

SHORT
COMMUNICATIONS

Regioselectivity in the Reaction of Hexaethylphosphorous Triamide with 6-Bromo-1,2-naphthoquinone. Synthesis of (7-Bromo-3,4-dioxo-3,4-dihydronaphthalen-1-yl)-tris(diethylamino)phosphonium Bromide

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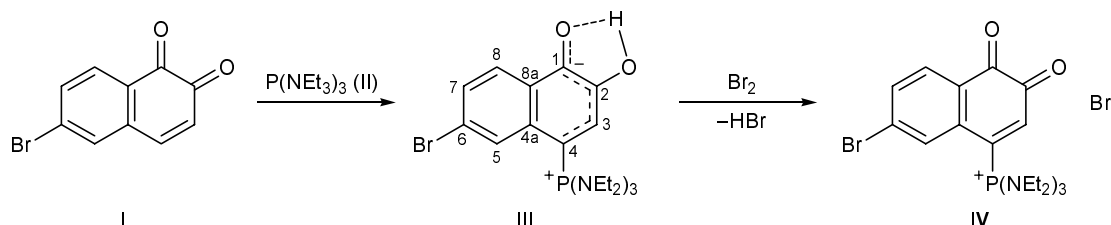
o-Quinones and related compounds (quinone methides) have been found in the nature; they exhibit versatile biological activity and are formed via biodegradation of benzene rings [1]. *o*-Quinones and *o*-quinone methides are used in organic synthesis, in particular in the synthesis of metal complexes [2, 3] and nitrogen- and oxygen-containing heterocycles [4, 5]. Reactions of *o*-quinones with phosphorus(III) compounds are generally limited to those with phosphites, which lead to formation of five-coordinate phosphorus derivatives, i.e., phosphoranes [6, 7].

In the present communication we report for the first time on the reaction of 6-bromo-1,2-naphthoquinone (**I**) (which is the base component of bonafton, an antiviral agent) with hexaethylphosphorous triamide (**II**), followed by treatment of primary zwitterionic adduct **III** with bromine. This reaction sequence provides a convenient synthetic route to phosphorus-containing *o*-quinones like **IV**.

The treatment of compound **III** (δ_p 54.7 ppm) with bromine was performed under mild conditions to obtain phosphorylated naphthoquinone **IV** which displayed a signal at δ_p 48.2 ppm in the $^{31}\text{P}\{-^1\text{H}\}$ NMR spectrum. Presumably, the process involves halophilic attack by hydride ion on the positively polarized

bromine atom. Compound **III** was isolated as a dark cherry glassy material. Its structure was determined by NMR spectroscopy. In the ^{13}C NMR spectrum of **III**, the C^4 atom attached to phosphorus gave a signal at δ_c 86.58 as a broadened doublet with a coupling constant $^1J_{\text{PC}}$ of 165.4 Hz. Despite negative charge delocalization over the ring bond system, signals from C^1 and C^2 are clearly distinguishable (δ_c 162.18 and 142.55 ppm, respectively). The C^1 atom has a more pronounced “carbonyl” character, while the C^2 signal corresponds to resonance of a $\text{C}(\text{OH})=\text{C}$ fragment. The strong difference in the chemical shifts of C^3 in molecules **III** and **IV** (δ_c 120.94 and 142.83 ppm, respectively) is also consistent with electron density distribution patterns therein. The C^1 and C^2 signals of naphthoquinone **IV** are located in the ^{13}C NMR spectrum in a downfield region (δ_c 175.97 and 176.32 ppm, respectively), typical of carbonyl carbon atoms.

(7-Bromo-3,4-dioxo-3,4-dihydronaphthalen-1-yl)tris(diethylamino)phosphonium bromide (IV). A solution of 1.11 ml of phosphorous triamide **II** in 3 ml of methylene chloride was added at 10°C to a suspension of 1 g (4.22 mmol) of quinone **I** in 10 ml of methylene chloride while bubbling argon through the mixture. The mixture turned dark cherry. Removal of



the solvent under reduced pressure (0.1 mm) left a dark cherry glassy material (compound **III**). ^1H NMR spectrum (600 MHz, CDCl_3), δ , ppm (J , Hz): 7.11 d (3-H, $^3J_{\text{PH}} = 16.7$), 7.66 d (5-H, $^4J_{\text{PH}} = 1.9$), 8.21 d.d (7-H, $^4J_{\text{HH}} = 1.9$, $^3J_{\text{HH}} = 8.9$), 7.13 d.d (8-H, $^5J_{\text{PH}} = 1.7$, $^3J_{\text{HH}} = 8.9$), 3.05 d.q (NCH_2 , $^3J_{\text{HH}} = 7.3$, $^3J_{\text{PH}} = 10.3$), 1.02 t (CH_3 , $^3J_{\text{HH}} = 7.1$). ^{13}C NMR spectrum (150.9 MHz, CDCl_3), δ_{C} , ppm (J , Hz) (hereinafter, in parentheses are given the multiplicities of signals in the $^{13}\text{C}\{-^1\text{H}\}$ NMR spectrum): 162.18 br.m (br.s) (C^1), 142.55 d.d (d) (C^2 , $^3J_{\text{CP}} = 11.0$, $^2J_{\text{CH}} = 4.7$), 120.94 br.d.d (br.d) (C^3 , $^1J_{\text{CH}} = 153.0$, $^2J_{\text{CP}} = 13.8\text{--}14.0$), 86.58 br.d.m (br.d) (C^4 , $^1J_{\text{CP}} = 165.4$), 126.6 d.d.d (d) (C^{4a} , $^2J_{\text{CP}} = 14.7$, $^3J_{\text{CH}} = 6.3\text{--}6.4$, $^3J_{\text{CH}} = 6.3\text{--}6.4$), 126.57 d.d.d (d) (C^5 , $^1J_{\text{CH}} = 161.1$, $^3J_{\text{CP}} = 4.8$, $^3J_{\text{CH}} = 4.8\text{--}5.0$), 119.94 d.d (s) (C^6 , $^3J_{\text{CH}} = 13.4$, $^2J_{\text{CH}} = 3.0$), 124.75 d.d (s) (C^7 , $^1J_{\text{CH}} = 167.3$, $^3J_{\text{CH}} = 5.3$), 127.52 d (s) (C^8 , $^1J_{\text{CH}} = 163.3$), 133.09 d.d.d (d) (C^{8a} , $^3J_{\text{CP}} = 8.2\text{--}9.0$, $^3J_{\text{CH}} = 7.8\text{--}8.0$, $^3J_{\text{CH}} = 8.0\text{--}8.2$), 40.45 t.m (d) (NCH_2 , $^1J_{\text{CH}} = 137.6$, $^2J_{\text{CP}} = 4.5$, $^2J_{\text{CH}} = 3.6\text{--}3.7$), 13.17 q.d.t (d) (CH_3 , $^3J_{\text{CP}} = 2.4$, $^2J_{\text{CH}} = 2.5$, $^1J_{\text{CH}} = 126.6$). ^{31}P NMR spectrum (162.0 MHz, CDCl_3): δ_{P} 54.7 ppm. Compound **III** was mixed with hexane, and a solution of 0.22 ml of bromine in 2 ml of hexane was added while passing a strong stream of dry argon. The mixture turned intensely red, and an orange solid separated. It was filtered off and dried under reduced pressure (12 mm) to obtain 0.9 g of quinone **IV**. IR spectrum, ν , cm^{-1} : 2921, 2854, 1686, 1670, 1577, 1546, 1463, 1378, 1300, 1272, 1252, 1207, 1155, 1084, 1061, 1017, 977, 969, 928, 892, 840, 807, 789, 711, 693, 671, 643, 595, 529, 502, 469. $^{31}\text{P}\{-^1\text{H}\}$ NMR spectrum (162.0 MHz, $\text{CDCl}_3\text{--DMSO-}d_6$, 3:1): δ_{P} 48.2 ppm. ^1H NMR spectrum (600 MHz, $\text{CDCl}_3\text{--DMSO-}d_6$, 1:1), δ , ppm (J , Hz): 6.81 d (3-H, $^3J_{\text{PH}} = 22.1$), 7.63 d (5-H, $^4J_{\text{HH}} = 1.6$), 8.03 d.d (7-H, $^3J_{\text{HH}} = 8.3$, $^4J_{\text{HH}} = 1.8$), 7.72 d.d (8-H, $^3J_{\text{HH}} = 8.3$, $^5J_{\text{PH}} = 1.8$), 3.23 d.q (NCH_2 , $^3J_{\text{HH}} =$

7.0, $^3J_{\text{PH}} = 11.0$), 1.19 m (CH_3 , $^3J_{\text{HH}} = 7.0$). ^{13}C NMR spectrum (150.9 MHz, $\text{CDCl}_3\text{--DMSO-}d_6$, 1:1), δ_{C} , ppm (J , Hz): 175.97 br.d.d (d) (C^1 , $^4J_{\text{CP}} = 0.8$, $^3J_{\text{CH}} = 4.5$, $^3J_{\text{CH}} = 4.0$), 176.32 d (d) (C^2 , $^3J_{\text{CP}} = 20.0$), 142.83 d.d (d) (C^3 , $^1J_{\text{CH}} = 168.8$, $^2J_{\text{CP}} = 7.5$), 133.28 d.d.d (d) (C^4 , $^1J_{\text{CP}} = 138.0$, $^3J_{\text{CH}} = 4.2$, $^2J_{\text{CH}} = 1.0$), 131.91 d.d.d (d) (C^{4a} , $^2J_{\text{CP}} = 13.2$, $^3J_{\text{CH}} = 7.4\text{--}7.5$, $^3J_{\text{CH}} = 7.4\text{--}7.5$), 130.80 d.d.d (d) (C^5 , $^1J_{\text{CH}} = 164.3$, $^3J_{\text{CH}} = 6.0$, $^3J_{\text{CP}} = 3.2$), 128.82 d.d.d (s) (C^6 , $^3J_{\text{CH}} = 11.7$, $^2J_{\text{CH}} = 4.0\text{--}4.1$, $^2J_{\text{CH}} = 3.1\text{--}3.2$), 134.06 d.d.d (s) (C^7 , $^1J_{\text{CH}} = 161.1$, $^3J_{\text{CH}} = 5.2$, $^2J_{\text{CH}} = 0.9\text{--}1.0$), 131.70 d.d (d) (C^8 , $^1J_{\text{CH}} = 167.4$, $^4J_{\text{CP}} = 2.2$), 132.97 d.d.d.d (d) (C^{8a} , $^3J_{\text{CP}} = 8.6$, $^3J_{\text{CH}} = 8.6\text{--}8.8$, $^3J_{\text{CH}} = 8.6\text{--}8.8$, $^2J_{\text{CH}} = 1.2$), 41.04 t.d.q (d) (NCH_2 , $^1J_{\text{CH}} = 138.8$, $^2J_{\text{CP}} = 3.7$, $^2J_{\text{CH}} = 3.7$), 13.07 q.d.t (d) (CH_3 , $^3J_{\text{CP}} = 2.8$, $^2J_{\text{CH}} = 2.8\text{--}3.0$, $^1J_{\text{CH}} = 127.3$). Found, %: C 46.47; H 6.11; N 7.33; P 5.17. $\text{C}_{22}\text{H}_{34}\text{Br}_2\text{N}_3\text{O}_2\text{P}$. Calculated, %: C 46.89; H 6.04; N 7.46; P 5.51.

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