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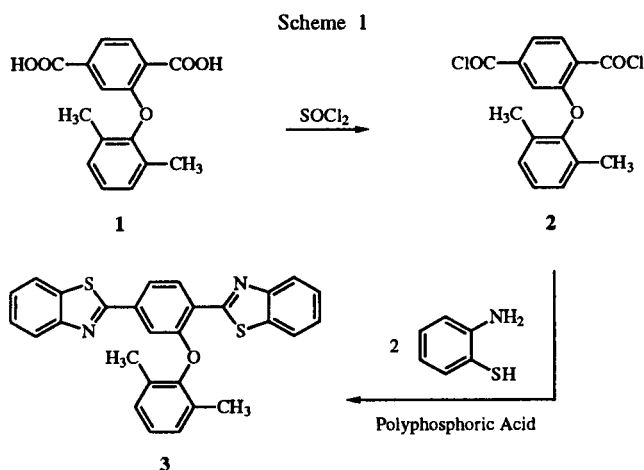
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Recently we reported the synthesis in polyphosphoric acid of a graft copolymer consisting of a rigid-rod poly[benzo(1,2-*d*;4,5-*d'*)bisthiazole-2,6-diyl]-1,4-phenylene backbone and flexible poly(oxy-1,3-phenylenecarbonyl-1,4-phenylene) side-chains [1]. However, upon extension of this synthetic approach to the analogous graft copolymer with a poly[benzo(1,2-*d*;5,4-*d'*)bisoxazole-2,6-diyl]-1,4-phenylene backbone, we encountered some unexpected results due to methyl group migration. In order to better understand these results, we carried out the synthesis of selected benzothiazole and benzoxazole structures under appropriate reaction conditions. The results are reported in this article.

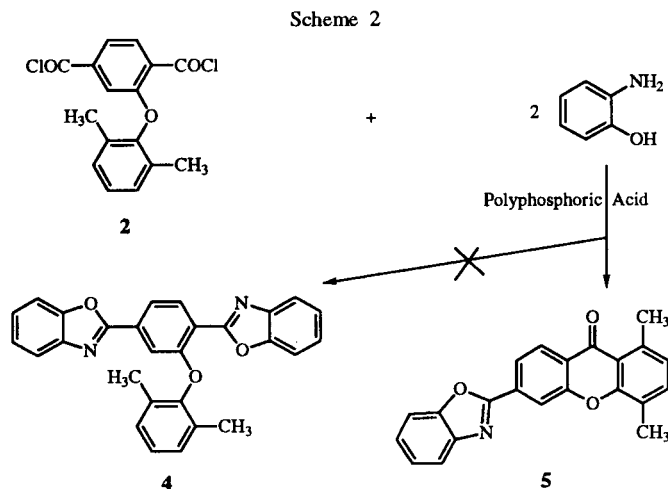
J. Heterocyclic Chem., **34**, 817 (1997).

These syntheses initially centered upon the condensations of 2-(2,6-dimethylphenoxy)terephthalic acid **1** and the corresponding diacid chloride **2** with 2-aminothiophenol and 2-aminophenol in polyphosphoric acid or trimethylsilyl polyphosphate. Compounds **1** and **2** were the key monomers in the above polymerization reactions [1] and contained methyl groups at the 2- and 6-positions of the phenoxy pendent specifically to hinder or prevent intramolecular acylation leading to xanthone formation [2]. They were prepared through the nucleophilic displacement of a nitro group from dimethyl 2-nitroterephthalate by potassium 2,6-dimethylphenoxide in dimethylformamide. The resultant dimethyl 2-(2,6-dimethylphenoxy)terephthalate was then saponified with sodium hydroxide to yield diacid **1**, which was converted to diacid chloride **2** by treatment with thionyl chloride (Scheme 1).



As expected, 2-(2,6-dimethylphenoxy)terephthaloyl chloride **2** reacted with 2-aminothiophenol to give 1,4-bis-

(2-benzothiazoyl)-2-(2,6-dimethylphenoxy)benzene **3** in 95% yield (Scheme 1). Since both methyl groups are chemically equivalent, only one singlet was observed at $\delta = 2.24$ ppm in ^1H -nmr as well as one peak at $\delta = 16.4$ ppm in ^{13}C -nmr. The ir showed no peaks in the carbonyl region. Under identical conditions, however, reaction of **2** with 2-aminophenol did not lead to the expected 1,4-bis(2-benzoxazolyl)-2-(2,6-dimethylphenoxy)benzene **4** (Scheme 2). The ir of the reaction product, obtained in

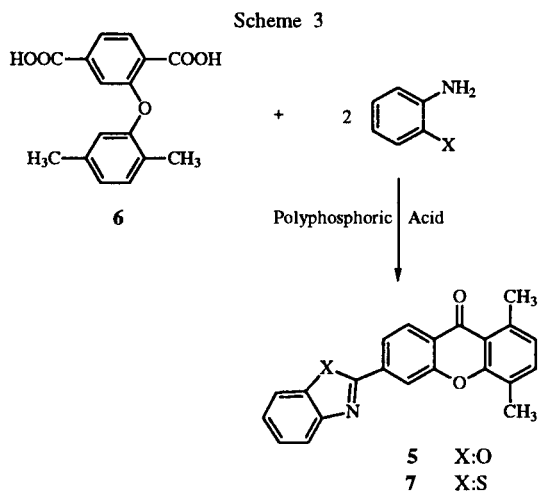


75% purified yield, exhibited a strong absorption in the carbonyl region at 1660 cm^{-1} . Two singlets were observed in ^1H -nmr at $\delta = 2.47$ ppm and $\delta = 2.84$ ppm integrating for 3 protons each. The ^{13}C -nmr exhibited two peaks in the methyl region at $\delta = 15.6$ ppm and $\delta = 22.6$ ppm as well as one peak in the carbonyl region at $\delta = 178.2$ ppm. The ms showed a molecular peak at 341 m/z (100% abundance). Based on these spectral data and the elemental analysis, we identified the unexpected product as 1,4-dimethyl-6-benzoxazolylxanthone **5**. Formation of xanthone

5 would require migration of a methyl group from the *ortho* position of the pendent phenoxy group to the *meta* position concurrent with or followed by an intramolecular acylation (Scheme 2).

Alkyl aromatics, in the presence of strong acids, undergo the Jacobsen rearrangement in which alkyl groups intramolecularly migrate from one position to another [3]. For example, sulfonation of durene gives prehnitenesulfonic acid [4]. Under a similar mechanism, formation of xanthone **5** was probably made possible during the reaction of **2** with 2-aminophenol due to concurrent or prior Jacobsen rearrangement of the 2-methyl group of the phenoxy pendent.

In order to decisively assign structure **5** to the product generated by the reaction of **2** with aminophenol, we prepared xanthone **5** by a different synthetic route and compared its spectra with those of the unexpected product. Xanthone **5** was formed in quantitative yield upon condensation in polyphosphoric acid of 2-aminophenol with 2-(2,5-dimethylphenoxy)terephthalic acid **6** (Scheme 3),

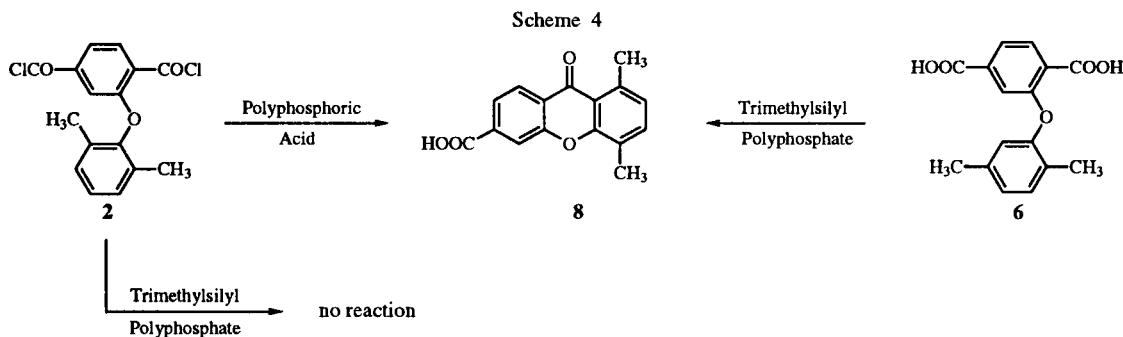


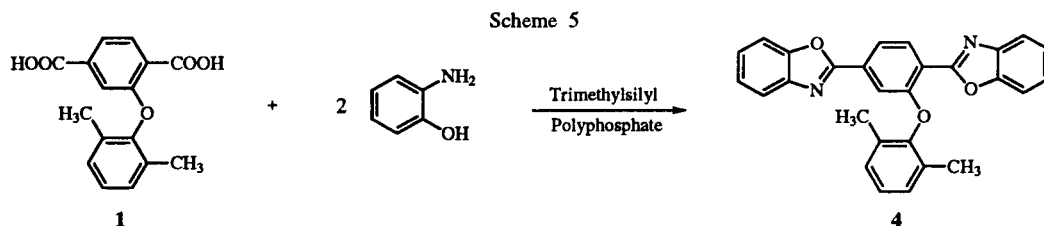
obtained from a synthesis procedure similar to that used for its structural isomer **1**. Under these circumstances, formation of xanthone **5** required only intramolecular acylation by the carboxy group onto the pendent phenol group at the unsubstituted *ortho* position. In a similar fashion, 1,4-bis(2-benzothiazoyl)-2-(2,5-dimethylphenoxy)benzene

7 was obtained through the reaction of **6** with 2-aminothiophenol (Scheme 3).

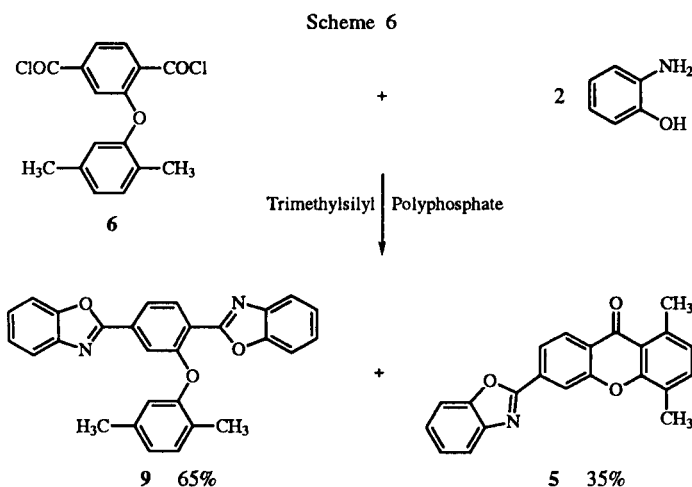
Significantly different results were obtained when the condensation reactions were carried out in trimethylsilyl polyphosphate, an initially neutral condensation reagent [4]. When **2** was heated in polyphosphoric acid, methyl group migration occurred and xanthone **8** was obtained in quantitative yield (Scheme 4). However, no methyl group migration occurred and **2** was quantitatively recovered when the treatment was carried in trimethylsilyl polyphosphate. Similarly, reaction of diacid **1** with 2-aminophenol in trimethyl polyphosphate provided 1,4-bis(2-benzoxazolyl)-2-(2,6-dimethylphenoxy)benzene **4** in 82% purified yield (Scheme 5). Similar to compound **3**, the two methyl groups in **4** are chemically equivalent; thus, only one singlet was observed on $^1\text{H-NMR}$ at $\delta = 2.24$ ppm in the alkyl region. The ir, ms and elemental analysis were found to be in agreement with the proposed structure. However, intramolecular acylation in a neutral condensation medium did take place when methyl group migration was not required. Thus, diacid **6** gave **8** when heated in trimethylsilyl polyphosphate (Scheme 4).

Depending upon the nature of coreactant, **2** is capable of undergoing two different processes in polyphosphoric acid leading to two different products: (1) an exclusively intermolecular condensation at both the carboxy groups leading to product **3** and (2) a methyl group migration coupled with an intramolecular acylation by one of the carboxy groups leading to **5**. When the coreactant is 2-aminothiophenol, the intermolecular condensation takes place exclusively while with 2-aminophenol, the intramolecular process also occurs. This behavior can possibly be attributed to the greater nucleophilicity of 2-aminothiophenol compared to 2-aminophenol and the resultant faster rate of reaction which permits benzothiazole ring formation before methyl group migration and xanthone formation can occur. A plausible mechanism for the formation of compound **5** under strongly acidic conditions could be *ipso* attack by the carboxy group positioned *ortho* to the phenoxy pendent coupled with a 1,2 migration of the methyl group at the *ipso* position of the phenoxy pendent.





The competing reaction process in the formation of 4 and 5 was demonstrated by the reaction of 6 with 2-aminophenol in trimethylsilyl polyphosphate. Two products were obtained and their yield ratio was determined by ^1H -nmr. Compound 9 arising from the exclusively intermolecular condensation process was formed in 65% yield while 5 resulting from both the intermolecular condensation reaction and the intramolecular acylation was obtained in 35% yield (Scheme 6).



To prevent 1,2 migration of the methyl group at the *ipso* position under strongly acidic condensation conditions, it appears necessary to protect the unsubstituted positions *ortho* to the 2- and 6-methyl groups. An effort is underway to synthesize appropriately substituted diacids and investigate their reactions with 2-aminophenol in polyphosphoric acid. Results of this investigation will be reported in the near future.

EXPERIMENTAL

2-(2,6-Dimethylphenoxy)terephthalic Acid 1.

Potassium *t*-butoxide (90.6 g, 0.80 mole) was added to a stirred solution of 97.6 g of 2,6-dimethylphenol (0.80 mole) in 320 ml of dry toluene and 800 ml of dry *N,N*-dimethylformamide under a nitrogen atmosphere. The reaction mixture was heated until a volume of 300 ml of toluene was removed by distillation, and was then cooled to room temperature. Dimethyl

2-nitroterephthalate (191.2 g, 0.80 mole) was added and the reaction was stirred at 100° overnight. After the reaction was allowed to cool to room temperature, approximately 600 ml of *N,N*-dimethylformamide was removed on a rotary evaporator at 80°/50 mm Hg. The remaining mixture was chilled and poured with stirring into ice-water. Following several extractions with ethyl acetate, the combined extracts were washed with saturated sodium chloride solution and then dried over anhydrous sodium sulfate. Removal of solvent from the dried solution yielded 88.4 g of dark brown liquid. Distillation using a short-path apparatus at 150–153°/0.1 mm Hg yielded a yellowish solid. Recrystallization from ethanol followed by recrystallization from hexane gave 58 g (23% yield) of dimethyl 2-(2,6-dimethylphenoxy)terephthalate as a white solid, mp 82–84°; ^1H -nmr (deuteriochloroform): 2.16 ppm (s, CH_3), 3.90 ppm (s, COOCH_3), 4.03 ppm (s, COOCH_3), 7.21–8.10 ppm (m, aromatic H); ir (potassium bromide): 1734 cm^{-1} , 1727 cm^{-1} (C=O), 1290 cm^{-1} (Ph-O-Ph); ms: (EI) 314 m/z (M^+).

Anal. Calcd. for $\text{C}_{18}\text{H}_{18}\text{O}_5$: C, 68.78; H, 5.77. Found: C, 68.65; H, 5.79.

To a stirred solution of 17 g (0.425 mole) of sodium hydroxide in 25 ml of water were added 26.79 g (0.085 mole) of dimethyl 2-(2,6-dimethylphenoxy)terephthalate and 50 ml of ethanol. The reaction mixture was stirred at reflux overnight. After cooling to room temperature, the reaction mixture was acidified with concentrated hydrochloric acid to yield a precipitate which was collected on a filter and suction dried to yield 24.45 g of white solid. Recrystallization from ethanol/water (3:1) yielded 22.6 g (93%) of white crystalline product, mp 315–317°; ^1H -nmr (d_6 -acetone): 2.16 ppm (s, CH_3), 7.20–8.20 ppm (m, aromatic H); ir (potassium bromide): 3057 cm^{-1} (OH), 1697 cm^{-1} (C=O), 1289 cm^{-1} (Ph-O-Ph); ms: (EI) 286 m/z (M^+).

Anal. Calcd. for $\text{C}_{16}\text{H}_{14}\text{O}_5$: C, 67.12; H, 4.93. Found: C, 67.11; H, 5.05.

2-(2,5-Dimethylphenoxy)terephthalic Acid 6.

In a similar procedure, 2,5-dimethylphenol (61.1 g, 0.5 mole), dimethyl 2-nitroterephthalate (119.6 g, 0.5 mole) and potassium *t*-butoxide (56 g, 0.5 moles) in a mixture of 180 ml of dry toluene and 450 ml of dry *N,N*-dimethylformamide provided 50.3 g (32% yield) of dimethyl 2-(2,5-dimethylphenoxy)terephthalate, mp 85–87°; ^1H -nmr (deuteriochloroform): 2.20 ppm (s, CH_3), 2.26 ppm (s, CH_3), 3.86 ppm (COOCH_3), 6.70 ppm–8.00 ppm (m, aromatic H); ir (potassium bromide): 1726 cm^{-1} , 1709 cm^{-1} (C=O), 1290 cm^{-1} (Ph-O-Ph); ms: (EI) 314 m/z (M^+ , 100%).

Anal. Calcd. for $\text{C}_{18}\text{H}_{18}\text{O}_5$: C, 68.78; H, 5.77. Found: C, 68.24; H, 5.57.

The dimethyl ester was hydrolysed in ethanolic potassium hydroxide to diacid 6. Recrystallization from methanol/water provided white crystalline product, mp 312°, in 98% yield, ms: (EI) 286 m/z (M^+).

2-(2,6-Dimethylphenoxy)terephthaloyl Chloride 2.

2-(2,6-Dimethylphenoxy)terephthalic acid 1 (20.0 g, 0.069 mole), 100 ml of thionyl chloride and a few drops of dry *N,N*-dimethylformamide were stirred at reflux overnight. After removing excess thionyl chloride by distillation, 100 ml of dry toluene were added to the solution and then distilled to remove residual thionyl chloride. The remaining yellow material was distilled at 140–143°/0.07 mm Hg and the resultant solid was recrystallized twice from hexane to yield 14.7 g (65% yield) of white crystals, mp 65–67°; ¹H-nmr (deuteriochloroform): 2.10 ppm (s, CH₃), 7.20–8.30 ppm (m, aromatic H); ir (potassium bromide): 1776 cm⁻¹, 1758 cm⁻¹ (COCl); ms: (EI) 323 m/z (M⁺).

Anal. Calcd. for C₁₆H₁₂O₃Cl₂: C, 59.46; H, 3.74; Cl, 21.94. Found: C, 59.70; H, 3.91; Cl, 21.69.

1,4-Bis(2-benzothiazoyl)-2-(2,6-dimethylphenoxy)benzene 3.

2-(2,6-Dimethylphenoxy)terephthaloyl chloride 2 (1.0 g, 3.1 mmoles) and 2-aminothiophenol (0.92 g, 7.4 mmoles) were stirred under a nitrogen atmosphere in 15 g of 83% polyphosphoric acid at 165° for 24 hours. The homogeneous yellow solution was poured into ice water and the precipitated yellow crude product was isolated by filtration. Following air drying, recrystallization in toluene (charcoal) gave 1.35 g (95% yield) of white crystalline product, mp 252°; ¹H-nmr (deuteriochloroform): 2.24 ppm (s, CH₃), 7.23 ppm–8.82 ppm (m, aromatic H); ¹³C-nmr (deuteriochloroform ppm): 166.5, 161.8, 155.6, 154.4, 150, 136.7, 136.5, 135.3, 131.3, 130.5, 129.5, 126.4, 126.2, 126.0, 125.5, 125.0, 123.9, 123.5, 123.1, 121.6, 121.3, 121.1, 111.7, 16.4; ir (potassium bromide): 1605 cm⁻¹, 1561 cm⁻¹, (C=C, C=N), 1288 cm⁻¹ (Ph-O-Ph); ms: (EI) 464 m/z (M⁺, 64.2%).

Anal. Calcd. for C₂₅H₂₀N₂S₂O: C, 72.38; H, 4.33; N, 6.00; S, 13.80. Found: C, 72.41; H, 4.54; N, 5.98; S, 13.28.

1,4-Dimethyl-6-(2-benzoxazolyl)xanthone 5 (prepared from 2).

2-(2,6-Dimethylphenoxy)terephthaloyl chloride 2 (2.0 g, 6.2 mmoles) and 2-aminophenol (1.35 g, 12.4 mmoles) were stirred in a nitrogen atmosphere in 30 g of 83% polyphosphoric acid at 165° for 24 hours. The homogeneous orange yellowish solution was poured into ice water and the precipitated yellow crude product was isolated by filtration. Following air drying, recrystallization in toluene (charcoal) gave 2.0 g (95% yield) of tan crystalline product, mp 252°; ¹H-nmr (deuteriochloroform): 2.27 ppm (s, CH₃), 2.84 ppm (s, CH₃), 7.23 ppm–8.82 ppm (m, aromatic H); ¹³C-nmr (deuteriochloroform ppm): 178.2, 161.4, 155.2, 152.1, 141.9, 139.5, 135.0, 132.2, 127.6, 126.4, 125.9, 124.9, 124.2, 122.2, 120.5, 120.2, 116.8, 110.8, 22.6, 15.6; ir (potassium bromide): 1660 cm⁻¹ (C=O), 1627 cm⁻¹, (C=C, C=N), 1533 cm⁻¹; ms: (EI) 341 m/z (M⁺, 100%).

Anal. Calcd. for C₂₂H₁₅NO₃: C, 77.40; H, 4.43; N, 4.16. Found: C, 77.61; H, 4.36; N, 3.87.

1,4-Dimethyl-6-(2-benzoxazolyl)xanthone 5 (prepared from 6).

In a similar procedure, 2-(2,5-dimethylphenoxy)terephthalic acid 6 (1.06 g, 3.70 mmoles) reacted with 2-aminophenol (0.807 g, 7.4 mmoles) in 20 g of 83% polyphosphoric acid gave 1.12 g of 5 (89% yield).

1,4-Dimethyl-6-2-benzothiazoylxanthone 7.

In a similar procedure, 2-(2,5-dimethylphenoxy)terephthalic acid 6 (1.06 g, 3.70 mmoles) reacted with 2-aminothiophenol (0.925 g, 7.4 mmoles) in 30 g of 83% polyphosphoric acid gave 0.980 g of 7 (86% yield), mp 248° (toluene); ¹H-nmr (deuteriochloroform): 2.47 ppm (s, CH₃), 2.84 ppm (s, CH₃), 7.00 ppm–8.60 ppm (m, aromatic

H); ir (potassium bromide): 1665 cm⁻¹ (C=O), 1621 cm⁻¹, 1604 cm⁻¹ (C=C, C=N), 1530 cm⁻¹; ms: (EI) 357 m/z (M⁺, 100%).

Anal. Calcd. for C₂₂H₁₅NSO₂: C, 73.92; H, 4.23; N, 3.91; S, 8.97. Found: C, 73.75; H, 4.11; N, 3.91; S, 8.77.

1,4-Dimethyl-6-carboxyxanthone 8 (prepared from 2).

2-(2,6-Dimethylphenoxy)terephthaloyl chloride 2 (2.2 g, 6.80 mmoles) was stirred in a nitrogen atmosphere in 22 g of 83% polyphosphoric acid at 165° for 24 hours. The solution was then poured into ice water and the precipitated crude product was isolated by filtration. Following air drying, recrystallization in acetic acid gave 1.60 g (88% yield) of off-white crystalline product, mp 176°; ¹H-nmr (d₆-acetone): 2.48 ppm (s, CH₃), 2.78 ppm (s, CH₃), 7.00 ppm–8.20 ppm (m, aromatic H); ir (potassium bromide): 1699 cm⁻¹ (COOH), 1658 cm⁻¹ (C=O), 1605 cm⁻¹, 1575 cm⁻¹ (C=N, C=C); ms: (EI) 268 m/z (M⁺, 100%).

Anal. Calcd. for C₁₆H₁₂O₄: C, 71.63; H, 4.51. Found: C, 71.37; H, 4.34.

1,4-Bis(2-benzoxazolyl)-2-(2,6-dimethylphenoxy)benzene 4.

2-(2,6-Dimethylphenoxy)terephthalic acid 1 (1.34 g, 4.68 mmoles) and 2-aminothiophenol (1.17 g, 9.35 mmoles) were stirred in a nitrogen atmosphere in 6 g of trimethylsilyl polyphosphate and 10 ml of *o*-dichlorobenzene at 140° for 48 hours. After the solution was cooled to room temperature, methanol was added to precipitate the crude product. Recrystallization from toluene (charcoal) provided 1.20 g of needles, mp 274°. Further purification of the mother liquor by column chromatography (silica gel, hexane/ethyl acetate: 4/1) gave 0.44 g of pure product. The combined yield of purified product was 1.64 g (82% yield); ¹H-nmr (deuteriochloroform): 2.24 ppm (s, CH₃), 7.17 ppm–8.45 ppm (m, aromatic H); ir (potassium bromide): 1607, 1562, 1552, 1474, 1450, 1419 cm⁻¹; ms: (EI) 432 m/z (M⁺, 100%).

Anal. Calcd. for C₂₈H₂₀N₂O₃: C, 77.76; H, 4.46; N, 6.48. Found: C, 78.49; H, 4.74; N, 6.54.

1,4-Dimethyl-6-carboxyxanthone 8 (prepared from 6).

2-(2,5-Dimethylphenoxy)terephthalic acid 6 (1.5 g, 4.7 mmoles) was stirred in a nitrogen atmosphere in 12 g of trimethylsilyl polyphosphate and 20 ml of *o*-dichlorobenzene at 140° for 48 hours. After the solution was cooled to room temperature, methanol was added to precipitate the crude product. Recrystallization from acetic acid gave 8 (1.2 g, 79% yield).

1,4-Dimethyl-6-2-benzoxazolylxanthone 5 and 1,4-Bis(2-benzoxazolyl)-2-(2,5-dimethylphenoxy)benzene 9.

2-(2,5-Dimethylphenoxy)terephthalic acid 6 (2.862 g, 9.1 mmoles) and 2-aminophenol (2.182 g, 20 mmoles) were stirred in a nitrogen atmosphere in 12 g of trimethylsilyl polyphosphate and 20 ml of *o*-dichlorobenzene at 140° for 48 hours. After the solution was cooled to room temperature, methanol was added to precipitate the crude product, which was subjected for mass spectroscopy analysis and nmr study without further purification; ms: (EI) showed two molecular peaks at 341 m/z and 432 m/z, assigned for M⁺ peak of 5 and M⁺ of 9, respectively.

REFERENCES AND NOTES

- * To whom correspondence should be addressed.
- ! Deceased

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