Synthesis of Trifluoromethylthiazoles and Their Application to Azo Dyes

Kiyoshi Tanaka*, Kazuto Nomura, Hitoshi Oda,
Shouhei Yoshida and Keiryo Mitsuhashi

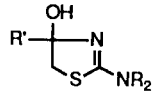
Faculty of Engineering, Seikei University,
Musashino-shi, Tokyo 180, Japan

Received January 4, 1991

3-Bromo-1,1,1-trifluoropropan-2-one (**2**) reacted with thiourea and *N*-monosubstituted thioureas to give the corresponding 4-trifluoromethylthiazoles, respectively. In the reactions with *N,N'*-diphenylthiourea and thioamides, the considerably stable intermediates, 4-hydroxy-4-trifluoromethylthiazoline derivatives **7** and **8**, were isolated. The reaction of ethyl 2-bromo-4,4,4-trifluoro-3-oxobutanoate (**4**) with thiourea was carried out under the gentle conditions to give both thiazole-5-carboxylate **10** and 4-hydroxythiazoline **11**. The thiazole **10** was applied to the azo dye synthesis and the absorption maxima of thus obtained azo dyes were discussed.

J. Heterocyclic Chem., **28**, 907 (1991).

The Hantzsch synthesis condensing α-haloketones with thioureas is well known to offer various 2-aminothiazoles and its reaction path is assumed to involve dehydration of the unstable intermediate 4-hydroxy-2-thiazoline (**1**) [1].

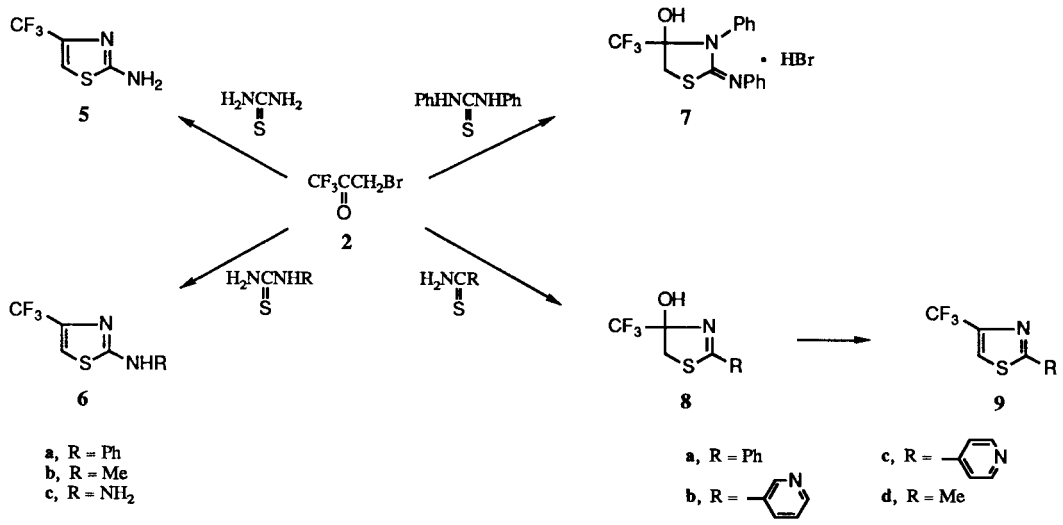


1

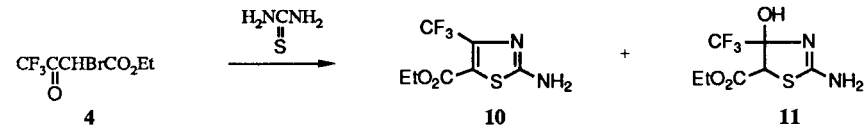
The Hantzsch thiazole synthesis is applied to prepare 2-amino-4-trifluoromethylthiazoles using 3-bromo-1,1,1-trifluoropropan-2-one (**2**) or ethyl 2-chloro-4,4,4-trifluoro-3-oxobutanoate (**3**) [2,3]. In this paper, to clarify the scope of these reactions, we carried out the Hantzsch reactions of **2** or ethyl 2-bromo-4,4,4-trifluoro-3-oxobutanoate (**4**) with various thioureas and thioamides, giving 4-trifluoromethylthiazole derivatives. And we also demonstrate the considerable stability of the intermediate 4-hydroxy-4-trifluoromethyl-2-thiazolines. On the other hand, azo dyes containing 4-chlorothiazoles are remarked as the dyes absorbing in the near infrared [4]. Therefore we describe here the synthesis of analogous azo dyes containing 4-trifluoromethylthiazoles, to compare the absorption properties with those of 4-chlorothiazole azo dyes.

The reaction of **2** with thiourea in ethanol was first performed at room temperature to give 2-amino-4-trifluoromethylthiazole (**5**) in only 20% yield and, however, refluxing of the mixture resulted in acceleration of the reaction, producing **5** in 75% yield. Under the similar conditions, *N*-phenyl- and -methylthioureas gave exclusively the corresponding 2-(*N*-substituted amino)-4-trifluoromethylthiazoles **6a** and **6b**, respectively, with no appreciable formation of the regioisomeric products, iminodihydrothiazoles [5]. Treatment with thiosemicarbazide resulted in the formation of the thiazole **6c** and another plausible product, 1,3,4-thiadiazine, was not noticed [6]. *N,N'*-Diphenylthiourea produced 4-hydroxy-3-phenyl-2-phenylimino-4-trifluoromethyltetrahydrothiazole hydrobromide (**7**) in fairly

Scheme 1



Scheme 2



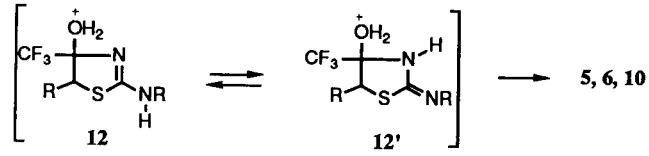
4 10 11

good yield. The considerable stability of 4-hydroxydihydrothiazolines **8a-8d** derived from thioamides was also notable. The hydrobromide salt **8a'** of **8a** is stable in ethanol at 55° and **8a** itself also remains unchanged after refluxing in toluene. However, dehydration of **8a** and **8d** into the corresponding thiazoles **9a** and **9d** was performed in refluxing toluene containing a catalytic amount of *p*-toluenesulfonic acid (Scheme 1). On the other hand, cyclization of **4** with thiourea under the gentle conditions gave both thiazole-5-carboxylate **10** and 4-hydroxy-2-thiazoline **11** in 3 and 22% yields, respectively. Refluxing of the reaction mixture in ethanol afforded only the thiazole **10** in 51% yield (Scheme 2).

Isolation of the intermediate 4-hydroxy-2-thiazolines in the Hantzsch synthesis has been limited to a few cases and these results obtained here offer another example of the stable intermediates [7]. An increase of stability in 4-hydroxy-2-thiazolines **7**, **8**, and **11** is ascribed to a trifluoromethyl group keeping the attached carbon to be sp^3 orbital. Although a neutral solvent is used, the medium becomes acidic since the thiazole synthesis is accompanied by the formation of an equivalent of hydrogen bromide. Therefore the formation of the thiazoles **5** and **6** could be rationalized by dehydration of the protonated intermediates **12** or **12'** (R = H) [5]. The hydroxythiazoline **11** was isolated under the mild conditions and this stability of **11** may be interpreted by the deficiently protonated intermediate **12** or **12'** (R = CO_2Et) because of the electron-withdrawing ester group attached at 5-position in thiazoline ring.

2-Aminothiazole **10** was diazotized effectively by nitrosylsulfuric acid to give the diazonium salt which coupled with *N,N*-diethylaniline, affording the azo dye **13**. Reduction of ester group of **13** with lithium aluminium hydride, followed by oxidation with activated manganese dioxide, produced 5-formylthiazole azo dye **14**. Formyl group of **14** was condensed with malononitrile and 3-dicyanomethyleneindan-1-one in the presence of a catalytic amount of piperidine to give the expected azo dyes **15** and **16a**, respectively. Condensation of **14** with 3-dicyanomethyleneindan-1-one under an excess of piperidine gave the piperidine substituted azo dye **16b** (Scheme 4). The absorption

Scheme 3



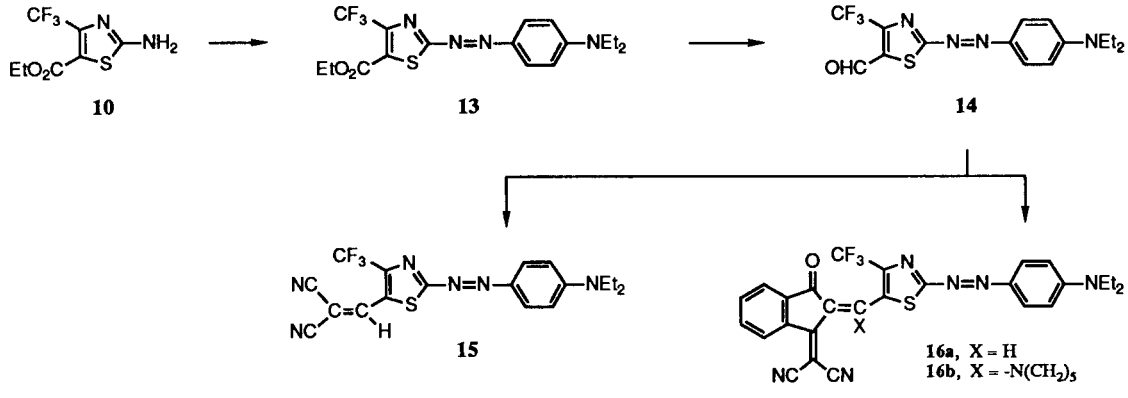
12 12' 5, 6, 10

Table 1
Light Absorption Properties of Azo Dyes

Dye	in Dichloromethane max/nm	max/l mol^{-1} cm^{-1}	in DMSO max/nm
13	541	51500	---
14	565 (574) [a]	49500	583 (592) [a]
15	641 (645) [a]	68100	654 (668) [a]
16a	680 (700) [a]	56100	[b]
16b	528	47900	548

[a] Absorption maxima of analoguous azo dyes containing 4-chlorothiazoles, which are reported in lit [4]. [b] Molar absorptivity of absorption maximum in 695 nm gradually reduces during measurment in DMSO because of its decomposition.

Scheme 4



10 13 14 15

16a, X = H
16b, X = -N(CH$_2$)$_5$

maxima of these dyes are summarized in Table 1. As expected for azo dye system, progressive shift to longer wavelengths is notable as the electron-withdrawing properties of 5-substituent of thiazole ring increase and these dyes show a positive solvatochromism; that is, longer wavelengths (13-20 nm) are observed in dimethyl sulfoxide (DMSO), compared with those in dichloromethane. The literature values of absorption maxima of analogous 4-chlorothiazole azo dyes are also collected in Table 1 [4]. It was surprising that replacement of trifluoromethyl group by chlorine atom at 4-position of thiazole causes an appreciable bathochromic shift. This tendency is reverse to that in the conventional 2′, 3′, or 4′-substituted 4-dimethylaminoazobenzene. 2′, 3′, or 4′-Trifluoromethylazobenzene absorbs at longer wavelength than the corresponding chloroazobenzene, respectively, as reported in the literature [8].

EXPERIMENTAL

The ir spectra were recorded on a JASCO A-100 spectrometer, samples being run as potassium bromide pellets for solid and film for oil. The ^{1}H nmr spectra were measured with JEOL JNM-GX 270 or -PMX 60 spectrometers using tetramethylsilane as an internal standard, the chemical shifts being given in δ ppm downfield. Samples were prepared by dissolving in deuteriochloroform-bis(deuteriomethyl) sulfoxide unless otherwise noted. The uv spectra were observed with a Hitachi 340 spectrometer. The bromide **2** was prepared by the method reported in the literature [9].

Preparation of Ethyl 2-Bromo-4,4,4-trifluoro-3-oxobutanoate (**4**).

Bromine (19.2 g, 0.119 mole) was added dropwise to a solution of ethyl trifluoroacetoacetate (21.9 g, 0.119 mole) in 35 ml of carbontetrachloride. The mixture was stirred at room temperature for 16 hours. After removal of the solvent, the residue was subjected to distillation, giving 22.2 g (71%) of **4** (boiling range 80-82°/31 mm Hg). This compound **4** had ^{1}H nmr (deuteriochloroform): δ 1.3 (t, 3H), 4.4 (q, 2H), 5.2 (s, 1H); ir: (cm^{-1}) 3430 (OH), 1750 (C=O), 1150 (CF_3).

Anal. Calcd. for $C_6H_6BrF_3O_3$: C, 27.40; H, 2.30. Found: C, 27.05; H, 2.30.

Preparation of 2-Amino-4-trifluoromethylthiazole (**5**).

A solution of **2** (2.00 g, 10.5 mmoles) and thiourea (0.80 g, 10.5 mmoles) in 20 ml of ethanol was stirred at 50-55° for 2 hours. The solvent was evaporated under reduced pressure to leave a solid which was washed with diethyl ether. Resulting solid was dissolved in water and the solution was made basic to *p*H 10-11 with 5% sodium hydroxide aqueous solution. The solution was extracted with diethyl ether, the extracts being evaporated to leave a solid which was recrystallized from hexane to give 1.33 g (75%) of **5**. This compound had mp 66-68° (lit [2] 68-69.5°); ^{1}H nmr (deuteriochloroform): δ 6.0 (s, 2H), 6.9 (s, 1H).

Preparation of 2-(Phenylamino)-4-trifluoromethylthiazole (**6a**).

A solution of **2** (2.00 g, 10.5 mmoles) and *N*-phenylthiourea (1.60 g, 10.5 mmoles) in 20 ml of ethanol was refluxed for 3 hours. The similar procedure to the above afforded 2.40 g (94%) of **6a**. This compound had mp 92-94° (hexane-ethanol); ^{1}H nmr: δ 6.8-7.8 (m, 6H), 10.2 (s, 1H); ir: (cm^{-1}) 3180 (NH), 1155, 1120 (CF_3).

Anal. Calcd. for $C_{10}H_7N_2F_3S$: C, 49.18; H, 2.89; N, 11.47. Found: C, 49.24; H, 2.85; N, 11.50.

Preparation of 2-(*N*-Methylamino)-4-trifluoromethylthiazole (**6b**).

The reaction with *N*-methylthiourea was performed at room temperature for 17 hours and the similar procedures gave **6b** in 55% yield. This compound had mp 105-106° (hexane); ^{1}H nmr (deuteriochloroform): δ 2.95 (d, 3H), 6.9 (s, 1H), 7.9 (br s, 1H); ir: (cm^{-1}) 3200 (NH), 1110 (CF_3).

Anal. Calcd. for $C_5H_5N_2F_3S$: C, 32.97; H, 2.77; N, 15.38. Found: C, 32.97; H, 2.49; N, 15.30.

Preparation of 2-Hydradino-4-trifluoromethylthiazole (**6c**).

The reaction with semicarbazide was carried out in refluxing ethanol for 6 hours to give **6c** in 21% yield. This compound had mp 117-119° (hexane-ethanol); ^{1}H nmr: δ 4.3 (s, 2H), 7.0 (s, 1H), 8.5 (s, 1H); ir: (cm^{-1}) 3350 (NH_2), 3200 (NH), 1125, 1115 (CF_3).

Anal. Calcd. for $C_4H_4N_3F_3S$: C, 26.23; H, 2.20; N, 22.94. Found: C, 26.51; H, 1.91; N, 22.57.

Preparation of 4-Hydroxy-3-phenyl-2-phenylimino-4-trifluoromethyltetrahydrothizole Hydrobromide (**7**).

A solution of **2** (2.00 g, 10.5 mmoles) and *N,N'*-diphenylthiourea (2.39 g, 10.5 mmoles) in 20 ml of ethanol was refluxed for 2.5 hours and the solvent was removed. The resulting solid was washed with diethyl ether and recrystallized from hexane-ethanol to give 3.11 g (71%) of **7**. This compound had mp >290°; ^{1}H nmr: δ 4.05 (s, 2H), 7.2-7.7 (m, 12H); ir: (cm^{-1}) 3000 (OH), 1575 (C=N), 1180 (CF_3).

Anal. Calcd. for $C_{16}H_{14}N_2BrF_3OS$: C, 45.84; H, 3.37; N, 6.68. Found: C, 45.74; H, 3.12; N, 6.70.

Preparation of 4-Hydroxy-2-phenyl-4-trifluoromethyl-2-thiazoline Hydrobromide (**8a'**).

A solution of **2** (2.00 g, 10.5 mmoles) and thiobenzamide (1.44 g, 10.5 mmoles) in 20 ml of ethanol was stirred at room temperature for 24 hours and the solvent was evaporated to leave a solid which was washed with acetone and recrystallized from hexane-ethanol, affording 2.37 g (69%) of **8a'**. This compound had mp 181-183°; ^{1}H nmr: δ 3.6 (d, 1H), 3.8 (d, 1H), 7.4-8.0 (m, 5H), 9.0 (s, 2H); ir: (cm^{-1}) 3000 (OH), 1550 (C=N), 1190 (CF_3).

Anal. Calcd. for $C_{10}H_9NBrF_3OS$: C, 36.60; H, 2.76; N, 4.27. Found: C, 36.36; H, 2.52; N, 4.20.

Preparation of 4-Hydroxy-2-phenyl-4-trifluoromethyl-2-thiazoline (**8a**).

The similar reaction to the above was performed at 50-55° for 3 hours and the solvent was removed to leave a solid which was washed with acetone and stirred in water. A formed solid was collected on a filter and recrystallized from hexane-ethanol to give 1.58 g (61%) of **8a**. This compound had mp 129-130°; ^{1}H nmr: δ 3.45 (d, 1H), 3.75 (d, 1H), 7.2 (s, 1H), 7.3-8.0 (m, 5H); ir: (cm^{-1}) 3080 (OH), 1560 (C=N), 1170 (CF_3).

Anal. Calcd. for $C_{10}H_8NF_3OS$: C, 48.58; H, 3.26; N, 5.67. Found: C, 48.43; H, 3.10; N, 5.68.

Preparation of 4-Hydroxy-2-(3-pyridyl)-4-trifluoromethyl-2-thiazoline (**8b**).

The reaction using thionicotinamide was carried out under refluxing ethanol for 6 hours. The similar procedure to the above

afforded 1.82 g (70%) of **8b**. This compound had mp 178-180°; ^{1}H nmr: δ 3.55 (d, 1H), 3.8 (d, 1H), 7.6 (s, 1H), 7.5-9.0 (m, 4H); ir: (cm^{-1}) 3000 (OH), 1590 (C=N), 1160 (CF_3).

Anal. Calcd. for $C_9H_7N_2F_3OS$: C, 43.55; H, 2.84; N, 11.29. Found: C, 43.60; H, 2.67; N, 11.34.

Preparation of 4-Hydroxy-2-(4-pyridyl)-4-trifluoromethyl-2-thiazoline (**8c**).

The similar procedure to the above using thioisonicotinamide afforded 1.30 g (50%) of **8c**. This compound had mp 167-169° (hexane-ethanol); ^{1}H nmr:δ 3.55 (d, 1H), 3.9 (d, 1H), 7.65 (s, 1H), 7.7-8.9 (m, 4H); ir: (cm^{-1}) 3000 (OH), 1580 (C=N), 1160 (CF_3).

Anal. Calcd. for $C_9H_7N_2F_3OS$: C, 43.55; H, 2.84; N, 11.29. Found: C, 43.68; H, 2.77; H, 11.22.

Preparation of 4-Hydroxy-2-methyl-4-trifluoromethyl-2-thiazoline (**8d**).

The similar reaction using thioacetamide was performed at room temperature for 18 hours and the similar procedure produced 0.90 g (46%) of **8d**. This compound had mp 101.5-102.5° (hexane); ^{1}H nmr: δ 2.3 (s, 3H), 3.35 (d, 1H), 3.7 (d, 1H), 6.5 (s, 1H); ir: (cm^{-1}) 3100 (OH), 1600 (C=N), 1160 (CF_3).

Anal. Calcd. for $C_5H_6NF_3OS$: C, 32.43; H, 3.27; N, 7.56. Found: C, 32.50; H, 3.11; N, 7.67.

Dehydration of **8a** into 2-Phenyl-4-trifluoromethylthiazole (**9a**).

A mixture of **8a** (5.75 g, 23.3 mmoles) and *p*-toluenesulfonic acid (0.1 g) in 70 ml of toluene was heated at reflux for 20 hours with a Dean-Stark apparatus. After removal of the solvent, the residue was extracted with diethyl ether. The ethereal solution was washed with brine and dried over magnesium sulfate. The solution was evaporated under reduced pressure to leave a residue which was recrystallized from hexane, affording 3.71 g (70%) of **9a**. This compound had mp 43-45°; ^{1}H nmr (deuteriochloroform): δ 7.3-7.6 (m, 3H), 7.7 (s, 1H), 7.8-8.1 (m, 2H); ir: (cm^{-1}) 1170, 1130 (CF_3).

Anal. Calcd. for $C_{10}H_6NF_3S$: C, 52.40; H, 2.64; N, 6.11. Found: C, 52.06; H, 2.43; N, 6.05.

Dehydration of **8d** into 2-Methyl-4-trifluoromethylthiazole (**9d**).

The similar procedure to the above gave **9d** in 28% yield, which was purified by preparative glc. This compound was obtained as a colorless oil; ^{1}H nmr (deuteriochloroform): δ 2.7 (s, 3H), 7.5 (s, 1H); ir: (cm^{-1}) 1175 (CF_3).

Anal. Calcd. for $C_5H_4NF_3S$: C, 35.93; H, 2.41; N, 8.38. Found: C, 36.01; H, 2.15; N, 8.06.

Reaction of **4** with Thiourea.

A solution of **4** (2.01 g, 7.64 mmoles) and thiourea (0.58 g, 7.63 mmoles) in 10 ml of ethanol was stirred at room temperature for 16 hours. After removal of the solvent, the residue was washed with diethyl ether, stirred in water, and collected on a filter. The resulting solid was recrystallized from hexane-ethyl acetate to give 0.05 g (3%) of ethyl 2-amino-4-trifluoromethylthiazole-5-carboxylate (**10**). This compound had mp 170-172° (lit [3] mp 168-171°); ^{1}H nmr: δ 1.35 (t, 3H), 4.3 (q, 2H), 6.7 (s, 2H); ir: (cm^{-1}) 3370 (NH_2), 1700 (C=O), 1140 (CF_3).

The filtrate was alkalined with 5% sodium bicarbonate aqueous solution and extracted with diethyl ether. The ethereal solution was dried over magnesium sulfate and evaporated to leave a solid which was recrystallized from hexane-ethanol to give 0.43 g (22%) of ethyl 2-amino-4-hydroxy-4-trifluoromethyl-2-thiazoline-5-carboxylate (**11**). This compound had mp 157-159°; ^{1}H nmr (bis(deuteriomethyl) sulfoxide): δ 1.2 (t, 3H), 4.1 (q, 2H), 4.7 (s, 1H), 7.1 (s, 1H), 7.3 (s, 2H); ir: (cm^{-1}) 3370, 3300 (NH_2, OH), 1715 (C=O), 1160 (CF_3).

Anal. Calcd. for $C_7H_9N_2F_3O_3S$: C, 32.56; H, 3.51; N, 10.85. Found: C, 32.39; H, 3.43; N, 10.95.

The similar reaction was carried out at room temperature for 4 hours and then under reflux for 3 hours. After removal of the solvent, the residue was washed with diethyl ether and dissolved in 5% sodium bicarbonate aqueous solution. The mixture was extracted with diethyl ether, ethereal solution being dried over magnesium sulfate and evaporated to leave a solid. The solid was recrystallized from hexane-ethyl acetate, giving 51% of **10** which had mp 171-172°.

Dyazo Coupling of **10** with *N,N*-Diethylaniline.

To a solution of **10** (2.45 g, 10.2 mmoles) in 15 ml of acetic acid was added dropwise a solution of nitrosylsulfuric acid (1.38 g, 10.9 mmoles) in 15 ml of acetic acid holding the temperature below 15° and the mixture was stirred for 30 minutes. To the mixture was added a solution of *N,N*-diethylaniline (1.82 g, 12.2 mmoles) in 15 ml of acetic acid, the mixture being stirred at 15-20° for 15 hours. After removal of the solvent, the residue was extracted with diethyl ether and ethereal solution was washed with brine, dried over magnesium sulfate, and evaporated to leave a solid which was recrystallized from hexane-ethyl acetate, giving 1.38 g (34%) of ethyl 2-(4-*N,N*-diethylamino)phenylazo-4-trifluoromethylthiazole-5-carboxylate (**13**). This compound had mp 124-126°; ^{1}H nmr (deuteriochloroform): δ 1.3 (t, 9H), 3.5 (q, 4H), 4.4 (q, 2H), 6.7 (d, 2H), 7.9 (d, 2H); ir: (cm^{-1}) 1720 (C=O), 1590 (N=N), 1120 (CF_3).

Anal. Calcd. for $C_{17}H_{19}N_4F_3O_2S$: C, 50.99; H, 4.78; N, 13.99. Found: C,. 50.77; H, 4.66; N, 14.02.

Reduction of **13** to 2-(4-*N,N*-Diethylamino)phenylazo-5-hydroxymethyl-4-trifluoromethylthiazole.

To a suspension of lithium alminium hydride (0.39 g, 10.3 mmoles) in 50 ml of diethyl ether was added dropwise a solution of **13** (1.25 g, 3.13 mmoles) holding the temperature below −10°. After the mixture was stirred at −10° for 15 hours, 8 ml of 20% sodium hydroxide aqueous solution was added. The resulting solid was filtered off and the filtrate was washed with water and brine, dried over magnesium sulfate, and evaporated to leave a residue. The residue was placed on a column (silica gel) and eluted with hexane-ethyl acetate (2:1) to give 0.63 g (56%) of 2-(4-*N,N*-diethylamino)phenylazo-5-hydroxymethyl-4-trifluoromethylthiazole, which was purified by recrystallization from hexane-ethyl acetate. This compound had mp 151-152.5°; ^{1}H nmr (deuteriochloroform): δ 1.2 (t, 6H), 3.4 (q, 4H), 2.5 (s, 1H), 5.0 (s, 2H), 6.6 (d, 2H), 7.8 (d, 2H); ir: (cm^{-1}) 3230 (OH), 1590 (N=N), 1130 (CF_3).

Anal. Calcd. for $C_{15}H_{17}N_4F_3OS$: C, 50.27; H, 4.78; N, 15.63. Found: C, 50.58; H, 4.75; N, 15.74.

Preparation of 2-(4-*N,N*-Diethylamino)phenylazo-4-trifluoromethylthiazole-5-carbaldehyde (**14**).

A mixture of activated manganese dioxide (0.25 g, 2.87 mmoles) and 2-(4-*N,N*-diethylamino)phenylazo-5-hydroxymethyl-4-trifluoromethylthiazole (0.25 g, 0.70 mmole) in 25 ml of diethyl ether was stirred at room temperature for 5 hours. The solid was

filtered off and the filtrate was evaporated to leave a residue which was subjected to column chromatography (silica gel, hexane-ethyl acetate, 2:1), giving 0.21 g (84%) of **14**. Further purification was done by recrystallization from hexane-ethyl acetate. This compound had mp 154-156°; ^{1}H nmr (deuteriochloroform): δ 1.3 (t, 6H), 3.5 (q, 4H), 6.8 (d, 2H), 7.9 (d, 2H), 10.2 (s, 1H); ir: (cm^{-1}) 1650 (C=O), 1585 (N=N), 1100 (CF_3).

Anal. Calcd. for $C_{15}H_{15}N_4F_3OS$: C, 50.56; H, 4.24; N, 15.72. Found: C, 50.57; H, 4.18; N, 15.64.

Preparation of 5-(2,2-Dicyanovinyl)-2-(4-*N*,*N*-diethylamino)phenylazo-5-trifluoromethylthiazole (**15**).

A solution of **14** (0.15 g, 0.42 mmole) and malononitrile (28 mg, 0.42 mmole) in 50 ml of ethanol was stirred at room temperature for 20 hours. The solvent was evaporated to leave a solid which was recrystallized from hexane-ethyl acetate to give 0.13 g (77%) of **15**. This compound had mp 220° dec; ^{1}H nmr (deuteriochloroform): δ 1.3 (t, 6H), 3.6 (q, 4H), 6.8-8.0 (m, 4H), 8.1 (s, 1H); ir: (cm^{-1}) 2200 (C≡N), 1580 (N=N), 1100 (CF_3).

Anal. Calcd. for $C_{18}H_{15}N_6F_3S$: C, 53.46; H, 3.74; N, 20.78. Found: C, 53.46; H, 3.61; N, 20.39.

Preparations of Azo Dyes **16a** and **16b**.

A solution of **14** (90 mg, 0.25 mmole), 3-dicyanomethyleneindan-1-one (49 mg, 0.27 mmole), and 2 μl of piperidine was refluxed for 5 hours under a nitrogen atmosphere. After removal of the solvent, the residue was subjected to column chromatography (silica gel, hexane-ethyl acetate, 2:1), giving 61 mg (46%) of **16a** which was further purified by recrystallization from choroform-ethyl acetate. This compound had mp 225-226°; ^{1}H nmr: δ 1.3 (t, 6H), 3.6 (q, 4H), 6.8-8.7 (m, 8H), 8.95 (s, 1H); ir: (cm^{-1}) 2200 (C≡N), 1700 (C=O), 1540 (N=N), 1110 (CF_3).

Anal. Calcd. for $C_{27}H_{19}N_6F_3OS$: C, 60.90; H, 3.60; N, 15.78. Found: C, 60.77; H, 3.45; N, 15.88.

The similar reaction in the presence of an excess of piperidine (5 equivalent of **14**) was refluxed for 17 hours. Usual workup gave 33% of **16b**. This compound had mp 233-234° (recrystallized from hexane-ethyl acetate); ^{1}H nmr (deuteriochloroform): δ 1.3 (t, 6H), 3.5 (q, 4H), 1.8 (m, 10H), 4.0 (m, 4H), 6.7-8.4 (m, 8H); ir: (cm^{-1}) 2200 (C≡N), 1700 (C=O), 1560 (N=N), 1130 (CF_3).

Anal. Calcd. for $C_{32}H_{28}N_7F_3OS$: C, 62.43; H, 4.58; N, 15.93. Found: C, 62.33; H, 4.46; N, 15.68.

REFERENCES AND NOTES

[1] J. V. Metzger, Thiazoles and their Benzo Derivatives in Comprehensive Heterocyclic Chemistry, Vol **6**, A. R. Katritzky and C. W. Rees, eds, Pergamon Press, 1984, Chapter 4.19.

[2] J. B. Dickey, E. B. Towne and G. F. Wright, *J. Org. Chem.*, **20**, 499 (1955).

[3] L. F. Lee, F. M. Schleppnik and R. K. Howe, *J. Heterocyclic Chem.*, **22**, 1621 (1985).

[4] K. A. Bello and J. Griffiths, *J. Chem. Soc., Chem. Commun.*, 1639 (1986).

[5] S. E. Bramley, V. Dupplin, D. G. C. Goberdhan and D. Meakins, *J. Chem. Soc., Perkin Trans. 1*, 639 (1987).

[6] H. Beyer, H. Höhn and W. Lässig, *Chem. Ber.*, **85**, 1122 (1952).

[7] K. Arakawa, T. Miyasaka and H. Ohtsuka, *Chem. Pharm. Bull.*, **20**, 1041 (1972).

[8] H. Mustroph and J. Epperlein, *J. Prakt. Chem.*, **323**, 755 (1981).

[9] E. T. McBee and T. M. Burton, *J. Am. Chem. Soc.*, **74**, 3902 (1952).