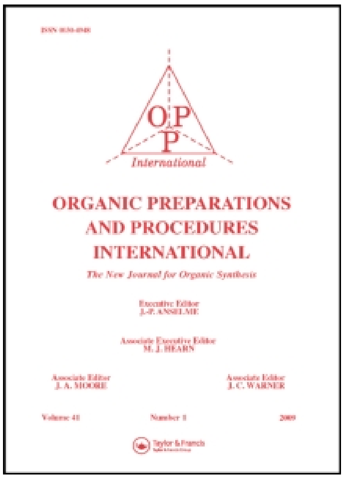

Organic Preparations and Procedures International
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t902189982

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To cite this Article Pinkus, A. G. , Chang, Tsung C. and Meng, Lily Y. C.(2004) 'REACTION OF 5-CHLORO-2-HYDROXYBENZOPHENONE WITH PHOSPHORUS OXYCHLORIDE AND RELATED REACTIONS', Organic Preparations and Procedures International, 36: 6, 600 — 604

To link to this Article: DOI: 10.1080/00304940409355978

URL: http://dx.doi.org/10.1080/00304940409355978

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REACTION OF 5-CHLORO-2-HYDROXYBENZOPHENONE WITH PHOSPHORUS OXYCHLORIDE AND RELATED REACTIONS

Submitted by
(06/03/04)

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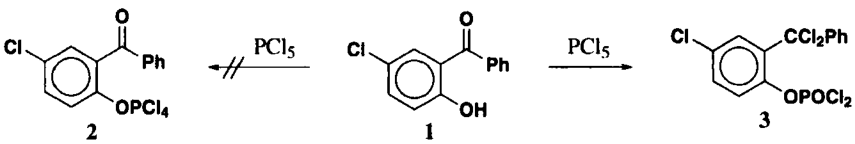
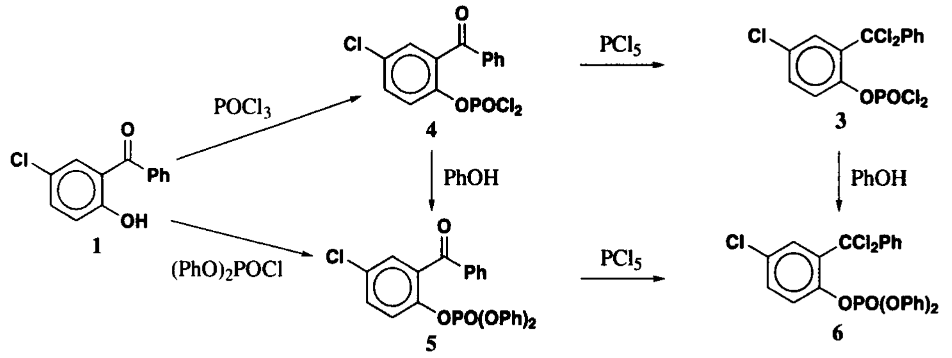
5-Chloro-2-hydroxybenzophenone (**1**) has been shown[1] to react with phosphorus pentachloride to yield the substituted phenylphosphorodichloridate (**3**) rather than the tetrachlorophosphate (**2**) as would be expected[2-4] on the basis of previously reported reactions of PCl_5 with phenols (*Scheme 1*). More conclusive substantiation of these findings is provided in the present communication.



Scheme 1

5-Chloro-2-hydroxybenzophenone (**1**) reacted at the hydroxy group with phosphorus oxychloride to give the phenylphosphorodichloridate (**4**) which, upon treatment with phosphorus pentachloride, afforded compound **3**. Reaction of **3** with phenol occurred at phosphorus to yield the diphenoxy product **6**. Treatment of compound **4** with phenol gave the diphenoxy derivative **5** which was converted into compound **6** by reaction with phosphorus pentachloride. Compound **5** was also produced by treatment of 5-chloro-2-hydroxybenzophenone with diphenylphosphoryl chloride. Pyrolysis of **6** gave high yields of 2,5-dichlorobenzophenone which was similarly obtained earlier from the pyrolysis of **4**.[1] The by-product, diphenylphosphoryl chloride, could not be separated from 2,5-dichlorobenzophenone by distillation. It was removed by hydrolysis to the corresponding acid, isolated as its dihydrate.

The substituted phenylphosphorodichoridate (**3**) was synthesized by an unambiguous series of reactions shown in *Scheme 2*. 5-Chloro-2-hydroxybenzophenone was first reacted with phosphorus oxychloride (using 2,4,6-collidine or 1,4-diazabicyclo[2.2.2]octane as a base)



Scheme 2

via reaction with the hydroxyl group to form the phenylphosphorodichloridate (**4**) which showed the expected carbonyl and P=O IR absorptions. The phenylphosphorodichloridate (**4**) was then treated with phosphorus pentachloride to form the expected product **3** which was initially formed by reaction of 5-chloro-2-hydroxybenzophenone and phosphorus pentachloride as evidenced by a mixture mp and by comparison of its IR spectrum with that of an authentic sample. The conversion of the ketone function to CCl_2 is a well-documented[5-7]reaction. The phosphorus pentachloride product (**3**) was then reacted with phenol (2 equiv) to form the diphenoxide (**6**). In order to demonstrate unequivocally that substitution had occurred on phosphorus and not on CCl_2, 5-chloro-2-hydroxybenzophenone was treated with diphenylphosphoryl chloride and the product from this reaction was then reacted with phosphorus pentachloride to afford the same product (**5**) (*see Scheme 1*). The mechanisms for the reactions are similar to those reported previously.[1]

EXPERIMENTAL SECTION

Chemicals and equipment were the same as used previously.[1] Elemental analyses were carried out by MHW Laboratories, Garden City, MI. Molecular weights were determined by cryoscopy in benzene.

Reaction of 5-Chloro-2-hydroxybenzophenone and Phosphorus Oxychloride.- A solution of phosphorus oxychloride (15 g, 97.9 mmol) and 1,4-diazabicyclo[2.2.2]octane (6.37 g, 59.3 mmol) in 200 mL of benzene was placed in a 3-necked flask equipped with dropping funnel, magnetic stirrer, and condenser with calcium chloride drying tube. A solution of 5-chloro-2-hydroxybenzophenone (13.8 g, 59.3 mmol) in 90 mL of benzene was added over a period of 6 hr. A precipitate of amine hydrochloride was removed by filtration and the solvent was removed from the filtrate by evaporation *in vacuo*. Amine hydrochloride which had again formed was removed by filtration. A light yellow, viscous liquid of product **4** (19.7 g, 95%) was isolated. (with 2,4,6-collidine as base, a 92% yield was obtained). IR (CCl_4): 1677 (C=O str), 1377 (P=O str) and no OH str at 3040 cm^{-1}. MW: Calcd: 350. Found: 359

Anal. Calcd for $C_{13}H_8Cl_3O_3P$: C, 44.68; H, 2.31; P, 8.16. Found: C, 44.44; H, 2.40; P, 8.33

Reaction of 2-Benzoyl-4-chlorophenylphosphorodichloridate (4) with Phosphorus Pentachloride to Compound 1.- 2-Benzoyl-4-chlorophenylphosphorodichloridate (**4**) (2.88 g, 8.23 mmol) and phosphorus pentachloride (2.18 g, 10.5 mmol) were mixed in a long sidearm distilling flask equipped with a calcium chloride/phosphorus pentoxide drying tube and then heated in an oil bath at 129-131°C for 3 hr. The PCl_5, which sublimed during reaction, was returned to the flask during reaction. The product was then distilled under reduced pressure to obtain 1.35 g (107%) of phosphorus oxychloride. The residue (3.51 g) solidified on cooling and was shaken with cyclohexane; insoluble phosphorus pentachloride was removed by filtration. After two recrystallizations, large crystals of **3** were obtained, mp 70-71°C, identical (mixture mp and IR spectrum) with the product of the direct reaction of 5-chloro-2-hydroxybenzophenone with phosphorus pentachloride.

Reaction of 2-Benzoyl-4-chlorophenylphosphorodichloridate (4) with Phenol.- Phenol (2.26 g, 24.0 mmol) was dissolved in dry benzene (35 mL) and this solution added over a 2 hr period to a stirred solution of compound **4** (4.20 g, 12.0 mmol) and 1,4-diazabicyclo[2.2.2]octane in 45 mL of dry benzene in a 3-necked flask The amine hydrochloride precipitated during the addition and was removed by filtration in a drybox. The benzene solvent was removed *in vacuo* to yield 5.49 g (99%) of diphenoxy product **5** (the yield by using triethylamine as a base was 91%). The product was dissolved in hot cyclohexane and seeded with crystals of **5**. The crystals obtained on standing in a refrigerator were recrystallized from cyclohexane to afford large colorless crystals, mp 38-39°C. MW: Calcd: 465. Found: 468.

Anal. Calcd for $C_{25}H_{18}ClO_5P$: C, 64.60; H, 3.90; P, 6.66; Cl, 7.63
Found: C, 64.67; H, 3.85; P, 6.63; Cl, 7.55

Reaction of 5-Chloro-2-hydroxybenzophenone and Diphenylphosphoryl Chloride.- A solution of diphenylphosphoryl chloride (13.5 g, 50.3 mmol) and 1,4-diazabicyclo[2.2.2]octane (5.65 g, 50.3 mmol) in 200 mL benzene were placed in a 3-necked flask equipped with dropping funnel, magnetic stirrer, and calcium chloride protected condenser. A solution of 5-chloro-2-hydroxybenzophenone (11.7 g, 50.3 mmol) in 100 mL benzene was added dropwise with stirring over a period of 5 hr. A white precipitate of hydrochloride formed during the addition. Since a yellow color (apparently from the hydroxybenzophenone and amine) did not disappear after standing overnight, more of the base (1.01 g, 9.0 mmol) in 10 mL of benzene was added dropwise. After 2 days, the yellow color faded and the hydrochloride was removed by filtration and the solvent was removed *in vacuo*. The mixture was refiltered 3 times to remove hydrochloride which kept reprecipitating. The product **5** amounted to 25.5 g of a liquid which began to solidify after 10 days standing. After three recrystallizations from cyclohexane, large crystals formed, mp 38-39°C. The IR spectrum was identical to that of the product **5** obtained from the reaction of compound **3** with phenol. An earlier reaction using triethylamine as base yielded a brown liquid product (92%) which did not solidify even upon standing for a long period of time.

Reaction of 2-Benzoyl-4-chlorophenyldiphenyl Phosphate (5) and Phosphorus Pentachloride.- 2-Benzoyl-4-chlorophenyldiphenyl phosphate (**5**, 2.97 g, 6.38 mmol) and phosphorus pentachloride (1.33 g, 6.38 mmol) were mixed in a distilling flask equipped with a finger condenser and with a long side-arm connected to a calcium chloride/phosphorus pentoxide drying tube. The flask was heated by an oil bath at 134-136°C for 2 hr and the residue was then distilled under reduced pressure. Phosphorus oxychloride (0.941 g, 96%) (identified from its IR spectrum) was collected in a cold trap. The residue (33.3 g, 99%) was a thick colorless liquid which, upon seeding with 4-chloro-2-(α,α-dichlorobenzyl)phenyldiphenyl phosphate (**6**) solidified. Recrystallization from cyclohexane gave large, white crystals, mp 75-76°C. The IR spectrum and mixture mp identified the product as **6**.

Anal. Calcd. for $C_{25}H_{18}Cl_3O_4P$: C, 57.76; H, 3.49; P, 5.96; Cl, 20.47

Found: C, 58.07; H, 3.65; P, 5.61; Cl, 20.12

Pyrolysis of 4-Chloro-2-(α,α-dichlorobenzyl)phenyldiphenyl Phosphate (6).- 4-Chloro-2-(α,α-dichlorobenzyl)phenyldiphenyl phosphate (**6**) (4.48 g, 8.62 mmol) was placed in a Claisen flask protected with a calcium chloride drying tube attached to a distillation receiver. The flask was heated in an oil bath at 245°C for 2 hr whereupon the compound turned brown. The mixture was cooled and dissolved in 15 mL of benzene. Water (10 mL) was added and the mixture stirred for 24 hr by means of a magnetic stirrer. The benzene was evaporated *in vacuo* and the resulting aqueous mixture was boiled for 5 min and then decanted through a filter paper and the filtrate collected. The procedure was repeated and the aqueous filtrates were combined. The oily residue on the filter paper was transferred to a flask and dissolved in 10 mL of boiling 95% ethanol and on cooling, seeded with 2,5-dichlorobenzophenone. The white needle-like crystals (1.01 g, 46%) of 2,5-dichlorobenzophenone formed were identified by mp, mixture mp, and its IR spectrum. After cooling, the aqueous layers (from above) were seeded with authentic diphenylhydrogen phosphate dihydrate which precipitated on standing in the refrigerator (0.432 g, 18%), mp 45-47.5°C. Recrystallization from hot water gave small colorless rectangular crystals, mp 47-49°C, *lit.*[8,9,10] 51-52°C; 51°C. A mixture mp was unchanged and its IR spectrum was identical to that of authentic diphenylhydrogen phosphate dihydrate.

Acknowledgement.-The authors express appreciation for support of the research by grants from the Public Health Service, National Institutes of Health.

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