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SYNTHESIS OF AROMATIC ALDEHYDES VIA 2-ARYL-N,N'-DIACYL-4-IMIDAZOLINES

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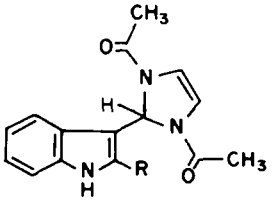
Abstract—Diacylimidazolium ions yield adducts with aromatic compounds. Thus the N,N'-diacetylimidazolium ion and indole gives 1,3-diacetyl-2-(3-indolyl)-4-imidazoline. Less reactive substrates such as thiophene, anisole and 1,3-dimethylbenzene fail to react with this reagent but do form adducts (*e.g.* 1,3-bis-(trifluoroacetyl)-2-(2-thienyl)-4-imidazoline) with an imidazole/trifluoroacetic anhydride reagent. All of the adducts could be converted to the corresponding aldehyde under mild conditions. The synthetic scope of the new synthesis is similar to that of the Vilsmeier–Haack reaction.

Diheterosubstituted carbonium ions[1] are interesting agents for the introduction of aldehyde functions (protected as well as unprotected). The well-known Vilsmeier–Haack reagent is just one example.[2] In this paper we will discuss the potential and limitations of N,N'-diacylimidazolium ions as reagents in organic synthesis.

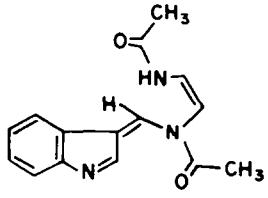
In connection with acylation studies, one of us earlier found[3] that indole, when heated with imidazole in acetic anhydride (125°), gives rise to the light-sensitive adduct **5a**, formed by electrophilic attack of the diheterosubstituted carbonium ion **3** at the 3-position of the indole ring.

Two reactions (A and B) and a possible side reaction (C) involved in the formation of the reagent **3** are given in Scheme 1. Later Sheinkman *et al.*[4–6] studied these reactions and arrived at similar conclusions.

The dihydroimidazole ring in the adduct is readily cleaved by nucleophilic reagents. Thus, heating **5** (R=H) at 140° with indole in acetic anhydride gives tris-(3-indolyl)methane, and mild hydrolysis with NaOH in ethanol/water affords 3-formylindole in good yield. To account for the easy formation of tris-(3-indolyl)methane, it is suggested that the equilibrium **5** (R=H) ⇌ **6** occurs. Indole then adds to **6**, followed by cleavage of the resultant species and the indole addition is then repeated. The ring opening may be visualised as an intramolecular Bamberger cleavage.[7–10] Interestingly, all attempts to prepare **7** were unsuccessful. The high



5a: R = H
b: R = CH_3



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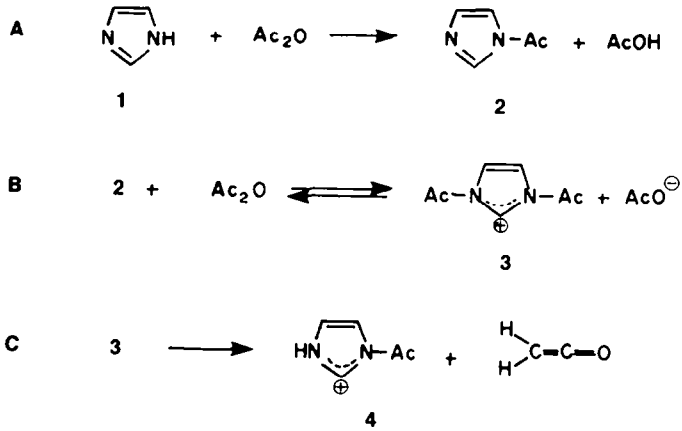
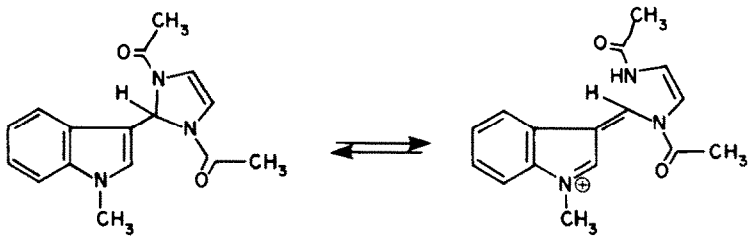
yield product was tris-(N-methylindol-3-yl)methane.[11] This may be explained by the formation of the quaternary ion **8**, and subsequent addition of N-methylindole to **8**, which would be much more facile than the addition of indole to **6**. The formation of tris-(4-dimethylaminophenyl)methane (leuco crystal violet) upon treatment of N,N-dimethylaniline with the imidazole/acetic anhydride reagent at reflux, may be similarly explained.

Treatment of pyrrole with imidazole/acetic anhydride at 125° gave no adduct due to formation of N-acetylpyrrole. In contrast the bis-adduct **19** was obtained in high yield (94%) when imidazole was replaced by benzimidazole. Interestingly, several other N-acylheterocyclic cations (e.g. the N-acetylisoquinolinium ion) have subsequently been reported[12] to likewise yield 2,5-substituted bis-adducts with pyrrole. Only small amounts of N-acetylpyrrole were formed in addition to **19**. This



Scheme 1.



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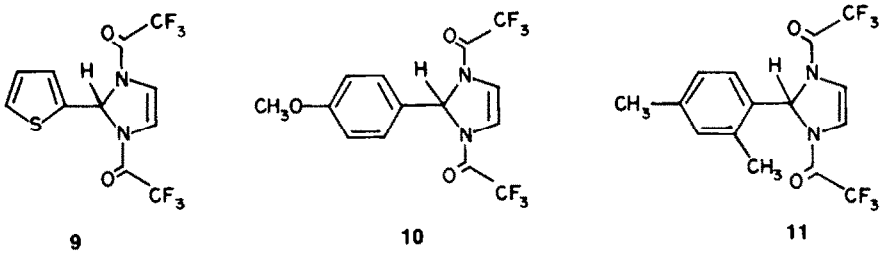
adduct (**19**) could be related to the known[13] compound **20**, which on catalytic hydrogenation in acetic anhydride (at 95°) was converted to **19**. The great difference between the two reagents seems to depend on the fact that N-acetylimidazole is a more powerful transacylation reagent than N-acetylbenzimidazole, rather than on a higher reactivity of the N,N'-diacetylbenzimidazolium ion compared with the N,N'-diacetylimidazolium ion. In a supplementary experiment it was found that pyrrole was N-acetylated about four times more rapidly with N-acetylimidazole than with N-acetylbenzimidazole (*cf* Ref. 14). Alternatively, the intermediate mono-adduct in the formation of **19** can be prepared[5] from benzimidazole, pyrrole and acetyl chloride in hot benzene.

Aromatic compounds less reactive than indole and pyrrole, such as 1-methoxynaphthalene, 2-methylfuran and thiophene, failed to react with both imidazole and benzimidazole in hot acetic anhydride. This may be due either to the low reactivity of **3** or its rapid decomposition according to the reaction C (Scheme 1).

The trifluoroacetic anhydride/imidazole reagent, which should generate the more electrophilic N,N'-bis(trifluoroacetyl)imidazolium ion (**3**, Ac=$COCF_3$), did react with e.g. thiophene and anisole at 40° (reflux temp), giving the corresponding adducts **9** and **10** in moderate yield. If the reaction was carried out at 125° (sealed tube), less reactive aromatics, such as m-xylene did react to give **11**, although in low yield. In these reactions, excess of trifluoroacetic anhydride was used as solvent. However, the yields often increased considerably when refluxing acetonitrile was used as solvent and the anhydride only in slight excess.

Reactive substrates such as 1,3-dimethoxybenzene and N-ethylcarbazole yielded disubstituted adducts in high yields, whereas highly reactive substrates gave monoacylated derivatives. Thus, treatment of indole and pyrrole with imidazole/trifluoroacetic anhydride under various conditions gave 3-trifluoroacetylindole and 2-trifluoroacetylpyrrole, respectively. Trichloroacetic anhydride in e.g. CH_2Cl_2 at $-10°$ similarly yielded 3-trichloroacetylindole and 2-trichloroacetylpyrrole, respectively (*cf* Refs. 15 and 16). No adducts could be isolated, but when the reactive positions were blocked, the normal adducts were obtained. Thus, 1,2,5-trimethylpyrrole and imidazole/trifluoroacetic anhydride in refluxing acetonitrile yielded the bis-adduct **13**, which can be converted to the known[17] compound 1,2,5-trimethyl-3,4-diformylpyrrole.

The mechanism of the formation of adducts probably involves an equilibrium analogous to (B) as shown in the route (D). The fact that treatment of thiophene and 2-methylfuran with **2** (Ac=$COCF_3$) in trifluoroacetic acid



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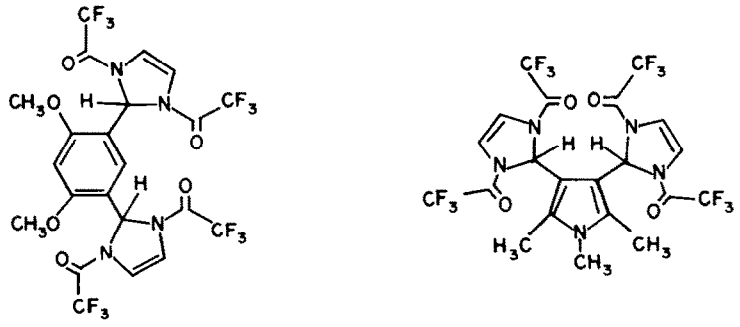

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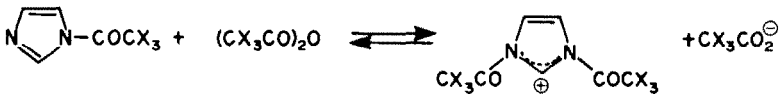

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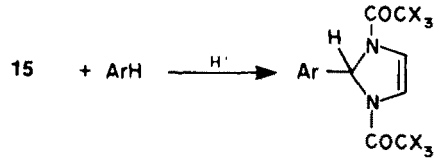
D



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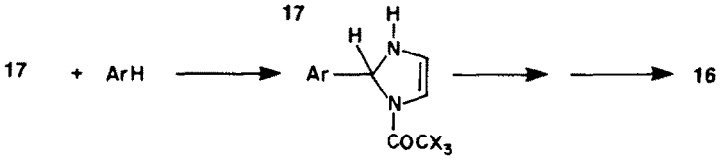
E



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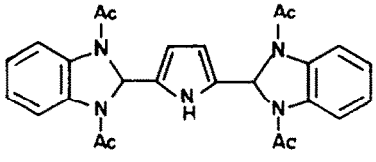
gave only 2-trifluoroacetylthiophene and 2-trifluoroacetyl-5-methylfuran, respectively, and no adducts seems to exclude route (E) as an alternative. Consistent with these results, it was found that a reagent composed of N-methylimidazole and trifluoroacetic anhydride failed to produce any adduct even with reactive substrates such as 1,3-dimethoxybenzene.

Alkaline hydrolysis of compound **19** gave 2-methylbenzimidazole (**24**) and 2,5-diformylpyrrole (**21**) in fair yield (40%). Compounds **22** and **23**, which could be isolated by interrupting the hydrolysis after 90 min, are intermediates in the formation of **21** and **24**. An intermediate (**25**) with a structure related to **22** and **23** could be isolated by mild hydrolysis of the 2-methylindole adduct **5b**.

Alkaline hydrolysis of the adducts generally gave the



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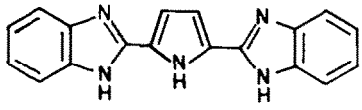

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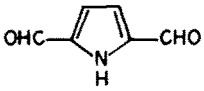

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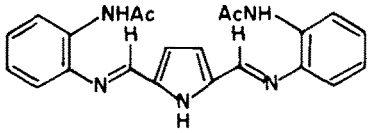

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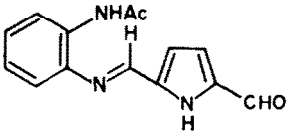

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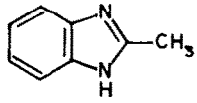

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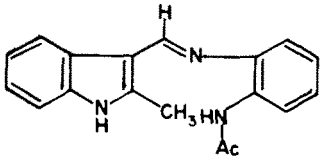

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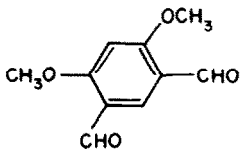

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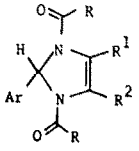
corresponding aldehyde. To avoid secondary reactions with alkali-sensitive aldehydes, the products were, when appropriate, continuously removed from the reaction mixture by steam distillation. Quite expectedly, the adducts containing $COCF_3$-groups could be hydrolysed quickly and under mild conditions. Thus **12** was completely hydrolysed to **26** within 5 min when treated with sodium hydroxide in hot aqueous ethanol. This route to **26**, which is not available *via* Vilsmeier formylation, is much more convenient than the previous one.[18]

From the present results, it is quite clear that the preparative scope of this new route to monoaldehydes is largely the same as the well-known Vilsmeier formylation. However, the new route is often simpler and faster and often gives better yields. Preparatively the most important difference between the two reactions is the fact that the aldehyde function introduced in the first step of the new reaction is protected and can be used directly for the introduction of further substituents. The regiospecificity of further functionalisation would sometimes be expected to differ from that observed using unprotected aldehydes. This effect is exemplified by the 2,5-substitution pattern established by the synthesis of **19** (and subsequently **21**) from pyrrole and a benzimidazole/acetic anhydride reagent as compared with the predominantly 2,4-substitution pattern observed[19] in vigorous Vilsmeier formylation of pyrrole.

The bulky substituent introduced by the imidazole/acetic anhydride reagent might be expected to induce, at least in certain cases, a regiospecificity different from that observed in Vilsmeier monoformylations. As a probe, formylation of 3-bromothiophene was studied, but somewhat unexpectedly it was found that both methods yielded 3-bromothiophene-2-carboxaldehyde.

Giesecke and Hocker[20] recently reported the formation of electrophilic substitution products such as **27** upon treatment of phenols, e.g. 2,6-dimethylphenol, with compound **28**. Under the reaction conditions **28** would be expected to generate the ion **29**. We have now studied the reactions of 2,6-dimethylphenol with imidazole/acetic anhydride and imidazole/trifluoroacetic

Table 1. N,N'-Diacyl-2-aryl-4-imidazolines prepared



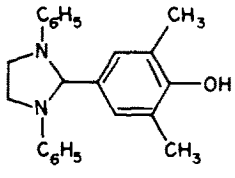
Ar	R	R^1	R^2	Yield %	m.p. °C
3-Indolyl	CH_3	H	H	72	214-215
3-Indolyl	CH_3	$-(CH)_4-$		63	251-252
2-Methylindol-3-yl	CH_3	H	H	69	235-236
5-Methoxyindol-3-yl	CH_3	H	H	67	169.5-171
2-Thienyl	CF_3	H	H	78	74-75
4-Methoxyphenyl	CF_3	H	H	53	107-108
2,4-Dimethoxyphenyl	CCl_3	H	H	73	186-187
2,4-Dimethoxyphenyl	CF_3	$-(CH)_4-$		90	131-133
2,5-Dimethoxyphenyl	CF_3	H	H	85	112-113
4,6-Dimethoxy-1,3-phenylene	CF_3	H	H	98	251-252
4-Methoxy-1-naphthyl	CF_3	H	H	89	185-186
2-Methoxy-1-naphthyl	CF_3	H	H	94	171-171.5
5-Methyl-2-furyl	CCl_3	H	H	48	172-173
2,4-Dimethylphenyl	CF_3	H	H	27	100-101
3,4-Dimethoxy-2-methylphenyl	CF_3	H	H	84	113-114
5-Acenaphthyl	CF_3	H	H	62	151-152.5
2,5-Furandiyl	CF_3	H	H	10	163-164
5-Ethyl-2-thienyl	CF_3	H	H	45	62-63
3-Bromo-2-thienyl	CF_3	H	H	21	109-110
5-Bromo-2-thienyl	CF_3	H	H	40	79-80
1,2,5-Trimethyl-3,4-pyrrolediyl	CF_3	H	H	94	269-271
9-Ethyl-3,6-carbazolediyl	CF_3	H	H	88	274-276
2-Thienyl	CF_2Cl	H	H	62	71-72
3-(2,3'-Biindolyl)	CH_3	H	H	99.5	281-283

Table 2. Aldehydes prepared

Aldehyde	Yield from imidazoline	m.p. °C	m.p. lit. °C
3-Formylindole	88	200--202	196--198 [21]
3-Formyl-2-methylindole	94	197--198	200--202 [23]
5-Bromo-3-formylindole	90	210--211	211 [24]
3-Formyl-5-methoxyindole	91	178--179	181--182 [25]
Thiophene-2-carboxaldehyde	79	223--224[a]	220--221 [26]
4-Methoxybenzaldehyde	38	88--89[b]	92 [27]
2,4-Dimethoxybenzaldehyde	59	67--68	65.5--67.5 [18]
2,5-Dimethoxybenzaldehyde		49--50	49--50 [33]
4,6-Dimethoxyisophthalaldehyde	92	224--226	217.5--223 [18]
2-Methoxy-1-naphthaldehyde	67	79--81	82 [28]
4-Methoxy-1-naphthaldehyde	52	250--252[c]	258 [29]
5-Methylfurfural	32	109--110[b]	112--113 [30]
5-Formylacenaphthene	72	104--106	107--108 [31]
2,5-Diformylpyrrole	40	124--125	121 [22]
3-Formyl-2,3'-biindolyl	95	201--202	

[a] semicarbazone. [b] oxime. [c] thiosemicarbazone.

anhydride reagents and conclude that these reagents are unsuitable for the introduction of cyclic aminal functions in simple phenols.



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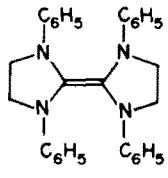

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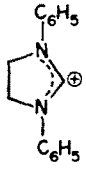

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EXPERIMENTAL

General methods. M.ps were determined on a Leitz melting point apparatus and are uncorrected. IR spectra were recorded on a Perkin–Elmer 257 spectrophotometer as KBr discs. ^{1}H NMR spectra were recorded on a Varian EM-360 or a Bruker WP 200 instrument, using $CDCl_3$ as solvent. Mass spectra were obtained on an LKB 9000 instrument (IP 70 eV).

1,3-*Diacetyl*-2-(3-*indolyl*)-4-*imidazoline*(**5a**). Indole (11.7 g, 0.1 mol) in Ac_2O (20 ml) was added dropwise over a 30 min period to a stirred soln of imidazole (6.8 g, 0.1 mol) in Ac_2O (40 ml) at 125°. After completion of the addition the soln was stirred at 125° for an additional 30 min, whereupon the solvent was removed at reduced pressure. The residue was treated with 100 ml of hot acetonitrile and after cooling yielded crystals of 1,3-diacetyl-2-(3-indolyl)-4-imidazoline, 19.4 g (72%), m.p. 214–215°. IR: 3320 (N–H) and 3140 (C–H) cm^{-1}; ^{1}H NMR: δ = 8.55 (broad s, 1 H), 7.70–6.34 (several peaks, 8 H), 2.10, 2.07, 1.93 and 1.90 (s, 6 H); MS[*m/e* (% rel. int.)]: 269 (36), 227 (16), 185 (18) and 184 (100).

The following derivatives were prepared in the same way.

1,3-*Diacetyl*-2-(3-*indolyl*)-*benzimidazoline.* Yield: 63%, m.p. 251–252° (lit.[5] m.p. 241–242°). MS[*m/e* (% rel. int.)]: 320 (15), 319 (61), 262 (11), 235 (20), 234 (100) and 233 (13).

1,3-*Diacetyl*-2-(2-*methylindol*-3-*yl*)-4-*imidazoline* (**5b**). Yield: 69%, m.p. 235–236°. IR: 3280 (N–H) and 3130 (C–H) cm^{-1}; ^{1}H NMR: δ = 8.02 (broad s, 1 H), 7.52–6.39 (several peaks, 7 H), 2.65, 2.63, 2.06, 2.05, 1.84 and 1.56 (s, 9 H); MS[*m/e* (% rel. int.)]: 284 (11), 283 (54), 241 (12), 199 (18), 198 (100), 183 (20), 182 (49) and 181 (16).

1,3-*Diacetyl*-2-(5-*methoxyindol*-3-*yl*)-4-*imidazoline.* Yield: 67%, m.p. 169.5–171°. IR: 3385 (N–H) and 3120 (C–H) cm^{-1}; ^{1}H NMR: δ = 8.39 (broad s, 1 H), 7.37–6.34 (several peaks, 7 H), 3.84 (s, 3 H), 2.10, 2.07, 1.91 and 1.61 (s, 6 H); MS[*m/e* (% rel. int.)]: 299 (45), 257 (21), 215 (20) and 214 (100).

3-*Formylindole.* 1.0 g of 1,3-diacetyl-2-(3-indolyl)-4-imidazoline (**5a**) was added to a soln of NaOH (0.5 g) in EtOH (10 ml)/water (5 ml). The mixture was refluxed for 1 hr after which it was poured into 50 ml water and neutralised with HCl. After standing over night the crystals were collected and recrystallised from EtOH, giving 0.47 g (88%) of 3-formylindole, m.p. 200–202° (lit.[21] 196–198°).

The other formylindoles were likewise prepared.

Tris((N-*methylindol*-3-*yl*)*methane.* A soln of N-methylindole (1.31 g) and imidazole (0.68 g) in Ac_2O (15 ml) was kept at 140° for 1 hr, whereupon the solvent was removed using reduced pressure. The residue was crystallised from pyridine giving tris-(N-methylindol-3-yl)methane, yield 1.10 g (78%), m.p. 268–270° (lit.[11] 268–270°).

Tris-(4-*dimethylaminophenyl*)*methane* (*Leuco crystal violet*). The procedure given above was used starting with N,N-dimethylaniline, yield: 85%.

2,5-*Bis*-(1,3-*diacetyl*-1,2-*dihydrobenzimidazol*-2-*yl*)*pyrrole* (**19**). Pyrrole (6.7 g, 0.1 mol) in 10 ml Ac_2O is added dropwise during 15 min to a well stirred soln of benzimidazole (24.8 g, 0.21 mol) in Ac_2O (90 ml) at 120°. After 3 hr of reflux the mixture was cooled, the crystals collected and washed with MeOH, yield: 44.1 g (94%), m.p. 308–310°. IR: 3110(C–H) cm^{-1}; MS[*m/e* (% rel. int.)]:

471 (35), 429 (15), 387 (11), 386 (15), 345 (14), 344 (59), 328 (11), 327 (37) and 326 (100).

2,5-Diformylpyrrole (**21**). A mixture of EtOH (250 ml), 3M NaOH (200 ml) and 2,5-bis-(1,3-diacetyl-1,2-dihydrobenzimidazol-2-yl)pyrrole (23.5 g) was refluxed for 6 hr. After cooling the pH was adjusted to *ca.* 4.5 by addition of 2M H_2SO_4. Continuous extraction with CH_2Cl_2 for 6 hr and evaporation of the extract gave a sticky mass from which 2,5-diformylpyrrole was isolated by column chromatography (silica gel/CH_2Cl_2). The crude product was recrystallised from CCl_4/hexane, yield: 2.46 g (40%), m.p. 124–125° (lit.[22] m.p. 121°).

Preparation of compounds **22** *and* **23**. A mixture of **20** (10 g), EtOH (60 ml) and 2M NaOH (40 ml) was refluxed for 90 min, allowed to cool and then neutralised with 2M H_2SO_4. The mixture was then evaporated and the residue extracted with hot $CHCl_3$ (in some experiments **22** crystallised from this soln on cooling). The evaporated extract was then chromatographed on silica gel with CH_2Cl_2 containing slowly increasing amounts of MeOH, which yielded 2,5-diformylpyrrole (120 mg), **23** (1.3 g, 24%), **22** (4.2 g, 51%) and 2-methylbenzimidazole (2.2 g, 39%). Compound **22** (m.p. 343–345°) gave the following spectral data: IR: 1660 (C=O) cm^{-1}; MS[*m/e* (% rel. int.)]; 388 (14), 387 (53), 345 (15), 344 (56), 326 (18) and 302 (21). Only peaks stronger than 10% of the base peak (*m/e* = 184) and above *m/e* 300 are given. Compound **23** (m.p. 198–200°) gave the following spectral data: IR: 1665 (C=O) cm^{-1}; MS[*m/e* (% rel. int.)]: 256 (11), 255 (65), 213 (47), 212 (100), 211 (14), 197 (20), 196 (15) and 184 (60).

1,3-Bis-(trifluoroacetyl)-2-(4-methoxyphenyl)-4-imidazoline (**10**). Imidazole (1.36 g, 0.02 mol), acetonitrile (20 ml) and trifluoroacetic anhydride (7.5 ml) were mixed and heated to reflux. Anisole (2.16 g, 0.02 mol) was added dropwise and the mixture was refluxed for 2 hr, after which the solvent was evaporated and the residue treated with ice. The resulting semisolid was recrystallised from EtOH, giving 3.9 g (53%) of **10**, m.p. 107–108°. IR: 3170 (C–H) cm^{-1}; ^1H NMR: δ = 7.4 (d, 2 H), 7.0 (s, 1 H), 6.9 (d, 2 H), 6.7 (s, 2 H) and 3.8 (s, 3 H); MS[*m/e* (% rel. int.)]; 368 (100), 337 (44), 299 (16), 271 (68), 261 (21), 256 (19), 255 (11) and 201 (17).

The following compounds were likewise prepared.

1,3-Bis-(trifluoroacetyl)-2-(2-thienyl)-4-imidazoline (**9**), yield: 78%, m.p. 74–75°. IR: 3153 (C–H) cm^{-1}; ^1H NMR: δ = 7.5 (s, 1 H), 7.5–7.25 (AB region of ABX system, 2 H), 7.0 (X region of ABX system, 1 H) and 6.7 (s, 2 H); MS[*m/e* (% rel. int.)]: 344 (100), 275 (21), 261 (21) and 247 (82).

1,3-Bis-(chlorodifluoroacetyl)-2-(2-thienyl)-4-imidazoline, yield: 62%, m.p. 71–72°. IR: 3160 (C–H) cm^{-1}; MS[*m/e* (% rel. int.)]: 380 (15), 378 (70), 376 (100), 293 (32), 291 (47), 265 (29) and 263 (77).

1,3-Bis-(trifluoroacetyl)-2-(5-ethylthien-2-yl)-4-imidiazoline, yield: 45%, m.p. 62–63°. IR: 3153 (C–H) cm^{-1}; ^1H NMR: δ = 7.4 (s, 1 H), 7.1 (d, 1 H), 6.7 (d, 1 H), 6.6 (s, 2 H), 2.8 (q, 2 H) and 1.3 (t, 3 H); MS[*m/e* (% rel. int.)]: 372 (74), 303 (36), 275 (100), 261 (21), 259 (36), 207 (10) and 206 (14).

1,3-Bis-(trifluoroacetyl)-2-(3,4-dimethoxy-2-methylphenyl)-4-imidazoline, yield: 64%, m.p. 113–114°. IR: 3155 (C–H) cm^{-1}; ^1H NMR: δ = 7.15 (s, 1 H), 7.09 (d, 1 H), 6.76 (d, 1 H), 6.72 (s, 2 H), 3.84 (s, 3 H), 3.78 (s, 3 H) and 2.60 (s, 3 H); MS [*m/e* (% rel. int.)]: 412 (100), 315 (100), 300 (37), 299 (16), 261 (51), 204 (53), 203 (33), 202 (93) and 201 (28).

1,3-Bis-(trifluoroacetyl)-2-(2-methoxy-1-napthyl)-4-imidazoline, yield: 94%, m.p. 171–171.5°. IR: 3190 (C–H) cm^{-1}; ^1H NMR: δ = 8.0–7.25 (several peaks, 7 H), 6.72 (s, 2 H) and 3.95 (broad s, 3 H); MS[*m/e* (% rel. int.)]: 418 (100), 387 (37), 321 (66), 306 (12), 294 (19), 261 (22) and 251 (15).

1,3-Bis-(trifluoroacetyl)-2-(4-methoxy-1-naphthyl)-4-imidazoline, yield: 89%, m.p. 185–186°. IR: 3160 (C–H) cm^{-1}; ^1H NMR: δ = 8.4–7.5 (several peaks, 7 H), 6.82 (s, 2 H) and 4.00 (s, 3 H); MS[*m/e* (% rel. int.)]: 418 (100), 321 (64), 306 (61), 305 (27), 294 (16), 261 (15) and 251 (14).

1,3-Bis-(trifluoroacetyl)-2-(5-acenaphthyl)-4-imidazoline, yield: 62%, m.p. 151–152.5°. IR: 3150 (C–H) cm^{-1}; ^1H NMR: δ = 8.0–7.2 (several peaks, 6 H), 6.80 (s, 2 H) and 3.37 (s, 4 H); MS[*m/e* (% rel. int.)]: 414 (100), 318 (13), 317 (63), 303 (11), 302 (59), 301 (19) and 290 (14).

1,5-Bis-(1,3-bistrifluoroacetyl-4-imidazolin-2-yl)-2,4-dimethoxybenzene (**12**). Same experimental procedure as above but the ratio imidazole reagent; 1,3-dimethoxybenzene was 2.05:1, yield: 98%, m.p. 251–252°. IR: 3162 (C–H) cm^{-1}; ^1H NMR: δ = 7.52 (s, 1 H), 7.17 (s, 2 H), 6.65 (s, 4 H), 6.43 (s, 1 H and 3.89 (s, 6 H); MS[*m/e* (% rel. int.)]: 658 (28), 561 (25), 44 (15), 409 (11), 397 (23) and 261 (100).

2,4-Bis-(1,3-bistrifluoroacetyl-4-imidazolin-2-yl) furan. Procedure as for **12**, yield: 10%, m.p. 163–164°. IR: 3160 (C–H) cm^{-1} ^1H NMR: δ = 7.16 (s, 2 H), 6.66 (s, 2 H) and 6.62 (s, 4 H); MS[*m/* (% rel. int.)]: 588 (100), 519 (19), 491 (67) and 378 (24).

3,4-Bis-(1,3-bistrifluoroacetyl-4-imidazolin-2-yl)-1,2,5-trimethylpyrrole (**13**). Procedure as for **12**, yield: 94%, m.p. 269 271°. IR: 3160 (C–H) cm^{-1}; MS[*m/e* (% rel. int.)]: 629 (28), 53 (24), 434 (38), 428 (23), 368 (40) and 261 (100).

3,6-Bis-(1,3-bistrifluoroacetyl-4-imidazolin-2-yl)-9-ethylcarbazole. Procedure as for **12**, yield: 88%, m.p. 274–276°. IR: 314 (C–H) cm^{-1}; MS[*m/e* (% rel. int.)]: 715 (40), 618 (19), 602 (20) an 455 (100).

1,3-Bis-(trifluoroacetyl)-2-(2,4-dimethylphenyl)-4-imidazoline (**11**). Imidazole (1.36 g, 0.02 mol), *m*-xylene (2.12 g 0.02 mol) and trifluoroacetic anhydride (15 ml) were mixed whil cooling (−78°) in a sealed tube. The mixture was heated to 125° an kept at that temp for 12 hr, after which it was poured into ice. Th mixture was extracted with chloroform, and subsequent evapora tion left a gummy residue that was crystallised from EtOH givin 2.0 g (27%) of **11**, m.p. 100–101°. IR: 3160 (C–H) cm^{-1}; ^1H NMR δ = 7.22 (d, 1 H), 7.18 (s, 1 H), 7.02 (d, 1 H), 7.00 (s, 1 H), 6.73 (s, 1 H) 2.67 (s, 3 H) and 2.26 (s, 3 H); MS[*m/e* (% rel. int.)] 366 (100), 269 (81), 261 (70), 254 (23) and 253 (22).

The following two compounds were also prepared by th sealed tube method, but heated at 110° for only 4 hr.

1,3-Bis-(trifluoroacetyl)-2-(5-bromothien-2-yl)-4-imidazoline yield: 40%, m.p. 79–80°. IR: 3150 (C–H) cm^{-1}; ^1H NMR: δ = 7.3 (s, 1 H), 7.09 (d, 1 H), 6.96 (d, 1 H) and 6.66 (s, 2 H); MS[*m/e* (% rel. int.)]: 424 (100), 422 (99), 355 (22), 353 (21), 344 (51), 343 (21) 327 (61), 325 (62), 311 (14) and 309 (14).

1,3-Bis-(trifluoroacetyl)-2-(3-bromothien-2-yl)-4-imidazoline yield: 21%, m.p. 109–110°. IR: 3150 (C–H) cm^{-1}; ^1H NMR: δ = 7.42 (s, 1 H), 7.35 (d, 1 H), 6.95 (d, 1 H) and 6.70 (s, 2 H); MS[*m/* (% rel. int.)]: 424 (100), 422 (98), 355 (12), 353 (11), 343 (30), 32 (53) and 325 (51).

1,3-Bis-(trichloroacetyl)-2-(2,4-dimethoxyphenyl)-4-imidazoline. A mixture of imidazole (0.68 g, 0.01 mol), 1,3-dimethoxy benzene (1.3 ml, 0.01 mol) and trichloroacetic anhydride wa stirred for 20 hr at room temp. The mixture was poured int 100 ml water. The resulting oil was treated with EtOH, givin 3.6 g (73%) of 1,3-bis-(trichloroacetyl)-2-(2,4-dimethoxyphenyl)-4 imidazoline, m.p. 186–187°. IR: 3145 (C–H) cm^{-1}; ^1H NMR δ = 7.41 (d, 1 H), 7.19 (s, 1 H), 7.00 (s, 2 H), 6.48 (d, 1 H), 6.46 (s 1 H), 3.87 (s, 3 H) and 3.80 (s, 3 H); MS[*m/e* (% rel. int.)]: 50 (24), 498 (38), 496 (47), 494 (24), 465 (11), 463 (34), 461 (53), 45 (33), 381 (32), 379 (96) and 377 (100).

1,3-Bis-(trichloroacetyl)-2-(5-methylfuran-2-yl)-4-imidazoline A mixture of imidazole (1.36 g, 0.02 mol), trichloroacetic anhydride (12 ml) and 2-methylfuran (1.64 g, 0.02 mol) was left a room temp for 6 hr after which it was poured into water. Th crystalline material was recrystallised from EtOH giving 4.2 (48%) of 1,3-bis-(trichloroacetyl)-2-(5-methylfuran-2-yl)-4-imida zoline, m.p. 172–173°. IR: 3150 (C–H) cm^{-1}; ^1H NMR: δ = 7.05 (s 1 H), 6.95 (s, 2 H), 6.50 (d, 1 H), 5.96 (d, 1 H) and 2.21 (s, 3 H) MS[*m/e* (% rel. int.)]: 444 (11), 442 (26), 440 (32), 438 (16), 32 (33), 323 (96) and 321 (100).

4-Methoxybenzaldehyde. A soln of NaOH (1.0 g) in wate (50 ml) was heated. As the water started to distil, 1,3-bis-(tri fluoroacetyl)-2-(4-methoxyphenyl)-4-imidazoline (1.0 g) was ad ded in small portions. The distilled water phase was extracte with ether, which after evaporation left 140 mg (38%) of 4 methoxybenzaldehyde.

Aldehydes which are possible to steam distil were prepared b this procedure.

4,6-Dimethoxyisophthalaldehyde. 1,5-Bis-1,3-bistrifluoroacetyl 4-imidazolin-2-yl)-2,4-dimethoxybenzene (1.0 g) was added to mixture of EtOH (10 ml), water (5 ml) and NaOH (0.5 g). Th

mixture was refluxed for 5 min, then diluted with water (50 ml) and neutralised with HCl. The resulting crystalline material consisting of 4,6-dimethoxyisophthalaldehyde was collected, giving 270 mg (92%), m.p. 224–226° (lit.[18] m.p. 217.5–223°).

This method was used for aldehydes which could not be steam distilled.

1,3-Bis-(acetyl)-2-[3-(2,3'-biindolyl)]- 4 -imidazoline. 2,3-Biindolyl[32] (2.32 g) and imidazole (0.68) dissolved in Ac_2O (25 ml) were refluxed for 15 min (crystals were formed within 45 sec). The mixture was cooled and the crystals collected ans washed with MeOH giving 3.82 g (99.5%), MS[*m/e* (% rel. int.)]: 384, M^+ (15), 341 (10), 299 (37), 274 (19), 232 (100), 231 (32), 204 (13).

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