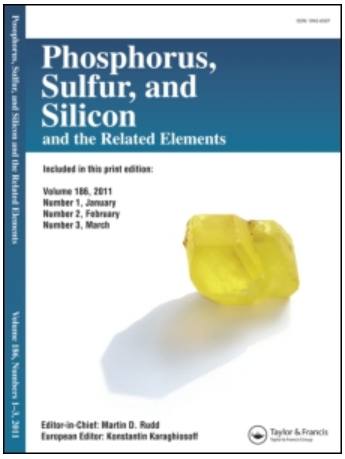


Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

Synthesis of Some New 1,3,2-Oxazaphosphinine, 1,3,2-Diazaphosphinine, Acyclic, and/or Cyclic α-Aminophosphonate Derivatives Containing the Chromone Moiety

Tarik E. Ali[a]
[a] Department of Chemistry, Faculty of Education, Ain Shams University, Roxy, Cairo, Egypt

Online publication date: 28 December 2009

To cite this Article Ali, Tarik E.(2010) 'Synthesis of Some New 1,3,2-Oxazaphosphinine, 1,3,2-Diazaphosphinine, Acyclic, and/or Cyclic α-Aminophosphonate Derivatives Containing the Chromone Moiety', Phosphorus, Sulfur, and Silicon and the Related Elements, 185: 1, 88 — 96
To link to this Article: DOI: 10.1080/10426500802713309
URL: http://dx.doi.org/10.1080/10426500802713309

Phosphorus, Sulfur, and Silicon, 185:88–96, 2010

ISSN: 1042-6507 print / 1563-5325 online
DOI: 10.1080/10426500802713309

Taylor & Francis
Taylor & Francis Group

SYNTHESIS OF SOME NEW 1,3,2-OXAZAPHOSPHININE, 1,3,2-DIAZAPHOSPHININE, ACYCLIC, AND/OR CYCLIC α-AMINOPHOSPHONATE DERIVATIVES CONTAINING THE CHROMONE MOIETY

Tarik E. Ali
Department of Chemistry, Faculty of Education, Ain Shams University, Roxy, Cairo, Egypt

The synthesis of some new 1,3,2-oxazaphosphinine 18, 1,3,2-diazaphosphinine 19, acyclic, and cyclic α-aminophosphonate derivatives 3–17 containing the chromone moiety have been achieved via reaction of 3-(phenyliminomethyl)chromone (1), 3-(phenylaminomethylene)-2-hydroxychromanone (4), and/or 3-(phenylamino-methylene)-2-(phenylamino)chromanone (5) with diethyl phosphite, tris(2-chloroethyl)phosphite, and phenylphosphonic dichloride. Structures of the products were verified on the basis of their elemental analyses, IR, ^{1}H, and ^{31}P NMR spectral data.

Keywords α-Aminophosphonate; chromone; 1,3,2-diazaphosphinine; 1,3,2-oxazaphosphinine; synthesis

INTRODUCTION

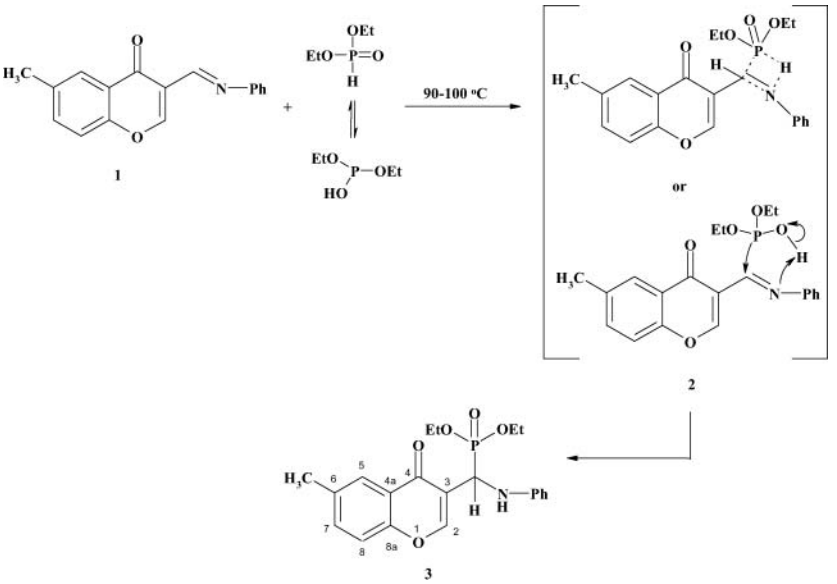
Chromones are well known natural and synthetic products that possess diverse biological activities, namely anticancer,[1–3] neuroprotective,[4] HIV-inhibitory,[5] antimicrobial,[6–10] and antioxidant activity.[11] Due to their abundance in plants and their low mammalian toxicity, chromone derivatives are present in large amounts in the diets of humans.[12] On the other hand, the addition of compounds with phosphorus–hydrogen bonds to C=C or C=N bonds provides an economic method for the synthesis of organophosphorus derivatives. Among phosphorus compounds, α-aminophosphonic acids and their derivatives have received considerable attention in recent years because they exhibit intriguing biological activities.[13] Being considered as α-amino acid analogues,[14] they have found widespread use as biologically attractive materials particularly in connection with the design of enzyme inhibitors[15,16] and as catalytic antibodies.[17] In addition, they have been used as antibacterial[18] and anti-HIV agents.[19]

Received 27 August 2008; accepted 26 December 2008.
The author is grateful to Prof. Kolio D. Troev and Dr. I. Krachieva, from Institute of Polymers, Bulgarian Academy of Science, Sofia, Bulgaria, for providing laboratory facilities. The financial support of this research through the grant of The Egyptian Ministry of Higher Education and Scientific Research (ParOwn Grant) is gratefully acknowledged as well.
Address correspondence to Tarik E. Ali, Department of Chemistry, Faculty of Education, Ain Shams University, Roxy 11711, Cairo, Egypt. E-mail: tarik_elsayed1975@yahoo.com

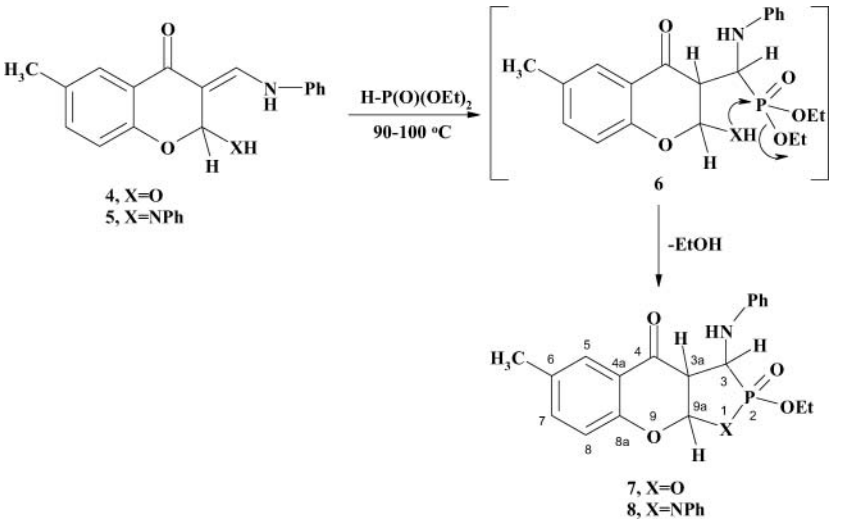
It is known that the reaction of 3-formylchromone with aniline derivatives in benzene yielded three different types of condensation products, namely 3-(phenyliminomethyl)chromone (**1**), 3-(phenylaminomethylene)-2-hydroxychromanone (**4**), and 3-(phenylaminomethylene)-2-(phenylamino)chromanone (**5**), depending on the ratio of reactants and conditions.[20] Chromone derivatives of α-aminophosphonates have been rarely reported in the literature,[21–24] and these products were obtained by addition reaction of dialkyl or trialkyl phosphites to 3-(aryliminomethyl)chromone (**1**) only. Thus, we focused our attention on reactions of diethyl phosphite, tris(2-choloroethyl)phosphite, and phenylphosphonic dichloride with different condensation products of 6-methyl-3-formylchromone with aniline.

RESULTS AND DISCUSSION

6-Methyl-3-[(phenylimino)methyl]-4*H*-chromen-4-one (**1**) reacted with diethyl phosphite at 90−100°C without solvent to furnish diethyl[(phenylamino)(6-methyl-4-oxo-4*H*-chromen-3-yl)methyl]phosphonate (**3**) as a pale red crystalline material. Due to the phosphonate ↔ phosphite tautomerism in diethyl phosphite, the addition to imine **1** occurred by either a four- or five-membered transition state **2** (Kabachink–Fields reaction) (Scheme 1).[25] Elemental analysis of compound **3** confirmed the molecular formula $C_{21}H_{24}NO_5P$, and the IR spectrum revealed the presence of strong absorption bands at 3385, 1642, 1230, and 1046 cm^{-1}, which are due to NH, C=O, P=O, and P−O−Et, respectively. Moreover, its ^1H NMR spectrum showed signals for OCH_2CH_3 groups attached to phosphorus as a triplet at δ 1.07 (J = 6.8 Hz) and a broad signal at δ 3.92 ppm. The NH proton gave a broad signal at δ 3.05 ppm, and the exocyclic methane proton appeared as a broad signal at δ 5.45 ppm. Furthermore, the ^{31}P NMR spectrum recorded a singlet at δ 22.45 ppm.



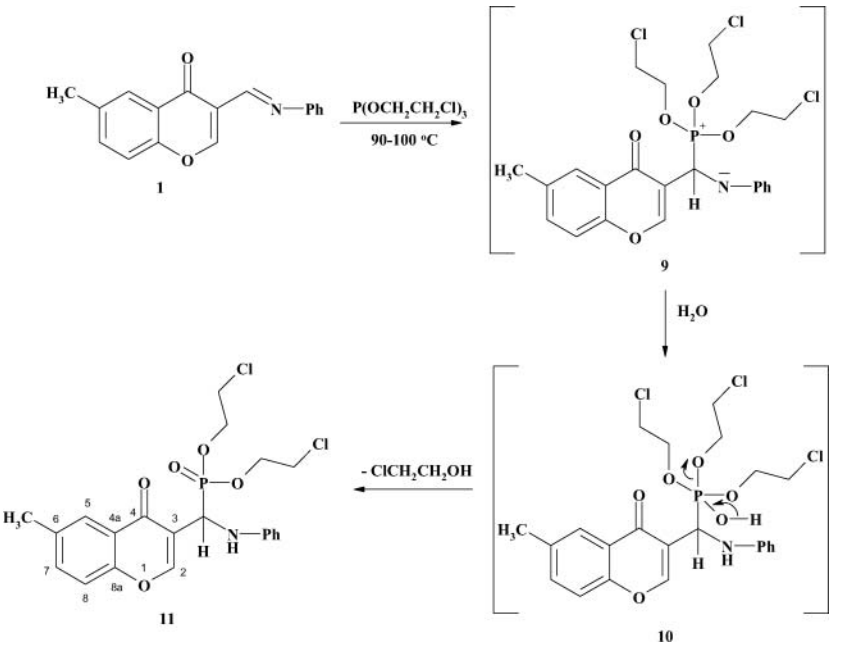
Scheme 1



Scheme 2

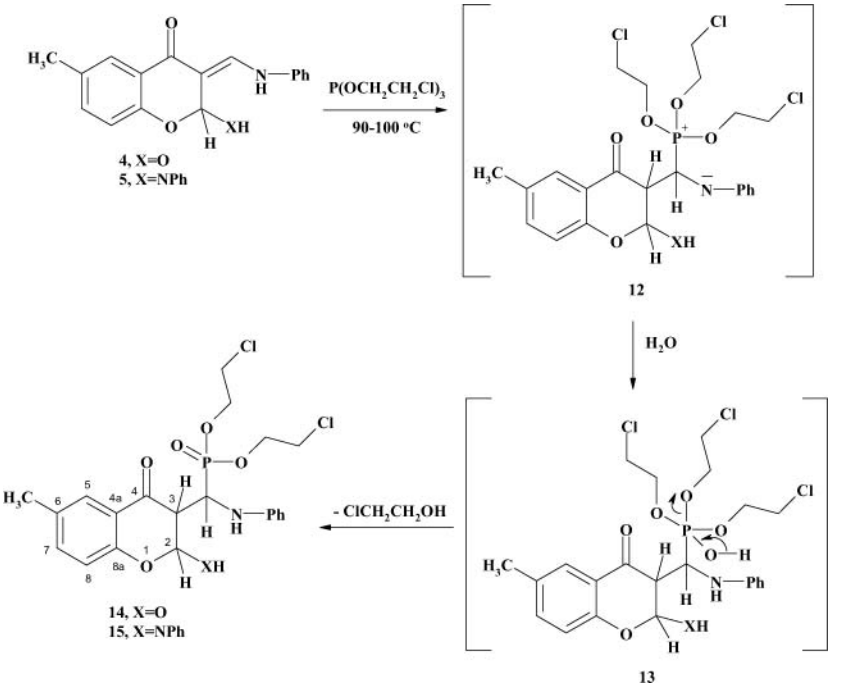
Similarly, the reaction of 3-(phenylaminomethylene)-2-hydroxy/*N*-phenylamino-6-methyl-2,3-dihydro-4*H*-chromen-4-ones (**4**) and/or (**5**) with diethyl phosphite at 90−100°C afforded 2-ethoxy-6-methyl-2-oxo-3-phenylamino-2,3,3a,9a-tetrahydro-4*H*-1,2-oxaphospholo[5,4-*b*]chromen-4-one (**7**) and 2-ethoxy-6-methyl-2-oxo-1-phenyl-3-phenylamino-2,3,3a,9a-tetrahydro-4*H*-1,2-azaphospholo[5,4-*b*]chromen-4-one (**8**), respectively, as cyclic α-aminophosphonate derivatives. Formation of compounds **7** and **8** may be interpreted as resulting from a nucleophilic attack of the phosphorus atom at the α,β-unsaturated ketone moiety of **4** and/or **5** (Pudovik reaction) to give the nonisolable intermediate **6**. The latter intermediate underwent cyclization via elimination of one molecule of ethanol to give the final products **7** and **8**, respectively (Scheme 2). IR spectra of compounds **7** and **8** showed three absorptions bands for NH, C=O, and P=O functions at regions 3296−3290, 1644−1646, and 1223−1232 cm^{-1}, respectively. Both compounds showed ^{31}P NMR chemical shifts around δ 19.05 and 18.23 ppm, respectively. The ^{1}H NMR spectrum of **7** showed a doublet signal due to the CH−P proton at δ 5.33 ppm (J = 23.4 Hz) while that at δ 5.41 ppm (J = 23.8 Hz) was noted for **8**. The broad signals of NH protons of both compounds appeared at δ 3.03 and δ 3.02 ppm, respectively. The H−3 and H−2 protons of chromanone moiety of **7** appeared at δ 6.28 and δ 8.51 ppm, respectively, while in compound **8**, they appeared at δ 6.25 and δ 8.11 ppm, respectively. The remaining aromatic protons of **7** and **8** appeared as multiplets in the range δ 6.60−8.04 ppm, beside the presence of ethoxy protons as triplets at δ 1.10, 1.15 ppm (J = 7.4/6.4 Hz) and quartets at δ 4.01, 4.04 ppm (J = 8.2/7.2 Hz), respectively.

Reaction of compounds **1**, **4**, and/or **5** with tris(2-chloroethyl)phosphite in the presence of a certain amounts of distillated water, which accelerate the reactions, produced the corresponding α-aminophosphonate derivatives **11**, **14**, and **15**, respectively.[22] A possible mechanism for these reactions could involve a nucleophilic phosphorus attack on the electrophilic carbons of compounds **1**, **4**, and/or **5** to give the intermediate dipolar species of type **9** and/or **12**, respectively, which could be solvated by water present in the reaction media to give transients such as **10** and/or **13**, respectively. The latter transients decompose via removal of a 2-chloroethanol molecule to afford the final products **11**, **14**, and **15**, respectively (Schemes 3 and 4).



1 9 10 11

Scheme 3



4, X=O
5, X=NPh

12 13

14, X=O
15, X=NPh

Scheme 4

The structure of **11** was established on the basis of elemental analysis and spectral data. Its IR spectrum showed absorption bands at 3396, 1620, and 1212 cm^{-1} due to NH, C=O, and P=O functions, respectively. In addition, the ^{31}P NMR spectrum displayed a singlet at δ 24.06 ppm, while the ^{1}H NMR spectrum revealed two broad signals at δ 3.25 and δ 5.40 ppm corresponding to NH and CH−P, respectively. In addition, the aromatic protons were recorded at δ 7.02−7.97 ppm with multiplets at δ 3.42−4.03 ppm, which were due to 2-chloroethoxy protons.

In a similar way, the structures **14** and **15** were deduced. Their ^{1}H NMR spectra showed signals for CH−P protons at δ 5.42 and δ 5.72 ppm, respectively, coupled with the phosphorus atom ($J = 22.8$ Hz), while signals for C_3−H protons appeared at δ 6.40 and δ 6.13 ppm, respectively. The eight protons of 2-chloroethoxy moieties in both compounds **14** and **15** gave multiplets signals at δ 3.62−4.22 ppm. However, weak signals for OH and/or NH at C−2 of the chromanone moieties appeared at δ 4.5 and/or δ 3.29 ppm, respectively. In addition, protons of C_2−H appeared at δ 8.18 and δ 8.20 ppm for **14** and **15**, respectively. The ^{31}P NMR spectra of **14** and **15** recorded positive signals at δ 20.37 and 20.56 ppm, respectively. Furthermore, their IR spectra showed presence of OH, NH groups, C=O, and P=O functions at regions 3387−3260, 1639−1640, and 1209−1205 cm^{-1}, respectively.

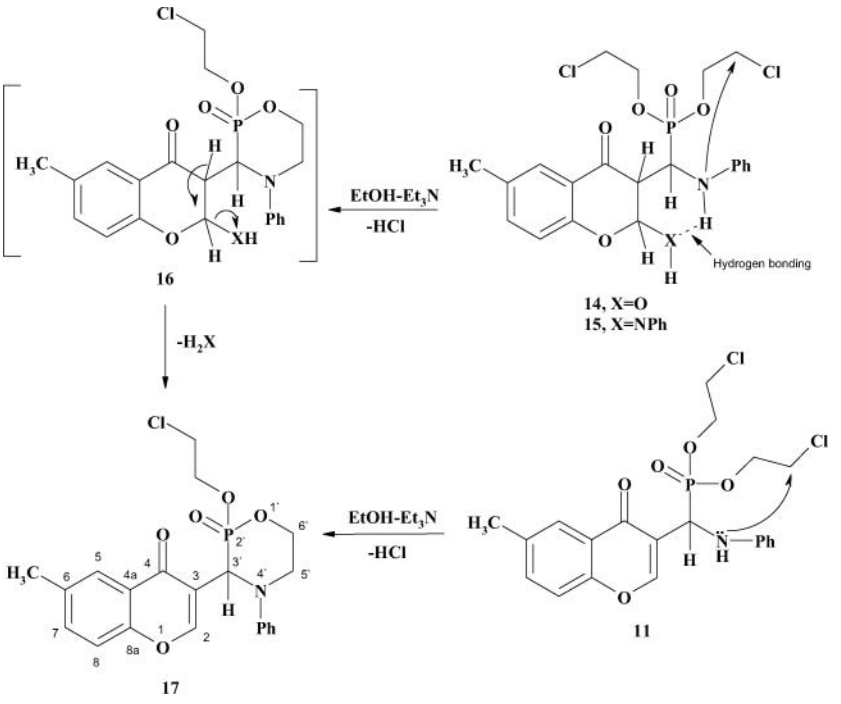
Compounds **11**, **14**, and/or **15** were heated in absolute ethanol containing a catalytic amount of triethylamine. This reaction afforded 3-[2-(2-chloroethoxy)-2-oxo-4-phenyl-1,4,2-oxazaphosphinan-3-yl]-6-methyl-4-oxo-4*H*-chromen-4-one (**17**) (IR, mp, and mixed mp gave no depression). Formation of compound **17** is assumed to take place via loss of one HCl molecule from **11**, **14**, and **15**, followed by elimination of both water and/or aniline in the case of **14** and **15**, respectively. Hydrogen bonding between XH and NH groups gives stability to systems **14** and **15**, but destruction of this hydrogen bond, after removing the HCl molecule, may facilitate elimination of water and/or aniline (Scheme 5).

Structure **17** was confirmed on the basis of its correct elemental analysis and spectral data. Its IR spectrum was void of OH, NH groups but showed the presence of C=O and C=C at 1639 and 1614 cm^{-1}, respectively. The ^{1}H NMR spectrum had a signal at δ 5.04 ppm, which is assigned to the CH−P proton, in addition to multiplets at δ 3.24−3.28 and δ 3.62−3.75 ppm, corresponding to 2-chloroethoxy and OCH_2CH_2N moieties, respectively. Moreover, the ^{31}P NMR spectrum was characterized by a signal at δ 13.72 ppm.

1,3,2-Oxazaphosphinane and 1,3,2-diazaphosphinane derivatives have attracted great interest due to their valuable pharmacological effects and potential for synthetic applications.[26] Thus, cyclization of compounds **4** and/or **5** with phenylphosphonic dichloride was performed in dry benzene containing few drops of triethylamine to produce 2,3-diphenyl-7-methyl-2-oxo-3,10a-dihydro-2*H*,5*H*-chromeno[3,2-*e*][1,3,2]oxazaphosphinin-5-one (**18**) and 7-methyl-2-oxo-1,2,3,-triphenyl-10a-tetrahydro-5*H*-chromeno[2,3-*d*][1,3,2]diazaphosphinin-5-one (**19**), respectively, in good yields (Scheme 6). The IR spectra showed the absence of OH and NH groups and the presence of strong bands at 1641−1650 and 1620−1605 cm^{-1} corresponding to C=O and C=C, respectively. Also, the ^{1}H NMR spectra of **18** and **19** revealed multiplets signals at δ 7.01−7.95 and δ 7.28−7.60 ppm, respectively, which are due to aromatic protons. The ^{31}P NMR spectra recorded signals at δ 20.75 and δ 20.05 ppm for both compounds, respectively.[27]

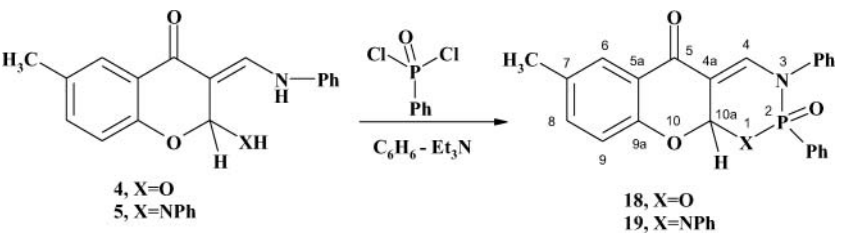
EXPERIMENTAL

Melting points of the products were determined on a Kofler microscope and were uncorrected. The IR spectra were recorded on a Bruker IFS 1113 spectrophotometer or



Scheme 5

Elmer 293 spectrophotometer (cm^{-1}) using KBr disks. ^1H NMR spectra were recorded on Gemini-200 spectrometer (200 MHz), using DMSO-d_6 as a solvent and TMS (δ, 0.0 ppm) as the internal standard. ^{31}P NMR spectra were registered on a Varian Inova 500 MHz spectrometer at room temperature using DMSO-d_6 as a solvent and TMS as internal standard and 85% H_3PO_4 as external reference, respectively. The purity of the synthesized compounds was checked by thin layer chromatography (TLC), which was performed on Kieselgel 60 F254 plastics sheets (Merck Sigma Chemical Co., Germany). Elemental microanalyses were performed at the microanalysis center at the Bulgarian Academy of Science, Sofia, Bulgaria. 3-(Phenyliminomethyl)chromone (**1**), 3-(phenylaminomethylene)-2-hydroxychromanone (**4**), and 3-(phenylaminomethylene)-2-(*N*-phenylamino)chromanone (**5**) were prepared according to the reported methods.[20]



Scheme 6

Reaction of Compounds 1, 4, and/or 5 with Diethyl Phosphite: Formation of 3, 7, and 8: General Procedure

A mixture of compounds **1**, **4**, and/or **5** (0.005 mol) and diethyl phosphite (0.008 mol, 1.03 mL), was heated on water bath at 90−100°C for 10 h. Excess diethyl phosphite was removed under vacuum. The residues were treated with petroleum ether. The solids obtained were filtered off and crystallized from benzene to give the corresponding products **3**, **7**, and **8**, respectively.

Diethyl[(phenylamino)(6-methyl-4-oxo-4*H*-chromen-3-yl)methyl]phosphonate (3). Pale red crystals, yield 66%; mp 100−102°C. IR (KBr), ν (cm^{-1}): 3385 (NH), 3029 (C−H_{arom}), 2977, 2921, 2862 (C−H_{aliph}), 1642 (C=O_{pyrone}), 1615 (C=C), 1230 (P=O), 1046 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 1.07 (t, 6H, J = 6.8 Hz, CH_3CH_2O), 2.36 (s, 3H, CH_3), 3.05 (br, 1H, NH), 3.92 (br, 4H, CH_3CH_2O), 5.45 (br, 1H, CH−P), 6.90−7.80 (m, 8H, Ph−H, H−8, H−7 and H−5), 8.15 (br, 1H, H−2). ^{31}P NMR (DMSO-d_6) δ: 22.45 ppm. Anal. Calcd for $C_{21}H_{24}NO_5P$ (401.39): C, 62.84; H, 6.03; N, 3.49; Found: C, 62.59; H, 5.81; N, 3.22.

2-Ethoxy-6-methyl-2-oxo-3-phenylamino-2,3,3a,9a-tetrahydro-4*H*-1,2-oxaphospholo[5,4-*b*]chromen-4-one (7). Yellow crystals, yield 44%; mp 142−142°C. IR (KBr), ν (cm^{-1}): 3296 (NH), 3034 (C−H_{arom}), 2981, 2924, 2854 (C−H_{aliph}), 1644 (C=O_{pyrone}), 1601 (C=C), 1223 (P=O), 1023 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 1.10 (t, 3H, J = 7.4 Hz, CH_3CH_2O), 2.38 (s, 3H, CH_3), 3.03 (br, 1H, NH), 4.01 (q, 2H, J = 8.2 Hz, CH_3CH_2O), 5.33 (d, 1H, J = 23.4 Hz, CH−P), 6.28 (t, 1H, J = 4.6 Hz, H−$3_{chromanone}$), 6.60−7.77 (m, 7H, Ph−H, H−8 and H−7), 7.91 (s, 1H, H−5), 8.51 (d, 1H, J = 3.4 Hz, H−$2_{chromanone}$). ^{31}P NMR (DMSO-d_6) δ: 19.05 ppm. Anal. Calcd for $C_{19}H_{20}NO_5P$ (373.33): C, 61.12; H, 5.40; N, 3.75; Found: C, 60.83; H, 5.21; N, 3.58.

2-Ethoxy-6-methyl-2-oxo-1-phenyl-3-phenylamino-2,3,3a,9a-tetrahydro-4*H*-1,2-azaphospholo[5,4-*b*]chromen-4-one (8). Yellow crystals, yield 51%; mp 128−130°C. IR (KBr), ν (cm^{-1}): 3290 (NH), 3051 (C−H_{arom}), 2982, 2907 (C−H_{aliph}), 1646 (C=O_{pyrone}), 1600 (C=C), 1232 (P=O), 1028 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 1.15 (t, 3H, J = 6.4 Hz, CH_3CH_2O), 2.32 (s, 3H, CH_3), 3.02 (br, 1H, NH), 4.04 (q, 2H, J = 7.2 Hz, CH_3CH_2O), 5.41 (d, 1H, J = 23.8 Hz, CH−P), 6.25 (br, 1H, H−$3_{chromanone}$), 6.63−7.74 (m, 12H, Ph−H, H−8 and H−7), 8.04 (s, 1H, H−5), 8.11 (d, 1H, J = 3.4 Hz, H−$2_{chromanone}$). ^{31}P NMR (DMSO-d_6) δ: 18.23 ppm. Anal. Calcd for $C_{25}H_{25}N_2O_4P$ (448.45): C, 66.96; H, 5.62; N, 6.25; Found: C, 66.59; H, 5.48; N, 5.97.

Reaction of Compounds 1, 4, and/or 5 with Tris(2-chloroethyl) Phosphite: Formation of 11, 14, and 15: General Procedure

A mixture of **1**, **4**, and/or **5** (0.005 mol) and tris(2-chloroethyl) phosphite (0.008 mol, 1.62 mL) in the presence of distillated water (0.005 mol, 0.09 mL) was heated on a water bath at 90−100°C for 10 h. Excess tris(2-chloroethyl) phosphite was removed under vacuum. The solids obtained were crystallized from methanol to give the corresponding products **11**, **14**, and **15**, respectively.

Bis(2-chloroethyl)[(phenylamino)(6-methyl-4-oxo-4*H*-chromen-3-yl)methyl]phosphonate (11). Pale brown crystals, yield 71%; mp 113−115°C. IR (KBr), ν (cm^{-1}): 3396 (NH), 3059 (C−H_{arom}), 2923, (C−H_{aliph}), 1620 (C=O_{pyrone}), 1212 (P=O), 1036 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.37 (s, 3H, CH_3), 3.25 (br, 1H, NH), 3.42–4.03 (m, 8H, CH_2CH_2), 5.40 (br, 1H, CH−P), 7.02−7.81 (m, 7H, Ph−H, H−8 and H−7), 7.97

(s, 1H, H−5), 8.76 (br, 1H, H−2). ^{31}P NMR (DMSO-d_6) δ: 24.06 ppm. Anal. Calcd for $C_{21}H_{22}Cl_2NO_5P$ (470.28): C, 53.63; H, 4.72; N, 2.98; Found: C, 53.28; H, 4.53; N, 2.68.

Bis(2-chloroethyl)[(2-hydroxy-6-methyl-4-oxo-3,4-dihydro-2*H*-chromen-3-yl)(phenyl-amino)methyl]phosphonate (14). Brown crystals, yield 69%; mp 142−144°C. IR (KBr), ν (cm^{-1}): 3375 (OH), 3260 (NH), 3050 (C−H$_{arom}$), 2923, (C−H$_{aliph}$), 1639 (C=O$_{pyrone}$), 1621 (C=C), 1209 (P=O), 1078 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.38 (s, 3H, CH_3), 3.09 (br, 1H, NH), 3.62–4.00 (m, 8H, CH_2CH_2), 4.5 (br, 1H, OH), 5.42 (br, 1H, CH−P), 6.40 (br, 1H, H−3), 7.04−7.80 (m, 7H, Ph−H, H−8 and H−7), 7.96 (s, 1H, H−5), 8.18 (br, 1H, H−2). ^{31}P NMR (DMSO-d_6) δ: 20.37 ppm. Anal. Calcd for $C_{21}H_{24}Cl_2NO_6P$ (488.29): C, 51.65; H, 4.95; N, 2.87; Found: C, 51.31; H, 4.69; N, 2.59.

Bis(2-chloroethyl)[(2-phenylamino-6-methyl-4-oxo-3,4-dihydro-2*H*-chromen-3-yl)(phenylamino)methyl]phosphonate (15). Brown crystals, yield 56%; mp 132−135°C. IR (KBr), ν (cm^{-1}): 3387 (NH), 3050 (C−H$_{arom}$), 2925, (C−H$_{aliph}$), 1640 (C=O$_{pyrone}$), 1619 (C=C), 1205 (P=O), 1071 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.29 (s, 3H, CH_3), 3.07 (br, 1H, NH), 3.29 (br, 1H, NH), 3.62−4.22 (m, 8H, CH_2CH_2), 5.72 (d, 1H, J = 22.8 Hz, CH−P), 6.13 (t, 1H, H-3), 6.84−8.20 (m, 14H, Ph−H, H−8, H−7, H−5 and H−2). ^{31}P NMR (DMSO-d_6) δ: 20.56 ppm. Anal. Calcd for $C_{27}H_{29}Cl_2N_2O_5P$ (563.40): C, 57.56; H, 5.19; N, 4.97; Found: C, 57.23; H, 4.88; N, 4.69.

3-[2-(2-Chloroethoxy)-2-oxo-4-phenyl-1,4,2-oxazaphosphinan-3-yl]-6-methyl-4*H*-chromen-4-one (17). A solution of **11**, **14**, and/or **15** (0.5 g) in absolute ethanol (10 mL) containing a few drops of triethylamine was heated under reflux for 6 h. The solids obtained after cooling were filtered off and crystallized from ethanol to give brown crystals, in yields 62–64%; mp 282−285°C. IR (KBr), ν (cm^{-1}): 3030 (C−H$_{arom}$), 2925, (C−H$_{aliph}$), 1639 (C=O$_{pyrone}$), 1614 (C=C), 1228 (P=O), 1061 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.41 (s, 3H, CH_3), 3.24−3.28 (m, 4H, CH_2CH_2), 3.62−3.75 (m, 4H, CH_2CH_2), 5.04 (br, 1H, CH−P), 7.03−7.81 (m, 8H, Ph−H, H−8, H−7 and H−5), 8.76 (br, 1H, H−2). ^{31}P NMR (DMSO-d_6) δ: 13.72 ppm. Anal. Calcd for $C_{21}H_{21}ClNO_5P$ (433.82): C, 58.14; H, 4.88; N, 3.23; Found: C, 57.82; H, 4.51; N, 2.89.

Reaction of Compounds 4 and/or 5 with Phenylphosphonic Dichloride: Formation of 18 and 19: General Procedure

A mixture of **4** and/or **5** (0.005 mol) and phenylphosphonic dichloride (0.005 mol, 0.72 mL) in dry benzene (20 mL) containing a few drops of triethylamine was heated under reflux for 4 h. The solids obtained were filtered off and crystallized from ethanol to give the corresponding products **18** and **19**, respectively.

2,3-Diphenyl-7-methyl-2-oxo-3,10a-dihydro-2*H*,5*H*-chromeno[3,2-*e*][1,3,2]oxazaphosphinin-5-one (18). Yellow crystals, yield 57%; mp 166−167°C. IR (KBr), ν (cm^{-1}): 3045 (C−H$_{arom}$), 2936, (C−H$_{aliph}$), 1641 (C=O$_{pyrone}$), 1620 (C=C), 1204 (P=O), 1033 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.50 (s, 3H, CH_3), 7.01−7.95 (m, 13H, aromatic protons), 8.13−8.17 (m, 2H, C_4−H$_{oxazaphosphinine}$ and C_2−H$_{chromone}$). ^{31}P NMR (DMSO-d_6) δ: 20.75 ppm. Anal. Calcd for $C_{23}H_{18}NO_4P$ (403.36): C, 68.49; H, 4.50; N, 3.47; Found: C, 68.09; H, 4.18; N, 3.12.

7-Methyl-2-oxo-1,2,3,-triphenyl-10a-tetrahydro-5*H*-chromeno[2,3-*d*][1,3,2]diazaphosphinin-5-one (19). Yellow crystals, yield 67%; mp 169−170°C. IR (KBr), ν (cm^{-1}): 3036 (C−H$_{arom}$), 2935, (C−H$_{aliph}$), 1650 (C=O$_{pyrone}$), 1605 (C=C),

1207 (P=O), 1032 (P−O−C). ^{1}H NMR (DMSO-d_6), δ: 2.51 (s, 3H, CH_3), 7.28−7.60 (m, 18H, aromatic protons), 7.96 (br, 2H, $C_4-H_{diazaphosphinine}$ and $C_2-H_{chromone}$). ^{31}P NMR (DMSO-d_6) δ: 20.05 ppm. Anal. Calcd for $C_{29}H_{23}N_2O_3P$ (478.47): C, 72.80; H, 4.85; N, 5.85; Found: C, 72.41; H, 4.52; N, 5.55.

REFERENCES

1. P. Valenti, A. Bisi, A. Rampa, F. Belluti, S. Gobbi, A. Zampiron, and M. Carrara, *Bioorg. Med. Chem.*, **8,** 239 (2000).
2. L.-C. Lim, Y.-C. Kuo, and C.-J. Chou, *J. Nat. Prod.*, **63,** 627 (2000).
3. Y. Q. Shi, T. Fukai, H. Sakagami, W.-J. Chang, P.-Q. Yang, F.-P. Wang, and T. Nomura, *J. Nat. Prod.*, **64,** 181 (2001).
4. R. Larget, B. Lockhart, P. Renard, and M. Largeron, *Bioorg. Med. Chem. Lett.*, **10,** 835 (2000).
5. A. Groweiss, J. H. Cardellins, and M. R. Boyd, *J. Nat. Prod.*, **63,** 1537 (2000).
6. Y. Deng, J. P. Lee, M. T. Ramamonjy, J. K. Synder, S. A. Des Etages, D. Kanada, M. P. Synder, and C. J. Turner, *J. Nat. Prod.*, **63,** 1082 (2000).
7. I. A. Khan, M. A. Avery, C. L. Burandt, D. K. Goins, J. R. Mikell, T. E. Nash, A. Azadega, and L. A. Walker, *J. Nat. Prod.*, **63,** 1414 (2000).
8. T. E. Ali, *Phosphorus, Sulfur, and Silicon*, **182,** 1717 (2007).
9. T. E. Ali, S. A. Abdel-Aziz, H. M. El-Shaaer, F. I. Hanafy, and A. Z. El-Fauomy, *Turk. J. Chem.*, **32,** 365 (2008).
10. T. E. Ali, S. A. Abdel-Aziz, H. M. El-Shaaer, F. I. Hanafy, and A. Z. El-Fauomy, *Phosphorus, Sulfur, and Silicon*, **183,** 2139 (2008).
11. P. J. Pietta, *J. Nat. Prod.*, **63,** 1035 (2000).
12. G. R. Beecher, *J. Nutr.*, **133,** 3248 (2003).
13. V. P. Kukhar and H. R. Hudson, Eds., *Aminophosphonic and Aminophosphinic Acids* (John Wiley, New York, 2000).
14. A. B. Smith, K. M. Yager, and C. M. Taylor, *J. Am. Chem. Soc.*, **117,** 10879 (1995).
15. K. D. Troev, *Chemistry and Applications of H-Phosphonate* (Elsevier, Amsterdam, 2006), pp. 253–261.
16. B. L. Kafarski, *Phosphorus, Sulfur, and Silicon*, **63,** 193 (1991).
17. J. Ding, M. E. Fraser, J. H. Meyer, P. A. Bartlett, and M. N. G. James, *J. Am. Chem. Soc.*, **120,** 4610 (1998).
18. F. R. Atherton, C. H. Hassall, and R. W. Lambert, *J. Med. Chem.*, **29,** 29 (1986).
19. E. Alonso, A. Solis, and C. del Pozo, *Synlett*, 698 (2000).
20. A. O. Fitton, J. R. Frost, H. Suschitzy, and P. G. Houghton, *J. Chem. Soc. Perkin. Trans. 1* , **7,** 1601 (1979).
21. K. Kostka and R. Modranka, *Phosphorus, Sulfur, and Silicon*, **57,** 279 (1991).
22. D. Khidre, H. M. Abou-Yousef, and M. R. Mahran, *Phosphorus, Sulfur, and Silicon*, **140,** 147 (1998).
23. B. Boduszek, M. Lipinski, and M. W. Kowalska, *Phosphorus, Sulfur, and Silicon*, **143,** 179 (1998).
24. T. E. Ali, *Arkivoc*, **ii**, 71 (2008).
25. D. Pettersen, M. Marcolini, L. Bernardi, F. Fini, R. Herrera, V. Sgarzani, and A. Ricci, *J. Org. Chem.*, **71,** 6269 (2006).
26. H. Kivelä, Z. Zalän, P. Tähtinen, R. Sillanapää, F. Fulöp, and K. Pihlaja, *Eur. J. Org. Chem.*, **6,** 1189 (2005).
27. M. Ben Mosbah, M. Kossentini, and M. Salem, *Phosphorus, Sulfur, and Silicon*, **181,** 1315 (2006).