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PREPARATION, CHARACTERIZATION AND ANTIBACTERIAL STUDIES OF SOME HYDRAZINIUM CARBOXYLATES

Manimekalai, R.* and K. Kuppusamy
*Department of Chemistry, Kongunadu Arts and Science College, Coimbatore – 641 029.
*E-mail –manimekalair@ymail.com

ABSTRACT

Some new hydrazinium salt of aromatic carboxylic acids have been prepared by neutralization of acid with hydrazine hydrate in aqueous medium and characterized by Analytical, IR spectral and TG-DTA analysis. All compounds undergo two, three or four step decomposition yielding carbon residue as the final product. The in vitro antibacterial screening of 2,4-dichlorophenoxyacetic acid and its hydrazinium salt against *Escherichia coli* have been investigated. The antibacterial activity of the prepared hydrazinium salt shows more promising activity than the free acid.

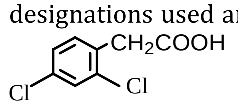
Keywords: Hydrazinium salt, Aromatic carboxylic acids, IR spectral.

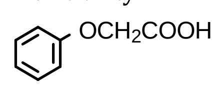
1. INTRODUCTION

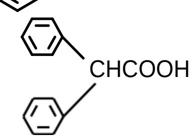
Hydrazine is the simplest diamine and forms salt with mineral and carboxylic acids (Vogel, 1962; Yasodhai and Govindarajan, 1999). The preparation of hydrazinium salts has become a subject of recent interest due to their wide use as additives in propellants, drugs to treat cancer and Hodgkin's diseases and explosives (Vogel, 1962). They have also been used as ligands for the preparation of metal hydrazinium/hydrazine complexes (Patil *et al.,* 1980, Govindarajan *et al.,* 1986 a and b; Chandra and Singh, 1983). Some of these salts are used as flame – retardants (Schmidt, 1984; Balague *et al.,* 2001) and proton conductors (Patil *et al.,* 1979). Only few of these salts show antibacterial activity (Govindarajan, *et al.,* 1980). Preparation and thermal behaviour of some salts from few aliphatic acid (Patil *et al.,* 1981) and aromatic carboxylic acids (Allan, *et al.,* 1998; Vairam and Govindarajan, 2004) have been reported. There is no literature citations about hydrazinium salt of aromatic substituted acetic acids, aromatic unsaturated acids and hetero acids except hydrazinium salt of pyrazine mono and di-carboxylic acids (Premkumar and Govindarajan, 2006). It is therefore, considered interesting to prepare hydrazinium salt of aromatic substituted acetic acids namely 2,4-dichlorophenylacetic acid, phenoxyacetic acid, 2,4-dichlorophenoxyacetic acid, and Diphenylacetic acid, aromatic unsaturated acid namely cinnamic acid, hetero acids namely picolinic acid and nicotinic acid.

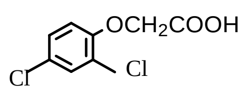
Generally all phenolic derivatives show antibacterial property. Particularly 2,4-dichlorophenoxyacetic acid altered envelope properties of the bacteria Escherichia coli, such as hydrophobic index Unsubstituted phenoxyacetic acid is also a phenolic derivative. But, it has no potent substituents to have antibacterial property. 2,4-dichlorophenoxyacetic acid contain two potent chloro substituents. It influences it to have antibacterial property like chloroxylenol (4-chloro-2,5-Xylenol) which acts as antiseptic as well as disinfectants. This prompted us to make antibacterial study of hydrazinium salt of 2,4-dichlorophenoxyacetic acid against *Escherichia coli*

The structures of acids and their designations used are shown below for clarity

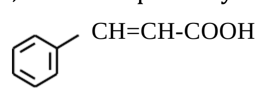




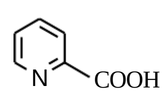


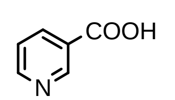


2,4-dichlorophenylacetic acid phenoxy acetic acid
2,4-dichlorophenoxyacetic acid Diphenylacetic acid



Cinnamic acid





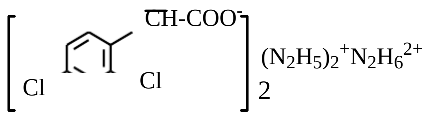
Picolinic acid Nicotonic acid

2. EXPERIMENTAL

All the salts reported have been prepared by the neutralization of the respective carboxylic acids in aqueous medium with hydrazine hydrate (99 – 100 %) in appropriate molar ratios.

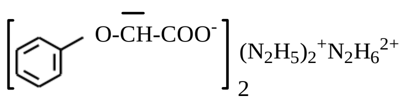
2.1. Preparation

2.2.1. Hydrazinium 2,4-dichlorophenyl acetate



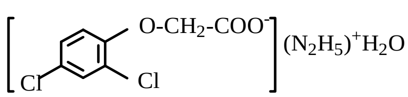
This is prepared by mixing hydrazine hydrate and 2,4-dichlorophenylacetic acid in 2:3 molar ratio in 50 mL of distilled water. The resulting turbid solution is heated over water bath to obtain clear solution and concentrated to nearly 20 mL. Then it is allowed to crystallize at room temperature. Light yellow coloured hydrazinium salt is crystallized out after 24 hours. The crystals are filtered off and washed by using benzene and dried in air.

2.2.2. Hydrazinium phenoxyacetate



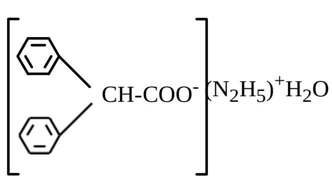
This is also prepared by the same procedure as above by mixing the acid with the base in the molar ratio of 2:3. Spongy white coloured salt is crystallized within 20 minutes. The product is washed by using benzene and air dried.

2.2.3. Hydrazinium 2,4-dichlorophenoxy acetate

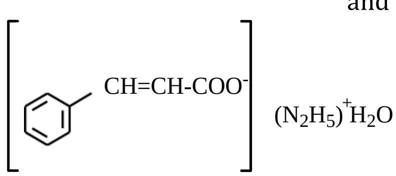


The hydrated salt is also prepared by the same procedure by mixing hydrazine hydrate and 2,4-dichlorophenoxyacetic acid with molar ratio 1:1. White coloured salt is crystallized out immediately. This is washed by using alcohol and air dried.

2.2.4. Hydrazinium diphenyl acetate hydrate and hydrazinium cinnamate hydrate

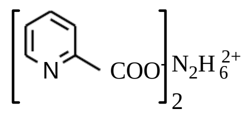


and

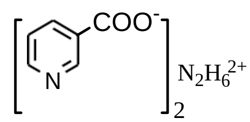


These are prepard by mixing hydrazine hydrate and Diphenyl acetic acid or cinnamic acid in 1:1 molar ratio in 50 mL of water. The contents of the beaker are heated on water bath. Then the undissolved acid is removed by filtration. The resulting clear solution is concentrated on water bath to 20 mL. Then it is allowed to crystallize at room temperature. While the white coloured monohydrated hydrazinium(+1) salt of cinnamic acid separated out after 24 hours, whereas light yellow coloured monohydrated hydrazinium (+1) salt of Diphenylacetic acid separated out after 48 hours, they are filtered off and washed by using alcohol and air dried.

2.2.5. Hydrazinium picolinate and Hydrazinium nicolinate



and



These are prepared by mixing hydrazine hydrate and picolinic acid or nicotinic acid with 1:1 molar ratio in 50 mL of distilled water. The resulting clear solution is concentrated on water bath to 20 mL. Then it is allowed to crystallize in a vacuum desiccator over calcium chloride. Light yellow coloured hydrazinium(+2) salt of picolinic acid separated out after 2 days, filtered and washed by using alcohol, whereas white coloured hydrazinium(+2) salt of nicotinic acid is also separated out after 2 days, filtered and washed by using ether.

2.2.6. Physico-Chemical techniques

The hydrazine content of these salts are determined volumetrically using a standard (0.025 m) KIO_3 solution under Andrew's condition [17]. IR spectra are recorded as KBr pellets with a Shimadzu spectrophotometer in the range 4000-400 cm^{-1}. Elemental analyses are performed on a Perkin-Elmer 240 B CHN analyzer. Simultaneous TG-DTA measurements are carried out using STA 1500 thermal analyzer. All thermal analyses are carried out in air at a heating rate of 10°C per minute. Platinum cups are used as sample holders and alumina as reference.

The microorganism used to test the biological potential of 2,4-dichlorophenoxyacetic acid and its hydrazinium(+1) salt is Escherichia coli, obtained from the stock cultures of the Biotechnology Laboratory of the Department of Biotechnology, Kongunadu Arts and Science College, Coimbatore, India.

2.2. Antibacterial activity

The antibacterial activity of 2,4-dichlorophenoxyacetic acid and its hydrazinium salt are determined by the disc diffusion method

(Cruickshank, 1968). The bacteria are cultured in nutrient agar medium and used as inoculum for the study. Bacterial cells are swabbed on to nutrient agar medium (prepared from NaCl (5.0g), peptone (5.0g), beef extract powder (3.0g), yeast extract powder (3.0 g), agar (20.0 g) in 100 mL distilled water, pH = 7.5 ± 0.2) in Petri dishes. The test solutions are prepared in distilled water to a final concentration of 2% and 4% and then applied to filter paper discs (Whatmann/No. 4.5 mm dia). These discs were placed on the already seeded plates and incubated at 35±2°C for 24hr. the zone of inhibition around the discs are measured after 24hr. Co-trimoxazole is used as a standard positive control.

3. RESULTS AND DISCUSSION

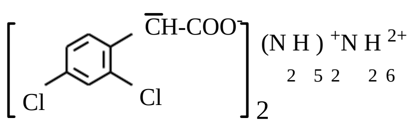
The analytical data of the salts (Table 1) are consistent with the proposed formulae for them.

3.1. Infrared spectra

The important IR bands of the salts are listed in Table 2. The IR spectra of the hydrated salts display absorption bands in the region of 3346 - 3330 cm^{-1} due to O-H stretching of water molecule. The bands in the region of 1390-1323 cm^{-1} and 1598-1521 cm^{-1} for these salts are corresponds to symmetric and asymmetric stretching frequencies of the carboxylate ions. The N-N stretching frequencies of $N_2H_5^+$ ion appear in the range of 963-951 cm^{-1} and the N-N stretching frequencies of $N_2H_6^{2+}$ ion shows bands in the region of 1047 - 1026 cm^{-1}.

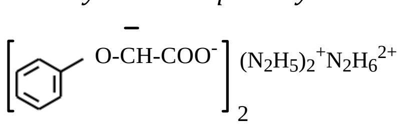
3.2. Thermal analysis

3.2.1. Hydrazinium 2,4-dichlorophenyl acetate



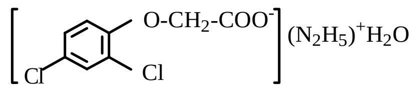
The thermogram of this salt indicates that the decomposition of the salt takes place in multi steps. In the first step, dehydrazination with melting takes place with endothermic peak at 99°C. In the second step the carboxylate intermediate decomposes to phenol with endothermic peak at 211°C and an exothermic peak at 269°C. In the next step showing exothermic peak at 305°C and 461°C due to the formation of formic acid. Finally it decomposes to carbon residue at 546°C.

3.2.2. Hydrazinium phenoxy acetate



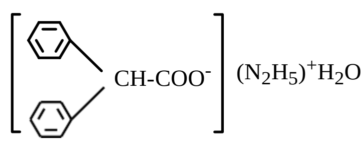
This undergoes decomposition in three steps. In the first step, compound undergoes melt with endothermic peak at 99°C. Then the compound decomposes to diphenyl glycol with exothermic peak at 149°C and 265°C. Finally at 327°C it decomposes to carbon residue.

3.2.3. Hydrazinium 2,4-dichlorophenoxy acetate hydrate



The thermogram of this salt indicates that the decomposition of the salt takes place in two steps. In the first step, both dehydration and dehydrazination occur simultaneously showing a sharp endotherm at 170°C. In the second step the acid intermediate decomposes exothermally at 285°C and 488°C to carbon residue.

3.2.4. Hydrazinium diphenyl acetate hydrate

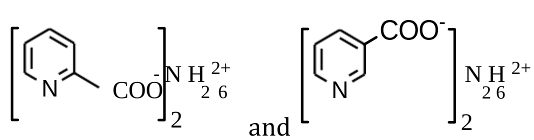


This undergoes decomposition in three steps. First step shows an endothermic peak at 106°C corresponding to the removal of moisture. In the second step, both dehydration and dehydrazination occur simultaneously showing two exothermic peaks at 186°C and 233°C to form formic acid. In the final step, formic acid completely decomposes to carbon residue.

3.2.5. Hydrazinium cinnamate hydrate

This compound also undergoes three steps decomposition. First step shows an endothermic peak at 92°C corresponding to liberation of water molecule. Second step shows on endothermic peak at 150°C due to the elimination of one molecule of hydrazine. In the third step complete decomposition to carbon residue takes place.

3.2.6. Hydrazinium picolinate and hydrazinium nicolinate



Both compounds undergo two step decomposition. First step is the removal of moisture with endothermic peaks at 121°C and 117°C respectively. In the second step, the compound completely decomposes to carbon residue.

TG – DTA curves of some compounds are given (Fig 1 - 4) as representative examples.

3.3. Antibacterial activity

The antibacterial activity of the 2,4-dichlorophenoxyacetic acid and its salt are determined by disc diffusion method. From the result (Table 4) it has been observed that hydrazinium salt of 2,4-dichlorophenoxyacetic acid shows more activity than the free acid.

4. CONCLUSION

2,4-dichlorophenylacetic acid and Phenoxyacetic acid form peculiar type of hydrazinium salts similar to double salts. These type of salts are not been reported so far in the literature. They contain both hydrazinium(+1) and hydrazinium(+2) ions. Their compositions are confirmed by analytical, IR spectral and Thermal studies. In these salts 'CH_2' group loses H^+ ion because of the presence of more electronegative groups on both sides and becomes carbanion and their charges are compensated by the extra hydrazinium(+2) ions. Phenoxyacetic acid, 2,4-dichlorophenoxyacetic acid, Diphenylacetic acid and Cinnamic acid form salts containing only hydrazinium(+1) ions, whereas picolinic and nicotinic acid formed as hydrazinium(+2) salts.

All compounds undergo two, three or four step exothermic or endothermic decomposition through various intermediates. The double salts have more lattice enery than the other salts. Therefore they undergo melting before decomposition as observed in TG – DTA analysis, whereas the other simple salts decomposes before melting. All the salts decompose completely to give carbon residue as the final product.

The antibacterial activity of 2, 4-dichlorophenoxyacetic acid and its hydrazinium salt against *Escherichia coli*

has been studied. The antibacterial activity of the hydrazinium salt show more promising activity than the free acid.

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Table 1. Analytical data

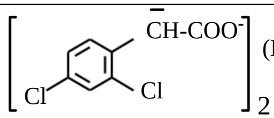
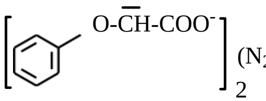
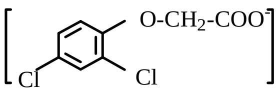
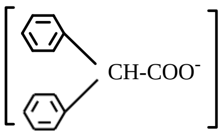
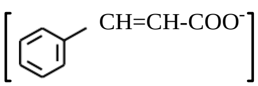
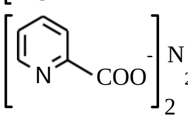
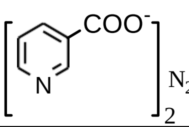
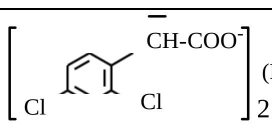
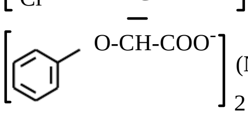
S.No	Compound	Colour	Found(calculated) %			
			Hydrazine	Carbon	Hydrogen	Nitrogen
1	 $(N_2H_5)_2^+N_2H_6^{2+}$	Light yellow	19.20(19.47)	37.40(37.70)	4.50(4.91)	16.30(16.49)
2	 $(N_2H_5)_2^+N_2H_6^{2+}$	White	24.19(24.70)	47.20(47.82)	7.11(7.20)	20.14(20.92)
3	 $(N_2H_5)^+H_2O$	White	11.21(12.14)	47.10(47.04)	4.10(4.41)	8.80(8.82)
4	 $(N_2H_5)^+H_2O$	Light yellow	12.00(12.55)	63.20(63.80)	6.20(6.83)	10.59(10.63)
5	 $(N_2H_5)^+H_2O$	White	17.40(17.19)	51.00(51.19)	7.04(7.02)	14.85(14.05)
6	 $N_2H_6^{2+}$	Light yellow	12.71(12.10)	51.29(51.38)	2.89(2.85)	9.96(9.99)
7	 $N_2H_6^{2+}$	White	12.83(12.10)	51.20(51.38)	2.80(2.85)	9.95(9.99)

Table 2. IR spectral data (cm⁻¹)

S.No	Compound	υ_{OH} of water/acid	υ_{N-H}	υ_{asymm} (OCO)	υ_{sym} (OCO)	υ_{N-N}
2	 $(N_2H_5)_2^+N_2H_6^{2+}$	-	3276 3257	1590	1380	958 1030
4	 $(N_2H_5)_2^+N_2H_6^{2+}$	-	3443(b)	1589 1541	1375 1338	959 1026 1047

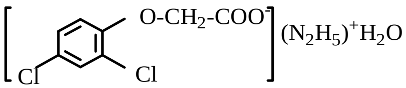
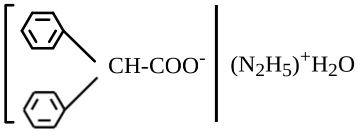
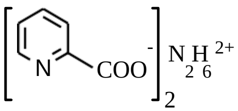
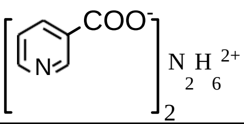
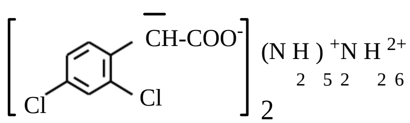
6		3330(s)	3172 3072	1577 1569	1390 1328	951
8		3346(s) 3331(s)	3276 3245	1596 1527	1375 1340	963
10		3332(b)	3251 3236	1558 1521	1386 1338	953
11		-	3276 3213	1583 1560	1385 1331	1043
12		-	3265 3246	1598 1544	1386 1323	1029

Table 3. TG - DTA data

S.No	Compound	DTA peak temp(°C)	Thermogravimetry(TG)			Decomposition product
			Temp range °C	Mass loss (%)		
				Observed	Calculated	
1		99(+)	25-133	5.18	6.49	Melting and dehydrazination
		211(+) 269(-)	133-286	79.43	81.54	Decomposition to phenol
		305(-) 461(-)	286-329	90.38	90.91	Decomposition to formic acid
		546(-)	329-585	95.86	-	Decomposition to carbon residue

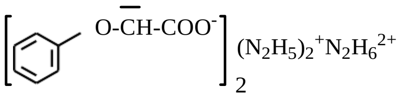
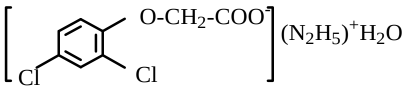
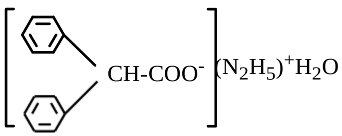
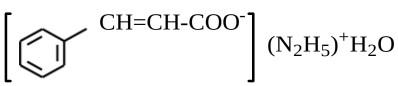
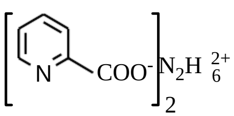
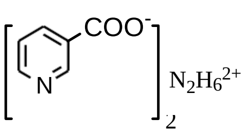
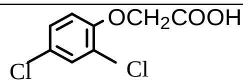
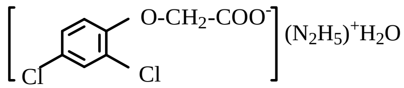
2		99(+)	25-90	-	-	Melting
		149(-) 265(-)	90-234	50.41	47.00	Decomposition leads to diphenyl glycol
		327(-)	234-344	97.6	-	Decomposition to carbon residue
3		170(+)	103-225	18.21	18.39	Dehydration and dehydrazination
		285(-) 488(-)	225-528	96	-	Complete decomposition to carbon residue
4		106(+)	25-86	1	-	Removal of moisture
		186(-) 233(-)	86-354	81.51	82.53	Dehydration and dehydrazination leads to formic acid
		484(-)	354-483	97	-	Complete decomposition to carbon residue
5		92(+)	25-102	9.67	9.03	Dehydration
		150(+)	102-150	25.04	26.13	dehydrazination
		289(-) 458(-)	150-481	98.41	-	Decomposition to carbon residue
6		121(+)	25-99	-	-	Removal of moisture
		155(-) 191(+)	99-218	87.70	-	Decomposition to carbon residue
7		117(+)	25 – 127	3.69		Removal of moisture
		183(-) 282(+)	127 - 304	90.20	-	Decomposition to carbon residue

Table 4. Antibacterial activity of 2,4-dichlorophenylacetic acid and its hydrazinium salt (The test solution is prepared in distilled water)

S.No	Compound	Diameter of inhibition zone (mm)	
		2 %	4%
1.		7	10
2.		19	26

Diameter of Zone of inhibition is a mean of triplicates

Fig 1 TG – DTA of 

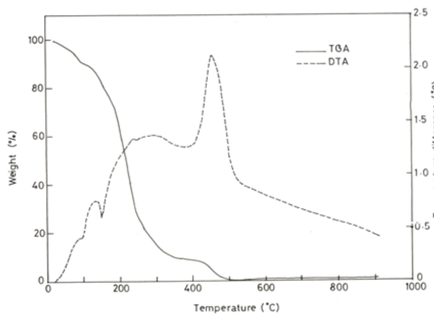
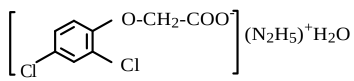


Fig 2 TG – DTA of 

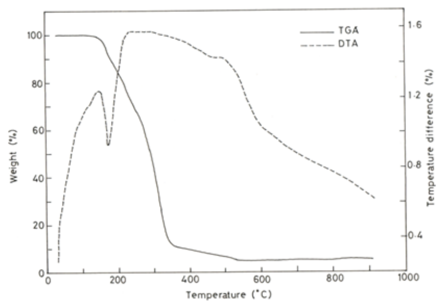
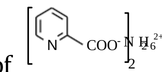


Fig 3 TG – DTA of 

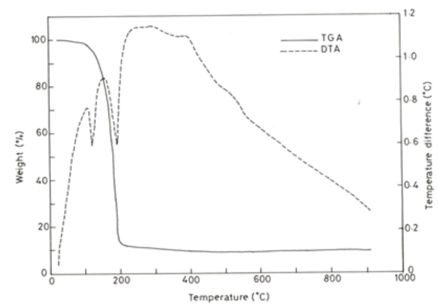


Fig 4 TG – DTA of