

SHORT
COMMUNICATIONS

Thiophosphorylation of Thymol with Phosphorus Sulfides

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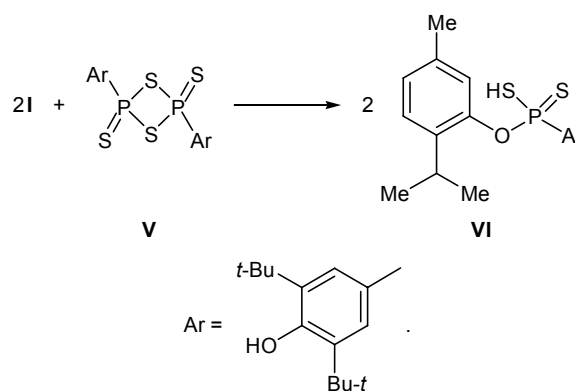
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In continuation of our studies on thiophosphorylation of alcohols [1], the present communication reports on the reaction of one of the most accessible [2] aromatic monoterpenoids, thymol (**I**), with tetraphosphorus decasulfide (**II**) and 2,4-bis(3,5-di-*tert*-butyl-4-hydroxyphenyl)-1,3,2λ⁵,4λ⁵-dithiadiphosphetane 2,4-disulfide (**V**). The reaction of thymol (**I**) with sulfide **II** at 50°C in 2 h afforded *O,O*-bis(2-isopropyl-5-methylphenyl) hydrogen dithiophosphate (**III**) in good yield (Scheme 1). Compound **III** displayed in the ³¹P NMR spectrum a singlet at δ_P 76.5 ppm which appeared in a stronger field relative to the corresponding signal of an aliphatic analog of **III**, *O,O*-bis-[(1*R*,2*S*,5*R*)-2-isopropyl-5-methylcyclohexyl] hydrogen dithiophosphate (δ_P 81.9 ppm), recently prepared by reaction of **II** with L-(–)-menthol [1]. Treatment of acid ester **III** with gaseous ammonia produced ammonium salt **IV**; the phosphorus nuclei in **IV** resonated

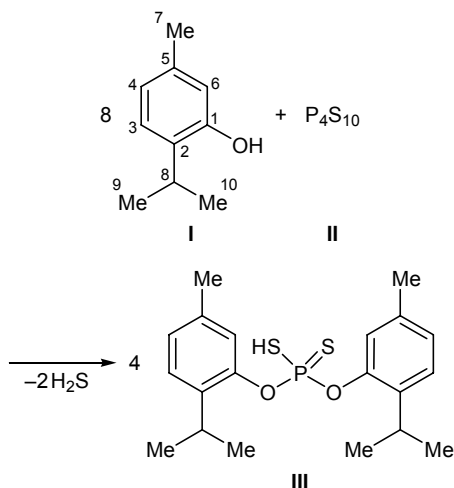
at δ_P 105.8 ppm, i.e., in the region typical of dithiophosphoric acid salts [3].

Dithiophosphorylation of thymol with dithiadiphosphetane disulfide **V** (50°C, 1 h) gave *O*-3,5-di-*tert*-butyl-4-hydroxyphenyl hydrogen dithiophosphonate **VI** (Scheme 2).

Scheme 2.



Scheme 1.



***O,O*-Bis(2-isopropyl-5-methylphenyl) hydrogen dithiophosphate (**III**).** Tetraphosphorus decasulfide (**II**), 3.3 g (7.4 mmol), was added in portions at 20°C under stirring in a stream of dry argon to a solution of 9.0 g (6.0 mmol) of thymol (**I**) in 20 ml of anhydrous benzene. The mixture was stirred for 2 h at 50°C, cooled, and filtered, and the filtrate was evaporated at 40°C under reduced pressure (for 1 h at 0.5 mm and for 1 h at 0.02 mm). Yield 9.3 g (79%). IR spectrum, ν, cm⁻¹: 3035 (C–H_{arom}), 2959, 2928, 2869 [ν_{as,s}(CH₃), ν(CH)], 2487 (S–H, unassoc.), 2345, 2323 (S–H, assoc.), 1622, 1585, 1517 (C=C_{arom}), 1459 [δ_{as}(CH₃)], 1386, 1361 [δ_sC(CH₃)₂], 1091, 1050 (P–O), 944 (OC–C), 739 [ν_{as,s}(PO₂)], 692 (P=S), 526 (P–S).

^1H NMR spectrum, δ , ppm (J , Hz): 1.26 d [12H, $(\text{CH}_3)_2\text{CH}$, $^3J_{\text{HH}} = 7.0$], 2.29 s (6H, CH_3), 3.18 sept [2H, $(\text{CH}_3)_2\text{CH}$, $^3J_{\text{HH}} = 7.0$], 6.60 s (2H, 6-H), 6.75 d (2H, 4-H, $^3J_{\text{HH}} = 7.6$), 7.09 (2H, 3-H, $^3J_{\text{HH}} = 7.6$). Found, %: C 60.68; H 6.91; P 7.33; S 16.11. $\text{C}_{20}\text{H}_{27}\text{O}_2\text{PS}_2$. Calculated, %: C 60.89; H 6.90; P 7.85; S 16.26.

Ammonium *O,O*-bis(2-isopropyl-5-methylphenyl) dithiophosphate (IV). A suspension of 8.1 g (53.9 mmol) of thymol (**I**) and 3.0 g (6.8 mmol) of sulfide **II** in 30 ml of anhydrous benzene was stirred for 1 h at 50°C . The mixture was cooled to $\sim 20^\circ\text{C}$ and filtered, and gaseous ammonia was bubbled through the filtrate at $\sim 20^\circ\text{C}$ over a period of 1 h. The mixture was stirred for 12 h at $\sim 20^\circ\text{C}$ and evaporated at 40°C under reduced pressure (1 h at 0.5 mm and 1 h at 0.02 mm). Yield 6.1 g (55%), mp $50\text{--}51^\circ\text{C}$. Found, %: C 58.66; H 2.24; N 3.01; P 7.11; S 15.44. $\text{C}_{20}\text{H}_{30}\text{NO}_2\text{PS}_2$. Calculated, %: C 58.37; H 7.35; N 3.40; P 7.53; S 15.58.

***O*-(2-Isopropyl-5-methylphenyl) hydrogen (3,5-di-*tert*-butyl-4-hydroxyphenyl)dithiophosphate (VI).** Disulfide **V**, 1.1 g (1.8 mmol), was added in portions at 20°C under stirring in a stream of dry argon to a solution of 0.6 g (4.0 mmol) of thymol (**I**) in 20 ml of anhydrous benzene. The mixture was stirred for 1 h at 50°C , cooled to 20°C , and filtered. The filtrate was evaporated at 40°C under reduced pressure (1 h at 0.5 mm and 1 h at 0.02 mm). Yield 2.4 g (72%). IR spectrum, ν , cm^{-1} : 3620 (O–H), 3034 (C–H_{arom}), 2963, 2872 [$\nu_{\text{as,s}}(\text{CH}_3)$, $\nu(\text{CH})$], 2535 (S–H, unassoc.), 2345 (S–H, assoc.), 1579, 1479 (C=C_{arom}), 1363, 1323 [$\delta_s\text{C}(\text{CH}_3)_2$], 1086 [PO–C], 963 (OC–C), 678, 662 (P=S), 502 (P–S). ^1H NMR spectrum, δ , ppm (J , Hz):

1.24 d [6H, $(\text{CH}_3)_2\text{CH}$, $^3J_{\text{HH}} = 7.2$], 1.43 s (18H, *t*-Bu), 2.27 s (3H, CH_3), 3.14 sept [$(\text{CH}_3)\text{CH}$, $^3J_{\text{HH}} = 6.8$]; 6.58 s (1H, 6-H), 6.73 d (1H, 4-H, $^3J_{\text{HH}} = 7.9$); 7.08 d (1H, 3-H, $^3J_{\text{HH}} = 7.9$), 7.83 d (2H, H_{arom}, $^3J_{\text{PH}} = 15.7$). ^{31}P NMR spectrum (C_6H_6): δ_{P} 86.0 ppm. Found, %: C 64.00; H 7.81; P 6.68; S 14.17. $\text{C}_{24}\text{H}_{35}\text{O}_2\text{PS}_2$. Calculated, %: C 63.97; H 7.83; P 6.87; S 14.23.

The IR spectra were recorded on a Bruker Vector 22 spectrometer with Fourier transform from samples prepared as thin films, suspensions in mineral oil, or KBr pellets. The ^1H NMR spectra were measured on a Bruker Avance-600 spectrometer (600 MHz) from solutions in CDCl_3 ; the chemical shifts were determined relative to the residual proton signal of the solvent. The ^{31}P NMR spectra were obtained on a Bruker Avance-400 instrument at 161.98 MHz using benzene as solvent and 85% phosphoric acid as external standard.

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