented, reports of these reactions involving α,β-didehydroamino acids as

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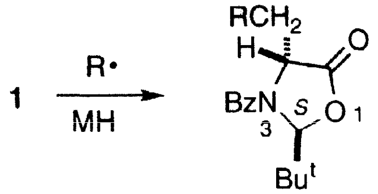
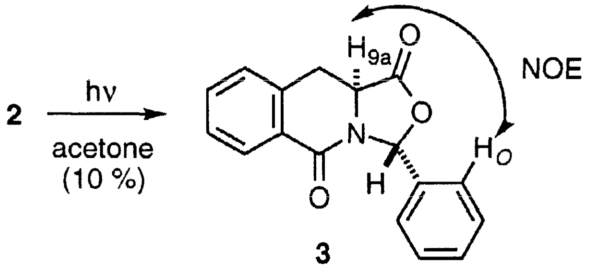
substrates have not been reported as far as we are aware. The addition of radicals to **1** has been reported by Beckwith.[9] These reactions proceed with moderate to excellent diastereoselectivities, depending upon the nature of the radical, and favoured formation of *trans* 2,4-disubstituted-oxazolidinones (eq 2).



(eq 2)

Results and Discussion

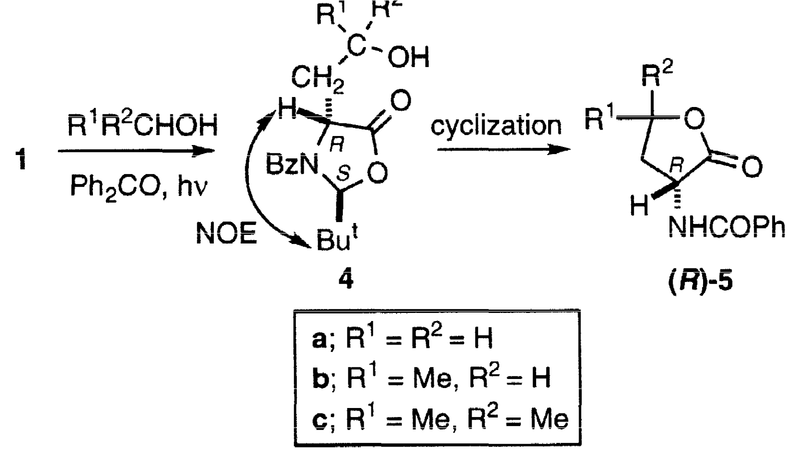
In some preliminary studies on the photolytic stability of **1** and **2** upon irradiation in acetone we found that both **1** and **2** gave numerous products after irradiation with a medium pressure mercury lamp (140 W) for 1 h. Only in the case of **2** could any discrete product be isolated, that being the photocyclization product **3** in 10 % isolated yield. The formation of similar tricyclic products from the photocyclization of related *N*-aryl-enaminoketones[10] and lactones[11] is well known. The stereochemistry of **3** was evident from NOESY experiments that showed cross peaks between the signals for the ortho proton H_O and H9a.



Photoinduced Reactions of 1 and 2 with Alcohols

Photolysis of a solution of **1** in neat alcohol (R^1R^2CHOH) in the presence of the sensitiser benzophenone (1 molar equiv.) for 1h at ambient temperature (water cooled system) gave mixtures of the photoadducts **4** and their cyclized products, the lactones **5** (Scheme 1). When methanol was employed as the solvent then ^{1}H NMR analysis of the crude photolysis mixture showed the formation of a photoadduct as a 77 : 23 mixture of diastereoisomers (major: δ 6.08 (s, H2), 1.05 (s, Bu^t); minor: δ 6.06 (s, H2), 0.94 (s, Bu^t)). We assume the major and minor diastereoisomers are **4a** and its 2,4-*cis* diastereoisomer, respectively. Attempted purification of **4a** on silica gel gave the lactone **5a** in low yield (30%), however, none of the photoadduct **4a** was isolated. Photolysis of a solution of **1** in ethanol or isopropanol gave the photoadducts **4b** (d. r. = 58 : 42) and **4c** (d. r. = >98 : <2), respectively, from ^{1}H NMR analysis of the crude reaction mixtures. Purification of these crude photolysis mixtures on silica gel gave pure samples of **4b/5b** and **4c/5c**, respectively (Scheme 1). The 4*R* stereochemistry of both diastereoisomers of **4b** and that of **4c** was evident from NOESY experiments which showed NOE cross peaks between H4 and the C2 Bu^t group. The moderate yields obtained from these reactions prompted us to examine the direct hydrolysis/cyclization of the crude photolysis product from the reaction of **1** and isopropanol. Hydrolysis of the crude photoadduct **4c** with 6N HCl at 90 °C for 12 h gave, after purification by recrystallization from ethanol/ether, the hydrochloride salt of the α-amino lactone (*R*)-**6** in 90 % overall yield from **1** (Scheme 2). The enantiomeric purity of (*R*)-**6**, however, was 56 % based on ^{1}H NMR analysis of its Mosher amide (*R*,*S*)-**7** (78 : 22 mixture of diastereoisomers). The low ee of **6** indicated that epimerization at the α-carbon of **6** must have occurred during the acid hydrolysis conditions since **4c** was essentially diastereomerically pure and the enantiomeric purity of **1** was >98 %.[6] Unfortunately, less harsh hydrolysis conditions, in which epimerization would be less likely, did not completely hydrolyse the benzamide group of **5c**.

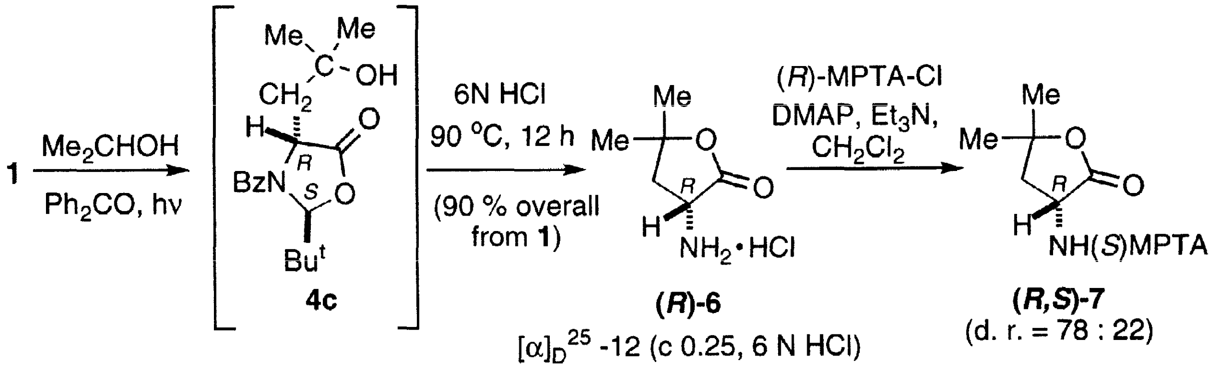
Scheme 1



a; $R^1 = R^2 = H$
b; $R^1 = Me$, $R^2 = H$
c; $R^1 = Me$, $R^2 = Me$

R^1	R^2	Yield (%)	
		4 (d. r.)	**5** (d. r.)
H	H	0	30
Me	H	23 (58 : 42)	30 (55 : 45)
Me	Me	17 (>98 : < 2)	36

Scheme 2

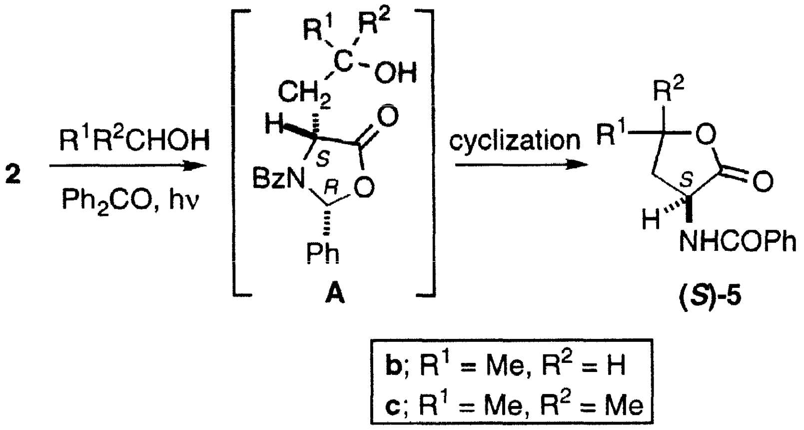


(R)-6
$[\alpha]_D^{25}$ -12 (c 0.25, 6 N HCl)

(R,S)-7
(d. r. = 78 : 22)

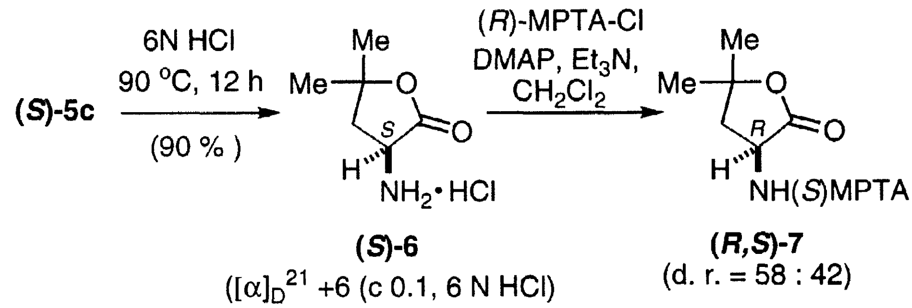
In contrast, the photolysis of **2** in ethanol or isopropanol lead directly to the lactones **5b** and **5c**, respectively in moderate yields (54 %, Scheme 3). The intermediate photoadducts **A** could not be detected in the crude photolysis product mixtures. The lactone **5b** was a 55 : 45 mixture of diastereoisomers. Acid hydrolysis of the lactone (*S*)-**5c** gave the hydrochloride salt of the amine (*S*)-**6** in 90 % (Scheme 4). The *S* stereochemistry of this salt was evident from the positive sign of its specific rotation which was opposite in sign to (*R*)-**6** described above in Scheme 2. The enantiomeric purity of (*S*)-**6** was 16 % from ^1H NMR analysis of its Mosher amide (*R*,*S*)-**7** a value much lower than that found for its enantiomer (*R*)-**6**. The low enantiomeric purity of (*S*)-**6** might be due to the low diastereoselectivity in the formation of **A** (R^1 = Me, R^2 = H), however this compound could not be detected by ^1H NMR and thus its d. r. could not be measured. However, the different magnitudes for the specific rotations of (*R*)-**6** ($[\alpha]_D^{25}$ -12 (c 0.25, 6N HCl) and (*S*)-**6** ($[\alpha]_D^{21}$ +6 (c 0.1, 6N HCl)), suggested that the formation of **A** (R^1 = R^2 = Me) was less diastereoselective than the formation of its *tert*-butyl analogue **4c**.

Scheme 3



R^1	R^2	Yield (%) of (*S*)-5 (d. r.)
Me	H	54 (55 : 45)
Me	Me	54

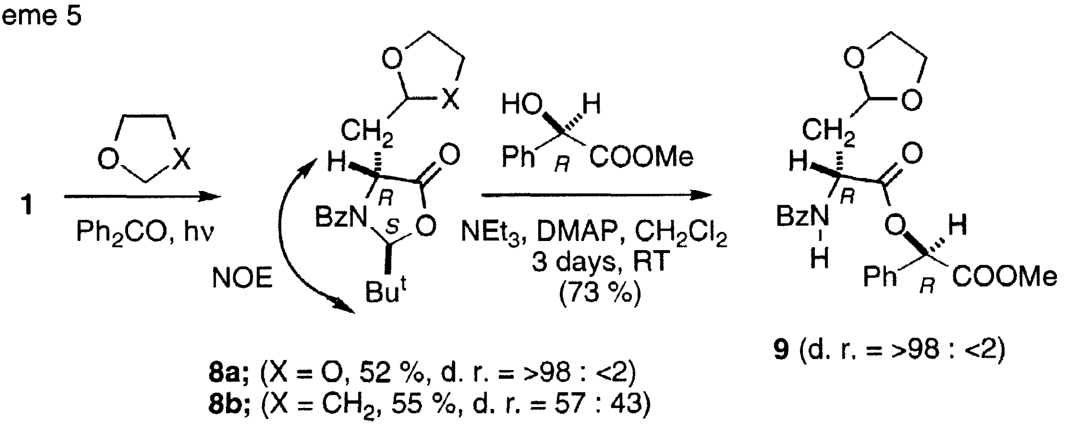
Scheme 4



Photoinduced Reactions of 1 and 2 with Ethers

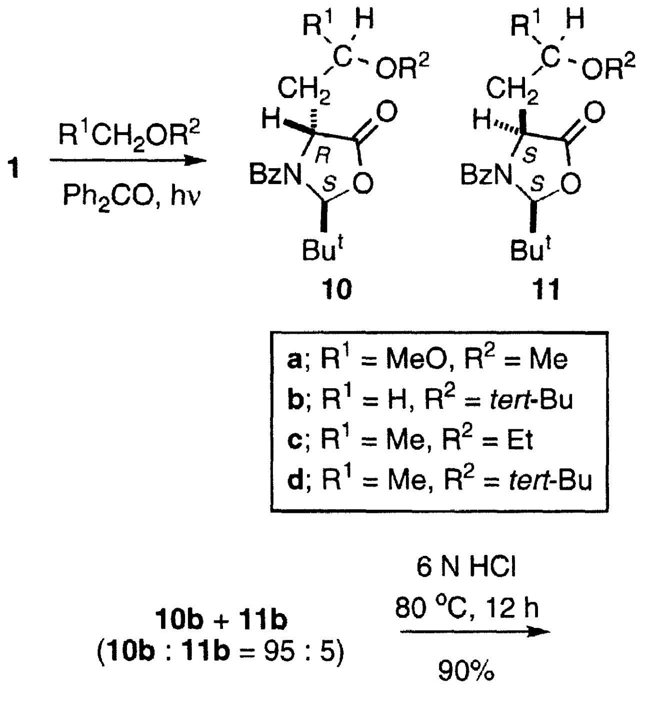
The photolysis products from **1** and the cyclic ethers, 1,3-dioxolane and THF, are shown below in Scheme 5. The photochemical induced reaction of **1** with 1,3-dioxolane gave the photoadduct **8a** as a single diastereoisomer in 52 % yield after column chromatography. While that with THF gave a 57 : 43 mixture of diastereoisomeric photoadducts **8b** in 55 % yield (Scheme 5). All three adducts (**8a** and the two diastereoisomers of **8b**) had the 2,4-*trans* stereochemistry from NOESY experiments (Scheme 5). The enantiomeric purity of **8a** was > 96 % from ^{1}H NMR analysis of its ester derivative **9** that was prepared from the reaction of **8a** and methyl (*R*)-mandelate under mild based catalysed conditions.

Scheme 5



Photoinduced reactions of the acyclic ethers, dimethoxymethane and *tert*-butyl methyl ether with **1** gave mixtures of the 2,4-*trans* and 2,4-*cis*-adducts **10** and **11** respectively in poor yields (Scheme 6), while the reaction of diethyl ether and *tert*-butyl ethyl ether with **1** gave a mixture of four and three diastereoisomeric products, respectively. In these latter two reactions, the major adducts (**10c** and **10d**, respectively) had the 2,4-*trans* stereochemistry of the oxazolidinone ring (from NOESY studies) but were formed as a mixture of epimers at the exocyclic stereogenic centre (Scheme 6). A 95 : 5 mixture of **10b** and **11b** was hydrolysed with 6N HCl to give after purification (*R*)-**12**. The enantiomeric purity of this compound was estimated as 62 % based upon its specific rotation ($[\alpha]_D^{20}$ -20 (c 0.1, 6N HCl) when compared to the literature value ($[\alpha]_D$ -32 (c 0.2, 2N HCl)).[12]

Scheme 6



10 **11**

R^1	R^2	Yield (%) of **10/11** (**10** : **11**)
MeO	Me	16 (83 : 17)
H	*tert*-Bu	36 (85 : 15)
Me	Et	40 (88[a] : 12[b])
Me	*tert*-Bu	48 (75[c] : 25)

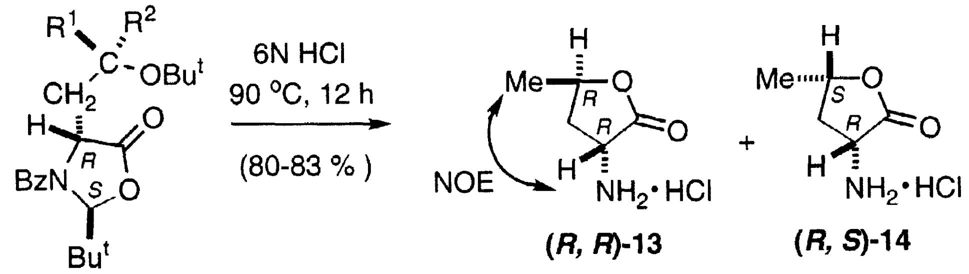
[a] 55 : 45 mixture of diastereoisomers
[b] 67 : 33 mixture of diastereoisomers
[c] 52 : 48 mixture of diastereoisomers

a; R^1 = MeO, R^2 = Me
b; R^1 = H, R^2 = *tert*-Bu
c; R^1 = Me, R^2 = Et
d; R^1 = Me, R^2 = *tert*-Bu

(*R*)-12
$[\alpha]_D^{20}$ -20 (c 0.1, 6N HCl)
lit. (ref. 12), $[\alpha]_D$ -32 (c 0.2, 2N HCl)

The two 2,4-*trans* diastereoisomers of **10d** could be separated by column chromatography and the individual isomers were subjected to acid catalysed hydrolysis (Scheme 7). The major diastereoisomer of **10d** gave mainly the *trans*-lactone **13** from NOESY experiments that showed cross peaks between the resonances for the γ-methyl group and the α-proton. The minor diastereoisomer of **10d** gave mainly the *cis*-lactone **14**

Scheme 7



(*R*, *R*)-13 **(*R*, *S*)-14**

10d (major); R^1 = H, R^2 = Me
10d (minor); R^1 = Me, R^2 =H

(**13** : **14** = 71 : 29, from **10d** (major))
(**13** : **14** = 9 : 91, from **10d** (minor))

that did not show any NOE between the γ-methyl group and the α-proton. Each hydrolysis reaction, **however gave a mixture of the two diastereoisomers 13 and 14** and the ratio of these diastereoisomers changed with **time** as monitored by ^{1} **H NMR.** For example, immediately after the hydrolysis of the minor diastereoisomer of **10d** the ratio of **14** : **13** was 91 : 9, however after the NMR sample had stood for 3 days the ratio had changed to 74 : 26. The ^{1}H NMR data for (*R*, *R*)-**13** and (*S*, *R*)-**14** from this study closely matched that reported in the literature for (*S*, *S*)-**13**[13-15] or (*R*, *R*)-**13**[13,16,17] and (*S*, *R*)-**14**,[14, 16-18] respectively.[19]

In conclusion, a method for preparing optically active homoserine derivatives via the photoinduced radical additions of alcohols and ethers to the chiral 4-methyleneoxazolidin-5-ones **1** and **2** has been achieved. These photoadducts, however, are prone to epimerization under the conditions required for their deprotection. Other protecting groups at the oxazolidinone nitrogen (e.g. Boc) may allow the synthesis of these compounds in higher enantiomeric purities.[20]

Experimental

General procedures were as described previously.[6] All NMR were determined in $CDCl_3$ solution, unless otherwise indicated, at 300 MHz (^{1}H NMR) or 77.5 MHz (^{13}C NMR). When D_2O was employed as the NMR solvent then 1,4-dioxane (67.8 ppm for ^{13}C) was used as an internal reference. Photolyses were carried out in a water cooled pyrex immersion-well reactor with the light from a 140 W mercury lamp. Prior to photolysis, nitrogen was bubbled through the reaction mixture for 0.5 h.

(3R,9aS)-*5-oxo-3-phenyloxazolidino[3,4-b]-3aH-4-oxo-9,9a-dihydroisoquinoline* (3). The oxazolidinone (**2**) (100 mg, 0.36 mmol) was dissolved in dry acetone (150ml) and photolysed under an atmosphere of nitrogen for 1 h. After removal of the solvent under reduced pressure the crude residue was chromatographed on silica gel, eluting with 10% ethyl aceate in light petroleum, to afford **3** as a white solid (10 mg, 10%), m.p. 129-132°C (Found : C, 73.3; H, 4.5; N, 4.9%. $C_{17}H_{13}NO_3$ requires C, 73.1; H, 4.7; N, 5.0%). $[\alpha]^{25}_D$ -90° (c, 0.08 in $CHCl_3$). ^{1}H n.m.r. δ 3.26, app. t, J 12.9 Hz, 1H, H-9α; 3.37, dd, J 15.6, 6.0 Hz, 1H, H-9β; 4.62, dd, J 12.9, 6.0 Hz, 1H, H-9a; 7.18, s, 1H, H-3; 7.31, d, J 7.5 Hz, 1H, H-8; 7.40-7.42, m, 4H, ArH; 7.51-7.55, m, 3H, ArH; 8.01, dd, J 7.5, 1.5 Hz, 1H, H-5. ^{13}C n.m.r. δ 29.68, CH_2; 52.17, CH; 88.45, CH; 125.85, CH; 127.78, CH; 128.07, CH; 128.17, CH; 128.60, C; 128.93, CH; 129.85, CH; 133.05, CH; 134.61, C; 135.66, C; 160.95, CO; 171.31, CO. Mass spectrum *m/z* 280 (M + H^+, 65%), 146 (65), 60 (100).

General Method: Photolysis of (2S)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Isopropyl Alcohol. A mixture of the oxazolidinone **1** (100 mg, 0.39 mmol) and benzophenone (70 mg, 0.39 mmol) in dry isopropyl alcohol (150ml) was photolysed under an atmosphere of nitrogen for 1 h. The reaction mixture was concentrated under reduced pressure and chromatographed on silica gel, eluting with 10% ether in light petroleum, to afford 2 compounds. The first compound was isolated as a colourless oil and identified as **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-hydroxy-2'-methylpropyl)oxazolidin-5-one*** (**4c**) (27 mg) in 23% yield. (Found : $M^{+\bullet}$ + H^+, 320.1827. $C_{18}H_{26}NO_4$ requires 320.1862). $[\alpha]^{22}_D$ -3° (c, 0.20 in $CHCl_3$). ^{1}H n.m.r. δ 0.95, s, 9H; 1.19, s, 3H, CH_3; 1.21, s, 3H, CH_3; 2.00, dd, J 14.7, 3.0 Hz, 1H, H-1'α; 2.20, dd, J 14.7, 9.6 Hz, 1H, H-1'β; 3.53, br. s, 1H, OH; 4.57, dd, J 9.9, 3.0 Hz, 1H, H-4; 6.11, s, 1H, H-2; 7.35-7.56, m, 5H, ArH. ^{13}C n.m.r. δ 25.03, CH_3; 28.47, CH_3; 30.41, CH_3; 37.11, C; 46.80, CH_2; 54.84, CH; 68.79, C; 96.11, CH; 126.51, CH; 128.94, CH; 130.50, CH; 135.44, C; 173.18, CO; 174.22, CO. Mass spectrum *m/z* 320 (M + H^+, 63%), 234 (100). The second compound was obtained as a white solid and identified as **(R)-*α-benzamido-γ,γ-***

dimethyl-γ-butyrolactone **(5c)** (33 mg, 36%), m.p. 150-153°C (Found : C, 66.7; H, 6.6; N, 5.6%. $C_{13}H_{15}NO_3$ requires C, 66.9; H, 6.5; N, 6.0%). $[\alpha]^{22}_{D}$ + 12° (c, 0.30 in $CHCl_3$). ^{1}H n.m.r. δ 1.40, s, 3H, CH_3; 1.45, s, 3H, CH_3; 2.03, app. t, J 12.3 Hz, 1H, H-βa; 2.66, dd, J 12.6, 9.0 Hz, 1H, H-βb; 4.91-5.02, m, 1H, H-α; 7.10, br. s, 1H, NH; 7.27-7.71, m, 5H, ArH. ^{13}C n.m.r. δ 26.99, CH_3; 28.87, CH_3; 41.99, CH_2; 50.59, CH; 83.08, C; 127.11, CH; 128.49, CH; 131.89, CH; 132.94, C; 167.47, CO; 175.27, CO. Mass spectrum *m/z* 234 (M + H^{+}, 100%), 122 (48), 105 (48).

Photolysis of (2*R*)-3-Benzoyl-4-methylene-2-phenyloxazolidin-5-one (2) in Isopropyl Alcohol. The photolysis of **2** (100 mg, 0.36 mmol) in isopropyl alcohol (150 ml) and benzophenone (65 mg, 0.36 mmol) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded ***(S)-α-benzamido-γ,γ-dimethyl-γ-butyrolactone*** **(5c)** as the sole product (45 mg, 54%), isolated as a white solid, m.p. 155-158°C. $[\alpha]^{22}_{D}$ - 11° (c, 0.10 in $CHCl_3$). The spectral data of this compound were identical to that reported above for (*R*)-**5c**.

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Ethanol. The photolysis of **1** (100mg, 0.36 mmol) in ethanol (150 ml) was carried out as above. Column chromatography, eluting with 10% ether in light petroleum, afforded 2 fractions. Fraction 1 yielded a colourless oil (27 mg, 23%) which was identified as **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-hydroxypropyl)oxazolidin-5-one*** **(4b)**, isolated as an inseparable mixture of two diastereomers (58:42). Major isomer: (Found : $M^{+\bullet}$ + H^{+}, 306.1716. $C_{17}H_{24}NO_4$ requires 306.1705). ^{1}H n.m.r. δ 0.99, s, 9H; 1.09, d, J 6.3 Hz, 3H, CH_3; 1.87, ddd, J 14.1, 9.9, 3.6 Hz, 1H, H-1'α; 2.10, ddd, J 13.8, 9.6, 2.7 Hz, 1H, H-1'β; 3.60, br. s, 1H, OH; 3.96-4.06, m, 1H, H-2'; 4.45, dd, J 9.9, 3.6 Hz, 1H, H-4; 6.11, s, 1H, H-2; 7.32-7.49, m, 5H, ArH. ^{13}C n.m.r. δ 23.53, CH_3; 25.12, CH_3; 36.99, C; 43.53, CH_2; 54.98, CH; 64.58, CH; 95.74, CH; 126.76, CH; 128.76, CH; 130.66, CH; 135.38, C; 172.83, CO; 173.67, CO. Mass spectrum *m/z* 306 (M + H^{+}, 100%), 237 (50), 220 (95), 105 (80). Minor isomer: ^{1}H n.m.r. δ 0.92, s, 9H; 1.11, d, J 6.3 Hz, 3H, CH_3; 1.53, ddd, J 8.7, 6.3, 6.3 Hz, 1H, H-1'α; 2.00, ddd, J 5.7, 5.7, 3.3 Hz, 1H, H-1'β; 3.60, br. s, 1H, OH; 3.96-4.06, m, 1H, H-2'; 4.55, dd, J 9.0, 5.7 Hz, 1H, H-4; 6.08, s, 1H, H-2; 7.32-7.49, m, 5H, ArH. ^{13}C n.m.r. δ 22.98, CH_3; 24.81, CH_3; 36.01, C; 43.42, CH_2; 56.57, CH; 64.96, CH; 96.36, CH; 126.55, CH; 128.90, CH; 130.51, CH; 133.50, C; 172.83, CO; 173.67, CO. Fraction 2 yielded a colourless oil (26 mg, 30%) which was identified to be the lactone **(R)-*α-benzamido-γ-methyl-γ-butyrolactone*** **(5b)**, isolated as an inseparable mixture of two diastereomers (55:45). (major isomer) : (Found : $M^{+\bullet}$ + H^{+}, 220.0977. $C_{12}H_{14}NO_3$ requires 220.0974). ^{1}H n.m.r. δ 1.46, d, J 6.6 Hz, 3H, CH_3; 2.40, ddd, J 12.6, 10.2, 8.4 Hz, 1H, H-βa; 2.57, ddd, J 12.6, 9.6, 2.1 Hz, 1H, H-βb; 4.77-4.92, m, 2H, H-α & H-γ; 7.19, br. d, J 6.0 Hz, 1H, NH; 7.38-7.79, m, 5H, ArH. ^{13}C n.m.r. δ 21.21, CH_3; 35.79, CH_2; 48.89, CH; 75.30, CH; 127.33, CH; 128.39, CH; 132.02, CH; 133.89, C; 167.67, CO; 175.57, CO. Mass spectrum *m/z* 220 (M + H^{+}, 100%), 105 (95). (minor isomer) : ^{1}H n.m.r. δ 1.48, d, J 6.6 Hz, 3H, CH_3; 1.99, ddd, J 12.3, 12.3, 12.0 Hz, 1H, H-βa; 3.01, ddd, J 12.6, 8.4, 5.1 Hz, 1H, H-βb; 4.65, ddd, J 10.8, 6.0, 5.1 Hz, 1H, H-γ; 4.77-4.92, m, 1H, H-α; 7.11, br. d, J 6.0 Hz, 1H, NH; 7.38-7.79, m, 5H, ArH. ^{13}C n.m.r. δ 20.59, CH_3; 38.39, CH_2; 51.31, CH; 75.08, CH; 127.13, CH; 128.59, CH; 132.02, CH; 131.44, C; 167.22, CO; 175.37, CO.

Photolysis of (2*R*)-3-Benzoyl-4-methylene-2-phenyloxazolidin-5-one (2) in Ethanol. The photolysis of **2** in ethanol was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded a colourless oil which was identified to be an inseparable mixture of two lactone diastereomers (*S*)-(**5b**) in a ratio of 55:45 (43 mg, 54%). The spectral data for the 2 diastereomers was identical to that reported above for (*R*)-(**5b**).

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Methanol. The photolysis of **1** in methanol was carried out as above. ^{1}H n.m.r. analysis of the crude residue showed this to be a mixture of two diastereomers of **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-hydroxyethyl)oxazolidin-5-one*** (**4a**) in a ratio of approximately 77 : 23 (H-2 at δ 6.08 and 6.06 ppm, respectively). Column chromatography, eluting with 10% ether in light petroleum, gave only the lactone **(R)-*α-benzamido-γ-butyrolactone*** (**5a**) (24 mg, 30%) as a colourless gum. $[\alpha]^{22}_{D}$ - 20° (c, 0.10 in $CHCl_3$). (Found : $M^{+\bullet} + H^+$, 206.0811. $C_{11}H_{12}NO_3$ requires 206.0817). ^{1}H n.m.r. δ 2.28, app. dq, J 11.4, 6.5, 6.5, 6.5 Hz, 1H, H-βa; 2.92, dddd, J 14.1, 8.4, 5.7, 1.0 Hz, 1H, H-βb; 4.34, ddd, J 11.1, 9.3, 5.7 Hz, 1H, H-α; 4.52, ddd, 9.0, 9.0, 1.0 Hz, 1H, H-βa; 4.77, ddd, J 11.7, 8.7, 6.0 Hz, 1H, H-γb; 6.98, br. d, J 6.0 Hz, 1H, NH; 7.38-7.79, m, 5H, ArH. ^{13}C n.m.r. δ 30.44, CH_2; 49.68, CH; 66.22, CH_2; 127.14, CH; 128.64, CH; 132.09, CH; 133.00, C; 167.77, CO; 175.67, CO. Mass spectrum *m/z* 206 (M + H^+, 100%), 105 (95).

Enantiomeric Excess Determination of the Lactone (*R*)-(6c). The crude residue from the photolysis of **1** (100 mg, 0.39 mmol) in isopropyl alcohol was heated at 90 °C in 6M hydrochloric acid (10 ml) for 12 h. The reaction mixture was cooled and washed with dichloromethane (4 x 10 ml). The aqueous fraction was evaporated to dryness. Purification of the residue by recrystallization from ethanol/ether afforded the hydrochloride salt of **(R)-*α-amino-γ-dimethyl-γ-butyrolactone*** ((*R*)-**6**) (58 mg, 90%) as a cream solid, m.p. 185-191°C (dec) (Found : C, 40.8; H, 7.5; N, 7.8%. $C_6H_{12}NO_2Cl$ requires C, 40.5; H, 7.3; N, 7.5%). $[\alpha]^{22}_{D}$ -12° (c, 0.25 in 6M HCl). ^{1}H n.m.r. (D_2O) δ 1.40, s, 3H, CH_3; 1.48, s, 3H, CH_3; 2.19, dd, J 12.3, 12.3 Hz, 1H, H-βa; 2.69, dd, J 12.9, 9.3 Hz, 1H, H-βb; 4.59, dd, J 12.0, 9.3 Hz, 1H, H-α. ^{13}C n.m.r. (D_2O) δ 27.02, CH_3; 28.94, CH_3; 39.57, CH_2; 50.95, CH; 87.45, C; 174.49, CO. Mass spectrum *m/z* 130 (M - HCl + H^+, 100%). A stirred sample of (*R*)-**6** (20 mg, 0.12 mmol) suspended in dry dichloromethane (1 ml) was treated with triethylamine (25 mg, 0.25 mmol) under a nitrogen atmosphere at room temperature. After 10 minutes, 4-dimethylaminopyridine (several crystals) and (*R*)-Mosher chloride (37 mg, 0.14 mmol) were added sequentially. After 3 h, the reaction mixture was diluted with ether (10 ml) and subsequently washed with 3M HCl (5 ml), 10% aqueous sodium carbonate (5 ml) and water (5 ml). The ethereal layer was dried, filtered and concentrated under reduced pressure to afford a pale yellow oil (24 mg, 58%). ^{1}H n.m.r. analysis of the crude residue showed this to be a mixture of two diastereomers in a ratio of approximately 78:22. Major isomer: (Found : $M^{+\bullet} + H^+$, 346.1264. $C_{16}H_{19}NO_4F_3$ requires 346.1266). ^{1}H n.m.r. δ 1.44, s, 3H, CH_3; 1.48, s, 3H, CH_3; 2.57, dd, J 12.9, 6.9 Hz, 1H, H-βa; 2.63, dd, J 12.6, 9.0 Hz, 1H, H-βb; 3.47, d, J 1.5 Hz, 3H, OCH_3; 4.75, ddd, J 11.7, 8.7, 6.6 Hz, 1H, H-α; 7.38-7.79, m, 6H, ArH & NH. ^{13}C n.m.r. δ 26.97, CH_3; 28.86, CH_3; 41.25, CH_2; 50.35, CH_3; 55.11, C; 55.14, CH_3; 55.16, C; 82.84, C; 127.47, CH; 128.59, CH; 129.63, CH; 132.23, C; 167.11, CO; 173.53, CO. Mass spectrum *m/z* 346 (M + H^+, 30%). Minor isomer: ^{1}H n.m.r. δ 1.45, s, 3H, CH_3; 1.52, s, 3H, CH_3; 1.97, dd, J 12.6, 7.4 Hz, 1H, H-βa; 2.72, dd, J 12.3, 8.4 Hz, 1H, H-βb; 3.34, d, J 1.2 Hz, 3H, OCH_3; 4.86, ddd, J 11.7, 8.7, 7.2 Hz, 1H, H-α; 7.38-7.79, m, 6H, ArH & NH. ^{13}C n.m.r. δ 26.83, CH_3; 28.80, CH_3; 41.74, CH_2; 50.12, CH_3; 54.85, C; 54.87, CH_3; 55.08, C; 82.89, C; 127.92, CH; 128.72, CH; 129.69, CH; 131.47, C; 167.03, CO; 173.77, CO.

Enantiomeric Excess Determination of the Lactone (*S*)-5c. By following the above procedure the lactone (*S*)-**5c** (120 mg, 0.52 mmol) was treated with 6M hydrochloric acid (10 ml) to give the hydrochloride salt of

(S)-α-amino-γ-dimethyl-γ-butyrolactone ((*S*)-**6**) as a white solid (77 mg, 90%), m.p. 193-197°C (dec). $[\alpha]^{22}_D$ +6° (c, 0.10 in 6M HCl). The spectral data of (*S*)-**6** were identical to that found for (*R*)-**6**. Mosher analysis of (*S*)-**6** (20 mg, 0.12 mmol) was subsequently carried out according to the procedure described above (yield = 70%). ^{1}H n.m.r. analysis of the crude residue showed this to be a mixture of two diastereomers in a ratio of approximately 58:42.

Photolysis of (2*S*)-3-Benzoyl-2-tert-butyl-4-methyleneoxazolidin-5-one (1) in 1,3-Dioxolane. The photolysis of **1** (100 mg, 0.39 mmol) in 1,3-dioxolane (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded ***(2S,4R)-3-benzoyl-2-tert-butyl-4-([1',3'-dioxan-2'-yl]methyl)oxazolidin-5-one*** (**8a**) (66 mg, 52%) as a white solid, m.p. 110-113°C (Found : C, 64.9; H, 7.1; N, 4.0%. $C_{18}H_{23}NO_5$ requires C, 64.8; H, 7.0; N, 4.2%). $[\alpha]^{24}_D$ + 15° (c, 0.10 in $CHCl_3$). ^{1}H n.m.r. δ 1.03, s, 9H; 2.00, ddd, J 13.5, 7.2, 3.3 Hz, 1H, CH_aH_b; 2.28, ddd, J 13.8, 10.5, 3.6 Hz, 1H, CH_aH_b; 2.00, app. dt, J 12.9, 12.9, 6.3 Hz, 1H, H-4'α or H-5'α; 3.66, app. dt, J 12.9, 12.9, 6.9 Hz, 1H, H-4'β or H-5'β; 3.74, app. dt, J 12.9, 12.9, 6.3 Hz, 1H, H-4'α or H-5'α; 3.83, app. dt, J 12.9, 12.9, 6.9 Hz, 1H, H-4'β or H-5'β; 4.35, dd, J 10.5, 3.3 Hz, 1H, H-4; 4.97, dd, J 7.5, 3.6 Hz, 1H, H-2'; 6.11, s, 1H, H-2; 7.35-7.47, m, 5H, ArH. ^{13}C n.m.r. δ 25.13, CH_3; 36.97, C; 39.23, CH_2; 54.37, CH; 64.53, CH_2; 64.78, CH_2; 95.68, CH; 100.66, CH; 126.66, CH; 128.70, CH; 130.39, CH; 135.46, C; 171.89, CO; 173.67, CO. Mass spectrum *m/z* 334 (M + H^+, 100%), 184 (48).

Enantiomeric Excess Determination of the Oxazolidinone 8a. A mixture of **8a** (16 mg, 0.05 mmol), (*R*)-methyl mandelate (9 mg, 0.055 mmol) and triethylamine (6 mg, 0.06 mmol) in dry dichloromethane (1 ml) was stirred at room temperature for 3 days under a nitrogen atmosphere. The reaction mixture was diluted with dichloromethane (5 ml) and washed with 2M HCl (1 x 5ml) and water (3 x 5 ml). The organic fraction was dried, filtered and evaporated to dryness. ^{1}H n.m.r. analysis of the crude residue showed this to be a single diastereomer (**9**). Column chromatography on silica gel, eluting with 30% ethyl acetate in light petroleum, yielded a pale yellow gum (15 mg, 73%). (Found : $M^{+\bullet}$ + H^+, 346.1276. $C_{16}H_{19}NO_4F_3$ requires 346.1266). ^{1}H n.m.r. δ 2.21, ddd, J 15.0, 4.8, 4.8 Hz, 1H, H-α; 2.35, ddd, J 15.0, 6.3, 3.6 Hz, 1H, H-β; 3.68, s, 3H, CH_3; 3.79-3.96, m, 4H, 2 x CH_2; 4.80, dd, J 11.4, 6.3 Hz, CH; 5.01, app. t, J 4.5 Hz, 1H, CH; 5.91, s, 1H, CH; 7.29-7.60, m, 11H, ArH & NH. ^{13}C n.m.r. δ 34.17, CH_2; 52.95, CH_3; 53.00, CH; 64.97, CH_2; 72.90, CH; 102.38, CH; 126.56, CH; 127.15, CH; 128.47, CH; 128.58, CH; 128.60, CH; 131.91, CH; 133.37, C; 138.21, C; 167.84, CO; 173.76, CO; 174.09, CO. Mass spectrum *m/z* 346 (M + H^+, 66%).

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Tetrahydrofuran. The photolysis of **1** (100 mg, 0.39 mmol) in tetrahydrofuran (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded an inseparable mixture of two diastereomers of ***(2S)-3-benzoyl-2-tert-butyl-4-[tetrahydrofuran-2'-yl)methyl]oxazolidin-5-one*** (**8b**) (71 mg, 55%) as a white solid, m.p. 105-110°C (Found : C, 68.8; H, 7.6; N, 4.1%. $C_{19}H_{25}NO_4$ requires C, 68.8; H, 7.6; N, 4.2%). Mass spectrum *m/z* 332 (M + H^+, 100%), 246 (40), 182 (73). Major isomer: ^{1}H n.m.r. δ 1.03, s, 9H; 1.61-2.05, m, 5H, CH_aH_b, H-3'α/β & H-4'α/β; 2.00, ddd, J 13.9, 10.5, 5.7 Hz, 1H, CH_aH_b; 3.58, app. dt, J 6.6, 6.6 Hz, 1H, H-5'α; 3.74, app. dt, J 6.3, 6.3 Hz, 1H, H-5'β; 3.78-3.86, m, 1H, H-2'; 4.03, dd, J 10.8, 3.0 Hz, 1H, H-4; 6.08, s, 1H, H-2; 7.36-7.48, m, 5H, ArH. ^{13}C n.m.r. δ 25.11, CH_3; 25.32, CH_2; 29.57, CH_2; 36.95, C; 40.05, CH_2; 55.64, CH; 67.35, CH_2; 75.09, CH; 95.46, CH; 126.43, CH; 128.82, CH; 130.39, CH; 135.74, C; 171.86, CO; 173.55, CO. Minor isomer: ^{1}H n.m.r. δ 1.04, s, 9H; 1.41, ddd, J 15.3, 11.1, 6.9

Hz, 1H, CH_aH_b; 1.61-2.05, m, 5H, CH_aH_b, H-3'α/β & H-4'α/β; 3.28, app. dt, J 7.8, 7.8 Hz, 1H, H-5'α; 3.48, app. dt, J 6.9, 6.9 Hz, 1H, H-5'β; 4.07-4.12, m, 1H, H-2'; 4.37, dd, J 11.1, 3.3 Hz, 1H, H-4; 6.10, s, 1H, H-2; 7.36-7.48, m, 5H, ArH. ^{13}C n.m.r. δ 25.16, CH_3; 25.35, CH_2; 31.30, CH_2; 36.87, C; 40.93, CH_2; 54.87, CH; 67.31, CH_2; 74.20, CH; 95.27, CH; 126.63, CH; 128.56, CH; 130.28, CH; 135.53, C;172.26, CO; 173.86, CO.

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Diethyl Ether. The photolysis of **1** (100 mg, 0.39 mmol) in diethyl ether (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded an inseparable mixture of 4 diastereomers **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-ethoxypropyl)oxazolidin-5-one*** (**10c**) and **(2S,4S)-*3-benzoyl-2-tert-butyl-4-(2'-hydroxypropyl)oxazolidin-5-one*** (**11c**) (52 mg, 40%) as a pale yellow gum (Found : $M^{+\bullet} + H^+$, 334.2012. $C_{19}H_{28}NO_4$ requires 334.2018). Mass spectrum *m/z* 334 (M + H^+, 83%), 184 (100). **10c** (major isomer): ^{1}H n.m.r. δ 0.82, d, J 6.3 Hz, 3H, H-3'; 1.05, s, 9H; 1.19, t, J 7.2 Hz, 3H, CH_3; 1.95, ddd, J 7.5, 6.0 Hz, 1H, H-1'α; 3.07, ddd, J 9.0, 6.9, Hz, 1H, H-1'β; 3.36, q, J 7.2 Hz, 2H, CH_2; 3.63, m, 1H, H-2'; 4.33, dd, J 7.8, 6.3 Hz, 1H, H-4; 6.11, s, 1H, H-2; 7.35-7.49, m, 5H, ArH. ^{13}C n.m.r. δ 15.55, CH_3; 19.77, CH_3; 25.21, CH_3; 36.66, C; 42.74, CH_2; 54.53, CH; 63.60, CH_2; 70.63, CH; 95.38, CH; 127.12, CH; 128.55, CH; 129.94, CH; 135.29, C; 172.56, CO, 174.23, CO. **10c** (minor isomer): ^{1}H n.m.r. δ 0.69, d, J 6.3 Hz, 3H, H-3'; 1.04, s, 9H; 1.11, t, J 6.9 Hz, 3H, CH_3; 1.78, ddd, J 13.5, 8.7, 3.6 Hz, 1H, H-1'α; 2.25, ddd, J 13.8, 10.5, 5.4 Hz, 1H, H-1'β; 3.19-3.45, m, 1H, H-2'; 3.41, q, J 6.9 Hz, 2H, CH_2; 4.00, dd, J 10.2, 3.0 Hz, 1H, H-4; 6.08, s, 1H, H-2; 7.35-7.49, m, 5H, ArH. ^{13}C n.m.r. δ 15.39, CH_3; 18.14, CH_3; 25.17, CH_3; 36.94, C; 41.69, CH_2; 55.16, CH; 63.61, CH_2; 71.15, CH; 95.39, CH; 126.42, CH; 128.90, CH; 130.47, CH; 135.76, C; 172.04, CO; 173.71, CO. **11c** (major isomer, in part): ^{1}H n.m.r. δ 6.16, s, 1H, H-2. **11c** (minor isomer, in part): ^{1}H n.m.r. δ 6.17, s, 1H, H-2.

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in Dimethoxymethane. The photolysis of **1** (100 mg, 0.39 mmol) in dimethoxymethane (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded an inseparable mixture of 2 diastereomers **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2',2'-dimethoxyethyl)oxazolidin-5-one*** (**10a**) and **(2S, 4S)-*3-benzoyl-2-tert-butyl-4-(2',2'-dimethoxyethyl)oxazolidin-5-one*** (**11a**) (21 mg, 16%) as a pale yellow oil (Found : $M^{+\bullet} + H^+$, 336.1805. $C_{18}H_{26}NO_5$ requires 336.1811). Mass spectrum *m/z* 336 (M + H^+, 30%). **10a** (major isomer): ^{1}H n.m.r. δ 1.03, s, 9H; 2.09-2.18, m, 2H, H-2'α; 2.94, s, 3H, OCH_3; 3.23, s, 3H, OCH_3; 4.21, dd, J 9.0, 5.4 Hz, 1H, H-4; 4.51, dd, J 7.5, 5.1 Hz, 1H, H-1'; 6.11, s, 1H, H-2; 7.39-7.48, m, 5H, ArH. ^{13}C n.m.r. δ 25.16, CH_3; 36.98, C; 37.62, CH_2; 52.77, CH_3; 53.40, CH_3; 54.42, CH; 95.59, CH; 100.71, CH; 126.65, CH; 128.75, CH; 130.51, CH; 134.45, C; 172.04, CO; 173.75, CO. **11a** (minor isomer, in part): ^{1}H n.m.r. δ 1.04, s, 9H; 6.07, s, 1H, H-2.

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in *tert*-Butyl Methyl Ether. The photolysis of **1** (100 mg, 0.39 mmol) in *tert*-butyl methyl ether (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded an inseparable mixture of the diastereomers **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-tert-butyloxyethyl)oxazolidin-5-one*** (**10b**) and **(2S,4S)-*3-benzoyl-2-tert-butyl-4-(2'-tert-butyloxyethyl)oxazolidin-5-one*** (**11b**) (49 mg, 36%) as a colourless oil (Found : $M^{+\bullet} + H^+$, 348.2185. $C_{20}H_{30}NO_4$ requires 348.2175). Mass spectrum *m/z* 348 (M + H^+, 65%). **10b** (major isomer): ^{1}H n.m.r. δ 0.99, s, 9H; 1.05, s, 9H; 2.01-2.20, m, 2H, CH_2; 3.29-3.38, 2H, CH_2; 4.14, dd, J 9.9, 3.3 Hz, 1H, H-4; 6.12, s, 1H, H-2; 7.39-7.48, m, 5H, ArH. ^{13}C n.m.r. δ 25.20,

CH_3; 27.27, CH_3; 36.30, CH_2; 36.76, C; 54.46, CH; 57.33, CH_2; 72.76, C; 95.49, CH; 126.74, CH; 128.71, CH; 130.55, CH; 135.41, C; 172.32, CO; 174.09, CO. **11b** (minor isomer): ^{1}H n.m.r. δ 1.00, s, 9H; 1.12, s, 9H; 2.01-2.20, m, 2H, CH_2; 3.17-3.21, 2H, CH_2; 4.41, dd, J 9.9, 3.3 Hz, 1H, H-4; 6.17, s, 1H, H-2; 7.39-7.48, m, 5H, ArH. ^{13}C n.m.r. δ 24.82, CH_3; 27.10, CH_3; 36.52, CH_2; 37.04, C; 55.39, CH; 56.54, CH_2; 73.12, C; 94.64, CH; 127.52, CH; 128.90, CH; 131.75, CH; 136.24, C; 170.59, CO; 173.14, CO.

Hydrolysis of 10b and 11b. A 95:5 mixture of **10b** and **11b** (30 mg, 0.086 mmol) in 6M hydrochloric acid (5 ml) was heated at 80 °C for 12 h. The reaction mixture was cooled and washed with dichloromethane (4 x 10 ml). The aqueous fraction was evaporated to dryness. Recrystallization of the crude residue from ethanol/ether afforded the hydrochloride salt of **(R)-*α-amino-γ-butyrolactone*** ((*R*)-**12**) as a white solid (11 mg, 90%), m.p. >200°C. (Found : $M^{+\bullet} + H^+$, 102.0542. $C_4H_8NO_2$ requires 102.0555). $[\alpha]^{20}_D$ -20° (c, 0.10 in 6M HCl) (lit.[12] $[\alpha]^{20}_D$ -32° (c, 0.2 in 2M HCl)). ^{1}H n.m.r. (D_2O) δ 2.32-2.43, m, 1H, H-βa; 2.67-2.76, m, 1H, H-βb; 4.43-4.55, m, 3H, H-α & H-γa/b. ^{13}C n.m.r. (D_2O) δ 28.00, CH_2; 49.78, CH; 68.58, CH_2; 175.69, CO. Mass spectrum *m/z* 102 (M - HCl + H^+, 100%).

Photolysis of (2*S*)-3-Benzoyl-2-*tert*-butyl-4-methyleneoxazolidin-5-one (1) in *tert*-Butyl Ethyl Ether. The photolysis of **1** (100 mg, 0.39 mmol) in a mixture of *tert*-butyl ethyl ether (2.5 g, 24.5 mmol) and dry acetonitrile (150 ml) was carried out as described above. Column chromatography on silica gel, eluting with 10% ether in light petroleum, afforded 3 partially separable stereoisomers **(2S,4R)-*3-benzoyl-2-tert-butyl-4-(2'-tert-butyloxypropyl)oxazolidin-5-one*** (**10d**) and **(2S,4S)-*3-benzoyl-2-tert-butyl-4-(2'-tert-butyloxypropyl)oxazolidin-5-one*** (**11d**) (67 mg) in a combined yield of 48%. Samples of **10d** (major) and **10d** (minor) were obtained diastereomerically pure (Found: $M^{+\bullet}$ + H^+, 362.2334. $C_{21}H_{32}NO_4$ requires 362.2331). Mass spectrum *m/z* 362 (M + H^+, 100%), 307 (40), 220 (45). **10d** (major isomer): colourless oil, $[\alpha]^{23}_D$ + 3° (c, 0.12 in $CHCl_3$). ^{1}H n.m.r. δ 0.89, s, 9H; 1.05, s, 9H; 1.07, d, J 6.3 Hz, 3H, CH_3; 1.90-1.96, m, 2H, H-1'α & H-1'β; 3.92, app. sextet, J 6.0 Hz, 1H, H-2'; 4.23, dd, J 7.5, 6.9 Hz, 1H, H-4; 6.13, s, 1H, H-2; 7.39-7.49, m, 5H, ArH. ^{13}C n.m.r. δ 24.22, CH_3; 25.31, CH_3; 28.54, CH_3; 36.63, C; 44.00, CH_2; 54.49, CH; 63.29, CH; 73.06, C; 95.29, CH; 126.97, CH; 128.78, CH; 130.73, CH; 135.28, C; 172.72, CO; 174.61, CO. **10d** (minor isomer): colourless oil, $[\alpha]^{23}_D$ + 8° (c, 0.12 in $CHCl_3$). ^{1}H n.m.r. δ 0.56, d, J 6.0 Hz, 3H, CH_3; 1.05, s, 9H; 1.11, s, 9H; 1.82, ddd, J 13.2, 10.2, 2.7 Hz, 1H, H-1'α; 2.16, ddd, J 12.9, 12.9, 3.3 Hz, 1H, H-1'β; 3.79-3.82, m, 1H, H-2'; 3.85, dd, J 10.2, 3.0 Hz, 1H, H-4; 6.10, s, 1H, H-2; 7.37-7.50, m, 5H, ArH. ^{13}C n.m.r. δ 20.60, CH_3; 25.14, CH_3; 28.10, CH_3; 36.90, C; 43.70, CH_2; 55.45, CH; 63.31, CH; 74.22, C; 95.43, CH; 126.41, CH; 128.97, CH; 130.57, CH; 135.63, C; 172.13, CO; 173.99, CO. **11d** (in part): ^{1}H n.m.r. δ 1.04, s, 9H; 1.10, s, 9H; 6.08, s, 1H, H-2.

Hydrolysis of the major diastereomer of 10d. A mixture of **10d** (major) (15 mg, 0.042 mmol) and 6M hydrochloric acid (5 ml) was heated at 90 °C for 12 h. The reaction mixture was cooled and washed with dichloromethane (4 x 10 ml). The aqueous fraction was evaporated to dryness to afford a pale yellow gum (5.5 mg, 88%). ^{1}H n.m.r. analysis of the crude residue showed this to be a mixture of 2 diastereomers hydrochloride salts of **(R,R)-*α-amino-γ-methyl-γ-butyrolactone*** ((*R*, *R*)-**13**) and **(R_α,S_γ)-*α-amino-γ-methyl-γ-butyrolactone*** ((*R,S*)-**14**) in a ratio of approximately 71 : 29 (Found : $M^{+\bullet}$ - HCl + H^+, 116.0703. $C_5H_{10}NO_2$ requires 116.0712). Mass spectrum *m/z* 116 (M - HCl + H^+, 100%). **13** (major isomer): ^{1}H n.m.r. (D_2O) δ 1.36, dd, J 6.6 Hz, 1.5 Hz, 3H, CH_3; 2.46-2.52, m, 2H, H-βa & H-βb; 4.50, app. t, J 9.9 Hz, 1H, H-α; 4.43-4.55, m, 1H, H-γ. ^{13}C n.m.r. (D_2O) δ 24.01, CH_3; 33.15, CH_2; 49.24, CH; 66.93, CH; 173.12, CO. **14** (minor isomer): ^{1}H n.m.r. (D_2O) δ 1.31, dd, J 6.3 Hz, 1.5 Hz, 3H, CH_3; 1.87, ddd, J 12.8, 10.1, 1.5 Hz, 1H, H-βa; 2.75, ddd, J 13.5, 8.7, 5.1 Hz, 1H, H-βb; 4.35, dd, J 11.7, 8.7 Hz, 1H, H-α; 4.65-4.73, m, 1H, H-γ. ^{13}C n.m.r. (D_2O) δ 20.76, CH_3; 35.72, CH_2; 51.34, CH; 68.40, CH; 175.15, CO.

Hydrolysis of the minor diastereomer of 10d. A sample of **10d** (minor) (12 mg, 0.033 mmol) was hydrolyzed according to the above procedure to afford a pale yellow gum (4 mg, 80%). ^{1}H n.m.r. analysis of the crude residue showed this to be a mixture of **14** : **13** in a ratio of approximately 91: 9, respectively. The spectral data of **13** and **14** were identical to that described above.

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