ration of the solvent in vacuo, the residue was distilled [bp 63–65 °C (3–4 mm)] to give slightly impure diethyl oxomalonate (1). Redistillation of this material in the presence of a small amount of P_2O_5 afforded 5.8 g (62%) of pure diethyl oxomalonate (1), bp 80–3 °C (4 mm) [lit.[7a] bp 106–108 °C (17 mm); lit.[7b] bp 92–96 °C (11 mm)].

Ethyl Glyoxylate (2a). Diethyl maleate (**5a**; 20 g, 0.116 mol) in 200 mL of dichloromethane was ozonized for 2.25 h at −78 °C. After the blue color of ozone was purged for 15 min with an oxygen flow, the cold solution was added to excess dimethyl sulfide (8.0 g, 0.13 mol) via an addition funnel under nitrogen at 25 °C. The solution refluxed by itself and then was allowed to stir at 25 °C under nitrogen overnight. The solvents and excess dimethyl sulfide were distilled off at atmospheric pressure, and the residue was fractionally distilled through a 20-cm Vigreaux column to give 15.34 g (65%) of ethyl glyoxylate (**2a**) bp 49 °C (35 mm) [lit.[8] bp 40–45 °C (22 mm)]; phenylhydrazone mp 130–132 °C (lit.[12] mp 130.5 °C). When we began with 10 g of diethyl maleate and used 4 g of dimethyl sulfide with removal of solvent and excess dimethyl sulfide on a rotary evaporator, the yield varied from 57% to 65% (6.8–7.7 g). Diethyl fumarate (**6a**) (10 g, 0.058 mol) produced 7.0 g (59%) of ethyl glyoxylate (**2a**).

Methyl Glyoxylate (2b). Dimethyl maleate (**5b**; 10 g, 0.069 mol) in 100 mL of dichloromethane was ozonized and worked up under identical conditions, using 4.76 g of dimethyl sulfide with removal of solvent and excess dimethyl sulfide on a rotary evaporator. The yield of methyl glyoxylate (**2b**) varied from 5.5 to 6.5 g (48.8–53.5%), bp 45–50 °C (29 mm) [lit.[8] bp 55–65 °C (20 mm)]. Dimethyl fumarate (**6b**; 10 g, 0.069 mol) was ozonized and worked up under identical conditions to give 5.7 g (47%) of methyl glyoxylate (**2b**).

Benzyl Glyoxylate (2c). A mixture of dibenzyl maleate (**5c**) and dibenzyl fumarate (**6c**) (prepared from maleic acid and benzyl alcohol; 20 g, 0.0675 mol) in 200 mL of dichloromethane was ozonized at −78 °C for 2.25 h. Normal workup with excess dimethyl sulfide (4.66 g, 0.075 mol), rotary evaporation of solvent and excess dimethyl sulfide, and distillation produced 7.9 g (36%) of benzyl glyoxylate (**2c**), bp 130–132 °C (25 mm).

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Registry No. 1, 609-09-6; **2a**, 924-44-7; **2a** phenylhydrazone, 80447-71-8; **2b**, 922-68-9; **2c**, 52709-42-9; **4**, 1462-12-0; **5a**, 141-05-9; **5b**, 624-48-6; **5c**, 622-06-0; **6a**, 623-91-6; **6b**, 624-49-7; **6c**, 538-64-7.

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Conversion of Acyclic Amines to Amides by Chlorine Dioxide

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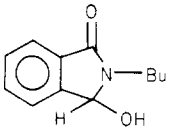
Chlorine dioxide (ClO_2) is well-known to react with aliphatic amines to give products of oxidative dealkylation or, in the presence of a β-hetero atom, oxidative fragmentation.[1] In most cases a single mechanism, involving rate-determining formation of an aminium cation radical, is operative.[1] Meta- and para-substituted benzyldimethylamines are unexceptional;[2] however, with benzyl-*tert*-butylamine and dibenzylamine, α-hydrogen abstraction competes with electron abstraction, and with benzylamine it is the predominant rate-determining process.[3] Kinetic studies had been carried out under pseudo-first-order conditions with a large excess of amine at controlled pHs (range 6–9), and product analyses were done following reaction of ClO_2 with excess or stoichiometric equivalents of the amine. Under these conditions only cleavage products were found.[1-3]

We here report that, for certain amines having an active α-methylene group, reaction with excess ClO_2 leads to a significant amount of amide formation in competition with oxidative dealkylation. An example is dibenzylamine (**1**, Table I). To determine the extent of competition between two different α-methylene groups in amide formation, we studied the reaction of ethyl *N*,*N*-dibenzylglycinate (**2**)[4] under different conditions of pH and solvent. Over the pH range 4–7 in the optimum medium, 1:1 acetonitrile–water, product composition did not greatly vary, and amides constituted 20–30% of the products. Of the two isomeric amides derived directly from **2**, **4** predominated by a factor of 3–5. Table I summarizes the results of a typical run. Below pH 4 (pH 2.5–3), **2** was consumed less readily, and the yields of amides were lower, with **4** still predominant.

While amide formation by ClO_2 has not been previously reported, the extent of competitive cleavage reactions under the above conditions precluded synthetic utility in these cases. However, treatment of **2** with ClO_2 generated in situ[5] from the reaction of chlorite and HOCl at pH 2.5–3 gave amides **4** and **5** in a combined yield of 80%, with **5** predominating (Scheme I). These amides were readily separated by preparative TLC. At higher pH the in situ reaction was slower, and the yields of amides were lower. It should be emphasized that HOCl alone at pH 2.8 gave only cleavage products, while chlorite alone was inert.

Previously reported conversions of amine α-methylene groups to carbonyls have been generally limited to cyclic amines. For example, ruthenium tetraoxide was useful for the oxidation of N-substituted pyrrolidines to amides, and in some cases further to imides.[6] *N*-Arylpyrrolidones were obtained on ozonation of *N*-arylpyrrolidines,[7] and air oxidation of *N*-butylisoindoline gave predominantly *N*-butylphthalimidine and *N*-butylphthalimide.[8] Some years prior to initiation of this work, *N*-butyl-3-hydroxyphthalimidine (**6**) had been observed in our laboratory as



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the major product of ClO_2 treatment of *N*-butylisoindoline.[9] We now anticipate that ClO_2 may be of general utility in the oxidation of active α-methylene groups in acyclic amines as well.

In addition to this practical aspect, the observed predominance of amide **4** over **5** except in the in situ reaction at low pH may be of some mechanistic significance. In the

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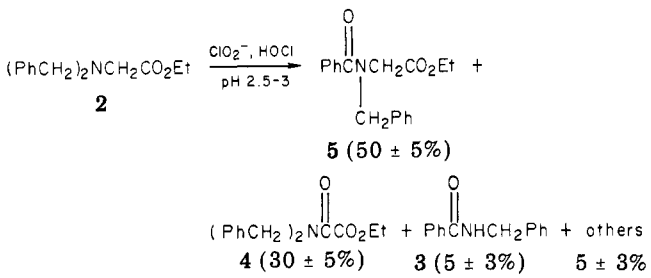
Table I. Products (mol %) of the Reaction of Acyclic Amines with Excess ClO_2 at pH 6.8

	PhCHO[a]	$PhCH_2NH_2$[a]	1	PhCH=NCH$_2$Ph[a]	$(HO)_2CHCO_2Et$[a]	3[a]	4	5	others
1[b]	trace	4	38[c]	27		16			15
1[d]	9	12	16[c]	25		24			14
2[b]	trace	0	23	12	27	5	21	4	8

[a] Identified on the basis of its mass spectrum. [b] One hour. [c] Starting material. [d] Two hours.

Scheme I



reactions of preformed ClO_2, loss of the more acidic proton from the initial aminium cation radical[10] appears to be the preferred process, whereas in the in situ case at low pH, direct abstraction of the α-hydrogen to give the more stable radical (benzyl vs. glycine α-carbon) may be favored. Thus the possibility of a difference in mechanism with the two reagents, preformed and in situ generated, suggested earlier by the observation of different ratios of cleavage products from benzyldimethylamines in the two cases,[2] remains to be investigated.

Experimental Section

A Hewlett-Packard Model 5985B gas chromatograph/mass spectrometer/data system (GC/MS/DS) equipped with a 180 × 0.2 cm glass column packed with 3% OV-1 on Gas Chrom Q was used for product analyses. High-resolution mass spectra were determined by the Middle Atlantic Mass Spectrometry Laboratory, The Johns Hopkins University School of Medicine. TLC separations were performed on Merck silica gel F-254 plates (0.25-mm thickness) with 1:1 hexane–ether as the eluant. The melting point (uncorrected) was determined on a Thomas-Hoover capillary apparatus. The ClO_2 solution (0.017 M) was prepared from reagent grade potassium persulfate and sodium chlorite.[11]

General Procedure for Chlorine Dioxide Oxidations. Solutions of the amine (1×10^{-2} mmol for 1, 5×10^{-3} mmol for 2) in acetonitrile (2.5 mL) and ClO_2 (2 mL of the 0.017 M solution in 0.5 mL of 0.1 M phosphate buffer, pH 6.8) were mixed and allowed to stand 1–2 h. For experiments at lower pH, dilute $HClO_4$ was added dropwise to the buffered ClO_2 solution before mixing. After the reaction, the mixtures were saturated with NaCl and, if necessary, adjusted to neutrality before extraction with CH_2Cl_2. The dried CH_2Cl_2 extracts were evaporated to dryness without heating, and the residues were dissolved in acetone for analysis by GC/MS.

Ethyl *N*,*N*-Dibenzyloxamate (4) and Ethyl *N*-Benzoyl-*N*-benzylglycinate (5) Formed with in Situ Generated ClO_2. A mixture of 2 (38 mg, 0.132 mmol), 0.16 M $NaClO_2$ (50 mL), 0.08 M NaOCl (50 mL), and 1 M $HClO_4$ (4.7 mL) had pH 2.6. It was stirred 1.5 h, adjusted to pH 6 with dilute KOH, and saturated with NaCl before extraction with two portions of CH_2Cl_2. The organic products (37 mg) were analyzed by GC/MS before separation and isolation of the two major amides by TLC: high-resolution mass spectrum, calcd for $C_{18}H_{19}NO_3$ m/e 297.1360, found for 4 m/e 297.1369, found for 5 m/e 297.1363. Characteristics of 4: mp 81–82 °C; IR (KBr) 1730, 1630 cm^{-1}; mass spectrum, m/e (relative intensity) 297 (1.5), 206 (97), 132 (21), 91 (100). Characteristics of 5: colorless syrup; IR (CCl_4) 1740, 1640 cm^{-1}; mass spectrum, m/e (relative intensity) 297 (1.2), 192 (90), 105 (100), 91 (23).

Registry No. 1, 103-49-1; 2, 77385-90-1; 3, 1485-70-7; 4, 80326-96-1; 5, 80326-97-2; PhCHO, 100-52-7; $PhCH_2NH_2$, 100-46-9; PhCH = NCH_2Ph, 780-25-6; $(HO)_2CHCO_2Et$, 64805-08-9; ClO_2, 10049-04-4.

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Some Reactions of Lithium α-Lithiocyclopropanecarboxylate[1]

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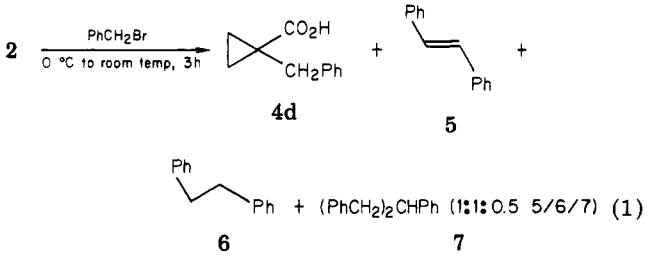
The authors[3] of a recent paper on the chemistry of ethyl cyclopropanecarboxylate report that the dianion (2) of cyclopropanecarboxylic acid (1) failed to react with acetic acid-*d*, D_2O, benzyl bromide, or methyl iodide. By implication, this calls into question the reported[4] trapping of 2 with Me_3SiCl at 0 °C. Our interest in 2 stemmed from the notion that decarboxylation might be possible, whereby the theoretically significant[5] 1,1-dilithiocyclopropane (3) would arise. While we cannot report having achieved decarboxylation, we do document the successful alkylation of 2 (Scheme I).

Table I summarizes the results of treating 2 with various electrophiles at room temperature.[6] It should be noted that 2 was completely soluble at temperatures above 0 °C; below that, however, precipitation of the dianion occurred. The main conclusion is that alkylation of 2 does indeed occur, although the conversions tend to be low (not helped by adding HMPA[7]), and side reactions intercede. These latter include elimination (with *n*-BuI) and coupling reactions[8-10] (with benzyl bromide, eq 1). In an effort to



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