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# Photodegradation of acetochlor in water and UV photoproducts identified by mass spectrometry

ZHENG He-hui<sup>1</sup>, YE Chang-ming<sup>2\*</sup>

(1. Institute of Environment &amp; Health Related Product Safety, Chinese Center for Disease Control and Prevention, Beijing 100021, China;

2. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China. E-mail: yechm@mail.reces.ac.cn.)

**Abstract:** The sunlight photodegradation half-lives of 20 mg/L acetochlor were 151, 154 and 169 days in de-ionized water, river water and paddy water, respectively. When exposed to ultraviolet (UV) light, acetochlor in aqueous solution was rapidly degraded. The half-lives were 7.1, 10.1, and 11.5 min in de-ionized water, river water and paddy water, respectively. Photoproducts of acetochlor were identified by gas chromatography/mass spectrometry (GC/MS) and found at least twelve photoproducts resulted from dechlorination with subsequent hydroxylation and cyclization processes. The chemical structures of ten photoproducts were presumed on the basis of mass spectrum interpretation and literature data. Photoproducts are identified as 2-ethyl-6-methylaniline; N, N-diethylaniline; 4, 8-dimethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 2-oxo-N-(2-ethyl-6-methylphenyl)-N-(ethoxymethyl) acetamide; N-(ethoxymethyl)-2'-ethyl-6'-methylformanilide; 1-hydroxyacetyl-2-ethoxyl-7-ethylindole; 8-ethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 4, 8-dimethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 2-hydroxy-2'-ethyl-6'-methyl-N-(ethoxymethyl) acetanilide and a compound related to acetochlor. The other two photoproducts were detected by GC/MS although their chemical structure was unknown.

**Keywords:** acetochlor; photoproducts; photodegradation; GC/MS; herbicide

## Introduction

Acetochlor [2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl) acetamide] (Fig. 1) was a germination inhibitor used widely to control competing grasses and some broadleaf weeds in corn (Capel, 1995). Acetochlor was applied preemergent to plant growth. Its solubility in water was 223 mg/L at 25 °C. Its persistence in soils when used at the recommended rates was generally 8 to 12 weeks, but the time might vary, depending on soil type and climatic conditions. Acetochlor was conditionally registered in March 1994 by the U. S. Environmental Protection Agency (USEPA, 1994) and has been classified as a B-2 carcinogen.

Use of acetachlor has been increasing and already is substantial. More than 10 million kg of acetochlor (active ingredient) has been applied every year since 1997 in China (Wang, 1999). It was the most widely used agricultural herbicide in China. About 3.4 million kg was applied in 1994 (USDA, 1994). According to a survey conducted on 10 corn-growing states, the fraction of corn acreage treated with acetochlor increased from 7% in 1994 to 20% in 1995. In 1995, usage increased to about 10.8 million kg (USDA, 1995). By 1996, acetochlor applications had reached 13.5 million kg, making it the third most heavily applied corn herbicide in the Midwest of USA, behind only atrazine and metolachlor (USDA, 1996). Although acetochlor has been used for years in Asia, Europe and South Africa, limited data has been collected to determine its fate and transport in the environment (Yu, 1998; Capel, 1995). Kolpin *et al.* (Kolpin, 1996) reported results from sampling conducted during 1994. Acetochlor was found in 35% of 53 midwestern streams sampled from May through July. Most of the detectable levels in rain and streams occurred during the spring application period. Maximum concentrations of acetochlor found in 1994 were 2.5 µg/L (rain) and 1.2 µg/L (streams). In 1995, the acetochlor concentrations in some midwest streams and in the Mississippi River at Baton Rouge had increased dramatically compared with 1994 concentrations (Crawford, 1997). Kalkhoff *et al.* (Kalkhoff, 1998) reported the median value of the summed concentrations of acetochlor, alachlor, and metolachlor was less than 0.05 µg/L in groundwater and 0.13 µg/L in surface water, acetochlor degradates were detected in about 10% of the wells sampled. The

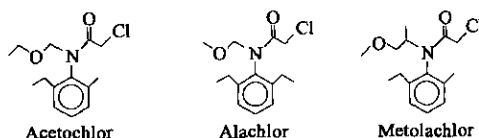


Fig. 1 Chemical structure of acetochlor, alachlor and metolachlor

oxanilic and sulfonic acid degradates of acetochlor were presented in 50% of the streams sampled. During the growing season of 1997, 78% of 375 samples collected at 32 stream sites in the Mississippi River Basin contained detectable concentrations of acetochlor. Concentrations in only 2% of the samples exceeded 2  $\mu\text{g/L}$  (Clark, 1999).

Acetochlor was a chloracetamide herbicide having chemical structure and properties similar to those of alachlor [2-chloro-N-(methoxymethyl)-N-(2, 6-diethylphenyl) acetamide] and metolachlor [2-chloro-N-(2-methoxy-1-methylethyl)-N-(2-ethyl-6-methylphenyl) acetamide (Fig. 1)]. The anticipated aim of acetochlor registration in the USA was that it will substantially reduce the use of other corn herbicides such as atrazine, alachlor, metolachlor, 2, 4-D and cyanazine. The USEPA (USEPA, 1990) had set the maximum contaminant level of alachlor or metolachlor in drinking water at 2  $\mu\text{g/L}$ . Chloracetamide herbicide degradation products were generally of lower molecular weight and more oxidized than the parent compound, therefore they might be consequently more water soluble, more mobile, and have a greater potential to leach (Baker, 1993; Kolpin, 1994; 1995a, 1995b; Malcomber, 1992). The fate of acetochlor in natural waters thus was of interest. One possible degradation pathway was photodegradation. Somich *et al.* (Somich, 1988) reported that alachlor was dechlorinated upon UV irradiation and forms a number of intermediates that retain the aromatic ring and carbonyl carbons. Photoproducts include hydroxyalachlor, norchloralachlor, 2, 6-diethylacetanilide, 2-hydroxyl-2', 6'-diethyl-N-methylacetanilide, and a lactam. Penuela and Barcelo (Penuela, 1996) reported that alachlor gave five photoproducts after UV irradiation. Three photoproducts were identified unequivocally: 2-hydroxyl-2', 6'-diethyl-N-methylacetanilide, 4-methyl-8-ethyl-1-methoxymethyl-2-oxo-1, 2, 3, 4-tetra-hydroquinoline and hydroxyalachlor. Mathew and Khan (Mathew, 1996) found that hydroxylation, dehalogenation, oxoquinoline formation, and demethylation were the main processes during the photodegradation of metolachlor. Kochany and Maguire (Kochany, 1994) found that sunlight photoproducts of metolachlor in water resulted from dechlorination, hydroxylation, dehydrochlorination with subsequent morpholine ring formation, and N-dealkylation. Chiron *et al.* (Chiron, 1995) reported that fourteen photoproducts resulted from alachlor dechlorination with subsequent hydroxylation and cyclization processes. The two major photoproducts were identified as hydroxyalachlor and 4-methyl-8-ethyl-1-methoxymethyl-2-oxo-1, 2, 3, 4-tetrahydro-quinoline. Wilson and Mabury (Wilson, 2000) found that monochloroacetic acid was a major photoproduct of alachlor, metolachlor, butachlor in synthetic field water. Sunlight photodegradation of metolachlor was found slow in aqueous solution, 6%-8% in a month (LeBaron, 1988; Chesters, 1989). Indirect photolysis of acetochlor was studied, summer-time half-lives of 1-20 days for acetochlor were estimated for the Blue Earth River (southern Minnesota) (Brekken, 1998). According to Potter and Carpenter (Potter, 1995), groundwater samples collected beneath a Massachusetts corn field were analyzed by GC/MS. 20 compounds were detected whose electron impact (EI) and chemical ionization (CI) MS data indicated that they were derived from alachlor, presumably via environmental degradation. Mangiapam *et al.* (Mangiapam, 1997) reported that the several alachlor metabolites were identified. Nine compounds were confirmed by comparison with synthetic standards and the formulae of other seven compounds were presumed on the basis of spectrum interpretation and literature data. Jacobsen (Jacobsen, 1991) reported that degradation, in particular, cleavage of alachlor's N-methoxymethyl group, contributed to detoxification. But other published data had indicated that at least one of the residues, 2, 6-diethylaniline, is a promutagen (Kimmel, 1986). We also used to research on the photodegradation of butachlor (Zheng, 2001a; 2001b), 11 photoproducts were discovered.

In this paper, the photodegradation of acetochlor in water was studied. We report the results of photoproducts analyzed by GC/MS to provide useful data for acetochlor risk assessment.

## 1 Materials and methods

### 1.1 Materials and apparatus

Acetochlor of 99.5% (analytical reference standard) were obtained from the Monsanto Company (St. Louis, MO, USA). Acetone, methanol, petroleum ether, sodium chloride, and anhydrous sodium sulfate of analytical-reagent grade were purchased from Beijing Chemical Factory. Methanol was purified by redistillation. Supplies of paddy water from Beijing Haidian rice field and river water from Jingmi canal which irrigated the rice field were filtered with a microporous funnel (4G). Other chemicals were reagent

grade from various suppliers.

A LC-6A high performance liquid chromatography was equipped with Shimadzu spectrophotometric detector. The stainless steel column used (25 cm  $\times$  4.6 mm i.d.) was packed with DuPont ODS chemically bonded phase, particle size 10  $\mu$ m, and was pre-tested by the manufacturer. The detection wavelength of 215 nm was selected in all measurements for acetochlor. The mobile phase was methanol-water (80/20, v/v) at a flow rate of 1.0 ml/min. The retention time of acetochlor was 6.9 min.

GC analysis were performed using a Finnigan trace gas chromatograph (2000 series) coupled with a Finnigan Voyager mass spectrometer detector (MSD), and Xcalibur software. A 15 m  $\times$  0.25 mm i.d. RTX-5 column (0.25  $\mu$ m film thickness) was used under the following temperature conditions: initial temperature at 50  $^{\circ}$ C, 20  $^{\circ}$ C/min at 200  $^{\circ}$ C, 10  $^{\circ}$ C/min at 280  $^{\circ}$ C, 3 min final hold. The inlet temperature was 250  $^{\circ}$ C. The helium carrier gas flow rate was 1 ml/min. The MSD was operated in electron impact mode with detection voltage 350.0 V and a source temperature of 200  $^{\circ}$ C, in full scan mode from  $m/z$  30 to 500.

## 1.2 Experimental procedure

Irradiations were carried out using a 100-W medium pressure quartz mercury vapor lamp (produced by Beijing Electric Light Source Institute) as UV irradiation source. The lamp was immersed inside a quartz glass immersion well through which cold tap water flowed to keep the lamp cool. The emission spectra of light source is shown in Fig.2. The light intensity was 658  $\mu$ W/cm<sup>2</sup> (measured by ZDZ-1 UV irradiation photometer, 254 nm). We had studied the UV photolysis of acetochlor in water solution using a 100-W medium pressure quartz mercury vapor lamp. 20 ml of samples of aqueous solution in a quartz test tube were irradiated with the 100-W medium pressure quartz mercury vapor lamp. Samples of 25  $\mu$ l were removed every 2 min and analyzed by HPLC. The samples were totally irradiated for 10 min. The dark control sample was wrapped in aluminum foil and was not degradation.

In order to determine photoproducts of acetochlor, 20 ml of 20 mg/L acetochlor aqueous solution in a quartz test tube was irradiated for 30 min. The whole water samples were extracted into petroleum ether and concentrated to about 3 ml under reduced pressure. The concentrated extract was directly dried under a gentle stream of nitrogen gas and the residue was dissolved in 1 ml of methanol, then analyzed by GC/MS to determine photoproducts.

Sunlight photodegradation experiments were done to estimate the rate constants and half-lives in Beijing (about latitude 40 degrees north, August 16, 2000 to October 14, 2000). The experiments were done in quartz test tubes containing 20 ml of 20 mg/L acetochlor in de-ionized water, river water and paddy water. Appropriate dark control samples were wrapped in aluminum foil. All samples were placed outdoor during the day and night except rain days. Periodically, the samples were analyzed by HPLC-UV every 7 days.

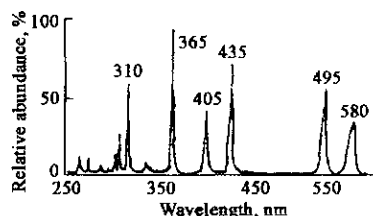


Fig.2 Emission spectra of medium pressure quartz mercury vapor lamp

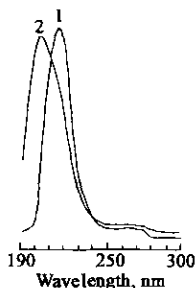


Fig.3 Acetochlor adsorption spectrogram  
1. in the methanol solution; 2. in the water solution

## 2 Results and discussion

### 2.1 Photodegradation kinetics of acetochlor in water

Acetochlor were scanned using a Shimadzu DU-650 spectrophotometer. Acetochlor's main absorbance wavelength was less than 280 nm (Fig. 3). It was indicated that photodegradation of acetochlor was mainly caused by absorbance of ultraviolet light less than 280 nm wavelength. Since little solar radiation below 300 nm reaches the earth's surface, sunlight photodegradation of acetochlor must be slow. To accelerate photolysis testing and avail to identify as many photoproducts as possible, a 100-W medium pressure quartz mercury vapor lamp was used in our laboratory studies.

The natural logarithm values of the ratio of the initial concentration

to the concentration at a given time ( $t$ ) vs time were plotted and the (pseudo-first-order) rate constants ( $k$ ) were determined by calculating the slope of the line, the half-life  $t_{1/2}$  was calculated by  $\ln 2/k$ .

$$\ln(C_0/C_t) = kt, \quad (1)$$

$$t_{1/2} = \ln 2/k. \quad (2)$$

Where,  $C_0$  is the initial concentration;  $C_t$  is the concentration at a given time ( $t$ ).

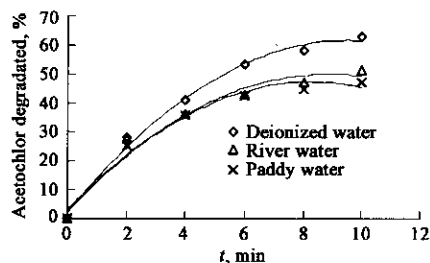


Fig. 4 The UV photolysis of acetochlor in water

The UV photolysis of 20 mg/L acetochlor in water is shown in Fig. 4. The half-lives of acetochlor at an initial concentration of 20 mg/L were 7.1, 10.1 and 11.5 min in de-ionized water, river water and paddy water, respectively. For sunlight photodegradation, the loss of all dark control samples was less than 3.4%. So the other degradation might be negative. After 49 days sunlight irradiation, the residues of acetochlor in de-ionized water, river water and paddy water were 15.1, 15.6 and 16.0 mg/L. According to Equations

(1) and (2) calculation, the half-lives of sunlight were 151, 154 and 169 days photodegradation in de-ionized water, river water, and paddy water. The results showed that the sunlight photodegradation of acetochlor is slow in water under experimental conditions.

## 2.2 Identification of photoproducts in water

When exposed to UV light, acetochlor in aqueous solution was rapidly degradation, giving at least twelve photoproducts (Table 1). After irradiation for 30 min, the major photoproducts were compounds 8, 9, and 10. The typical GC/MS chromatogram of the experiments photolysis is shown in Fig 5. Compound a was the parent compound acetochlor. The mass spectrum of acetochlor is shown in Fig. 6. Comparing with the standard mass spectrum of acetochlor, the probability of the compound a corresponding to acetochlor was 96.8%. Retention time of acetochlor was 7.75 min. The molecular ion peak was at  $m/z$  269. The ion peak at  $m/z$  234, 223, 174, 162, and 146 might correspond the molecular ion to loss of Cl, loss of  $C_2H_5OH$ , loss of  $C_2H_5OH$  and  $CH_2Cl$ , loss of  $C_2H_5$ , H and  $COCH_2Cl$ , loss of  $C_2H_5OH$  and  $COCH_2Cl$ . The base peak ion at  $m/z$  59 was  $C_2H_5OCH_2^+$ .

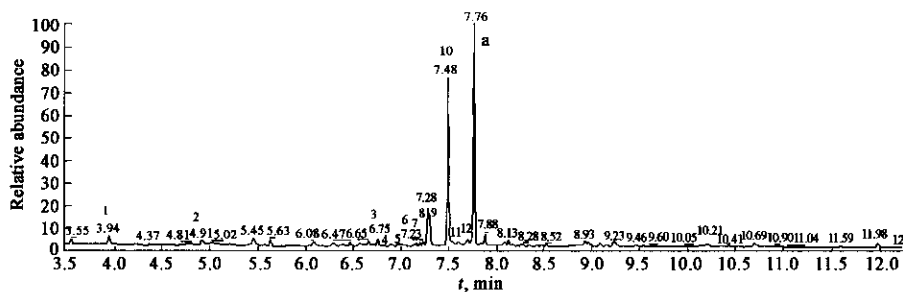


Fig. 5 The typical GC/MS chromatogram of the experiments potolysis

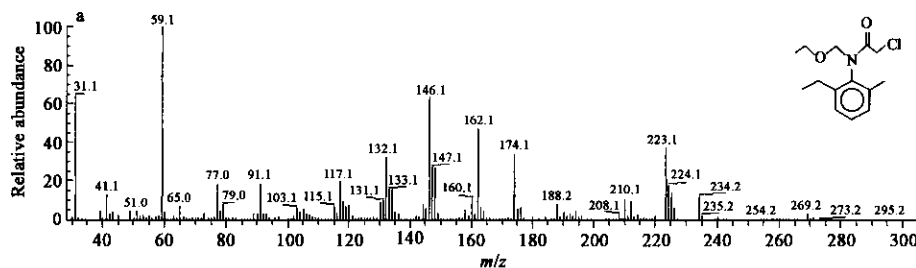


Fig. 6 The mass spectrum of compound a

Table 1 Photoproducts of acetochlor

Mass spectral data							Retention time, min	Photoproduct
Peak	MW <sup>+</sup>	BP <sup>+</sup>	Secondary ions					
1	135	120	65	77	91	135	3.94	2-ethyl-6-methylaniline
2	149	134	77	79	106	149	4.91	N, N-diethylaniline
3	175	175	118	132	147	160	6.75	4, 8-dimethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline
4	249	59	132	146	174	203	6.88	2-oxo-N-( 2-ethyl-6-methylphenyl )-N-( ethoxymethyl )acetamide
5	221	162	59	91	134	221	6.99	N-( ethoxymethyl ) 2-ethyl-6-methylformanilide
6	249	146	132	160	204	249	7.15	1-hydroxyacetyl-2-ethoxyl-7-ethylindole
7	251	162	91	121	134	148	7.23	Acetochlor related
8	233	160	59	188	204	233	7.28	8-ethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline
9	233	187	59	132	160	172	7.30	4, 8-dimethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline
10	251	59	134	146	174	205	7.48	2-hydroxy-2'-ethyl, 6'-methyl-N-( ethoxymethyl ) acetanilide
11		59	132	146	174	205	7.53	Acetochlor related
12		160	59	131	188	204	7.69	Acetochlor related

Notes: <sup>+</sup> MW, molecular weight; <sup>+</sup> BP, base peak

The GC/MS chromatogram and mass spectra of photoproducts 1-12 are shown in Fig. 7—Fig. 9. The structures of photoproducts 7, 11, and 12 were unknown. It should be noted that the structural assignments showed for those photoproducts were tentative: their full identification is still under investigation and may require other analytical methods such as NMR after an isolation step. Photoproducts corresponded mainly to dechlorination process of acetochlor. We did not find the literatures with photoproducts of acetochlor identified by MS. Spectra of the presumed photoproducts were compared with other chloracetamide herbicide literature data, when available.

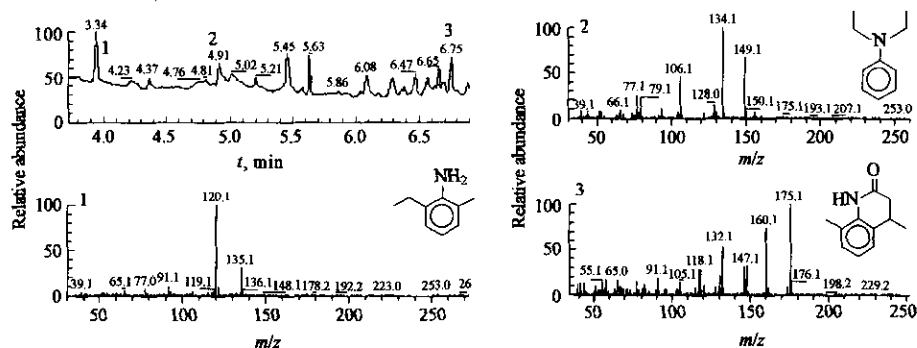


Fig. 7 The GC/MS chromatogram and mass spectra of photoproducts 1—3

Photoproduct 1, with MW 135, might correspond to 2-ethyl-6-methylaniline. Retention time was 3.94 min. Observing the spectrum, molecular M<sup>+</sup> (135) could lose CH<sub>3</sub> to give the base ion peak at m/z 120, CH<sub>3</sub> and CH<sub>3</sub>CH<sub>2</sub> to give the ion peak at m/z 91. The main ion peaks at m/z 65, 77, 91, 120, and 135 of photoproduct 1 matched with the standard mass spectrum of 2-ethyl-6-methylaniline very well.

Photoproduct 2, with MW 149, might correspond to N, N-diethylaniline. Retention time was 4.91 min. Observing the spectrum, molecular M<sup>+</sup> (149) could lose CH<sub>3</sub> to give the base ion peak at m/z 134, CH<sub>3</sub> and CH<sub>2</sub>CH<sub>2</sub> (one γ H rearrange) to give the ion peak at m/z 106. The main ion peaks at m/z 77, 106, 134, and 149 of photoproduct 2 matched with the standard mass spectrum of N, N-diethylaniline very well.

Photoproduct 3, with MW 175, might correspond to 4, 8-dimethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline. Retention time was 6.75 min. The base peak was the molecular ion peak at m/z 175. The molecular ion could lose CH<sub>3</sub> to give the ion peak at m/z 160, CH<sub>3</sub>CH to give the ion peak at m/z

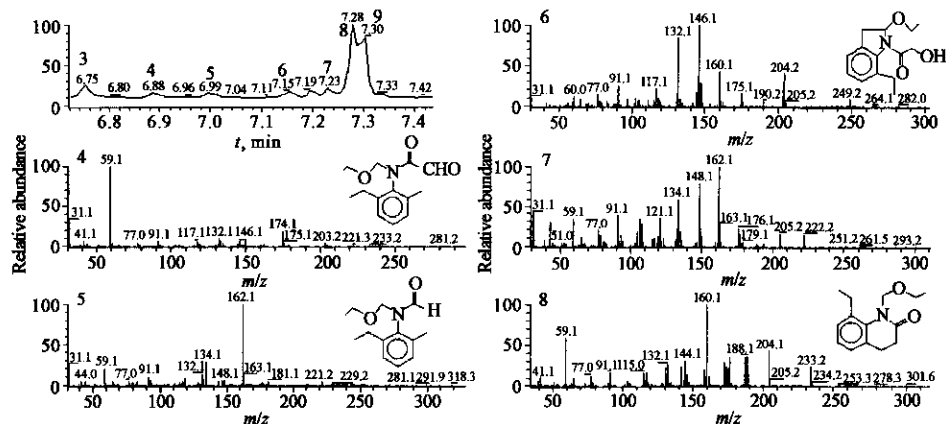


Fig.8 The GC/MS chromatogram and mass spectra of photoproducts 4—8

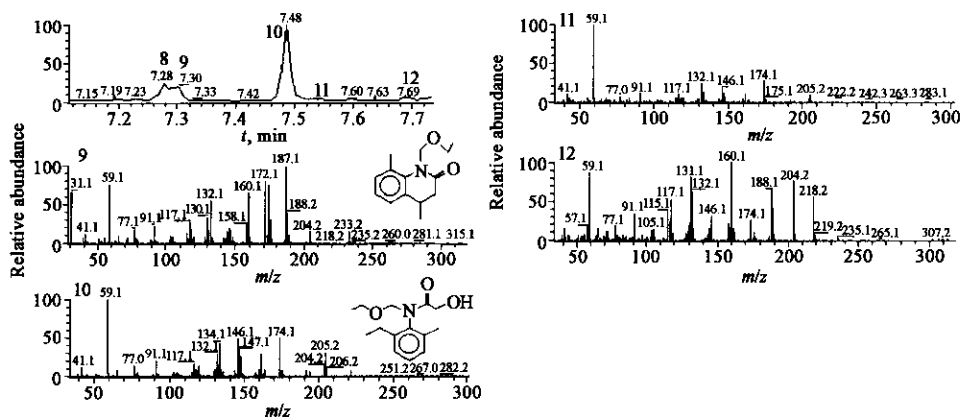


Fig.9 The GC/MS chromatogram and mass spectra of photoproducts 9-12

147,  $\text{CH}_3$  and CO to give the ion peak at  $m/z$  132.

Photoproduct 4, with MW 249, might correspond to 2-oxo-N-(2-ethyl-6-methylphenyl)-N-(ethoxymethyl)acetamide. Retention time was 6.88 min. The base peak ion at  $m/z$  59 was  $\text{C}_2\text{H}_5\text{OCH}_2^+$ . The molecular ion could lose  $\text{C}_2\text{H}_5\text{OH}$ , to give the ion peak at  $m/z$  203, and CHO to give the ion peak at  $m/z$  174. The mass spectrum of photoproduct 4 was similar to that of 2-oxo-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide which was one of metabolites of alachlor (Jacobson, 1991).

Photoproduct 5, with MW 221, might correspond to N-(ethoxymethyl)-2-ethyl-6-methylformanilide. Retention time was 6.99 min. The molecular ion lost  $\text{C}_2\text{H}_5\text{OCH}_2$  to give the base peak ion at  $m/z$  162, and CO to give the ion peak at  $m/z$  134. The ion peak at  $m/z$  59 was  $\text{C}_2\text{H}_5\text{OCH}_2^+$  peak.

Photoproduct 6, with MW 249, might correspond to 1-hydroxyacetyl-2-ethoxyl-7-ethylindole. Retention time was 7.15 min. The molecular ion could lose  $\text{C}_2\text{H}_5\text{O}$ , to give the ion peak at  $m/z$  204, and  $\text{C}_2\text{H}_5\text{OH}$  to give the ion peak at  $m/z$  203. The molecular ion could lose  $\text{C}_2\text{H}_5\text{O}$  and  $\text{COCHOH}$  (one  $\gamma\text{H}$  rearrange) to give the base ion peak at  $m/z$  146. The molecular ion could lose  $\text{C}_2\text{H}_5\text{OCH}$  and  $\text{COCH}_2\text{OH}$ , to give the ion peak at  $m/z$  132.

Photoproduct 8, with MW 233, might correspond to 8-ethyl-1-ethoxymethyl-2-oxo-1,2,3,4-tetrahydroquinoline. Retention time was 7.28 min. The molecular ion could lose  $\text{C}_2\text{H}_5$  to give the ion peak at  $m/z$  204,  $\text{C}_2\text{H}_5\text{O}$  to give the ion peak at  $m/z$  188,  $\text{C}_2\text{H}_5\text{OH}$  to give the ion peak at  $m/z$  187. The molecular ion could lose  $\text{C}_2\text{H}_5\text{OCH}_2$  and  $\text{CH}_2$  to give the base ion peak at  $m/z$  160. The ion peak at  $m/z$  59 was  $\text{C}_2\text{H}_5\text{OCH}_2^+$  peak.

Photoproduct 9, with MW 233, might correspond to 4, 8-dimethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline. Retention time was 7.30 min. Photoproduct 9 and photoproduct 8 should be similar compounds, since their retention time was almost simultaneous time, and the location of the ion peaks was almost the same place only the relative abundance of the ion peaks was different. The molecular ion could lose  $C_2H_5$  to give the ion peak at  $m/z$  204,  $C_2H_5O$  to give the ion peak at  $m/z$  188,  $C_2H_5OH$  to give the base ion peak at  $m/z$  187,  $C_2H_5OCH_2$  and  $CH_2$  to give the ion peak at  $m/z$  160,  $C_2H_5OCH_2$  and  $COCH_2$  to give the ion peak at  $m/z$  132. The molecular ion could lose  $C_2H_5OCH_2$  to give the ion peak at  $m/z$  174. According to the mechanism scheme of Somich *et al.* (Somich, 1988). The ion at  $m/z$  174 could lose two H to give the ion peak at  $m/z$  172. The ion peak at  $m/z$  59 was  $C_2H_5OCH_2^+$  peak.

Photoproduct 10, with MW 251, might correspond to 2-hydroxy-2'-ethyl-6'-methyl-N-(ethoxymethyl)acetanilide. Retention time was 7.48 min. The base peak ion at  $m/z$  5 was  $C_2H_5OCH_2^+$ . The ion peak at  $m/z$  205, 174, 146 might correspond the molecular ion to lose of  $C_2H_5OH$ ,  $C_2H_5OH$  and  $CH_2OH$ ,  $C_2H_5OH$  and  $COCH_2OH$  respectively. The mass spectrum of photoproduct 10 was similar to that of 2-hydroxy-2',6'-diethyl-N-(methoxymethyl)acetanilide which was one of photoproducts of alachlor (Penuela, 1996).

Dechlorination was presumably the first step in photodegradation of acetochlor in water when irradiated with UV light. Absorption of a photon by the carbonyl of acetochlor was followed by loss of chlorine at the  $\alpha$ -carbon, affording intermediate 13. Intermediate 13 proceeds to degrade to give various photoproducts. Photoproduct 1 and photoproduct 2 might be formed by other photoproducts proceeding to degrade. Fig. 10 shows the mechanism of acetochlor photodegradation. However, according to Wilson and Mabury's (Wilson, 2000) investigation, monochloroacetic acid was a major photoproduct of chloroacetanilide herbicides in synthetic field water. Monochloroacetic acid may be formed on another pathway of photodegradation. But monochloroacetic acid was not detected in our studies, maybe monochloroacetic acid was neglected due to our analytical method limitation, since monochloroacetic acid is a strong polar product. It should be noted that photolysis rates and photoproduct formation are actually dependent on the intensity and the wavelength distribution of the light used. The photodegradation mechanism and products of acetochlor in our study is not all the same as sunlight photodegradation on natural environmental conditions.

### 3 Conclusions

Twelve photoproducts of acetochlor were identified by GC/MS after photolysis. The chemical structures of ten photoproducts were presumed on the basis of mass spectrum interpretation and literature data corresponding to 2-ethyl-6-methylaniline; N, N-diethylaniline; 4, 8-dimethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 2-oxo-N-(2-ethyl-6-methylphenyl)-N-(ethoxymethyl)acetamide; N-(ethoxymethyl)-2-ethyl-6-methylformanilide; 1-hydroxyacetyl-2-ethoxyl-7-ethylindole; 8-ethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 4, 8-dimethyl-1-ethoxymethyl-2-oxo-1, 2, 3, 4-tetrahydroquinoline; 2-hydroxy-2'-ethyl-6'-methyl-N-(ethoxymethyl)acetanilide and a compound related to acetochlor. The other two photoproducts were detected by GC/MS although their chemical structure was unknown. Photoproduct 10 [2-hydroxy-2'-ethyl-6'-methyl-N-(ethoxymethyl)acetanilide] was found to be a major product in photolysis. Dechlorination was presumably the first step in photodegradation. The sunlight photodegradation of acetochlor was slow in water under the experiment conditions. The half-lives of 20 mg/L acetochlor in de-ionized water, river water and paddy water were 151, 154, and 169 days. However, when exposed to

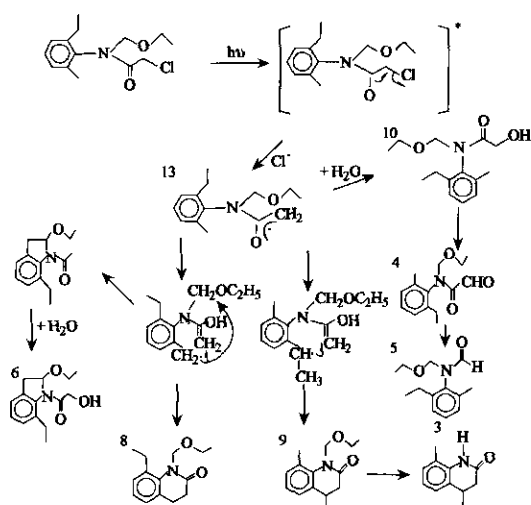


Fig. 10 The mechanism of acetochlor photodegradation

UV light, acetochlor in aqueous solution was rapidly degraded, the half-lives of 20 mg/L acetochlor were 7.1, 10.1, and 11.5 min in de-ionized water, river water and paddy water, respectively.

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