

Scientific paper

Synthesis and Characterization of Oxime-Phosphazenes Containing 2,2'-Dioxybiphenyl Groups

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Received: 22-04-2008

Abstract

2,2-Dichloro-4,4,6,6-bis[spiro(2',2''-dioxy-1',1''-biphenyl)]cyclophosphazene (**2**) was obtained from the reaction of hexachlorocyclophosphazene (**1**) with biphenyl-2,2'-diol. 2,2-Bis(4-acetylphenoxy)-4,4,6,6-bis[spiro(2',2''-dioxy-1',1''-biphenyl)]cyclophosphazene (**3**) was synthesized from the reaction of **2** with 4-hydroxyacetophenone. The novel oxime-cyclophosphazene containing 2,2'-dioxybiphenyl groups **4** was synthesized from the reaction of **3** with hydroxylamine hydrochloride in pyridine. The reactions of this oxime-cyclophosphazene with methyl iodide, benzyl chloride, acetyl chloride, benzoyl chloride, 4-methoxybenzoyl chloride, chloroacetyl chloride, propanoyl chloride, 2-bromoethanol and 2-chlorobenzoyl chloride were studied. Disubstituted compounds were obtained from the reactions of **4** with methyl iodide, benzyl chloride, acetyl chloride, benzoyl chloride and 4-methoxybenzoyl chloride. Pure and defined products could not be obtained from the reaction of **4** with chloroacetyl chloride, propanoyl chloride, 2-bromoethanol and 2-chlorobenzoyl chloride. All products were generally obtained in high yields. The structures of the compounds were proved by elemental analysis, IR, ¹H, ¹³C and ³¹P NMR spectroscopy.

Keywords: Hexachlorocyclophosphazene, phosphazene, oxime derivatives, oxime-phosphazenes.

1. Introduction

Phosphazenes, which are the best known and most intensively studied phosphorus-nitrogen compounds, are materials with interesting properties. For example, they exhibit fire-retardant properties, have high refractive indices, and might find application in non-linear optics, as ferroelectric materials, as liquid crystals or as photoactive materials.¹⁻⁷ They also possess a number of characteristics such as biomedical properties and applications due to their strong antitumor activity.⁸⁻¹² Their antimicrobial and biological activities on bacterial and yeast cells have been studied.¹³⁻¹⁵ Some applications include model compounds for polyphosphazenes, starting materials for the preparation of cycloliner and/or cyclomatrix phosphazene substrates, commercial polymers with carbon backbones containing pendant cyclophosphazene groups, inorganic hydraulic fluids and lubricants, biologically important substrates such as anti-

cancer agents, insect chemosterilants, pesticides and fertilizers, supports for catalysts, dyes, and crown ether phase transfer catalysts for nucleophilic substitution reactions, core substrates for dendrimers, thermal initiators for anionic polymerization reactions and photosensitive materials.¹⁶

The literature contains reports on the synthesis of different linear, cyclic or poly phosphazenes.¹⁷⁻²⁷ The synthesis and different reactions of phosphazenes containing 2,2'-dioxybiphenyl groups were reported.^{28,29} There are also a large number of literature reports on reactions of the functional groups on phosphazene substituents.^{11,30} Typical of these include coupling reactions of trimeric phosphazene azides with aryloxy, alkoxy and dialkylamino cosubstituents,³¹ *N*-vinylic phosphazenes with azodicarboxylic and acetylenic esters,³² oxime-phosphazene derivatives with alkyl and acyl substituents,³³⁻³⁶ polymers from 4-formylphenoxy,^{37,38} maleic,³⁹ and 3,4-methylenedioxyphenoxy substituents.⁴⁰

2. Experimental

2.1. General Remarks

Solvents and other liquids used in the experimental works were dried by conventional methods. Hexachlorocyclotriphosphazene [N₃P₃Cl₆] (**1**) was purchased from Aldrich and recrystallized from hexane. Other chemicals were used as purchased. 2,2-Dichloro-4,4,6,6-bis[spiro(2',2''-dioxo-1',1''-biphenyl)]cyclophosphazene (**2**) and 2,2-bis(4-acetylphenoxy)-4,4,6,6-bis[spiro(2',2''-dioxo-1',1''-biphenyl)]cyclophosphazene (**3**) were prepared as described by Carriedo et al.²⁹ The reaction of **1** with the biphenyl-2,2'-diol was carried out under dry nitrogen. IR spectra were recorded on an ATI Unicam Mattson 1000 FTIR spectrometer. ¹H, ¹³C, and ³¹P NMR spectra were recorded using a Bruker DPX-300 spectrometer operating at 300.13, 75.46 and 121.49 MHz, respectively. The ¹H and ¹³C NMR chemical shifts were measured using SiMe₄ as an internal standard, whereas those for ³¹P were measured using 85% H₃PO₄ as an external standard. Chemical shifts downfield from the standard were assigned positive δ values.

Synthesis of 2. A mixture of **1** (10.20 g, 29.34 mmol), biphenyl-2,2'-diol (10.70 g, 57.46 mmol), and K₂CO₃ (20.00 g, 144.70 mmol) was stirred in acetone (100 mL) at 0 °C and then reacted at ambient temperature for 24 h. The solvent was removed under vacuum. The residue was extracted with CH₂Cl₂ (4 × 75 mL). After the solvent was removed, a white solid **2** formed (15.48 g, 92%). Anal. Calcd. for C₂₄H₁₆Cl₂N₃O₄P₃ (574.22): C, 50.20; H, 2.81; N, 7.32. Found: C, 49.80; H, 2.70; N, 7.00%. IR (KBr/cm⁻¹): 3034 and 3071 ν_{C-H(ar)}, 1194 ν_{P=N}, 942 ν_{P-O-C}. ¹H NMR δ 7.68 (4H, d, *J* = 7.5 Hz, H⁵), 7.55 (4H, t, *J* = 7.6 Hz, H³), 7.40 (8H, m, H², H⁴). ¹³C NMR δ 147.3 (d, ²J_{POC} = 8.9 Hz, C¹), 130.7 (C⁵), 130.5 (C³), 129.0 (C⁶), 127.0 (C⁴), 122.0 (C²).

Synthesis of 3. A mixture of **2** (15 g, 26.12 mmol), 4-hydroxyacetophenone (7.70 g, 56.55 mmol), and K₂CO₃ (21.00 g, 151.94 mmol) was stirred in acetone (100 mL) at 0 °C and then refluxed for 4 h. The solvent was removed under vacuum. The residue was extracted with CH₂Cl₂ (4 × 75 mL). After the solvent was removed, a white solid **3** formed (18.40 g, 92%). Anal. Calcd. for C₄₀H₃₀N₃O₈P₃ (773.60): C, 62.10; H, 3.91; N, 5.43. Found: C, 61.98; H, 4.00; N, 5.45%. IR (KBr/cm⁻¹): 1684 ν_{C=O}, 1175 ν_{P=N}, 955 ν_{P-O-C}. ³¹P NMR (DMSO-*d*₆) δ 25.1 (2P, d, P(O₂C₁₂H₈)), 9.4 (1P, dd, P(OC₆H₄COCH₃)₂) (AB₂ system, *J*_{AB} = 94 Hz). ¹H NMR δ 8.17 (4H, d, *J* = 8.8 Hz, H⁹), 7.62 (4H, d, *J* = 7.6 Hz, H⁵), 7.55 (4H, d, *J* = 7.5 Hz, H⁸), 7.51 (4H, t, *J* = 6.5 Hz, H³), 7.44 (4H, t, *J* = 7.4 Hz, H⁴), 7.22 (4H, d, *J* = 8.0 Hz, H²), 2.62 (6H, s, H¹²). ¹³C-NMR δ 197.1 (C¹¹), 153.5 (d, ²J_{POC} = 3.0 Hz, C⁷), 147.3 (d, ²J_{POC} = 2.9 Hz, C¹), 134.7 (d, ⁵J_{POCCCC} = 1.5 Hz, C¹⁰), 130.9 (C⁹), 130.6 (C⁵), 130.2 (C³), 128.0 (C⁶), 127.0 (C⁴), 121.9 (C²), 121.2 (d, ³J_{POCC} = 7.1 Hz, C⁸), 27.0 (C¹²).

Synthesis of 4. A mixture of **3** (12.00 g, 15.52 mmol) and hydroxylamine hydrochloride (2.5 g, 35.14 mmol) was refluxed in pyridine (15 mL) for 3.5 h. After the reaction was complete, the mixture was allowed to cool and was slowly poured into water (100 mL) and reprecipitated twice from water. The white solid **4** was washed with alcohol and dried at 50 °C in a vacuum. Yield: 78% (9.77 g). Anal. Calcd. for C₄₀H₃₂N₅O₈P₃ (803.63): C, 59.78; H, 4.01; N, 8.71. Found: C, 60.00; H, 4.27; N, 8.59%. IR (KBr/cm⁻¹): 3376 ν_{OH}, 1636 ν_{C=N}, 1170 ν_{P=N}, 973 ν_{P-O-C}. ³¹P NMR (DMSO-*d*₆) δ 25.4 (2P, d, P(O₂C₁₂H₈)), 10.0 (1P, dd, P(OC₆H₄C(CH₃)NOH)₂) (AB₂ system, *J*_{AB} = 94 Hz). ¹H NMR δ 11.33 (2H, s, H¹³), 7.82 (4H, d, *J* = 7.9 Hz, H⁹), 7.68 (4H, d, *J* = 7.3 Hz, H⁵), 7.53 (4H, t, *J* = 8.3 Hz, H³), 7.51 (8H, m, H⁸, H⁴), 7.18 (4H, d, *J* = 7.9 Hz, H²), 2.20 (6H, s, H¹²). ¹³C NMR δ 152.7 (C⁷), 150.7 (²J_{POC} = 7.18 Hz, C¹), 149.7 (C¹¹), 147.6 (C⁹), 135.1 (C⁵), 130.6 (C¹⁰), 128.8 (C³), 127.7 (C⁶), 127.2 (C⁴), 122.1 (C²), 121.3 (d, ³J_{POCC} = 7.2 Hz, C⁸), 12.1 (C¹²).

Reaction of 4 with Methyl Iodide; Synthesis of 5. A solution of 1.00 mL (2.28 g, 16.06 mmol) methyl iodide in acetone (10 mL) was slowly added dropwise to a stirred and cooled (0–5 °C) mixture of **4** (0.70 g, 0.87 mmol) and K₂CO₃ (1.00 g, 7.24 mmol) in acetone (30 mL). The reaction was carried out at room temperature for 3 h and then refluxed for 12 h. After the reaction was complete, the precipitate was filtered off and the solvent was removed. The product was dissolved in a very little amount of acetone and precipitated with water several times. The white solid **5** was washed with alcohol and dried at 50 °C in a vacuum. Yield: 70% (0.51 g). Anal. Calcd. for C₄₂H₃₆N₅O₈P₃ (831.68): C, 60.65; H, 4.36; N, 8.42. Found: C, 60.39; H, 4.65; N, 8.18%. IR (KBr/cm⁻¹): 1601 ν_{C=N}, 1179 ν_{P=N}, 941 ν_{P-O-C}. ³¹P NMR (DMSO-*d*₆) δ 25.3 (2P, d, P(O₂C₁₂H₈)), 10.0 (1P, dd, P(OC₆H₄C(CH₃)NOCH₃)₂) (AB₂ system, *J*_{AB} = 92 Hz). ¹H NMR δ 7.83 (4H, d, *J* = 8.5 Hz, H⁹), 7.67 (4H, d, *J* = 7.5 Hz, H⁵), 7.52 (4H, t, *J* = 7.5 Hz, H³), 7.45 (4H, d, *J* = 7.4 Hz, H⁸), 7.38 (4H, t, *J* = 7.6 Hz, H⁴), 7.16 (4H, d, *J* = 7.7 Hz, H²), 3.40 (6H, s, H¹³), 2.19 (6H, s, H¹²). ¹³C NMR δ 153.6 (C¹¹), 152.7 (d, ²J_{POC} = 2.9 Hz, C⁷), 150.7 (d, ²J_{POC} = 3.0 Hz, C¹), 147.6 (d, ⁵J_{POCCCC} = 0.9 Hz, C¹⁰), 135.1 (C⁹), 130.6 (C⁵), 128.3 (C³), 127.8 (C⁶), 127.2 (C⁴), 122.1 (C²), 121.3 (d, ³J_{POCC} = 6.5 Hz, C⁸), 62.1 (C¹³), 12.1 (C¹²).

Reaction of 4 with Benzyl Chloride; Synthesis of 6. A solution of 1.00 mL (1.10 g, 8.69 mmol) benzyl chloride in acetone (10 mL) was slowly added dropwise to a stirred and cooled (0–5 °C) mixture of **4** (0.70 g, 0.87 mmol) and K₂CO₃ (1.00 g, 7.24 mmol) in acetone (30 mL). The reaction was carried out at room temperature for 24 h. After the reaction was complete, the precipitate was filtered off and the solvent was removed. The product was dissolved in a very little amount of acetone and was precipitated with alcohol several times. The white solid **6** formed (0.60 g,

70%). Anal. Calcd. for $C_{54}H_{44}N_5O_8P_3$ (983.87): C, 65.92; H, 4.51; N, 7.12. Found: C, 66.23; H, 4.74; N, 6.95%. IR (KBr/cm⁻¹): 1600 $\nu_{C=N}$, 1173 $\nu_{P=N}$, 947 ν_{P-O-C} . ³¹P NMR (DMSO-*d*₆) δ 25.3 (2P, d, P(O₂C₁₂H₈)), 10.0 (1P, dd, P(OC₆H₄C(CH₃)NOC₇H₇)₂) (AB₂ system, J_{AB} = 93 Hz). ¹H NMR δ 7.82 (4H, d, J = 8.3 Hz, H⁹), 7.68 (4H, d, J = 7.3 Hz, H⁵), 7.53 (4H, d, J = 7.3 Hz, H⁸), 7.47 (4H, d, J = 7.3 Hz, H¹⁵), 7.38 (10H, m, H³, H¹⁶, H¹⁷), 7.22 (4H, d, J = 8.1 Hz, H²), 7.16 (4H, t, J = 6.2 Hz, H⁴), 5.22 (4H, s, H¹³), 2.19 (6H, s, H¹²). ¹³C NMR δ 154.3 (C¹¹), 152.7 (d, ² J_{POC} = 3.5 Hz, C⁷), 147.6 (d, ² J_{POC} = 3.3 Hz, C¹), 138.4 (C¹⁴), 133.9 (C⁹), 131.1 (C³), 130.7 (C⁵), 130.4 (C⁶), 128.8 (C¹⁷), 128.5 (C¹⁵), 128.2 (C⁶), 127.8 (d, ⁵ J_{POCCCC} = 1.2 Hz, C¹⁰), 127.2 (C⁴), 122.1 (C²), 122.3 (d, ³ J_{POCC} = 6.7 Hz, C⁸), 75.9 (C¹³), 12.1 (C¹²).

Reaction of 4 with Acetyl Chloride; Synthesis of 7. A solution of 1.00 mL (1.20 g, 15.28 mmol) acetyl chloride in acetone (10 mL) was slowly added dropwise to a stirred and cooled (0–5 °C) mixture of **4** (0.70 g, 0.87 mmol) and K₂CO₃ (1.00 g, 7.24 mmol) in acetone (30 mL). The reaction was carried out at room temperature for 24 h. After the reaction was complete, the precipitate was filtered off and the solvent was removed. The product was dissolved in a very little amount of acetone and precipitated with alcohol several times. The white solid **7** formed (0.69 g, 90%). Anal. Calcd. for $C_{44}H_{36}N_5O_{10}P_3$ (887.70): C, 59.53; H, 4.09; N, 7.89. Found: C, 59.75; H, 4.38; N, 8.13%. IR (KBr/cm⁻¹): 1601 $\nu_{C=O}$, 1601 $\nu_{C=N}$, 1178 $\nu_{P=N}$, 937 ν_{P-O-C} . ³¹P NMR (DMSO-*d*₆) δ 25.3 (2P, d, P(O₂C₁₂H₈)), 9.8 (1P, dd, P(OC₆H₄C(CH₃)NOCOH₃)₂) (AB₂ system, J_{AB} = 94 Hz). ¹H NMR δ 8.15 (4H, d, J = 7.3 Hz, H⁹), 7.82 (4H, d, J = 7.3 Hz, H⁵), 7.65 (4H, d, J = 7.4 Hz, H⁸), 7.45 (8H, m, H³, H⁴), 7.18 (4H, d, J = 7.9 Hz, H²), 2.61 (6H, s, H¹²), 2.19 (6H, s, H¹⁴). ¹³C NMR δ 153.7 (C¹³), 150.4 (C¹¹), 147.4 (d, ³ J_{POC} = 2.7 Hz, C⁷), 134.8 (d, ³ J_{POC} = 3.2 Hz, C¹), 130.9 (d, ⁵ J_{POCCCC} = 1.0 Hz, C¹⁰), 130.5 (C⁹), 130.2 (C⁵), 128.1 (C³), 127.5 (C⁶), 127.0 (C⁴), 121.9 (C²), 121.1 (d, ³ J_{POCC} = 7.5 Hz, C⁸), 27.0 (C¹⁴), 11.9 (C¹²).

Reaction of 4 with Benzoyl Chloride; Synthesis of 8. A solution of 1.00 mL (1.20 g, 8.60 mmol) benzoyl chloride in acetone (10 mL) was slowly added dropwise to a stirred and cooled (0–5 °C) mixture of **4** (0.70 g, 0.87 mmol) and K₂CO₃ (1.00 g, 7.24 mmol) in acetone (30 mL). The reaction was carried out at room temperature for 24 h. After the reaction was complete, the precipitate was filtered off and the solvent removed. The product was dissolved in a very little amount of acetone and precipitated with alcohol several times. The white solid **8** formed (0.60 g, 68%). Anal. Calcd. for $C_{54}H_{40}N_5O_{10}P_3$ (1011.84): C, 64.10; H, 3.98; N, 6.92. Found: C, 64.35; H, 4.08; N, 7.13%. IR (KBr/cm⁻¹): 1747 $\nu_{C=O}$, 1599 $\nu_{C=N}$, 1173 $\nu_{P=N}$, 974 ν_{P-O-C} . ³¹P NMR (DMSO-*d*₆) δ 24.1 (2P, d, P(O₂C₁₂H₈)), 9.6 (1P, dd, P(OC₆H₄C(CH₃)NOC₇H₅O₂)₂) (AB₂ system, J_{AB} = 94 Hz). ¹H NMR δ 8.14 (4H, d, J = 7.4 Hz, H¹⁵), 8.11 (4H, d,

J = 7.3 Hz, H⁵), 8.09 (4H, d, J = 8.6 Hz, H⁹), 7.68 (4H, d, J = 7.6 Hz, H⁸), 7.60 (4H, d, J = 7.7 Hz, H²), 7.50 (10H, m, H³, H¹⁶, H¹⁷), 7.22 (4H, t, J = 4.5 Hz, H⁴), 2.61 (6H, s, H¹²). ¹³C NMR δ 163.4 (C¹³), 147.6 (C¹¹), 131.2 (d, ² J_{POC} = 3.3 Hz, C⁷), 131.8 (d, ² J_{POC} = 2.9 Hz, C¹), 130.4 (C¹⁷), 129.8 (d, ⁵ J_{POCCCC} = 1.3 Hz, C¹⁰), 129.5 (C⁹), 129.2 (C¹⁵), 129.0 (C⁶), 128.9 (C¹⁴), 128.3 (C⁵), 127.8 (C³), 127.2 (C⁶), 122.1 (C⁴), 121.6 (C²), 121.4 (d, ³ J_{POCC} = 7.0 Hz, C⁸), 12.1 (C¹²).

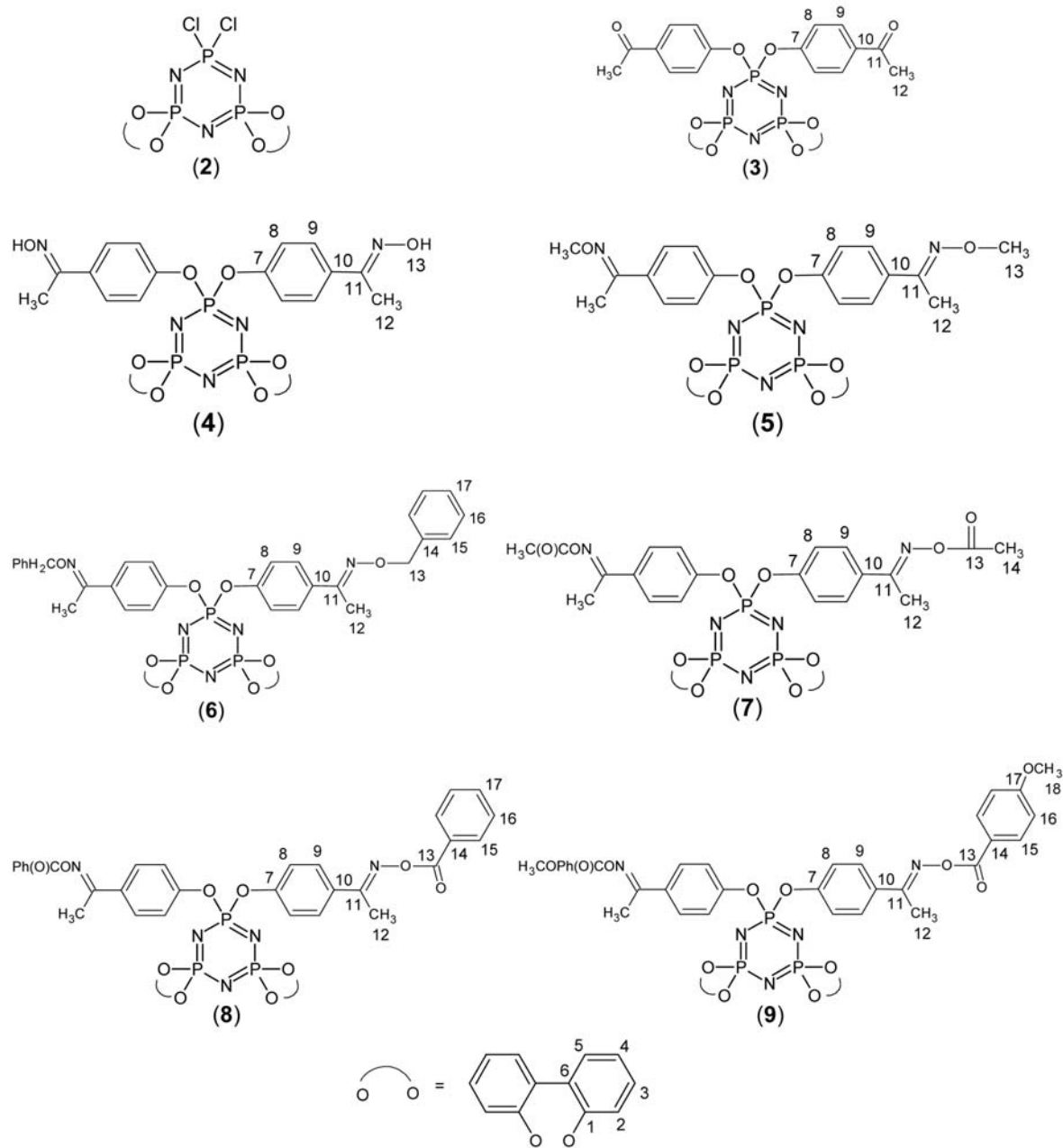
Reaction of 4 with 4-Methoxybenzoyl Chloride; Synthesis of 9. A solution of 0.5 g (2.92 mmol) 4-methoxybenzoyl chloride in acetone (10 mL) was slowly added dropwise to a stirred and cooled (0–5 °C) mixture of **4** (0.70 g, 0.87 mmol) and K₂CO₃ (1.00 g, 7.24 mmol) in acetone (30 mL). The reaction was carried out at room temperature for 24 h. After the reaction was complete, the precipitate was filtered off and the solvent removed. The product was dissolved in a very little amount of acetone and precipitated with alcohol several times. The white solid **9** formed (0.73 g, 68%). Anal. Calcd. for $C_{56}H_{44}N_5O_{12}P_3$ (1071.89): C, 62.75; H, 4.14; N, 6.53. Found: C, 63.00; H, 4.38; N, 6.30%. IR (KBr/cm⁻¹): 1739 $\nu_{C=O}$, 1604 $\nu_{C=N}$, 1167 $\nu_{P=N}$, 938 ν_{P-O-C} . ³¹P NMR (DMSO-*d*₆) δ 25.3 (2P, d, P(O₂C₁₂H₈)), 9.9 (1P, dd, P(OC₆H₄C(CH₃)NOC₈H₇O₂)₂) (AB₂ system, J_{AB} = 92 Hz). ¹H NMR δ 8.04 (8H, m, H¹⁵, H⁹), 7.66 (4H, d, J = 7.6 Hz, H⁵), 7.47 (12H, m, H³, H¹⁶, H⁴), 7.21 (4H, d, J = 8.0 Hz, H⁸), 7.11 (4H, d, J = 8.9 Hz, H²), 3.84 (6H, s, H¹⁸), 2.53 (6H, s, H¹²). ¹³C NMR δ 164.0 (C¹³), 163.2 (C¹⁷), 152.2 (C¹¹), 152.1 (d, ² J_{POC} = 3.0 Hz, C⁷), 147.6 (d, ² J_{POC} = 3.2 Hz, C¹), 132.7 (d, ⁵ J_{POCCCC} = 1.0 Hz, C¹⁰), 132.0 (C¹⁵), 130.8 (C⁹), 130.4 (C⁵), 129.5 (C³), 128.3 (C⁶), 127.2 (C⁴), 122.1 (C²), 121.6 (d, ³ J_{POCC} = 7.2 Hz, C⁸), 120.9 (C¹⁴), 114.8 (C¹⁶), 56.0 (C¹⁸), 14.9 (C¹²).

3. Results and Discussion

The reaction of **2** with 2 equiv. of 4-hydroxyacetophenone in the presence of K₂CO₃ in acetone gave 2,2-bis(4-acetylphenoxy)-4,4,6,6-bis[spiro(2',2''-dioxo-1',1''-biphenyl)cyclo triphosphazene (**3**). Oxime compound 2,2-bis(4-[(1)-*N*-hydroxyethanimidoyl]phenoxy)-4,4,6,6-bis[spiro(2',2''-dioxo-1',1''-biphenyl)cyclotriphosphazene (**4**) was synthesized from the reaction of **3** with hydroxylamine hydrochloride in pyridine.

Disubstituted compounds were obtained from the reactions of **4** with methyl iodide, benzyl chloride, acetyl chloride, benzoyl chloride and 4-methoxybenzoyl chloride in acetone in the presence of K₂CO₃ via replacement of all the oxime protons with alkyl and acyl groups. Pure and defined products could not be obtained from the reaction of **4** with chloroacetyl chloride, propanoyl chloride, 2-bromoethanol and 2-chlorobenzoyl chloride.

The structures of the compounds were elucidated by IR, ¹H, ¹³C and ³¹P NMR spectroscopy as well as by



Scheme 2. The structures of the compounds 2–9.

The detailed ^{13}C NMR spectral data are given in experimental section. The ketone carbon atom for **3** is observed at 153.7 ppm. The methyl carbons, which have attached carbon atoms of $-\text{C}=\text{N}-$ groups for **4–9** are observed between 11.9 and 14.9 ppm.

4. Conclusion

In this paper we report on the preparation of oxime-cyclophosphazene containing 2,2'-dioxo-biphenyl groups from 2,2-bis(4-acetylphenoxy)-4,4,6,6-bis[spi-

ro(2',2''-dioxo-1',1''-biphenyl)cyclotriphosphazene, and studies on its reactions with methyl iodide, benzyl chloride, acetyl chloride, benzoyl chloride, 4-methoxybenzoyl chloride, chloroacetyl chloride, propanoyl chloride, 2-bromoethanol and 2-chlorobenzoyl chloride.

5. Acknowledgement

We thank the Firat University Research Fund for support (project no: FUBAP 1385).

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Povzetek

2,2-Dikloro-4,4,6,6-bis[spiro(2',2''-dioksi-1',1''-bifenilil)]ciklotrifosfazen (**2**) je bil pripravljen z reakcijo med heksaklorociklotrifosfazenom (**1**) in bifenil-2,2'-diolom. 2,2-Bis(4-acetilfenoksi)-4,4,6,6-bis[spiro(2',2''-dioksi-1',1''-bifenilil)]ciklotrifosfazen (**3**) je bil sintetiziran z reakcijo med **2** in 4-hidroksiacetofenonom. Novi oksim-ciklofosfazen **4**, ki vsebuje 2,2'-dioksi-bifenilne skupine, je bil pripravljen z reakcijo med **3** s hidroksilamin hidrokloridom v piridinu. Razi-skane so bile reakcija tega oksim-ciklofosfazena z metil jodidom, benzil kloridom, acetyl kloridom, benzoil kloridom, 4-metoksibenzoil kloridom, kloroacetyl kloridom, propanoil kloridom, 2-bromoetanolum in 2-klorobenzoil kloridom. Disubstituirane spojine so nastale pri reakciji med **4** in metil jodidom, benzil kloridom, acetyl kloridom, benzoil kloridom in 4-metoksibenzoil kloridom. Definirani in čisti produkti pri reakciji med **4** in kloroacetyl kloridom, propanoil kloridom, 2-bromoetanolum in 2-klorobenzoil kloridom niso nastali. Vsi produkti so nastali z večinoma visokimi izkoristki. Strukture spojin smo dokazali z elementno analizo, IR, ¹H, ¹³C in ³¹P NMR spektroskopijo.