

Synthesis of 2-Oxo-3-phenylimidazolidine-1-carbonyl Chloride

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Abstract

The reaction of phosgene with *N*-methyl-*N*-phenylethane-1,2-diamine, with *N*-phenylethane-1,2-diamine and with 1-phenylimidazolidin-2-one, gives in each case 2-oxo-3-phenylimidazolidine-1-carbonyl chloride. This acid chloride reacts with ammonia to form 1,1'-carbonylbis(3-phenylimidazolidin-2-one).

2-[Methyl(phenyl)amino]ethyl isocyanate (1) was required for use in a study on the chemistry of isocyanates.¹ For the projected synthesis, *N*-methyl-*N*-phenylethane-1,2-diamine (2) was treated with phosgene in the usual manner.² The infrared spectrum of the crude reaction product did not show the characteristic (*c.* 2250 cm⁻¹) band of isocyanates, and the only product isolated was 2-oxo-3-phenylimidazolidine-1-carbonyl chloride (3; X = Cl).

This acid chloride was identified by alkaline hydrolysis which yielded the known *N*-phenylimidazolidin-2-one (4), presumably via the 3-carbamic acid, and by reaction with benzylamine which gave the corresponding *N*-benzylamide (3; X = NHCH₂Ph).

Surprisingly, reaction with ammonia did not give the primary amide but instead gave the triuret derivative, 1,1'-carbonylbis(3-phenylimidazolidin-2-one) (5). This product was also formed from the acid chloride (3; X = Cl) and (4) in the presence of a base. By hydrolysis with dilute alkali (5) was converted into (4).

This work was then extended with the aim of understanding the mechanism of this unexpected conversion of (2) into (3; X = Cl). It was found that the acid chloride (3; X = Cl) could also be obtained by phosgenation of *N*-phenylethane-1,2-diamine (6; Ar = Ph) and in near-quantitative yield by phosgenation of (4).

Obviously a demethylation step occurs in the conversion of (2) into (3; X = Cl) and dealkylation of tertiary amines to form a secondary carbamoyl chloride and an alkyl chloride has been reported³—although this does not always occur.⁴ Further, an oxoimidazolidine-1-carbonyl chloride (3; X = Cl, replace Ph by C₆Cl₅) has been identified⁵ as the product from phosgene and the corresponding *secondary* amine (6; Ar = C₆Cl₅).

¹ Guise, G. B., Jackson, M. B., and Maclaren, J. A., *Aust. J. Chem.*, 1972, **25**, 2583; Dalton, J. R., Kirkpatrick, A., and Maclaren, J. A., *Aust. J. Chem.*, 1976, **29**, 2201.

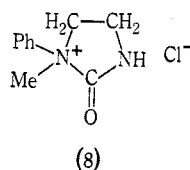
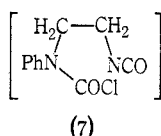
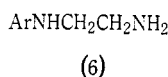
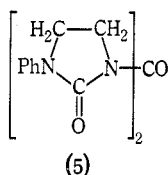
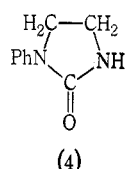
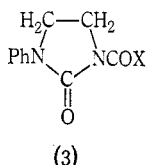
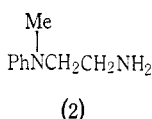
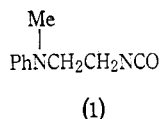
² Siefken, W., *Justus Liebigs Ann. Chem.*, 1949, **562**, 75.

³ Babad, H., and Zeiler, A. G., *Chem. Rev.*, 1973, **73**, 75.

⁴ Peck, R. M., Miller, G. L., and Creech, H. J., *J. Am. Chem. Soc.*, 1953, **75**, 2364.

⁵ Knopf, R. J., *J. Chem. Eng. Data*, 1968, **13**, 582.

Possibly, phosgene could convert (2) into methyl chloride and an intermediate (7), which then could cyclize to (3; X = Cl). An analogy to this last step is seen in the formation of substituted allophanoyl chlorides from the reaction of carbamoyl chlorides with isocyanates.^{6,7} Alternatively* the reaction could proceed via an intermediate (8), which by loss of methyl chloride could give (4), and thence by the known reaction with phosgene to (3; X = Cl).



Experimental

Microanalyses were performed by the Australian Microanalytical Service. Melting points are uncorrected.

2-Oxo-3-phenylimidazolidine-1-carbonyl Chloride (3; X = Cl)

(i) To a solution of phosgene (approx. 25 ml) in toluene (200 ml), cooled in an ethanol-dry ice bath, was added dropwise a solution of *N*-methyl-*N*-phenylethane-1,2-diamine (2) (5.0 g, 34 mmol, ex Fluka) in toluene (50 ml) with constant magnetic stirring. The reaction mixture was then allowed to reach room temperature (2 h) and finally refluxed (2 h). After cooling and purging with dry nitrogen, the solvent was evaporated in a vacuum. The buff-coloured residue was extracted with hot benzene and this extract yielded a colourless solid (2.7 g; 35% theory), m.p. 197–203°. Recrystallization from benzene gave colourless *needles*, m.p. 208–209.5° (Found: C, 53.6; H, 4.1; Cl, 15.7; N, 12.5. C₁₀H₉ClN₂O₂ requires C, 53.5; H, 4.0; Cl, 15.8; N, 12.5%). The infrared spectrum (KBr disc) shows ν_{max} 1600, 1710sh, 1795vs, 3060 cm⁻¹ (substituted allophanoyl chlorides are reported⁶ to absorb at 1745–1718 cm⁻¹). P.m.r. spectrum (CF₃CO₂D) δ 3.9–4.6 (m, 4H), 7.4–7.6 (m, 5H).

(ii) This preparation was carried out as in (i) but the reagent was *N*-phenylethane-1,2-diamine which was prepared by the method of Hicks and Coleman.⁸ The same product (3; X = Cl) was obtained in 33% yield, and also some 1,1'-carbonylbis(3-phenylimidazolidin-2-one) (5) as by-product.

(iii) To phosgene (approx. 5 ml) cooled in an ethanol-dry ice bath and stirred magnetically, a solution of *N*-phenylimidazolidin-2-one (4)⁹ (1 g) dissolved in dry chloroform (35 ml) was added dropwise. The reaction mixture was allowed to reach room temperature, and then a slow stream of phosgene was passed into the refluxing solution for 2 h. After cooling and purging with dry nitrogen the essentially pure product (1.16 g) (3; X = Cl) was filtered off and a further 0.19 g was isolated from the filtrate, giving a total yield of 94% theory.

* The author is indebted to a referee for this suggestion.

⁶ Ulrich, H., Tillye, J. N., and Sayigh, A. A. R., *J. Org. Chem.*, 1964, **29**, 2401.

⁷ Disselnoetter, H., and Holtschmidt, H., Ger. Pat. 2,008,116 (1970) (*Chem. Abstr.*, 1971, **75**, 140285).

⁸ Hicks, Z. A., and Coleman, G. H., *Proc. Iowa Acad. Sci.*, 1946, **53**, 207.

⁹ McKay, A. F., and Braun, R. O., *J. Org. Chem.*, 1951, **16**, 1829.

N^α-Benzyl-2-oxo-3-phenylimidazolidine-1-carboxamide (3; X = NHCH₂Ph)

This was obtained in quantitative yield from the above acid chloride (3; X = Cl) by treatment with excessive benzylamine in chloroform solution, as colourless needles, m.p. 133–134.5° (Found: C, 69.1; H, 5.8; N, 14.1. C₁₇H₁₇N₃O₂ requires C, 69.1; H, 5.8; N, 14.2%). P.m.r. spectrum (CDCl₃) δ 3.7–4.0 (m, 4H), 4.55 (d, 2H), 7.1–7.7 (m, 10H). The mass spectrum showed the molecular ion *m/e* 295 (calc. 295).

N-Phenylimidazolidin-2-one (4)

The above acid chloride (3; X = Cl) (100 mg, 0.445 mmol) was stirred at room temperature for 2 h in a mixture of dioxan (3 ml), water (2 ml) and 1 N NaOH (0.9 ml). After acidification and evaporation of solvent, the product was rubbed with water (2 ml), filtered and then recrystallized from water as colourless plates (69 mg, 95% of theory), m.p. 162–163° (Found: C, 66.8; H, 6.2; N, 17.2. Calc. for C₉H₁₀N₂O: C, 66.6; H, 6.2; N, 17.3%). The infrared spectrum (KBr disc) shows ν_{\max} 1600, 1620 cm⁻¹. P.m.r. spectrum [(CD₃)₂SO] δ 3.2–4.0 (two triplets?, 4H), 6.8–7.2 (m, 5H). The mass spectrum shows the molecular ion at *m/e* 162 (calc. 162). This product was identical with an authentic sample prepared by the method of McKay and Braun.⁹

1,1'-Carbonylbis(3-phenylimidazolidin-2-one) (5)

(i) The acid chloride (3; X = Cl) (0.247 g, 1.1 mmol) was dissolved in dimethylformamide (5 ml) and 15 N aqueous ammonia (0.3 ml) was added with ice cooling. After vacuum evaporation of solvent the residue was rubbed with water and then recrystallized from ethanol–dioxan (0.13 g, 54% yield), m.p. 209–211° (Found: C, 64.8; H, 5.2; N, 16.3. C₁₉H₁₈N₄O₃ requires C, 65.1; H, 5.2; N, 16.0%). The infrared spectrum (KBr disc) shows ν_{\max} 1600, 1667, 1730, 1760, 2890 cm⁻¹. The mass spectrum shows the molecular ion, *m/e* 350 (calc. 350). This same product was also obtained when the reaction was performed in aqueous dioxan or in dry chloroform. However, in this latter reaction mixture, an unidentified by-product was detected by t.l.c. on a silica plate with chloroform/benzene/ethanol, 47 : 47 : 6.

(ii) This product (5) can also be obtained by refluxing equivalent amounts of the acid chloride (3; X = Cl), *N*-phenylimidazolidin-2-one (4) and triethylamine in 1,2-dichloroethane for 4 h.

Hydrolysis of (5)

A suspension of (5) (0.297 g, 0.85 mmol) in aqueous sodium hydroxide (2.12 ml, 1 N) and ethanol (10 ml) was stirred overnight at room temperature, then acidified and evaporated to dryness. The product was stirred with water and filtered to give (4) (0.246 g, 90% theory), m.p. 160–161°.

Acknowledgments

The author is grateful to Mr J. R. Dalton for the infrared spectral data, to Mr D. J. Gale for the p.m.r. spectral data, and to Mr P. C. Davis for the mass spectral data.