

SYNLETT Spotlight 94

Phenyl Dichlorophosphate – A Versatile Reagent

Compiled by Avijit Kumar Adak



This feature focuses on a reagent chosen by a postgraduate, highlighting the uses and preparation of the reagent in current research

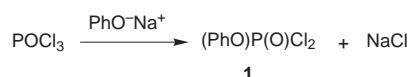
Avijit Kumar Adak was born in Midnapur, India in 1973 and began studying chemistry at the Vidyasagar University in 1992. After receiving his post-graduate (M. Sc) in chemistry in 1997, he joined the research group of Prof. S. P. Goswami at the Bengal Engineering College (Deemed University). He is currently completing his doctoral research on asymmetric total synthesis of the Compound Z, a precursor to the Molybdenum Cofactor (Moco). His primary research interests revolve around asymmetric synthesis and total synthesis.

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Introduction

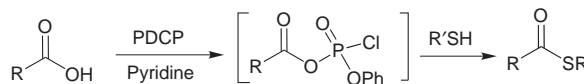
Among several phosphorus acid chlorides described for use in organic synthesis, phenyl dichlorophosphate (PDCP, **1**) has received added interest due to its powerful phosphorylating nature. The activity of PDCP compared to other chlorophosphate esters was shown to be superior. Phenyl dichlorophosphate is regarded as the most widely used reagent for the preparation of symmetrical phosphate diesters.¹ Other important PDCP-derived phosphorylating agents, e.g. phenylphosphoro di-(1-imidazolide), 2-phenyl-*bis*-triazoloylphosphate have been used in peptide synthesis.²

Phenyl dichlorophosphate (**1**) is conveniently prepared by reaction of phosphorus oxychloride with anhydrous powdered sodium phenoxide.³ The precipitated sodium chloride is filtered off and excess phosphorus oxychloride is removed under reduced pressure. The crude oil is distilled in a vigreux column and the fraction having the boiling point 103–106 °C (9 mmHg) is collected for chemical reactions.

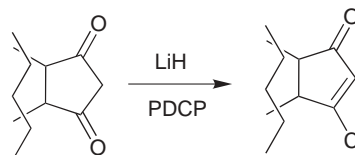


Abstracts

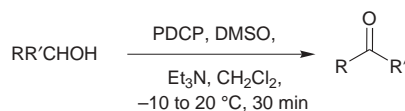
(A) PDCP acts as an activating agent for the formation of thiol esters in good yield by the condensation of carboxylic acids and thiols in the presence of pyridine. Other chlorophosphates such as $(\text{PhO})_2\text{P}(\text{O})\text{Cl}$ and $(\text{EtO})_2\text{P}(\text{O})\text{Cl}$ have proven to be less efficient for the direct transformation of carboxylic acid to thiol ester.⁴



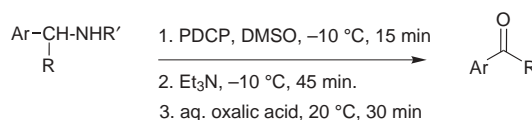
(B) PDCP has been used for the halogenation of β -diketones. Conversion of β -diketones to the corresponding β -chloro- α,β -unsaturated ketones is activated by PDCP in the presence of a base, generally lithium hydride.^{5a} A combination of PDCP and DMSO in methylene chloride provides immediate access to the intermediates of carvone and limonene derivatives by a facile rearrangements of pinenes.^{5b}



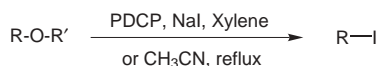
(C) PDCP has been shown to be an efficient DMSO-activating agent in the Pfitzner-Moffatt oxidation. It is conceivable that a complex salt $([\text{PhOPOClOS}^+(\text{CH}_3)_2]\text{Cl}^-)$, generated from the PDCP and DMSO, serves as an oxidizing agent for the conversion of primary and secondary alcohols to the corresponding aldehydes and ketones.⁶



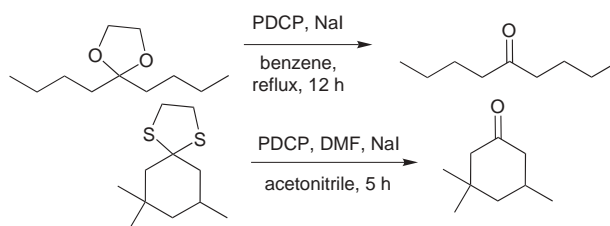
(D) PDCP and DMSO can be used in the oxidative deamination process for benzyl amines to the corresponding carbonyl compounds.⁷



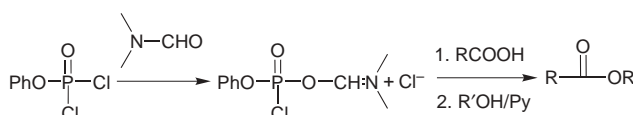
(E) Conversion of ethers to alkyl iodides can be directly effected by PDCP and sodium iodide in refluxing xylenes or acetonitrile.⁸



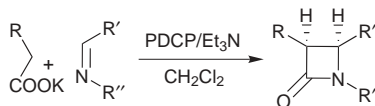
(F) PDCP can also act as an activating agent for the cleavage of C-O and C-S linkages. Treatment of ketals with PDCP and sodium iodide in refluxing benzene gives rise to ketones.^{9a} Conversion of thioacetals to the corresponding carbonyl compounds can be achieved by the combination of PDCP, DMF and sodium iodide in acetonitrile.^{9b}



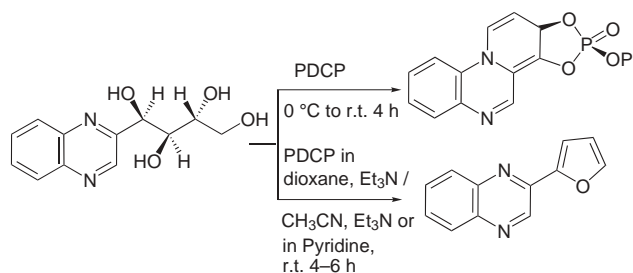
(G) PDCP is believed to form a complex^{10a} with dimethylformamide, which is then an effective reagent for carboxyl group activation.^{10b} The complex was the key to an effective one-pot procedure for the esterification of carboxylic acids.^{10c} This method is particularly useful for esterification of substituted malonic acid, which easily undergoes decarboxylation. PDCP has also been used for the synthesis of artificial receptors for the decarboxylation of malonic acid.^{10d}



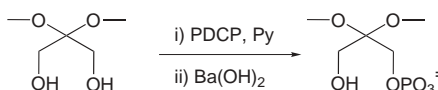
(H) PDCP and its complex with dimethylformamide have been reported to be quite suitable for the efficient synthesis of α -amino- β -lactams^{11a,b} and α -phthalimido- β -lactams^{11c} from Dane salt and imino compounds and also from β -amino acids^{11d} under mild reaction conditions.



(I) Goswami and Adak have shown that PDCP acts as a dehydrating as well as a cyclising agent leading to the formation of 2-(2-furyl)quinoxaline and a five membered cyclic pyrido[1,2-a]quinoxaline phosphate, respectively, from a quinoxaline derivative of sugar under different reaction conditions.¹²



(J) Dihydroxyacetone phosphate (DHAP) is a biochemical that acts as a precursor molecule in organic synthesis. Ferroni et al. have synthesized a stable protected DHAP precursor, dihydroxyacetone phosphate dimethyl acetal, by the reaction of dihydroxyacetone dimethyl acetal and PDCP followed by basic hydrolysis of the phosphate triester.^{13a} Additionally, Goswami and Adak have used PDCP for the synthesis of six-membered cyclic dihydroxyacetone phosphate (CDHAP) triesters.^{13b}



References

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