1,4-Pentandien-3-ones, XXXII[1]:

Reaction of 2-Acetylthiophene and 2-Acetylfuran with Malononitrile and Aldehydes, and Synthesis and Properties of Phenylene-bis [(thienyl/furyl)nicotinonitrile] Derivatives

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The (*E*)-1-hetaryl-2-propen-1-ones **3** and **4** are prepared by condensation of 2-acetylthiophenes (**1a,1c,1d**) or 2-acetylfuran (**1b**) with aldehydes. The *Michael* adducts **5/6** are obtained from **3/4** by reaction with malononitrile/LDA in THF at -78°C, or in DMSO with NaH at room temp. Reaction of **3/4** with malononitrile and methylate in methanol yielded the substituted nicotinonitriles **7/8**. From terephthalaldehyde, the diketones **9** are prepared, which yield with malononitrile the phenylene-bis[(thienyl/furyl)nicotinonitrile] derivatives **10** under similiar conditions. Structural and spectral data are discussed.

1,4-Pentandien-3-one, 32. Mitt.: Zur Reaktion von 2-Acetylthiophen und 2-Acetylfuran mit Malondinitril und Aldehyden, sowie Synthese und Eigenschaften von Phenylen-bis[(thienyl/furyl)nicotinonitril]-Derivaten

Die (*E*)-1-Hetaryl-2-propen-1-one **3** und **4** werden durch Kondensation der 2-Acetylthiophene **1a,1c,1d** oder des 2-Acetylfurans **1b** mit Aldehyden erhalten. Durch *Michael*-Reaktion mit Malondinitril in THF bei -78°C in Gegenwart von LDA oder in DMSO bei Raumtemp. mit NaH werden daraus die Addukte **5/6** dargestellt. Durch analoge Reaktionen in Methanol mit Methylat werden die Nicotinonitril-Derivate **7/8** gewonnen. Aus Terephthalaldehyd werden unter ähnlichen Bedingungen die Diketone **9** synthetisiert, aus denen die Phenylen-bis[(thienyl/furyl)nicotinonitril]-Derivate **10** zugänglich sind. Strukturelle und spektrale Daten werden diskutiert.

2-Acetylated thiophenes and furans **1** are versatile starting materials for many classes of heterocycles[2]. We are especially interested in the construction of highly substituted pyridines and related heterocycles starting from 1,4-pentadien-3-ones and other substituted α,β-unsaturated ketones by *Michael* and similiar reactions[3]. Here, we report about the reactions of **1** with aromatic aldehydes **2** and malononitrile.

Referring to a prescription given by *Murphy* and *Wattanasin*[4] **1a** was reacted with the aldehydes **2a-i** in absol. methanol in the presence of NaOH. The α,β-unsaturated ketones **3a-i** (Scheme 1) were obtained in yields between 80 and 90%[5]. **3y** was prepared from **1c**, and **3z** from **1d**. By a similiar procedure, from **1b** the unsaturated ketones **4a-i** were obtained.

According to spectroscopic data, all compounds **3/4** exist in the *E*-configuration. Their IR-spectra show a strong carbonyl absorption around 1640 cm^{-1}, and the C=C absorption appears between 1590 and 1600 cm^{-1}. The out-of-plane vibration bond at 980 cm^{-1} is a characteristic of *trans* alkenes. Additionally, the coupling constants of the olefinic proton signals in the ^{1}H-NMR spectra vary between 14 and 18 Hz[6]. 2-Acetylthiophene (**1a**) prefers the *s-trans* conformation, 2-acetylfuran (**1b**) on the other hand, normally exists as an equilibrium of equal amounts of *s-cis* and *s-trans* form[7]. α,β-Unsaturated ketones with *E*-configuration usually prefer the *s-trans* conformation[8,9]. As the propenones **3** and **4** contain the 1,4-pentadien-3-one system - one double bond of the system is included in the heteroaromatic ring - it might be of interest to know, whether these compounds exist in different conformers as shown in Scheme 2. The system is flexible, and, therefore, an equilibrium of at least four conformations should be possible in solution, and it was of special interest to see if **3** and **4** even prefer one conformation. Perhaps, the i.r. spectra suggest a preferred *s-cis* conformation as indicated by the ratio $I_{CO}/I_{C=C}$, and by the difference of 50-60 cm^{-1} between both bands. Using the ASIS effect[10] (deuterochloroform/deuterobenzene), we demonstrated that the *s-trans/s-cis* conformation A is the preferred one in solution. The differences in the shifts of the β-protons, $\delta_{C_6D_6} - \delta_{CDCl_3}$, vary between +0.05 and +0.3 ppm[11] (Table 1).

Table 1: ASIS effect on propenones **3** and **4** (values ppm)

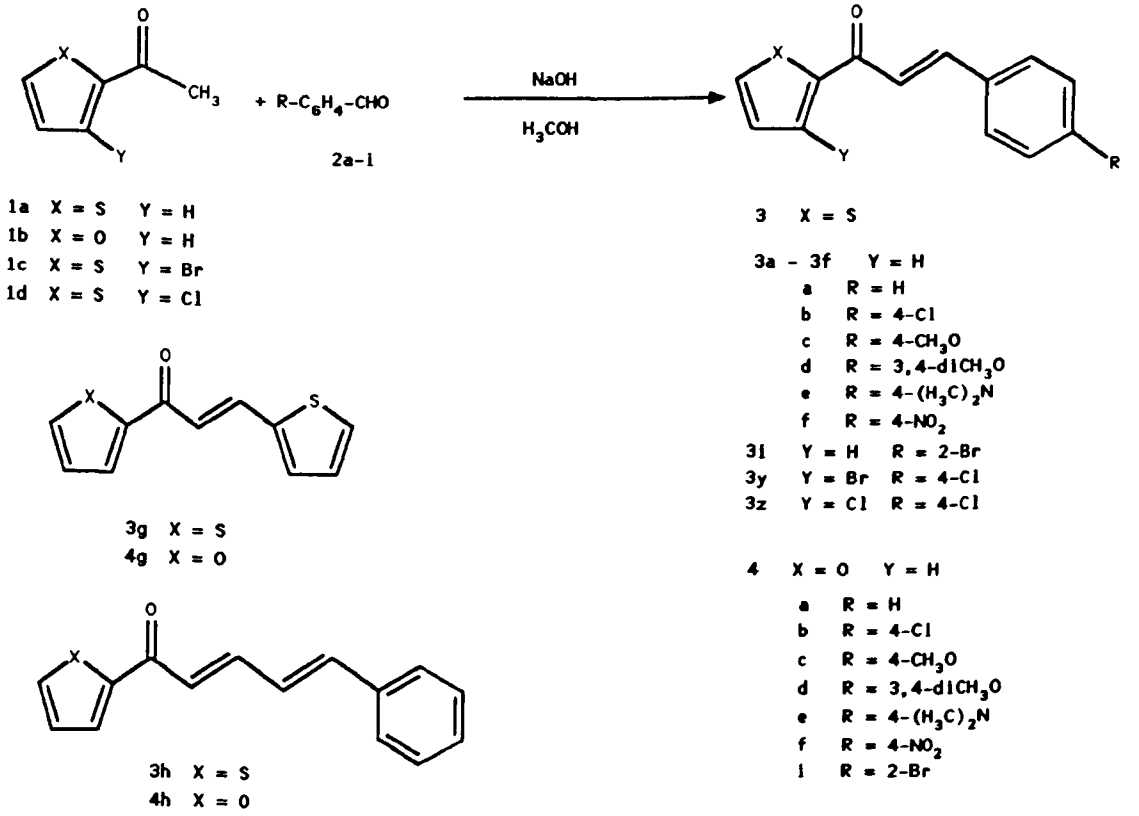
Nr.	δ[β-H (CDCl$_3$)]	δ[β-H(C$_6$D$_6$)]	Difference
3a	7.90	7.95	0.05
3d	7.75	8.05	0.30
4a	7.90	8.00	0.10
4d	7.90	8.10	0.30

  0365-6233/91/0909-0563 $ 3.50 + .20

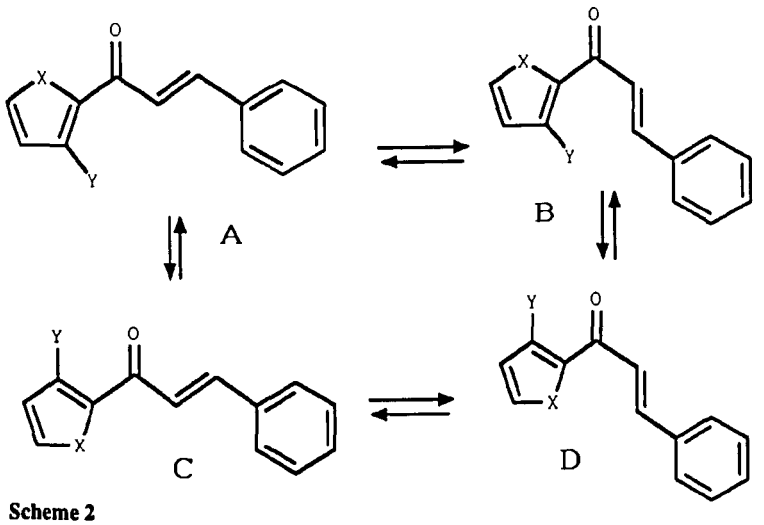
Table 2: UV spectra* of 7 - 10

No.	wavelength nm (absorption E)					
7a	346 (0.583),			264 (0.422),	224 (0.153)	
7b	352 (0.610),			272 (0.408),	224 (0.386)	
7c	350 (0.635),			236 (0.269),	224 (0.134)	
7d	350 (0.615),	286 (0.350),		265 (0.338),	224 (0.405)	
7e	380 (0.293),	348 (0.460),		304 (0.391),	224 (0.382)	
7f	358 (0.541),			288 (0.484),	224 (0.387)	
7g	360 (0.550),			294 (0.409),	224 (0.223)	
7h	358 (0.465),	340 (0.468),		304 (0.558),	222 (0.165)	
7y	338 (0.347)			268 (0.553),	221 (0.265)	
7z	344 (0.132),			268 (0.509),	234 (0.204)	
8a	340 (0.470),			256 (0.389),	224 (0.155)	
8b	352 (0.437),			262 (0.277),	224 (0.272)	
8c	350 (0.462),			284 (0.271),	224 (0.158)	
8d	352 (0.448),	280 (0.236),		260 (0.236),	228 (0.264)	
8e	382 (0.273),	344 (0.443),		294 (0.345),	224 (0.272)	
8f	354 (0.388),			288 (0.312),	224 (0.261)	
8g	358 (0.399),			292 (0.348),	220 (0.209)	
8h	358 (0.353),	325 (0.456),		299 (0.576),	225 (0.266)	
10a	348 (0.799),			276 (0.741),	224 (0.245)	
10b	360 (0.907),				235 (0.255)	
10y	348 (0.794),			278 (1.087),	234 (0.544)	
10z	345 (0.876),			283 (1.033),	234 (0.428)	

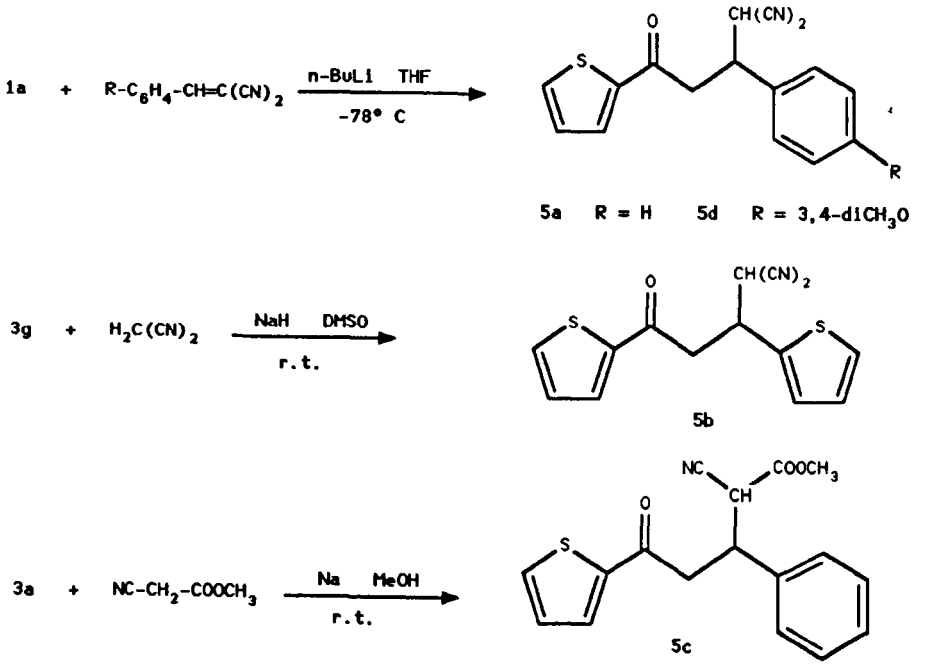
* All spectra were taken in $2\text{-}10^{-5}$molar solution in dichloromethane



Scheme 1



Scheme 2



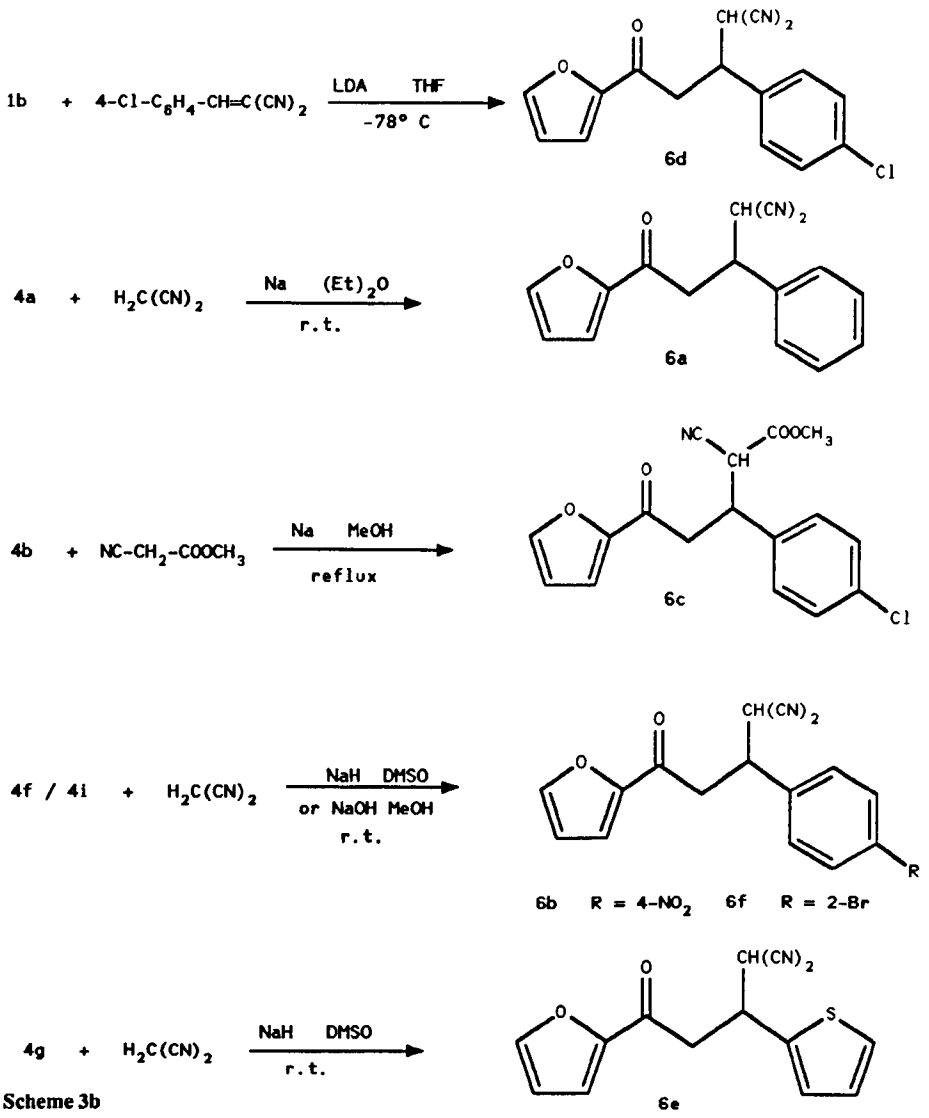
Scheme 3a

The addition of malononitrile to **3** or **4** in methanol did not result in the formation of the *Michael* adducts **5** or **6**. On the other hand, the adducts **5a**, **5d**, and **6d** became available (Scheme 3), when the reactions were done in tetrahydrofuran at -78°C in the presence of LDA or BuLi. Another possibility is given by the reaction in dimethyl sulfoxide with NaH at room temp., which was successfully used for the synthesis of **5b**, **6b**, and **6e**. **6a** was prepared in dry ether with cutted sodium at room temp. and the addition of methyl cyanoacetate yielding **5c** and **6c** was best performed in methanol with sodium. Some compounds **5** and **6** probably exist as mixtures of diastereomers if their structures contain two (vicinal) chiral atoms, but we did not try to separate them.

When the propenones **3** were refluxed in an appropriate alcohol with malononitrile and catalytic amounts of sodium (method **a**) we did not find either mono addition products of type **5** or **6**, or double addition products as known from reactions between dibenzalacetone or related systems with malononitrile. Instead, we obtained the highly substituted pyridines **7a-h** and **7x-z**, and from **4** we found the pyridines **8a-h** on the same route.

The pyridines **7** and **8** also were obtained by treatment of the parent **5** or **6** with sodium alcoholate at room temp. (method b). Finally, a third route (method c) starts with 2-acetylthiophene (**1**) or -furan (**1b**), from which the pyridines **7a**, **7d**, and **8b** are formed by reaction with arylidenemalononitriles. In all ways, the yields of **7** or **8** vary between 20 and 50%, in no case we were successful in increasing the yield to more than 50%.

The results encourage us to propose the following way of formation (Scheme 4), although we were not able to isolate intermediates - except **5** and **6** - as we did in former experiments[12]. In all cases **5** or **6** are the first products formed either by *Michael* reaction between **3**/**4** and malononitrile or between **1** and arylidenemalononitrile. Enolisation of the carbonyl group



Scheme 3b

in **5/6**, attack of the hydroxyl group to one cyano group, and tautomerisation results in the formation of the *4H*-pyrans (**P**). These are transformed by a *Dimroth* rearrangement[13] to 1,4-dihydropyridines (**D**), which may either be oxidized or transformed by disproportionation with aromatisation into the pyridines **7** and **8**. Refering to the yields lower than 50%, we believe in the disproportionation mechanism, although we could not detect any tetrahydropyridine derivatives.

From terephthalaldehyde (Scheme 5), we synthesized the diketones **9a-d**. Their reaction with malononitrile in methanol and sodium methylate yielded the corresponding phenylene-bis-[(thienyl/furyl)nicotinonitrile] derivatives **10a-d**.

Structures of all compounds are established by elementary analysis, I.R.- and ^{1}H-NMR-spectra. The ^{1}H-NMR spectra of **7** and **8** are not very characteristic. They contain a separated signal of the methoxy group around 4 ppm, a bulck of aromatic proton signals between 7 and 8 ppm, and in the furan serie the characteristic signal of the proton at C-4 at about 6.5 ppm. The ^{13}C-NMR-spectra of **7d** and **8d** clearly support the structure.

7 and **8** are examples of *meta*-connected ring assemblies from 3 different building blocks. Their UV-spectra (Table 2) show 3 maxima, one around 350 nm, one between 260 and 300 nm, and a third one about 224 nm. The dimethylamino substituted **7e/8e** have one more maximum at 380 nm, the dimethoxy compounds **7d/8d** one more at 286/280 nm, and the styryl substituted compounds **7h/8h** show additional maxima at 340/325 nm. 1,3-Diphenylbenzene shows maxima at ca. 400 and 250 nm depending on the solvent[14]. In accordance with other phenylene derivatives[14], the u.v.-spectra of the heterocyclic pentaarylenes **10** do not show any significant bathochromic shift when compared to the spectra of the triarylenic compounds **7** or **8**. Probably, this is caused by the *meta*-substitution interrupting the conjugation of the system.

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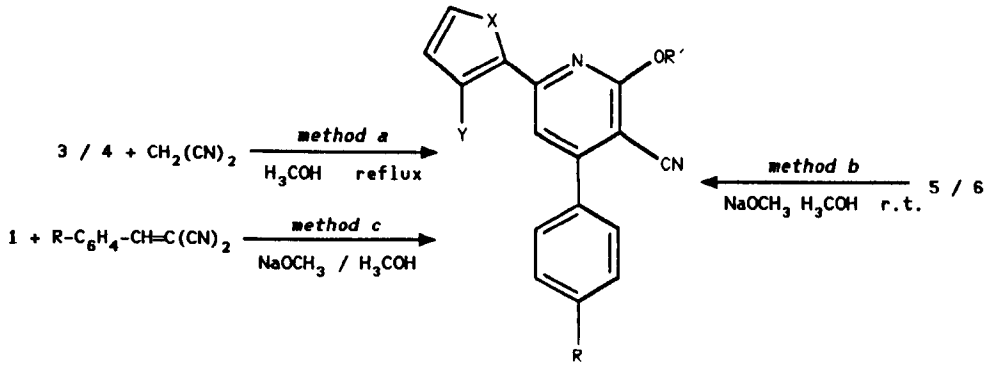
Experimental Part

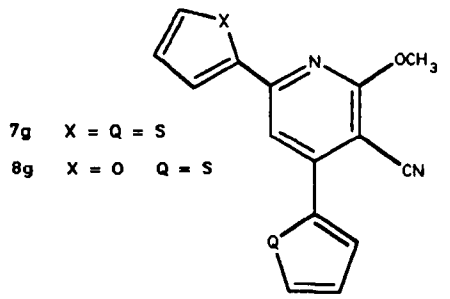
M.p. (uncorrected): Linström apparatus.- IR (KBr, cm^{-1}): Perkin-Elmer IR 1310, Beckman IR 4240.- ^{1}H-NMR: Varian T 60, Bruker WP 80, or Bruker WP 250; δ (ppm), δ_{TMS} = 0.00; temp. 37°C; δ values if not otherwise noted from 80 MHz spectra, solvent $CDCl_3$.- ^{13}C-NMR: Bruker WH 90 (22.63 MHz); δ (ppm), δ_{TMS} = 0.00, solvent $CDCl_3$.- MS: Finnigan GC MS 4000.- Elementary analyses: Pharmazeutisches Institut or Chemisches Laboratorium der Universität Freiburg.- Solvents were dried according to lit. procedures.- Abbreviations: THF = tetrahydrofuran; DMSO = dimethyl



7 / 8

7 X = S
- a Y = R = H R' = CH_3
- b Y = H R = 4-Cl R' = CH_3
- c Y = H R = 4-CH_3O R' = CH_3
- d Y = H R = 3,4-diCH_3O R' = CH_3
- e Y = H R = 4-$(H_3C)_2N$ R' = CH_3
- f Y = H R = 4-NO_2 R' = CH_3
- h Y = H R = C_6H_5-CH=CH R' = CH_3
- x Y = H R = 3,4-diCH_3O R' = C_2H_5
- y Y = Br R = 4-Cl R' = CH_3
- z Y = Cl R = 4-Cl R' = CH_3

8 X = O
- a Y = R = H R' = CH_3
- b Y = H R = 4-Cl R' = CH_3
- c Y = H R = 4-CH_3O R' = CH_3
- d Y = H R = 3,4-diCH_3O R' = CH_3
- e Y = H R = 4-$(H_3C)_2N$ R' = CH_3
- f Y = H R = 4-NO_2 R' = CH_3
- h Y = H R = C_6H_5-CH=CH R' = CH_3



7g X = Q = S
8g X = O Q = S

Scheme 3c

sulfoxide; BuLi = n-butyl lithium, 15% in hexane; LDA = lithium diisopropylamide, freshly prepared by mixing equimolar amounts of BuLi and diisopropylamine; MDN = malononitrile.

2-Acetylthiophene (**1a**), Janssen Nr. 10.272.87

2-Acetylfuran (**1b**), Janssen Nr. 10.255.70

2-Acetyl-3-bromothiophene (**1c**)[15]

100 g (0.75 mol) of $AlCl_3$ are given to 400 ml of dichloromethane, the mixture is cooled to 0°C, and 51 ml (713 mmol) of acetyl chloride are added. 70 ml (712 mmol) of 3-bromothiophene are added dropwise, the temp. may not exceed 20°C. After stirring for 3 h, the mixture is hydrolized with 400 ml cold dil. HCl, the aqueous layer is separated and twice extracted with 50 ml of dichloromethane. The dichloromethane layers are washed three times with 300 ml water, once with 300 ml 2% NaOH, once more with water, dried with K_2CO_3, and concentrated *in vacuo*. The residue is distilled, yield 135 g (88%), light green liquid, b.p. 104°C/4 Torr.- IR (film): 1650 (CO).- ^{1}H-NMR: δ = 2.55 (s, 3H, CH_3), 7.20 (d, J = 6 Hz, 1H), 7.55 (d, J = 6 Hz, 1H).- ^{13}C-NMR: δ = 28.82 (CH_3), 114.12 (C-3), 132.35 and 133.40 (C-4, C-5), 138.39 (C-2), 189.10 (CO).- C_6H_5BrOS (205.1) Calcd. C 35.1 H 2.46 Br 39.0 S 15.6 Found C 35.0 H 2.40 Br. 38.8 S 15.5.

2-Acetyl-3-chlorothiophene (**1d**)[16]

From 51 ml (713 mmol) of acetyl chloride and 66 ml (712 mmol) of 3-chlorothiophene as described for **1c**, yield 103 g (90%), yellow orange liquid, b.p. 95°C/2 Torr.- IR (film): 1660 (CO).- ^{1}H-NMR: δ = 2.65 (s, 3H, CH_3), 7.05 (d, J = 5 Hz, 1H), 7.55 (d, J = 5 Hz, 1H).- C_6H_5ClOS (160.6).

Preparation of unsaturated ketones **3** *und* **4**, *General procedure*

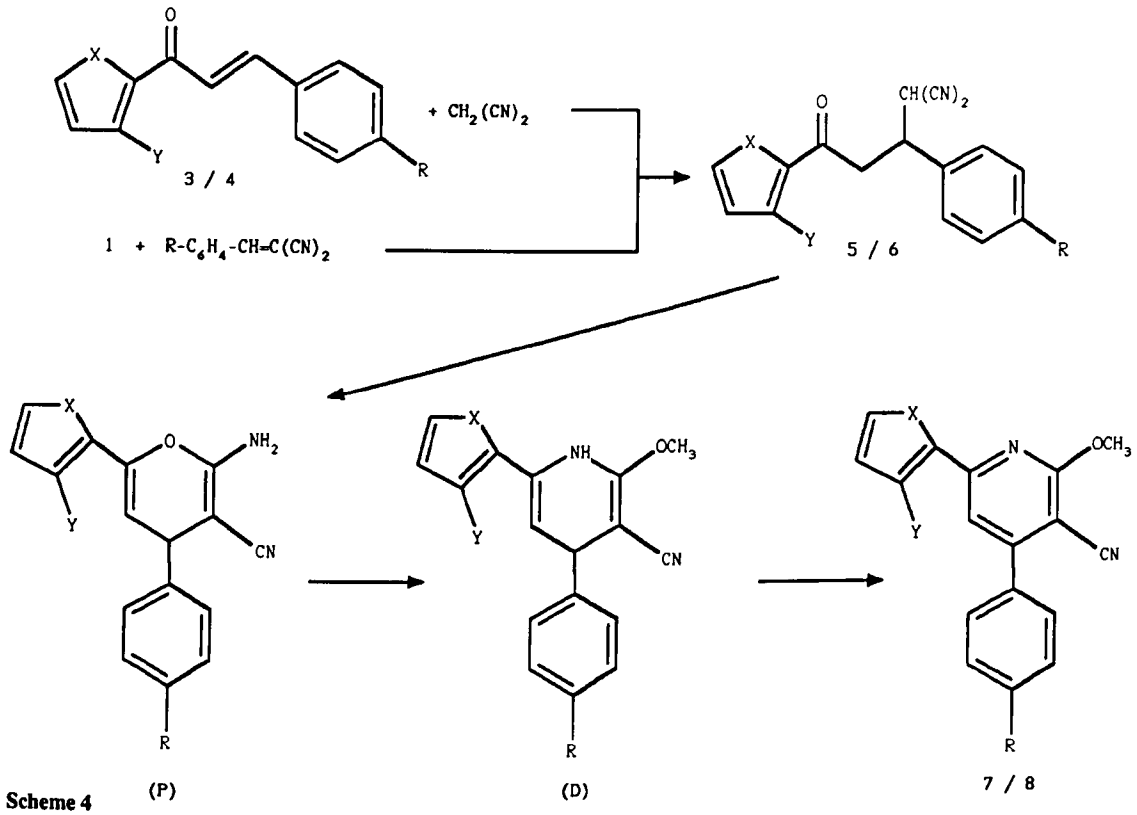
10 mmol of 2-acetylthiophene or -furan and the equimolar amount of the appropriate aldehyde are stirred in 20 ml methanol until the solids are dissolved, some pellets of solid NaOH, or 5 ml of a 20% NaOH are added, and the mixture is stirred for 10-120 min. The precipitate is collected and recrystallized.

3-Phenyl-1-(2-thienyl)-2-propen-1-one (**3a**)[5e]

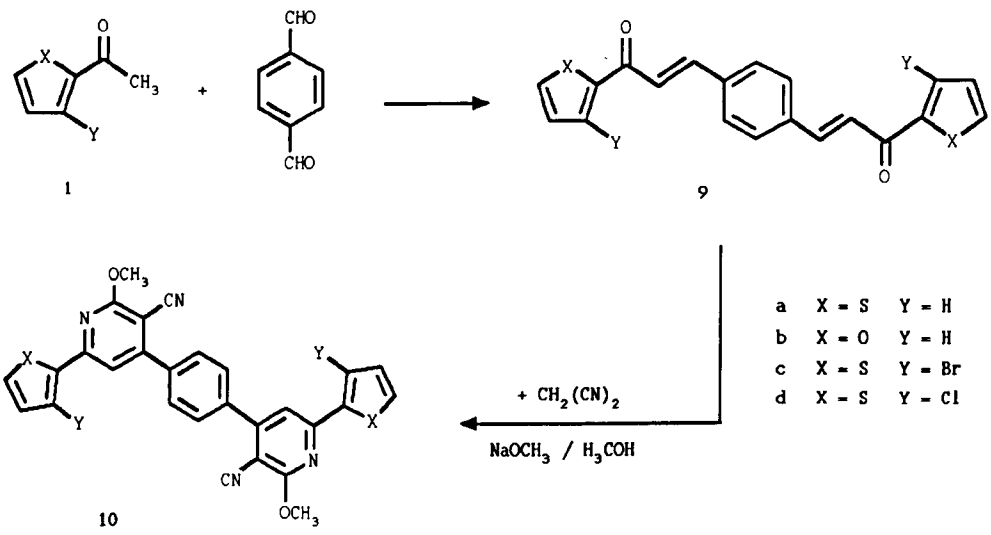
Yield 80%, colorless crystals, m.p. 83°C (methanol).

3-(4-Chlorophenyl-1-(2-thienyl)-2-propen-1-one (**3b**)[5a]

Yield 85%, colorless crystals, m.p. 133°C (methanol).



Scheme 4



Scheme 5

3-(4-Methoxyphenyl)-1-(2-thienyl)-2-propen-1-one (3c)[5h]

Yield 83%, light yellow crystals, m.p. 85°C (methanol).

3-(3,4-Dimethoxyphenyl)-1-(2-thienyl)-2-propen-1-one (3d)[5b]

Yield 80%, yellow crystals, m.p. 90°C (methanol), lit. 106°C.

3-(4-Dimethylaminophenyl)-1-(2-thienyl)-2-propen-1-one (3e)[5a]

Yield 65%, red crystals, m.p. 114°C (methanol).

3-(4-Nitrophenyl-1-(2-thienyl)-2-propen-1-one (3f)[5b]

Yield 86%, colorless crystals, m.p. 203°C (methanol), lit. 220°C.

1,3-Bis(2-thienyl)-2-propen-1-one (3g)[5e]

Yield 70%, yellow crystals, m.p. 95°C (methanol).

5-Phenyl-1-(2-thienyl)-2,4-pentadien-1-one (3h)[5b]

Yield 70%, yellow crystals, m.p. 94°C (methanol), lit. 100°C.

3-(2-Bromphenyl)-1-(2-thienyl)-2-propen-1-one (3l)

From 1.25 g (10 mmol) of 2-acetylthiophene and 1.85 g (10 mmol) of 2-bromobenzaldehyde, 2.4 g (82%), oily liquid.- IR (film): 1650 (C=O); 1595 (arom.); 970 (*trans* C=C); 750 (1,2-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 6.95-8.35 (m, 9H).- $C_{13}H_9BrOS$ (293.2).

1-[2-(3-Bromothienyl)]-3-(4-chlorophenyl)-2-propen-1-one(3y)

From 2.05 g (10 mmol) of 2-acetyl-3-bromothiophene (1c) and 1.41 g 4-chlorobenzaldehyde, 2.7 g (82%), colorless crystals, m.p. 97°C (methanol).- IR: 1640 (C=O); 1585 (arom.); 980 (*trans* C=C); 820 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 7.25-8.00 (m, 8H, arom. H).- $C_{13}H_8BrClOS$ (327.6) Calcd. C 47.7 H 2.46 Br 24.4 Cl 10.8 S 9.8 Found C 47.9 H 2.56 Br 24.7 Cl 10.9 S 9.9.

3-(4-Chlorophenyl)-1-[2-(3-chlorothienyl)]-2-propen-1-one(3z)

From 1.61 g (10 mmol) of 2-acetyl-3-chlorothiophene (1d) and 1.41 g 4-chlorobenzaldehyde, 2.4 g (85%), light yellow crystals, m.p. 131°C (methanol).- IR: 1635 (C=O); 1580 (arom.); 985 (*trans* C=C); 820 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 6.95-7.80 (m, 8H, arom. H).- $C_{13}H_8Cl_2OS$ (283.2) Calcd. C 55.1 H 2.85 Cl 25.0 S 11.3 Found C 55.0 H 2.94 Cl 25.0 S 11.5.

1-(2-Furyl)-3-phenyl-2-propen-1-one(4a)[5f]

Yield 88%, colorless crystals, m.p. 89°C (methanol).

3-(4-Chlorophenyl)-1-(2-furyl)-2-propen-1-one(4b)[5h]

Yield 73%, colorless crystals, m.p. 127°C (methanol).

1-(2-Furyl)-3-(4-methoxyphenyl)-2-propen-1-one(4c)[5i]

Yield 63%, light yellow crystals, m.p. 80°C (methanol).

3-(3,4-Dimethoxyphenyl)-1-(2-furyl)-2-propen-1-one(4d)[5i]

Yield 60%, yellow crystals, m.p. 100°C (methanol).- IR: 1645 (C=O); 1590 (arom.); 1260; 1040 (ar-O-C); 970 (*trans* C=C); 810 (1,3,4-trisubst. arom.).- ^{1}H-NMR (60 MHz): δ = 4.00 (s, 6H, OCH_3), 6.70 (m, 1H, furyl H-4), 6.90-8.15 (m, 7H, arom. H).

3-(4-Dimethylaminophenyl)-1-(2-furyl)-2-propen-1-one(4e)[5h]

Yield 55%, red crystals, m.p. 79°C (methanol), lit. 94°C.

1-(2-Furyl)-3-(4-nitrophenyl)-2-propen-1-one(4f)[5k]

Yield 85%, light yellow crystals, m.p. 218°C (methanol).- IR: 1650 (C=O); 1610 (arom.); 1360; 1055 (NO_2); 975 (*trans* C=C); 770 (1,4-disubst. arom.).

1-(2-Furyl)-3-(2-thienyl)-2-propen-1-one(4g)[5e]

Yield 76%, yellow crystals, m.p. 62°C (methanol), lit. 81°C (petroleum ether/benzene).

1-(2-Furyl)-5-phenyl-2,4-pentadien-1-one(4h)[5b]

Yield 49%, yellow crystals, m.p. 99°C (ethanol).- IR: 1640 (C=O); 1580 (arom.); 1005 (*trans* C=C); 760 (arom.).- ^{1}H-NMR (60 MHz): δ = 6.55 (m, 1H, furyl H-4), 6.80-7.90 (m, 11H, arom. H).

3-(2-Bromophenyl)-1-(2-furyl)-2-propen-1-one(4i)

From 1.10 g (10 mmol) of 1b and 1.85 g (10 mmol) of 2-bromobenzaldehyde, yield 2.3 g (88%), light oily liquid.- IR (film): 1650 (C=O); 1600 (arom.); 965 (*trans* C=C); 735 (1,2-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 6.70 (m, 1H, furyl, H-4), 7.25-8.60 (m, 8H, arom. H).- $C_{13}H_9BrO_2$ (277.3).

2-Cyano-5-oxo-3-phenyl-5-(2-thienyl)valeronitrile(5a)[17]

2.5 g of 2-acetylthiophene are added to a stirred solution of 2.20 g (20 mmol) of diisopropylamine and 13.8 ml of n-BuLi at -78°C under N_2 in dry THF, and after 10 min, a solution of 3.0 g 2-cyano-3-phenylacrylonitrile in THF is added dropwise. After 30 min, the mixture is extracted with a weakly acidic solution of NaCl, three times washed with cold water, and the org. layer is dried ($MgSO_4$). The solvent is evaporated *in vacuo*, and a dichloromethane/CCl_4 mixture is added to the remaining residue, whereupon the product crystalizes; yield 2.35 g (42%), colorless crystals, m.p. 122°C, lit. 144°C.- IR: 2260, 2220 (CN); 1660 (C=O); 775, 725 (phenyl).- ^{1}H-NMR: δ = 3.55 (d, J = 6 Hz, 2H, CH_2), 3.85 (m, 1H, H-3), 4.55 (d, J = 5 Hz, 1H, H-2), 7.05-7.80 (m, 8H, arom. H).- $C_{16}H_{12}N_2OS$ (280.4) Calcd. C 68.5 H 4.32 N 10.0 S 11.4 Found C 68.4 H 4.34 N 9.9 S 11.5.

2-Cyano-5-oxo-3,5-bis(2-thienyl)valeronitrile(5b)

0.25 g (11 mmol) of NaH are added to 0.7 g (11 mmol) of MDN in 10 ml DMSO at room temp. with stirring; when the formation of H_2 is finished, 2.2 g of 3g dissolved in a few ml of DMSO are added dropwise. Stirring is continued for 2 h, the mixture is carefully neutralized with dil. HCl, extracted with chloroform, washed with water, and dried with Na_2SO_4. The solvent is evaporated *i. vac.*, a few ml of a chloroform/CCl_4 mixture (1:1) is added, and after 24 h at -10°C, the crystals are separated; yield 1.5 g (56%), colorless crystals, m.p. 111°C.- IR: 2250 (CN); 1660 (C=O).- ^{1}H-NMR: δ = 3.60 (d, J = 6 Hz, 2H, CH_2), 4.25 (m, 1H, H-3), 4.65 (d, J = 5 Hz, 1H, H-2), 6.95-7.80 (m, 6H, arom. H).- $C_{14}H_{10}N_2OS_2$ (286.4) Calcd. C 58.7 H 3.52 N 9.8 S 22.4 Found C 58.9 H 3.37 N 9.7 S 22.5.

Methyl 2-cyano-5-oxo-3-phenyl-5-(2-thienyl)valerianoate (5c)

From 1.0 g (11 mmol) of methyl cyanoacetate, 0.25 g of sodium in 10 ml methanol, and 2.14 g (10 mmol) of 3a at room temp.; yield 0.85 g (32%), colorless crystals, m.p. 104°C (methanol).- IR: 2240 (CN); 1735 ($COOCH_3$); 1655 (C=O); 740; 700 (phenyl).- ^{1}H-NMR: δ = 3.45 (d, J = 6 Hz, 2H, H-4), 3.60 (s, 3H, OCH_3), 4.05 (m, 1H, H-3), 4.30 (d, J = 5 Hz, 1H, H-2), 7.05-7.80 (m, 8H, arom. H).- $C_{17}H_{15}NO_3S$ (313.4) Calcd. C 65.2 H 4.82 N 4.5 S 10.2 Found C 65.1 H 4.89 N 4.4 S 10.3.

2-Cyano-3-(3,4-dimethoxyphenyl)-5-oxo-5-(2-thienyl)valeronitrile(5d)

From 2.6 g (20 mmol) of 2-acetylthiophene and 4.3 g of 2-cyano-3-(3,4-dimethoxyphenyl)acrylonitrile with n-BuLi in THF, 30 min -78°C; yield 4.1 g (60%), oily solid.- IR: 2230 (CN); 1625 (C=O); 810 (1,3,4-trisubst. arom.).- ^{1}H-NMR: δ = 3.3 (m, 3H, H-3, H-4, H-4'), 3.90 (s, 6H, OCH_3), 4.15 (d, J = 5 Hz, 1H, H-2), 6.7-7.8 (m, 6H, arom. H).- $C_{18}H_{16}N_2O_3S$ (340.4).

2-Cyano-5-(2-furyl)-5-oxo-3-phenylvaleronitrile(6a)

To 0.25 g (11 mmol) of sodium in pieces in 50 ml of dry ether 0.66 g (10 mmol) of MDN are added, and the mixture is stirred at room temp. until the sodium is dissolved; than, 2.00 g (10 mmol) of 4a, dissolved in the appropriate amount of ether, are added dropwise. After 8 h the mixture is hydrolyzed with dilut HCl, washed three times with cold water, and the org. layer is dried ($CaCl_2$). The solvent is removed *i. vac.*, and the oily residue is chromatographed by CC with ether/hexane 3:1; yield 0.85 g (32%), m.p. 110°C (ether/hexane).- IR: 2250 (CN); 1660 (C=O); 1565 (arom.); 780; 720 (phenyl).- ^{1}H-NMR: δ = 3.50 (d, J = 6 Hz, 2H, CH_2), 3.90 (m, 1H, H-3), 4.55 (d, J = 5 Hz, 1H, H-2), 6.55 (m, 1H, furyl H-4), 7.20-7.65 (m, 7H, arom. H).- $C_{16}H_{12}N_2O_2$ (264.3) Calcd. C 72.7 H 4.58 N 10.6 Found C 72.6 H 4.78 N 10.4.

2-Cyano-5-(2-furyl)-3-(4-nitrophenyl)-5-oxovaleronitrile(6b)

0.70 g (11 mmol) of MDN, dissolved in 10 ml DMSO, 0.40 g of NaH, and 2.40 g (10 mmol) of 4f are stirred at room temp. for 10 min; yield 2.8 g (90%), colorless crystals, m.p. 117°C (chloroform/CCl_4 3:1).- IR: 2250; 2220 (CN); 1660 (C=O); 1600 (arom.); 1340; 1030 (NO_2); 850 (1,4-di-

subst. arom.).- ^{1}H-NMR: δ = 3.65 (d, J = 7 Hz, 2H, CH_2), 4.20 (m, 1H, H-3), 4.75 (d, J = 5 Hz, 1H, H-2), 6.65 (m, 1H, furyl H-4), 7.30-8.50 (m, 6H, arom. H).- $C_{16}H_{11}N_3O_4$ (309.3) Calcd. C 62.1 H 3.59 N 13.6 Found C 62.3 H 3.64 N 13.5.

Methyl 3-(4-chlorophenyl)-2-cyano-5-(2-furyl)-5-oxovalerianoate (**6c**)

From 1.0 g (11 mmol) of methyl cyanoacetate, 0.12 g of sodium in methanol, and 2.33 g (10 mmol) of **4b**, 1 h reflux; yield 1.25 g (38%), colorless crystals, m.p. 81°C (ethanol).- IR: 2250 (CN); 1740 ($COOCH_3$); 1670 (C=O); 1565 (arom.); 830 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 3.40 (d, J = 6 Hz, 2H, CH_2), 3.60 (s, 3H, OCH_3), 3.95 (m, 1H, H-3), 4.25 (d, J = 5 Hz, 1H, H-2), 6.50 (m, 1H, furyl H-4), 7.15-7.60 (m, 7H, arom. H).- $C_{17}H_{14}ClNO_4$ (331.8) Calcd. C 61.5 H 4.25 Cl 10.7 N 4.2 Found C 61.6 H 4.34 Cl 10.8 N 4.1.

3-(4-Chlorophenyl)-2-cyano-5-(2-furyl)-5-oxovaleronitrile(**6d**)

From 1.20 g (10 mmol) of **1b** and 1.50 g (10 mmol) of 3-(4-chlorophenyl)-2-cyanoacrylonitrile in THF with LDA at -78°C under N_2; yield 2.6 g (83%), red-brown oily liquid.- IR (film): 3110 (CH); 2200 (CN); 1630 (C=O); 800 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 3.30 (dd, J = 6 and 16 Hz, 2H, CH_2), 3.85 (m, 1H, H-3), 4.55 (d, J = 5 Hz, 1H, H-2), 6.45 (m, 1H, furyl H-4), 6.8-7.8 (m, 6H, arom. H).- $C_{16}H_{11}ClN_2OS$ (315.8).

2-Cyano-5-(2-furyl)-5-oxo-3-(2-thienyl)valeronitrile(**6e**)

From 0.70 g (11 mmol) of MDN and 2.04 g (10 mmol) of **4g** in DMSO with NaH; yield 1.9 g (70%), dark reddish liquid.- IR (film): 2250; 2205 (CN); 1670 (C=O).- ^{1}H-NMR (60 MHz): δ = 3.55 (m, 2H, CH_2), 4.30 (m, 1H, H-3), 4.70 (d, J = 5 Hz, 1H, H-2), 6.55 (m, 1H, furyl H-4), 6.80-7.95 (m, 5H, arom. H).- $C_{14}H_{11}N_2O_2S$ (270.4).

3-(2-Bromophenyl)-2-cyano-5-(2-furyl)-5-oxovaleronitrile(**6f**)

From 0.70 g (11 mmol) of MDN and 2.77 g (10 mmol) of **4i** in 20 ml of methanol with 5 ml of 20% NaOH at room temp., 15 min; yield 1.90 g (55%), colorless crystals, m.p. 120°C (ethanol).- IR: 2260 (CN); 1660 (C=O); 1570 (arom.); 770 (1,2-disubst. arom.).- ^{1}H-NMR: δ = 3.55 (m, 2H, CH_2), 4.60 (m, 2H, H-2, H-3), 6.70 (m, 1H, furyl H-4), 7.25-7.95 (m, 6H, arom. H).- ^{13}C-NMR: δ = 27.50 (C-2), 39.18 (C-3), 39.57 (C-4), 111.36 and 112.93 (CN), 118.32 (furyl C-5), 125.03 (furyl C-4), 125.02 (phen. C-2), 128.11, 128.51, 130.51, 134.00 and 135.56 (phen. C), 147.30 (furyl C-5), 152.00 (furyl C-2), 184.80 (C=O).- $C_{16}H_{11}BrN_2O_2$ (343.2) Calcd. C 56.0 H 3.23 Br 23.3 N 8.2 Found C 56.1 H 3.26 Br 23.2 N 8.3.

Nicotinonitriles **7** *and* **8**, *General Procedures*

a. 0.25 g (11 mmol) of sodium are dissolved in the appropriate alcohol (20 ml), and 0.7 g (11 mmol) of MDN are added. A solution of the α,β-unsaturated ketone (10 mmol) in alcohol is added, and the mixture is stirred (if noted with refluxing) until a precipitate is formed. After cooling to room temp., the precipitate is separated, and washed with cold alcohol.

b. 0.25 g (11 mmol) of sodium are dissolved in the appropriate alcohol (20 mmol); the solution is given to a stirred solution of 10 mmol 2-aryl-1-cyano-4-heteroaryl-4-oxovaleronitrile (**5/6**) in the same alcohol, and stirred at room temp. Work-up, as described for method **a**.

c. 0.25 g (11 mmol) of sodium are dissolved in the appropriate alcohol (20 ml), and 10 mmol of **1** are added. The mixture is stirred for 15 min., and than given to a stirred solution of the arylidenemalononitrile (10 mmol) in alcohol. Work-up as **a**. If not otherwise noted, method **a** was used.

2-Methoxy-4-phenyl-6-(2-thienyl)nicotinonitrile(**7a**)

Method **a**: From 4.28 g (20 mmol) of **3a** and 1.30 g (20 mmol) of MDN, 2 h reflux; yield 2.80 g (48%); *method* **b**: From 2.8 g (10 mmol) of **5a**, 2 h reflux; yield 1.3 g (43%); *method* **c**: From 2.5 g (20 mmol) of **1a** and 3.1 g (20 mmol) of benzylidenmalononitrile, 2 h reflux; yield 2.6 g (45%); light yellow crystals, m.p. 151°C (methanol).- IR: 2210 (CN); 1580 (arom.); 1240 (ar-O-C); 755; 690 (phenyl).- ^{1}H-NMR: δ = 4.10 (s, 3H, OCH_3), 7.00-7.75 (m, 9H, arom. H).- $C_{17}H_{12}N_2OS$ (292.4) Calcd. C 69.8 H 4.14 N 9.6 S 11.0 Found C 69.7 H 4.20 N 9.7 S 10.9.

4-(4-Chlorophenyl)-2-methoxy-6-(2-thienyl)nicotinonitrile(**7b**)

From 4.98 g (20 mmol) of **3b** and 1.30 g (20 mmol) of MDN, 30 min reflux; yield 2.80 g (48%), light yellow crystals, m.p. 253°C (methanol).- IR: 2210 (CN); 1580 (arom.); 1240 (ar-O-C); 825 (1,4-disubst. arom.).- $C_{17}H_{11}ClN_2OS$ (326.8) Calcd. C 62.5 H 3.39 Cl 10.9 N 8.6 S 9.8 Found C 62.6 H 3.48 Cl 11.0 N 8.4 S 9.7.

2-Methoxy-4-(4-methoxyphenyl)-6-(2-thienyl)nicotinonitrile(**7c**)

From 4.82 g (20 mmol) of **3c** and 1.30 g (20 mmol) of MDN, 1 h reflux; yield 3.0 g (49%), colorless crystals, m.p. 138°C (methanol).- IR: 2210 (CN); 1580 (arom.); 1250 (ar-O-C); 830 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 3.75 (s, 3H, phenyl-OCH_3), 4.05 (s, 3H, pyr-OCH_3), 6.90-7.75 (m, 8H, arom. H).- $C_{18}H_{14}N_2O_2S$ (322.4) Calcd. C 67.1 H 4.37 N 8.7 S 10.0 Found C 66.8 H 4.41 N 8.6 S 9.9.

4-(3,4-Dimethoxyphenyl)-2-methoxy-6-(2-thienyl)nicotinonitrile(**7d**)

Method **a**: From 5.50 g (20 mmol) of **3d** and 1.5 g (23 mmol) of MDN, 2 h reflux; yield 3.52 g (50%); *method* **b**: From 1.7 g (5 mmol) of **5d**, 2 h reflux; yield 0.85 g (48%); *method* **c**: From 2.5 g (20 mmol) of **1a** and 3.3 g (20 mmol) of 3,4-dimethoxybenzylidenemalononitrile, 2 h reflux; yield 3.2 g (45%); colorless crystals, m.p. 135°C (glacial acetic acid).- IR: 2200 (CN); 1580 (arom.); 1250 (ar-O-C); 840 (1,3,4-trisubst. arom.).- ^{1}H-NMR: δ = 3.95 (s, 6H, phen-OCH_3), 4.15 (s, 3H, pyr-OCH_3), 6.90-7.75 (m, 7H, arom. H).- ^{13}C-NMR: δ = 54.71 (pyr-OCH_3), 56.13 (phen-OCH_3), 111.62 (phen C-2, C-5, C-6), 115.98 (CN), 121.46 (pyr C-5), 127.03 (thien C-5), 128.51 (thien C-3), 129.88 (thien C-4), 143.46 (pyr C-4), 149.30 and 150.86 (phen C-3, C-4), 153.04 (thien C-2), 156.26 (pyr C-2), 165.22 (pyr C-6).- $C_{19}H_{16}N_2O_3S$ (352.4) Calcd. C 64.7 H 4.58 N 8.0 S 9.1 Found C 64.9 H 4.54 N 7.9 S 9.2.

2-Methoxy-4-[(4-dimethylamino)phenyl]-6-(2-thienyl)nicotinonitrile (**7e**)

From 2.57 g (10 mmol) of **3e** and 0.7 g (11 mmol) of MDN, 2 h reflux; yield 1.51 g (45%), light yellow crystals, m.p. 186°C (methanol).- IR: 2210 (CN); 1580 (arom.); 1240 (ar-O-C); 840 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 3.05 [s, 6H, $N(CH_3)_2$], 4.20 (s, 3H, OCH_3), 6.75 (m, 8H, arom. H).- $C_{19}H_{17}N_3OS$ (335.4) Calcd. C 68.0 H 5.11 N 12.5 S 9.6 Found C 68.0 H 5.09 N 12.4 S 9.7.

2-Methoxy-4-(4-nitrophenyl)-6-(2-thienyl)nicotinonitrile(**7f**)

From 5.20 g (20 mmol) of **3f** and 1.35 g (21 mmol) of MDN, 2 h room temp.; yield 2.6 g (40%), light yellow crystals, m.p. 210°C (methanol).- IR: 2205 (CN); 1595 (arom.); 1540; 1350 (NO_2); 850 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 4.20 (s, 3H, OCH_3), 7.10 (m, 8H, arom. H).- $C_{17}H_{11}N_3O_3S$ (337.4) Calcd. C 60.5 H 3.29 N 12.5 S 9.5 Found C 60.8 H 3.39 N 12.3 S 9.7.

4,6-Bis(2-thienyl)-2-methoxynicotinonitrile(**7g**)

From 2.20 g (10 mmol) of **3g** and 0.7 g (11 mmol) of MDN, 2 h room temp.; yield 1.12 g (37%), colorless crystals, m.p. 105°C (methanol).- IR: 2200 (CN); 1580 (arom.); 1250 (ar-O-C).- ^{1}H-NMR: δ = 4.05 (s, 3H, OCH_3), 7.00-7.95 (m, 7H, arom. H).- $C_{15}H_{10}N_2OS_2$ (298.4) Calcd. C 60.4 H 3.38 N 9.4 S 21.5 Found C 60.1 H 3.30 N 9.3 S 21.6.

2-Methoxy-4-styryl-6-(2-thienyl)nicotinonitrile (**7h**)

From 2.70 g (10 mmol) of **3h** and 0.75 g (11.5 mmol) of MDN, 2 h reflux; the solvent is evaporated i.vac., glacial acetic acid is added to the residue, and after 24 h the crystals are separated, yield 1.05 g (33%), light yellow crystals, m.p. 163°C (glacial acetic acid).- IR: 2210 (CN); 1580 (arom.); 1240 (ar-O-C); 750; 690 (arom.).- ^{1}H-NMR: δ = 4.20 (s, 3H, OCH_3), 7.10-8.10 (m, 11H, arom. H).- $C_{19}H_{14}N_2OS$ (318.4) Calcd. C 71.7 H 4.43 N 8.8 S 10.1 Found C 71.4 H 4.35 N 9.0 S 10.0.

2-Ethoxy-4-(3,4-dimethoxyphenyl)-6-(2-thienyl)nicotinonitrile (**7x**)

From 5.40 g (20 mmol) of **3d** and 1.5 g (23 mmol) of MDN; 1 h reflux in ethanol, yield 3.00 g (41%), colorless crystals, m.p. 127°C (ethanol).- IR: 2220 (CN); 1580 (arom.); 1265 (ar-O-C); 840 (1,3,4-trisubst. arom.).- ^{1}H-NMR: δ = 1.50 (t, J = 7 Hz, 3H, CH_3), 3.95 (s, 6H, OCH_3), 4.60 (q, J = 7 Hz, 2H, CH_2), 6.90-7.75 (m, 7H, arom. H).- $C_{20}H_{18}N_2O_3S$ (366.4) Calcd. C 65.6 H 4.95 N 7.7 S 8.8 Found C 65.6 H 4.95 N 7.7 S 8.7.

6-(3-Bromo-2-thienyl)-4-(4-chlorophenyl)-2-methoxynicotinonitrile (**7y**)

From 6.56 g (20 mmol) of **3y** and 0.70 g (22 mmol) of MDN, 1 h reflux, yield 1.5 g (37%), colorless crystals, m.p. 193°C (methanol).- IR: 2210 (CN); 1580 (arom.); 850 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 4.15 (s, 3H, OCH_3), 6.75-8.10 (m, 7H, arom. H).- $C_{17}H_{10}BrClN_2OS$ (405.7) Calcd. C 50.3 H 2.48 Br 19.7 Cl 8.7 N 6.9 S 7.9 Found C 50.1 H 2.51 Br 20.0 Cl 8.8 N 6.8 S 7.9.

4-(4-Chlorophenyl)-6-(3-chloro-2-thienyl)-2-methoxynicotinonitrile (**7z**)

From 5.66 g (20 mmol) of **3z** and 1.30 g (22 mmol) of MDN; 1 h room temp., yield 1.70 g (47%), colorless crystals, m.p. 203°C (glacial acetic acid).- IR: 3100; 3005; 2980; 2940; 2860 (CH); 2220 (CN); 1580 (arom.); 850 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 4.15 (s, 3H, OCH_3), 6.9-8.0 (m, 7H, arom. H).- $C_{17}H_{10}Cl_2N_2OS$ (361.3) Calcd. C 56.5 H 2.79 Cl 19.6 N 7.8 S 8.9 Found C 56.4 H 2.86 Cl 19.8 N 7.7 S 8.8.

6-(2-Furyl)-2-methoxy-4-phenylnicotinonitrile (**8a**)

Method **a**: 3.96 g (20 mmol) of **4a** and 1.30 g (20 mmol) of MDN, 2 h reflux; yield 1.99 g (36%); *method* **b**: From 2.6 g (10 mmol) of **6a**, 1 h reflux; yield 1.2 g (42%); light yellow crystals, m.p. 132°C (methanol).- IR: 2210 (CN); 1600 (arom.); 1265 (ar-O-C); 760; 700 (phenyl).- ^{1}H-NMR: δ = 4.20 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 7.15-7.75 (m, 8H, arom. H).- $C_{17}H_{12}N_2O_2$ (276.3) Calcd. C 73.9 H 4.38 N 10.1 Found C 73.8 H 4.43 N 10.2.

4-(4-Chlorophenyl)-6-(2-furyl)-2-methoxynicotinonitrile (**8b**)

Method **a**: 4.60 g (20 mmol) of **4b** and 1.50 g (23 mmol) of MDN, 2 h room temp.; yield 1.30 g (21%); *method* **c**: From 1.1 g (10 mmol) of **1b** and 1.9 g of 4-chlorobenzylidenemalononitrile, 1 h room temp.; yield 1.5 g (48%); colorless crystals, m.p. 216°C (glacial acetic acid).- IR: 2210 (CN); 1590 (arom.); 1090 (C-O-C); 840 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 4.15 (s, 3H, OCH_3), 6.55 (m, 1H, furyl H-4), 7.20-7.65 (m, 7H, arom. H).- $C_{17}H_{11}ClN_2O_2$ (310.7) Calcd. C 65.7 H 3.57 Cl 11.4 N 9.0 Found C 65.4 H 3.63 Cl 11.2 N 9.2.

6-(2-Furyl)-2-methoxy-4-(4-methoxyphenyl)nicotinonitrile (**8c**)

From 4.50 g (20 mmol) of **4c** and 1.30 g (20 mmol) of MDN, 1 h reflux; yield 2.52 g (50%), colorless crystals, m.p. 162°C (methanol).- IR: 2210 (CN); 1580 (arom.); 1250 (ar-O-C); 830 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 3.95 (s, 3H, phen-OCH_3), 4.15 (s, 3H, pyr-OCH_3), 6.50 (m, 1H, furyl H-4), 6.90-7.75 (m, 7H, arom. H).- $C_{18}H_{14}N_2O_3$ (306.3) Calcd. C 70.6 H 4.60 N 9.1 Found C 70.4 H 4.51 N 9.2.

6-(2-Furyl)-4-(3,4-dimethoxyphenyl)-2-methoxynicotinonitrile (**8d**)

From 3.90 g (15 mmol) of **4d** and 1.0 g (15 mmol) of MDN, 1 h reflux; yield 2.52 g (50%), colorless crystals, m.p. 120°C (methanol).- IR: 2220 (CN); 1600 (arom.); 1260 (ar-O-C); 850 (1,3,4-trisubst. arom.).- ^{1}H-NMR: δ = 3.95 (s, 6H, OCH_3), 4.15 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 6.90-7.75 (m, 6H, arom. H).- ^{13}C-NMR: δ = 54.53 (pyr-OCH_3), 56.04 and 56.19 (phen-OCH_3), 111.19, 111.45, 111.62, 112.06, 112.60 (phen C-2, C-5-, C-6, fur C-3, C-4), 116.06 (pyr C-3), 121.54 (pyr C-5), 128.62 (CN), 144.77 (fur C-5, pyr C-4), 149.22 and 150.78 (phen C-3, C-4), 152.72 (fur C-2), 156.25 (pyr C-2), 165.30 (pyr C-6).- $C_{19}H_{16}N_2O_4$ (336.3) Calcd. C 67.9 H 4.80 N 8.3 Found C 67.6 H 4.68 N 8.4.

6-(2-Furyl)-4-[4-(Dimethylamino)phenyl]-2-methoxynicotinonitrile (**8e**)

From 5.10 g (20 mmol) of **4e** and 1.35 g (21 mmol) of MDN, 1 h reflux; yield 2.75 g (43%), light yellow crystals, m.p. 178°C (methanol).- IR: 2205 (CN); 1595 (arom.); 1265 (ar-O-C); 815 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 3.00 (s, 6H, CH_3), 4.10 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 6.70-7.0 (m, 7H, arom. H).- $C_{19}H_{17}N_3O_2$ (319.4) Calcd. C 71.5 H 5.37 N 13.2 Found C 71.2 H 5.30 N 13.3.

6-(2-Furyl)-2-methoxy-4-(4-nitrophenyl)nicotinonitrile (**8f**)

From 5.20 g (20 mmol) of **4f** and 1.35 g (21 mmol) of MDN, 1 h reflux; yield 2.6 g (40%), light yellow crystals, m.p. 216°C (methanol).- IR: 2205 (CN); 1595 (arom.); 1265 (ar-O-C); 850 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 4.20 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 6.75 (m, 7H, arom. H).- $C_{17}H_{11}N_3O_4$ (321.3) Calcd. C 63.6 H 3.45 N 13.1 Found C 63.3 H 3.49 N 13.0.

6-(2-Furyl)-2-methoxy-4-(2-thienyl)nicotinonitrile (**8g**)

Method **a**: From 2.04 g (10 mmol) of **4g** and 0.7 g (11 mmol) of MDN, 1 h reflux; yield 1.0 g (37%); *method* **b**: From 2.70 g (10 mmol) of **6e**, yield 1.2 g (42%), colorless crystals, m.p. 127°C (methanol).- IR: 2205 (CN); 1595 (arom.).- ^{1}H-NMR: δ = 4.10 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 7.00-7.95 (m, 6H, arom. H).- $C_{15}H_{10}N_2O_2S$ (282.3) Calcd. C 63.8 H 3.57 N 9.9 S 11.4 Found C 63.7 H 3.61 N 10.0 S 11.3.

6-(2-Furyl)-2-methoxy-4-styrylnicotinonitrile (**8h**)

From 2.55 g (10 mmol) of **4h** and 0.75 g (11.5 mmol) of MDN, 2 h reflux; yield 1.05 g (33%), light yellow crystals, m.p. 157°C (methanol).- IR: 2205 (CN); 1585 (arom.); 1260 (ar-O-C); 765; 690 (arom.).- ^{1}H-NMR: δ = 4.05 (s, 3H, OCH_3), 6.50 (m, 1H, furyl H-4), 7.10-7.70 (m, 10H, arom. H).- $C_{19}H_{14}N_2O_2$ (302.3) Calcd. C 75.5 H 4.66 N 9.3 Found C 75.2 H 4.60 N 9.4.

3,3'-(1,4-Phenylene)bis[1-(2-thienyl)-2-propen-1-one] (**9a**)[50]

From 2.5 g (20 mmol) of **1a** and 1.35 g (10 mmol) of 1,4-benzenedicarbaldehyde; yield 2.3 g (65%), m.p. 223°C (methanol).- IR: 1640 (C=O); 1590 (arom.); 970 (C=C); 820 (1,4-disubst. arom.).- ^{1}H-NMR: δ = 7.20-8.30 (m, 14H, arom. H).- $C_{20}H_{14}O_2S_2$ (350.4) Calcd. C 68.5 H 4.03 S 18.3 Found C 68.5 H 4.11 S 18.2.

3,3'-(1,4-Phenylene)bis[1-(2-furyl)-2-propen-1-one] (**9b**)[50]

From 2.2 g (20 mmol) of **1b** and 1.35 g (10 mmol) of 1,4-benzenedicarbaldehyde; yield 1.9 g (60%), colorless crystals, m.p. 229°C (methanol), lit. 229°C.- IR: 1650 (C=O); 1590 (arom.); 1050 (C-O-C); 1005 (*trans* C=C); 820 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): 6.50 (m, 2H, furyl H-4), 6.85-7.65 (m, 12H, arom. H).- $C_{20}H_{14}O_4$ (318.3) Calcd. C 75.5 H 4.43 Found C 75.3 H 4.53.

3,3'-(1,4-Phenylene)bis[1-(3-bromo-2-thienyl)-2-propen-1-one](**9c**)

From 4.1 g (20 mmol) of **1c** and 1.35 g (10 mmol) of 1,4-benzenedicarbaldehyde; yield 4.8 g (95%), yellow crystals, m.p. 165°C (methanol).- IR: 1640 (C=O); 1590 (arom.); 975 (*trans* C=C); 815 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 7.30-8.20 (m, 12H, arom. H).- $C_{20}H_{12}Br_2O_2S_2$ (508.3) Calcd. C 47.3 H 2.38 Br 31.4 S 12.6 Found C 47.2 H 2.40 Br 31.6 S 12.7.

3,3'-(1,4-Phenylene)bis[1-(3-chloro-2-thienyl)-2-propen-1-one](**9d**)

From 3.2 g (20 mmol) of **1d** and 1.35 g (10 mmol) of 1,4-benzenedicarbaldehyde; yield 4.0 g (95%), yellow crystals, m.p. 195°C (glacial acetic acid).- IR: 1640 (C=O); 1585 (arom.); 975 (*trans* C=C); 820 (1,4-disubst. arom.).- ^{1}H-NMR (60 MHz): δ = 7.20-8.15 (m, 12H, arom. H).- $C_{20}H_{12}Cl_2O_2S_2$ (419.3) Calcd. C 57.3 H 2.89 Cl 16.9 S 15.3 Found C 57.1 H 2.82 Cl 17.0 S 15.2.

4,4'-(1,4-Phenylene)bis[6-(2-thienyl)-2-methoxynicotinonitrile](**10a**)

From 3.50 g (10 mmol) of **9a** and 1.4 g (22 mmol) of MDN, 2 h room temp.; yield 2.0 g (40%), colorless crystals, m.p. 240°C dec.- IR: 2210 (CN); 1580 (arom.); 1240 (ar-O-C); 830 (1,4-disubst. arom. H).- ^{1}H-NMR: δ = 4.10 (s, 3H, OCH_3), 4.20 (s, 3H, OCH_3), 6.8-7.8 (m, 12H, arom.).- $C_{28}H_{18}N_4O_2S_2$ (506.6) Calcd. C 66.4 H 3.58 N 11.1 S 12.7 Found C 66.2 H 3.69 N 11.0 S 12.5.

4,4'-(1,4-Phenylene)bis[6-(2-furyl)-2-methoxynicotinonitrile](**10b**)

From 3.18 g (10 mmol) of **9b** and 1.4 g (22 mmol) of MDN, 2 h room temp.; yield 2.4 g (47%), yellow crystals, m.p. 300°C dec. (glacial acetic acid).- IR: 2210 (CN); 1595 (arom.); 830 (1,4-disubst. arom.).- $C_{28}H_{18}N_4O_4$ (474.5) Calcd. C 70.9 H 3.82 N 11.8 Found C 70.8 H 3.92 N 12.0.

4,4'-(1,4-Phenylene)bis[6-(3-bromo-2-thienyl)-2-methoxynicotinonitrile] (**10c**)

From 5.08 g (10 mmol) of **9c** and 1.4 g (22 mmol) of MDN, 2 h room temp.; yield 2.5 g (38%), light brown crystals, m.p. 192°C dec. (methanol).- IR: 2210 (CN); 1585 (arom.); 1210 (ar-O-C); 835 (1,4-disubst. arom.).- $C_{28}H_{16}Br_2N_4O_2S_2$ (664.4) Calcd. C 50.6 H 2.43 Br 24.1 N 8.4 S 9.7 Found C 50.7 H 2.59 Br 24.3 N 8.3 S 9.5.

4,4'-(1,4-Phenylene)bis[6-(3-chloro-2-thienyl)-2-methoxynicotinonitrile] (**10d**)

From 4.20 g (10 mmol) of **9d** and 1.4 g (22 mol) of MDN, 2 h room temp.; yield 2.6 g (45%), light yellow crystals, m.p. 275°C dec. (methanol).- IR: 2220 (CN); 1580 (arom.); 1210 (ar-O-C); 830 (1,4-disubst. arom.).- $C_{28}H_{16}Cl_2N_4O_2S_2$ (575.5) Calcd. C 58.4 H 2.80 Cl 12.3 N 9.7 S 11.1 Found C 58.3 H 2.95 Cl 12.4 N 9.6 S 11.0.

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