CHEMISTRY LETTERS, pp. 923-926, 1978. Published by the Chemical Society of Japan

# A CONVENIENT PROCEDURE FOR THE TRANSFORMATION OF ALCOHOLS TO OLEFINS AND ALKYL CHLORIDES

Hsing-Jang LIU, Wing Hong CHAN, and Sing Ping LEE
Department of Chemistry, University of Alberta
Edmonton, Alberta, Canada, T6G 2G2

Treatment of 1° alcohols with N,N-dimethylphosphoramidic dichloride in refluxing 1,2-dimethoxyethane gave the corresponding chlorides. Upon similar treatment, 3° alcohols underwent dehydration giving olefinic products, whereas 2° alcohols afforded olefins or chlorides as predominant products.

N,N-Dimethylphosphoramidic dichloride (DMPADC), which is readily accessible from the reaction of phosphorus oxychloride and dimethylamine,[1] has been known since the turn of the century.[2] Its synthetic utility, however, has been limited to the preparation of phosphorus-containing compounds.[3] In exploring the possible use of DMPADC in other areas of organic synthesis, we have examined its reaction with alcohols.

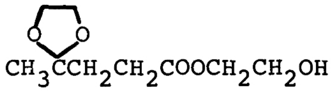
Although DMPADC was found to react with alcohols only at a negligible rate at room temperature, at temperature slightly above 80°C its reaction with 1° alcohols occurred readily giving rise to excellent yields of the corresponding alkyl chlorides. For instance, the reaction of hexadecanol (1 mmol) and DMPADC (5 mmol) in refluxing 1,2-dimethoxyethane (DME; 12 ml) was found to be complete within 7 hr. Addition of water followed by extraction with ether and work-up of the extracts in the usual manner gave the crude product, which, after a rapid column chromatography on silica gel with pet. ether elution, afforded 1-chlorohexadecane of analytical purity in quantitative yield.[7] The generality of the reaction is apparent from the results (Table 1) obtained for the seven cases examined under the same conditions.

The reaction of 3° alcohols with DMPADC in refluxing DME was found to proceed at a rate generally slower than that of 1° alcohols and dehydration was the sole process observed. In all the cases studied (Table 2) olefinic products were formed exclusively and in good yields. An especially noteworthy case is 3-vinyl-1-

dodecen-3-ol (Entry 5), which underwent dehydration cleanly to give 3-vinyl-1,3-dodecadiene without apparent formation of 1-chloro-3-vinyl-2-dodecene despite the hydroxyl group being doubly allylic.

Table 1. Reactions of 1° Alcohols with DMPADC

$$\mathrm{ROH} \xrightarrow[\text{DME ; reflux}]{\text{5 eq. DMPADC}} \mathrm{RCl}$$

| Entry | ROH | Time(hr) | Yield(%) |
|---|---|---|---|
| 1 | $CH_3(CH_2)_{15}OH$ | 7 | 100 |
| 2 | $CH_3(CH_2)_{21}OH$ | 7 | 97 |
| 3 | $C_6H_5(CH_2)_3OH$ | 5 | 99 |
| 4 | $C_6H_5CH_2OCH_2CH_2OH$ | 5 | 92 |
| 5 | $C_6H_5CH_2OH$ | 4 | 90 |
| 6 |  | 5 | 85 |
| 7 | $CH_3COCH_2CH_2COOCH_2CH_2OH$ | 8 | 95 |

Secondary alcohols reacted with DMPADC in refluxing DME giving rise to alkyl chlorides and/or olefins as a result of the competing displacement and dehydration processes. As revealed by the experimental results compiled in Table 3, the general trend of product formation is such that the displacement reaction occurs preferentially when the hydroxyl group is sterically less hindered (Entries 1-3). In cases of sterically congested alcohols (Entries 5-7), dehydration was shown to be the predominant process. It is also noted when two positional isomers could be theoretically produced from dehydration that the thermodynamically more stable isomer was formed predominantly and often exclusively.

Table 2. Dehydration of 3° Alcohols with DMPADC

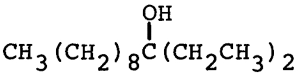
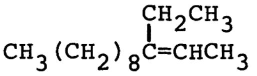
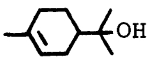
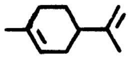
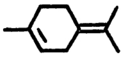
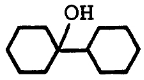
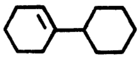
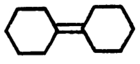
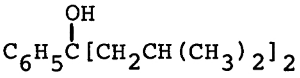
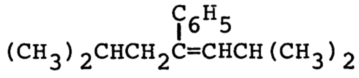
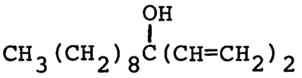
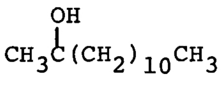
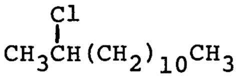
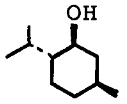
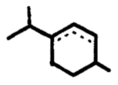
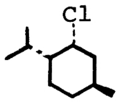
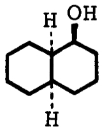
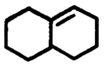
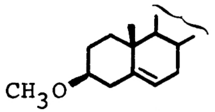
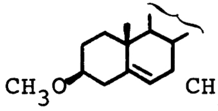
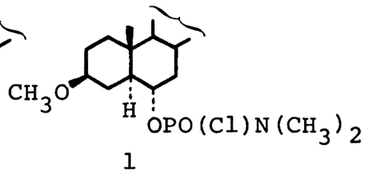
| Entry | Alcohol | Time(hr) | Products (Ratio) | | Total Yield(%) |
|---|---|---|---|---|---|
| 1 |  $CH_3(CH_2)_8C(OH)(CH_2CH_3)_2$ | 30 |  $CH_3(CH_2)_8C(CH_2CH_3)=CHCH_3$<br>$CH_3(CH_2)_7CH=C(CH_2CH_3)_2$ | (4:1) | 93 |
| 2 |  | 60 |   | (3:1) | 78 |
| 3 |  | 96 |   | (4:1) | 90 |
| 4 |  $C_6H_5C(OH)[CH_2CH(CH_3)_2]_2$ | 60 |  $(CH_3)_2CHCH_2C(C_6H_5)=CHCH(CH_3)_2$ | (E:Z= 2:1) | 96 |
| 5 |  $CH_3(CH_2)_8C(OH)(CH=CH_2)_2$ | 1 | $CH_3(CH_2)_7CH=C(CH=CH_2)_2$ | | 79 |

Table 3. Reactions of 2° Alcohols with DMPADC

| Entry | Alcohol | Time(hr) | Products (Ratio) | | Total Yield(%) |
|---|---|---|---|---|---|
| 1 |  $CH_3CH(OH)(CH_2)_{10}CH_3$ | 24 |  $CH_3CH(Cl)(CH_2)_{10}CH_3$<br>$CH_3CH{=}CH(CH_2)_9CH_3$ | (7:1) | 79 |
| 2 | Cholestanol | 72 | 3α-Chlorocholestane<br>2-Cholestene | (3.4:1) | 92 |
| 3 | Epicholestanol | 100 | 3β-Chlorocholestane<br>2-Cholestene | (2.4:1) | 91 |
| 4 |  | 24 |   | (3:2) | 78 |
| 5 |  | 24 |  | | 63 |
| 6 | 3β-methoxycho-<br>lestan-6β-ol | 70 |  | | 65 |
| 7 | 3β-methoxycho-<br>lestan-6α-ol | 140 |  <br>1<br>(3.4:1) | | 61 |

A logical mechanistic pathway involves the condensation of alcohols with DMPADC to give amidate derivatives of general formula $ROPO(Cl)N(CH_3)_2$ which subsequently undergo elimination or displacement reaction by chloride ion. In agreement with this postulation are the following observations. When the reaction of 3β-methoxycholestan-6α-ol and DMPADC (Table 3, Entry 7) was worked up soon after the alcohol was consumed (30 hr), the major product was found to be the corresponding amidate 1, whereas prolonged treatment resulted in the formation of increasing amount of 3β-methoxycholest-5-ene at the expense of the amidate derivative 1. Furthermore, the amidate $CH_3(CH_2)_{15}OPO(Cl)N(CH_3)_2$ (2)[8] was shown to undergo clean displacement with lithium chloride in refluxing DME to give 1-chlorohexadecane. The latter finding and the fact that the amidate 2 was recovered intact after extended heating in refluxing DME coupled with the inversion of stereochemistry observed for unsymmetrical alcohols (Table 3, Entries 2-4) gave strong indication that the displacement is $S_N2$ in nature. On the basis of the results obtained for the epimeric 3β-methoxycholestan-6-ols (Table 3, Entries 6 and 7), it appears that both *trans* and *cis* elimination are operative with the former being more facile.

The foregoing report illustrates the first examples of direct use of DMPADC in synthesizing non-phosphorus-containing substrates and a new method for the transformation of alcohols to olefins and alkyl chlorides. The procedure is operationally simple and involves a neutral reagent of low volatility which is easy to manipulate. Despite a small quantity of hydrogen chloride being produced during the reaction, the conditions are sufficiently mild that moderately acid-sensitive functional groups such as acetals (Table 1, Entry 6) are uneffected and polymerization and extended migration of the double bond are precluded. These promising features coupled with generally high yields of products render the described method an attractive alternative to those existing.[9,10]

## References and Notes

1. E.N. Walsh and A.D.F. Toy, Inorg. Synth., 7, 69 (1963).
2. A. Michaelis, Ann., 326, 179 (1903).
3. Among the phosphorus compounds prepared using DMPADC, *N*,*N*,*N*',*N*'-tetramethyldiamidophosphorochloridates[4] and cyclic phosphates derived from 1,2-diols have served as intermediates for the deoxygenation of alcohols[5] and the conversion of 1,2-diols to olefins,[6] respectively.
4. H.J. Liu, S.P. Lee, and W.H. Chan, Can. J. Chem., 55, 3797 (1977).
5. R.E. Ireland, D.C. Muchmore, and U. Hengartner, J. Am. Chem. Soc., 94, 5098 (1972).
6. J.A. Marshall and M.E. Lewellyn, Synth. Commun., 5, 293 (1975); J. Org. Chem., 42, 1311 (1977).
7. Yields reported are for isolated products.
8. Amidate **2** was prepared from 1-hexadecanol by treatment with DMPADC and *N*,*N*,-*N*',*N*'-tetramethylethylenediamine in DME at room temperature for 36 hr.
9. For reviews see: S.R. Sandler and W. Karo, "Organic Functional Group Preparations", Vol. I, Academic Press, New York, N.Y. 1968, Chapters 2 and 6; C.A. Buehler and D.E. Pearson, "Survey of Organic Syntheses", Wiley-Interscience, New York, N.Y. 1970, Chapters 2 and 7.
10. The authors are grateful to the National Research Council of Canada and the University of Alberta for financial support.

(Received June 14, 1978)