acid, humic acid and humin fractions after 30 days were 3.5, 10.1 and 7.2, and after 60 days were 5.5, 14.5 and 13.1, respectively.

The data reported in this paper indicate that DBSC was rapidly degraded to form I. Compound I was hydrolyzed at the carbamate ester to form IV which, in turn, was bound to the soil organic matter. DBSC appeared to loosely bind to the soil at the time of fortification by hydrophobic interaction of the dibutylaminosulfenyl group with the soil organic matter.

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Degradation of 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl (Morpholinosulfenyl)methylcarbamate in Cosad Sandy Loam

Val E. Clay, James P. Martin,[1] and T. Roy Fukuto*

MSC [FMC-31768 or 2,3-dihydro-2,2-dimethyl-7-benzofuranyl (morpholinosulfenyl)methylcarbamate] was degraded rapidly in Cosad sandy loam with a half-life of about 2 days. Carbofuran and carbon dioxide were the only major degradation products identified. The thiolysis of MSC was first order.

INTRODUCTION

Clay et al. (1980) described the fate in Cosad sandy loam of FMC-35001 [2,3-dihydro-2,2-dimethyl-7-benzofuranyl (di-*n*-butylaminosulfenyl)methylcarbamate], a dialkylaminosulfenyl derivative of carbofuran. FMC-31768 [2,3-dihydro-2,2-dimethyl-7-benzofuranyl (morpholinosulfenyl)methylcarbamate, hereinafter referred to as MSC] is another dialkylaminosulfenyl derivative of carbofuran which has shown good insecticidal activity and lower toxicity to mammals (Fukuto et al., 1974). The metabolic fate of MSC in corn and cotton plants and the stability of MSC in aqueous buffers was recently described (Umetsu et al., 1979). This report is concerned with the alteration of MSC in aerobic Cosad sandy loam.

MATERIALS AND METHODS

The physical properties, storage and preparation of the Cosad sandy loam used in this study were described previously (Clay et al., 1980).

[*carbonyl*-^{14}C]MSC (specific activity 14.36 mCi/mmol) was provided by FMC Corp. and purified by column chromatography according to Umetsu et al. (1979). The final radiochemical purity was 98.2%. D-Glucose-*UL*-^{14}*C* (specific activity 220 mCi/mmol) was obtained from Mallinckrodt. The structures of MSC and nonradioactive standards are shown in Table I. Compounds I through XIX were available from previous studies (Umetsu et al., 1979).

Soil Incubations. The incubation apparatus was described previously by Clay et al. (1980). Radiolabeled compounds were incorporated into the soil from ethanol solutions by adding appropriate volumes (not greater than 100 μL) of stock solution to 5–10 g of soil in a mortar. After evaporation of the ethanol, the treated soil was pulverized and added to 40–45 g of soil (total of 50 g of soil). The soil was mixed for 2 min and then moistened to 70% holding capacity ($\sim^1/_3$ bar).

Extraction Procedure. All solvents were redistilled prior to use or were of chromatographic quality. Soil treated with MSC was moistened with 58 mL of water and 50 mL of methanol and thoroughly mixed for 15 min. After the addition of 100 mL of chloroform, the mixture was stirred for 30 min and filtered, and the aqueous (aqueous extract) and organic (organic extract) phases were separated. The organic extract was dried over sodium sulfate, passed through a short Florisil column, and concentrated under reduced pressure. The concentrate was analyzed as previously described (Clay et al., 1980).

RESULTS AND DISCUSSION

[^{14}C]Glucose Metabolism. [^{14}C]Glucose (10 ppb) was incubated in soil treated with 3 and 30 ppm of MSC. Approximately 40–45% and 30–35% of the applied radioactivity was recovered as [^{14}C]carbon dioxide after 19 days from the treated and nontreated soils under aerobic and anaerobic conditions, respectively. These data indicate that MSC does not inhibit the metabolism of glucose by the soil microbes.

Degradation of MSC. Results summarizing the fate of [*carbonyl*-^{14}C]MSC in aerobic soil up to 30-days incubation are presented in Table II. The data show that MSC was rapidly degraded, yielding I as the principal product. Other than I, the only organosoluble radioactive product was a small amount of one unknown compound.

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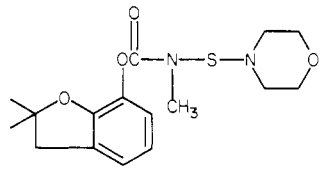
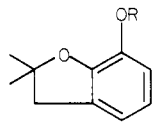
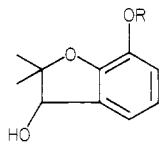
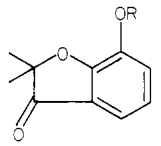
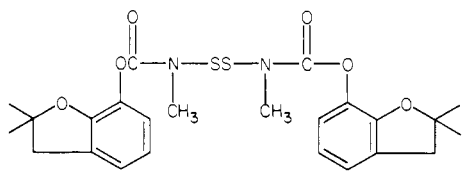
Table I. Structures of MSC and Authentic Standards.

	R	designation
		MSC
	$C(O)NHCH_3$ $C(O)NHCH_2OH$ $C(O)NH_2$ H	I (carbofuran) II III IV
	$C(O)NHCH_3$ $C(O)NHCH_2OH$ $C(O)NH_2$ H	V VI VII VIII
	$C(O)NHCH_3$ $C(O)NHCH_2OH$ $C(O)NH_2$ H	IX X XI XII
		XIII

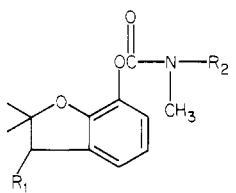
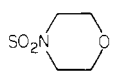
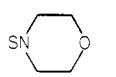
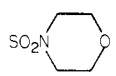
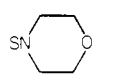
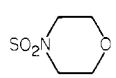
	R_1	R_2	designation
	H		XIV
			XV
	HO		XVII
	HO		XVIII
	O		
	O		XIX

Table II. Percentage of Applied Radioactivity Recovered as MSC and Degradation Products from Aerobic Cosad Sandy Loam after Treatment with 35 ppm of [*carbonyl*-^{14}C]MSC

	incubation time, days					
	0	2	5	13	16	30
carbon dioxide		0.9	2.6	13.4	14.8	32.4
aqueous extract	0.5	3.2	3.9	5.5	3.5	2.0
organic extract	98.4	88.9	91.9	84.5	82.1	62.8
MSC	90.8	31.6	3.5	1.4	0.9	0.8
I	5.9	55.4	86.6	82.3	80.6	61.5
unknown	1.8	1.9	1.9	0.8	0.6	0.5
total recovered	98.9	93.0	98.4	103.4	100.4	97.2

The unknown (R_f 0.67) chromatographed above MSC (R_f 0.54) on silica gel TLC plates developed in benzene–methanol (19:1). The degradation of MSC was first order, and the half-life was about 2 days. The decrease in the amount of I after 5 days was accompanied by a commensurate increase in the amount of evolved [^{14}C]carbon dioxide, indicating that the [^{14}C]carbon dioxide was produced by the decomposition of I and not MSC.

Overall, these data indicate that the degradation of MSC is very similar to that of DBSC. The thiolysis of *N*-alkylsulfenyl derivatives of carbonfuran appears to be a simple first-order reaction, yielding carbofuran.

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