The Effect of Fused Heterocycles on the Liquid Crystalline Properties of Di(alkoxy-substituted-phenyl)pyridazines and Di(alkoxy-substituted-phenyl)pyridines

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Di(alkoxy-substituted-phenyl)pyridines and di(alkoxy-substituted-phenyl)pyridazines annelated with heterocycles such as imidazole, triazole, pyrazine, and 1,2,5-oxa(thia)diazole were prepared and the effect of the fused heterocycles on the liquid crystalline properties were investigated.

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Introduction.

Recently, much effort has been devoted to searching for a new liquid crystal. Since heterocycles are superior to benzoaromatic rings in their variation, it was expected that substitution of a central benzoaromatic core with heteroaromatic nuclei might lead to the formation of a variety of heterocyclic liquid crystalline products. Nevertheless, heterocyclic liquid crystals have been relatively less studied than their benzo analogues.

The present paper describes di(*p*-alkoxyphenyl)pyridines and di(*p*-alkoxyphenyl)pyridazines in which 5- and 6-membered heterocyclic rings are fused to the pyridine and pyridazine moiety and that the products formed a colored liquid crystalline phase.

Results and Discussion.

Preparation.

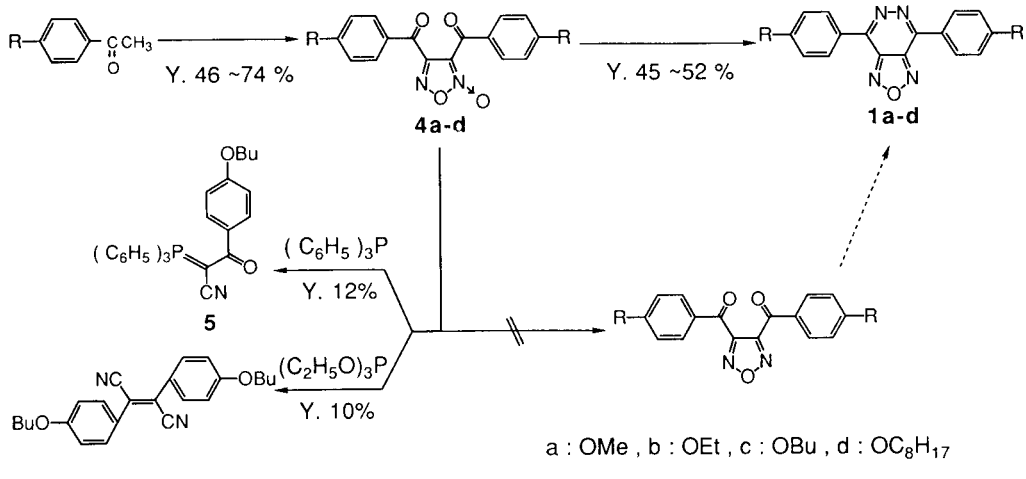
1,2,5-Oxadiazolo[3,4-*d*]pyridazines **1** were prepared according to Scheme 1.

Oxidation of 4-alkoxyacetophenones according to the reported procedure [1] gave 3,4-diaroylfuroxanes **4a-d** in 46-74% yield. The attempted de-oxygenation of **4c** with phosphorus derivatives was unsuccessful: treatment of **4c** with triphenylphosphine afforded the stabilized ylide **5** in 12% yield and 1,2-dicyano-1,2-di(*p*-butoxyphenyl)ethene was formed in the reaction with triethylphosphite in 10% yield (Scheme 1). It was earlier reported that alkoxy-substituted **4** was unreactive towards hydrazinium chloride in methanol under reflux though **4** with an electron-withdrawing group gave the corresponding pyridazine *N*-oxide [1]. The reaction of **4** with hydrazine hydrate was carried out in acetic acid under reflux to afford the desired **1a-d** in 45-52% yields.

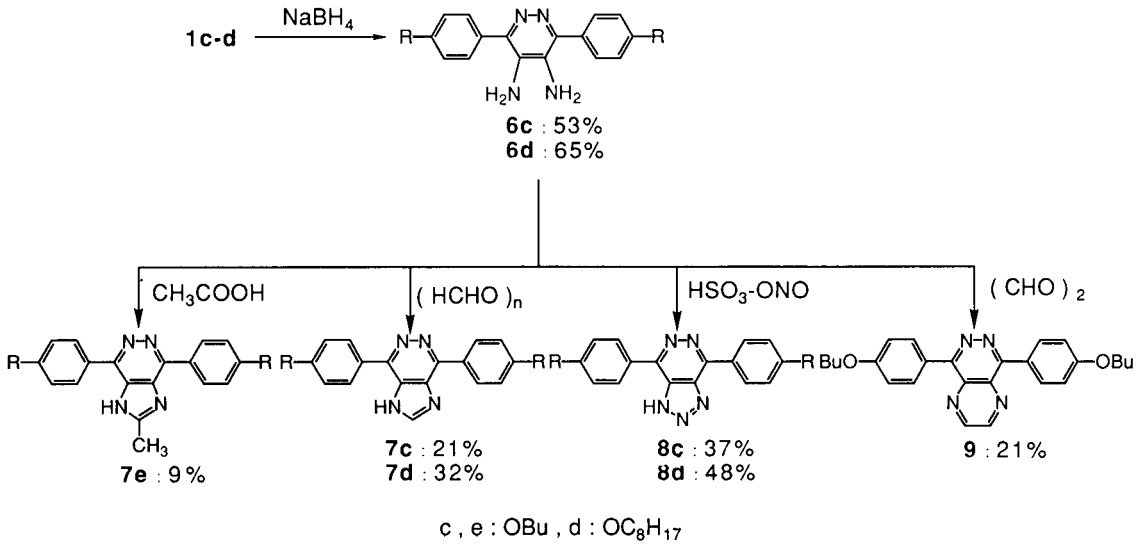
Reduction of **1c** and **1d** with sodium borohydride gave the corresponding diamine **6c** and **6d** in 53% and 65% yield, respectively. Imidazolo- **7**, triazolo- **8**, and pyrazinopyridazine **9** were prepared from **6** as usual (Scheme 2).

Thiadiazolopyridazine **2** was easily obtained from 3,4-

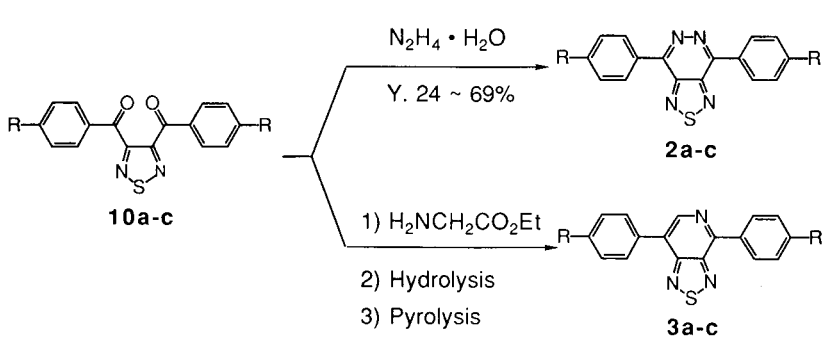
Scheme 1



Scheme 2



Scheme 3



diaroyl-1,2,5-thiadiazole **10** and thiadiazolopyridine **3** was prepared as described previously [2,3] (Scheme 3).

The electronic spectra of **1**, **2**, **3**, **7**, **8**, and **9** are tabulated in Table 1. With changing the fused five-membered heterocycle from imidazole, triazole, 1,2,5-thiadiazole, and 1,2,5-oxadiazole, the λ max values of pyridazines **1**, **2**, **8**, and **7** showed a red shift in that order. Such a red shift was earlier observed in the spectra of five-membered heterocycle-fused triphenylpyridines [4]. In contrast to the corresponding pyridine derivatives, the above pyridazines are non-fluorescent except for the triazolopyridazine **8**.

DSC Analysis.

DSC analysis of **1**, **2**, and **3** are given in Table 2. Compound **1a** and **2a** did not form a liquid crystalline phase. Methoxy **3a** and ethoxy derivatives **2b** and **3b** are monotropic liquid crystals. Ethoxy **1b**, and all derivatives of

Table 1
Electronic Spectra of **1**, **2**, **3**, **7**, **8** and **9**

	λ max (log ε) [a]					
	1	**2**	**3**	**7**	**8**	**9**
a	448 (4.33)	430 (4.22)	433 (4.11)			
b	452 (4.32)	435 (4.23)	437 (4.14) [2]			
c	452 (4.35)	437 (4.23)	437 (4.14) [2]	322 (4.50)	367 (4.49)	394 (4.13)
d	452 (4.36)			314 (4.45)	367 (4.45)	

[a] Solvents, dichloromethane (**1**, **2**, **7**, **9**) and chloroform (**3**, **8**).

Table 2
Transition Temperatures of 1, 2, and 3

	1	2	3
R	Transition Temp /°C (ΔH / kcal • mol^{-1})		
a	Cry. 256 Dec.	Cry. 211(9.2) / 206(9.2) Iso.	Cry. 185(9.0) Iso. / 139(7.5) N 165(0.1)
b	Cry. 210(6.8) / 198(6.8) N 226(0.1) / 217(0.1) Iso.	Cry. 207(9.5) Iso. / 195(9.7) N 201	Cry. 191(11.1) Iso. / 169(10.2) N 187(0.2)
c	Cry. 140(3.5) / 135(9.9) 161(6.3) N 182(0.2) / 178(0.2) Iso.	Cry. 132(6.8) / 127(11.1) 150(4.4) N 155(0.1) / 154(0.1) Iso.	Cry. 116(10.6) / 90(7.5) N 149(0.2) / 149(0.2) Iso.
d	Cry. 128(10.8) / 123(11.0) N 150(0.2) / 150(0.2) Iso.		

butoxy **1c**, **2c**, and **3c** and octyloxy **1d** are enantiotropic liquid crystals. These liquid crystals have a nematic phase with Schlieren texture. Butoxy derivatives **1c** and **2c** have two crystalline forms.

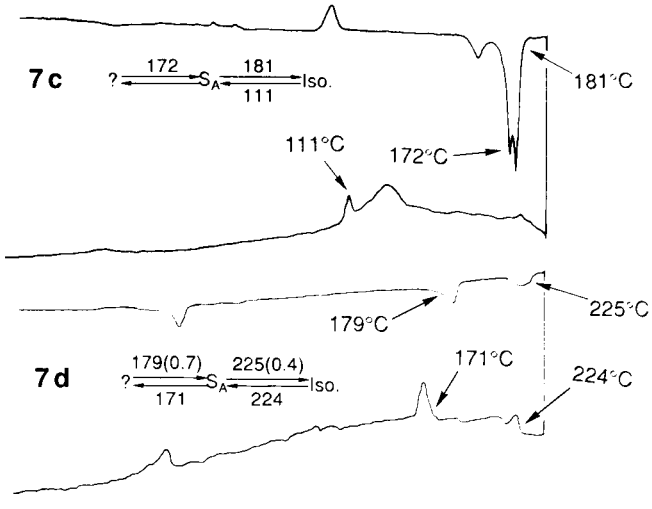


Figure 1 . DSC diagrams of 7

The intermolecular interaction through a hydrogen bond between the nitrogen atom of pyridine and the imino hydrogen of the imidazole ring is expected in imidazolopyridazine **7**. The DSC diagrams of butoxy **7c** and of octyloxy **7d** are complicated as given in Figure 1. Though more detailed study is needed to understand their thermal behavior, both **7c** and **7d** were observed to form liquid crystals of fan-like textures (smectic A) after appearance of bâtonnets in the temperature range shown in Figure 1. Methyl derivative **7e** did not form a liquid crystalline phase. The above-mentioned interaction through hydrogen bonds is also expected in the triazolo derivative **8**. In contrast to **7**, **8** did not form a liquid crystalline phase and decomposed before melting. Compound **8** might exist in a dimeric form in the solid phase. Six-membered ring-fused **9** did not form a liquid crystalline phase.

EXPERIMENTAL

Melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. The ir spectra were recorded on a Nippon Bunko A-102 and IR-700 spectrophotometer as potassium bromide pellets. The ^{1}H-nmr spectra were taken on a Nippon Denshi JEOL FX-100 (at 100 MHz) and GSX-270 (at 270 MHz) nmr spectrometer using tetramethylsilane in deuteriochloroform unless otherwise stated. Mass spectra were recorded on a Nippon Denshi JMS-01SG-2 mass spectrometer at 75 eV using a direct-inlet system. Absorption spectra were measured on a Hitachi 220A spectrophotometer. DSC analysis was carried out on a SEIKO DSC 200. Column chromatography was carried out on silica gel (Wako gel, C-300).

3,4-Di(*p*-ethoxybenzoyl)furoxan (**4b**).

A mixture of sodium nitrite (0.6 g) and nitric acid (d = 1.38, 8 ml) in acetic acid (16 ml) was added to a stirred solution of 4-ethoxyacetophenone [5] (6.56 g, 40 mmoles) in acetic acid (8 ml) at room temperature. After the mixture was heated at 60° for 11 hours, the precipitated solids were collected by filtration, washed with cold methanol, and recrystallized from methanol to give **4b** (3.65 g, 48% yield). This compound was obtained as colorless prisms, mp 131-134°; ir: 2978, 1686, 1658, 1512, 1469; ^{1}H-nmr: δ 1.42 (t, J = 6 Hz, 3H), 1.44 (t, J = 6 Hz, 3H), 4.08 (q, J = 6 Hz, 2H), 4.10 (q, J = 6 Hz, 2H), 6.90 (dd, J = 9 and 2 Hz, 2H), 6.93 (dd, J = 9 and 2 Hz, 2H), 7.78 (dd, J = 9 and 2 Hz, 2H), 8.14 (dd, J = 9 and 2 Hz, 2H); ms: m/z 382 (M$^+$).

Anal. Calcd. for $C_{20}H_{18}N_2O_6$: C, 62.82; H, 4.75; N, 7.33. Found: C, 62.73; H, 4.87; N, 6.98.

3,4-Di(*p*-butoxybenzoyl)furoxan (**4c**).

A mixture of sodium nitrite (3.0 g) and nitric acid (d = 1.38, 40 ml) in acetic acid (80 ml) was added to a stirred solution of 4-butoxyacetophenone [6] (38.4 g, 200 mmoles) in acetic acid (40 ml) at room temperature. After the mixture was heated at 60° for 10 hours, it was poured into water, neutralized with sodium hydrogen carbonate, and extracted with methylene dichloride. The extract was dried over magnesium sulfate and the solvent was evaporated *in vacuo*. The residue was triturated with methanol to give crude **4c**. Recrystallization gave pure **4c** (20.1 g) in 46% yield. This compound was obtained as colorless crystals from ethanol, mp 83-84°; ir: 2958, 2936, 2874, 1673, 1657, 1618, 1599, 1473, 1268, 1174, 1104, 897; ^{1}H-nmr: δ 0.98 (t, J = 6 Hz, 6H), 1.20-1.92 (m, 8H), 4.02 (t, J = 6 Hz, 2H), 4.04 (t, J = 6 Hz, 2H), 6.92 (dd, J = 9 and 2 Hz, 2H), 6.96 (dd, J = 9 and 2 Hz, 2H), 7.78 (dd, J = 9 and 2 Hz, 2H), 8.14 (dd, J = 9 and 2 Hz, 2H); ms: m/z 438 (M$^+$).

Anal. Calcd. for $C_{24}H_{26}N_2O_6$: C, 65.74; H, 5.98; N, 6.39. Found: C, 65.86; H, 6.02; N, 6.48.

3,4-Di(*p*-octyloxybenzoyl)furoxan (**4d**).

A mixture of sodium nitrite (1.2 g) and nitric acid (d = 1.38, 16 ml) in acetic acid (32 ml) was added to a stirred solution of 4-octyloxyacetophenone [7] (20.0 g, 81 mmoles) in acetic acid (16 ml) at room temperature. After the mixture was heated at 60° for 12 hours, it was worked up as described above, giving **4d** (16.5 g, 74% yield). This compound was obtained as colorless crystals from ethanol, mp 40-43°; ir: 2950, 2922, 1666, 1652, 1598, 1474, 1340, 924, 897; ^{1}H-nmr: δ 0.89 (t, J = 6 Hz, 6H), 1.00-1.98 (m, 24H), 4.02 (t, J = 6 Hz, 2H), 4.04 (t, J = 6 Hz, 2H), 6.92 (dd, J = 9 and 2 Hz, 2H), 6.95 (dd, J = 9 and 2 Hz, 2H), 7.78 (dd, J = 9 and 2 Hz, 2H), 8.16 (dd, J = 9 and 2 Hz, 2H); ms: m/z 550 (M$^+$).

Anal. Calcd. for $C_{32}H_{42}N_2O_6$: C, 69.79; H, 7.69; N, 5.09. Found: C, 69.55; H, 7.64; N, 4.98.

Triphenylphosphonium (*p*-Butoxybenzoyl)cyanomethylide (**5**).

A mixture of **4c** (1.00 g, 2.28 mmoles) and triphenylphosphine (600 mg, 2.29 mmoles) in dry benzene (10 ml) was heated under reflux for 36 hours. After it was cooled, the solvent was evaporated *in vacuo* and the residue was chromatographed. Unchanged **4c** (240 mg, 24%) was eluted with a 3:7-mixture of benzene and hexane and **5** (133 mg, 12%) with benzene. This compound was obtained as colorless prisms from a 1:1-mixture of benzene and hexane, mp 190-192°; ir: 2956, 2168, 1604, 1530, 1511, 1345, 1252, 1174, 1108, 1005, 757, 719, 692; ^{1}H-nmr: δ 0.96 (t, J = 7 Hz, 3H), 1.26-1.92 (m, 4H), 3.98 (t, J = 7 Hz, 2H), 6.85 (d, J = 9 Hz, 2H), 7.32-7.77 (m, 15H), 7.99 (d, J = 9 Hz, 2H); ms: m/z 477 (M$^+$).

Anal. Calcd. for $C_{31}H_{28}NO_2P$: C, 77.97; H, 5.91; N, 2.93. Found: C, 77.75; H, 5.89; N, 3.06.

1,2-Di(*p*-butoxyphenyl)-1,2-dicyanoethylene.

A mixture of **4c** (200 mg, 0.46 mmole) and triethyl phosphite (115 mg, 0.69 mmole) in benzene (3 ml) was heated under reflux for 24 hours. It was cooled, washed with 2*N* sulfuric acid, and dried over magnesium sulfate. The solvent was evaporated *in vacuo* and the residue was chromatographed and the titled compound (16 mg, 10%) was eluted with a 1:1-mixture of benzene and hexane. This compound was obtained as pale green plates from hexane, mp 105-106°; ir: 2956, 2872, 2214, 1603, 1511, 1283, 1258, 1186, 1038, 1003, 833; ^{1}H-nmr: δ 1.00 (t, J = 6 Hz, 6H), 1.25-1.94 (m, 8H), 4.02 (t, J = 6 Hz, 4H), 6.96 (dd, J = 9 and 2 Hz, 4H), 7.75 (dd, J = 9 and 2 Hz, 4H); ms: m/z 374 (M$^+$).

Anal. Calcd. for $C_{24}H_{26}N_2O_2$: C, 76.97; H, 7.00; N, 7.48. Found: C, 76.74; H, 7.02; N, 7.04.

4,7-Di(*p*-methoxyphenyl)-1,2,5-oxadiazolo[3,4-*d*]pyridazine (**1a**).

A mixture of **4a** [1] (300 mg, 0.85 mmole) and hydrazine hydrate (423 mg, 8.46 mmoles) in acetic acid (5 ml) was heated under reflux for 4 hours. After it was cooled to room temperature, precipitates were collected by filtration, and washed with water to give **1a** (128 mg, 45%). This compound was obtained as deep red needles from a 1:1-mixture of benzene and ethanol, mp 263-264° dec; ir: 1603, 1444, 1304, 1266, 1179, 1157, 1030, 836; ^{1}H-nmr: δ 4.03 (s, 6H), 7.15 (d, J = 9 Hz, 4H), 8.75 (d, J = 9 Hz, 4H); ms: m/z 334 (M$^+$).

Anal. Calcd. for $C_{18}H_{14}N_4O_3$: C, 64.66; H, 4.22; N, 16.76. Found: C, 65.10; H, 4.33; N, 16.82.

4,7-Di(*p*-ethoxyphenyl)-1,2,5-oxadiazolo[3,4-*d*]pyridazine (**1b**).

A mixture of **4b** (1.00 g, 2.62 mmoles) and hydrazine hydrate (1.31 g, 26.2 mmoles) in acetic acid (12 ml) was heated under reflux for 5 hours and worked up as described above, giving **1b** (0.45 g, 48%). This compound was obtained as orange needles from a 7:3-mixture of hexane and benzene, mp 210-226°; ir: 2982, 1605, 1519, 1416, 1254; ^{1}H-nmr: δ 1.48 (t, J = 7 Hz, 6H), 4.13 (q, J = 7 Hz, 4H), 7.06 (dd, J = 9 and 2 Hz, 4H), 8.66 (dd, J = 9 and 2 Hz, 4H); ms: m/z 362 (M$^+$).

Anal. Calcd. for $C_{20}H_{18}N_4O_3$: C, 66.28; H, 5.01; N, 15.46. Found: C, 66.31; H, 5.19; N, 15.43.

4,7-Di(*p*-butoxyphenyl)-1,2,5-oxadiazolo[3,4-*c*]pyridazine (**1c**).

A mixture of **4c** (8.00 g, 18 mmoles) and hydrazine hydrate (9.12 g, 182 mmoles) in acetic acid (96 ml) was heated under reflux for 4 hours and worked up as described above, giving **1c** (3.96 g, 52%). This compound was obtained as orange needles from a 4:1-mixture of hexane and benzene, mp 143-180.5°; ir: 2958, 1604, 1518, 1445, 1416, 1251, 1184, 1160; ^{1}H-nmr: δ 1.00 (t, J = 7 Hz, 6H), 1.20-1.98 (m, 8H), 4.06 (q, J = 7 Hz, 4H), 7.05 (dd, J = 9 and 2 Hz, 4H), 8.64 (dd, J = 9 and 2 Hz, 4H); ms: m/z 418 (M$^+$).

Anal. Calcd. for $C_{24}H_{26}N_4O_3$: C, 68.88; H, 6.26; N, 13.39. Found: C, 69.14; H, 6.25; N, 13.44.

4,7-Di(*p*-octyloxyphenyl)-1,2,5-oxadiazolo[3,4-*d*]pyridazine (**1d**).

A mixture of 3,4-di(*p*-octyloxyphenyl)furoxan **4c** (0.50 g, 0.91 mmole) and hydrazine hydrate (0.50 g, 10.0 mmoles) in acetic acid (8 ml) was heated under reflux for 4.5 hours and worked up as described above, giving **1d** (0.24 g, 50%). This compound was obtained as orange plates from hexane, mp 128-150°; ir: 2922, 1417, 1252; ^{1}H-nmr: δ 0.89 (t, J = 6 Hz, 6H), 1.01-1.99 (m, 24H), 4.05 (t, J = 6 Hz, 4H), 7.06 (dd, J = 9 and 2 Hz, 4H), 8.65 (dd, J = 9 and 2 Hz, 4H); ms: m/z 530 (M$^+$).

Anal. Calcd. for $C_{32}H_{42}N_4O_3$: C, 72.42; H, 7.98; N, 10.56. Found: C, 72.79; H, 8.00; N, 10.77.

4,7-Di(*p*-methoxyphenyl)-1,2,5-thiadiazolo[3,4-*d*]pyridazine (**2a**).

A mixture of **10a** (177 mg, 0.50 mmole) and hydrazine hydrate (250 mg, 5.0 mmoles) in acetic acid (4 ml) was heated under reflux for 4.5 hours. After it was cooled to room temperature, precipitates were collected by filtration and recrystallized to give **2a**

(0.45 g, 48%). This compound was obtained as orange prisms from a 2:3-mixture of hexane and benzene, mp 211°; ir: 2930, 1605, 1521, 1422, 1407, 1248; ^{1}H-nmr: δ 3.90 (s, 6H), 7.07 (dd, J = 9 and 2 Hz, 4H), 8.70 (dd, J = 9 and 2 Hz, 4H); ms: m/z 350 (M^+).

Anal. Calcd. for $C_{18}H_{14}N_4O_2S$: C, 61.71; H, 4.03; N, 16.00. Found: C, 61.53; H, 4.23; N, 15.74.

4,7-Di(*p*-ethoxyphenyl)-1,2,5-thiadiazolo[3,4-*d*]pyridazine (**2b**).

A mixture of **10b** (191 mg, 0.50 mmole), hydrazine hydrate (250 mg, 5.0 mmoles) in acetic acid (4 ml) was heated under reflux for 5 hours and worked up as described above, giving **2b** (171 mg, 90%). This compound was obtained as light orange prisms from a 9:1-mixture of hexane and benzene, mp 207°; ir: 2978, 1605, 1510, 1423, 1406, 1250; ^{1}H-nmr: δ 1.46 (t, J = 6 Hz, 6H), 4.12 (q, J = 6 Hz, 4H), 7.06 (dd, J = 9 and 2 Hz, 4H), 8.67 (dd, J = 9 and 2 Hz, 4H); ms: m/z 378 (M^+).

Anal. Calcd. for $C_{20}H_{18}N_4O_2S$: C, 63.48; H, 4.80; N, 14.81. Found: C, 63.51; H, 4.82; N, 14.53.

4,7-Di(*p*-butoxyphenyl)-1,2,5-thiadiazolo[3,4-*c*]pyridazine (**2c**).

A mixture of **10c** (123 mg, 0.30 mmole) and hydrazine hydrate (160 mg, 3.2 mmoles) in acetic acid (3 ml) was heated under reflux for 4 hours and worked up as described above, giving **2c** (86 mg, 70%). This compound was obtained as dark orange prisms from ethanol, mp 132-155°; ir: 2960, 1603, 1506, 1404, 1259; ^{1}H-nmr: δ 1.00 (t, J = 7 Hz, 6H), 1.12-1.99 (m, 8H), 4.07 (t, J = 7 Hz, 4H), 7.06 (dd, J = 9 and 2 Hz, 4H), 8.69 (dd, J = 9 and 2 Hz, 4H); ms: m/z 434 (M^+).

Anal. Calcd. for $C_{24}H_{26}N_4O_2S$: C, 66.34; H, 6.03; N, 12.90. Found: C, 65.98; H, 6.17; N, 12.60.

4,5-Diamino-3,6-di(*p*-butoxyphenyl)pyridazine (**6c**).

A mixture of **1c** (3.00 g, 7.2 mmoles) and sodium borohydride (1.36 g, 36 mmoles) in ethanol (150 ml) was heated under reflux for 15 minutes. After it was cooled to room temperature, precipitates were collected by filtration and recrystallized from dimethyl sulfoxide, giving **6c** (1.54 g, 53%). This compound was obtained as a skin-colored crystalline powder, mp >300°; ir: 3474, 3346, 3258, 3194, 1667, 1609, 1564, 1507, 1251; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.94 (t, J = 6 Hz, 6H), 1.20-1.82 (m, 8H), 4.01 (t, J = 6 Hz, 4H), 5.05 (br, 4H), 7.00 (d, J = 9 Hz, 4H), 7.49 (d, J = 9 Hz, 4H); ms: m/z 406 (M^+).

Anal. Calcd. for $C_{24}H_{30}N_4O_2$: C, 70.91; H, 7.44; N, 13.78. Found: C, 70.73; H, 7.30; N, 13.77.

4,5-Diamino-3,6-di(*p*-octyloxyphenyl)pyridazine (**6d**).

A mixture of **1d** (228 mg, 0.43 mmole) and sodium borohydride (82 mg, 2.2 mmoles) in ethanol (12 ml) was heated under reflux for 25 minutes and worked up as described above, giving **6d** (144 mg, 65%). This compound was obtained as pale yellow crystalline powder from dimethyl sulfoxide, mp >300°; ir: 3474, 3346, 3258, 3194, 2924, 1666, 1609, 1564, 1506, 1251; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.88 (t, J = 6 Hz, 6H), 1.16-1.90 (m, 24H), 4.14 (t, J = 6 Hz, 4H), 4.96 (br s, 4H), 7.18 (dd, J = 9 and 2 Hz, 4H), 8.66 (dd, J = 9 and 2 Hz, 4H); ms: m/z 518 (M^+).

Anal. Calcd. for $C_{32}H_{46}N_4O_2$: C, 74.09; H, 8.94; N, 10.80. Found: C, 74.21; H, 8.63; N, 11.03.

4,7-Di(*p*-butoxyphenyl)imidazolo[4,5-*d*]pyridazine (**7c**).

After a mixture of **6c** (200 mg, 0.49 mmole) in formic acid (2 ml) was heated under reflux for 48 hours, it was poured into water and neutralized with sodium hydrogen carbonate. Precipitates were collected by filtration, washed with water, and chromatographed using a 9:1-mixture of benzene and ethyl acetate as an eluent, giving **7c** (142 mg, 69%). This compound was obtained as colorless prisms from a 1:1-mixture of hexane and benzene, mp 177-181°; ir: 2958, 2870, 1611, 1517, 1387, 1251, 1177; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.94 (t, J = 6 Hz, 6H), 1.20-1.82 (m, 8H), 4.01 (t, J = 6 Hz, 4H), 5.16 (br s, 4H), 7.00 (d, J = 9 Hz, 4H), 7.49 (d, J = 9 Hz, 4H), 8.36 (s, 1H); ms: m/z 416 (M^+).

Anal. Calcd. for $C_{25}H_{28}N_4O_2$: C, 72.09; H, 6.78; N, 13.45. Found: C, 71.95; H, 6.85; N, 13.34.

4,7-Di(*p*-octyloxyphenyl)imidazolo[4,5-*d*]pyridazine (**7d**).

After a mixture of **6d** (70 mg, 0.14 mmole) and paraformaldehyde (53 mg, 1.77 mmoles) in formic acid (3 ml) was heated under reflux for 4 hours, it was poured into water, then the mixture was neutralized with sodium hydrogen carbonate. The precipitated solid material was collected by filtration, washed with water, and chromatographed using a 1:1-mixture of benzene and chloroform as an eluent, giving **7d** (23 mg, 32%). This compound was obtained as colorless powder from methanol, mp 179-225°; ir: 3442, 2924, 2854, 1612, 1518, 1388, 1251; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.92 (t, J = 6 Hz, 6H), 1.18-1.84 (m, 24H), 3.83 (t, J = 6 Hz, 4H), 5.18 (br s, 1H), 6.76 (d, J = 9 Hz, 4H), 8.16 (d, J = 9 Hz, 4H), 8.36 (s, 1H); ms: m/z 528 (M^+).

Anal. Calcd. for $C_{33}H_{44}N_4O_2$: C, 74.96; H, 8.39; N, 10.60. Found: C, 74.53; H, 8.20; N, 10.27.

4,7-Di(*p*-butoxyphenyl)-2-methylimidazolo[4,5-*d*]pyridazine (**7e**).

After a mixture of **6a** (200 mg, 0.49 mmole) in acetic acid (2 ml) was heated at reflux for 48 hours, it was poured into water and neutralized with sodium hydrogen carbonate. The precipitated solid was collected by filtration and washed with hot benzene to give unchanged **6a** (124 mg, 62% yield). The washings were evaporated and the residue was washed with hexane, giving a crude product which, on recrystallization from benzene, gave the monohydrate of **7e** as colorless prisms, mp 113-115° dec; ir: 3562, 2954, 2868, 1612, 1510, 1373, 1244, 1177, 1041, 835.

Anal. Calcd. for ($C_{26}H_{30}N_4O_2 \cdot H_2O$): C, 69.62; H, 7.19; N, 12.49. Found: C, 69.53; H, 7.02; N, 12.28.

An analytical sample of water-free **7e** was obtained by heating the hydrate at 100° *in vacuo* overnight as a colorless powder, mp 155-158°; ^{1}H-nmr: δ 0.94 (t, J = 7 Hz, 6H), 1.12-1.84 (m, 8H), 2.68 (s, 3H), 3.88 (t, J = 7 Hz, 4H), 5.10 (br s, 1H), 6.81 (d, J = 8 Hz, 4H), 8.14 (d, J = 8 Hz, 4H); ms: m/z 430 (M^+).

Anal. Calcd. for $C_{26}H_{30}N_4O_2$: C, 72.53; H, 7.02; N, 13.01. Found: C, 72.64; H, 6.81; N, 13.10.

4,7-Di(*p*-butoxyphenyl)triazolo[4,5-*d*]pyridazine (**8c**).

To a mixture of **6c** (100 mg, 0.25 mmole) in acetic acid (2 ml) was added nitrosyl sulfate (128 mg, 1.00 mmole) and the mixture was stirred below 20° for 9 hours. It was poured into water and neutralized with sodium hydrogen carbonate. The precipitates were collected by filtration, washed with water, and recrystallized from ethanol giving **8c** (38 mg, 37%). This compound was obtained as a skin-colored crystalline powder, mp 280-323° dec; ir: 3444, 2958, 2934, 2872, 1610, 1258; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.97 (t, J = 7.3 Hz, 6H), 1.42-1.55 (m, 4H), 1.72-1.83 (m, 4H), 4.15 (t, J = 6.6 Hz, 4H), 5.09 (br s, 1H), 7.27 (d, J = 8.4 Hz, 4H), 8.74 (d, J = 8.4 Hz, 4H); ms: m/z 417 (M^+).

Anal. Calcd. for $C_{24}H_{27}N_5O_2$: C, 69.04; H, 6.52; N, 16.78. Found: C, 69.09; H, 6.47; N, 16.79.

4,7-Di(*p*-octoxyphenyl)triazolo[4,5-*d*]pyridazine (**8d**).

To a mixture of **6d** (68 mg, 0.13 mmole) in acetic acid (3 ml) was added nitrosyl sulfate (68 mg, 0.54 mmoles) and the mixture was stirred below 20° for 6 hours. The mixture was worked up as described above, giving **8d** (33 mg, 48%). This compound was obtained as a skin-colored crystalline powder from ethanol, mp 215-280° dec; ir: 3440, 2924, 2854, 1611, 1259; ^{1}H-nmr (hexadeuteriodimethyl sulfoxide): δ 0.88 (t, J = 7 Hz, 6H), 1.18-1.92 (m, 24H), 4.14 (t, J = 6 Hz, 4H), 4.98 (br s, 1H), 7.18 (dd, J = 9 and 2 Hz, 4H), 8.68 (dd, J = 9 and 2 Hz, 4H); ms: m/z 529 (M^+).

Anal. Calcd. for $C_{32}H_{43}N_5O_2$: C, 72.55; H, 8.18; N, 13.22. Found: C, 72.25; H, 8.06; N, 13.13.

4,7-Di(*p*-butoxyphenyl)pyrazino[5,6-*d*]pyridazine (**9**).

A mixture of **6c** (100 mg, 0.25 mmole) and 40% aqueous glyoxal (40 mg, 0.28 mmole) in ethanol (2 ml) was heated under reflux for 34 hours. After it was cooled to room temperature, the precipitate was collected by filtration and washed with chloroform, giving unchanged **6c** (41 mg, 41%). The washings were evaporated *in vacuo*, leaving **9** (41 mg, 39%). This compound was obtained as yellow plates from a 3:2-mixture of hexane and benzene, mp 270-274°; ir: 2958, 2872, 1609, 1517, 1417, 1254, 1179; ^{1}H-nmr: δ 1.00 (t, J = 6 Hz, 6H), 1.20-1.98 (m, 8H), 4.05 (t, J = 6 Hz, 4H), 7.06 (dd, J = 9 and 2 Hz, 4H), 8.22 (dd, J = 9 and 2 Hz, 4H), 9.15 (s, 2H); ms: m/z 428 (M^+).

Anal. Calcd. for $C_{26}H_{28}N_4O_2$: C, 72.87; H, 6.59; N, 13.07. Found: C, 72.63; H, 6.63; N, 13.45.

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