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CONCLUSIONS:

Degradation - Photodegradation in Water

1. This study cannot be used to fulfill data requirements at this time. It does not meet EFGWB standards because concentrations of parent and photodegradates in the irradiated solutions were only analyzed for later samples. The submitted data has not established that the process is linear over the time range studied. Therefore, it cannot be assumed that unreported degradates are necessarily present at levels less than those reported.

   In order for the study to be upgraded, the registrant must provide the photodegradate distributions for the nonsensitized samples collected at 21.0 and 46.75 hours postirradiation. Also, they must provide an explanation for the apparent increase in concentration of parent MON 13900 detected at the final sampling interval when the acidic and neutral fractions of the nonsensitized solution were analyzed using HPLC gradient 3 (see Comment 2).

2. MON 13900 photodegraded readily, with a half-life of 4.2 days in a nonsensitized sterile aqueous buffered solution (pH 7) that was continuously irradiated with a xenon light source at approximately 25 C; the half-life decreased to approximately 2 hours when a sensitizer (humic acid) was added to the solution. The registrant estimated that MON 13900 would have photodegraded with half-lives of 29.9 days and 7.85 hours in the nonsensitized and sensitized solutions, respectively, in natural sunlight assuming 12 hours of sunlight per day. MON 13900 did not degrade in similar solutions when incubated in darkness. The major degradates identified in the irradiated nonsensitized and sensitized solutions were N-(dichloroacetyl)glycine and 3-(dichloroacetyl)-2,2-dimethyl-5-oxazolidinylcarboxylic acid.

METHODOLOGY:

Filter-sterilized (0.2 um) 0.01 M potassium phosphate buffer solution (pH 7) was placed in a Pyrex glass photolysis cell, oxygenated for 30 minutes, then treated with oxazolidine ring-labeled [4-$^{13}C/^{14}C$]MON 13900 (radiochemical purity >98%, specific activity 0.25 mCi/mMol, Monsanto) plus unlabeled MON 13900 (purity >99%, Monsanto), dissolved in acetonitrile, at a nominal concentration of 50 ppm; the final concentration of the cosolvent (acetonitrile) was 0.05%. The treated solution was stirred for 25 hours, then aliquots were analyzed for total radioactivity using LSC and the actual treatment rate was determined to be 48.5 ppm. The remaining treated solution was continuously irradiated using a xenon arc lamp (total intensity 182.3 mW/cm^2 at 300-750 nm; Table 14). The solution was stirred during irradiation and maintained at 24-26 C using cooling coils within the photolysis cell that were attached to a circulating coolant bath (Figure 2). The Pyrex glass of the photolysis cell was used to eliminate radiation below 290 nm (Figure 11); the distance from the photolysis cell to the xenon lamp was 10 cm. It was reported that the intensity of the xenon lamp was approximately 3.5X greater than that of natural sunlight at 300-750 nm (total intensity 51.6 mW/cm^2 at noon on June 21 at St. Louis, MO; Table 12 and Figure 10), and that 3.4 hours of irradiation with the xenon lamp was equivalent to 1 day of sunlight (assuming 12 hours of sunlight per day). A "trapping tower" containing sequentially, from bottom to top, two foam plugs, a 15-g layer of Drierite, two 10- to 12-g layers of Ascarite II, and a final 12-g layer of Drierite was wrapped in aluminum foil and attached to the photolysis cell to trap [^{14}C]volatiles and $^{14}CO_2$. For a dark control, additional pH 7 buffer solution was placed in a flask, treated with oxazolidine ring-labeled [4-$^{13}C/^{14}C$]MON 13900 at 45.3 ppm, and incubated in darkness at 25 C; a foam plug was placed in the neck of the flask to trap any [^{14}C]volatiles. Irradiated and dark control solutions were sampled after 0, 21.0, 46.75, 69.9, 105.5, and 142.5 hours of irradiation; sampling intervals were not reported in terms of hours posttreatment. The trapping tower attached to the photolysis cell and foam plug in the dark control flask were collected and replaced (as necessary) at 46.75, 105.5, and 142.5 hours postirradiation.

Triplicate aliquots (0.6-1.1 g) of each sample were analyzed for total radioactivity using LSC. An additional aliquot (1 mL) was analyzed for MON 13900 by reverse HPLC using UV (254 nm) and radioactivity detection on a Brownlee CS-GU Speri-5 Cyano precolumn followed by a Beckman Altex Ultrasphere-CN column eluted with an isocratic and linear gradient mobile phase of acetonitrile and 0.002 M dibasic ammonium phosphate. Radioactive compounds were identified by comparison to retention times of unlabeled reference MON 13900.

Foam plugs from the trapping tower and dark control flask were placed in scintillation cocktail and analyzed for total radioactivity using LSC. Ascarite from the trapping towers was placed in a flask and dissolved in distilled water. The flask was immersed in ice, then adsorbed $^{14}CO_2$ was released from the Ascarite using concentrated sulfuric acid and trapped in phenethylamine solution; the trapping solution was analyzed for total radioactivity using LSC.

To characterize photoproducts, the 69.9-, 105.5-, and 142.5-hour irradiated samples were fractionated into neutral and acidic fractions using anion exchange chromatography. The samples were applied to a column of AG 1-X2 anion exchange resin, then neutral (non-acidic) compounds were eluted with 50% aqueous methanol and acidic compounds were eluted with 1 N ammonium carbonate in 50% aqueous methanol. Aliquots of each fraction were analyzed for total radioactivity using

LSC. The remaining portion of each fraction was concentrated and analyzed by HPLC using UV (254 nm) and radioactivity detection on either a Bio-Rad Aminex HPX-87H column eluted with an isocratic and linear gradient mobile phase of acetonitrile and 0.01 N sulfuric acid, or a Brownlee RP-18 precolumn followed by a Beckman Altex Ultrasphere-ODS column eluted with an isocratic and linear gradient mobile phase of acetonitrile and 0.002 M dibasic ammonium phosphate. Photoproducts were also identified using GC with flame ionization and radioactivity detection, GC/MS with electron and chemical ionization, direct probe MS (DP/MS) with electron and chemical ionization, LC/MS on a Water u-Bondapak C-18 column eluted with a linear gradient of 5 to 95% aqueous methanol, high resolution MS in the electron ionization mode, NMR, and high voltage electrophoresis.

The photolysis of MON 13900 in the presence of a sensitizer was also investigated. Approximately 489 g of pH 7 buffer solution was placed in a flask and sensitized with 25 ppm humic acid, sodium salt. The solution was then sterilized, oxygenated, and treated with oxazolidine ring-labeled [4-^{13}C/^{14}C]MON 13900 plus unlabeled MON 13900 at 49.0 ppm. The treated solution was stirred for 18 hours and analyzed for total radioactivity using LSC. A 320.3-g aliquot of the treated solution was placed in the photolysis cell and irradiated as described above. The remaining treated solution was incubated in darkness at 25 C. The irradiated solution was sampled after 0, 0.07, 0.18, 0.32, 0.52, 1.23, 5.13, 5.32, 27.0, 51.45, 75.93 and 122.9 hours of irradiation. The dark control solution was sampled at the 5.32-, 51.45-, 75.93-, and 122.9-hour irradiation sampling intervals. The trapping tower attached to the photolysis cell and foam plug in the dark control flask were collected and replaced (as necessary) at 51.45 and 122.9 hours postirradiation. The irradiated and dark control samples were analyzed for parent MON 13900, and the 0.32-, 27.0-, 51.45-, and 75.93-hour irradiated samples were analyzed for photoproducts as described above. Foam plugs and Ascarite were analyzed for total radioactivity as described above.

To produce additional material for photoproduct characterization, sterile sensitized (25 ppm humic acid) pH 7 buffer solution was placed in the photolysis cell (no trapping tower), treated with oxazolidine ring-labeled [4-^{13}C/^{14}C]MON 13900 plus unlabeled MON 13900 at 80 ppm, and irradiated for 64.3 hours as described above. At the end of the irradiation period, the test solution was analyzed for MON 13900 and photoproducts as described above. In addition, the acidic fraction was either derivatized with n-butanol:sulfuric acid to form n-butyl esters of the acidic compounds, or with diazomethane to form methyl esters of carboxylic acids; derivatized compounds were analyzed by GC with radioactivity detection and GC/MS with chemical ionization.

DATA SUMMARY:

Oxazolidine ring-labeled [4-^{14}C]MON 13900 (radiochemical purity >98%), at 48.5 ppm, photodegraded with a reviewer-calculated half-life of 4.2 days (101.5 hours) in nonsensitized sterile buffered solution (0.01 M phosphate, pH 7) that was continuously irradiated with a Pyrex glass-filtered xenon arc lamp (intensity 182.3 mW/cm^2 at 300-750 nm) at 24-26 C for 5.9 days (142.5 hours); the registrant calculated a theoretical half-life of 29.9 days in natural sunlight. The intensity of the lamp was reported to be approximately 3.5X greater than noontime sunlight in June at St. Louis, Missouri, and 3.4 hours of irradiation with the xenon lamp was equivalent to 1 day of sunlight assuming 12 hours of sunlight per day. In contrast, $[^{14}C]$MON 13900 did not degrade in a similar solution incubated in the dark. The major degradate in the irradiated nonsensitized solution was N-(dichloroacetyl)glycine (Fraction X)(Table 11).

In the irradiated <u>nonsensitized</u> solution at 5.9 days postirradiation,

MON 13900 comprised 48.0% of the radioactivity recovered from the solution

N-(dichloroacetyl)glycine comprised 9.2%

3-(dichloroacetyl)-2,2-dimethyl-5-oxazolidinylcarboxylic acid (MON 13900 oxazolidine acid; Fraction XI) comprised 8.3%,

Fraction IX (tentatively identified as either 3-[(dichloroacetyl)amino]-2-hydroxypropanoic acid, 3-[(dichloroacetyl)amino]-2-oxopropanoic acid, or N-(dichloroacetyl)-β-alanine) comprised 7.1%

four unidentified acidic $[^{14}C]$compounds were each ≤8.6%

six unidentified neutral $[^{14}C]$compounds were each ≤4.2% (Tables 3 and 11).

At 142.5 hours postirradiation, evolved $^{14}CO_2$ totaled 1.5% of the applied radioactivity (Table 6). In the nonsensitized dark control at the 142.5-hour irradiation sampling interval, only MON 13900 was identified. Material balances were 102.0% of the applied from the irradiated solution and 108.8% from the dark control (Table 6).

In irradiated <u>sensitized</u> (25 ppm humic acid) sterile pH 7 buffered solution, Oxazolidine ring-labeled $[4-^{14}C]$MON 13900, at 49.0 ppm, photodegraded with a reviewer-calculated half-life of 2.2 hours ; the registrant calculated a theoretical half-life of 7.85 hours in natural sunlight. In contrast, $[^{14}C]$MON 13900 did not degrade in a similar solution incubated in the dark.

At 3.2 days (75.93 hours) postirradiation,

MON 13900 comprised 2.9% of the radioactivity recovered from the solution

N-(dichloroacetyl)glycine comprised 23.5% (maximum 39.5% at 51.45 hours)

MON 13900 oxazolidine acid comprised 12.6%

Fraction IX comprised 11.7% (maximum 12.3% at 27.0 hours)

Fraction VI (tentatively identified as either 1-(dichloroacetyl)-2-(2-furanyl)-2,5-piperazinediol or 4-(dichloroacetyl)-5-(2-furanyl)-1,2,3,4-tetrahydropyrazinol) comprised 3.6% (maximum 12.0% at 27.0 hours)

the remaining twelve unidentified acidic and neutral $[^{13}C/^{14}C]$compounds were each ≤9.0% (Table 11).

At 122.9 hours postirradiation, evolved $^{14}CO_2$ totaled 4.9% of the applied radioactivity (Table 8). Material balances were 98.8% of the applied from the irradiated solution and 107.7% from the dark control (Table 7).

COMMENTS:

1. For the nonsensitized irradiated solution, concentrations of parent and photodegradate were given for the samples collected at 69.9, 105.5, and 142.5 hours postirradiation, but not for the samples collected at 0, 21.0, and 46.75 hours postirradiation. If these samples were analyzed, the applicant should provide those results.

2. The concentrations of parent MON 13900 detected in the nonsensitized solution and presented in Table 10 (data reported as percent HPLC distribution) and Table 11 (data reported as percent of solution-contained radioactivity) were obtained using HPLC gradient 3 and appear to disagree with the concentrations of MON 13900 presented in Table 3 (data reported as percent HPLC distribution) that were obtained using HPLC gradient 1. In Table 10, MON 13900 comprised 64.7% of the HPLC distribution at 69.9 hours postirradiation, 59.8% at 105.5 hours, and 82.9% at 142.5 hours; however, in Table 3, MON 13900 comprised 69.67, 55.9, and 37.78% of the HPLC distribution, respectively, at the same sampling intervals. The registrant must address why the concentration of parent MON 13900 detected appeared to increase at the final sampling interval when the acidic and neutral fractions of the nonsensitized solution were analyzed using HPLC gradient 3. The registrant and the Dynamac reviewer calculated the half-lives of photodegradation using the concentrations of MON 13900 detected in the nonsensitized and sensitized solutions analyzed with HPLC gradient 1 (Tables 3 and 4).

3. Sampling intervals were reported in terms of hours postirradiation rather than in terms of hours posttreatment. It was reported that for the nonsensitized solution, the pH 7 buffer solution was treated, stirred for 25 hours, then analyzed for total radioactivity to determine the actual treatment rate. Irradiation of the nonsensitized solution was initiated September 27, 1988; however, it was not reported on what date the solution was initially treated. The dark control solution was sampled at the same intervals as the irradiated solution; it was not reported on what date the dark control solution was prepared. Since MON 13900 does not degrade in pH 7 buffer solution when maintained in darkness, reporting the sampling intervals in terms of hours postirradiation does not have any significant impact on the outcome of the review of this study; however, reporting the sampling intervals in terms of hours posttreatment is standard practice.

4. Output of the xenon lamp was measured by placing the lamp in front of the entrance slit of an excitation monochromator. It was not specified if the reported intensities of the xenon arc lamp (Tables 13 and 14) were measured at the same distance (10 cm) that the photolysis cell containing the treated solutions was placed from the lamp.

5. Absorption spectra of the test substance in pH 7 buffer solution and sensitized (humic acid) buffer solution are provided in Figures 7 and 9, respectively.

6. It was reported that samples were analyzed for parent MON 13900 within 1 hour after collection. The remaining portion of each sample was stored at -4 C until further analysis. To demonstrate stability of the samples during storage, it was reported that in the 142.5-hour nonsensitized irradiated sample MON 13900 comprised 37.8% of the recovered radioactivity on the day of sampling, 38.7% of the recovered after 15 days of frozen storage, and 42.9% of the recovered after 75 days of storage. In addition, HPLC analysis of the sample after 15 and 75 days of storage indicates similar photoproduct profiles (Figures 47a and 47b).

It was also reported that repeat analyses of acidic and neutral fractions from irradiated samples after freezer storage indicated that degradation did not occur; however, no data were provided.

7. Using first order kinetics where x = time and y = ln(concentration of MON 13900), the Dynamac reviewer calculated half-lives for MON 13900 of 101.5 hours (4.2 days) (r^2 = 0.9810) in the nonsensitized solution and 2.2 hours (r^2 = 0.9880) in the sensitized solution (using data points up to 5.32 hours postirradiation).

8. The aqueous solubility of MON 13900 was reported to be 214 ppm.

9. The registrant reported that MON 13900 [3-(dichloroacetyl)-5-(2-furanyl)-2,2-dimethyloxazolidine] is a safener intended for use with chloroacetanilide and sulfonylurea herbicides in corn and sorghum. The maximum projected use rate for MON 13900 is 0.4 lb/A.

10. The registrant reported that for studies conducted using radiolabeled MON 13900, the compound was synthesized with the radiolabel in the carbon atom adjacent to the nitrogen in the oxazolidine ring portion of the molecule. Studies were not conducted with the compound labeled in the furan ring portion of the molecule because degradation of the radiolabeled furan ring would result in radiolabeled ring fragments that would be natural products composed of low numbers of carbon, hydrogen, and oxygen atoms.

Table 3. Quantification of MON 13900 in the Unsensitized Aqueous Photolysis Experiment

Timepoint	Lamp Hours	Sunlight Hours	Sunlight Days	Total PPM[a]	MON 13900		
					% Dist[b]	PPM	ln(PPM)[c]
IRRADIATED							
Initial	0.00	0.00	0.00	48.5	99.62	48.3	3.878
1	21.00	74.13	6.18	49.7	92.12	45.8	3.824
2	46.75	165.03	13.75	49.7	82.00	40.8	3.708
3	69.90	246.75	20.56	49.3	69.67	34.4	3.537
4	105.50	372.42	31.03	48.7	55.90	27.2	3.304
5	142.50	503.03	41.92	48.3	37.78	18.2	2.903
CONTROL							
Initial	0.00	0.00	0.00	45.3	99.72	45.2	3.810
1	21.00	74.13	6.18	46.9	99.57	46.7	3.844
2	46.75	165.03	13.75	47.6	99.42	47.3	3.857
3	69.90	246.75	20.56	48.2	99.59	48.0	3.871
4	105.50	372.42	31.03	49.0	99.60	48.8	3.888
5	142.50	503.03	41.92	49.9	99.38	49.6	3.904

[a] PPM expressed as MON 13900 equivalents.

[b] Percent of HPLC/RAD distribution using HPLC Gradient 1.

[c] Data for irradiated samples plotted in Figure 13.

Table 6. Recovery of Applied ^{14}C-Radioactivity from the MON 13900 Unsensitized Aqueous Photolysis Experiment

Sample	Sample Weight (g)	DPM/g	Total DPM in Sample	% of Applied DPM
IRRADIATED				
Initial Solution	333.02	97102	32336908	100.0
Samples Removed	10.00	97102	971020	3.0
	10.00	99602	996020	3.1
	10.00	99581	995810	3.1
	10.00	98828	988280	3.1
	10.00	97584	975840	3.0
	10.00	96680	966800	3.0
Solution Remaining	275.12	96680	26598602	82.3
Volatiles			10455	<0.1
CO2			491431	1.5
TOTAL RECOVERY			32994258	102.0
CONTROL				
Initial Solution	170.30	90696	15445529	100.0
Samples Removed	10.00	90696	906960	5.9
	10.00	94000	940000	6.1
	10.00	95349	953490	6.2
	10.00	96584	965840	6.3
	10.00	98076	980760	6.3
	10.00	99988	999880	6.5
Solution Remaining	110.30	99988	11028676	71.4
Volatiles			30268	0.2
TOTAL RECOVERY			16805874	108.8

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Table 7. Recovery of Applied ^{14}C-Radioactivity from the MON 13900 Sensitized Aqueous Photolysis Experiment

Sample	Sample Weight (g)	DPM/g	Total DPM in Sample	% of Applied DPM
IRRADIATED				
Initial Solution	320.29	98122	31427495	100.0
Samples Removed	10.00	98122	981220	3.1
	10.00	97930	979300	3.1
	10.00	98200	982000	3.1
	10.00	97936	979360	3.1
	10.00	98163	981630	3.1
	10.00	98158	981580	3.1
	10.00	98038	980380	3.1
	10.00	98118	981180	3.1
	10.00	96422	964220	3.1
	10.00	94302	943020	3.0
	10.00	92345	923450	2.9
Solution Remaining	211.05	89256	18837479	59.9
Volatiles			6423	<0.1
CO2			1534878	4.9
TOTAL RECOVERY			30983057	98.8
CONTROL				
Initial Solution	151.98	98122	14912582	100.0
Samples Removed	10.00	99217	992170	6.7
	10.00	104128	1041280	7.0
	10.00	106044	1060440	7.1
	10.00	106539	1065390	7.1
Solution Remaining	111.76	106539	11906799	79.8
Volatiles			2460	<0.1
TOTAL RECOVERY			16068539	107.7

Table 8. Generation of $^{14}\mathrm{CO}_2$ From the MON 13900 Aqueous Photolysis Experiments, Irradiated Solutions[a]

Timepoint	Lamp Hours	Sunlight Days	% of Applied DPM $^{14}\mathrm{CO}_2$	 Cumulative $^{14}\mathrm{CO}_2$
Unsensitized Experiment				
2	46.75	13.75	0.1	0.1
4	105.5	31.03	0.7	0.8
5	142.5	41.92	0.8	1.5
Sensitized Experiment				
9	51.45	15.13	1.3	1.3
11	122.9	36.15	3.6	4.9

[a] $^{14}\mathrm{CO}_2$ was not trapped from the dark control solutions.

Table 9. Distribution of ^{14}C-Radioactivity in Fractions from the Anion Exchange Chromatography of Solutions from the MON 13900 Aqueous Photolysis Experiments

Timepoint	Lamp Hours	Sunlight Days	PPM[a]	% of Solution-Contained Radioactivity Unretained (Neutral)	 Retained (Acidic)	 Remaining on AG 1 Resin[b]
Unsensitized Experiment						
3	69.90	20.56	49.3	79.1	18.9	2.0
4	105.50	31.03	48.7	62.5	25.1	9.7
5	142.50	41.92	48.3	58.0	37.4	4.6
Sensitized Experiment						
3	0.32	0.09	48.9	82.3	9.6	8.1
8	27.00	7.94	48.1	41.2	53.3	5.5
9	51.54	15.16	47.1	26.4	62.0	11.6
10	75.93	22.34	46.1	27.3	58.9	13.8

[a] PPM expressed as MON 13900 equivalents.

[b] This portion of the solution-contained radioactivity was not further characterized.

Table 10. Quantification of Photolyte Fractions as Percent of HPLC Distribution for the MON 13900 Photolysis Experiments (HPLC Gradient 3)

Photolyte Fraction	Percent of HPLC Distribution							Experiments Conducted
	Unsensitized Timepoint			Sensitized Timepoint				
	3	4	5	3	8	9	10	
Neutral Fraction								
Unretained	n.d.	n.d.	n.d.	n.d.	2.4	1.5	0.9	Characterized
I	0.9	4.4	n.d.	2.8	11.8	7.8	5.6	Characterized
II	n.d.	5.3	3.8	n.d.	n.d.	2.2	2.4	Characterized
III	2.1	10.8	7.3	1.1	16.7	18.3	24.6	Characterized
IV	5.0	3.8	6.0	4.0	21.7	15.5	21.7	Characterized
V	2.7	7.8	n.d.	n.d.	2.4	2.6	12.4	Identified: 7 or 8
VI	n.d.	n.d.	n.d.	6.1	29.0	31.8	13.3	Identified: 9
VII[a]	20.0	n.d.	n.d.	14.0	n.d.	n.d.	n.d.	Characterized
MON 13900 Region	64.7	59.8	82.9	71.0	9.2	15.4	10.8	Identified: 1
Acidic Fraction								
VIII[b]	16.8	20.9	23.1	18.4	16.3	8.8	15.3	Characterized
IX	38.7	33.7	18.9	12.6	23.0	12.9	19.8	Characterized
X	10.4	20.2	24.6	42.1	27.1	63.8	39.8	Identified: 3
XI	11.6	8.8	22.3	15.4	21.1	7.7	21.5	Identified: 2
XII	n.d.	n.d.	n.d.	n.d.	4.6	n.d.	n.d.	Characterized
XIII	n.d.	n.d.	1.9	n.d.	6.1	1.6	1.6	Characterized
XIV[c]	4.4	1.8	2.3	3.8	1.0	1.0	1.0	Characterized
XV[c]	12.8	2.5	n.d.	7.3	0.4	n.d.	n.d.	Characterized
Total of Neutral Photolyte Fractions[d]	95.4	91.9	100.0	99.0	93.2	95.1	91.7	
Total of Acidic Photolyte Fractions[e]	94.7	87.9	93.1	99.6	99.6	95.8	99.0	

[a] This is the smear of radioactivity eluting before the MON 13900 Region.

[b] Contains multiple unresolved components.

[c] Has HPLC retention time of peaks in the MON 13900 Region.

[d] Total of HPLC distribution represented in Fractions I through VII and the MON 13900 Region.

[e] Total of HPLC distribution represented in Fractions VIII through XV.
n.d. = not detected

Table 11. Quantification of Photolyte Fractions as Percent of Solution-Contained Radioactivity for the MON 13900 Photolysis Experiments (HPLC Gradient 3)

Photolyte Fraction	Percent of Solution-Contained Radioactivity							Experiments Conducted
	Unsensitized Timepoint			Sensitized Timepoint				
	3	4	5	3	8	9	10	
Neutral Fraction								
Unretained	n.d.	n.d.	n.d.	n.d.	2.4	0.4	0.3	Characterized
I	0.7	2.8	n.d.	2.3	4.9	2.1	1.5	Characterized
II	n.d.	3.3	2.2	n.d.	n.d.	0.6	0.7	Characterized
III	1.7	6.7	4.2	0.9	6.9	4.8	6.7	Characterized
IV	4.0	2.3	3.5	3.3	8.9	4.1	5.9	Characterized
V	2.1	4.9	n.d.	n.d.	1.0	0.7	3.4	Identified: 7 or 8
VI	n.d.	n.d.	n.d.	5.0	12.0	8.4	3.6	Identified: 9
VII[a]	15.9	n.d.	n.d.	11.5	n.d.	n.d.	n.d.	Characterized
MON 13900 Region	51.2	37.3	48.0	58.4	3.8	4.1	2.9	Identified: 1
Acidic Fraction								
VIII[b]	3.2	5.2	8.6	1.8	8.7	5.5	9.0	Characterized
IX	7.3	8.4	7.1	1.2	12.3	8.0	11.7	Characterized
X	2.0	5.1	9.2	4.0	14.4	39.5	23.5	Identified: 3
XI	2.2	2.2	8.3	1.5	11.3	4.8	12.6	Identified: 2
XII	n.d.	n.d.	n.d.	n.d.	2.4	n.d.	n.d.	Characterized
XIII	n.d.	n.d.	0.7	n.d.	3.3	1.0	0.9	Characterized
XIV[c]	0.8	0.5	0.8	0.4	0.5	0.6	0.6	Characterized
XV[c]	2.4	0.6	n.d.	0.7	0.2	n.d.	n.d.	Characterized
Total Neutral Photolyte Fractions I - VI[d]	8.5	20.0	9.9	11.5	33.7	20.7	21.8	
Total Acidic Photolyte Fractions VIII - XV	17.9	22.0	34.7	9.6	53.1	59.4	58.3	
Uncharacterized[e]	2.0	9.7	4.6	8.1	5.5	11.6	13.8	

[a] This is a smear of radioactivity eluting before the MON 13900 Region.

[b] Contains multiple unresolved components (Figure 17b).

[c] Has HPLC retention time of peaks in the MON 13900 Region.

[d] Does not include Fraction VII or the MON 13900 Region.

[e] Radioactivity not recovered from anion exchange chromatography.
n.d. = not detected.

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Table 12. Intensity Data for Simulated Sunlight Calculated by SERI Program SPCTRAL2 (Data plotted in Figure 10)

Wavelength Interval (nm)	Intensity (mw/cm2-nm)	Wavelength (nm)	Intensity (mw/cm2)
300-304	0.002	300	0.000
305-309	0.015	305	0.003
310-314	0.035	310	0.007
315-319	0.070	315	0.014
320-324	0.090	320	0.018
325-329	0.130	325	0.026
330-334	0.175	330	0.035
335-339	0.185	335	0.037
340-344	0.190	340	0.038
345-349	0.200	345	0.040
350-359	0.450	350	0.045
360-369	0.490	360	0.049
370-379	0.600	370	0.060
380-389	0.620	380	0.062
390-399	0.610	390	0.061
400-409	0.920	400	0.092
410-419	1.010	410	0.101
420-429	1.160	420	0.116
430-439	1.090	430	0.109
440-449	1.300	440	0.130
450-459	1.450	450	0.145
460-469	1.510	460	0.151
470-479	1.490	470	0.149
480-489	1.550	480	0.155
490-499	1.470	490	0.147
500-509	1.490	500	0.149
510-519	1.520	510	0.152
520-529	1.460	520	0.146
530-539	1.510	530	0.151
540-549	1.530	540	0.153
550-569	3.060	550	0.153
570-592	3.427	570	0.149
593-609	2.465	593	0.145
610-629	2.880	610	0.144
630-655	3.666	630	0.141
656-667	1.584	656	0.132
668-689	2.948	668	0.134
690-709	2.380	690	0.119
710-717	1.000	710	0.125
718-723	0.696	718	0.116
724-739	1.840	724	0.115
740-750	0.585	740	0.117
300-750	**51.555**		

Data simulated for sunlight in St. Louis, Missouri, on June 21 at noon.

Table 13. Intensities of the Xenon Arc Lamp (Unfiltered and Filtered) Used in the MON 13900 Aqueous Photolysis Studies (Data plotted in Figure 10)

Wavelength (nm)	Intensity	
	Unfiltered Arc Lamp	Filtered Arc Lamp
300	0.150	0.002
305	0.180	0.002
310	0.212	0.004
315	0.243	0.013
320	0.239	0.030
325	0.273	0.061
330	0.299	0.102
335	0.319	0.145
340	0.333	0.184
345	0.351	0.220
350	0.340	0.233
355	0.354	0.259
360	0.368	0.281
365	0.373	0.294
370	0.380	0.305
375	0.390	0.313
380	0.406	0.326
385	0.391	0.320
390	0.412	0.340
395	0.479	0.396
400	0.419	0.352
405	0.440	0.365
410	0.467	0.386
415	0.449	0.377
420	0.459	0.381
425	0.448	0.374
430	0.448	0.374
435	0.451	0.377
440	0.458	0.385
445	0.444	0.371
450	0.463	0.390
455	0.491	0.406
460	0.568	0.469
465	0.596	0.485
470	0.555	0.463
475	0.506	0.423
480	0.664	0.576
485	0.508	0.432
490	0.581	0.475
495	0.498	0.424
500	0.494	0.421
505	0.499	0.421
510	0.503	0.424
515	0.506	0.432
520	0.512	0.436
525	0.513	0.432
530	0.514	0.436
535	0.520	0.436
540	0.530	0.444
545	0.530	0.447
550	0.536	0.446
555	0.545	0.453
560	0.538	0.449
565	0.540	0.448
570	0.554	0.459
575	0.554	0.458
580	0.569	0.468
585	0.589	0.484
590	0.600	0.492
595	0.575	0.469
600	0.557	0.452
605	0.551	0.444
610	0.577	0.463
615	0.753	0.511
620	0.802	0.647
625	0.740	0.522
630	0.517	0.385
635	0.508	0.394
640	0.504	0.394
645	0.551	0.433
650	0.569	0.450
655	0.547	0.433
660	0.552	0.443
665	0.580	0.469
670	0.578	0.469
675	0.584	0.484
680	0.571	0.471
685	0.716	0.597
690	0.749	0.626
695	0.574	0.475
700	0.559	0.462
705	0.534	0.441
710	0.833	0.680
715	0.692	0.577
720	0.674	0.474
725	0.649	0.535
730	0.788	0.650
735	0.657	0.543
740	0.941	0.788
745	0.666	0.553
750	0.754	0.623

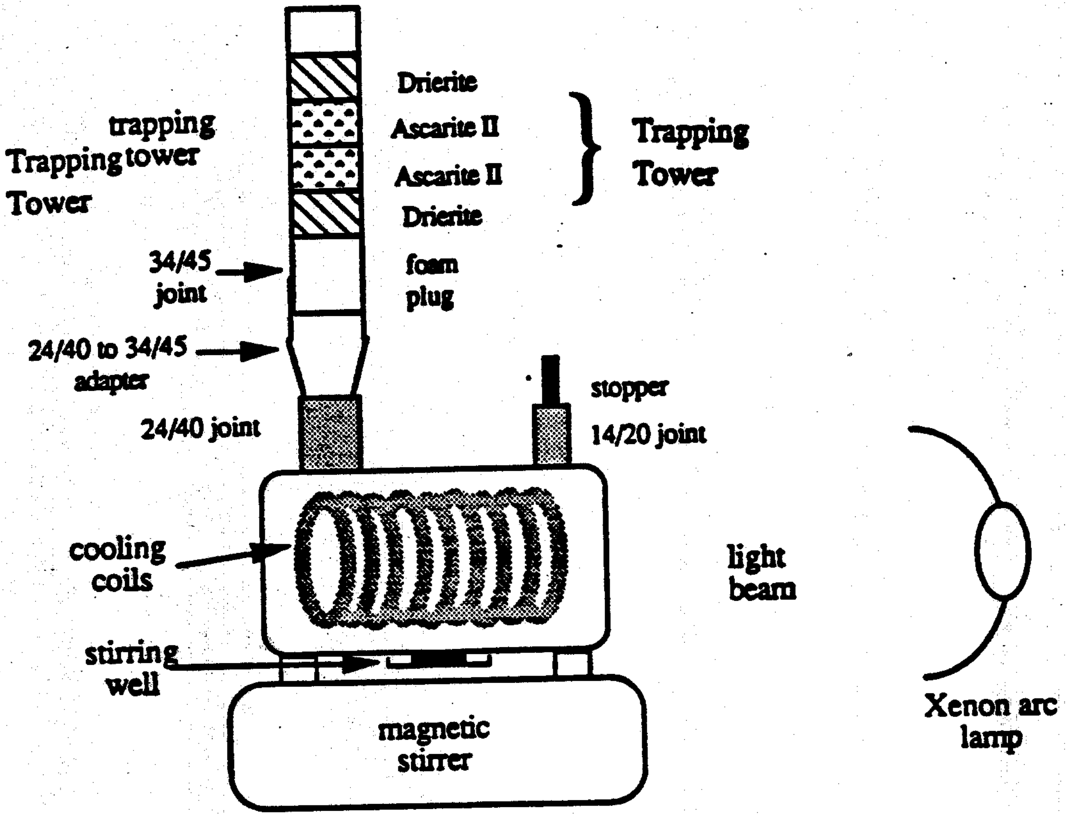
Intensity in mw/cm^2-nm.
Pyrex was used for the filtered lamp measurements.

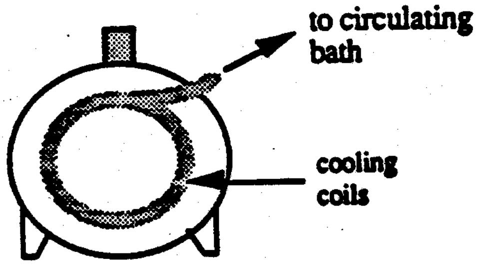
Table 14. Total Intensities of the Xenon Arc Lamp (Unfiltered and Filtered) Used in the MON 13900 Aqueous Photolysis Studies

Wavelength Interval (nm)	Intensity	
	Unfiltered Arc Lamp	Filtered Arc Lamp
300-304	0.750	0.010
305-309	0.900	0.010
310-314	1.060	0.020
315-319	1.215	0.065
320-324	1.195	0.150
325-329	1.365	0.305
330-334	1.495	0.510
335-339	1.595	0.725
340-344	1.665	0.920
345-349	1.755	1.100
350-354	1.700	1.165
355-359	1.770	1.295
360-364	1.840	1.405
365-369	1.865	1.470
370-374	1.900	1.525
375-379	1.950	1.565
380-384	2.030	1.630
385-389	1.955	1.600
390-394	2.060	1.700
395-399	2.395	1.980
400-404	2.095	1.760
405-409	2.200	1.825
410-414	2.335	1.930
415-419	2.245	1.885
420-424	2.295	1.905
425-429	2.240	1.870
430-434	2.240	1.870
435-439	2.255	1.885
440-444	2.290	1.925
445-449	2.220	1.855
450-454	2.315	1.950
455-459	2.455	2.030
460-464	2.840	2.345
465-469	2.980	2.425
470-474	2.775	2.315
475-479	2.530	2.115
480-484	3.320	2.880
485-489	2.540	2.160
490-494	2.905	2.375
495-499	2.490	2.120
500-504	2.470	2.105
505-509	2.495	2.105
510-514	2.515	2.120
515-519	2.530	2.160
520-524	2.560	2.180
525-529	2.565	2.160
530-534	2.570	2.180
535-539	2.600	2.180
540-544	2.650	2.220
545-549	2.650	2.235
550-554	2.680	2.230
555-559	2.725	2.265
560-564	2.690	2.245
565-569	2.700	2.240
570-574	2.770	2.295
575-579	2.770	2.290
580-584	2.845	2.340
585-589	2.945	2.420
590-594	3.000	2.460
595-599	2.875	2.345
600-604	2.785	2.260
606-609	2.755	2.220
610-614	2.885	2.315
615-619	3.765	2.555
620-624	4.010	3.235
625-629	3.700	2.610
630-634	2.585	1.925
635-639	2.540	1.970
640-644	2.520	1.970
645-649	2.755	2.165
650-654	2.845	2.250
655-659	2.735	2.165
660-664	2.760	2.215
665-669	2.900	2.345
670-674	2.890	2.345
675-679	2.920	2.420
680-684	2.855	2.355
685-689	3.580	2.985
690-694	3.745	3.130
695-699	2.870	2.375
700-704	2.795	2.310
705-709	2.670	2.205
710-714	4.165	3.400
715-719	3.460	2.885
720-724	3.370	2.370
725-729	3.245	2.675
730-734	3.940	3.250
735-739	3.285	2.715
749-744	4.705	3.940
745-749	3.330	2.765
750	0.754	0.623
300-750	**231.749**	**182.298**

Intensity in mw/cm2-nm. Pyrex was used for the filtered lamp measurements.

Figure 2. Apparatus Used in the MON 13900 Aqueous Photolysis Experiments





cross-sectional view of photolysis cell

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Figure 7. Ultraviolet Spectrum of MON 13900 (48.5 ppm) in Aqueous Buffer Solution (pH 7, 0.01 M), Used in the MON 13900 Unsensitized Photolysis Experiment

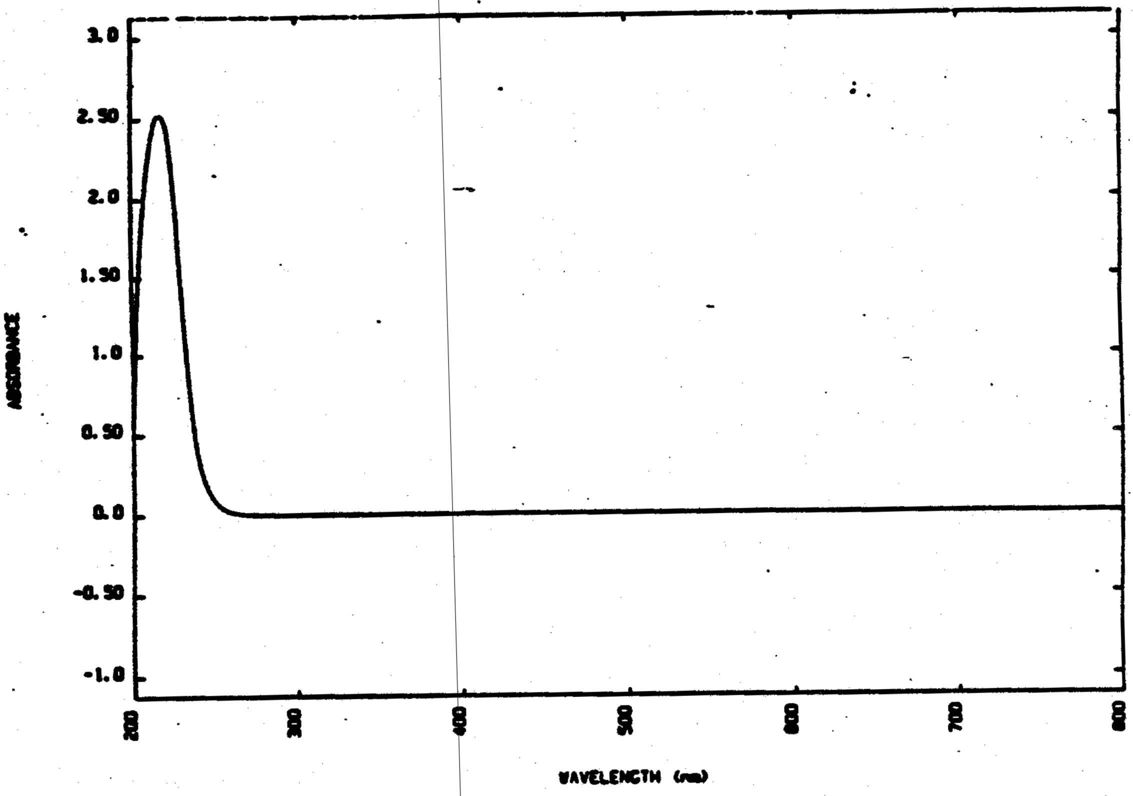

Figure 9. Ultraviolet Spectrum of MON 13900 (49.0 ppm) in Aqueous Buffer Solution (pH 7, 0.01 M) with 25 ppm Humic Acid, Used in the MON 13900 Sensitized Photolysis Experiment

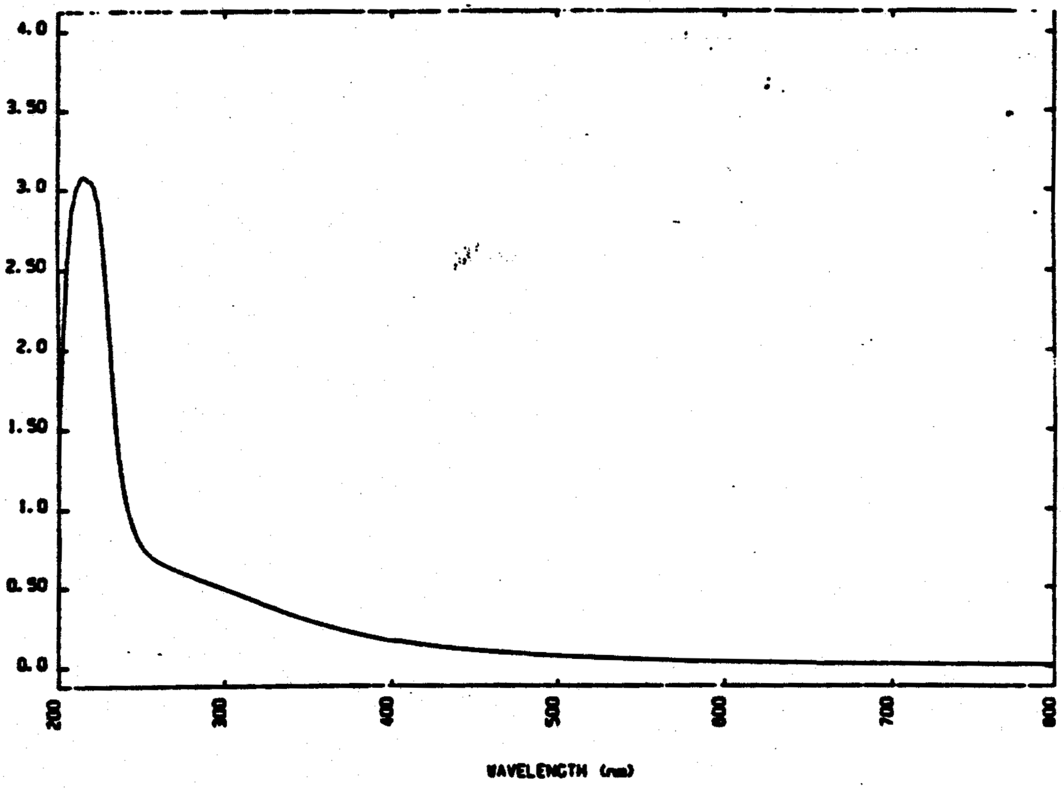

Figure 10. Intensities of Natural Sunlight, Simulated Sunlight, the Unfiltered Lamp, and the Filtered Lamp Used in the MON 13900 Aqueous Photolysis Studies

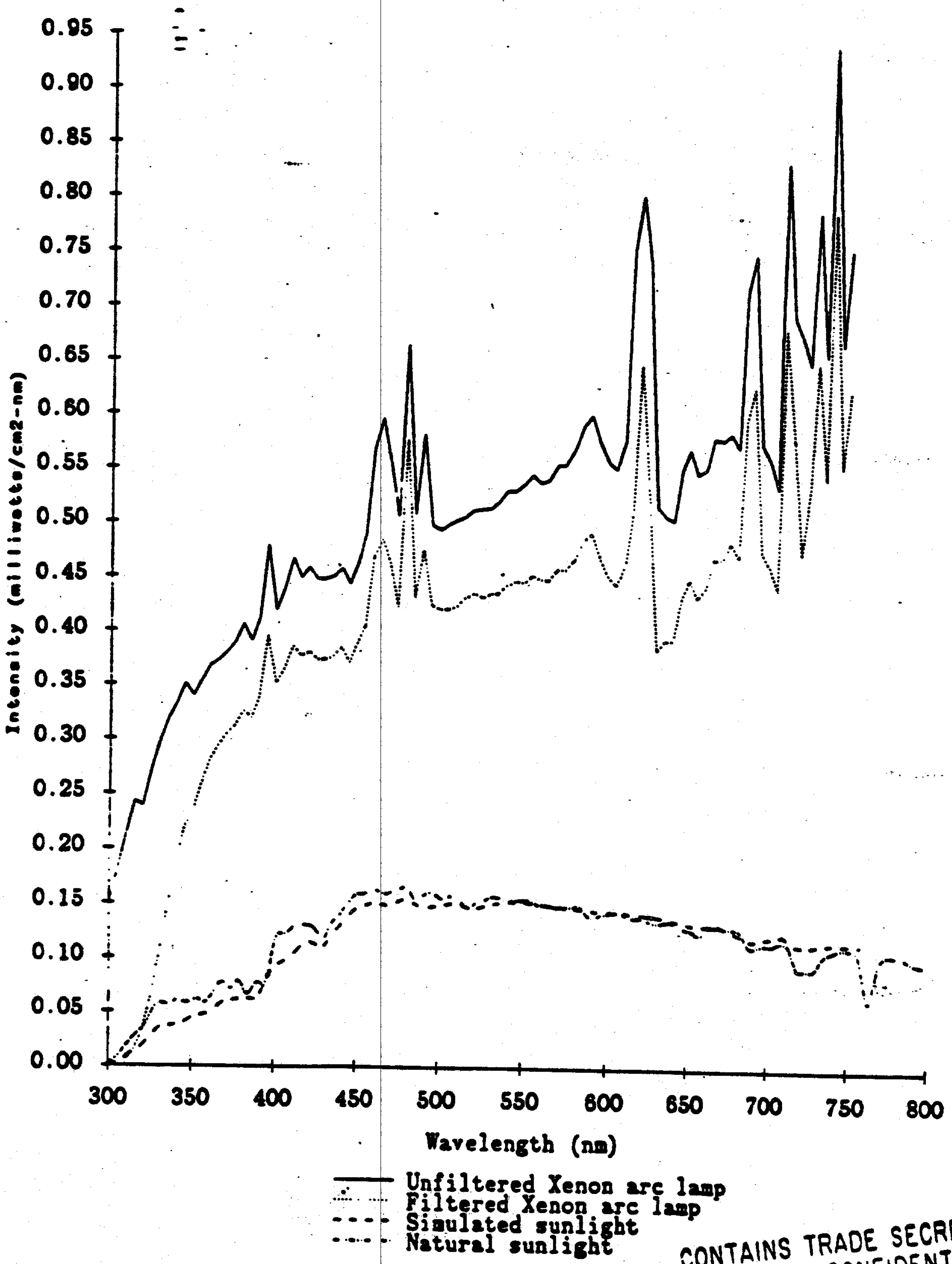

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Figure 11. Transmittance Spectrum of Photolysis Cell Filled with Deionized Water

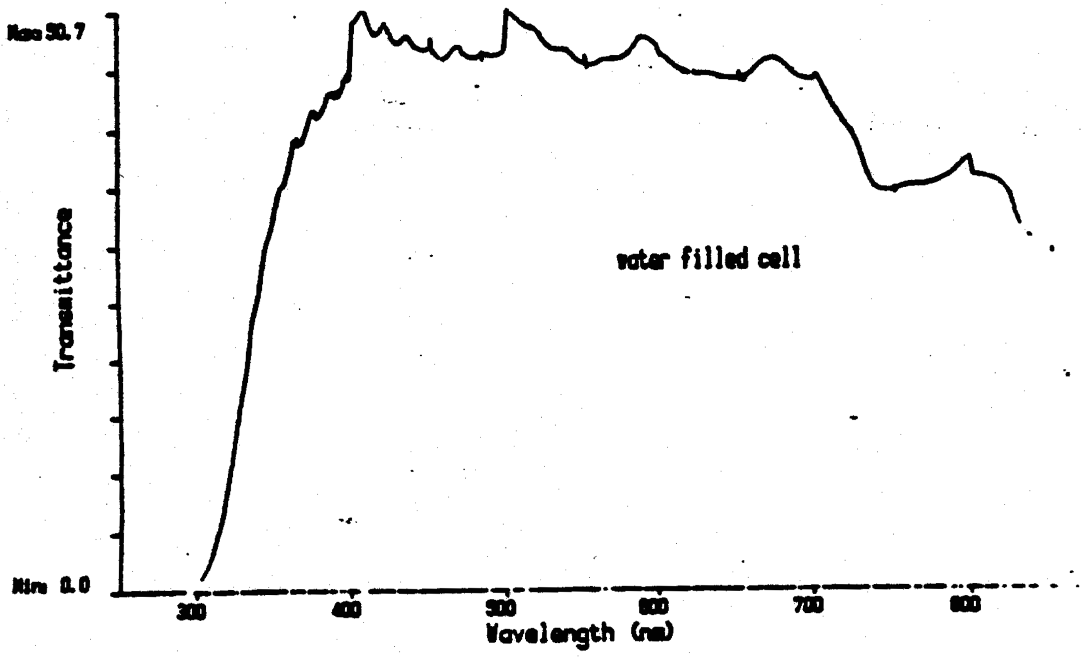

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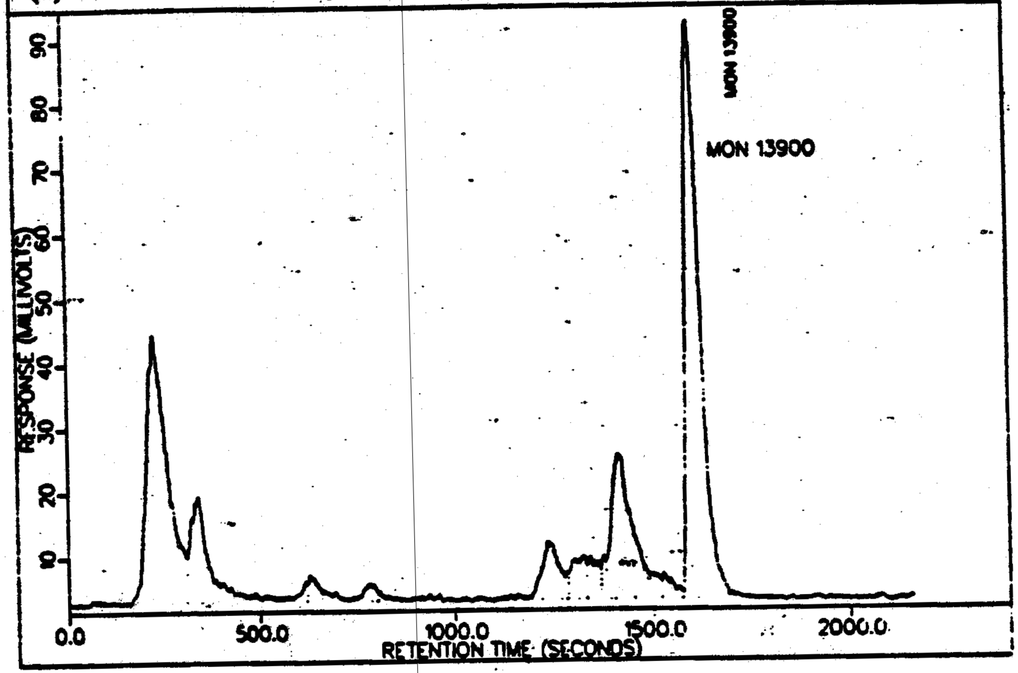
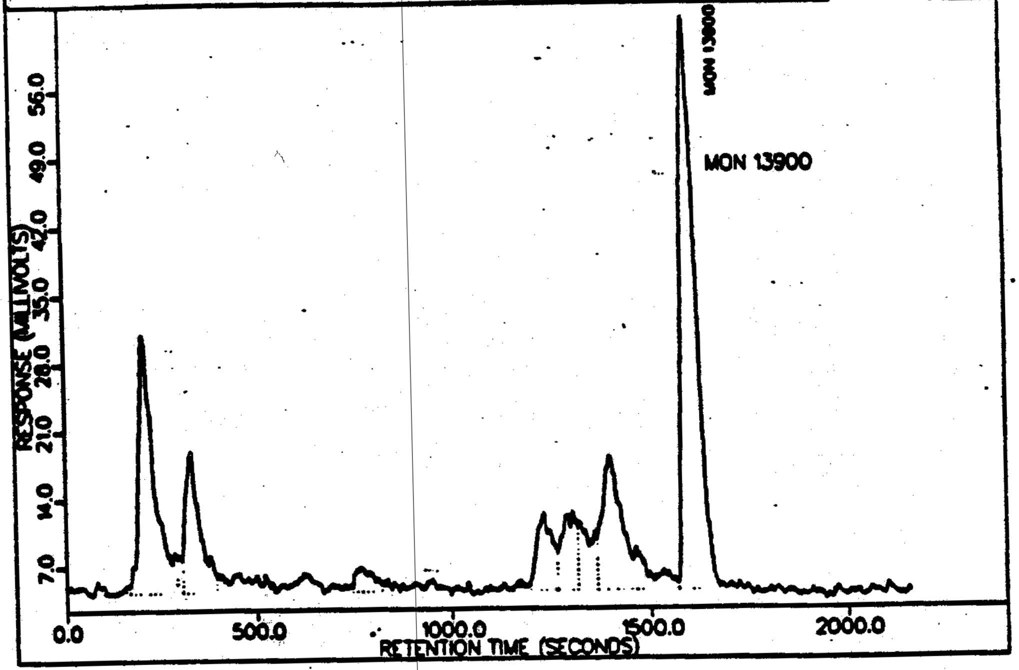
Figure 47. HPLC Analyses of Photolysis Solutions for Stability Experiments (HPLC Gradient 4)

(a) Unsensitized Photolysis, Timepoint 5, after 15 days of freezer storage



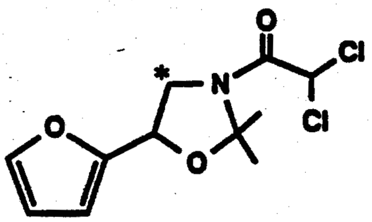
(b) Unsensitized Photolysis, Timepoint 5, after 75 days of freezer storage



4 RESULTS & DISCUSSION

4.1 STUDY DESIGN

This study was designed to provide kinetic data and information about the photoproducts of MON 13900, 1, in aqueous solution when irradiated with artificial sunlight. The protocol for this study was Monsanto Protocol Number 88-27-M23 (see Appendix A) and was designed to satisfy the U.S. Environmental Protection Agency Pesticide Assessment Guidelines, Subdivision N: Environmental Fate, Section 161-2, Photodegradation in Water.



1, MON 13900

*position of ^{12}C and ^{14}C isotopic labels

This study was conducted using an aqueous buffer at pH 7, which previous studies had indicated was a hydrolytically stable pH for MON 13900.[5] The nominal concentration of $^{13}C/^{14}C$-MON 13900 was 50 parts per million, the same as was used in the previously conducted Hydrolysis Studies of MON 13900.[5] The estimated water solubility of MON 13900 at 25 °C in deionized water is 214 ppm.*

4.1.2 Photolysis Experiments -- Two definitive photolysis experiments and a supplemental experiment were conducted using $^{13}C/^{14}C$-MON 13900 as the test substance:

(1) An unsensitized photolysis experiment was conducted in sterile deionized water buffered to pH 7. The concentration of MON 13900 was 48.5 ppm, with irradiation for the equivalent of 41.92 days of sunlight. Samples were taken as described in Table 2.

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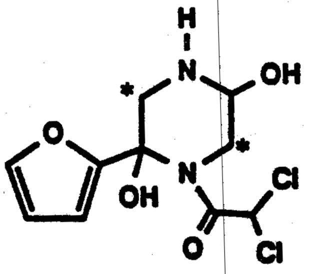
*Experiments conducted by P.R. Rahn, Monsanto Notebook Page 3423070.

for an additional cluster in the m/z 251,252 region in Figure 29d. This data suggests that two acetyl groups were added to Fraction VI during the derivatization, which suggests the presence of two reactive functionalities, probably hydroxyl moieties. The presence of two chlorine atoms suggests that the $HNC(O)CHCl_2$ part of the original molecule is intact.

Repeated attempts at fast atom bombardment (FAB) mass spectral analysis on µg quantities of Fraction VI were unsuccessful. This result is consistent with the generally low sensitivity of the FAB method with MON 13900 and its degradates.

High voltage electrophoresis (HVE) was conducted with underivatized Photolyte Fraction VI to confirm its non-acidic nature. Figure 37b depicts the results of an HVE experiment at pH 9.0. The results indicate that Fraction VI is neutral at pH 9.0, since the majority of the applied radioactivity migrated slightly toward the cathode from the origin. This result is consistent with the presence of Fraction VI in the neutral fraction from the anion exchange chromatography. Photolyte Fraction VI is not preferentially soluble in dichloromethane when dissolved in a pH 7 aqueous solution.

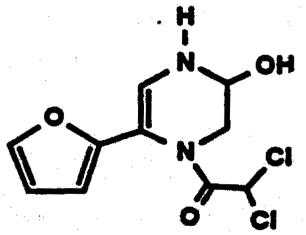
<u>Summary of Fraction VI Characterization Experiments</u>: Based on the above data, the following tentative structure, 9, 4-(dichloroacetyl)-5-(2-furanyl)-1,2,3,4-tetrahydropyrazinol, was proposed for Fraction VI (molecular weight of 294):



9

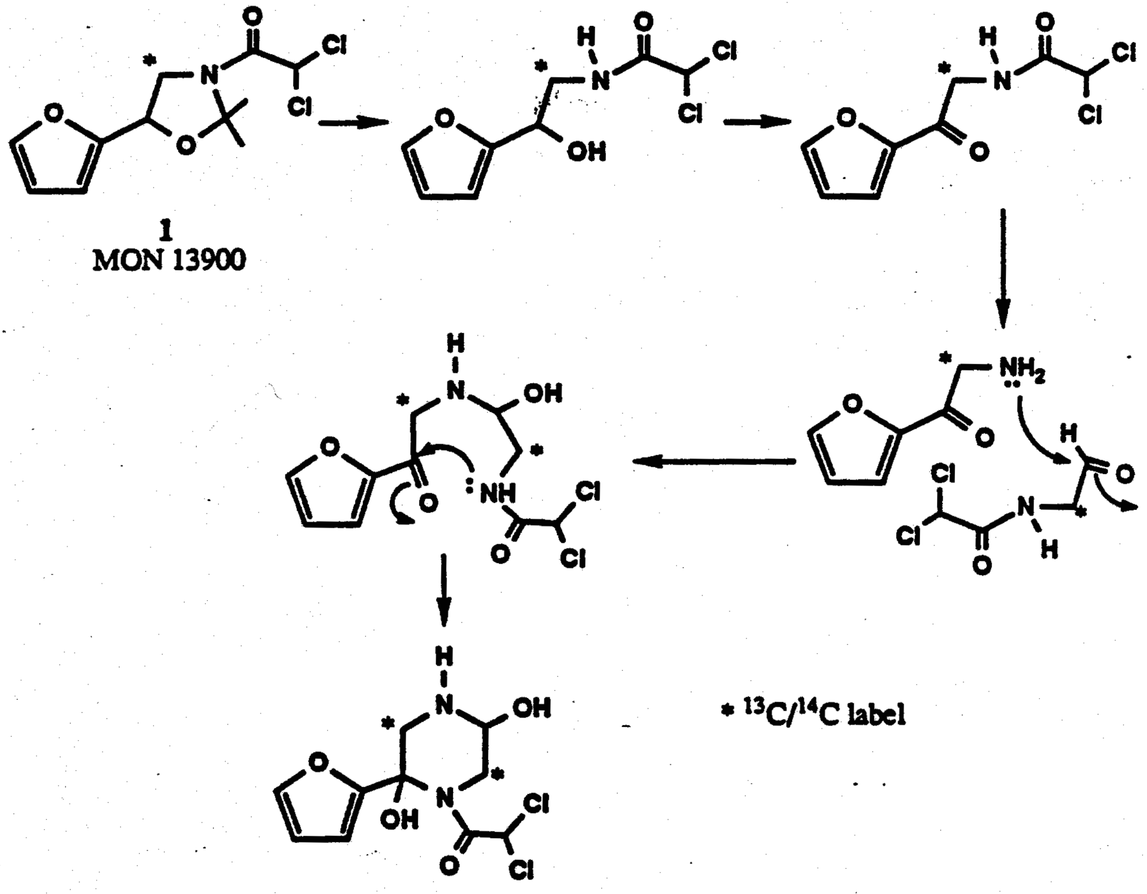
* = $^{13}C/^{14}C$-label

A loss of 18 in the mass spectrometer would result in **10**, which has a molecular weight of 276:



10

A scheme for the formation of **9** is postulated as follows:



1
MON 13900

* $^{13}C/^{14}C$ label

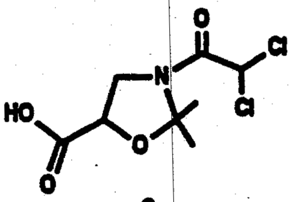
9

Structure **9** is consistent with the presence of two nitrogen atoms and two ^{13}C atoms in the molecule (as indicated by the mass spectral data), and the presence of two hydroxyl groups

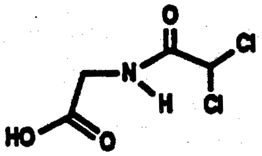
4.8 DISCUSSION OF MON 13900 PHOTODEGRADATION

The results of this study demonstrate that MON 13900 is readily photolyzed in aqueous solution. The half-life is 7.85 hours in aqueous solution with humic acid (sensitized solution), and 29.9 days in unsensitized aqueous solution. A large number of photoproducts were formed in both the unsensitized and sensitized experiments. Of the three acidic photolytes that constituted greater than 10% of the solution-contained radioactivity, two were unequivocally identified. These major photolytes (2 and 3) were assigned structures based on high resolution mass spectrometry of the photolyte methyl esters and comparisons of the mass spectra of authentic compounds with those of the derivatized photolytes. Structures were postulated for three additional acidic photolytes and one neutral photolyte based upon mass spectral characterization of the photoproducts or a derivative (structures 4 through 9). The structures assigned to the MON 13900-derived photolytes from this study are summarized below.

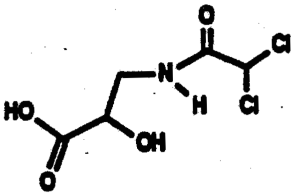
Acidic Photoproducts:



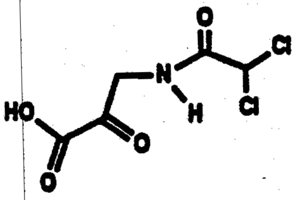
2



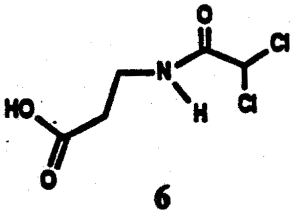
3



4

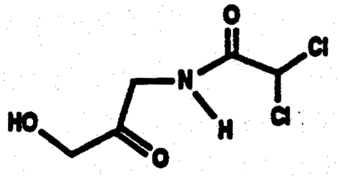


5



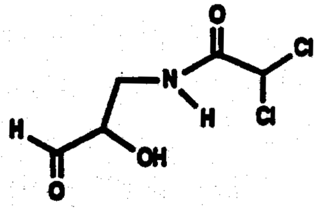
6

Neutral Photoproducts:

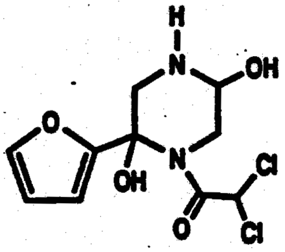


7

or

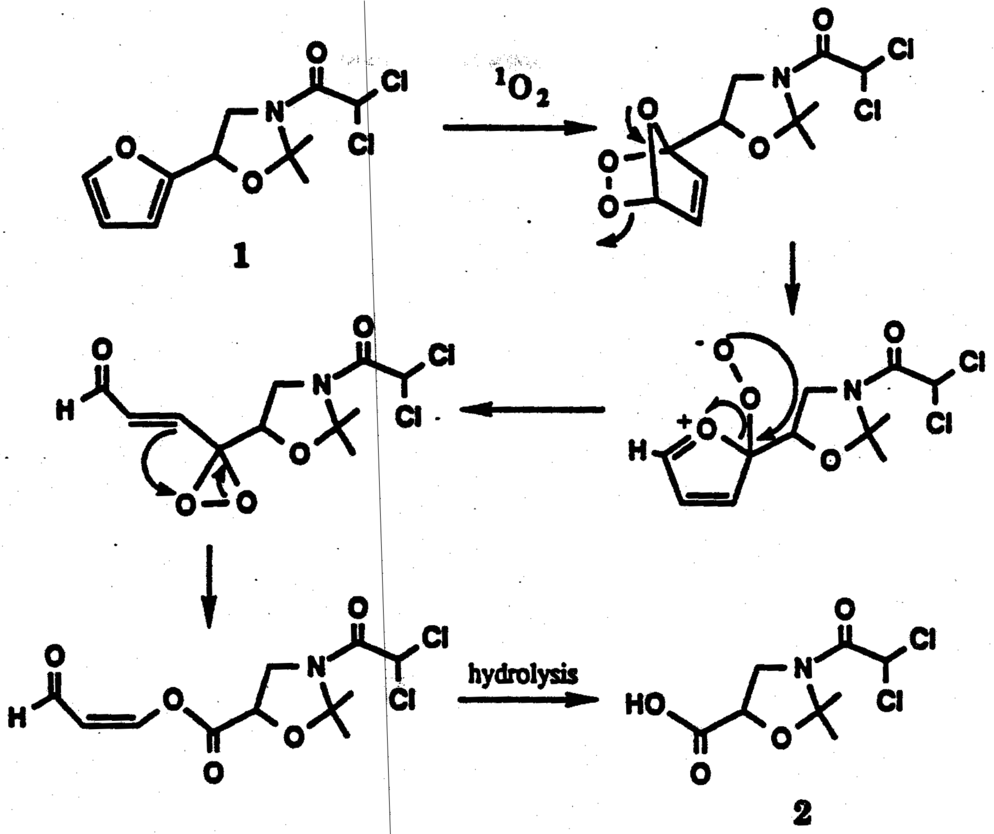


8



9

An examination of the structures of the photolytes derived from MON 13900 shows that the furan moiety of MON 13900 has photolyzed and the dichloroacetyl moiety has remained intact (in all the identified photolytes except 9). Figure 4 contains the proposed pathway for the photolytic degradation of MON 13900 in aqueous solution. The initial photolysis of the furan moiety of MON 13900 leads to the formation of the oxazolidine acid 2, which upon the opening of the oxazolidine ring and loss of acetone, gives the photolyte 4. Further dehydrogenation and decarboxylation lead to the formation of other photolytes (3, 5, 6, 7 or 8, 9) observed in this study. The photochemical degradation of the furan moiety has been extensively investigated and reported in the literature.[7,8,9,10] Based on reported mechanisms, the following scheme is postulated for the formation of 2, the MON 13900 oxazolidine acid, from MON 13900 during photolysis.



As described previously, the photolysis of MON 13900 leads to the formation of a large number of acidic and neutral photolytes. In sensitized solution, the acidic photolytes are more abundant than the neutral photolytes after approximately 30 days of sunlight. Based on the scheme postulated above for the photolysis of the furan moiety of MON 13900, the formation of a large number of photolytes can be rationalized. These can be intermediates that lead to the formation of the oxazolidine acid 2 from MON 13900.