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OPTICALLY ACTIVE α- AND β-NAPHTHALENE DERIVATIVES—III[1,2]

SYNTHESIS AND OPTICAL PURITY OF 2-(α- AND β-NAPHTHYL)-BUTANES

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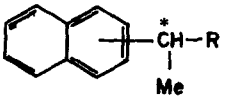
Abstract—Optically active 2-(α- and β-naphthyl)-butanes were prepared starting from 2-(α- and β-naphthyl)-propionic acid. Their relative configurations and maximum rotatory powers were chemically established by relating them to know naphthalene derivatives and (S)-2-methyl-butan-1-ol.

In connection with our studies on the chiroptical properties of aromatic chromophores[3-6] we have undertaken the preparation of new optically active naphthalene hydrocarbons having different steric requirements at the asymmetric C atom.



R = Et, Pr^i, Bu^t; α-$C_{10}H_7$(a), β-$C_{10}H_7$(b)

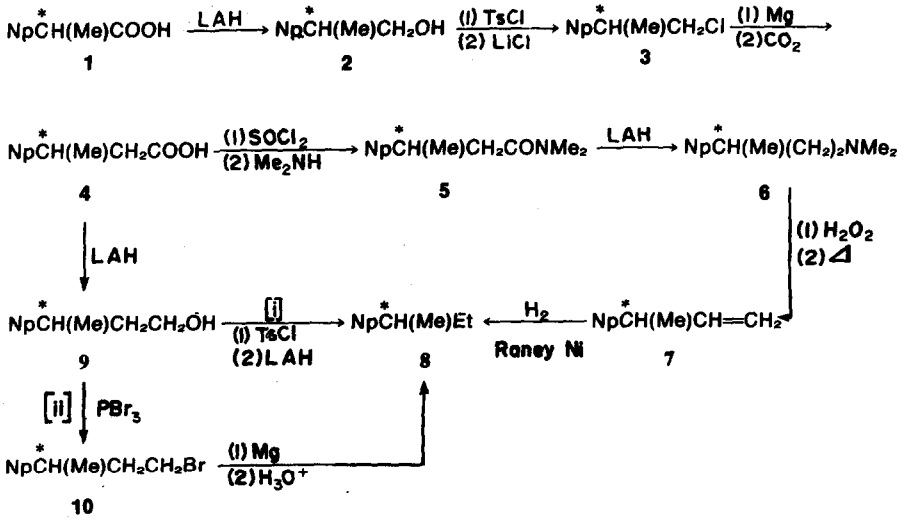
The present report deals with the synthesis and the determination of the relationship between the sign of the optical rotation and the absolute configuration as well as that between optical purity and the value of the rotary power of 2-(α- and β-naphthyl)-propionic acids (**1a, b**), 2-(α- and β-naphthyl)-butanes (**8a, b**) and of their intermediates (Scheme 1).

The optically active acids **1a, b** were chosen as starting materials: the synthesis and the resolution of **1a** were known;[7,8] the preparation of racemic acid **1b** was achieved by 2-methylation of methyl (β-naphthyl)-acetate and after hydrolysis its resolution was accomplished as reported.[9] The conversion of **2a, b** into **3a, b** was carried out by reacting lithium chloride in DMF with the corresponding tosylate[10] as the usual reagents ($SOCl_2$ in pyridine, PCl_5 in benzene) yielded variable amounts of isomeric products. The 3-(α- and β-naphthyl)-but-1-enes **7a, b** were obtained by already described sequences.[3,4,10] The 2-(α- and β-naphthyl)-butanes **8a, b** were prepared from **7a, b** by catalytic hydrogenation and from **9a, b** by independent routes (Scheme 1).

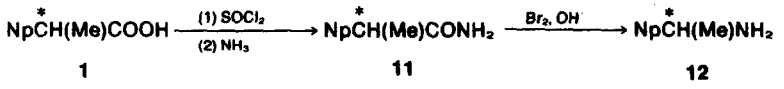
Some physical properties of the prepared compounds and their rotatory powers, evaluated as medium values by some repeated sequences using precursors of comparable optical purities, are given in Tables 1 and 2. The structures of all the compounds prepared were confirmed by chemical and/or spectroscopic analyses.

The compounds **1a, b** were correlated to known 1-(α- and β-naphthyl)-ethylamines **12a**[12,13a] and **12b**[12c,13] by Hofmann degradation of the corresponding amides **11a, b** to verify their stereochemical assignments[8,11] (Scheme 2, Table 3).

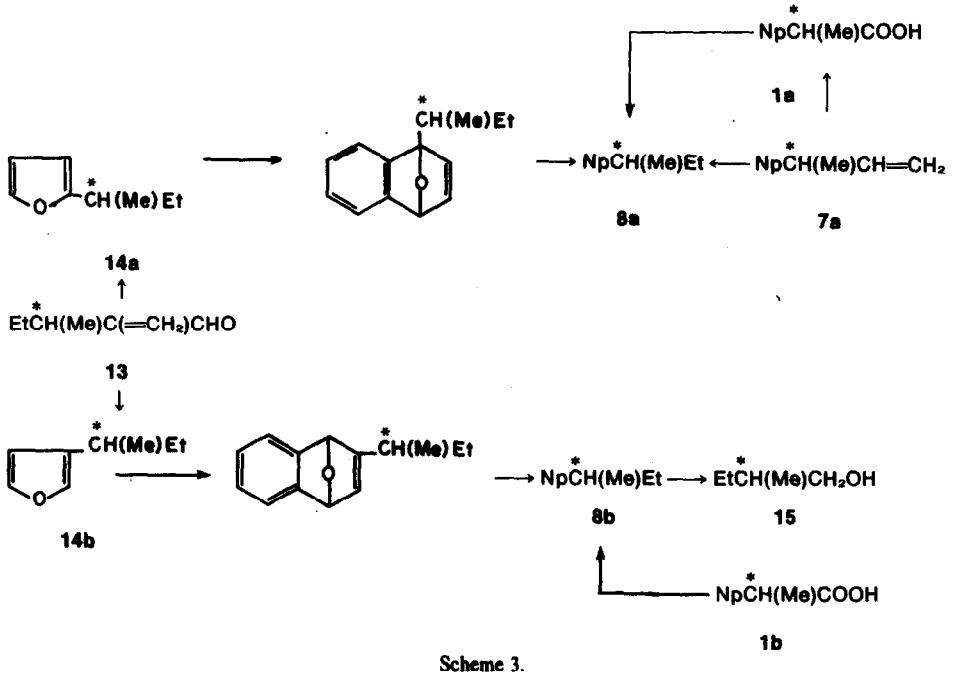
Moreover to check the stereospecificity of the adopted reactions (Scheme 1) and to establish the relationship between optical purity and optical rotation of our products the following sequences (Scheme 3) were accomplished: (1) Compound **7a** was converted into **1a** by



Scheme 1.



Scheme 2.



Scheme 3.

Table 1. α-naphthyl derivatives 1a–8a

Compound	m.p.°C	b.p.°C (Torr)	$[\alpha]_D^{25}$ (c, solvent)
1a	60		-129.38(2.250, Me_2CO)
2a		133(0.7)	- 8.02(3.543, PhH)
3a		109(0.3)	+46.03(2.543, PhH)[a]
4a	63 - 68		+16.59(11.024, Me_2CO)[a]
6a		116(03)	- 23.88(2.120, PhH)
7a		95(0.6)	- 36.80(neat)[b]
8a		87(0.6)	+22.40(neat)[c,d] +18.49(neat)

[a] At 365 nm; [b] d_4^{25} 0.9997; [c] d_4^{25} 0.9798; [d] Sequence [i]; [e] From 7a $[\alpha]_D^{25}$ -29.44(neat).

oxidative degradation;[10] (2) The naphthyl hydrocarbons **8a, b** were prepared starting from (*S*)-2-methylene-3-methylpentanal **13**[14] via (*S*)-2-(2- and 3-furyl)-butanes **14a, b**;[15,16] (3) Compound **8b** was transformed into (*S*)-2-methyl-butan-1-ol **15**.

DISCUSSION AND CONCLUSIONS

The more noticeable observation, in the context of the preparation of naphthylhydrocarbons **8a, b**, concerns the conversion of 2-(α- and β-naphthyl)-propan-1-ols **2a, b** into the corresponding chlorides (Scheme 1). These alcohols produce the isomeric 1-(α- and β-naphthyl)-2-chloropropanes in accordance with the nature of the halogenation agent (Table 4).

The maximum extent of such an isomerization (90%) was observed by reacting PCl_5 in benzene[17] either with **2a** or **2b**. Thionyl chloride in pyridine, while giving appreciable isomerization (35%) in the case of **2a** is a satisfactory halogenation agent for **2b**, although the yields are always poor in both cases (39 and 22–36% respectively).

Such rearrangement in the course of the halogenation of the alcohols characterized by the presence of an aromatic system in the α-position is known;[10,18,19] however in our case it emphasises that the behaviour of α- and β-derivatives (Table 4) is not plain by using criteria of different steric and electronic requirements of α- and β-naphthyl groups. The formation of an inter-

Table 2. β-naphthyl derivatives 1b–10b[a]

Compound	m.p.°C	b.p.°C (Torr)	$[\alpha]_D^{25}$ (c, solvent)
1b	135-143		+65.35(0.812, EtOH)
2b	43-46	121(0.4)	-26.33(2.463, PhH)
3b	54-60	123(0.6)	-28.55(2.157, PhH)
4b	67-69		-34.95(0.933, EtOH)
6b		128(0.9)	-34.21(2.288, PhH)
7b		87(0.7)	- 9.83(neat)[b]
8b		93(0.9)	-27.98(neat)[c]
9b		136(0.5)	-48.39(1.890, PhH)
10b		134(0.5)	-87.32(1.838, PhH)

[a] The experimental values of the rotatory power are referred to the same sample of 1b to simplify the evaluation of maximum optical rotations; [b] d_4^{25} 0.982; [c] d_4^{25} 0.966.

Table 3. Stereochemical correlations of 1a, b and 12a, b ($[\alpha]_D^{25}$, c, solvent)

	1	11	12
a	+ 63.81 (2.241, Me_2CO) -119.95(2.405, Me_2CO)	----	- 34.37 (neat)[a] + 67.76 (neat) [b]
b	+ 65.30(0.812, EtOH) -59.55(0.879, EtOH)	---- - 32.40 (1.045, Me_2CO)	- 21.50 (2.041, EtOH) + 17.36 (2.502, EtOH)

[a] $[\alpha]_D^{23}$ - 34.61 (neat); [b] $[\alpha]_D^{23}$ + 68.23 (neat).

Table 4. Isomerization in the conversion of 2a, b into 3a, b

Halogenation agent	Solvent	Relative percentage (mole %) [a] 3		$NpCH_2CH(Me)Cl$	
		a	b	a	b
$SOCl_2$	Py	65	97 - 98	35	3 - 2
PCl_5	PhH	13	6	87	94
LiCl [b]	DMF	90-100	100	10 - 0	0

[a] Determined by g.l.c. analysis; [b] On the tosylate of 2.

mediate cyclopropylium ion[18b] represents a satisfactory explanation of the isomerization but it is too oversimplified to allow a quantitative rationalization of our results.

A different reactivity of the β- vs α-naphthalene derivatives was observed also in the Cope and Hofmann reactions (Schemes 1 and 2): the chemical yields were always the poorest in the former case.

The correlation of 1a to 12a (Scheme 2) has confirmed the absolute configuration of the acid 1a[8] and has shown that the maximum rotations of both the substrates 1a and 12a established on maximum resolution criteria[8,12] are consistent. In fact by assuming for optically pure 12a $[\alpha]_D^{25}$ 80.8 (neat)[12b-d] and $[\alpha]_D^{23}$ 81.7 (neat)[12a] and, on the basis of the experimental results reported in Table 3, the value for optically pure 1a, $[\alpha]_D^{25}$ 146.8 (Me_2CO) (medium value) is in excellent agreement with the value 145.9 (Me_2CO) reported by Fredga.[8]

The analogous correlation for 1b and 12b (Scheme 2), while it confirms the reported absolute configurations of these compounds,[11,13] it shows that the values of the maximum optical rotations of 12b[12c,13] are uncorrected since a sample of amine 12b, $[\alpha]_D^{25}$ 21.50 (EtOH) (Table 3) was recovered starting from 1b (95% optically pure):[9] the highest value reported for 12b is $[\alpha]_D^{25}$ 21.0 (EtOH).[13a]

The minimum optical purity of 8a, $[\alpha]_D^{25}$ + 18.49 (neat) could be evaluated on the basis of the olefin 7a, $[\alpha]_D^{25}$ - 29.44 (neat) (70.5% optically pure) since the oxidative

Table 5. Optical rotations, absolute configurations, optical purity of compounds of Scheme 3

Compound	$[\alpha]_D^{25}$ (c, solvent)	absolute configuration	o.p. %
14a	+18.30 (3.032, n.C_7H_{16})	S	84.4
14b	+17.88 (3.020, n.C_7H_{16})	S	90.5
8a	+18.49(neat)[a]	S	71.6[b]
	+22.40(neat)[c]	S	88.1[d]
	+19.95(neat)[e]	S	84.4[f]
8b	-27.98(neat)[g]	R	95.0[h]
	+13.60(neat)	S	45.0[i]
	+27.65(neat)[j]	S	90.5[k]
7a	-29.44(neat)	S	71.6[l]
15	-3.01(3.400, n, C_7H_{16})	S	45.0[m]

[a] From 7a; [b] Evaluated on the basis of the optical purity of 7a; [c] From 9a (Scheme 1, sequence [i]) [d] Evaluated on the basis of the optical purity of 1a; [e] From 14a; [f] Assuming the optical purity of 14a; [g] From 1b (Scheme 1); [h] Assuming for 1b, optically pure $[\alpha]_D^{25}$ 68.8 (EtOH); [i] Evaluated on the basis of the optical purity of 15; [j] From 14b; [k] Assuming the optical purity of 14b; [l] by oxidative degradation to 1a; [m] $[\alpha]_{D\,max}^{25}$ 6.66 (3.020, n.C_7H_{16}) [G.P.Giacomelli, A.M.Caporusso, L.Lardicci, J.Chem.Soc., Perkin I, 1333 (1977)].

degradation of 7a showed no racemization in the sequence 1a→7a (Scheme 3).†

To determine the stereospecificity[20] of the hydrogenation reaction 7a→8a: (i) a sample of 4a (88.1% optically pure) was converted, via 9a, into 8a, $[\alpha]_D^{25}$ + 22.40 (neat) (Scheme 1, seq. i); (ii) a sample of (*S*)-2-(2-furyl)-butane 14a (84.4% optically pure)[15] afforded 8a, $[\alpha]_D^{25}$ + 19.95 (neat) (Scheme 3).

On the basis of the overall results and taking into account the nature of the sequence adopted, $[\alpha]_{D_{max}}^{25}$ 25.4 (neat) is the most reliable value for 8a (Table 5).

By using the experimental results of the Scheme 1, the minimum optical purity of 8b could be evaluated on the basis of the maximum rotation of 1b, the reported values of which had however to be checked. The preparation of 8b, starting from a sample of (*S*)-2-(3-furyl)-butane 14b (71.8% optically pure)[16] resulted in a maximum rotation of 1b 30% *ca* higher than that previously reported.[9] This disagreement impelled us to carry out the further correlation of 8b with (*S*)-2-methylbutan-1-ol 15: a sample of 8b, $[\alpha]_D^{25}$ + 13.60 (neat), by reductive ozonolysis, yielded 45% optically pure 15 (Scheme 3, Table 5).

On the basis of this experimental result a maximum rotation of 70.5 (EtOH), was attributed to 1b in a good agreement with the value 68.8 (EtOH) reported by Sjöberg[9] (Table 5).

In this context we again estimated the maximum rotation of 14b:[16] by reductive ozonolysis of a sample of (*S*)-2-(3-furyl)-butane as $[\alpha]_D^{25}$ 18.04 (*n*-C_7H_{16}). The yield of (*S*)-2-methylbutan-1-ol (91.6% optically pure); confirmed the stereochemical correlations between 1b, 8b and 14b (Table 5).

The estimation of the minimum optical purity of 14b, previously performed by two different oxidative degradations, the results of which appeared consistent,[16] was really erroneous. This evidence suggests that more and quite different sequences should be used to correctly solve like problems.

EXPERIMENTAL

M.ps and b.ps are uncorrected. Glc analyses [2 m × 0.29 cm columns packed with: 8% Carbowax 20 M + 2% KOH on 80–100 mesh Chromosorb W (CW 20 M); 15% Butanediol succinate on 90–100 mesh Chromosorb W (BDS); 2.5% Silicone gum rubber on 80–100 mesh AW-DMCS Chromosorb G (SE 301)] were performed on a Perkin Elmer F 30 or a C.Erba Fractovap mod. Instrument with flame ionization detectors and nitrogen as carrier gas. Preparative glc's were carried out on a Perkin Elmer F 21 chromatograph, using 2 or 3 m × 0.95 cm columns packed with: 3% Silicone gum rubber on 60–80 mesh Chromosorb G (SE 301), 20% Butanediol succinate on 45–60 mesh Chromosorb A (BDS) 8% Carbowax 20 M + 2% KOH on 80–100 mesh Chromosorb W (CW 20 M). NMR spectra were recorded with a Varian T 60 or a Jeol PS 100 spectrometer with TMS as internal standard. Mass spectra were obtained with a Varian Mat CH 7 mass spectrometer (70 eV). Optical rotations were taken with a Perkin Elmer 142 or with a Schmidt–Haensch polarimeters and refer to pure liquid unless otherwise stated. Microanalyses were carried out in the Microanalysis Laboratory of the Faculty of Pharmacy of the University of Pisa. Solvents and commercial reagents were purified by conventional methods before use.

2-(Naphthyl)-propionic acids 1a, b. (*R*)(*S*)-1a was prepared as previously described[7] from (1-naphthyl) acetonitrile [75%; m.p. 150–1° (lit.[7b,21] m.p. 148–9°); 98% pure (BDS; 190° on the corresponding methyl ester)] and its resolution was performed with cinchonidine.[8] A sample of (*R*)-1a ([α_D^{25} – 129.38 (*c* 2.250, Me_2CO)) afforded, by diazomethane, its methyl ester [b.p. 110–1°/0.7 Torr; 100% pure (BDS; 190°); $[\alpha]_D^{25}$ – 159.71 (*c* 2.551, PhH); lit.[22] m.p. 48–50°].

In a typical run to obtain 1b the following procedure was adopted: to a stirred suspension of 11.3 g (0.29 mol) of sodamide in 1100 ml of liquid ammonia were added 50.0 g (0.25 mol) of methyl- (β-naphthyl) acetate dissolved in 25 ml of dry ether followed after 15 min, by an ethereal soln of 59.5 g (0.42 mol) of MeI. The mixture, after 1.5 hr, was hydrolyzed by 20.0 g (0.37 mol) of NH_4Cl and worked up in the usual manner.[23]

The recovered ester [94%; b.p. 122°/0.6 Torr; 95% pure (SE 301; 165°); NMR δ (neat) 7.2–7.9 (7H, m, aromatic), 3.8 (1H, q, –C<u>H</u>(CH_3)–), 3.5 (3H, s, –COOC<u>H</u>$_3$), 1.6 (3H, d, –CH(C<u>H</u>$_3$)–)], hydrolyzed by an alcoholic soln of KOH, afforded quantitatively (*R*)(*S*)-1b [m.p. 125–7° (lit.[9] 129–30°)] that was resolved.[9] The

†In our opinion it was necessary to accomplish a stereospecific degradation 7a→1a to verify if the isomerization observed in the conversion of 2a into 3a (Scheme 1) affected the chiral centre.

corresponding methyl ester [100% pure (SE 301; 165°)] from (*S*)-**1b** ($[\alpha]_D^{25}$ + 65.35 (*c* 0.812, EtOH)) showed; m.p. 38–41°; $[\alpha]_D^{25}$ + 103.73 (*c* 2.624, PhH).

2-(*Naphthyl*)-1-*propanols* **2a, b.** In a representative procedure 27.4 g (0.14 mol) of (*R*)-**1a** in 450 ml dry ether was reduced with 8.1 g (0.21 mol) LAH, during 15 hr, to 24.4 g of (*R*)-**2a** [96%; n_D^{25} 1.614; 98% pure (SE 301; 200°); Found: C, 83.90; H, 7.50. Calc. for $C_{13}H_{14}O$: C, 83.83: H, 7.58%]. Analogously 41.0 g (0.21 mol) of (*S*)-**1b** afforded 38.0 g of (*S*)-**2b** [99%; 99% pure (SE 301; 180°) Found: C, 83.90: H, 7.89; mass spectrum *m/e* rel. intensity: 186 (M^+, 33) 155 (100)].

2-(*Naphthyl*)-1-*chloropropanes* **3a, b.** To 23.3 (0.13 mol) of (*R*)-**2a** in 47.1 g (0.60 mol) dry pyridine was added, at 0–10°, 28.6 g (0.15 mol) tosyl chloride. The resulting mixture was stirred at room temp. for 16 hr, hydrolyzed with 10% HCl, extracted with ether and worked up in usual manner. The solvent was removed under reduced pressure and the crude oil, dissolved in 125.0 g (1.7 mol) DMF, was reacted at 90–95° with 6.9 g (0.16 mol) of LiCl in 78.1 g (1.1 mol) DMF. The mixture was stirred for 2 hr at 90–95°, then hydrolyzed with water and extracted with ether. After distillation 23.9 g of (*R*)-**3a** was recovered [90%; 100% pure (SE 301; 155°); NMR δ (CCl_4) 7.4–6.4 (7H, m, aromatic), 3.7–3.2 (1H, m, –CH(CH₃)–), 3.4–2.9 (2H, 2d, –CH₂Cl), 1.2 (3H, d, –CH(CH₃)–)]. In other runs, 90–95% pure chloride was obtained the impurity being 1-(1-naphthyl)-2-chloropropane. The structure of this product, recovered as the main component using PCl_5 chlorination, was determined on the basis of the structure of the methyl 2-methyl-3-(α-naphthyl)-propionate, obtained via carbonatation of the Grignard reagent prepared from the chloride [mass spectrum *m/e* rel. intensity: 228 (M^+, 19), 141 (100); NMR δ (CCl_4) 8.0–7.1 (7H, m, aromatic), 3.4 (3H, s, –COOCH₃) 3.2–2.3 (3H, m, –CH₂–CH(CH₃)–), 1.0 (3H, d, –CH(CH₃)–)]. Under identical conditions 36.5 g (0.200 mol) of (*S*)-**2b** afforded 66.0 g of crude tosylate which was recovered by filtration of the mixture [a sample, recrystallized from MeOH, showed: m.p. 87–92°, $[\alpha]_{365}^{25}$ – 11.79 (*c* 2.545, Me_2CO); Found: S, 9.45. Calc. for $C_{20}H_{20}O_3S$: S, 9.42]. The tosylate was converted into 36.6 g of (*S*)-**3b** [89%; ~ 100% pure (SE 301; 155°) Found: C, 76.16; H, 6.37; Cl, 17.18. Calc. for $C_{13}H_{13}Cl$: C, 76.28; H, 6.40: Cl, 17.32%; mass spectrum, *m/e* rel. intensity: 204 (M^+, 31), 155 (100), 141 (55); NMR δ (CCl_4) 7.9–7.1 (7H, m, aromatic), 3.7–3.5 (2H, 2d, –CH₂Cl), 3.2 (1H, M, –CH(CH₃–), 1.5 (3H, d, –CH(CH₃)–)].

3-(*Naphthyl*)-*butanoic acids* **4a, b.** The Grignard reagent in dry ether from 23.0 g (0.11 mol) of (*R*)-**3a** and 2.9 g (0.12 g atoms) of Mg was carbonated with dry ice. The mixture was processed in the usual way to give 21.5 g of (*S*)-**4a** [90%; 100% pure (SE 301; 170°) on the corresponding methyl ester]. A sample of **4a** ($[\alpha]_{365}^{25}$ + 16.59 (*c* 11.024, Me_2CO)) afforded, by diazomethane, its methyl ester [b.p. 148°/1.5 Torr; $[\alpha]_{365}^{25}$ + 36.15 (*c* 3.020, PhH); mass spectrum *m/e* rel. intensity: 228 (M^+, 39), 155 (100); NMR δ (CCl_4) 8.0–7.1 (7H, m, aromatic), 4.0 (1H, m, –CH(CH₃)–), 3.4 (3H, s, –COOCH₃), 2.5 (2H, 2d, –CH₂–), 1.3 (3H, d, –CH(CH₃)–)].

In a similar manner, 34.1 g (0.17 mol) of (*S*)-**3b** was converted into 18.9 g of (*R*)-**4b** [53%; 99% pure (SE 301; 170°) on the methyl ester Found: C, 78.65; H, 6.28. Calc. for $C_{14}H_{14}O_2$: C, 78.48; H, 6.59%]. The methyl ester, obtained from a sample of **4b** ($[\alpha]_D^{25}$ – 34.95 (*c* 0.933, EtOH)), showed: b.p. 111–2°/0.2–0.3 Torr; $[\alpha]_D^{25}$ – 53.40 (*c* 3.873, PhH).

N,N-*Dimethyl*-3-(*naphthyl*)-*butanamides* **5a, b.** To an ether soln of 16.0 g (0.074 mol) of (*S*)-**4a** was added 20.5 g (0.17 mol) of $SOCl_2$ and the mixture was left for 24 hr and then refluxed for 8 hr. The crude chloride in ether, was cooled to – 10°, and an ether soln of 2 equivalents of dimethylamine was added. The mixture was hydrolyzed and the organic product extracted in ether, the solvent was removed to leave after distillation, 15.5 g of (*S*)-**5a** [86%; b.p. 187°/2.5 Torr Found: C, 79.20; H, 8.38; N, 5.90. Calc. for $C_{16}H_{18}NO$: C, 79.63; H, 7.94; N, 5.80%]. Analogously 14.8 g (0.069 mol) of (*R*)-**4b** afforded 15.8 g of (*R*)-**5b** [95%; m.p. 91–2° Found: C, 79.40; H, 7.77; N, 5.96%; NMR δ ($CDCl_3$) 7.2–8.0 (7H, m, aromatic), 3.6 (1H, m, –CH(CH₃)–), 2.9 (6H, 2s, –CON(CH₃)₂), 2.7 (2H, d, –CH₂–), 1.4–1.5 (3H, d, –CH(CH₃)–)]. A sample of **5b**, recrystallized from n-hexane, showed $[\alpha]_D^{25}$ – 79.18 (*c* 2.248, PhH).

N,N-*Dimethyl*-3-(*naphthyl*)-*butylamines* **6a, b.** A soln of 15.5 g (0.064 mol) of (*S*)-**5a** in 150 ml anhyd ether was slowly added to a stirred suspension of 5.8 g (0.15 mol) of LAH, in 50 ml ether. The resulting mixture was stirred under reflux for 16 hr and then worked up by the standard procedure to give 14.1 g of (*S*)-**6a** [96% Found: C, 84.60; H, 9.51; N, 6.26. Calc. for $C_{16}H_{21}N$: C, 84.53; H, 9.31; N, 6.16%]. Under identical conditions, 14.8 g (0.061 mol) of (*R*)-**5b** afforded 13.4 g of (*R*)-**6b** [96% Found: C, 84.45; H, 9.59; N, 6.16%].

3-(*Naphthyl*)-1-*butenes* **7a, b.** 14.0 g (0.061 mol) of (*S*)-**6a** was converted into its oxide[10] which was heated under N_2 (1.5 Torr) at a temp. of 145° until the decomposition was complete (~ 15 min). The distillate was worked up by the usual manner and the crude alkene was distilled to give 9.6 g of (*S*)-**7a** [85%; ~ 99% pure (BDS, 160°) Found: C, 91.89; H, 7.90. Calc. for $C_{14}H_{14}$: C, 92.26; H, 7.74%; NMR (100 MHz) δ (neat) 7.96 (1H, m, aromatic), 7.56 (2H, m, aromatic), 7.27 (4H, m, aromatic), 6.00 (1H, m, –CH=CH₂), 5.05–4.93 (2H, 2d, –CH=CH₂), 4.04 (1H, m, –CH(CH₃)–), 1.28 (3H, d, –CH(CH₃)–)]. The oxide of 13.1 g (0.058 mol) of (*R*)-**6b**, under an analogous procedure, afforded 6.3 g of (*R*)-**7b** [60%; > 99% pure (SE 301; 160°); n_D^{25} 1.5920 Found: C, 92.13; H, 8.01%; NMR (100 MHz) δ (neat) 7.60 (4H, m, aromatic), 7.22 (3H, m, aromatic) 5.97 (1 H, m, –CH=CH₂), 5.07–4.94 (2H, 2d, –CH=CH₂), 3.30 (1 H, m, –CH(CH₃)–), 1.25 (3H, d, –CH(CH₃)–)].

2-(*Naphthyl*)-*butanes* **8a, b.** A soln of 1.9 g (0.010 mol) of (*S*)-**7a**, $[\alpha]_D^{25}$ – 29.44 (neat), in 15 ml of 95% EtOH was hydrogenated, at room temp., in the presence of catalytic amount of Raney Ni to give a quantitative yield of 1.9 g of (*S*)-**8a** [~ 97% pure (BDS; 160°)]. A sample of 8a, purified by glpc (BDS, 170°), showed $[\alpha]_D^{25}$ + 18.49 (neat) Found: C, 91.00; H, 8.98. Calc. for $C_{14}H_{16}$: C, 91.25; H, 8.75%; NMR (100 MHz) δ (neat) 7.93 (1H, m, aromatic), 7.67 (2H, m, aromatic), 7.18 (4H, m, aromatic), 3.29 (1H, m, –CH(CH₃)–), 1.58 (2H, m, –CH₂–), 1.19 (3H, d, –CH(CH₃)–), 0.76 (3H, t, –CH₂CH₃). In the same manner 1.7 g (0.0093 mol) of (*R*)-**7b** ($[\alpha]_D^{25}$ – 9.75 (neat)) afforded 1.6 g of (*R*)-**8b** [93%; > 99% pure (BDS; 150°) Found: C, 91.1; H, 8.70%; $[\alpha]_D^{25}$ – 27.40 (neat); NMR (100 MHz) δ (neat) 7.56 (4H, m, aromatic), 7.18 (3H, m, aromatic), 2.49 (1H, m, –CH(CH₃)–), 1.48 (2H, m, –CH₂–), 1.16 (3H, d, –CH(CH₃)–), 0.76 (3H, t, –CH₂CH₃)].

Oxidation of 3-(*naphthyl*)-1-*butane.* 3.0 g (0.016 mol) of (*S*)-**7a** ($[\alpha]_D^{25}$ – 29.44 (neat)) was oxidized in 70 hr by $KMnO_4$–$NaIO_4$ mixture in 60% aqueous t-BuOH, according to the standard procedure.[4,10] The crude acid, **1a**, was esterified with diazomethane to give the corresponding methylester ($[\alpha]_D^{25}$ – 129.85 (*c* 2.318, PhH)).

3-(*Naphthyl*)-1-*butanols* **9a, b.** 4.5 g (0.019 mol) of (*S*)-**4a** was reduced in 15 hr with 1.7 g (0.044 mol) of LAH in 60 ml dry ether at the reflux temp. to 4.1 g of (*S*)-**9a** [98%; b.p. 148–50°/2 Torr].

In a similar manner 7.2 g (0.034 mol) of (*R*)-**4b** ($[\alpha]_D^{25}$ – 33.25 (*c* 0.954, EtOH)) and 8.0 g (0.037 mol) of (*R*)-**4b** ($[\alpha]_D^{25}$ – 34.05 (*c* 0.984, EtOH)) afforded respectively 6.4 g [96%; $[\alpha]_D^{25}$ – 46.87 (*c* 1.960, PhH)] and 6.7 g [90%; $[\alpha]_D^{25}$ – 48.00 (*c* 1.890, PhH)] of **9b**.

3-(β-*Naphthyl*)-1-*bromobutane* **10b.** 6.5 g (0.032 mol) of (*R*)-**9b** ($[\alpha]_D^{25}$ – 48.00 (*c* 1.890, PhH)) was treated at 0° with 7.1 g (0.026 mol) of PBr_3, following the procedure adopted by Levene and Marker,[24] to give 7.1 g of (*R*)-**10b** [83% pure (SE 301; 170°); $[\alpha]_D^{25}$ – 86.66 (*c* 1.838, PhH) Found: C, 63.80; H, 5.89; Br, 29.93. Calc. for $C_{14}H_{15}Br$: C, 63.89; H, 5.74; Br 30.07%].

2-(β-*Naphthyl*)-*butane* **8b** (*seq. ii*). The Grignard reagent, prepared from 6.6 g (0.025 mol) of (*R*)-**10b** ($[\alpha]_D^{25}$ – 86.66 (*c* 1.838, PhH)) and 0.7 g (0.029 g atoms) of Mg, in 60 ml dry ether, was hydrolyzed, at 0°, with a saturated soln of NH_4Cl and, after the usual procedure, afforded 3.2 g of (*R*)-**8b** [69%; 95% pure (CW 20 M; 180°)]. A sample of (*R*)-**8b** purified by glpc (3 m SE 301; 120°) showed $[\alpha]_D^{25}$ – 27.98.

2-(*Naphthyl*)-*butanes* **8a, b** (*seq. i*). 4.1 g (0.021 mol) of (*S*)-**9a** was converted, in the usual manner, into the corresponding tosylate which, without purification was reduced with 2.0 g (0.053 mol) LAH, in 50 ml of dry ether, to 2.8 g of (*S*)-**8a** [73%; 96% pure (SE 301; 160°); $[\alpha]_D^{25}$ + 21.50]. Analogously 6.4 g (0.032 mol) of (*R*)-**9b** ($[\alpha]_D^{25}$ – 46.87 (*c* 1.960 PhH)) afforded 3.2 g of (*R*)-**8b** [54%; 99% pure (SE 301; 155°); $[\alpha]_D^{25}$ – 26.64].

2-(*Naphthyl*)-*propionamides* **11a, b.** 15.0 g (0.074 mol) of (*R*)-**1a** ($[\alpha]_D^{25}$ – 119.95 (*c* 2.405, Me_2CO) was converted into the cor-

responding acid chloride as previously described and the crude product was slowly added, at −20°, to an aqueous soln of NH_3 (32%). The mixture was left aside for a night, then stirred for 2 hr and worked up as usual to give 15.0 g of (*R*)-**11a** [99%; m.p. 133–8°; $[\alpha]_D^{25}$ − 74.04 (*c* 2.073, Me_2CO/PhH 1/1, V/V), (lit.[22] m.p. 140–2°)]. Analogously 13.0 g (0.065 mol) of (*R*)-**1b** ($[\alpha]_D^{25}$ − 59.55 (*c* 0.879, EtOH) gave 9.6 g of (*R*)-**11b** [m.p. 135–142°; $[\alpha]_D^{25}$ − 31.10 (*c* 1.045, Me_2CO) Found: C, 78.56; H, 6.62; N, 7.10. Calc. for $C_{13}H_{13}NO$: C, 78.36; H, 6.58; N, 7.03%; NMR δ ($CDCl_3$) 8.0–7.2 (7H, m, aromatic), 5.9–5.1 (2H, s, $-CONH_2$), 3.8 (1H, q, $-CH(CH_3)-$), 1.6 (3H, d, $-CH(CH_3)-$)]; 2.5 g of (*R*)-**1b**, whose methyl ester showed $[\alpha]_D^{25}$ − 97.03 (*c* 2.410, PhH) were also recovered.

1-(*Naphthyl*)-*ethylamines* **12a, b**. To a soln of 13.1 g (0.33 mol) of NaOH and 13.6 g (0.085 mol) of Br_2 in 82 ml of H_2O was slowly added, at 0°, 14.0 g (0.070 mol) of (*R*)-**11a**. The resulting mixture was gently heated on the steam-bath for 2 hr and then worked up to give 7.8 g of (*R*)-**12a** [65%; b.p. 124°/2 Torr; $[\alpha]_D^{25}$ 67.76 (lit., b.p. 125°/3 Torr,[12d] d_4^{25} 1.055[12c])]. In a similar manner from 8.3 g (0.042 mol) of (*R*)-**11b**, 1.9 g of (*R*)-**12b** was recovered [27%; b.p. 120°/1.8 Torr; 99% pure (CW 20 M; 200°); $[\alpha]_D^{25}$ + 17.36 (*c* 2.502, EtOH) (lit.,[13b] b.p. 140–3°/7–8 Torr)].

(S)-2-(*Naphthyl*)-*butanes* **8a, b** *from* (S)-(2- *and* 3-*furyl*)-*butanes* **14a, b**. A soln of 3.7 g (0.030 mol) of (*S*)-**14a**, 1.4 g (0.010 mol) of o-anthranilic acid and 3.5 ml dry dioxane was slowly added to a refluxing mixture of 0.8 g (0.007 mol) (*S*)-**14a**, 10 ml of dichloroethane and 7 ml of i-amylnitrite. After 1 hr the volatile products were removed at 20 Torr and the residue hydrolyzed with 10% KOH aq. The organic products, extracted in purified pentane yielded, by distillation, 0.49 g of unsaturated endoxide (b.p. 94°/0.6 Torr) which was hydrogenated, in 3 hr, at room temp., in the presence of a catalytic amount of Raney Ni, to give 0.45 g of saturated endoxide. The aromatization was carried out, in 8 hr in 7 ml of absolute EtOH saturated with HCl (g) at reflux temp., according to a described procedure.[27] The solvent was removed at 20 Torr and the residue, after neutralization and distillation yielded, 0.33 g of (*S*)-**8a** [~ 100% pure (SE 301; 170°)]. Analogously 4.5 g (0.037 mol) of (*S*)-**14b** afforded 1.4 g of unsaturated endoxide (b.p. 104°/15 Torr) which, after hydrogenation, gave 1.1 g of saturated endoxide (b.p. 94°/1 Torr). The subsequent aromatization yielded 0.8 g of (*S*)-**8b** [~ 100% pure (SE 301; 170°)].

(S)-2-*Methylbutan*-1-*ol* **15** *from* (S)-2-(β-*naphthyl*)-*butane* **8b**. 3.0 g (0.016 mol) of (*S*)-**8b** ($[\alpha]_D^{25}$ + 13.60) was dissolved in 80 ml glacial AcOH and a stream of ozonized O_2 was bubbled into the soln for 25 hr at room temp. The mixture was concentrated at reduced pressure (18 Torr) and the residue, in 200 ml dry ether, was reduced with an ethereal suspension of 6.0 g (0.16 mol) LAH. The hydrolysis was accomplished as usual and after glc purification (3 m CW 20 M; 100°) 0.068 g [5%; $[\alpha]_{589}^{25}$ − 3.01 (*c* 3.400, n-C_7H_{16}); lit.[25] $[\alpha]_{589_{max}}^{25}$ 6.66 (n-C_7H_{16})] were recovered.

(S)-2-*Methylbutan*-1-*ol* **15** *from* (S)-2-(3-*furyl*)-*butane* **14b**. 1.6 g (0.013 mol) of (*S*)-**14b** ($[\alpha]_D^{25}$ + 18.04 (*c* 3.118, n-C_7H_{16})) in 100 ml dry pentane was ozonized in 4.5 hr, as previously described. The reduction of the ozonide was carried out with 7.0 g (0.18 mol) LAH in 150 ml dry ether to give, after glc purification (3 m CW 20 M, 100°), a sample of (*S*)-**15** showing $[\alpha]_D^{25}$ − 5.33 (lit.[26] $[\alpha]_{D_{max}}^{25}$ 5.82).

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