ISSN 1070-3632, Russian Journal of General Chemistry, 2008, Vol. 78, No. 1, pp. 157–159. © Pleiades Publishing, Ltd., 2008.
Original Russian Text © N.I. Svintsitskaya, A.V. Aleksandrova, A.V. Dogadina, B.I. Ionin, 2008, published in Zhurnal Obshchei Khimii, 2008, Vol. 78, No. 1, pp. 165–167.

LETTERS TO THE EDITOR

A New Procedure for Synthesis of Phosphorylated Ynamines

N. I. Svintsitskaya, A. V. Aleksandrova, A. V. Dogadina, and B. I. Ionin

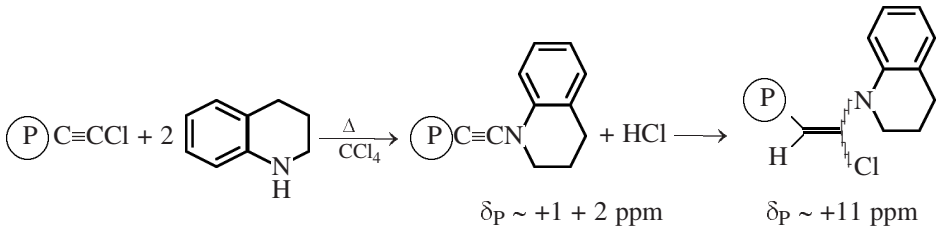
St. Petersburg State Institute of Technology,
Moskovskii pr. 26, St. Petersburg, 190013 Russia
e-mail: bi@thesa.ru

Received September 11, 2007

DOI: 10.1134/S1070363208010313

Phosphorylated ynamines are commonly formed in reactions of chloroethynylphosphonates with secondary [1] or tertiary amines [2]. In the reactions with secondary amines, the parent amine taken in a double molar excess serves as acceptor of the evolved hydrogen chloride. However, while the reactions with chloroethynylphosphonates with highly basic secondary amines, such as diethylamine (pK_a 10.58) [1, 3], morpholine (pK_a 8.51), or piperidine (pK_a 11.22) [4], in an apolar solvent (anhydrous carbon tetrachloride) proceed vigorously with heat release and afford phosphorylated ynamines in quantitative yields, attempted synthesis of ynamines using secondary amines of moderate or low basicity did not lead to an unequivocal result. In the cited works, the basicities of amines were estimated using the Marvin Sketch program, version 3.5.7 (ChemAxon, http://chemaxon.com/marvin). The pK_a values calculated by this program for aromatic amines well fit reference values.

We explored the progress of the reaction of dimethyl chloroethynylphosphonate with 1,2,3,4-tetrahydroquinoline (pK_a 5.00) in anhydrous CCl_4 (reagent molar ratio 1 : 2) by means of ^1H and ^{31}P NMR spectroscopy and ^1H–{^{31}P} double resonance (decoupling and INDOR experiments). One hour after reagent mixing, the ^1H–{^{31}P} INDOR spectrum of the reaction mixture shows two signals: one at δ_P 1.5 ppm (characteristic of phosphorylated ynamines) and the second, stronger signal at δ_P 11 ppm. The ^1H NMR spectrum of the reaction mixture contains a downfield doublet at δ ~5.3 ppm (J_{HP} ~11 Hz). This observation together the above phosphorus chemical shift suggests formation of a compound with an sp^2 carbon atom attached to phosphorus and bearing hydrogen. We can thus conclude that the second product is an ynamine hydrochlorinated by the triple bond:

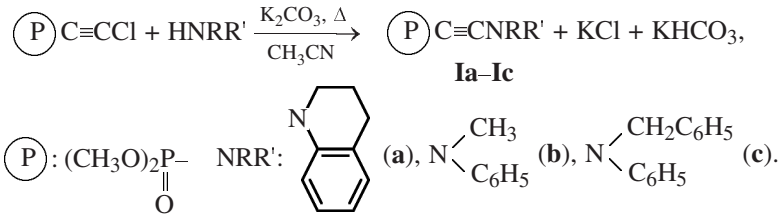


Probably, because of the insufficiently high basicity, 1,2,3,4-tetrahydroquinoline is incapable of fast binding the evolved HCl, and, as a result, the latter adds across the triple bond of the forming aminoethynylphosphonate. On further heating for 1.5 h, a precipitate formed, probably, amine hydrochloride. The ^1H NMR spectrum of the reaction mixture showed already two characteristic doublet signals split by coupling with phosphorus: Along with the downfield doublet at δ_H 5.3 ppm, a doublet in an upper

field and with a smaller J_{HP} constant is observed at δ 4.63 ppm (J_{HP} 7.4 Hz). According to the INDOR experiment, this new doublet corresponds to the phosphorus resonance at δ_P ~25 ppm, which implies formation of a 2,2-bis-aminated vinylphosphonate via reaction of excess amine with the phosphorylated ynamine. Knowing that addition of secondary amines to aminoethynylphosphonates readily occurs in the presence of acid catalysts [5, 6], we can suggest that the latter reaction is catalyzed by the formed HCl or amine hydrochloride.

Thus, the reaction of chloroethynylphosphonate with 1,2,3,4-tetrahydroquinoline is not strictly chemoselective and should be studied in mode detail to solve the problem of fast binding the evolved HCl.

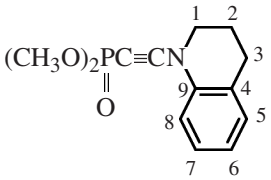
It was found that the reaction of dimethyl chloroethynylphosphonate with secondary amines, such as 1,2,3,4-tetrahydroquinoline (pK_a 5.00), *N*-methylaniline (pK_a 4.85), and *N*-benzylaniniline (pK_a 3.92), in the presence of anhydrous potassium carbonate (HCl acceptor) at an equimolar reagent ratio in a polar solvent (anhydrous acetonitrile) results in quantitative formation of phosphorylated ynamines **Ia**–**Ic**.



After reaction completion, the inorganic salts were filtered off, and the solvent was removed in a vacuum. Since ynamines readily add water to form amides [5], the formed ynamines were not isolated and immediately introduced in further syntheses. Nevertheless, the purity and quantitative formation of compounds **Ia**–**Ic** were confirmed by ^{1}H, ^{13}C, and ^{31}P NMR spectroscopy. The spectra of the reaction mixtures show no other signals than those of the phosphorylated ynamines. The ^{13}C NMR spectra are the most informative; they contain two typical doublet signals corresponding to the carbon atoms of the triple bond: The signal at δ_C ~57 ppm with a large coupling constant ($^1J_{CP}$ ~320 Hz) belongs to the carbon atoms directly bound to phosphorus and that at δ_C 100 ppm ($^2J_{CP}$ ~64–65 Hz) to the carbon atom bound to the amine fragment. The phosphorus chemical shift of ynamines **Ia**–**Ic** is close to zero, as expected. These data fit well the spectral characteristics of phosphorylated ynamines obtained earlier [1, 3, 4].

Aminoethynylphosphonates Ia–Ic *(general procedure).* To a solution of 1 g of dimethyl chloroethynylphosphonate in 3 ml of anhydrous acetonitrile, 1 g of anhydrous potassium carbonate was added, after which an equimolar amount (5.93 mmol) of the corresponding secondary amine in 2 ml of anhydrous acetonitrile was slowly added dropwise with vigorous stirring. The reaction mixture was refluxed for 2 h. The inorganic salts were then filtered off, and the quantitatively formed phosphorylated ynamine dissolved in acetonitrile was immediately brought in further transformations.

Dimethyl (1,2,3,4-tetrahydroqunolyl)ethynylphosphonate (Ia). ^{1}H NMR spectrum, δ, ppm ($CDCl_3$): 1.90 q (2H, $^2CH_2$), 2.67 t (2H, $^3CH_2$), 3.63 t (2H, NCH_2), 3.69 d (6H, CH_3O, $^3J_{HP}$ 12.5 Hz), 6.81 t (1H, H^6), 6.94 d (1H, H^8), 7.06 t (1H, H^7), 7.13 d (1H, H^5). ^{13}C NMR spectrum, δ_C, ppm ($CDCl_3$): 20.68 (C^2), 26.12 (C^3), 49.95 (C^1), 52.69 d (CH_3O, $^2J_{CP}$ 5.4 Hz), 57.88 d (CP, $^1J_{CP}$ 321.5 Hz), 99.92 d (CN, $^2J_{CP}$ 65.1 Hz), 115.33 (C^6), 121.99 (C^8), 123.96 (C^4), 127.06 (C^7), 129.19 (C^5), 136.76 (C^9). ^{31}P NMR spectrum, δ_P, ppm ($CDCl_3$): 1.62.



Dimethyl (*N*-methyl-*N*-phenylamino)ethynylphosphonate (Ib). ^{1}H NMR spectrum, δ, ppm ($CDCl_3$): 3.22 (3H, CH_3Ph), 3.67 d (6H, CH_3O, $^3J_{HP}$ 12.5 Hz), 6.92 t (1H, *p*-CH, Ph), 6.99 d (2H, *o*-CH, Ph), 7.22 t (2H, *m*-CH, Ph). ^{13}C NMR spectrum, δ_C, ppm ($CDCl_3$): 38.22 (CH_3Ph), 52.67 d (CH_3O, $^2J_{CP}$ 5.4 Hz), 56.63 d (CP, $^1J_{CP}$ 320.1 Hz), 100.60 d (CN, $^2J_{CP}$ 63.8 Hz), 114.61 (*o*-CH, Ph), 122.40 (*p*-CH, Ph),

129.03 (*m*-CH, Ph), 141.53 (*ipso*-C, Ph). ^{31}P NMR spectrum, δ_P, ppm (CDCl3): 0.46.

Dimethyl (*N*-benzyl-*N*-phenylamino)ethynylphosphonate (Ic). ^{1}H NMR spectrum, δ, ppm ($CDCl_3$): 3.57 d (6H, CH_3O, $^3J_{HP}$ 12.5 Hz), 4.68 (2H, CH_2Ph), 6.87 t (1H, *p*-CH, Ph), 7.02 d (2H, *o*-CH, Ph), 7.08 t (1H, *p*-CH, $PhCH_2$), 7.15 t (2H, *m*-CH, Ph), 7.19 m (4H, *o,m*-CH, $PhCH_2$). ^{13}C NMR spectrum, δ_C, ppm ($CDCl_3$): 52.64 d (CH_3O, $^2J_{CP}$ 5.4 Hz), 54.61 (CH_2Ph), 57.47 d (CP, $^1J_{CP}$ 317.4 Hz), 100.23 d (CN, $^2J_{CP}$ 63.8 Hz), 115.60 (*o*-CH, Ph), 122.72 (*p*-CH, Ph), 126.92 (*o*-CH, CH_2Ph), 127.73 (*p*-CH, CH_2Ph), 128.49 (*m*-CH, CH_2Ph), 129.08 (*m*-CH, Ph), 134.71 (*ipso*-C, CH_2Ph), 140.97 (*ipso*-C, Ph). ^{31}P NMR spectrum, δ_P, ppm ($CDCl_3$): 0.96.

The organic solvents were purified and dried by conventional procedures. The ^{1}H, ^{13}C and ^{31}P NMR spectra were registered on the spectrometers Bruker C-400 at 400 MHz (^{1}H) and Bruker C-200 at 50.328 (^{13}C) and 81.014 MHz (^{31}P), solvent $CDCl_3$, internal reference TMS (^{1}H, ^{13}C), external reference 85% phosphoric acid (^{31}P). Preliminary ^{1}H and ^{1}H–{^{31}P} NMR spectra were registered on a Tesla BS-497 instrument at 100 MHz.

REFERENCES

1. Garibina, V.A., Dogadina, A.V., Ionin, B.I., and Petrov, A.A., *Zh. Obshch. Khim.,* 1979, vol. 49, no. 10, p. 2385.
2. Ionin, B.I., Dogadina, A.V., and Petrov, A.A., *Zh. Obshch. Khim.,* 1965, vol. 35, no. 12, p. 2255.
3. Garibina, V.A., *Cand. Sci. (Chem.) Dissertation,* Leningrad, 1980.
4. Panarina, A.E., Aleksandrova, A.V., Dogadina, A.V., and Ionin, B.I., *Zh. Obshch. Khim.,* 2005, vol. 75, no. 1, p. 5.
5. *Acetylenes,* Viehe, H.G., Ed., New York: Marcel Dekker, 1969.