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Kinetic Resolution of Vinyl Carbonates through a Lipase-Mediated Synthesis of their Carbonate and Carbamate Derivatives.

Marcos Pozo and Vicente Gotor*

Departamento de Química Orgánica e Inorgánica, Facultad de Química, Universidad de Oviedo, 33071 Oviedo, Spain

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Abstract *Lipase from Candida antarctica was used in the synthesis of different chiral carbonates and carbamates through the enzymic resolution of the starting racemic vinyl carbonates A striking feature was the changeover of the enantioselectivity with regard to the one showed when vinyl carbonates were used in the resolution of alcohols and amines, thus the S enantiomer of the vinyl carbonate was resolved whereas the same enzyme was selective towards R ones when resolving alcohols and amines In this way, compounds obtained beforehand as R carbonates were now achieved as S ones with better e e 's and shorter reaction times*

INTRODUCTION

Carbonate and carbamate derivatives are either utilized in the synthesis of compounds with medical properties, insecticides and peptides or moieties of them [1-8]

On the other hand, and due to the interest of the carbamate group,[9] many reagents and synthetic procedures to achieve the alkoxycarbonylation of amines have been put forth In general these processes involve specific reactions and, in some cases, poisonous reagents such as phosgene[10] or organometallic compounds [11] Ghosh *et al* have developed two efficient synthesis of carbamates with disuccinimidyl carbonate [12]

Recently, we have developed the synthesis of chiral carbonates[13] and chiral carbamates[14] through a lipase-mediated resolution of a series of alcohols and amines with vinyl carbonates Herein, as a part of our ongoing research on the field of alkoxycarbonylation reactions, we report another procedure for the synthesis of the aforementioned chiral derivatives This method improves the enantioselectivity achieved in our previous papers[13,14] and it relies on the resolution of racemic vinyl carbonates with alcohols and amines to yield chiral carbonates and carbamates respectively

RESULTS AND DISCUSSION.

Our synthetic strategy relied on the ability of CAL (*Candida antarctica* lipase) to catalyze reactions between vinyl carbonates and alcohols[13] and amines[14] As in our previous work,[14] we decided to carry out reactions in a non-polar solvent like hexane The racemic vinyl carbonates **2**, **3**, and **4** were prepared from the appropriate racemic alcohol and vinyl chloroformate

The alkoxycarbonylation procedure was applied to a series of alcohols **5**, *n*-octanol, *n*-butanol and benzyl alcohol The reaction of different racemic vinyl carbonates with these nucleophiles were carried out in hexane (Scheme I) and the results are shown in the Table I

It is noteworthy that the enzyme was enantioselective towards the *S* enantiomer Thus, this methodology shows a complementary role to the resolution of alcohols through an enzymic alkoxycarbonylation aforementioned, where the same enzyme was enantioselective towards the *R* alcohols[13]

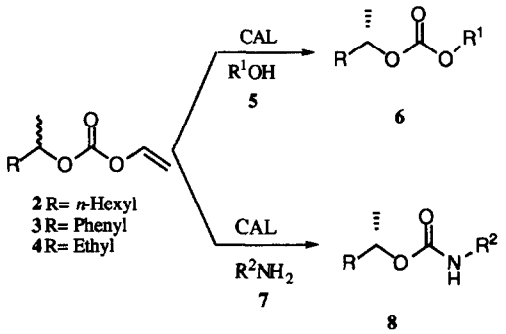

Table I. Carbonates **6** from **2**, **3**, **4**, and alcohols **5**

Entry	R	R¹	Time,h	Conv (%)[a]	$[\alpha]_D^{25}$ (c)[b]	e e %(Conf)
6a	*n*-Hexyl	*n*-Octyl	4	40	+4 1 (0 7)	93 (*S*)
6b	*n*-Hexyl	$PhCH_2$	5	45	+10 3 (1 1)	96 (*S*)
6c	*n*-Hexyl	*n*-Butyl	5	48	+3 5 (0 6)	81 (*S*)
6d	Ph	*n*-Octyl	6	42	-49 1 (1 4)	92 (*S*)
6e	Ph	$PhCH_2$	4	40	-62 9 (0 9)	95 (*S*)
6f	Ph	*n*-Butyl	5	52	-57 8 (0 7)	86 (*S*)
6g	Ethyl	*n*-Octyl	10	50	+6 0 (1 0)	98 (*S*)
6h	Ethyl	$PhCH_2$	9	50	+9 8 (0 4)	93 (*S*)
6i	Ethyl	*n*-Butyl	10	51	+11 1 (1 2)	90 (*S*)

[a] Calculated with respect to the carbonate **2**, **3** or **4** by NMR

[b] In chloroform

The same series of racemic vinyl carbonates was faced to *n*-octylamine, *n*-butylamine and benzylamine under the same reaction conditions (Scheme I)

The results achieved are depicted in Table II As in the synthesis of the above carbonates, the enzyme was again selective towards the *S* enantiomer of the vinyl carbonate (see Table II)

Table II. Carbamates **8** from vinyl carbonates **2**, **3** and **4**, and amines **7**

Entry	R	R2	Time,h	Conv (%)[a]	$[\alpha]_D^{25}$ (c)[b]	e e %(Conf)
8a	*n*-Hexyl	*n*-Octyl	6	47	+7 0 (1 4)	70 (*S*)
8b	*n*-Hexyl	$PhCH_2$	4	43	+14 3 (0 4)	98 (*S*)
8c	*n*-Hexyl	*n*-Butyl	5	46	+8 8 (0 7)	84 (*S*)
8d	Ph	*n*-Octyl	3	41	-21 1 (1 0)	85 (*S*)
8e	Ph	$PhCH_2$	4	47	-14 1 (0 5)	97 (*S*)
8f	Ph	*n*-Butyl	3	45	-29 4 (0 8)	93 (*S*)
8g	Ethyl	*n*-Octyl	9	49	+11 9 (1 3)	96 (*S*)
8h	Ethyl	$PhCH_2$	8	49	+12 9 (0 3)	99 (*S*)
8i	Ethyl	*n*-Butyl	7	50	+14 8 (0 6)	93 (*S*)

[a] Calculated with respect to the carbonate **2**, **3** or **4** by NMR

[b] In chloroform

From the data of preceding Table II, we can see that the lowest e e was achieved in case **8a**, which is in aggrement with our previous conclusions about alkoxycarbonylation of racemic amines [14]

When the Table I results are compared with data previously reported,[13] in cases **6a** and **6b** e e 's are comparable and reaction times were shortened noticeably These times, too decreased in cases **6e**, **6g** and **6h** but the e e 's achieved were higher than the ones of the former cited paper Thus , it is a hard fact that the methodology pointed out throughout this work is an improvement over our preceding research

CONCLUSIONS

Herein we report an improvement in the synthesis of chiral carbonates and carbamates The e e 's and the reaction times are noteworthy since the former ones are higher and latter ones are shorter than in our previously reported procedures This method overcomes some of the operational problems of chemical methods

EXPERIMENTAL

We used an immobilized lipase from *Candida antarctica* SP 435A (CAL) (gifted by Novo Nordisk) All reagents were of commercial produced quality and were purchased from Aldrich Chemie Solvents were distilled over an adequate

desiccant and stored under argon For column chromatography, Merck silica gel 60/230-400 mesh was used Optical rotations were measured using a Perkin-Elmer 241 polarimeter IR spectra were recorded on a Mattson 3000 Infrared Fourier Transform spectrophotometer ^1H and ^{13}C-NMR were obtained with TMS (tetramethylsilane) as internal standard, using a Bruker AC-300 (^1H-300 MHz and ^{13}C-75 5 MHz) spectrometer Mass spectra were recorded on a Hewlett-Packard 5897 A spectrometer Microanalyses were performed on a Perkin-Elmer 240B elemental analyzer

Determination of enantiomeric excess and absolute configuration was as follows All the e e and configurations were calculated in comparison with the optically active carbonates previously prepared to our preceding paper[13] New optically active carbonates were synthetized from the appropriate chiral alcohol and chloroformate, carbamates were prepared with the adequate chiral amine and alcohol according the methodology developed by Ghosh [14a] (All these compounds gave satisfactory ^1H-, ^{13}C-NMR and mass spectra)

General procedure for the synthesis of compounds 2, 3 and 4: vinyl chloroformate (50 mmol) was slowly added to a solution of the appropriate racemic alcohol (35 mmol) in dry pyridine (4 mL) under argon at O° C The solution was stirred for 2h and then was acidified with HCl (3N) and extracted with dichloromethane, the organic layer was dried over sodium sulphate and submitted to flash chromatography on silica using hexane-ethyl ether 95 5 The final yields were 80%, 88% and 75% for **2**, **3** and **4** respectly

Characterization of products 2, 3 and 4:

(±)-2-Octylvinyl carbonate (2): oil, R_f=0 55 (Hexane ethyl ether 95 5), IR (neat) $\upsilon_{c=o}$= 1757 cm $^{-1}$, (found C, 66 01, H, 10 05 $C_{11}H_{20}O_3$ requires C, 65 95, H, 10 07), ^1H-NMR ($CDCl_3$) δ(ppm) 7 10 (dd, J= 6 2, 13 9 Hz, 1H, CH), 4 90 (dd, J=1 95, 13 9 Hz, 1H, CH), 4 80 (m, 1H, CH), 4 55 (dd, J= 1 95, 6 2 Hz, 1H, CH), 1 70-1 50 (m, 2H, CH_2), 1 30 (m, 11H), 0 85 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 152 26 (C=O), 142 55 (CH), 97 20 (CH_2), 76 34 (CH), 35 64 (CH_2), 31 59 (CH_2), 28 95 (CH_2), 25 09 (CH_2), 22 46 (CH_3), 19 70 (CH_2), 13 93 (CH_3), MS (EI, 70 eV), m/z 157 (<1), 112 (22 30), 71 (100 00), 57 (93 00), 43 (44 45)

(±)-1-Phenylethylvinyl carbonate (3): oil, R_f=0 46 (Hexane ethyl ether 95 5), IR (neat) $\upsilon_{c=o}$= 1759 cm $^{-1}$, (found C, 68 79, H, 6 28 $C_{11}H_{12}O_3$ requires C, 68 72, H, 6 30), ^1H-NMR ($CDCl_3$) δ(ppm) 7 40 (m, 5H, ar), 7 10 (dd, 1H, CH), 5 80 (q, 1H, CH), 4 90 (dd, 1H, CH), 4,50 (dd, 1H, CH), 1 60 (d, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 151 92 (C=O), 142 46 (CH), 140 29 (C), 128 49 (2CH), 128 24 (CH), 125 96 (2CH), 97 43 (CH_2), 77 11 (CH), 22 02 (CH_3), MS (EI, 70 eV), m/z 177 (<1), 149 (<1), 105 (100 00), 77 (18 77)

(±)-2-Butylvinyl carbonate (4): oil, R_f=0 53 (Hexane ethyl ether 95 5), IR (neat) $\upsilon_{c=o}$= 1758 cm $^{-1}$, (found C, 58 24, H, 8 41 $C_7H_{12}O_3$ requires C, 58 30, H, 8 39), ^1H-NMR ($CDCl_3$) δ(ppm) 7 20 (dd, 1H, CH), 4 90 (dd, 1H, CH), 4 70 (m, 1H, CH), 4 55 (dd, 1H, CH), 1 60 (m, 2H, CH_2), 1 3 (d, 3H, CH_3), 0 95 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 152 19 (C=O), 142 49 (CH), 97 04 (CH_2), 77 27 (CH), 28 46 (CH_2), 19 04 (CH_3), 9 31 (CH_3), MS (EI, 70 eV), m/z 144 (M^+, <1), 129 (3 19), 115 (16 51), 57 (100 00), 41 (45 87)

Synthesis of carbonates 6a-6i. General procedure: To a solution of racemic carbonates **2**, **3** or **4** (1 mmol) and alcohol (0 6mmol) in hexane (15 mL) with molecular sieve (4Å) (1 5 g), CAL (100 mg) was added (see Table I) The reaction was monitored by TLC and was terminated by filtering off the enzyme The organic solvent was evaporated under reduced pressure and chromatographic separation on silica gel of the resulting residue gave the carbonate Compounds **6a**, **6b**, **6e**, **6g** and **6h** were characterized in a foregoing paper [13]

***S*-(+)-*n*-Butyl-2-octyl carbonate (6c):** oil, R_f=0 47 (Hexane ethyl ether 95 5), IR (neat) $\upsilon_{c=o}$= 1744 cm^{-1}, (found C, 67 87, H, 11 35 $C_{13}H_{26}O_3$ requires C, 67 77, H, 11 38), ^{1}H-NMR ($CDCl_3$) δ(ppm) 4 75 (m, 1H, CH), 4 15 (t, 2H, CH_2), 1 65 (m, 2H, CH_2), 1 55-1 20 (m, 15H), 1 00-0 8 (m, 6H, $2CH_3$), ^{13}C-NMR ($CDCl_3$) δ(ppm) 154 86 (C=O), 74 95 (CH), 67 28 (CH_2), 35 74 (CH_2), 31 56 (CH_2), 30 53 (CH_2), 28 92 (CH_2), 25 12 (CH_2), 22 39 (CH_3), 19 72 (CH_2), 18 78 (CH_2), 13 85 (CH_3), 13 48 (CH_3) , MS (EI, 70 eV), m/z 112 (23 36), 71 (41 28), 57 (100 00)

***S*-(-)-*n*-Octyl-1-phenylethyl carbonate (6d):** oil, R_f=0 62 (Hexane ethyl ether 9 1), IR (neat) $\upsilon_{c=o}$= 1745 cm ^{1}, (found C, 73 55, H, 9 38 $C_{17}H_{26}O_3$ requires C, 73 33, H, 9 42), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 40 (m,5H, ar), 5 70 (q, J= 6 6 Hz, 1H, CH), 4 10 (m, 2H, CH_2), 1 65 (m, 5H, CH_3 and CH_2), 1 30 (m, 10H, $5CH_2$), 0 90 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 154 56 (C=O), 141 04 (C), 128 42 (2CH), 127 97 (CH), 125 90 (2CH), 76 08 (CH), 67 99 (CH_2), 31 63 (CH_2), 29 04 ($2CH_2$), 28 52 (CH_2), 25 57 (CH_2), 22 51 (CH_2), 22 25 (CH_3), 13 97 (CH_3), MS (EI, 70 eV), m/z 278 (M^+), 122 (56 13), 105 (92 72), 104 (100 00), 77 (22 44)

***S*-(-)-*n*-Butyl-1-phenylethyl carbonate (6f):** oil, R_f=0 55(Hexane ethyl ether 9 1), IR (neat) $\upsilon_{c=o}$= 1744 cm^{-1}, (found C, 70 32, H, 8 15 $C_{13}H_{18}O_3$ requires C, 70 23, H, 8 17), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 35 (m, 5H, ar), 5 70 (q, J= 6 6 Hz, 1H, CH), 4 10 (m, 2H, CH_2), 1 70-1 60 (m, 5H, CH_2 and CH_3), 1 40 (m, 2H, CH_2), 0 90 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 154 56 (C=O), 141 04 (C), 128 42 (2CH), 127 97 (CH), 125 90 (2CH), 76 08 (CH), 67 69 (CH_2), 30 50 (CH_2), 22 25 (CH_3), 18 79 (CH_2), 13 55 (CH_3), MS (EI, 70 eV), m/z 222 (M^+, 9 90), 122 (44 30), 105 (100 00), 104 (96 67), 77 (23 26)

***S*-(+)-2-Butyl-*n*-butyl carbonate (6i):** oil, R_f=0 7 (Hexane ethyl ether 9 1), IR (neat) $\upsilon_{c=o}$= 1743 cm ^{1}, (found C, 61 96, H, 10 45 $C_9H_{18}O_3$ requires C, 62 02, H, 10 42), ^{1}H-NMR ($CDCl_3$) δ(ppm) 4 70 (m, 1H, CH), 4 15 (t, 2H, CH_2), 1 65 (m, 4H, $2CH_2$), 1 40 (m, 2H, CH_2), 1 25 (d, J= 6 02 Hz, 3H, CH_3), 0 95 (m, 6H, $2CH_3$), ^{13}C-NMR ($CDCl_3$) δ (ppm) 154 92 (C=O), 76 17 (CH), 67 37 (CH_2), 30 56 (CH_2), 28 62 (CH_2), 19 24 (CH_3), 18 81 (CH_2), 13 52 (CH_3), 9 49 (CH_3), MS (EI, 70 eV), m/z 159 (M^+-15, <1), 118 (3 08), 57 (100 00), 41 (34 32)

Synthesis of carbamates 8a-8i. General procedure: To a solution of the racemic carbonates (**2**), (**3**) or (**4**) (1 mmol) and amine (0 6 mmol) in hexane (15 mL) with molecular sieve (1g), CAL (100mg) was added (see Table II) The reaction was followed by TLC and was finished by filtering off the enzyme The organic solvent was evaporated and flash chromatography of the resulting residue yielded the carbamate

***S*-(+)-*N*-Octyl-2-Octyl carbamate (8a):** oil, R_f=0 5 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1692 cm ^{1}, (found C, 71 59, H, 12 34, N, 4 92 $C_{17}H_{35}NO_2$ requires C, 71 51, H, 12 37, N, 4 91), ^{1}H-NMR ($CDCl_3$) δ (ppm) 4 80 (m, 1H, CH), 4 55 (bs, 1H, NH), 3 15 (q, 2H, CH_2), 1 50 (m, 4H, $2CH_2$), 1 30 (m, 18H, $9CH_2$), 1 15 (d, 3H, $2CH_3$), 0 90 (t, 6H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 156 45 (C=O), 71 19 (CH), 40 86 (CH_2), 36 23 (CH_2), 31 72 ($2CH_2$), 29 98 (CH_2), 29 18 ($2CH_2$), 29 14 (CH_2), 26 69 (CH_2), 25 31 (CH_2), 22 57 (CH_2), 22 52 (CH_3), 20 26 (CH_2), 14 01 ($2CH_3$), MS (EI, 70 eV), m/z 285 (M^+), 186 (1 69), 174 (84 98), 112 (25 58), 71 (100 00), 43 (41 10)

***S*-(+)-*N*-Benzyl-2-octyl carbamate (8b):** white solid, mp 45-46° C, R_f=0 31 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1692 cm^{-1}, (found C, 72 80, H, 9 58, N, 5 33 $C_{16}H_{25}NO_2$ requires C, 72 95, H, 9 57, N, 5 32), ^{1}H-

NMR ($CDCl_3$) δ(ppm) 7 30 (m, 5H, ar), 5 00 (bs, 1H, NH), 4 80 (m, 1H, CH), 4 30 (d, 2H, CH_2), 1 50 (m, 2H, CH_2), 1 40-1 20 (m, 11H), 0 85 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 156 43 (C=O), 138 68 (C), 128 50 (2CH), 127 36 (2CH), 127,26 (CH), 71 59 (CH), 44 86 (CH_2), 36 16 (CH_2), 31 67 (CH_2), 29 07 (CH_2), 25 25 (CH_2), 22 48 (CH_3), 20 21 (CH_2), 13 98 (CH_3), MS (EI, 70 eV), m/z 263 (M^+, 1 35), 151 (56 56), 150 (100 00), 106 (22 39), 91 (38 83)

***S*-(+)-*N*-Butyl-2-octyl carbamate (8c):** oil, R_f=0 34 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1694 cm ^{1}, (found C, 67 94, H, 11 91, N, 6 09 $C_{13}H_{27}NO_2$ requires C, 68 06, H, 11 87, N, 6 11), ^{1}H-NMR ($CDCl_3$) δ(ppm) 4 80 (m, 1H, CH), 4 65 (bs, 1H, NH), 3 15 (q, 2H, CH_2), 1 60-1 20 (m, 14H, $7CH_2$), 1 15 (d, 3H, CH_3), 0 90 (m, 6H, $2CH_3$), ^{13}C-NMR ($CDCl_3$) δ(ppm) 156 46 (C=O), 71 15 (CH), 40 52 (CH_2), 36 20 (CH_2), 32 04 (CH_2), 31 68 (CH_2), 29 10 (CH_2), 25 28 (CH_2), 22 49 (CH_3), 20 22 (CH_2), 19 81 (CH_2), 13 97 (CH_3), 13 64 (CH_3) MS (EI, 70 eV), m/z 229 (M^+, 1 54), 186 (6 49), 118 (100 00), 71 (16 86)

***S*-(-)-*N*-Octyl-1-phenylethyl carbamate (8d):** oil, R_f=0 39 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1695 cm^{-1}, (found C, 73 70, H, 9 85, N, 5 03 $C_{17}H_{27}NO_2$ requires C, 73 59, H, 9 82, N, 5 05), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 40 (m, 5H, ar), 5 80 (q, J= 6 5 Hz, 1H, CH), 4 85 (bs, 1H, NH), 3 15 (m, 2H, CH_2), 1 50 (m, 5H, CH_3 and CH_2), 1 35-1 20 (m, 10 H, $5CH_2$), 0 85 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 155 82 (C=O), 142 14 (C), 128 26 (2CH), 127 51 (CH), 125 82 (2CH), 72 32 (CH), 40 85 (CH_2), 31 63 (CH_2), 29 81 (CH_2), 29 08 ($2CH_2$), 26 61 (CH_2), 22 51 (CH_2), 22 30 (CH_3), 13 97 (CH_3), MS (EI,70 eV), m/z 277 (M^+, 2 04), 122 (92 40), 105 (100 00), 104 (20 82), 77 (18 69)

***S*-(-)-*N*-benzyl-1-phenylethyl carbamate (8e):** oil, R_f=0 26 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1690 cm^{-1}, (found C, 75 32, H, 6 73, N, 5 48 $C_{16}H_{17}NO_2$ requires C, 75 26, H, 6 72, N, 5 49), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 40-7 20 (m, 10H, ar), 5 85 (q, J= 6 6 Hz, 1H, CH), 5 10 (bs, 1H, NH), 4 30 (d, 2H, CH_2), 1 55 (d, J=6 6 Hz, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ (ppm) 155 85 (C=O), 141 97 (C), 138 34 (C), 128 50 (2CH), 128 33 (2CH), 127 63 (CH), 127 39 (2CH), 127 31 (CH), 125 86 (2CH), 72 81 (CH), 44 89 (CH_2), 22 36 (CH_3), MS (EI, 70 eV), m/z 255 (M^+, 2 11), 122 (50,21), 105 (100 00), 77 (48 45)

***S*-(-)-*N*-Butyl-1-phenylethyl carbamate (8f):** oil, R_f=0 23 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1693 cm^{-1}, (found C, 70 60, H, 8 64, N, 6 34 $C_{13}H_{19}NO_2$ requires C, 70 54, H, 8 66, N, 6 33), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 35 (m, 5H, ar), 5 80 (q, J= 6 6 Hz, 1H, CH), 4 80 (bs, 1H, NH), 3 15 (m, 2H, CH_2), 1 60 (d, J= 6 6 Hz, 3H, CH_3), 1 45 (m, 2H, CH_2), 1 30 (m, 2H, CH_2), 0 90 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ(ppm) 155 84 (C=O), 142 15 (C), 128 30 (2CH), 127 55 (CH), 125 85 (2CH), 72 36 (CH), 40 56 (CH_2), 31 89 (CH_2), 22 32 (CH_3), 19 76 (CH_2), 13 61 (CH_3), MS (EI, 70 eV), m/z 221 (M^+), 122 (64 14), 105 (100 00), 77 (15 88)

***S*-(+)-*N*-Octyl-2-butyl carbamate (8g)** oil, R_f=0 43 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{c=o}$= 1694 cm ^{1}, (found C, 67 99, H, 11 89, N, 6 10 $C_{13}H_{27}NO_2$ requires C, 68 06, H, 11 87, N, 6 11), ^{1}H-NMR ($CDCl_3$) δ(ppm) 4 70 (m, 2H, NH and CH), 3 15 (q, 2H, CH_2), 1 60-1 20 (m, 14H, $7CH_2$), 1 15 (d, 3H, CH_3), 0 90 (m, 6H, $2CH_3$), ^{13}C-NMR ($CDCl_3$) δ(ppm) 156 42 (C=O), 72 20 (CH), 40 80 (CH_2), 31 66 (CH_2), 29 91 (CH_2), 29 12 ($2CH_2$), 28 98 (CH_2), 26 64 (CH_2), 22 52 (CH_2), 19 67 (CH_3), 13 97 (CH_3), 9 57 (CH_3), MS (EI, 70 eV), m/z 229 (M^+, 1 39), 214

(M+-15), 174 (31 56), 130 (37 08), 57 (100 00), 41 (34 41)

***S*-(+)-*N*-Benzyl-2-butyl carbamate (8h):** oil, R_f=0 27 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{C=O}$= 1692 cm $^{-1}$, (found C, 69 60, H, 8 18, N, 6 78 $C_{12}H_{17}NO_2$ requires C, 69 52, H, 8 27, N, 6 76), ^{1}H-NMR ($CDCl_3$) δ(ppm) 7 30 (m, 5H, ar), 5 15 (bs, 1H, NH), 4 75 (m, 1H, CH), 4 35 (d, 2H, CH_2), 1 55 (m, 2H, CH_2), 1 20 (d, 3H, CH_3), 0 85 (t, 3H, CH_3), ^{13}C-NMR ($CDCl_3$) δ (ppm) 156 52 (C=O), 138 57 (C), 128 45 (2CH), 127 31 (2CH), 127 22 (CH), 72 72 (CH), 44 77 (CH_2), 28 92 (CH_2), 19 63 (CH_3), 9 54 (CH_3), MS (EI, 70 eV), m/z 207 (M+, 3 11), 150 (100 00), 91 (64 43), 79 (13 45), 57 (9 89)

***S*-(+)-*N*-Butyl-2-butyl carbamate (8i):** oil, R_f=0 32 (Hexane ethyl ether 7 3), IR (neat) $\upsilon_{C=O}$= 1694 cm^{-1}, (found C, 62 43, H, 11 05, N, 8 12 $C_9H_{19}NO_2$ requires C, 62 38, H, 11 06, N, 8 09), ^{1}H-NMR ($CDCl_3$) δ(ppm) 4 70 (bs, 2H, CH and NH), 3 15 (m, 2H, CH_2), 1 70-1 25 (m, 6H, $3CH_2$), 1 20 (d, J=6 2 Hz, 3H, CH_3), 0 90 (m, 6H, $2CH_3$), ^{13}C-NMR ($CDCl_3$) δ(ppm) 156 42 (C=O), 72 19 (CH), 40 47 (CH_2), 31 98 (CH_2), 28 97 (CH_2), 19 78 (CH_2), 19 66 (CH_3), 13 61 (CH_3), 9 57 (CH_3), MS (EI, 70 eV), m/z 173 (M+, 3 84), 158 (M+-15), 118 (54 37), 100 (47 76), 57 (100 00), 41 (30 42)

***R*-(-)-*n*-Butyl-2-octyl carbonate:** $[\alpha]_D^{25}$= -4 3 (c= 1 4 $CHCl_3$)

***R*-(+)-*n*-Octyl-1-phenylethyl carbonate:** $[\alpha]_D^{25}$= +53 4 (c= 1 1 $CHCl_3$)

***R*-(+)-*n*-Butyl-1-phenylethyl carbonate:** $[\alpha]_D^{25}$= +67 2 (c= 0 9 $CHCl_3$)

***R*-(-)-*n*-Butyl-2-butyl carbonate:** $[\alpha]_D^{25}$= -12 3 (c= 1 3 $CHCl_3$)

***S*-(+)-*N*-Octyl-2-octyl carbamate:** $[\alpha]_D^{25}$= +10 0 (c= 0 7 $CHCl_3$)

***R*-(-)-*N*-Benzyl-2-octyl carbamate:** $[\alpha]_D^{25}$= -14 6 (c= 2 1 $CHCl_3$)

***R*-(-)-*N*-Butyl-2-octyl carbamate:** $[\alpha]_D^{25}$= -10 5 (c= 1 0 $CHCl_3$)

***R*-(+)-*N*-Octyl-1-phenylethyl carbamate:** $[\alpha]_D^{25}$= +24 8 (c= 0 8 $CHCl_3$)

***R*-(+)-*N*-Benzyl-1-phenylethyl carbamate:** $[\alpha]_D^{25}$= +14 6 (c= 1 6 $CHCl_3$)

***R*-(+)-*N*-Butyl-1-phenylethyl carbamate:** $[\alpha]_D^{25}$= +31 5 (c= 1 2 $CHCl_3$)

***R*-(-)-*N*-Octyl-2-butyl carbamate:** $[\alpha]_D^{25}$= -12 4 (c= 1 0 $CHCl_3$)

***R*-(-)-*N*-Benzyl-2-butyl carbamate:** $[\alpha]_D^{25}$= -13 1 (c= 0 9 $CHCl_3$)

***R*-(-)-*N*-Butyl-2-butyl carbamate:** $[\alpha]_D^{25}$= -15 9 (c= 0 7 $CHCl_3$)

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