

## <sup>1</sup>H and <sup>13</sup>C NMR Studies of Some N-alkylimines Derived from Thiophenes

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ABSTRACT. A series of 18 imines, Ar(Me)C=N ~ R, Ar(Ph)C=N ~ R, where Ar = C<sub>4</sub>H<sub>3</sub>S (2 or 3 thienyl), X-C<sub>4</sub>H<sub>2</sub>S (X = 5-Br, 5-Me, X<sub>2</sub>-C<sub>4</sub>HS (X<sub>2</sub> = 2,5-diMe), R = Me, <sup>i</sup>pr, <sup>t</sup>Bu, <sup>n</sup>Bu, Bz) have been prepared and thoroughly investigated by <sup>1</sup>H and <sup>13</sup>C NMR spectroscopy. The NMR results show that the imines exist in solution as an equilibrating E/Z isomer mixture at ambient temperature for X<sub>2</sub>-C<sub>4</sub>HS (X<sub>2</sub> = 2,5-diMe) imines and only a single E-isomer exists for other imines. In addition, <sup>1</sup>H NMR spectra have been obtained in different solvents and analysed; UV and IR spectra of some of the title compounds are also reported.

There has been considerable interest in the chemistry of imines and some related compounds (Jennings *et al.* 1983, 1976; Boyd *et al.* 1978; Bjorgo *et al.* 1972 and Echeveria *et al.* 1978). However, a literature survey indicates that there are only few reports dealing with the investigations of N-arylimines derived from heterocyclic aldimines and ketimines (Andoye *et al.* 1982). On the other hand, N-alkylimines derived from five membered ring heterocyclic aldehyde or ketones have not received much attention.

In the present work, the E/Z isomer distribution of 18 imines derived from different thiophenes have been investigated in the light of electronic, steric and other factors such as solvent and temperature.

### Results and Discussion

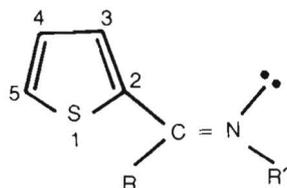
The imines (1-18) in the present work were obtained from the reaction of 2-acetylthiophene, 2-benzoylthiophene, 2-acetyl-5-methylthiophene, 2-acetyl-5-bromothiophene and 3-acetyl-2,5-dimethylthiophene with the appropriate primary

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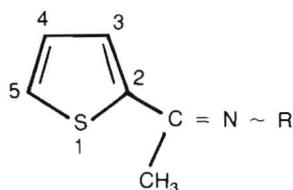
amine (Weingarten *et al.* 1967). The products were liquids unless otherwise stated and the yields were reasonably high which indicates great reactivity of these carbonyl compounds.

The stereochemistry of these imines was assigned using UV, IR,  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR spectroscopy. The UV spectra of imines (Table 1) have a characteristic

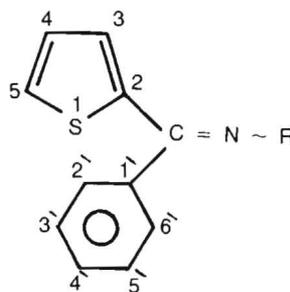


**Table 1.** UV and IR spectra of imines (1-9)

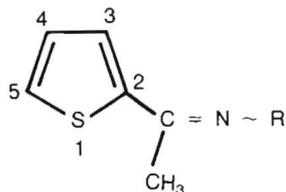
Compound	R	R'	UV $\lambda_{\text{max}}$ nm. in $\text{CH}_2\text{Cl}_2$ & $\text{CH}_3\text{OH}$	IR $\text{C}=\text{N}$ $\text{cm}^{-1}$ neat or nujol mull
1	$\text{CH}_3$	$-\text{CH}_3$	$\lambda_{\text{max}}$ 255.0 259.4 275.1	1625
2	$\text{CH}_3$	$-\text{CH}(\text{CH}_3)_2$	$\epsilon$ (22,100)(22,260)(18,110) - 260.6 278.1 - (19,630)(16,850)	1620
3	$\text{CH}_3$	$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	254.7 260.9 277.4 (33,680)(34,450)(29,170)	1625
4	$\text{CH}_3$	$-\text{CH}_2-\text{Ph}$	255.1 261.1 279.7 (39,760)(39,420)(32,800)	1621
5	$\text{CH}_3$	$-\text{C}(\text{CH}_3)_3$	- 260.6 278.1 - (21,270)(18,260)	1625
6	Ph	$-\text{CH}_3$	258.1 263.1 279.8 (16,250)(16,532)(14,678)	1612
7	Ph	$-\text{CH}(\text{CH}_3)_2$	255.9 - 280.0 (31,858) - (27,653)	1609
8	Ph	$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	257.1 263.5 281.1 (32,290)(33,000)(29,850)	1611
9	Ph	$-\text{C}(\text{CH}_3)_3$	258.7 261.8 281.8 (71,854)(77,049)(67,585)	1611



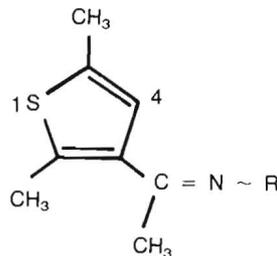
- 1)  $\text{R} = \text{CH}_3$
- 2)  $\text{R} = \text{CH}(\text{CH}_3)_2$
- 3)  $\text{CH}_2\text{CH}(\text{CH}_3)_2$
- 4)  $\text{CH}_2\text{-Ph}$
- 5)  $\text{C}(\text{CH}_3)_3$



- 6)  $\text{R} = \text{CH}_3$
- 7)  $\text{R} = \text{CH}(\text{CH}_3)_2$
- 8)  $\text{R} = \text{CH}_2\text{CH}(\text{CH}_3)_2$
- 9)  $\text{R} = \text{C}(\text{CH}_3)_3$



- 10)  $\text{R} = \text{CH}_3, \text{X} = \text{CH}_3$
- 11)  $\text{R} = \text{CH}(\text{CH}_3)_2, \text{X} = \text{CH}_3$
- 12)  $\text{R} = \text{C}(\text{CH}_3)_3, \text{X} = \text{CH}_3$
- 13)  $\text{R} = \text{CH}_3, \text{X} = \text{Br}$
- 14)  $\text{R} = \text{CH}(\text{CH}_3)_2, \text{X} = \text{Br}$
- 15)  $\text{R} = \text{C}(\text{CH}_3)_3, \text{X} = \text{Br}$



- 16)  $\text{R} = \text{CH}_3$
- 17)  $\text{R} = \text{CH}(\text{CH}_3)_2$
- 18)  $\text{R} = \text{CH}_2 - \text{CH}(\text{CH}_3)_2$

absorption bands for the  $\text{C}=\text{N}$  group. It has been pointed out that UV can be used as an effective tool to distinguish between E- and Z- diastereoisomers (Curtin and Hausser 1961). The results indicate that only one set of the  $\text{C}=\text{N}$  absorption bands for the imines (1-9) occur at ca. 255-268 nm which is compatible with the absorption by the E-isomer taking in account the aromaticity of both thiophene

and benzene. The theoretical interpretation of the UV spectra of five membered heteroaromatic compounds is not simple (Silverstein *et al.* 1981 and Jaffé and Orchin 1961). The absorption of these compounds has been compared to that of cyclopentadiene (Table 2), where the *cis*-diene analog shows strong diene absorption near 200 nm, and moderately intense absorption near 238 nm. The aromatic properties increase in the order of furan, pyrrole and thiophene.

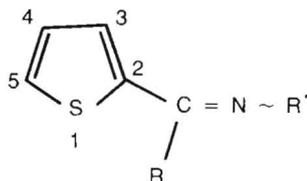


Table 2.  $^1\text{H}$  NMR data in  $\text{CDCl}_3$  at  $28^\circ\text{a}$

Compound	R	R'	$\delta_{\text{N-R'}}$	$\delta_{\text{C-R}}$	$\delta_{\text{H}_3}$	$\delta_{\text{H}_4}$	$\delta_{\text{H}_5}$	$^3J_{4,5}$ Hz	$^3J_{3,4}$ Hz	$^4J_{3,5}$ Hz	$^5J_{\text{HCCNCH}^b}$ Hz	isomer ratio	
												E	Z
1	$\text{CH}_3$	$\text{CH}_3$	3.28	2.20	7.28	6.99	7.28	4.15	3.91	—	0.73	100	—
2	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	3.79; 1.18	2.21	7.24	6.98	7.24	4.88	3.66	0.98	—	100	—
3	$\text{CH}_3$	$\text{CH}_2\text{-CH}(\text{CH}_3)_2$	3.25; 2.01 0.98	2.20	7.30	7.00	7.26	5.12	3.64	—	0.73	100	—
4	$\text{CH}_3$	$\text{CH}_2\text{-Ph}$	4.72	2.30	7.30	7.02	7.30	5.13	3.91	—	—	100	—
5	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	1.36	2.34	7.25	6.97	7.22	4.88	3.66	0.98	—	100	—
6	Ph	$\text{CH}_3$	3.19	7.18- 7.50	6.74	6.78	7.30	5.13	3.66	0.98	—	100	—
7	Ph	$\text{CH}(\text{CH}_3)_2$	3.50; 1.13	7.22- 7.56	6.68	6.90	7.30	4.88	3.66	1.22	—	100	—
8	Ph	$\text{CH}_2\text{CH}(\text{CH}_3)_2$	3.15; 1.98; 0.89	7.25- 7.47	6.72	6.90	7.20	5.10	3.66	1.22	—	100	—
9	Ph	$\text{C}(\text{CH}_3)_3$	1.14;	7.24- 7.40	6.50	6.83	7.30	5.12	3.66	1.22	—	100	—

a)  $\delta$  in ppm relative to TMS

b)  $^5J$  value recorded when observed.

The results (Table 1) indicate clearly the effect of the auxochromic substituent ( $\text{C}=\text{N}$ ,  $\text{CHO}$ ,  $\text{COCH}_3$ ) upon the five membered unsaturated heterocyclics, which causes a bathochromic shift and an increase in the intensity of the bands of the parent molecules. The UV data (Table 1) for imines (1-9) compared with the data of the parent molecules indicate that only one set of isomers, attributed to the E-isomer, absorbs at  $\lambda_{\text{max}}$  255-268 nm. The other two absorption bands are about the same absorption as the parent molecule.

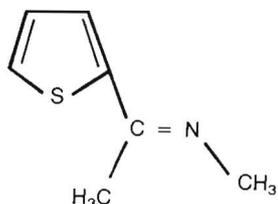
The infrared data (Table 1) show that the absorption of the  $\text{C}=\text{N}$  group for imines (1-9) occurred in the region  $1609\text{-}1635\text{ cm}^{-1}$  as one band for each imine. Inspection of the region  $700\text{-}900\text{ cm}^{-1}$ , where C-H out of plane bending vibrations of the aromatic ring is expected, did not result in the observation of mixtures of E- and Z-diastereoisomers (Curtin and Hausser 1961). The IR results are in good agreement with an earlier study of some imines derived from some thiophene derivatives which have been reported to exist exclusively in the E-form (Andoye *et al.* 1982 and Head and Jones 1966).

The most valuable information came from the  $^1\text{H}$  NMR spectra (Table 2). The  $^1\text{H}$  NMR chemical shifts show only one set of the N-alkyl signals and one set of the  $=\text{C}-\text{CH}_3$  signals which indicate that only one diastereoisomer is present in solution for these imines (1-15).

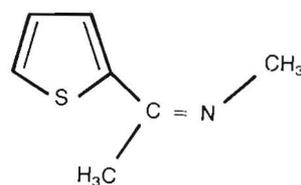
The  $^1\text{H}$  NMR spectrum of imine (1) has been chosen as a model in order to simplify the NMR spectra. The N- $\text{CH}_3$  and  $=\text{C}-\text{CH}_3$  groups of this imine resonate apart from each other in chloroform at  $28^\circ$ . The spectrum shows two quartets for N- $\text{CH}_3$  at  $\delta$  3.28, indicating that these protons are long-range coupled with  $=\text{C}-\text{CH}_3$  protons,  $^5J_{\text{HCCNCH}} = 0.73\text{ Hz}$  and for  $=\text{C}-\text{CH}_3$  at  $\delta$  2.20 ( $^5J_{\text{HCCNCH}} = 0.73\text{ Hz}$ ). The thienyl protons (3,4, and 5) appear as  $\text{B}_2\text{A}$  pattern,  $\text{H}_3$  appears at  $\delta$  7.28,  $\text{H}_4$  at  $\delta$  6.99 and  $\text{H}_5$  at  $\delta$  7.28. The same behaviour was observed for thienyl protons in different solvents (acetone- $\text{d}_6$ , benzene- $\text{d}_6$  and dimethylsulphoxide- $\text{d}_6$ ) except that the simple first order AMX pattern was obtained when dimethylsulphoxide- $\text{d}_6$  was used in which the signal of the  $\text{H}_3$  appears at  $\delta$  7.46 as a doublet of doublets ( $^3J_{3,4} = 3.91$ ),  $^4J_{3,5} = 1.2\text{ Hz}$  and  $\text{H}_4$  at  $\delta$  7.06 as a doublet of a doublets ( $^3J_{4,5} = 5.13\text{ Hz}$ ). The  $\text{H}_5$  signal appears at  $\delta$  7.53 as a doublet of doublets ( $^3J_{4,5}$  and  $^4J_{5,3}$  as above).

Further support was obtained from the spectrum of N( $\alpha$ -methyl(2)thienylidene)isopropylamine. The spectrum of this compound is also simple. Assignments are given in Table 2. The  $=\text{C}-\text{CH}_3$  signal appears as a single peak at  $\delta$  2.21 in chloroform-d, no long-range coupling appears, this may be due to its low value. The N-CH signal appears as a multiplet at  $\delta$  3.79 ( $^3J_{\text{HCCH}} = 6.35\text{ Hz}$ ) and the two methyl  $\text{CH}(\text{CH}_3)_2$  appear as a doublet at  $\delta$  1.18 ( $^3J_{\text{HCCH}} = 6.35\text{ Hz}$ ). The thienyl protons appear as a  $\text{B}_2\text{A}$  pattern as described before.

Decisive experimental information concerning the stereochemistry of these imines was obtained from the homoallylic coupling constants ( $^5J_{\text{HCCNCH}}$ ) of the N-alkyl protons with the methyl protons directly bonded to the imino group (Table 2). The coupling magnitude was ca. 0.73 Hz which is consistent with the E-isomer where the coupled protons are *cis* to each other. On the other hand, the magnitude for the Z-isomer where the coupled protons are *trans* to each other is expected to be much higher (Al-Showiman 1985). Indeed, the homoallylic coupling in the Z-isomer was found to be ca. 1.5 Hz whereas the coupling of the E-isomer was ca. 0.75 Hz. (Al-Showiman 1985 and Bjorgo *et al.* 1974).



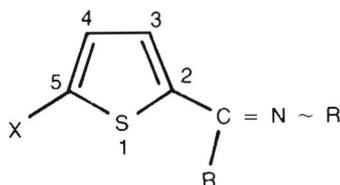
(2) E-diastereoisomer



(2) Z-diastereoisomer

The argument that E and Z-diastereoisomer signals may be isochronous has been discarded as a result of the observations obtained from the solvent and the temperature effects. The solvents used (chloroform-d, acetone-d<sub>6</sub>, benzene-d<sub>6</sub> and dimethylsulphoxide-d<sub>6</sub>) differ in many properties and are capable in resolving isochronous signals as well as affecting the E/Z diastereoisomer distribution (Bjorgo *et al.* 1974, Al-Showiman 1985 and Jennings *et al.* 1976, Bjorgo *et al.* 1972). However, no other signals attributable to the other isomer have been observed in these solutions.

Inspection of  $^1\text{H}$  NMR data (Table 3) of the imines (10-15), having 5-methyl or 5-bromo groups attached to the ring indicate that only one diastereomeric form is present. For example, compound (10), shows only one set of signals. Thus, N-CH<sub>3</sub> was at  $\delta$  3.26, = C-CH<sub>3</sub> at  $\delta$  2.16 and the aromatic protons were present as an AB pattern at  $\delta$  7.08;  $\delta$  6.66 in chloroform-d at 28°. Similar observations were obtained in acetone-d<sub>6</sub>, benzene-d<sub>6</sub>, dimethylsulphoxide-d<sub>6</sub> which confirm the existence of these imines in 100% one diastereomeric form. Further evidence came from  $^5J_{\text{HCCNCH}}$  where imine (10) shows a value of ca. 0.73 Hz which is in good agreement of an earlier study concerning E-conformation of similar imines (Boyd *et al.* 1978 and Weingerten 1967). The Z-configuration of imines (10) and (13)

Table 3.  $^1\text{H}$  NMR data in  $\text{CDCl}_3$  at  $28^\circ\text{a}$ 

Compound	X	R	R'	$\delta_{\text{N-R}}$	$\delta_{\text{C-R}}$	$\delta_{\text{H}_3}$	$\delta_{\text{H}_4}$	$\delta_{\text{S-X}}$	$^3\text{J}_{3,4}$ Hz	$^4\text{J}_{\text{X,H}}$	$^5\text{J}_{\text{HCCNCH}}$ Hz	isomer ratio	
												E	Z
10	$\text{CH}_3$	$\text{CH}_3$	$\text{CH}_3$	3.26	2.16	7.08	6.66	2.27	3.91	0.98	0.73	100	—
11	$\text{CH}_3$	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	3.77; 1.17	2.16	7.05	6.64	2.43	3.66	0.98	—	100	—
12	$\text{CH}_3$	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	1.34	2.28	7.01	6.62	2.41	3.66	0.98	—	100	—
13	Br	$\text{CH}_3$	$\text{CH}_3$	3.26	2.15	7.43	7.10	—	3.90	—	0.73	100	—
14	Br	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	3.76 1.16	2.15	6.96	6.96	—	3.91	—	—	100	—
15	Br	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	1.33	2.26	6.92	6.92	—	3.90	—	—	100	—

a-  $\delta$  ppm relative to TMS

requires the  $=\text{C}-\text{CH}_3$  group to be *trans* to the N-alkyl which will lead to a coupling constant ( $^5\text{J}_{\text{HCCNCH}}$ ) ranging ca. 1.22 - 1.50 Hz. (Boyd *et al.* 1978 and Al-Showiman 1985).

The effect of the 5-substituent has not led to changes in the E/Z ratio which remained 100% in the E-form. These observations indicate that the inductive and resonance effects of the ring substituent are not enough to bring changes in the E/Z isomer distribution. These results are similar to those obtained from the unsubstituted thiophene imines (1-9) which indicate that the stereochemistry is

similar in both cases. The findings confirm the idea that the electronic and inductive effects resulting from changes in the C=N substituents attached either to the nitrogen or carbon atoms are not enough to lead to mixtures of diastereoisomers. These observations may be rationalized on the basis that the steric situation is not hindered enough to force the aryl ring to twist out of the C=N double bond

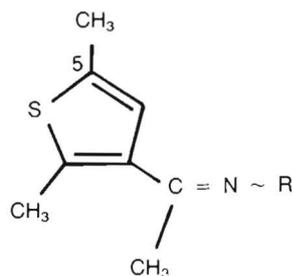


Table 4.  $^1\text{H}$  NMR data in  $\text{CDCl}_3$  at  $28^\circ$

Com- pound	isomer	R	$\delta_{\text{N-R}}$	$\delta_{\text{=C-CH}_3}$	$\delta_{\text{S-CH}_3}$	$\delta_{\text{2-CH}_3}$	$\delta_{\text{H}_4}$	$^4\text{J}^*$ CH <sub>3</sub> -H	$^5\text{J}_{\text{HCCNCH}}$ Hz	isomer ratio			
										b	c	d	e
16	E	CH <sub>3</sub>	3.27	2.12	2.49	2.37	6.73	0.98	0.75	68	72	73	72
	Z		3.04	2.17	2.37	2.21	6.36	0.98	1.34	32	28	27	28
17	E	CH(CH <sub>3</sub> ) <sub>2</sub>	3.77 1.19	2.11	2.48	2.37	6.69	—	—	62	63	84	83
	Z		3.38 1.06	2.15	2.40	2.24	6.32	—	—	38	37	16	17
18	E	CHCH <sub>2</sub> (CH <sub>3</sub> ) <sub>3</sub>	3.18 2.00 1.00	2.10	2.52	2.37	6.72	1.22	0.86	67	69	69	68
	Z		2.96 2.00 0.85	2.18	2.40	2.20	6.31	1.22	1.22	33	31	31	32

\* Coupling constant of  $-\text{CH}_3$  at ring position 5 with  $\text{H}_4$

1-  $\delta$  ppm relative to TMS

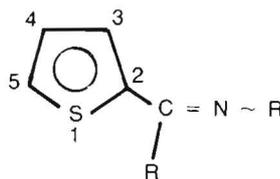
2- in  $\text{CDCl}_3$ ; c) in acetone- $d_6$  d) in benzene- $d_6$ ; e) in dms $o$ - $d_6$

plane. The results obtained in the present work suggest that a greater steric effect would be required to change the E/Z equilibrium position. Thus, imines having 2,5-dimethyl substituents (16-18) showed mixtures of E- and Z- diastereoisomers. For example, imine (16) was obtained in an E/Z isomer mixture. The  $^1\text{H}$  NMR spectrum shows two set of N-CH<sub>3</sub> at  $\delta$  3.27 and  $\delta$  3.04 assigned for the E- and Z- diastereoisomer respectively. The upfield N - CH<sub>3</sub> signal at  $\delta$  3.04 was assigned for the Z-isomer on the basis that the aromatic ring will be close enough in the Z-conformation to shield the N-CH<sub>3</sub> protons. The =C-CH<sub>3</sub> was at  $\delta$  2.12 (E) and  $\delta$  2.17 (Z) while the aromatic protons (H<sub>4</sub>) appear at  $\delta$  6.73 and  $\delta$  6.36 for the E and Z-diastereoisomer respectively.  $^5J_{\text{HCCNCH}}$  values of ca. 0.73 Hz for the major isomer and ca. 1.34 Hz for the minor isomer provided unambiguous confirmation that the major isomer is the E-form and the minor isomer is the Z-form.

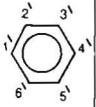
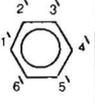
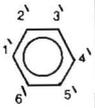
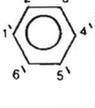
The  $^{13}\text{C}$  NMR chemical shift of imines (1-15) (Tables 5 and 6) leads to precise stereochemical assignments of these imines. Inspection of the spectra shows that each carbon gave one signal in the complete decoupled spectra. No satellites or any other small signal which may be due to the minor isomer have been observed. These observations confirm the previous ones obtained from UV, IR and  $^1\text{H}$  NMR that these imines (1-15) exist in one diastereomeric form (E-form) only.

The  $^{13}\text{C}$  chemical shifts of the imine (1) are given in Table 5. The quaternary carbon C-2 and the carbon of the imino group C=N, are readily identified since they are less intense compared with other signals as a result of long relaxation times of the quaternary carbons (Al-Showiman *et al.* 1982). The  $^{13}\text{C}$  spectrum shows (in chloroform-d) signals at  $\delta$  161.63 assigned to the C=N group and at  $\delta$  147.54 assigned to the C-2 quaternary carbon and confirmed by using the NOE technique. N-CH<sub>3</sub> resonates at  $\delta$  39.92 and the upfield signal at  $\delta$  14.85 was assigned to the C-CH<sub>3</sub> as expected. Thienyl carbons C-3, C-4, C-5 appear at  $\delta$  128.22, 126.35 and 127.11 respectively. These values were confirmed by using the substituent chemical shift (SCS) effect of the imino group C=N on the  $\alpha$ -position, long-range C-H coupling, and comparison with the parent thiophene compound (Ewing 1979).

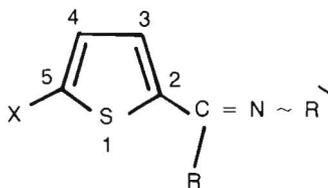
The  $^{13}\text{C}$  chemical shifts of other imines (2-9) are listed in Table 5. It is worth noting that the C-2 and the C=N carbons are sensitive to the groups attached to the C=N group (Table 5). The  $^{13}\text{C}$  chemical shift of the =C-CH<sub>3</sub> are slightly affected by the groups attached to the nitrogen atom of the C=N group. It is worth noting that when the attached group is t-butyl, a considerable shift to low field occurred for the =C-CH<sub>3</sub>, which appears at  $\delta$  18.61 (see Table 5). This shift may be due to the steric effect of the t-butyl group upon the adjacent =CCH<sub>3</sub> group (Clark *et al.* 1976).



**Table 5.**  $^{13}\text{C}$  NMR chemical shifts in  $\text{CDCl}_3$  at  $28^\circ\text{a}$

Compound	R	R'	$\delta_{\text{C=N}}$	$\delta_{\text{C-2}}$	$\delta_{\text{C-3}}$	$\delta_{\text{C-4}}$	$\delta_{\text{C-5}}$	$\delta_{\text{R}}$	$\delta_{\text{N-R}}$
1	$\text{CH}_3$	$\text{CH}_3$	161.63	147.54	128.22	126.35	127.11	14.85	39.92
2	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	156.57	148.30	127.93	125.05	126.99	14.85	50.84; 23.54
3	$\text{CH}_3$	$\text{CH}_2\text{CH}(\text{CH}_3)_2$	158.99	148.30	128.11	125.93	126.99	15.26	59.47; 29.94; 20.78
4	$\text{CH}_3$	$\text{CH}_2$ 	160.80	147.80	128.80	126.50	127.10	15.68	55.0; C-1' 140.14; C-2' 128.30; C-3' 127.40; C-4' 126.70
5	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	156.43	150.35	128.70	125.29	126.93	18.61	55.13; 30.53
6		$\text{CH}_3$	164.50	146.95	128.81	127.11	128.63	C-1' 135.62; C-2' 128.46; C-3' 127.58; C-4' 130.10	40.80
7		$\text{CH}(\text{CH}_3)_3$	160.16	147.36	128.46	126.93	128.30	C-1' 136.50; C-2' 128.28; C-3' 127.34; C-4' 129.86	52.49; 23.84
8		$\text{CH}_2\text{CH}(\text{CH}_3)_2$	162.39	147.54	128.63	127.05	128.30	C-1' 136.27; C-2' 128.28; C-3' 127.75; C-4' 129.75	60.94; 30.12; 20.72
9		$\text{C}(\text{CH}_3)_3$	158.63	150.47	128.58	126.87	127.99	C-1' 139.03; C-2' 128.16; C-3' 127.64; C-4' 129.05	56.83; 31.47

a)  $\delta$  ppm relative to TMS

**Table 6.**  $^{13}\text{C}$  NMR chemical shifts in  $\text{CDCl}_3$  at  $28^\circ\text{a}$ 

Compound	X	R	R <sup>b</sup>	$\delta_{\text{C=N}}$	$\delta_{\text{C-2}}$	$\delta_{\text{C-3}}$	$\delta_{\text{C-4}}$	$\delta_{\text{C-5}}$	$\delta_{\text{R}}$	$\delta_{\text{N-R}}$
10	$\text{CH}_3$	$\text{CH}_3$	$\text{CH}_3$	161.68	143.25	126.58	125.41	145.25 C-5' 15.73	14.50	38.92
11	$\text{CH}_3$	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	156.57	145.89	126.23	125.23	142.78 C-5' 15.62	14.38	50.84; 23.54
12	$\text{CH}_3$	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	156.41	147.95	125.41	125.11	142.90 C-5' 15.56	18.08	54.95; 30.53
13	Br	$\text{CH}_3$	$\text{CH}_3$	160.87	149.12	130.04	126.23	116.19	14.15	38.92
14	Br	$\text{CH}_3$	$\text{CH}(\text{CH}_3)_2$	155.87	150.00	129.87	125.93	115.89	13.97	50.84; 23.43
15	Br	$\text{CH}_3$	$\text{C}(\text{CH}_3)_3$	155.70	152.06	129.87	125.11	155.70	17.67	50.25; 30.41

a-  $\delta$  ppm relative to TMS

The  $^{13}\text{C}$  NMR data for imines (10-15), (Table 6) proved once again that only one type of diastereoisomers was obtained for the imines having a 5-methyl or 5-bromo substituted thiophene ring as indicated by one set of  $^{13}\text{C}$  signals in chloroform-d or in different solvents (benzene- $\text{d}_6$ , acetone- $\text{d}_6$  and dimethylsulphoxide- $\text{d}_6$ ). However, the case will be different for imines having 2,5-dimethyl substituents (16-18).

The  $^{13}\text{C}$  NMR spectra of these imines showed two sets of signals with different intensities indicating that these imines are available in solution as an E/Z-diastereomeric mixture. Combination of the  $^1\text{H}$  NMR observations with those

obtained from the  $^{13}\text{C}$  NMR spectra proved beyond doubt that imines (1-15) are 100% E-form while imines (16-18) yield mixtures of E- and Z-diastereoisomers.

In addition, observations obtained from the solvent effects together with the earlier observations from the spectroscopic methods gave no doubt that these imines (1-15) exist only in the E- form.

In 2,5-dimethyl substituted imines (16-18) the steric interactions between the C- $\text{CH}_3$  group and the 2-methyl ring substituents are responsible for the stereomutation of the E-diastereoisomer towards the less hindered Z-diastereoisomer.

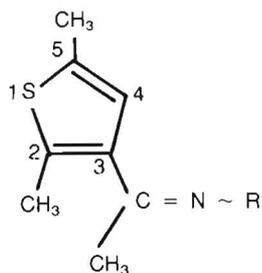
The chemical shift of the carbons of  $^{13}\text{C}=\text{N}$  and  $=\text{C}-^{13}\text{CH}_3$  of 5-substituted imines (10-12) and (13-15) shows a relatively good correlation to the inductive/field effect which largely dominates the substituent effect on these carbon shifts. Thus, an electron withdrawing bromo substituent in the 5-position to C=N group, imines (13-15), shifts the  $^{13}\text{C}=\text{N}$  and the  $=^{13}\text{C}-\text{CH}_3$  resonances to higher field (Table 5,6).

The  $^{13}\text{C}=\text{N}$  for imine (12), R = t-butyl, appears at  $\delta$  156.41 and  $=^{13}\text{C}-\text{CH}_3$  at  $\delta$  18.08 but in case of the imine (15), R =  $^t\text{Bu}$ ,  $^{13}\text{C}=\text{N}$  appears at  $\delta$  155.70 and  $=^{13}\text{C}-\text{CH}_3$  at  $\delta$  17.67. Similar results were recorded on other imines. The mechanism by which the inductive/field effect influences distant carbon chemical shifts is not well understood but following the suggestion of Jones and Wilkins (1978) the field effect from electron withdrawing substituents might decrease the polarization ( $\text{C}=\overset{\ominus}{\text{N}}$ ) in the imino bond and shift the carbon resonance to higher field. Recently, similar results were reported for  $^{13}\text{C}=\text{N}$  in other aryl-substituted imines (Jennings *et al.* 1983).

Comparison was also made between  $^{13}\text{C}=\text{N}$  of unsubstituted thiophene (Tables) and the substituted thiophene (Table 6 and 7). The results indicate that there is no appreciable differences between  $^{13}\text{C}=\text{N}$  obtained for the imines having 5- $\text{CH}_3$  on the ring, and those obtained for imines having an unsubstituted ring. The only difference was in the case of imines (13-15) when a bromo atom was present in position 5.

The case will be different in 2,5-dimethyl substituted imines (16-18) (see Table 7) and there is an appreciable downfield shift for  $^{13}\text{C}=\text{N}$  resonance, compared with imines (1-15). The downfield shift of  $^{13}\text{C}=\text{N}$  may involve the steric effect between the 2-methyl group and the methyl group attached to the imino (C=N) group.

Generally, (Tables 5,6 and 7) may suggest that the steric factor is more important than the electronic factor in determining the equilibrium position of the E/Z diastereoisomers of these imines derived from thiophene.

**Table 7.**  $^{13}\text{C}$  NMR Chemical shifts in  $\text{CDCl}_3$  at  $28^\circ$ 

Compound	isomer	R	$\delta_{\text{C-N}}$	$\delta_{\text{C-2}^a}$	$\delta_{\text{C-3}}$	$\delta_{\text{C-4}}$	$\delta_{\text{C-5}^c}$	$\delta_{\text{C-11CH}_3}$	$\delta_{\text{N-R}}$
16	E	$\text{CH}_3$	164.97	137.27 (13.86)	134.68	125.81	135.97 (15.97)	28.53	39.04
	Z		166.62	139.32 (14.97)	132.04	123.76	135.62 (17.73)	29.77	40.80
17	E	$\text{CH}(\text{CH}_3)_2$	160.28	137.15 (13.68)	134.80	125.64	135.80 (17.67)	28.80	52.60; 23.72
	Z		162.80	139.55 (14.68)	130.92	123.82	136.62 (15.03)	28.65	50.90; 23.72
18	E	$\text{CHCH}_2(\text{CH}_3)_2$	162.74	136.15 (15.21)	134.56	125.88	137.03 (15.03)	29.65	59.49; 29.94; 20.96
	Z		164.97	139.26 (13.86)	131.57	123.88	136.50 (18.20)	29.94	61.35; 29.65; 20.78

1)  $\delta$  ppm relative to TMSb) values in parentheses are for  $2\text{-}^{13}\text{CH}_3$  attached to the ringc) values in parentheses are for  $5\text{-}^{13}\text{CH}_3$  attached to the ring

### Experimental

2-Acetylthiophene, 2-acetyl-5-methylthiophene, 2-acetyl-5-bromothiophene and 3-acetyl-2-5-dimethylthiophene were obtained from Lancaster Synthesis Ltd and were used without any further purification. 2-Benzoylthiophene was prepared from thiophene and benzoyl chloride in presence of  $ZnCl_2$  as a catalyst (Hartaugh and Kosak 1947).

All the imines were prepared from the reaction of the above ketones with the appropriate alkylamines by standard methods (Morreti and Torre 1970), microanalytical and physical properties are as follow:

1. (b.p. 88-93°/3 Torr), yield 95%, analysis for  $C_7H_9NS$  calc. C 60.39; H 6.52; N 10.06%. Found: C 60.18; H 6.41; N 9.89%.
2. (b.p. 110-115°/11 Torr), yield 95%, analysis for  $C_9H_{13}NS$  calc. C 64.63; H 7.83; N 8.37%. Found: C 64.78; H 8.53; N 8.20%.
3. (b.p. 94-98°/0.7 Torr), yield 91%, analysis for  $C_{10}H_{15}NS$  calc. C 66.25; H 8.34; N 7.73%. Found: C 65.90; H 7.91; N 7.72%.
4. (b.p. 165-170°/1.8 Torr), yield 82%, analysis for  $C_{13}H_{13}NS$  calc. C 72.52; H 6.09; N 6.51%. Found: C 71.65; H 6.07; N 6.47%.
5. (b.p. 120-125°/8 Torr), yield 87%, analysis for  $C_{10}H_{15}NS$  calc. C 66.25; H 8.34; N 7.73%. Found: C 66.13; H 8.28; N 6.60%.
6. (b.p. 138-140°/0.5 Torr), yield 79%, analysis for  $C_{12}H_{11}NS$  calc. C 71.80; H 5.30; N 6.70%. Found: C 71.60; H 5.30; N 6.60%.
7. (b.p. 100-105°/1.4 Torr), yield 87%, analysis for  $C_{14}H_{15}NS$  calc. C 73.35; H 6.60; N 6.11%. Found: C 73.00; H 6.41; N 5.82%.
8. (b.p. 140-142°/0.3 Torr), yield 81%, analysis for  $C_{15}H_{17}NS$  calc. C 74.03; H 7.03; N 5.76%. Found: C 73.80; H 6.80; N 5.50%.
9. (m.p. 67°), yield 92%, analysis for  $C_{15}H_{17}NS$  calc. C 74.03; H 7.05; N 5.76%. Found: C 74.10; H 6.80; N 5.60%.
10. (m.p. 72°), yield 82%, analysis for  $C_8H_{11}NS$  calc. C 62.68; H 7.24; N 9.15%. Found: C 62.90; H 7.50; N 9.10%.
11. (b.p. 88°/0.7 Torr), yield 87%, analysis for  $C_{10}H_{15}NS$  calc. C 66.25; H 8.34; N 7.73%. Found: C 66.70; H 8.50; N 7.60%.
12. (b.p. 98-100°/2 Torr), yield 85%, analysis for  $C_{11}H_{17}NS$  calc. C 67.63; H 8.78; N 7.18%. Found: C 68.00; H 8.90; N 6.70%.
13. (m.p. 70°), yield 98%, analysis for  $C_7H_8NS$  calc. C 38.55; H 3.70; N 6.42%. Found: C 38.80; H 3.90; N 6.10%.
14. (b.p. 120-125°/6.5 Torr), yield 94%, analysis for  $C_9H_{12}NS$  calc. C 43.91; H 4.91; N 5.69%. Found: C 44.00; H 4.91; N 6.10%.
15. (b.p. 140-142°/2 Torr), yield 90%, analysis for  $C_{10}H_{14}BrNS$  calc. C 46.16; H 5.4; N 5.38%. Found: C 46.00; H 5.60; N 5.10%.

16. (b.p. 92-95 $^{\circ}$ /1.7 Torr), yield 87%, analysis for  $\text{C}_9\text{H}_{13}\text{NS}$  calc. C 64.62; H 7.83; N 8.37%. Found: C 64.31; H 7.75; N 7.26%.
17. (b.p. 75-80 $^{\circ}$ /0.5 Torr), yield 91%, analysis for  $\text{C}_{11}\text{H}_{17}\text{NS}$  calc. C 76.64; H 8.70; N 7.20%. Found: C 76.32; H 8.78; N 7.10%.
18. (b.p. 85-90 $^{\circ}$ /0.5 Torr), yield 88%, analysis for  $\text{C}_{12}\text{H}_{19}\text{NS}$  calc. C 68.84; H 9.15; N 6.70%. Found: C 68.84; H 9.13; N 6.43%.

The NMR spectra were obtained on a Jeol JNM FX-100 spectrometer operating in the Fourier Transform (FT) mode. All the spectra were recorded at ambient temperature, 28 $^{\circ}$ , and the sample concentration was generally 0.2M in the appropriate solvent. Chemical shifts were determined relative to the internal standard tetramethylsilane (TMS). The instrument conditions were as follow:

i)  $^{13}\text{C}$  NMR spectra

$^{13}\text{C}$  observe frequency 25 MHz; pulse width 10  $\mu\text{s}$  (45 $^{\circ}$ ); pulse delay 15 sec, acquisition time auto set; data points 8k; spectral width 5000 Hz, effective resolution 0.015 ppm, sample tube 10 mm; probe  $^1\text{H}/^{13}\text{C}$  dual probe,  $^1\text{H}$  noise<sup>1</sup> decoupling and internal lock on the deuterium signal of the solvent.

ii)  $^1\text{H}$  NMR spectra

$^1\text{H}$  observe frequency 100 MHz; pulse width 20  $\mu\text{s}$  (45 $^{\circ}$ ); pulse delay auto set, acquisition time auto set; data points 8k; spectral width 1000 Hz, effective resolution 0.10 Hz, probe temperature 28 $^{\circ}$ , sample tubes 10 mm, probe  $^1\text{H}/^{13}\text{C}$  dual probe and deuterium internal lock.

iii) Nuclear Overhauser Enhancement (NOE) measurements  
(Al-Showiman *et al.* 1982)

The absolute NOE determined at 25 MHz was recorded after gating the decoupler to allow interrupted (pulse modulated)  $^1\text{H}$  decoupling. Using the technique of decoupling just before the short  $^{13}\text{C}$  pulses and during short ( $\mu$  1 s) acquisitions of the free-induction decays, while leaving the decoupler off for the longer ( $\geq 4T_1$ ) pulse intervals, allowed direct measurements of the NOE values from the  $^1\text{H}$  decoupled spectra.

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## دراسة لبعض ن - الكيل الأمينات المشتقة من الثيوفين باستخدام طيف الرنين المغناطيسي النووي للبروتونات والكربون - ١٣

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المملكة العربية السعودية

تم تحضير ١٨ إميناً، تحتوي على مجموعة الكيلية مرتبطة بذرة النتروجين مثل مجموعة المثيل، الأيزوبروبيل، البيوتيل الثالثي، البيوتيل الثانوي، والبنزيل. وتحتوي هذه المركبات على حلقة الثيوفين كما أن بعضها تحمل حلقة الثيوفين فيها مجموعة ٥ - برومو، ٥ - مثيل وكذلك ٢,٥ - ثنائي المثيل. لقد تمت دراسة هذه المركبات دراسة مستفيضة بوساطة طيف الرنين المغناطيسي النووي للبروتونات والكربون - ١٣، وتم الحصول على مواقع خطوط الطيف لهذه المركبات لأول مرة. لقد دل طيف الرنين المغناطيسي النووي على أن هذه المركبات تظهر في المحلول عند درجة حرار الغرفة على هيئة مماكنين فراغيين عند الاتزان للمركبات التي تحتوي حلقة الثيوفين فيها على ٢,٥ ثنائي مثيل، بينما المركبات التي لا تحتوي حلقة الثيوفين فيها على بدل في الموضعين ٢,٥ فتظهر على هيئة شبيه ومشاكل واحد هو E. كما تطرقت الدراسة إلى الحصول على أطيايف هذه المركبات في مذيبات مختلفة علاوة على دراسة أطيايف الأشعة فوق البنفسجية UV وأطيايف الأشعة تحت الحمراء IR.