Journal of Fluorine Chemistry, 60 (1993) 135–140

A convenient synthesis of ferroelectric liquid crystals bearing the trifluoromethyl group

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(Received December 10, 1991; accepted June 20, 1992)

Abstract

A practical synthetic route to a series of (*R*)- or (*S*)-(1-trifluoromethyl)alkyl 4-hydroxybenzoates has been developed. These materials were prepared by the reaction of *p*-hydroxybenzoic acid with (*R*)- or (*S*)-1-(trifluoromethyl)alkanols in the presence of *p*-toluenesulfonic acid under reflux conditions. Further reaction with the acid chloride of 4′-alkoxybiphenyl-4-carboxylic acid gave the desired liquid crystals.

Introduction

Recently, it has been reported that the real cause of stabilization of the third state [1, 2] and the possibility of tristable switching in surface-stabilized ferroelectric liquid crystal display devices were based on the characteristic influence of a fluoroalkyl group on the chiral center [3–5]. However, the synthetic route to such ferroelectric liquid crystals shown in Scheme 1 is not convenient because of the high cost of *p*-cyanobenzyl alcohol. In particular, reduction using the Pd–C/H_2 system only proceeds under ultrasonic irradiation, and the overall yield of (1-trifluoromethyl)alkyl 4-hydroxybenzoates (**2** and **3**) from *p*-benzyloxybenzyl alcohol was poor (about 25–35%) [5].

Results and discussion

In this paper, we describe an improved method for preparing (1-trifluoromethyl)alkyl 4-hydroxybenzoates (**2** and **3**) from alcohols **1**. To achieve the desired conversion, we investigated the direct condensation reaction of *p*-hydroxybenzoic acid with (*R*)- or (*S*)-(1-trifluoromethyl)alkanols [6]. These reactions proceeded smoothly in the presence of *p*-toluenesulfonic acid in

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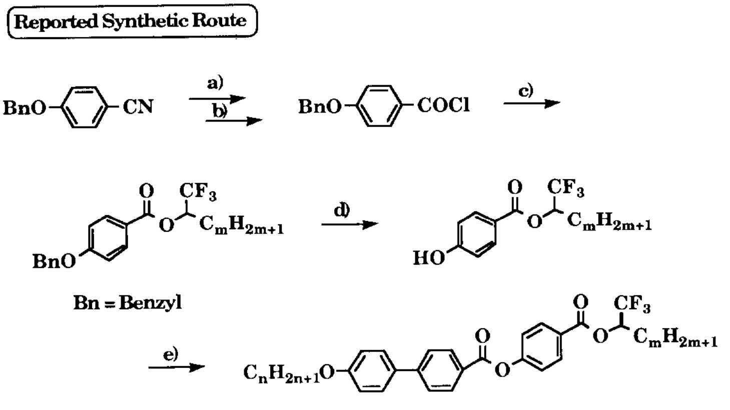
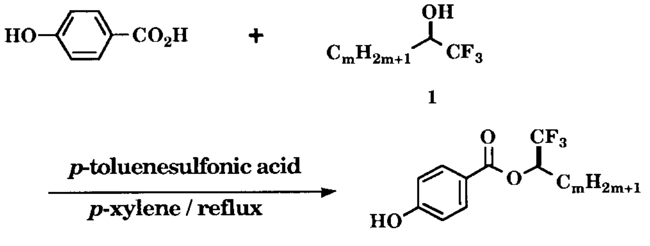


4 : (R) - (-) - : m = 7 ; n = 6
5 : (S) - (-) - : m = 8 ; n = 8

a, $KMnO_4$; b, $SOCl_2$; c, $C_mH_{2m+1}CH(CF_3)OH$ (1), pyr., Et_2O; d, Pd–C/H_2, EtOH, ultrasonics; e, $C_nH_{2n+1}OC_6H_4COCl$, pyr., CH_2Cl_2

Scheme 1.



2 : (R) - isomer
3 : (S) - isomer

Scheme 2.

p-xylene under reflux conditions, with retention of optical purity (Scheme 2). The use of this procedure instead of the synthetic route shown in Scheme 1 increased the yield of (1-trifluoromethyl)alkyl 4-hydroxybenzoates up to 57–71%. The final step was the condensation reaction of the above-obtained benzoates with 4′-alkyloxybiphenyl-4-carboxylic acid chloride, made with thionyl chloride in dichloromethane, proceeding to the desired trifluoromethylated ferroelectric liquid crystals in moderate to good yields.

Experimental

General procedure

All commercially available reagents were used without further purification. Infrared spectra were obtained by using a JASCO A-102 spectrometer and

TABLE 1

(1-Trifluoromethyl)alkyl *p*-hydroxybenzoates (**2** and **3**)

Compd. No.	C_mH_{2m+1}	Yield	b.p. (°C/Torr)	$[\alpha]_D^{21}$ (MeOH)	O.P.[a] (%ee)
2a	C_6H_{13}	64	118–121/0.5	+56.47 (c, 1.29)	>95
2b	C_7H_{15}	57	120–123/0.4	+51.05 (c, 1.04)	>94
2c	C_8H_{17}	71	124–127/0.5	+50.36 (c, 1.31)	>95
3a	C_6H_{13}	58	116–119/0.5	−56.03 (c, 1.16)	>94
3b	C_7H_{15}	66	123–125/0.5	−51.12 (c, 1.15)	>95
3c	C_8H_{17}	64	121–123/0.5	−49.97 (c, 1.07)	>93

[a] Optical purity: satisfactory microanalyses (C, ±0.4%; H, ±0.4%) were obtained for each of the six products (**2a**–**3c**).

TABLE 2

NMR spectra; data for compounds **2** and **3**

Compound No.	^1H NMR ($CDCl_3$) δ(ppm)	^{19}F NMR ($CDCl_3$) δ(ppm); (J in Hz)[a]
2a, **3a**	0.71–2.04 (m, 13H); 5.58 (m, CH); 7.05–8.12 (OH, H_{arom})	−0.6 (d, $J_{F-H}=6.6$)
2b, **3b**	0.69–1.95 (m, 15H); 5.61 (m, CH); 7.02–8.09 (OH, H_{arom})	−0.5 (d, $J_{F-H}=6.6$)
2c, **3c**	0.67–2.10 (m, 17H); 5.60 (m, CH); 7.01–8.10 (OH, H_{arom})	−0.5 (d, $J_{F-H}=7.5$)

[a] δ(ppm) from ext. CF_3CO_2H.

KBr pellets. Nuclear magnetic resonance (NMR) spectra were recorded at 200 MHz for ^1H NMR (internal Me_4Si) and 56.4 MHz for ^{19}F NMR (external CF_3CO_2H). Specific rotations were recorded by using a JASCO DIP-140 digital polarimeter. Yields were those of the products actually isolated. The preparation of the trifluoromethylated alcohols was as given in ref. 6.

(R)-(+)-(1-Trifluoromethyl)heptyl p*-hydroxybenzoate (**2a**) [5]*

A mixture of (*R*)-(+)-(1-trifluoromethyl)heptanol (3.5 g, 20 mmol; $[\alpha]_D^{21}$ (MeOH), +27.20° (c, 1.46) >96 %ee), *p*-hydroxybenzoic acid (6.0 g, 43.4 mmol) and *p*-toluenesulfonic acid (0.6 g) in *p*-xylene (80 ml) was refluxed for 15 h, and then poured into diisopropyl ether (500 ml). The ethereal layer was washed with sat. sodium carbonate, brine and water, and then dried over magnesium sulfate. After removal of the solvent, distillation gave the recovered (*R*)-(+)-1-trifluoromethylheptanol (1.9 g) and (*R*)−(+)-(1-trifluoromethyl)hexyl *p*-hydroxybenzoate (1.70 g; 64% recovered yield); b.p., 118–121 °C/0.5 Torr, $[\alpha]_D^{21}$ (MeOH), +56.47° (c, 1.29); >95 %ee. IR (KBr): 3410 (OH); 1725 (C=O) cm^{-1}.

(R)-(+)-(1-Trifluoromethyl)octyl p-*hydroxybenzoate* ***(2b)*** *(nc)*

A mixture of (*R*)-(+)-(1-trifluoromethyl)octanol (1.86 g, 10 mmol; $[\alpha]_D^{21}$ (MeOH), +23.52° (c, 1.46) >94 %ee), *p*-hydroxybenzoic acid (3.0 g, 21.7 mmol) and *p*-toluenesulfonic acid (0.3 g) in *p*-xylene (50 ml) was refluxed for 15 h, and then poured into diisopropyl ether (300 ml). Distillation gave the recovered (*R*)-(+)-1-trifluoromethyloctanol (0.8 g) and (*R*)-(+)-(1-trifluoromethyl)octyl *p*-hydroxybenzoate (1.03 g; 57% recovered yield); b.p., 120–123 °C/0.4 Torr, $[\alpha]_D^{21}$ (MeOH), +51.05° (c, 1.04); >94 %ee. IR (KBr): 3405 (OH); 1725 (C=O) cm^{-1}. Analysis: Calcd. for $C_{16}H_{21}F_3O_3$ (318.3): C, 60.37; H, 6.65%. Found: 318.3374.

(R)-(+)-(1-Trifluoromethyl)nonyl p-*hydroxybenzoate* ***(2c)*** *[5]*

A mixture of (*R*)-(+)-(1-trifluoromethyl)nonanol (2.0 g, 10 mmol; $[\alpha]_D^{21}$ (MeOH), +23.13° (c, 1.14) >97 %ee), *p*-hydroxybenzoic acid (3.0 g, 21.7 mmol) and *p*-toluenesulfonic acid (0.3 g) in *p*-xylene (50 ml) was refluxed for 15 h, and then poured into diisopropyl ether (300 ml). Distillation gave the recovered (*R*)-(+)-1-trifluoromethylnonanol (0.9 g) and (*R*)-(+)-(1-trifluoromethyl)nonyl *p*-hydroxybenzoate (1.24 g; 71% recovered yield); b.p., 124–127 °C/0.5 Torr, $[\alpha]_D^{21}$ (MeOH), +50.36° (c, 1.31); >95 %ee. IR (KBr): 3410 (OH); 1725 (C=O) cm^{-1}.

(S)-(−)-(1-Trifluoromethyl)hexyl p-*hydroxybenzoate* ***(3a)*** *[5]*

A mixture of (*S*)-(−)-(1-trifluoromethyl)hexanol (3.5 g, 20 mmol; $[\alpha]_D^{21}$ (MeOH), −26.97° (c, 1.04) >94 %ee), *p*-hydroxybenzoic acid (6.0 g, 43.4 mmol) and *p*-toluenesulfonic acid (0.6 g) in *p*-xylene (80 ml) was refluxed for 15 h, and then poured into diisopropyl ether (500 ml). Distillation gave the recovered (*S*)-(−)-1-trifluoromethylhexanol (1.7 g) and (*S*)-(−)-(1-trifluoromethyl)hexyl *p*-hydroxybenzoate (1.73 g; 58% recovered yield); b.p., 116–119 °C/0.5 Torr, $[\alpha]_D^{21}$ (MeOH), −56.03° (c, 1.16); >94 %ee.

(S)-(−)-(1-Trifluoromethyl)octyl p-*hydroxybenzoate* ***(3b)****(nc)*

A mixture of (*S*)-(−)-(1-trifluoromethyl)octanol (1.84 g, 10 mmol; $[\alpha]_D^{21}$ (MeOH), −23.67° (c, 1.24) >95 %ee), *p*-hydroxybenzoic acid (3.0 g, 21.7 mmol) and *p*-toluenesulfonic acid (0.3 g) in *p*-xylene (50 ml) was refluxed for 15 h, and then poured into diisopropyl ether (300 ml). Distillation gave the recovered (*S*)-(−)-1-trifluoromethyloctanol (0.9 g) and (*S*)-(−)-(1-trifluoromethyl)octyl *p*-hydroxybenzoate (1.06 g; 66% recovered yield); b.p., 123–125 °C/0.5 Torr, $[\alpha]_D^{21}$ (MeOH), −51.12° (c, 1.15); >95 %ee. IR (KBr): 3405 (OH); 1725 (C=O) cm^{-1} Analysis: Calcd. for $C_{16}H_{21}F_3O_3$ (318.3): C, 60.37; H, 6.65%. Found: C, 60.63; H, 6.41%. High-resolution MS: Calcd. for $C_{16}H_{21}F_3O_3$: 318.3362. Found: 318.3354.

(S)-(−)-(1-Trifluoromethyl)nonyl p-*hydroxybenzoate* ***(3c)*** *[5]*

A mixture of (*S*)-(−)-(1-trifluoromethyl)nonanol (4.0 g, 20 mmol; $[\alpha]_D^{21}$ (MeOH), −22.87° (c, 1.25) >93 %ee), *p*-hydroxybenzoic acid (6.0 g, 43.4

mmol) and *p*-toluenesulfonic acid (0.6 g) in *p*-xylene (100 ml) was refluxed for 15 h, and then poured into diisopropyl ether (500 ml). Distillation gave the recovered (*S*)-(−)-1-trifluoromethylnonanol (2.1 g) and (*S*)-(−)-(1-trifluoromethyl)nonyl *p*-hydroxybenzoate (1.93 g; 64% recovered yield); b.p., 121–123 °C/0.5 Torr, $[\alpha]_D^{21}$ (MeOH), −49.97° (c, 1.07); >93 %ee.

(R)-(+)-4-[(1-Trifluoromethyloctyloxycarbonyl)phenyl] 4′-hexyloxybiphenyl-4-carboxylate (4)(nc)

A mixture of 4′-hexyloxybiphenyl-4-carboxylic acid (0.89 g, 2.9 mmol) and freshly dried thionyl chloride (9 ml) was refluxed for 1 h, and then the remaining thionyl chloride was removed under dynamic vacuum at 90 °C. Into a mixture of the above-obtained acid chloride and (*R*)-(+)-(1-trifluoromethyl)octyl *p*-hydroxybenzoate (0.77 g, 2.45 mmol; $[\alpha_D^{21}$ (MeOH), +51.05° (c, 1.04) >94 %ee) in dichloromethane (15 ml) under an atmosphere of nitrogen, pyridine (1.0 ml) was added via a syringe. After 3 d stirring at room temperature, the mixture was quenched with 1 N HCl and then washed with brine. The trifluoromethylated ferroelectric liquid crystal **4** was separated by column chromatography on silica gel using a mixture of hexane/ethyl acetate (3:1), and was then recrystallized from ethanol; m.p., 109–110 °C, $[\alpha]_D^{21}$ ($CHCl_3$), +38.19° (c, 0.49) >94 %ee. IR(KBr): 1735 (C=O) cm^{-1}. ^{19}F NMR ($CDCl_3$/ext. CF_3CO_2H) δ: 0.83 (d, $J_{F\text{-}H}=7.5$ Hz) ppm. ^1H NMR ($CDCl_3$) δ: 0.90–1.93 (m, 26 H); 4.01 (t, OCH_2, $J_{H\text{-}H}=3.3$ Hz); 5.57 (m, $CHCF_3$); 7.00–8.25 ($12H_{arom}$) ppm. Analysis: Calcd. for $C_{35}H_{41}F_3O_5$ (598.7): C, 70.22; H, 6.90%. Found: C, 70.09; H, 7.04%. High-resolution MS: Calcd. for $C_{35}H_{41}F_3O_5$: 598.7028. Found: 598.7044.

(S)-(−)-4-[(1-Trifluoromethylnonyloxycarbonyl)phenyl] 4′-octyloxybiphenyl-4-carboxylate (5)(nc)

A mixture of 4′-octyloxybiphenyl-4-carboxylic acid (1.30 g, 4.0 mmol) and freshly dried thionyl chloride (11.8 ml) was refluxed for 1 h, and then the remaining thionyl chloride was removed under dynamic vacuum at 90 °C. Into a mixture of the above-obtained acid chloride and (*S*)-(−)-(1-trifluoromethyl)nonyl *p*-hydroxybenzoate (0.73 g, 2.18 mmol; $[\alpha]_D^{21}$ (MeOH), −49.97° (c, 1.07) >93 %ee) in dichloromethane (17 ml) under an atmosphere of nitrogen, pyridine (1.2 ml) was added via a syringe and the mixture then worked-up similarly. The trifluoromethylated ferroelectric liquid crystal **5** was separated by column chromatography on silica gel using a mixture of hexane ethyl acetate (3:1), and was then recrystallized from ethanol in 64% yield; m.p., 81.5–82 °C, $[\alpha]_D^{21}$ ($CHCl_3$), −28.09° (c, 0.78) >93 %ee. IR(KBr): 1735 (C=O) cm^{-1}. ^{19}F NMR ($CDCl_3$/ext. CF_3CO_2H) δ: −0.17 (d, $J_{F\text{-}H}=7.5$ Hz) ppm. ^1H NMR ($CDCl_3$) δ: 0.67–2.00 (m, 32 H); 4.10 (m, 2 H); 5.67 (m, $CHCF_3$); 7.00–8.50 ($12H_{arom}$) ppm. Analysis: Calcd. for $C_{38}H_{47}F_3O_5$ (640.8): C, 71.23; H, 7.39%. Found: C, 71.51; H, 7.46%. High-resolution MS: Calcd. for $C_{38}H_{47}F_3O_5$: 640.7834. Found: 640.7821.

References

1 A. D. L. Chandani, Y. Ouchi, H. Takezoe and A. Fukuda, *Jpn. J. Appl. Phys.*, *27* (1988) L276.

2 A. D. L. Chandani, Y. Ouchi, H. Takezoe and A. Fukuda, *Jpn. J. Appl. Phys.*, *27* (1988) L729.

3 K. Yoshino, M. Ozaki, H. Taniguchi, M. Ito, K. Satoh, N. Yamasaki and T. Kitazume, *Jpn. J. Appl. Phys.*, *26* (1987) L77.

4 K. Yoshino, M. Ozaki, H. Taniguchi, M. Ito, K. Satoh, N. Yamasaki and T. Kitazume, *Chem. Express*, *2* (1987) 53.

5 Y. Suzuki, T. Hagiwara, I. Kawamura, N. Okamura, T. Kitazume, M. Kakimoto, Y. Imai, Y. Ouchi, H. Takezoe and A. Fukuda, *Liquid Crystal*, *6* (1989) 167.

6 J. T. Lin, T. Yamazaki and T. Kitazume, *J. Org. Chem.*, *52* (1987) 3211.