



RESEARCH ARTICLE

SYNTHESIS AND CHARACTERIZATION OF FORMAMIDINE DISULFIDE SCHIFF BASES AND THEIR CORRESPONDING 1, 3-OXAZEPINES

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ABSTRACT

Thiourea was oxidized in the presence of potassium permanganate to yield formamidine disulfide. This was then reacted with various aldehydes to yield formamidine disulfide Schiff bases. Each Schiff base was then condensed with maleic and phthalic anhydride to give corresponding seven-membered heterocyclic ring derivatives respectively. The structures were identified by their uncorrected melting point, FT-IR spectra and mass spectra fragmentation pattern.

INTRODUCTION

Schiff bases are condensation products of primary amines with carbonyl compounds and they were first reported by Schiff (Cimerman *et al.*, 2000) in 1864. The common structural feature of these compounds is the azomethine group with a general formula $RHC=N-R_1$, where R and R₁ are alkyl, aryl, cyclo alkyl or heterocyclic groups which may be variously substituted. The electrophilic carbon atoms of aldehydes and ketones can be targets of nucleophilic attack by amines. The seven (7) membered heterocyclic ring system 1,3-oxazepine has been reported in many literatures (Al-Rubaay, A.K., 2008 and Toshio *et al.*, 1977). In this work formamidine disulfide Schiff bases are synthesized and condensed with maleic and phthalic anhydrides to yield their corresponding 1,3-oxazepine derivatives.

Experimental

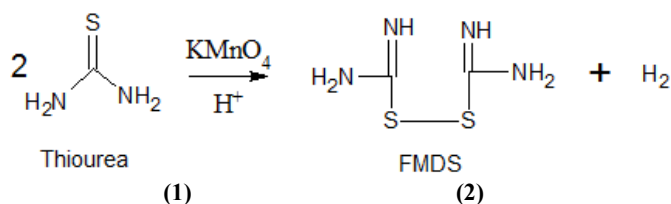
Melting points were determined on Gallen Kamp melting point apparatus and were uncorrected. The FTIR spectra were recorded with Shimadzu FTIR 8400 spectrophotometer. The GC-MS spectra were recorded on GCMS-QP2010 PLUS Shimadzu, Japan.

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Synthesis of Formamidine disulfide

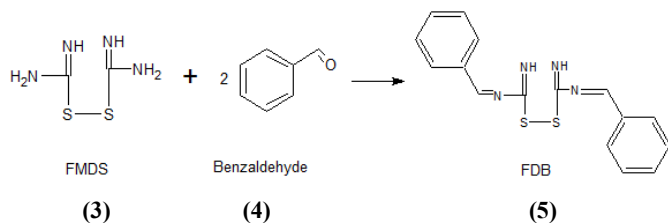
Prepared acidified $KMnO_4$ was slowly added into the conical flask containing a solution of thiourea until a purple color was obtained. After about 30-45 minutes $NaHCO_3$ and distilled water were added until the solution turned a red litmus paper blue.



Scheme 1. Oxidation of thiourea

Synthesis of 1,1'-(disulfanediy) bis (carbon imido) nitrilo (Z) methylidene; dibenzene

Two grams of formamidine disulfide (2) was dissolved in 5ml dilute methanol. 10ml of benzaldehyde (30) was then added into the solution in a conical flask and warm on a water bath for about 15 minutes with continuous stirring. On cooling, crystals formed, filtered off, allowed to dry and melting point determined.



Scheme 2. Reaction of FMDS and FDB

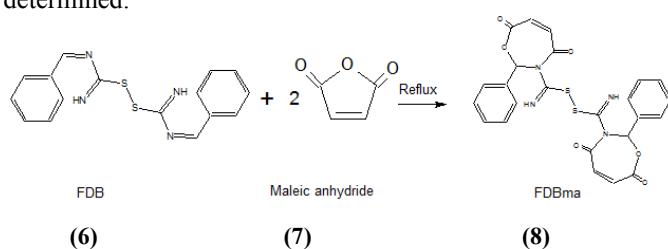
FMDS; formamidine disulfide,

FDB; 1,1'-bis[disulfanediybis(carbonimidoylnitrilo(Z)methylidene)]dibenzene

Other derivatives were prepared by the same method (see table)

Synthesis of 3 - (n - n - 4, 7 - dioxo - 2 - phenyl - 2, 3, 4, 7 - tetrahydro- 1, 3 - oxazepine - 3 carboximidoyl disulfanyl carboximidoyl) - 2 - phenyl -2, 3, 4, 7 - tetrahydro -1, 3 - oxazepine-4, 7-dione

A mixture of the prepared Schiff base, FDB (5) (0.027M) and Maleic anhydride (0.00726M) were dissolved in 20ml dry toluene and the mixture was refluxed for about 3hrs. Excess solvent was distilled and the precipitate obtained was filtered after cooling, recrystallized in ethanol and melting point was determined.



Scheme 3. Reaction of FDB with Maleic anhydride to yield FDBma

FDB: 1,1'-bis[disulfanediybis (carbonimidoyl nitrilo(Z)methylidene)]dibenzene

FDBma: 3-(N-N-4,7-dioxo-2-phenyl-2,3,4,7-tetrahydro-1,3-oxazepine-3-carboximidoyl)disulfanylcarboximidoyl-2-phenyl-2,3,4,7-tetrahydro-1,3-oxazepine-4,7-dione

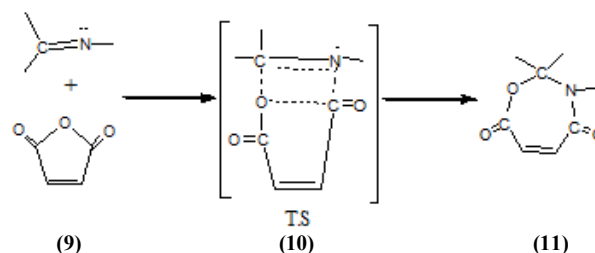
Phthalic anhydride was then used instead of maleic anhydride to prepare more 1,3-oxazepine derivatives using the same method of preparation.

RESULTS AND DISCUSSION

Formamidine disulfide Schiff bases are prepared by condensation of formamidine disulfide with aromatic aldehydes to give the azomethine/imine compounds (Scheme 1) and identified by melting point (See Table 1), FTIR and GC-MS.

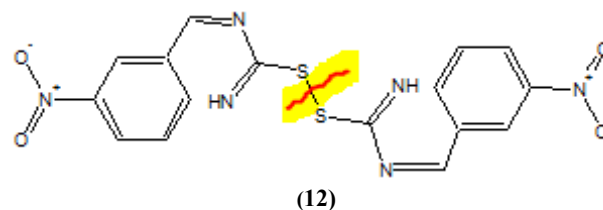
The reaction is followed by disappearance of (C=O) absorption band at (1690-1720) cm^{-1} with the appearance of (C=N) absorption band at (1645-1649) cm^{-1} (see Table 2). Derivatives of oxazepine are prepared by reaction of maleic anhydride with Schiff bases derivatives (Scheme 3). It was noted disappearance of the azomethine (C=N) absorption band and

appearance of the (C=O) absorption band at (1670-1730) cm^{-1} . The compounds of oxazepine derivatives are identified by m.p. (see Table 1), and other important FTIR absorptions of compounds are shown in Table 2. The reaction of maleic anhydride with various Schiff bases (9) is a type of a cyclo-addition reaction. Cyclo addition is a ring formation that results from the addition of π bonds to other σ or π with formation of a new σ bond. The reaction is initiated by attack of the azomethine nitrogen at one of the two carbonyl groups of maleic anhydride to yield the dipolar intermediate (10) which collapses to the natural species (11) which may be attributed to the fact that the combined (C=O) of the lactone and the (C=O) of the lactam in 7-membered ring.



Scheme 4. Approximate transition state (TS) geometry for addition of maleic anhydride to imine group (Al-Hadithi M.A., 2006)

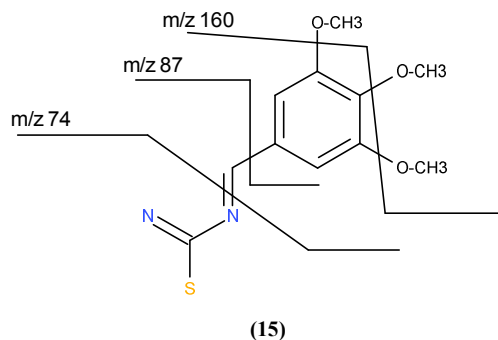
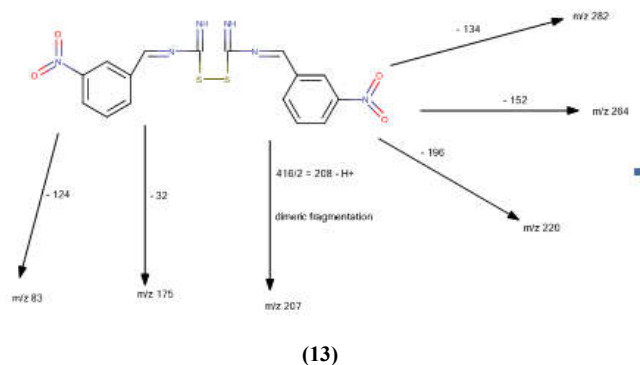
It was demonstrated that the basic hydrolysis of 2,3-dihydro-1,3-oxazepine-4,7-diones is unsuccessful due to immediate reclosure on acidification to the original cyclic structure as evidenced by the fact that both the original 1,3-oxazepine-4,7-dione and assumed hydrolysis product have the same m.p., FTIR, and ^1HMR (Hussein *et al.*, 2001). The absence of characteristic absorption bands of (S-S) group in some of the FT-IR spectra (FDN, FDPma and FDPpa) is observed and reported by Brian Smith., (1998); He said, "sulfur-oxygen bonds have intense infrared bands because of their large dipole moments. However, S-S, S-H and C-S bonds have weak infrared bands because of their small (or nonexistent) dipole moments, and are sometimes difficult to detect via infrared spectroscopy. In these cases alternative forms of analysis may be necessary to determine if there is an S-S or S-H band in a sample". As noted in many literatures, molecular ions are energetically unstable, and some of them will break up into smaller pieces. The simplest case is that a molecular ion breaks into two parts (Jim Clark., 2014) as observed in (12), thus;



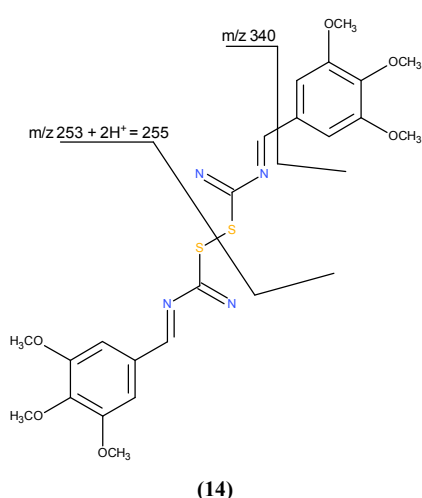
Molecular Weight: 416

$416 \div 2 = 208 - \text{H}^+ = \text{product ion at } m/z \text{ 207}$

The compound (12) breaks into two parts (dimeric fragmentation-(Somogyi *et al.*, 2006) with a subsequent loss of a proton, H^+ to yield a monomer at m/z 207. The summary of the fragmentation pattern of (12) is shown below

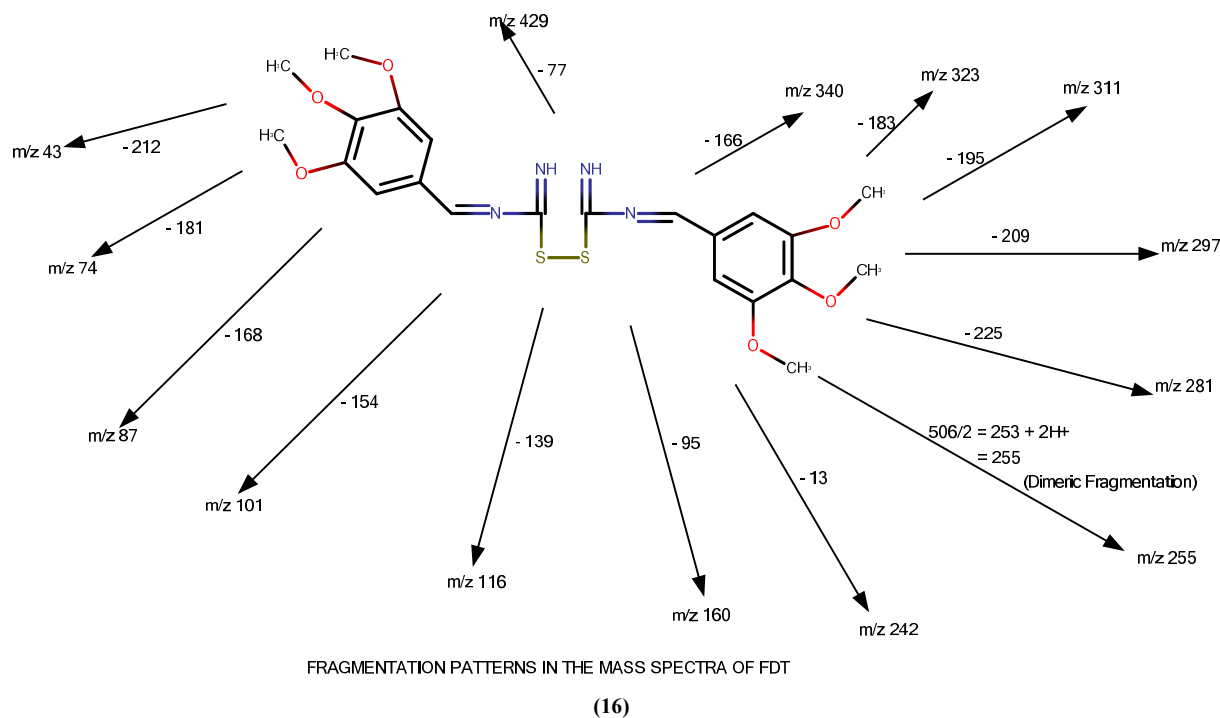


FDT (14) undergoes dimeric fragmentation with a subsequent absorption of $2H^+$ to yield a product ion at m/z 255



The product ion at m/z 340 was consequent to the loss of the protonated ion of 3,4,5-trimethoxy benzene (14). Dimer product ions at m/z 160, m/z 87 and m/z 74 were also observed in the mass spectra (15). The summary of the fragmentation pattern of FDT (14) is thus;

Although no protonated molecule $(M+H)^+$ at m/z 306 was found in the mass fragmentation pattern of (17); adducts of the monomer at m/z 227, m/z 213, m/z 207, m/z 185, m/z 171 and of the dimer at m/z 256 were detected in the mass spectrum (18) as shown below; Considering the mass fragmentation of (19) no protonated molecule $(M+H)^+$ of the dimer was observed in the spectrum but product ions of the monomer at m/z 355 was obtained and, subsequent fragmentation product ions at m/z 265, m/z 203 and m/z 69 were the only fragmentation product ions obtained from the spectrum (19). The small number of fragmentation product ions observed may be, probably, due to stability conferred by phthalic anhydride on the compound. The summary of the fragmentation pattern of (19) is shown below (20);



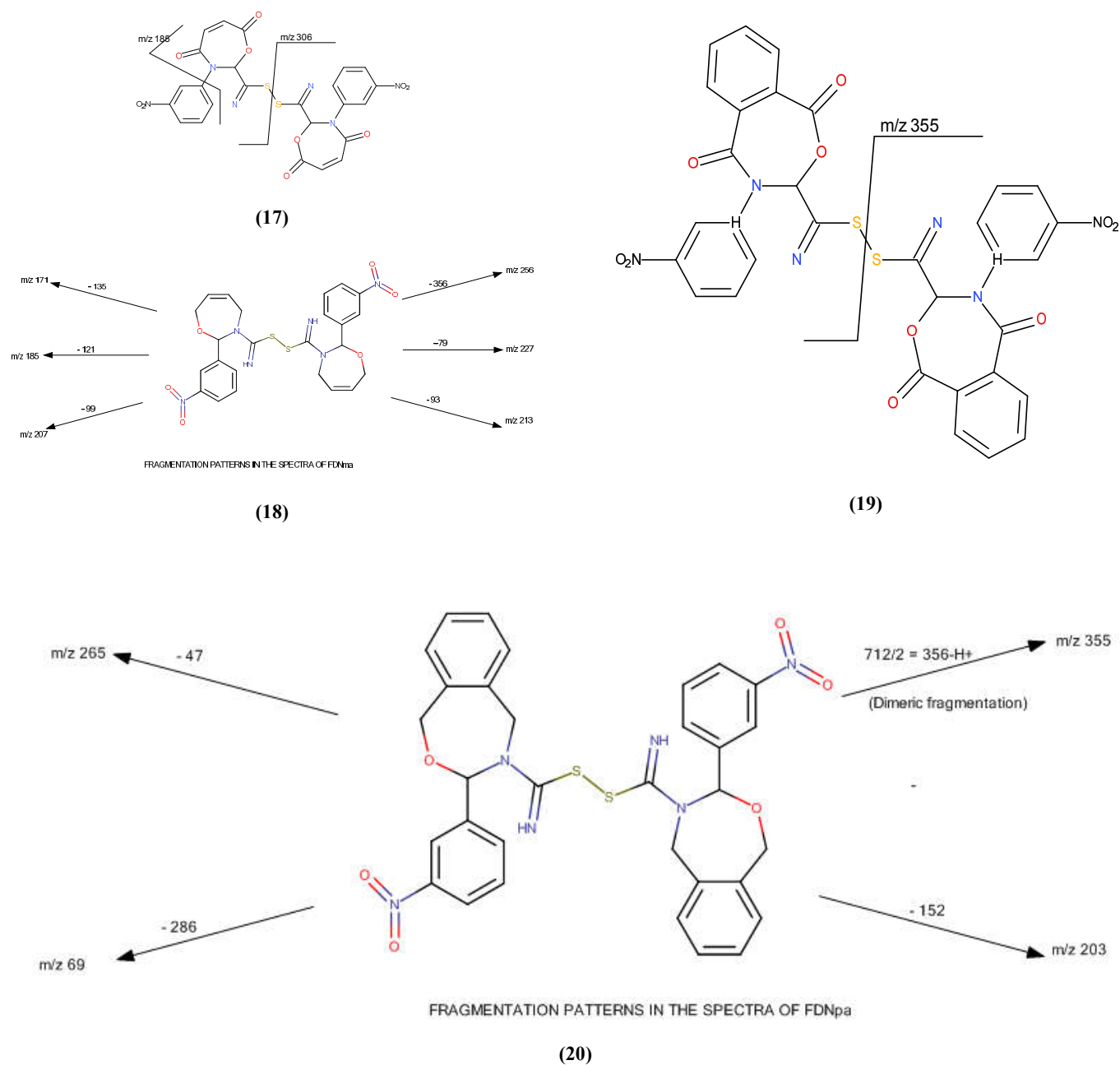
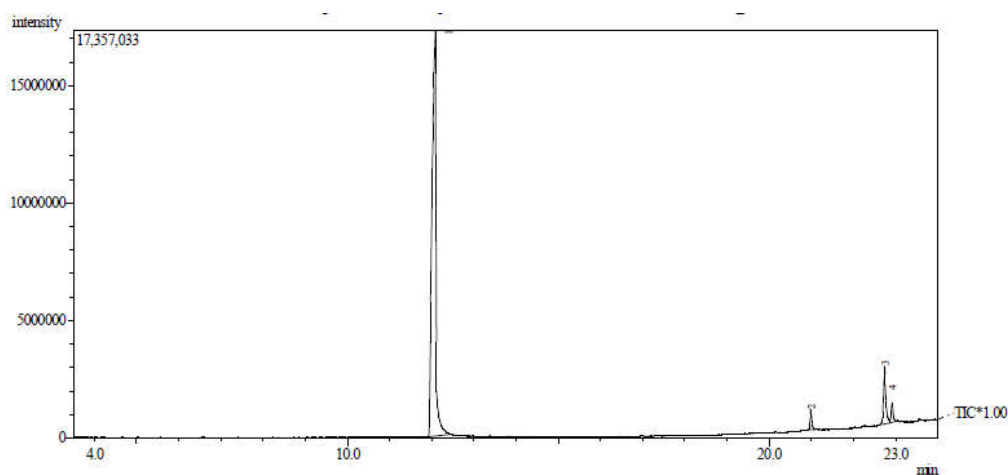
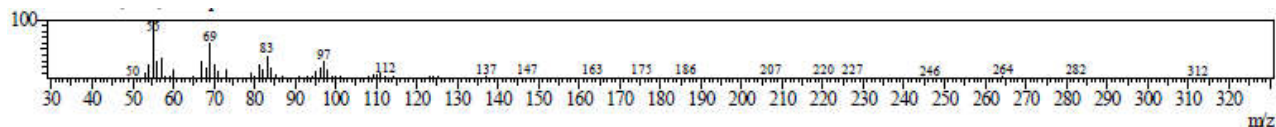
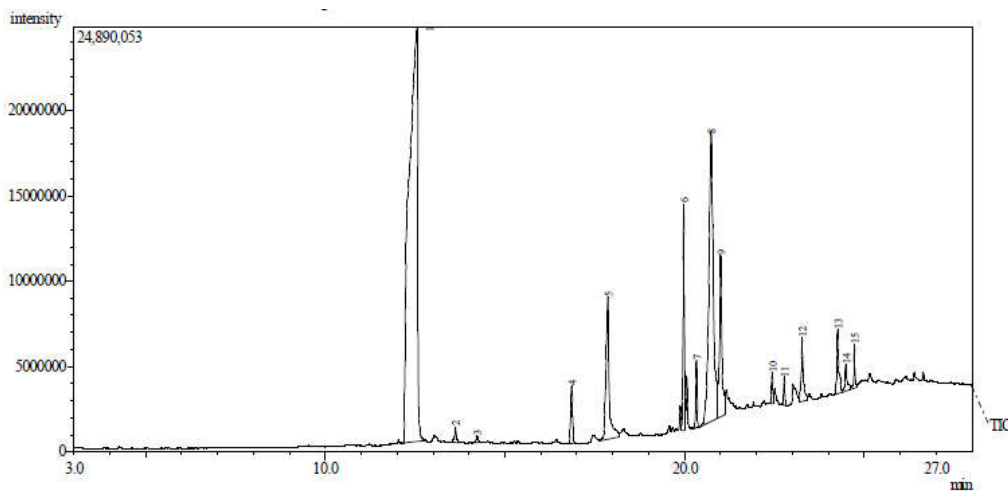
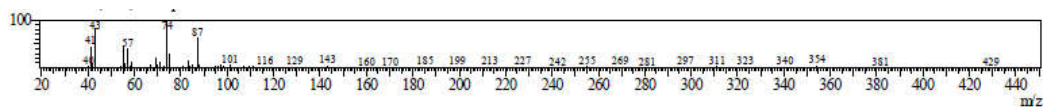


Table 1. Melting Point, Yield (%), Molecular Formula and Molecular Weight

Serial No	Compound	Melting Point (°C)	Yield (%)	Molecular Formula	Molecular Weight
1	FDB	100-110	19.0	C ₁₆ H ₁₄ N ₄ S ₂	326
2	FDM	160-170	32.3	C ₁₈ H ₁₈ N ₄ S ₂	354
3	FDN	55-65	30.1	C ₁₆ H ₁₂ N ₆ O ₄ S ₂	416
4	FDD	75-85	33.9	C ₁₈ H ₂₆ N ₈ S ₂	418
5	FDT	70-80	32.5	C ₂₂ H ₂₆ N ₄ O ₆ S ₂	506
6	FDP	55-65	31.8	C ₁₈ H ₁₈ N ₄ O ₄ S ₂	418
7	FDBma	90-100	85.0	C ₂₄ H ₁₈ N ₄ O ₆ S ₂	522
8	FDMma	145-165	84.5	C ₂₆ H ₂₂ N ₄ O ₆ S ₂	550
9	FDNma	165-175	85.5	C ₂₄ H ₁₆ N ₆ O ₁₀ S ₂	612
10	FDDma	65-75	84.2	C ₂₈ H ₂₈ N ₆ O ₆ S ₂	608
11	FDTma	58-62	84.0	C ₃₁ H ₃₂ N ₄ O ₁₂ S ₂	716
12	FDPma	38-44	81.4	C ₂₆ H ₁₈ N ₄ O ₁₀ S ₂	610
13	FDMpa	160-166	75.7	C ₃₄ H ₂₆ N ₄ O ₆ S ₂	650
14	FDNpa	60-70	68.5	C ₃₂ H ₂₀ N ₆ O ₁₀ S ₂	712
15	FDDpa	88-92	73.1	C ₃₆ H ₃₂ N ₆ O ₆ S ₂	708
16	FDTpa	65-75	77.5	C ₃₉ H ₃₈ N ₄ O ₁₂ S ₂	818
17	FDPpa	165-175	57.9	C ₃₄ H ₂₂ N ₄ O ₁₀ S ₂	710

Table 2. The major FT-IR absorption (cm^{-1}) of compounds [1-17]

S/ N	Comp.	N-H	C-H arom	C-H aliph	C=O keton	S-S	C=N	C=C arom	C-N	C-H 'oops'	C-Br
1	FDB	1586	-	2861	-	541	1687	1425	1117	693	541
2	FDM	-	-	2978	-	542	1681	1609	1125	756	542
3	FDN	3470	3069	2878	-	-	1613	1461	1111	726	644
4	FDD	3323	3062	2914	-	501	1668	1596	1152	717	590
5	FDT	3359	3178	2963	-	518	1683	1587	1130	732	518
6	FDP	3359	3074	2997	-	428	1688	1458	1104	808	614
7	FDBma	-	3011	2860	1705	538	-	1430	1188	694	538
8	FDMma	-	-	2978	1681	538	1681	1600	1286	756	538
9	FDNma	3371	3069	2876	1701	532	1612	1529	1081	725	532
10	FDDma	3446	-	2917	1690	495	1690	1577	1150	721	593
11	FDTma	3476	-	2961	1687	529	1687	1588	1132	736	529
12	FDPma	3500	3078	2996	1687	400	1687	1467	1103	700	605
13	FDMpa	-	3001	2886	1683	549	1683	1511	1156	758	549
14	FDNpa	3371	3069	2963	1702	468	1611	1527	1084	726	651
15	FDDpa	-	-	2918	1699	506	1699	1546	1153	739	596
16	FDTpa	-	-	-	-	-	-	-	-	-	-
17	FDPpa	-	3079	2882	1697	557	1608	1532	1081	733	666

**Figure 2a. Gas chromatogram of fdn****Figure 2b. Line No. (3); Mass spectrum of fdn****Figure 3a. Gas chromatogram of fdt****Figure 3b. Line no. 15; mass spectrum of fdt**

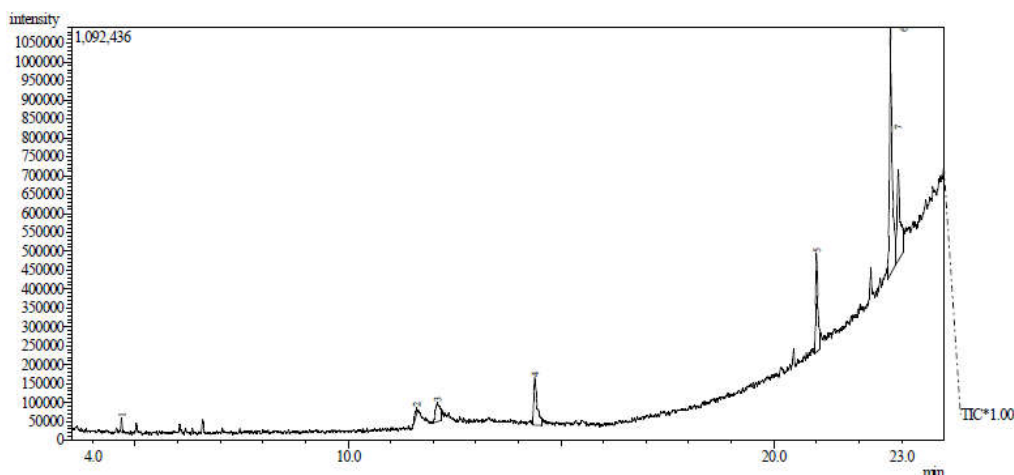


Figure 4a. Gas Chromatogram of fdnma

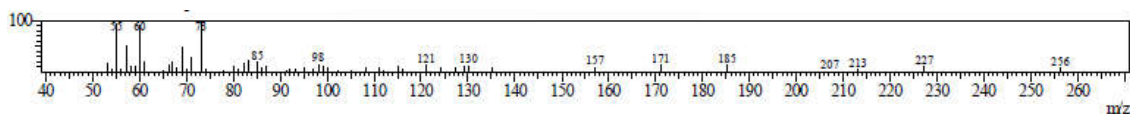


Figure 4b. Mass spectrum of fdnma

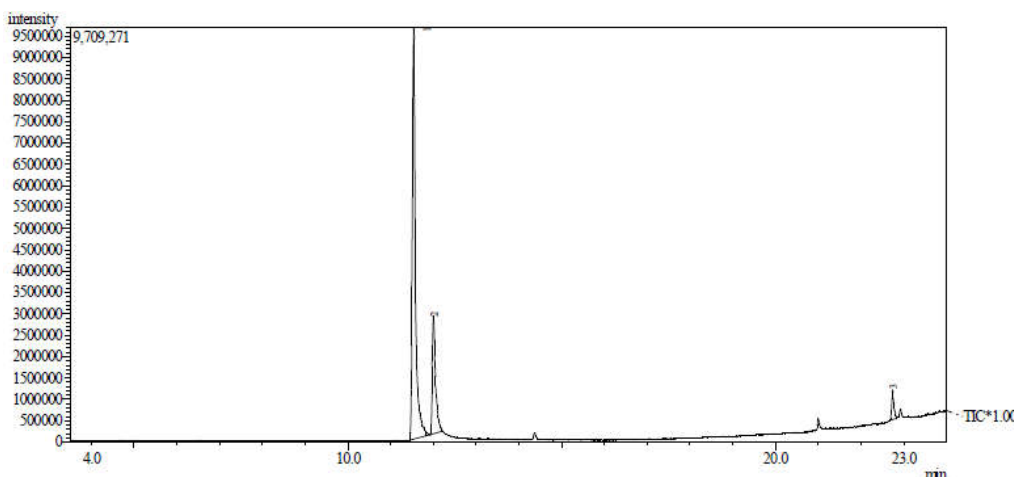


Figure 5a. Gas chromatogram of fdnpa

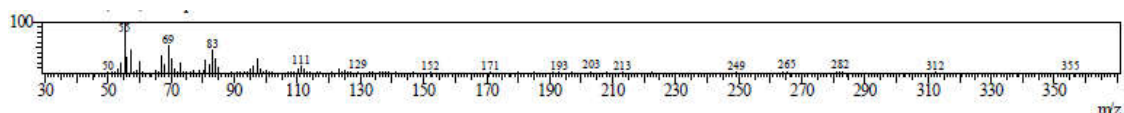


Figure 5b. Line no. 3: mass spectrum of FDNpa

Conclusion

In this work, schiff bases were synthesized, characterized by melting point, FTIR and mass fragmentation. They were condensed with maleic and phthalic anhydrides to give 7-membered ring compounds. The structures were also identified by melting point, FTIR and mass spectra.

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