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SYNTHESIS OF *N*-ACYLOXY-1-(DIMETHOXYPHOSPHORYLOXY)BENZIMIDATES FROM *N*-ACYLOXY-*N*-CHLOROBENZAMIDES

Vasiliy G. Shtamburg[1], Evgeniy A. Klots[1], Victor V. Shtamburg[1], Andrey A. Anishchenko[2], Svitlana V. Shishkina[3,4], Alexander V. Mazepa[5], Svetlana V. Kravchenko[6*]

[1]*Ukrainian State University of Science and Technologies, Science Ave., 8, Dnipro, 49005, Ukraine*
[2]*Oles Honchar Dnipro National University, Science Ave., 72, Dnipro, 49050, Ukraine,*
[3]*SSI Institute for Single Crystals, National Academy of Sciences of Ukraine, Science Ave., 60, Kharkiv, 61001, Ukraine*
[4]*Institute of Organic Chemistry of National Academy of Sciences of Ukraine, Academician Kukhar St., 5, Kyiv-94, 02660, Ukraine*
[5]*A.V. BogatskyPhysico-Chemical Institute of National Academy of Sciences of Ukraine, LuystdorfskayaDorogaSt., 86, Odessa,65080, Ukraine*
[6]*Dnipro State Agrarian and Economic University, S. Yefremova St., 25, Dnipro, 49600, Ukraine*
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Abstract

Aim. The objective of this research was to investigate the potential interaction between *N*-acyloxy-*N*-chlorobenzamides and trialkyl phosphites, along with the characterization of the resulting products' structures. Methods. Employing techniques such as ^{1}H, ^{31}P and ^{13}C NMR spectroscopy, mass spectrometry, and single crystal X-ray diffraction, we have proved that the reaction of *N*-acyloxy-*N*-chlorobenzamides with trimethyl phosphite in diethyl ether produces *N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates. Our research demonstrates that the reaction between N-acyloxy-N-chlorobenzamides and trialkyl phosphites offers a novel approach to synthesize Z-*N*-acyloxy-1-(dialkoxyphosphoryloxy)benzimidates. This discovery unveils a significant chemical transformation of *N*-acyloxy-*N*-chlorobenzamides. The structure of *N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates has been confirmed by ^{1}H, ^{31}P and ^{13}C NMR spectroscopy, mass spectrometry, and XRD study. The study of the *N*-(4-nitrobenzoyloxy)-1-(dimethoxyphosphoryloxy)benzimidate structure has revealed that the *N*-(4-nitrobenzoyloxy)-1-(dimethoxyphosphoryloxy)benzimidate is the Z-isomer, with the dimethoxyphosphoryloxy moiety and the *N*-4-nitrobenzoyloxy group being *cis*-oriented to the N=C double bond. The ether moiety and the N=C double bond are coplanar, while the dimethoxyphosphoryl substituent is orthogonal to the plane of the N=C double bond. The interaction of *N*-acyloxy-*N*-chlorobenzamides with trimethyl phosphite has led to a new synthesis of Z-*N*-acyloxy-1-(dialkoxyphosphoryloxy)benzimidates. The new chemical properties of *N*-acyloxy-*N*-chlorobenzamides have been established. The X-ray study of Z-*N*-4-nitrobenzoyoxy-1-benzimidate has demonstrated the peculiarities of its structure. Notably, an intriguing phenomenon of nitrogen-to-oxygen migration of the dimethoxyphosphoryl group has been observed.

Keywords: *N*-acyloxy-*N*-chlorobenzamides, trimethyl phosphite, Z-*N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates, nitrogen-to-oxygen migration of dimethoxyphosphoryl moiety.

СИНТЕЗ *N*-АЦИЛОКСИ-1-(ДИМЕТОКСИФОСФОРИЛОКСИ)БЕНЗІМІДАТІВ З *N*-АЦИЛОКСИ-*N*-ХЛОРОБЕНЗАМІДІВ

Василь Г. Штамбург[1], Євген О. Клоц[1], Віктор В. Штамбург[1], Андрій О. Аніщенко[2], Світлана В. Шишкіна[3,4], Олександр В. Мазепа[5], Світлана В. Кравченко[6]

[1]*Український державний університет науки і технологій, пр. Науки, 8, м. Дніпро, 49005, Україна*
[2]*Дніпровський національний університет імені Олеся Гончара, пр. Науки, 72, м. Дніпро, 49050, Україна*
[3]*Державна наукова установа «Інститут монокристалів» НАН України, пр. Науки, 60, м. Харків, 61001, Україна*
[4]*Інститут органічної хімії НАН України, вул. Академіка Кухаря, 5, м. Київ, 02660, Україна*
[5] *Фізико-хімічний інститут імені О.В. Богатського НАН України, вул. Люстдорфська дорога, 86, м. Одеса, 65080, Україна*
[6]*Дніпровський державний аграрно-економічний університет, вул. С. Єфремова., 25, м. Дніпро, 49600, Україна*

Анотація

Мета. Дослідити можливість взаємодії *N*-ацилокси-*N*-хлоробензамідів з триметилфосфітом та будову продуктів цієї реакції. Методи. Мас-спектрометрія, ^{1}H, ^{31}P та ^{13}C ЯМР спектроскопія, рентгеноструктурний аналіз. Результати. Знайдено, що взаємодія *N*-ацилокси-*N*-хлоробензамідів з триметилфосфітом у діетиловому етері призводить до утворення *N*-ацилокси-1-(диметоксифосфорилокси)бензімідатів. Ми довели, що взаємодія*N*-ацилокси-*N*-хлоробензамідів з триалкілфосфітами є новим засобом синтезу *N*-ацилокси-1-(диметоксифосфорилокси)бензімідатів. Таким чином встановлено нове цікаве хімічне

**Correspondingauthor: e-mail: svtailor@ukr.net*
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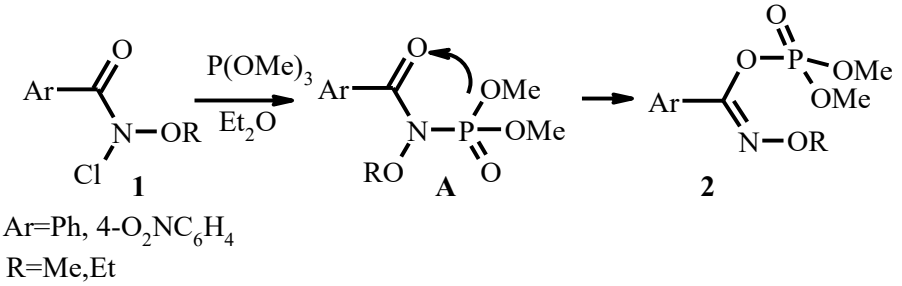
перетворення *N*-алкокси-*N*-хлоробензамідів. Структуру *N*-ацилокси-1-(диметоксифосфорилокси)-бензімідатів підтверджено спектрами ^{1}H, ^{31}P і ^{13}C ЯМР, мас-спектрами та рентгеноструктурним аналізом. Згідно з даними рентгеноструктурного аналізу *N*-(4-нітробензоїлокси)-1-(диметоксифосфорилокси)бензімідату він є Z-ізомером, тобто диметоксифосфорилоксигрупа та *N*-4-нітробензоїлоксигрупа знаходяться в *цис*-положенні до подвійного зв'язку N=C. Естерна група та зв'язок N=C є компланарними. $(MeO)_2P(O)$-група розташована ортогонально щодо площини подвійного зв'язку N=C. Висновки. Взаємодія *N*-ацилокси-*N*-хлоробензамідів з триметилфосфітом у діетиловому етері за кімнатної температури є новим способом синтезу *N*-ацилокси-1-(диметоксифосфорилокси)бензімідатів. Було встановлено нові хімічні властивост *N*-ацилокси-*N*-хлоробензамідів. РСА дослідження Z-*N*-4-нітробензоїлокси-1-(диметоксифосфорилокси)бензімідату показало особливості його структури. Встановлено цікавий різновид внутрішньомолекулярної міграції фосфорильної групи з атому азоту на атом кисню.

Ключові слова: *N*-ацилокси-*N*-хлоробензаміди; триметилфосфіт; Z-*N*-ацилокси-1-(диметоксифосфорилокси)бензімідати; азот-кисень міграція диметоксифосфорильної групи.

Introduction

Phosphoric acid esters exhibit extensive applications in the domains of medicine, medicinal chemistry, and drug design [1; 2]. These compounds are present within a diverse array of biologically active natural products [2]. Despite the fact that synthetic methodologies for the production of phosphate esters have broadened considerably [1], the exploration of novel synthetic pathways remains a valuable endeavor.

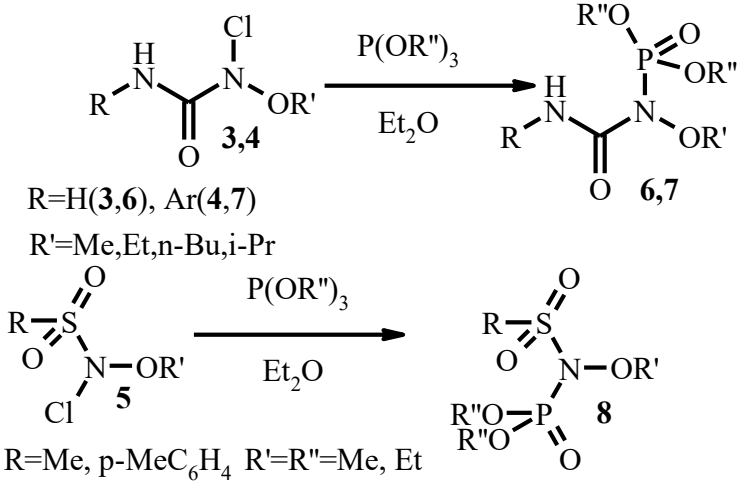
In previous investigations, we found that the interaction of *N*-alkoxy-*N*-chlorobenzamides **1** with trimethyl phosphite yields Z-*N*-alkoxy-1-(dimethoxyphosphoryloxy)benzimidates **2** [3] (Scheme 1).



Scheme 1. **The interaction of *N*-alkoxy-*N*-chlorobenzamides 1 with trimethyl phosphite [3]**

The obtained Z-*N*-alkoxy-1-(dimethoxyphosphoryloxy)benzimidates **2** can be regarded as new unusual kind of organophosphates. In this case, the nitrogen-to-oxygen migration of the dimethoxyphosphoryl group probably occurs in the primary substitution product **A**. Thus, different kinds of nitrogen-to-oxygen phosphoryl group migration have been reported [4; 5].

The probable reaction mechanism is supported by the formation of the corresponding phosporamidates **6**–**8**, under the interaction of *N*-alkoxy-*N*-chloroureas [6], *N*-alkoxy-*N*'-aryl-*N*-chloroureas **4** [7], and *N*-alkoxy-*N*-chloro-R-sulfonamides [7; 8] with trialkyl phosphites.



Scheme 2. **The interaction of *N*-alkoxy-*N*-chloroureas 3 [6], *N*-alkoxy-*N*'-aryl-*N*-chloroureas 4 [7], and *N*-alkoxy-*N*-chloro-R-sulfonamides 5 [7; 8] with trialkyl phosphites**

However, the potential interaction of *N*-acyloxy-*N*-chlorobenzamides with trimethyl phosphite has yet to be explored. Prior research has indicated that when subjected to nucleophiles such as AcONa or 4-dimethylaminopyridine (DMAP), nucleophilic substitution at the nitrogen atom of *N*-benzoyloxy-N-chlorobenzamides does not occur [9].

Thus, the aim of our study was to establish the possibility of the interaction of *N*-acyloxy-*N*-chlorobenzamides with trimethyl phosphite, as well as to analyze the structural characteristics of the resulting products.

Experimental part

^{1}H NMR spectra were recorded on a VARIAN VNMRS 400 spectrometer (400 MHz). ^{13}C NMR spectra were recorded on a VARIAN VNMRS 400 spectrometer (100 MHz). The solvent $CDCl_3$ was used. ^{1}H NMR chemical shifts relative to the residual solvent protons as an internal standard [$CDCl_3$: 7.260 ppm,] were reported. Solvent carbon atoms served as an internal standard for ^{13}C NMR spectra [$CDCl_3$: 77.16 ppm]. ^{31}P NMR spectra were recorded on a VARIAN VNMRS 400 spectrometer (161.95 MHz), the solvent $CDCl_3$ was used, 98 % H_3PO_4 was used as an external standard. Mass spectra were recorded on a VG 70–70EQ mass spectrometer in fast atom bombardment mode (FAB). The solvents were purified and dried according to the standard procedures.

Benzoyloxybenzamide **9a** was synthesized according to [9], colorless crystals, mp. 167–168 °C ($CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.439–7.537 (4H, C(3,5,3',5')H Ph, Ph'CO_2); 7.575 (1H, t, ^3J = 7.4 Hz, C(4)H, Ph); 7.647 (1H, t, ^3J = 7.4 Hz, C(4')H, Ph'CO_2); 7.888 (2H, dd, ^3J = 8.0 Hz, ^4J = 1.6 Hz, C(2)H, C(6)H Ph); 8.157 (2H, dd, ^3J = 8.4 Hz, ^4J = 1.6 Hz, C(2)H, C(6)H Ph'CO_2); 10.155 (1H, br.s, NH). ^{13}C NMR (100.6093 MHz, $CDCl_3$, ppm): δ = 126.77 $C(1)_q$ Ph; 127.71 $2C_{Ph}$(H); 128.88 $2C_{Ph}$(H); 129.01 $2C_{Ph'CO2}$(H); 130.21 $2C_{Ph'CO2}$(H); 131.03 $C(1`)_q$ Ph'CO_2; 132.94 C(4)H Ph; 134.44 C(4')H Ph'CO_2; 165.44 C=O(NH); 166.71 C=O(O). *N*-Chloro-*N*-benzoyloxybenzamide **10a** was synthesized from *N*-benzoyloxybenzamide **9a** by *t*-BuOCl chlorination according to [9], colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.455–7.533 (4H, C(3,5,3',5')H Ph, Ph' CO_2); 7.583 (1H, t, ^3J = 7.4 Hz, C(4)H, Ph); 7.652 (1H, t, ^3J = 7.6 Hz, C(4')H, Ph'CO_2); 7.885 (2H, dd, ^3J = 8.4 Hz, ^4J = 1.2 Hz, C(2)H, C(6)H Ph); 8.158 (2H, dd, ^3J = 8.4 Hz, ^4J = 1.2 Hz, C(2)H, C(6)H Ph'CO_2). ^{13}C NMR (100.6093 MHz, $CDCl_3$): δ = 128.66 $2C_{Ph}$(H); 128.96 $2C_{Ph}$(H); 129.53, $2C_{Ph'CO2}$(H); 130.16 $C(1)_q$ Ph; 130.23 $2C_{Ph'CO2}$(H); 130.71 $C(1`)_q$ Ph'CO_2; 133.28 C(4)H Ph; 134.81 C(4')H Ph'CO_2; 163.42 C=O(O); 173.71 C=O(NCl). Mass spectrum (FAB), m/z(I_{rel},%): 278 $[M+H]^+$ (2.0); 276 $[M+H]^+$ (6.5); 105 Bz^+ (100).

N-Chloro-N-(4-nitrobenzoyloxy)benzamide **10b** was synthesized from *N*-(4-nitrobenzoyloxy)-benzamide **9b** by *t*-BuOCl chlorination using a similar method [9], colorless liquid. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 7.445 (2H, t, ^3J = 7.6 Hz, C(3)H, C(5)H Ph); 7.571 (1H, t, ^3J = 7.4 Hz, C(4)H Ph); 7.840 (2H, dd, ^3J = 8.4 Hz, , ^4J = 1.2 Hz, C(2)H, C(6)H Ph); 8.143 (2H, d, ^3J = 8.8 Hz, C(2)H, C(6)H $C_6H_4NO_2$); 8.302 (2H, d, ^3J = 8.8 Hz, C(3)H, C(5)H $C_6H_4NO_2$). ^{13}C NMR (100.6093 MHz, $CDCl_3$): δ = 124.08 $2C_{Ar}$(H); 128.85, $2C_{Ar}$(H); 129.58 $C(1)_q$ Ph; 129.65, $2C_{Ar}$(H); 131.41 $2C_{Ar}$(H); 131.84 $C(1)_q$ $C_6H_4NO_2$; 133.78 C(4)H Ph; 151.51 C(4)–NO_2 $C_6H_4NO_2$; 161.65 C=O(O); 173.56 C(=O)N(Cl).

N-Benzoyloxy-1-(dimethoxyphosphoryloxy)-benzimidate (**11a**). The solution of trimethyl phosphite (112 mg, 0.9036 mmol) in Et_2O (1 mL) was added to the solution of *N*-chloro-*N*-benzoyloxybenzamide**10a** (125 mg, 0.452 mmol) [9] in Et_2O (1 mL). The reaction mixture was maintained at 4°C for 2 h, at 14 °C for 16 h, then it was cooled (0 °C), the obtained precipitate was filtered off, washed by Et_2O (1 mL), dried under vacuum (2 mmHg), giving 13 mg (11.9 %) of *N*-benzoyloxybenzamide **9a**. The combined Et_2O-filtrate was evaporated under vacuum, the residue was heated at 78–80 °C under vacuum (2 mmHg) for 10 min, yielding 119 mg (75.4 %) of *N*-benzoyloxy-1-(dimethoxyphosphoryloxy)-benzimidate **11a**, colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.847 (6H, d, ^{HP}J = 11.6 Hz, $P(O)(OMe)_2$); 7.442–7.533 (5H, C(3,4,5,3',5')H Ph, Ph'CO_2); 7.602–7.651 (1H, m, C(4')H, Ph'CO_2); 7.996 (2H, dd, ^3J = 8.4 Hz, ^4J = 1.6 Hz, C(2)H, C(6)H Ph); 8.271 (2H, dd, ^3J = 8.4 Hz, ^4J = 1.2 Hz, C(2)H, C(6)H Ph'CO_2). ^{13}C NMR (100.6093 MHz, $CDCl_3$): δ = 55.69 d, ^{CP}J = 6.04 Hz, $P(O)(OMe)_2$); 127.90 $2C_{Ph}$(H); 128.72 $2C_{Ph}$(H); 128.83 $2C_{Ph'CO2}$(H); 130.25 $2C_{Ph'CO2}$(H); 132.37 C(4)H Ph; 132.80 $C(1)_q$ Ph; 133.78 C(4')H Ph'CO_2; 134.32 $C(1`)_q$ Ph'CO_2; 152.495 d, ^{CP}J = 9.05 Hz, C=N; 163.30 C=O(O). ^{31}P NMR (161.95 MHz, $CDCl_3$, ppm): –7.246. Mass spectrum (FAB), m/z(I_{rel},%):350 $[M+H]^+$ (16); 224 (20; 127(10); 109(10); 105(100).

Z-N-(4-nitrobenzoyloxy)-1-(dimethoxyphosphoryloxy)benzimidate (**11b**). The solution of trimethyl phosphite (97 mg, 0.783 mmol) in Et_2O (3 mL) was added to the solution of *N*-chloro-*N*-(4-nitrobenzoyloxy)benzamide **10b** (125 mg, 0.391 mmol) in Et_2O (5 mL) at 17 °C. The

reaction mixture was maintained at 17 °C for 70 h, then obtained precipitate was filtered off, washed by Et_2O (2 mL), dried under vacuum (2 mmHg), yielding 109 mg (70.6 %) of Z-*N*-4-nitrobenzoyloxy-1-(dimethoxyphosphoryloxy)-benzimidate **11b**, colorless crystals, mp. 141–143 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.870 (6H, ^{HP}J = 12.0 Hz, P(O)$(OMe)_2$); 7.490 (2H, t, ^3J = 7.6 Hz, C(3)H, C(5)H Ph); 7.579 (1H, t, ^3J = 7.4 Hz, C(4)H Ph); 7.971–8.017 (2H, m, C(2)H, C(6)H Ph); 8.363 (2H, d, ^3J = 8.8 Hz, C(2)H, C(6)H $C_6H_4NO_2$); 8.494 (2H, d, ^3J = 8.8 Hz, C(3)H, C(5)H $C_6H_4NO_2$). ^{1}H NMR (400 MHz, $(CD_3)_2SO$): δ = 3.847 (6H, ^{HP}J = 11.60 Hz, P(O)$(OMe)_2$); 7.615 (2H, t, ^3J = 7.4 Hz, C(3)H, C(5)H Ph); 7.70 (1H, t, ^3J = 7.4 Hz, C(4)H Ph); 7.917 (2H, dd, ^3J = 8.8 Hz, ^3J = 1.6 Hz, C(2)H, C(6)H Ph); 8.362 (2H, d, ^3J = 8.8 Hz, C(2)H, C(6)H $C_6H_4NO_2$); 8.465 (2H, d, ^3J = 8.8 Hz, C(3)H, C(5)H $C_6H_4NO_2$). ^{13}C NMR (100.6093 MHz, $CDCl_3$): δ = 55.79 d, ^{CP}J = 6.04 Hz, P(O)$(OMe)_2$); 123.86 $2C_{Ar}$(H); 127.94, $2C_{Ar}$(H); 128.97, $2C_{Ar}$(H); 129.07 C(1)$_q$ Ph; 131.50 $2C_{Ar}$(H); 132.74 C(4)H Ph; 133.88 C(1)$_q$ $C_6H_4NO_2$; 151.02 C(4)–NO_2 $C_6H_4NO_2$; 153.295 d, ^{CP}J = 9.05 Hz, C=N; 165.51 s C=O(O). ^{31}P NMR (161.95 MHz, $CDCl_3$, ppm): –7.281. Mass spectrum (FAB), *m/z*(I_{rel}, %): 353(6); 269(23); 187 (100); 127 (11). Found, %: C 48.59; H 3.91; N 7.02. $C_{16}H_{15}N_2O_8P$. Calculated, %: C 48.74; H 3.83; N 7.10.

The study of the Z-*N*-4-(nitrobenzoyloxy)-1-(dimethoxyphosphoryloxy)-benzimidate **(11b)** structure.

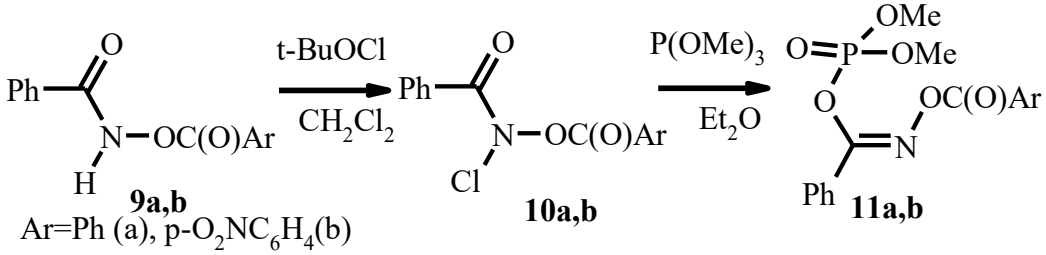
The colorless crystals of compound **11b** are triclinic,·$C_{16}H_{15}N_2O_8P$, at -100.5°C; ***a*** = 6.6011 (8), ***b*** = 10.7700 (12), ***c*** = 13.0496(15) Å, α = 102.004(7), β =98.528(7)°, γ = 104.122(7)°, V = 860.44(18) Å^3, M_r = 394.27, Z = 2, space group $P\bar{1}$, d_{calc}= 1.522 g/cm^3, μ(MoK_α) = 0.210 mm^{-1}, F(000) = 408. Intensities of 12255 reflections (3031 independed, R_{int}=0.0749) were measured on the «Bruker APEX-II CCD» diffractometer (graphite monochromated MoK_α radiation, CCD detector, ω-scaning, $2\theta_{max}$= 50°).

The structure was solved by direct method using SHELXTL package [10]. Positions of the hydrogen atoms were located from electron density difference maps and refined by "riding" model with U_{iso} = nU_{eq} (n= 1.5 for methyl groups and n=1.2 for other hydrogen atoms) of the carrier atom. Full-matrix least-squares refinement against F^2 in anisotropic approximation for non-hydrogen atoms using 3031 reflections was converged to wR_2 = 0.1218 (R_1 = 0.0506 for 2157 reflections with F>4σ(F), S = 1.017).

The atomic coordinates, molecular geometry parameters, and crystallographic data of compound **11b** are preserved at the Cambridge Crystallographic Data Center, 12 Union Road, CB2, 1EZ UK [fax:+44-1223-336033, e-mail: deposit@ccdc.cam.ac.ukand are available upon request with the CCDC N 2425292 (**11b**).

Discussion

N-Acyloxybenzamides **9a, b** undergo a reaction with *t*-BuOCl yielding *N*-acyloxy-*N*-chlorobenzamides**10a, b.** We have investigated the interaction between *N*-acyloxy-*N*-chlorobenzamides **10a,b** and trimethyl phosphite. *N*-Acyloxy-*N*-chlorobenzamides **10a, b** react with trimethyl phosphite in ether at room temperature giving *N*-acyloxy-1-(dimethoxyphosphoryloxy)-benzimidates **11a,b** with good yields as illustrated in Scheme 3.



Scheme 3. **The synthesis of *N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates 11a,b**

In the case of *N*-benzoyloxy-*N*-chlorobenzamide **10a** the small amounts of *N*-benzoyloxybenzamide **9a** were obtained as a by-product.

Consequently, this reaction may be regarded as a new original approach for the synthesis of *N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates **11a, b**.

The structural configuration of *N*-acyloxy-*N*-phosphorylureas **11a**, **b** has been elucidated through the analysis of ^{1}H, ^{13}C, ^{13}P NMR spectra, and mass spectra. Furthermore, the structural integrity of compound **11b** has been confirmed by the X-ray diffraction (XRD) study (Figures 1).

The ^{1}H NMR spectra of compounds **11a**, **b** show such a common characteristic as doublet of dimethoxyphosphoryl moiety (3.847–3.870 ppm).

In the ^{31}P NMR spectra of compounds **11a**, **b**

the chemical shifts of the phosphorus atom lie in the range –7.246–(–7.281) ppm.

The ^{13}C NMR spectra of compounds **11a**, **b** demonstrate two common characteristics. They include the chemical shifts of the carbon atoms of dimethoxyphosphoryl group (doublet at 55.69–55.79 ppm) and the carbon atom of C=N bond (doublet at 152.5–153.3 ppm).

The structure of *N*-(4-nitrobenzoyloxy)-1-(dimethoxyphosphoryl)-benzimidate **11b** is represented on Figure 1.

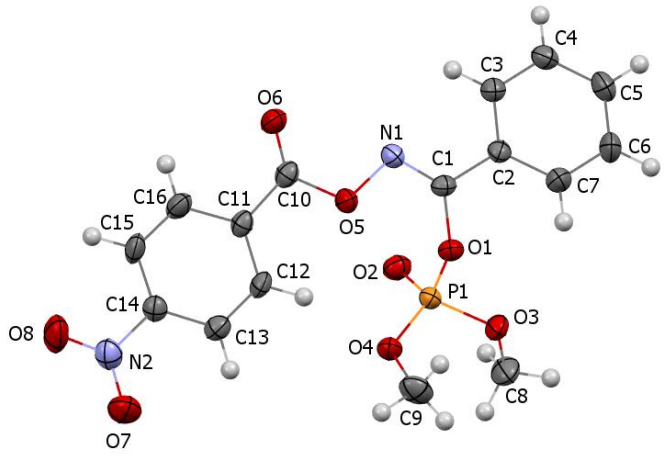


Fig. 1. Molecular structure of *Z*-*N*-(4-nitrobenzoyloxy)-1-(dimethoxyphosphoryloxy)-4-nitrobenzimidate (11b) according to X-ray diffraction data. The thermal ellipsoids are shown with a probability of 50 %

The 4-nitrobenzoyloxy moiety and the phenyl group are *trans*-orientated to the N(1)=C(1) double bond (the torsion angle O(5)–N(1)–C(1)–C(2) is 178.8(2)°). The phenyl group is slightly rotated towards the N(1)=C(1) double bond (the N(1)–C(1)–C(2)–C(3) torsion angle is -15.4(4)°).

The dimethoxyphosphoryloxy moiety and the O(5)–N(1) bond are *cis*-orientated to the N(1)=C(1) double bond (the O(5)–N(1)–C(1)–O(1) torsion angleis –2.2(3)°).

In the molecule of compound **11b** the ester moiety and the N(1)=C(1) double bond are coplanar (the C(10)–O(5)–N(1)–C(1) torsion angle is –170.0(2)°, the N(1)–O(5)–C(10)–O(6) torsion angle is 3.0(4)°).

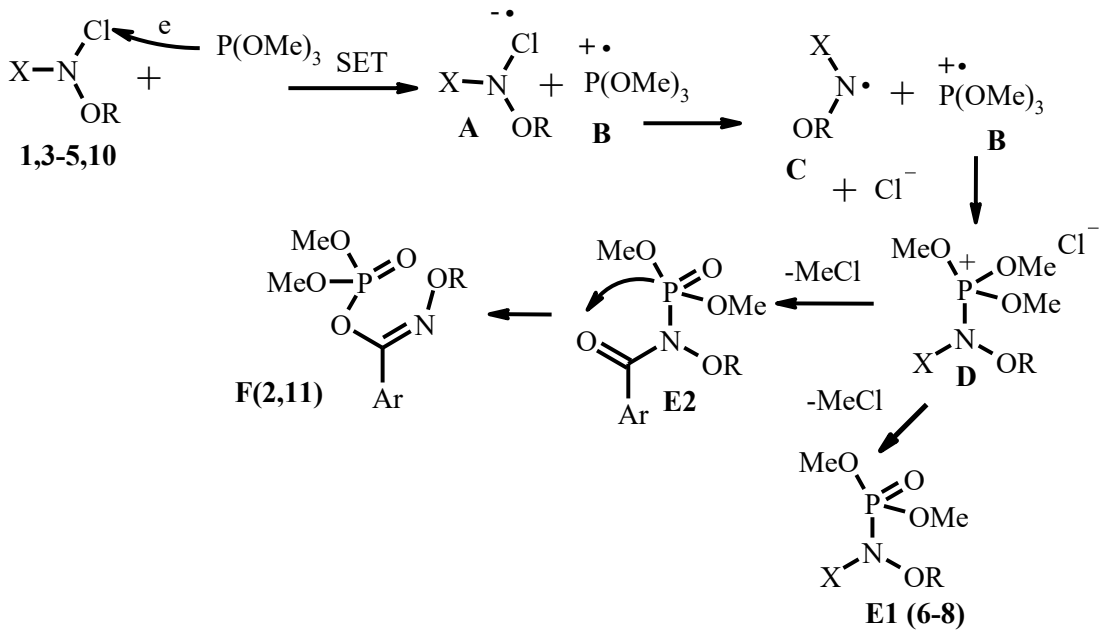
The *para*-nitrophenyl substituent and the ester group are coplanar (the C(16)–C(11)–C(10)–O(6) torsion angle is 0.3(4)°). The nitro group is some rotated towards the benzene ring (the C(13)–C(14)–N(2)–O(7) torsion angle is –10.0(4)°).

The dimethoxyphosphoryl moiety is orthogonal to the N(1)=C(1) double bond (the N(1)–C(1)–O(1)–P(1) torsion angle is 87.1(3)°). The P(1)=O(2) bond is syn-peryplanar with the C(1)–O(1) bond (the C(1)–O(1)–P(1)–O(2) torsion angle is -7.8(2)°).

The $C(9)H_3$ methyl group is located in *–sc*-position in relation to the C(1)–P(1) bond (the O(1)–P(1)–O(4)–C(9) torsion angle is –63.1(2)°). The $C(8)H_3$ methyl group is located in *ap*-position in relation to the C(1)–P(1) bond (the O(1)–P(1)–O(3)–C(8) torsion angle –174.1(2)°).

It is plausible that the mechanism underlying the formation of *N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates **11** is analogous to the mechanism responsible for the formation of Z-*N*-alkoxy-1-(dimethoxyphosphoryloxy)benzimidates **2** [3].

The possible mechanism of these both reactions gives rise to various hypotheses and induces some speculations. The nucleophilic substitution didn't occur at the nitrogen atom at the *N*-benzoyloxy-*N*-chlorobenzamide **10a** interaction with AcONa [9]. *N*-Alkoxy-*N*-chloro-R-sulfonamides **5** [11] and *N*-acyloxy-*N*-chlorobenzamides [12] are known as the electrophilic chlorinating agents. In these compounds the N–Cl bond polarization is unfavorable for nucleophilic substitution at the nitrogen atom [13–20]. Diethyl ether, being a non-polar solvent, is unfavorable for nucleophilic substitution reactions via S_N2 or S_N1 mechanisms. It is likely that the interaction of *N*-alkoxy-*N*-chloroamides **1**,**3**,**4**,**5** and *N*-acyloxy-*N*-chlorobenzamides **10** with trialkyl phosphites occurs via the intermediate formation of radical anions and radical cations through single electron transfer (SET) (Scheme 4).



Scheme 4. The possible mechanism of *N*-alkoxy-*N*-chloroamides 1,3,4,5 and *N*-acyloxy-*N*-chlorobenzamides 10 interaction with trialkyl phosphites. R=Alk, X=ArC(O) (1,2), $H_2NC(O)$ (3,6), ArHNC(O) (4,7), $R'SO_2$ (5,8); R=C(O)Ar, X=ArC(O) (10,11)

At the first stage, single-electron transfer (SET) occurs from triakyl phosphite (the trimethyl phosphite is shown in Scheme 4) to *N*-alkoxy-*N*-chloroamide **1**,**3**–**5**,**10** resulting in the generation of the radical anion of *N*-alkoxy-*N*-chloroamide**A** and the radical cation of trialkyl phosphite **B**. In non-polar diethyl ether, these radical ions should form a close ion pair. The radical anion **A** is unstable and decomposes into stable chloride anion and *N*-alkoxyamidyl radical **C**. *N*-Alkoxyamidyl radical **C** combines with radical cation **B** yielding the phosphonium cation **D**. Dealkylation of cation **D** by chloride anion leads to the formation of the product **E1** (these are compounds **6**–**8**) or the intermediate **E2**. However, the greater degree of polarization of the C=O double bond in the amide group compared to urea should influence the course of this nitrogen-to-oxygen migration of dimethoxyphosphoryl group in the intermediate **E2**, yielding product **F** (compounds **2**, **11**). The underlying driving force here is the formation of a very strong P–O bond (E_{P-O} is 84 kcal/mol) instead of weaker P–N bond (E_{P-O} is 50 kcal/mol).

The proposed mechanism appears plausible and warrants further investigation.

Conclusions

We have studied interaction between *N*-acyloxy-*N*-chlorobenzamides and trialkyl phosphites, along with the characterization of the resulting product's structures. Our research demonstrates that the reaction between *N*-acyloxy-*N*-chlorobenzamides and trialkyl phosphites offers a new approach to synthesize Z-*N*-acyloxy-1-(dialkoxyphosphoryloxy)-benzimidates. This discovery unveils a significant chemical transformation of *N*-acyloxy-*N*-chlorobenzamides. The new chemical properties of *N*-acyloxy-*N*-chlorobenzamides have been established. The structure of Z-*N*-acyloxy-1-(dimethoxyphosphoryloxy)benzimidates **11a, b** was confirmed by ^{1}H, ^{13}C, ^{31}P NMR spectra, mass spectra, and by XRD study.

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