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LETTERS TO THE EDITOR

To the 80th Anniversary of B.I. Ionin

Diphenyl[(3,5-di-*tert*-butyl-4-oxo-2,5-cyclohexadienylidene)-methyl]phosphonate in Reactions with *o*-Phenylenediamine

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Benzimidazole derivatives containing sterically hindered phenolic moieties exhibit remarkable biological activity [1–3]. Oxidation of 4-(1*H*-benzo[*d*]imidazol-2-yl)-2,6-di-*tert*-butylphenol with lead(IV) oxide yields stable solid phenoxyl radical promising for development of molecular magnetic materials [4]. 4-(1*H*-Benzo[*d*]imidazol-2-yl)-2,6-di-*tert*-butylphenol can be obtained via two classical methods: (a) the Phillips–Ladenburg reaction (interaction of *o*-phenylenediamine with 3,5-di-*tert*-butyl-4-hydroxybenzylcarboxylic acid) [5] and (b) the Weidenhagen reaction (interaction of diaminobenzenes with 3,5-di-*tert*-butyl-4-hydroxybenzylaldehyde) [4, 6]. Benzimidazole derivatives have been prepared via reaction of diaminobenzenes with 3,5-di-*tert*-butyl-4-hydroxybenzyl carboxyimidate hydrochloride [7, 8]. An example of *o*-phenylenediamine reaction with *S*,*S*-ethylenebisthio-2,6-di-*tert*-butyl-4-methylene-2,5-cyclohexadienone affording benzimidazole bearing a hindered phenol moiety has been described [9].

In this report we propose a new method to prepare benzimidazoles containing hindered phenolic moiety based on the reaction of diphenyl[(3,5-di-*tert*-butyl-4-oxo-2,5-cyclohexadienylidene)methyl]phosphonate with *o*-phenylenediamine derivatives (*o*-phenylenediamine, 4-methyl-1,2-diaminobenzene, and 4-nitro-1,2-diaminobenzene).

Interaction of methylenequinones **I** with *o*-phenylenediamine in dioxane upon heating gave a 2 : 1 complex **II** of the benzimidazole derivative with phosphorous acid **II** in high yield. Similarly, the reaction of methylenequinones **I** with 4-methyl-1,2-diaminobenzene and 4-nitro-1,2-diaminobenzene afforded complexes **III** and **IV**, respectively.

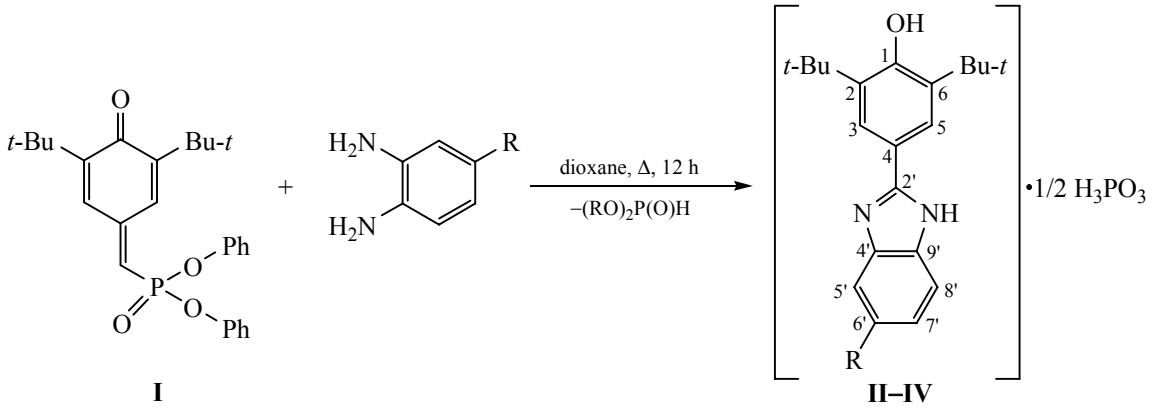
The resulting compounds were solids sparingly soluble in organic solvents. Composition and structure of compounds **II**–**IV** were confirmed by means of elemental analysis, IR, ^{1}H, ^{13}C, and ^{31}P NMR spectroscopy.

To conclude, the interaction of diphenyl[(3,5-di-*tert*-butyl-4-oxo-2,5-cyclohexadienylidene)methyl]-phosphonate with *o*-phenylenediamine derivatives is a promising way to obtain new benzimidazole derivatives (Scheme 1).

Diphenyl-(3,5-di-*tert*-butyl-4-oxocyclohexa-2,5-dienylidenemethyl)phosphonate **I** was synthesized as described [10].

General preparation procedure. *o*-Phenylenediamine (0.1 mmol) was added to a solution of 0.45 g (0.1 mmol) of methylenequinone **I** in 4 mL of dioxane. The reaction mixture was refluxed during 12 h. The resulting precipitate was filtered off, washed with dioxane, and dried in vacuum (1.5×10^{-2} mmHg) for 1 h at 40°C.

Scheme 1.



I **II–IV**

R = H (**II**), CH_3 (**III**), NO_2 (**IV**).

4-(1*H*-Benzo[*d*]imidazol-2-yl)-2,6-di-*tert*-butylphenol (hydrophosphite) (II). Yield 0.27 g (74%), mp >310°C (DMSO). IR spectrum, ν, cm^{-1}: 2961 (CH), 3446 (NH), 3630 (OH). ^1H NMR spectrum, δ, ppm (*J*, Hz): 1.46 s [18H, $C(CH_3)_3$], 5.94 d (1H, PH, J_{PH} 630.0), 7.21 m (2H, $H^{6',7'}$), 7.61 m (2H, $H^{5',8'}$), 7.98 s (2H, $H^{3,5}$). ^{13}C NMR spectrum, δ_C, ppm (*J*, Hz): 29.6 q [$C(\underline{C}H_3)_3$, $^1J_{CH}$ 126.0], 35.4 [$\underline{C}(CH_3)_3$], 115.0 d ($C^{3,5}$, $^1J_{CH}$ 163.0), 120.4 (C^4), 123.1 d ($C^{5',8'}$, $^1J_{CH}$ 160.0), 124.5 d ($C^{6',7'}$, $^1J_{CH}$ 158.0), 138.3 ($C^{2,6}$), 140.12 ($C^{4',9'}$), 152.6 (C^1), 157.1 ($C^{2'}$). ^{31}P NMR spectrum: δ_P 1.9 ppm (d, J_{PH} 630.0 Hz). Mass spectrum (MALDI): *m*/*z* 322.7399 $[M]^+$. Found, %: C 69.19; H 7.78; N 7.45; P 4.67. $C_{42}H_{52}N_4O_2 \cdot H_3PO_3$. Calculated, %: C 69.40; H 7.63; N 7.71; P 4.26.

4-(6-Methyl-1*H*-benzo[*d*]imidazol-2-yl)-2,6-di-*tert*-butylphenol (hydrophosphite) (III). Yield 0.3 g (79%), mp >300°C (DMSO). IR spectrum, ν, cm^{-1}: 2957 (CH), 3443 (NH), 3626 (OH). ^1H NMR spectrum, δ, ppm (*J*, Hz): 1.46 s [18H, $C(CH_3)_3$], 2.42 s (3H, CH_3), 5.91 d (1H, PH, J_{PH} 630.0), 7.00 d (1H, $H^{7'}$, $^3J_{HH}$ 8.1), 7.35 d (1H, $H^{8'}$, $^3J_{HH}$ 8.3), 7.45 s (1H, $H^{5'}$), 7.93 s (2H, $H^{3,5}$). ^{13}C NMR spectrum, δ_C, ppm (*J*, Hz): 24.6 q (CH_3, $^1J_{CH}$ 125.0), 29.8 [$C(\underline{C}H_3)_3$, $^1J_{CH}$ 126.0), 35.8 [$\underline{C}(CH_3)_3$], 115.2 d ($C^{3,5}$, $^1J_{CH}$ 160.0), 120.4 (C^4), 122.6 d ($C^{5',8'}$, $^1J_{CH}$ 160.0), 125.8 d ($C^{7'}$, $^1J_{CH}$ 160.0), 130.8 ($C^{6'}$), 138.8 ($C^{2,6}$), 142.2 ($C^{4',9'}$), 152.9 (C^1), 158.4 ($C^{2'}$). ^{31}P NMR spectrum: δ_P 1.9 ppm (d, J_{PH} 630.0 Hz). Mass spectrum (MALDI): *m*/*z* 336.7262 $[M]^+$. Found, %: C 68.13; H 7.95; N 7.25; P 4.01. $C_{44}H_{56}N_4O_2 \cdot H_3PO_3$. Calculated, %: C 70.00; H 7.88; N 7.42; P 4.10.

4-(6-Nitro-1*H*-benzo[*d*]imidazol-2-yl)-2,6-di-*tert*-butylphenol (hydrophosphite) (IV). Yield 0.2 g (49%), mp >300°C (DMSO). IR spectrum, ν, cm^{-1}: 1538 (NO_2), 2957 (CH), 3470 (NH), 3607 (OH). ^1H NMR spectrum, δ, ppm (*J*, Hz): 1.47 s [18H, $C(CH_3)_3$], 5.91 d (1H, PH, J_{PH} 630.0), 7.71 d (1H, $H^{8'}$, $^3J_{HH}$ 8.3), 8.01 s (2H, $H^{3,5}$), 8.08 d (1H, $H^{7'}$, $^3J_{HH}$ 8.3), 8.42 s (1H, $H^{5'}$). ^{31}P NMR spectrum: δ_P 1.9 ppm (d, J_{PH} 630.0 Hz). Mass spectrum (MALDI): *m*/*z* 367.9402 $[M]^+$. Found, %: C 60.32; H 6.74; N 9.85; P 3.54. $C_{42}H_{50}N_6O_6 \cdot H_3PO_3$. Calculated, %: C 61.75; H 6.54; N 10.29; P 3.79.

^{13}C NMR spectra were recorded with a Bruker Avance-600 instrument operating at 150 MHz using residual proton signals of the deuterated solvent (DMSO-d_6) as reference. ^1H and ^{31}P NMR spectra were registered with a Bruker MSL-400 spectrometer operating at 400.13 and 161.94 MHz, respectively. IR spectra were recorded using a Bruker Vector 22 FTIR spectrometer (400–4000 cm^{-1}, mineral oil). Mass spectra (MALDI-TOF) were obtained using an ULTRAFLEX III TOF/TOF Bruker instrument (*p*-nitroaniline as matrix). Elemental analysis was performed using a Carlo-Erba EA 1108 analyzer.

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