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The reaction of piperidine or morpholine with 2*H*-pyran-2-ones was found to give open chain δ-oxoamides, while with 2*H*-thiopyran-2-ones, thiophene derivatives were formed. For 2*H*-pyran-2-thiones, either open chain δ-oxothioamides or thiophene derivatives were obtained. From the $^1$H nmr data of the pyran derivatives, the effect of the replacement of ring and carbonyl oxygens with sulphur on the chemical shift of the H-3 proton could be studied.

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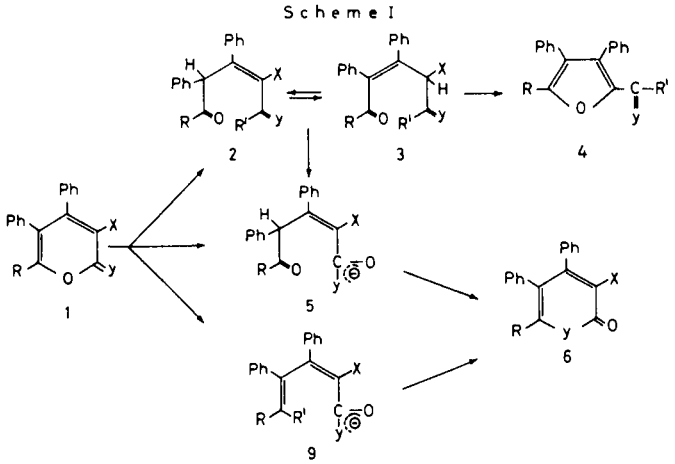
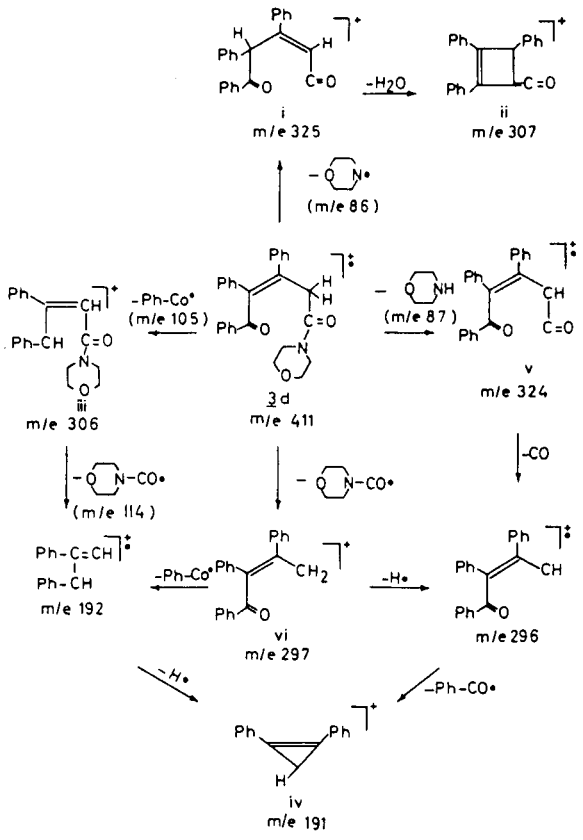
The reaction of 2*H*-pyran-2-ones with ammonia or primary amines generally leads to the formation of dihydropyridin-2-ones through ring opening at the 1,2-bond with the formation of intermediate δ-oxoamides and subsequent cyclization. Ring opening at position 6 was also postulated and in some cases the intermediates formed could be isolated (1,2). No cases were reported in which intermediates corresponding to ring opening at 1,2-bond were separated. However, 6-phenyl-2*H*-pyran-2-one was shown (3) to give with piperidine the dipiperidide of 2-(β-benzoylvinyl)-2-phenacylglutaric acid or the piperidide of 3-benzoyl-4-phenylbenzoic acid. Their formation was explained on the basis of an initial attack of the amine on carbon 2 of the pyrone ring. In the present study, the reaction of several 2*H*-pyran-2-ones, 2*H*-thiopyran-2-ones, 2*H*-pyran-2-thiones and 2*H*-thiopyran-2-thiones with piperidine and morpholine have been studied.

In the reaction of piperidine or morpholine with 4,5,6-triaryl-2*H*-pyran-2-ones **1a-c**, we were able to isolate 1,5-dioxo-1-(*N*-piperidino or morpholino)-3,4,5-triarylpent-3-enes **3a-e**, which are the products expected from the fission of the 2-pyrone ring at the 1,2-bond. The amides **3a,d** were susceptible to alkaline hydrolysis to the known δ-keto-acid **3f** (4) (Scheme 1). In agreement with the suggested structures, the infrared spectra of these amides exhibited a tertiary amide (5a) as well as α,β-unsaturated carbonyl (5b) absorptions at 1640-1645 and 1660-1670 cm$^{-1}$, respectively. Their $^1$H nmr spectra showed a methylene singlet at δ 3.48 which is consistent with the β,γ-unsaturated amide structure **3**. It is generally observed that in the $^1$H nmr spectra of 1-acylpiperidines, the shielding of axial and equatorial protons α- to nitrogen is averaged to a single value because of rapid ring inversions of the two chair conformations. However, the protons alpha to nitrogen in the piperidides **3a-c** appeared as two multiplets centered at δ 3.48 and 3.20. The low field multiplet can be assigned to the equatorial protons since the axial protons usually absorb at higher fields (6). The observation of separate signals for axial and equatorial protons can be attributed to the predominance of one

Scheme I



Scheme II



conformation as observed in the case of piperidines having a substituent in position 4 (7).

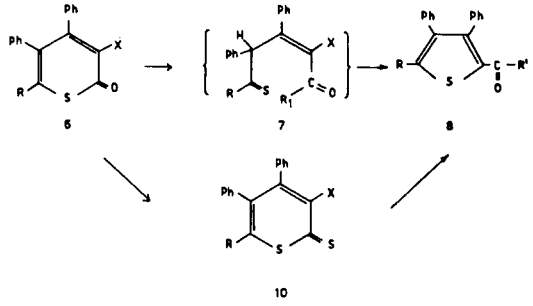
Further confirmation of the structure of the amides **3** is derived from their mass spectral data. The mass spectrum of **3d** showed the molecular ion peak at m/e 411 (7%). Other peaks are observed at m/e 325 (2), 324 (4), 307 (2.5), 306 (100), 297 (3.5), 296 (10), 192 (1.5), 191 (4.5), 114 (15), 105 (30), 87 (1.5), 86 (3), and 77 (14.5) which could be assigned to some of the fragments shown in Scheme 2. The species at m/e 325 is formulated as *i* formed by loss of $C_4H_8NO$ radical (m/e 86) from the molecular ion. Further loss of water molecule from *i* would lead to the ion *ii* at m/e 307. Another mode of fragmentation of the molecular ion is by loss of benzoyl group (m/e 105) leading to the ion *iii* at m/e 306 which is the base peak in the spectrum. Subsequent loss of $C_5H_8NO_2$ group (m/e 114) and proton from *iii* leads to the ion *iv* at m/e 191. Meanwhile, loss of morpholine molecule from the molecular ion affords the species *v* at m/e 324 which is converted to the ion *iv* through the loss of CO molecule and benzoyl radical, respectively. The formation of the ion *iv* is also possible from the molecular ion by loss of the radical $C_5H_8NO_2$ leading to the ion *vi* at m/e 297 and subsequent loss of benzoyl group and proton.

The reaction of 3-bromo-4,5,6-triaryl-2*H*-pyran-2-ones **1h,i** with piperidine or morpholine led to the formation of resinous products which could not be identified. It was only with **1g** and morpholine that gave a product which could be characterized as 3,4,5-triphenylfuran-2-carboxymorpholide (**4d**) assumed to be formed *via* the amide **2g** and subsequent cyclization through elimination of hydrogen bromide (Scheme 1).

In order to compare the behaviour of 2*H*-pyran-2-ones with the corresponding thio-analogues towards piperidine and morpholine it was necessary to find a simple method for the synthesis of the latter compounds. In a previous publication (8) 4,5,6-triphenyl-2*H*-thiopyran-2-one (**6j**) was reported to be formed as a by-product in poor yield from the reaction of 4,5,6-triphenyl-2*H*-pyran-2-thione (**1j**) and aqueous dimethylamine. Also at elevated temperatures, 2*H*-pyran-2-thiones undergo rearrangement to 2*H*-thiopyran-2-ones accompanied by exchange of substituents in the 3 and 5 positions (9). This rearrangement was assumed to occur *via* reversible electrocyclic ring opening to ketene aldehydes which undergo reversible [1,5]-sigmatropic shifts of the aldehydic hydrogen. In the present work aqueous sodium carbonate was found to effect a quantitative transformation of a series of 4,5,6-triaryl-2*H*-pyran-2-thiones **1j-l** as well as 3-bromo-4,5,6-triaryl-2*H*-pyran-2-thiones **1m-o** to the corresponding 2*H*-thiopyran-2-ones **6j-l** and **6m-o**, respectively. The course of these reactions can be considered to involve fission of the 2-thiones to the intermediate thio-acids **5** which subsequently undergo ring closure to the corresponding 2*H*-thiopyran-2-ones. The facile transformation of the 2*H*-pyran-2-thiones to their thio-analogues is understandable in view of the destabilization of a thiocarbonyl group relative to its carbonyl isomer (10). It is worthy to mention that the above reaction offers a simple synthetic route to 2*H*-thiopyran-2-ones since 2*H*-pyran-2-thiones are generally available by the action of phosphorus pentasulphide on 2*H*-pyran-2-ones. The infrared spectra of the 2*H*-thiopyran-2-ones showed a carbonyl absorption at lower frequency (1635-1640 $cm^{-1}$) (11) relative to the corresponding 2*H*-pyran-2-ones (4), and their $^1H$ nmr spectra exhibited a singlet at δ 6.60-6.70 for the H-3 proton.

The reaction of the 4,5,6-triaryl-2*H*-thiopyran-2-ones **6j-l** with piperidine or morpholine afforded the thiophene derivatives **8j-l,p** which were also obtained from the 3-bromo-4,5,6-triaryl-2*H*-thiopyran-2-ones **6m-o** on similar treatment. These reactions are assumed to proceed through nucleophilic attack of the nitrogen base on C-2 of the thiopyrone leading to ring fission with the formation of the amides **7j-q**. However, it seems likely that these intermediate δ-thioamides **7** unlike their δ-oxo-analogues **2** or

Scheme III



Substituents of Compounds **1-9**

| | R | X | Y | R′ |
|---|---|---|---|---|
| a | $C_6H_5$ | H | O | $C_5H_{10}N$ |
| b | $p$-$CH_3C_6H_4$ | H | O | $C_5H_{10}N$ |
| c | $p$-$CH_3OC_6H_4$ | H | O | $C_5H_{10}N$ |
| d | $C_6H_5$ | H | O | $C_4H_8NO$ |
| e | $p$-$CH_3C_6H_4$ | H | O | $C_4H_8NO$ |
| f | $C_6H_5$ | H | O | OH |
| g | $C_6H_5$ | Br | O | $C_4H_8NO$ |
| h | $p$-$CH_3C_6H_4$ | Br | O | |
| i | $p$-$CH_3OC_6H_4$ | Br | O | |
| j | $C_6H_5$ | H | S | $C_5H_{10}N$ |
| k | $p$-$CH_3C_6H_4$ | H | S | $C_5H_{10}N$ |
| l | $p$-$CH_3OC_6H_4$ | H | S | $C_5H_{10}N$ |
| m | $C_6H_5$ | Br | S | $C_5H_{10}N$ |
| n | $p$-$CH_3C_6H_4$ | Br | S | $C_5H_{10}N$ |
| o | $p$-$CH_3OC_6H_4$ | Br | S | $C_5H_{10}N$ |
| p | $C_6H_5$ | H | S | $C_4H_8NO$ |
| q | $C_6H_5$ | Br | S | $C_4H_8NO$ |
| r | $C_6H_5$ | | | OH |
| s | $C_6H_5$ | H | | OH |
| t | $C_6H_5$ | | | $OCH_3$ |

Table I

Piperidides and Morpholides **2** and **3**

| Compound | M.p. °C | Formula | Calcd. % C | H | N | S | Br | Found % C | H | N | S | Br |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3a** | 157 | $C_{28}H_{27}NO_2$ | 82.1 | 6.6 | 3.4 | | | 82.0 | 6.4 | 3.5 | | |
| **3b** | 190 | $C_{29}H_{29}NO_2$ | 82.2 | 6.9 | 3.3 | | | 82.2 | 6.6 | 3.1 | | |
| **3c** | 195 (a) | $C_{29}H_{29}NO_3$ | 79.2 | 6.6 | 3.2 | | | 79.4 | 6.6 | 3.1 | | |
| **3d** | 138 (b) | $C_{27}H_{25}NO_3$ | 78.8 | 6.1 | 3.4 | | | 78.9 | 6.3 | 3.5 | | |
| **3e** | 190 (b) | $C_{28}H_{27}NO_3$ | 79.0 | 6.4 | 3.3 | | | 79.0 | 6.6 | 3.7 | | |
| **2k** | 190 | $C_{29}H_{29}NOS$ | 79.2 | 6.6 | 3.2 | 7.3 | | 79.3 | 6.5 | 2.8 | 7.4 | |
| **3l** | 217 | $C_{29}H_{29}NO_2S$ | 76.4 | 6.4 | 3.1 | 7.0 | | 76.5 | 6.5 | 3.2 | 6.9 | |
| **2** or **3m** | 201 | $C_{28}H_{26}BrNOS$ | 66.7 | 5.2 | 2.8 | 6.4 | 15.8 | 66.8 | 5.3 | 3.2 | 6.7 | 15.9 |
| **2** or **3o** | 232 | $C_{29}H_{28}BrNO_2S$ | 65.2 | 5.3 | 2.6 | 6.0 | 14.9 | 65.0 | 5.5 | 2.4 | 5.7 | 14.8 |
| **2** or **3q** | 168 | $C_{27}H_{24}BrNO_2S$ | 64.0 | 4.8 | 2.8 | 6.3 | 15.8 | 63.9 | 4.4 | 2.7 | 6.1 | 15.9 |

(a) Crystallized from benzene-ethanol. (b) Crystallized from ethanol.

Table II

Infrared and Electronic Spectral Data of Piperidides and Morpholides **2** and **3**

| Compound | Ir ($cm^{-1}$) C=O amide | C=O ketonic | C=S | Uv λ max, nm, (ε) | |
|---|---|---|---|---|---|
| **3a** | 1645 | 1670 | | 213 (18200) | 248 (18030) |
| **3b** | 1640 | 1660 | | 222 (15040) | 260 (18090) |
| **3c** | 1640 | 1660 | | 226 (17890) | 286 (14840) |
| **3d** | 1640 | 1660 | | 218 (16580) | 250 (49480) |
| **3e** | 1640 | 1660 | | 210 (13430) | 261 (9330) |
| **2k** | | 1672 | 1130 | 210 (12780) | 258 (10710) |
| **3l** | | 1660 | 1132 | 213 (21759) | 286 (22426) |
| **2** or **3m** | | 1670 | 1130 | 210 (12920) | 248 (9301) 306 (3624) |
| **2** or **3o** | | 1665 | 1132 | 215 (25530) | 284 (22930) |
| **2** or **3q** | | 1670 | 1125 | 213 (22810) | 252 (23020) |

**3** are susceptible to cyclization to the thiophene amides **8** through dehydrogenation or dehydrobromination (Scheme 3). The facile cyclization in the former case can be related to the greater nucleophilicity of sulphur over oxygen. The infrared spectra of the thiophene amides **8** exhibited a tertiary amide carbonyl absorption at 1625-1630 $cm^{-1}$ and their $^1H$ nmr spectra showed the signals of piperidine or morpholine besides the aromatic protons and other characteristics. Unlike the open chain δ-oxo-amides **3**, the equatorial and axial protons α- to nitrogen in the thiophene piperidides **8j,k** appeared as a single multiplet centered at δ 3.31 suggesting a rapid interconversion, on the $^1H$ nmr scale, of the two chair conformations of piperidine.

The structure of the thiophene derivatives **8** could be confirmed through synthesis from the corresponding acids. A well established route for the formation of furan-2-carboxylic acids is the reaction of 3-halo-2*H*-pyran-2-ones with alkalis (8,12). On the same basis, 3,4,5-triphenylthiophene-2-carboxylic acid (**8r**) was prepared by the action of alcoholic potassium hydroxide on 3-bromo-4,5,6-triphenyl-2*H*-thiopyran-2-one (**6m**). It is worthy to mention that the same thiophene acid **8r** was also formed from 4,5,6-triphenyl-2*H*-thiopyran-2-one (**6j**) on similar treatment which indicates that the intermediate δ-thio-acid **7s** is susceptible to spontaneous cyclization through dehydrogenation. The thiophene acid **8r** could be converted to the piperidide **8j** *via* the formation of the acid chloride and subsequent reaction with piperidine (Scheme 3).

The reaction of 4,5,6-triphenyl-2*H*-pyran-2-thione (**1j**) with piperidine or morpholine in 90% methanol at 20° led to the formation of the corresponding 2*H*-thiopyran-2-one **6j** while at higher temperature (about 70°), the thiophene amides **8j,p** were formed. Since **6j** was also formed from **1j** on mild treatment with aqueous sodium carbonate or potassium hydroxide, it is reasonable to suggest that such transformation with the nitrogen bases takes place through hydrolysis of an initially formed thioamides **2** or **3j,p** and subsequent cyclization of the resulting thio-acid **5j**. An alternative sequence is also possible since the same products **6j** or **8j,p** were formed when the above reaction

Table III

$^1$H Nmr Spectral Data of Piperidides and Morpholides **2** and **3**

| Compound | $^1$H Nmr Chemical Shift (δ/ppm) | | | | |
|---|---|---|---|---|---|
| | $CH_2$ (a) (2H) | H-2 (a) (1H) | Piperidine or Morpholine (b) | Ar-H (b) | Others (a) |
| **3a** | 3.48 | | 1.50 (6H), 3.20 (2H), 3.48 (2H) | 7.6 (15H) | |
| **3b** | 3.48 | | 1.50 (6H), 3.25 (2H), 3.48 (2H) | 7.6 (14H) | 2.25 (3H, $CH_3$) |
| **3c** | 3.45 | | 1.47 (6H), 3.17 (2H), 3.45 (2H) | 7.5 (14H) | 3.70 (3H, $OCH_3$) |
| **3d** | 3.50 | | 3.40 (8H) | 7.6 (15H) | |
| **3e** | 3.48 | | 3.40 (8H) | 7.5 (14H) | 2.25 (3H, $CH_3$) |
| **2k** | | 6.07, 5.75 (c) | 1.40 (6H), 3.59 (2H), 4.00 (2H) | 7.5 (14H) | 2.37 (3H, $CH_3$) |
| **3l** | 4.05 | | 1.50 (6H), 3.43 (2H), 4.05 (2H) | 7.4 (14H) | 3.75 (3H, $OCH_3$) |
| **2** or **3m** | | 6.33 | 1.58 (6H), 3.67 (2H), 4.08 (2H) | 7.6 (15H) | |
| **2** or **3o** | | 6.23 | 1.55 (6H), 3.80 (4H) | 7.6 (14H) | 3.80 (3H, $OCH_3$) |
| **2** or **3q** | | 6.28 | 3.55 (4H), 3.92 (4H) (d) | 7.4 (15H) | |

(a) Singlet. (b) Multiplet. (c) This signal is attributed to the H-4 proton. (d) The low field multiplet is most probably attributed to the protons α to O in the morpholine (24).

Table IV

2*H*-Thiopyran-2-ones **6** and 2*H*-Thiopyran-2-thiones **10**

| Compound | M.p. °C | Formula | Calcd. % | | | | Found % | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | H | S | Br | C | H | S | Br |
| **6k** | 165 | $C_{24}H_{18}OS$ | 81.3 | 5.1 | 9.0 | | 81.3 | 5.4 | 9.1 | |
| **6l** | 134 | $C_{24}H_{18}O_2S$ | 77.8 | 4.9 | 8.6 | | 77.6 | 5.2 | 8.8 | |
| **6m** | 197 | $C_{23}H_{15}BrOS$ | 65.9 | 3.6 | 7.6 | 19.1 | 66.1 | 3.4 | 7.9 | 19.3 |
| **6n** | 179 | $C_{24}H_{17}BrOS$ | 66.5 | 3.9 | 7.4 | 18.4 | 66.3 | 4.0 | 7.2 | 18.3 |
| **6o** | 197 | $C_{24}H_{17}BrO_2S$ | 64.1 | 3.8 | 7.1 | 17.8 | 64.2 | 3.9 | 7.3 | 17.6 |
| **10j** | 181 | $C_{23}H_{16}S_2$ | 77.5 | 4.5 | 18.0 | | 77.4 | 4.9 | 17.6 | |
| **10k** | 198 | $C_{24}H_{18}S_2$ | 77.8 | 4.9 | 17.3 | | 77.8 | 4.9 | 17.3 | |
| **10l** | 172 | $C_{24}H_{18}OS_2$ | 74.6 | 4.7 | 16.5 | | 74.3 | 4.3 | 16.4 | |
| **10m** | 246 | $C_{23}H_{15}BrS_2$ | 63.4 | 3.5 | 14.7 | 18.4 | 63.1 | 3.5 | 14.9 | 18.7 |
| **10n** | 190 | $C_{24}H_{17}BrS_2$ | 64.1 | 3.8 | 14.3 | 17.8 | 64.3 | 3.4 | 14.5 | 17.6 |
| **10o** | 228 | $C_{24}H_{17}BrOS_2$ | 61.9 | 3.7 | 13.8 | 17.2 | 61.7 | 3.7 | 14.0 | 17.0 |

was carried out in neat piperidine or morpholine at 20° or under reflux, respectively. This route involves an initial attack of the amine molecule at position 6 of the 2-thione forming the intermediate dienoic acids **9j,p** which subsequently cyclize *via* elimination of the base molecule (Schemes 1,3).

In contrast to the 2-thione **1j**, 4,5-diphenyl-6-*p*-tolyl- **1k** and 4,5-diphenyl-6-*p*-methoxyphenyl- **1l** 2*H*-pyran-2-thiones afforded with piperidine the thio-piperidides **2k** and **3l**, respectively (Scheme 1). The infrared spectra of these thioamides showed a ketonic carbonyl as well as thiocarbonyl absorptions at 1660-1672 and 1130-1132 $cm^{-1}$ (4,13), respectively. The $^1$H nmr spectrum of **2k** exhibited two singlets at δ 6.07 and 5.75 for the olefinic (position 2) and methine (position 4) protons, respectively indicating that this compound possesses an α,β-unsaturated amide structure **2**. On the other hand, the spectrum of **3l** showed a methylene singlet at δ 4.05 which is consistent with the tautomeric β,γ-unsaturated amide form **3**.

The reaction of 3-bromo-4,5,6-triaryl-2*H*-pyran-2-thiones **1m,o** with piperidine at 20° afforded the corresponding α-bromothioamides **2** or **3m,o**. Similarly, with morpholine **1m** gave the morpholide **2** or **3q**. Subsequent dehydrobromination into 3,4,5-triphenylfuran-2-thiocarb-

Table V

Spectral Data for 2*H*-Pyran-2-ones, 2*H*-Pyran-2-thiones, 2*H*-Thiopyran-2-ones and 2*H*-Thiopyran-2-thiones

| Compound | Ir ($cm^{-1}$) C=O | Ir ($cm^{-1}$) C=S | Electronic λ max, nm (ε) | $^1$H Nmr Chemical Shift (δ/ppm) H-3 (a) | Ar-H (b) | Others (a) |
|---|---|---|---|---|---|---|
| **1a** | 1721 (c) | | 205 (6284) 230 (15830) 253 (18610) 340 (8710) | 6.35 | 7.0 (15H) | |
| **1b** | 1715 | | 206 (23029) 231 (13864) 253 (17154) 339 (8460) | 6.32 | 7.1 (14H) | 2.25 (3H, $CH_3$) |
| **1c** | 1717 | | 209 (21638) 237 (15675) 263 (17038) 350 (11926) | 6.30 | 7.0 (14H) | 3.73 (3H, $OCH_3$) |
| **1j** | | 1111 (c) | 202 (42540) 299 (22840) 416 (9227) | 7.30 (d) | 7.1 (15H) | |
| **1k** | | 1100 (e) | 209 (23630) 229* (13661) 297 (24011) 408 (10153) | 7.23 (d) | 7.0 (14H) | 2.25 (3H, $CH_3$) |
| **6j** | 1635 | | 225 (17430) 250 (15810) 370 (4762) | 6.73 | 7.1 (15H) | |
| **6k** | 1640 | | 222 (7764) 254 (5620) 370 (2570) | 6.60 | 7.1 (14H) | 2.23 (3H, $CH_3$) |
| **6l** | 1635 | | 214 (20052) 265 (11823) 370 (7067) | | | |
| **6m** | 1640 | | 219 (15280) 236 (14810) 370 (7173) | | 7.1 (15H) | |
| **6n** | 1635 | | 214 (19952) 242* (13618) 370 (7917) | | 7.0 (14H) | 2.23 (3H, $CH_3$) |
| **6o** | 1635 | | 220 (18934) 232 (18699) 376 (8180) | | | |
| **10j** | | 1155 | 217 (8793) 239 (14235) 320 (17577) 460 (7185) | 7.75 | 7.1 (15H) | |
| **10k** | | 1158 | 213 (23230) 238 (25016) 318 (16618) 452 (7683) | | | |
| **10l** | | 1145 | 217 (20171) 239 (19115) 322 (16183) 466 (7739) | | | |
| **10m** | | 1156 | 217 (19783) 234 (22255) 325 (22255) 468 (7171) | | 7.5 (15H) | |
| **10n** | | 1158 | 215 (21949) 240* (19162) 324 (11845) 468 (7316) | | | |
| **10o** | | 1156 | 226 (22925) 250* (17592) 327 (11861) 474 (6797) | | | |

(a) Singlet. (b) Multiplet. (c) Taken from reference (4). (d) Assignment of the H-3 signal which is overlapped by the complex aromatic multiplet was possible by comparison with the $^1$H nmr spectra of the analogous 3-bromo derivatives. (e) Taken from reference (8). * Shoulder.

Table VI

Thiophene Derivatives **8**

| Compound | M.p. °C | Formula | Calcd. % C | H | N | S | Found % C | H | N | S |
|---|---|---|---|---|---|---|---|---|---|---|
| **8j** | 196 | $C_{28}H_{25}NOS$ | 79.4 | 5.9 | 3.3 | 7.5 | 79.2 | 5.8 | 3.2 | 7.7 |
| **8k** | 184 | $C_{29}H_{27}NOS$ | 79.6 | 6.2 | 3.2 | 7.3 | 79.9 | 6.4 | 3.2 | 7.5 |
| **8l** | 190 | $C_{29}H_{27}NO_2S$ | 76.8 | 6.0 | 3.1 | 7.1 | 76.7 | 5.9 | 2.9 | 7.2 |
| **8p** | 193 | $C_{27}H_{23}NO_2S$ | 76.2 | 5.4 | 3.3 | 7.5 | 76.6 | 5.4 | 3.6 | 7.6 |
| **8r** | 266 (a) | $C_{23}H_{16}O_2S$ | 77.5 | 4.5 | | 9.0 | 77.7 | 4.9 | | 9.3 |
| **8t** | 152 | $C_{24}H_{18}O_2S$ | 77.8 | 4.9 | | 8.7 | 78.2 | 4.5 | | 8.8 |

(a) Melts with decomposition.

oxypiperidide (**4m**) took place in the case of **2** or **3m** when the reaction was carried out at higher temperature (Scheme 1). The $^1$H nmr spectra of the α-bromothioamides exhibited a singlet at δ 6.30 which can be assigned either to C-4 or C-2 protons for structures **2** or **3**, respectively. However, the observation that this proton resonates at a relatively low field may favour structure **3** in which the proton at position 2 is expected to be highly deshielded.

2*H*-Thiopyran-2-thiones are generally obtained from the reaction of enamines with carbon disulphide (14,15). However, several 4,6- (16) and 3,6-disubstituted-2*H*-thiopyran-2-thiones (17) were prepared from the corresponding 2*H*-thiopyran-2-ones and phosphorus pentasulphide, a method which was applied in the present work for the preparation of a series of 4,5,6-triaryl-2*H*-thiopyran-2-thiones **10j-l** and their 3-bromo derivatives **10m-o**. The infrared spectra of these compounds exhibited a thiocarbonyl absorption in the region 1145-1158 $cm^{-1}$ and their $^1$H nmr spectra showed a singlet at δ 7.73 for the H-3 proton (Scheme 3).

The reaction of the 2*H*-thiopyran-2-thione **10j** or its 3-bromo derivative **10m** with piperidine led to the formation of the thiophene piperidide **8j** which is understandable taking into consideration the ease of hydrolysis of 2*H*-thiopyran-2-thiones to the corresponding 2*H*-thiopyran-2-ones (18).

The available $^1$H nmr data of the 2*H*-pyran derivatives involved in the present study, may throw some light on the effect of the replacement of the ring and carbonyl oxygens with sulphur on the chemical shift of the H-3 proton. The spectra of 4,5,6-triaryl-2*H*-pyran-2-ones showed the H-3 proton signal at δ 6.30-6.35. Replacement of the ring oxygen with sulphur resulted in a downfield

Table VII

Spectral Data of Thiophene Derivatives **8**

| Compound | Ir ($cm^{-1}$) C=O | Uv λ max, nm (ε) | | | $^1$H Nmr Chemical Shift (δ/ppm) Piperidine or Morpholine (a) | Ar-H (a) | Others (b) |
|---|---|---|---|---|---|---|---|
| **8j** | 1630 | 215 (24180) | 239 (24620) | 275* (11430) | 1.28 (6H), 3.31 (4H) | 7.1 (15H) | |
| **8k** | 1630 | 215 (25190) | 240 (25190) | 280* (11720) | 1.28 (6H), 3.31 (4H) | 7.0 (14H) | 2.28 (3H, $CH_3$) |
| **8l** | 1630 | 217 (24800) | 240 (23172) | 281* (12300) | | | |
| **8p** | 1625 | 215 (22430) | 238 (24150) | 275* (11310) | 3.25 (8H) | 7.1 (15H) | |
| **8r** (c) | 1690 | 210 (3897) | 235 (3240) | 300 (2380) | | 7.0 (d) | |
| **8t** (c) | 1710 | 216 (16294) | 235 (18566) | 308 (12377) | | 7.0 (15H) | 3.70 (3H, ester $CH_3$) |

(a) Multiplet. (b) Singlet. (c) The $^1$H nmr spectra carried out in DMSO-$d_6$. (d) The carboxylic proton signal is probably overlapped by the complex aromatic multiplet.
* Shoulder.

shift of this signal about 0.30 ppm which may be related to the fact that sulphur heterocycles show enhanced ring currents due probably to d-orbital conjugation (19). However, substitution of a sulphur for the carbonyl oxygen shifted the H-3 proton downfield of about 0.90-1.0 ppm. Similar downfield shifts of the H-3 proton for other 2*H*-pyran-2-thiones (9) and pyridthiones (20) relative to those of the corresponding oxygen analogues were reported. Also for 4*H*-pyran-4-ones a downfield shift in the α-vinylic proton signal was observed when the oxygen atom of the carbonyl group was replaced by sulphur (21). The significant deshielding of the H-3 proton in 2*H*-pyran-2-thiones can be attributed to increased magnetic anisotropy of the thione over carbonyl. This view finds a support by the studies on the thiocarbonyl group which have established that the deshielding cones are much like those in the carbonyl group but more effective (22). Moreover, the thione group in thioanilides deshields an ortho aromatic proton more strongly than does carbonyl (23). For the 2*H*-thiopyran-2-thiones a greater downfield shift (about 1.40 ppm) for the H-3 proton signal was observed. Probably, this shift is a function of the thione deshielding cone as well as ring currents.

## EXPERIMENTAL

Microanalyses were performed by Microanalysis Unit, Cairo University, Cairo. Infrared spectra were measured with a Unicam SP200 spectrophotometer for potassium bromide pellets or in Nujol and electronic spectra were measured for ethanolic solutions with a Unicam SP 800 spectrophotometer. The $^1$H nmr spectra were recorded on a Varian A-60 A instrument for solutions in deuteriochloroform with TMS as internal standard. Mass spectra were recorded on AEI MS902 instrument.

1,5-Dioxo-1-(*N*-piperidino or morpholino)-3,4,5-triarylpent-3-enes (Tables I, II, III).

A solution of 4,5,6-triaryl-2*H*-pyran-2-one (0.5 g., 0.0015 mole) in piperidine or morpholine (3 ml.) was refluxed for one hour. The amides (75% yield) separated after dilution with water and crystallized from methanol.

5-Oxo-3,4,5-triphenylpent-2-enoic acid (**2f**).

A solution of **3a** or **d** (0.5 g., 0.0012 mole) was refluxed with 5% methanolic potassium hydroxide (20 ml.) for 2 hours. On acidification with 10% sulphuric acid and extraction with ether, the acid **2f** separated in 55% yield and crystallized from benzene in needles, m.p. 189° dec. [Lit. (4) 190° dec.]. The methyl ester of **2f** was prepared by diazomethane and had m.p. and mixed m.p. 130° (4).

3,4,5-Triphenylfuran-2-carboxymorpholide (**4d**).

A solution of 3-bromo-4,5,6-triphenyl-2*H*-pyran-2-one (1 g., 0.0025 mole) in ethanol (10 ml.) was kept with morpholine (2 ml.) at 20° overnight. The furan **4d** (0.6 g., 60% yield) was obtained after dilution with water and crystallized from methanol in needles, m.p. 98°; ν max ($cm^{-1}$): 1650 (CO amide); λ max (nm) 209, 232, 258sh, 299 (ε, 10,610, 10,750, 6,430, 5,685).

*Anal.* Calcd. for $C_{27}H_{23}NO_3$: C, 79.2; H, 5.7; N, 3.4. Found: C, 79.3; H, 5.5; N, 3.2.

2*H*-Thiopyran-2-ones (Tables IV, V).

A suspension of 4,5,6-triaryl-2*H*-pyran-2-thione or 3-bromo-4,5,6-triaryl-2*H*-pyran-2-thione (1 g., 0.0029 mole) in methanol (20 ml.) was refluxed with 10% aqueous sodium carbonate (5 ml.) for 2 hours. The 2*H*-thiopyran-2-one which separated in 80% yield after dilution with water crystallized from methanol or ethanol.

The 3-bromo-2*H*-thiopyran-2-ones were also prepared quantitatively when a solution of bromine (0.6 g., 0.0075 mole) in chloroform (10 ml.) was gradually added to a solution of the 2*H*-thiopyran-2-one (1 g., 0.0029 mole) in chloroform (15 ml.), refluxing for 2 hours, evaporation of the solvent and addition of methanol.

3,4,5-Triarylthiophene-2-carboxypiperidides or Morpholides (Tables VI, VII).

4,5,6-Triaryl-2*H*-thiopyran-2-one (0.5 g., 0.0015 mole) was refluxed with piperidine or morpholine (2 ml.) for one hour, then the reaction mixture was diluted with water and the separated thiophene amide (60% yield) crystallized from methanol or ethanol. The same products were also obtained in 80% yield by refluxing a suspension of 3-bromo-4,5,6-triaryl-2*H*-thiopyran-2-one (0.5 g., 0.0015 mole) in methanol (8 ml.) with piperidine or morpholine (5 ml.) for 10 minutes.

3,4,5-Triphenylthiophene-2-carboxylic Acid (**8r**) (Tables VI, VII).

A solution of 3-bromo-4,5,6-triphenyl-2*H*-thiopyran-2-one or 4,5,6-triphenyl-2*H*-thiopyran-2-one (1 g., 0.0029 mole) in 5% methanolic potassium hydroxide (20 ml.) was refluxed for 15 minutes. The acid **8r** (0.5 g., 60% yield) separated after acidification with 10% sulphuric acid and crystallized from benzene-methanol in yellow needles. Its methyl ester **8t** (Tables VI, VII), prepared by diazomethane crystallized from methanol in needles. The acid chloride of **8r** prepared by thionyl chloride, m.p. 188°, was converted to the piperidide **8j**, m.p. and mixed m.p. 196°, on reaction with piperidine.

Reaction of 4,5,6-Triphenyl-2*H*-pyran-2-thione (**1j**) with Piperidine or Morpholine.

A suspension of **1j** (0.5 g., 0.0015 mole) in 90% methanol (10 ml.) was kept with piperidine or morpholine (1 ml.) at 20° overnight. On dilution with water, 4,5,6-triphenyl-2*H*-thiopyran-2-one (**6j**) (0.35 g., 70% yield), m.p. and mixed m.p. 163°, was obtained. However, when the reactants were refluxed in 90% methanol for one hour, 3,4,5-triphenylthiophene-2-carboxypiperidide and morpholide (**8j** and **p**) were obtained in 60% yield.

The same products were obtained when the reaction was carried out between **1j** and neat piperidine or morpholine.

5-Oxo-1-(*N*-piperidino)-3,4,5-triaryl-1-thiopent-2 or 3-enes (Tables I, II, III).

4,5,6-Triaryl-2*H*-pyran-2-thione (0.5 g., 0.0015 mole) was refluxed with piperidine (2 ml.) for 30 minutes. After dilution with water, the product which separated (0.4 g., 80% yield) was crystallized from benzene or ethanol in needles.

2-Bromo-5-oxo-1-(*N*-piperidino or morpholino)-3,4,5-triaryl-1-thiopent-2 or 3-enes (Tables I, II, III).

A suspension of 3-bromo-4,5,6-triaryl-2*H*-pyran-2-thione (0.5 g., 0.0012 mole) in methanol (8 ml.) was kept with piperidine or morpholine at 20° overnight, then diluted with water. The product (80% yield) was crystallized from methanol or benzene in needles.

3,4,5-Triphenylfuran-2-thiocarboxypiperidide (**4m**).

3-Bromo-4,5,6-triphenyl-2*H*-pyran-2-thione (**1m**) (0.5 g., 0.0012 mole) or the α-bromothio-amide **2** or **3m** (0.6 g., 0.0012 mole) was refluxed with piperidine (2 ml.) for 4 hours. After removal of excess piperidine and treating the residue with cold methanol, the furan **4m** (50% yield) separated and was crystallized from ethanol in yellow needles, m.p. 168°; ν max ($cm^{-1}$): 1125 (CS); λ max (nm): 214, 230, 254, 299 (ε, 21,170, 20,110, 16,830, 20,110); $^1H$ nmr (deuteriochloroform): δ 1.47 (m, 6H, β and γ protons of piperidine), 3.77 (m, 4H, α-protons of piperidine), 7.3 (m, 15H, aromatic protons).

*Anal.* Calcd. for $C_{28}H_{25}NOS$: C, 79.4; H, 5.9; N, 3.3; S, 7.5. Found: C, 79.5; H, 6.0; N, 3.1; S, 7.6.

2*H*-Thiopyran-2-thiones (Tables IV, V).

A solution of 4,5,6-triaryl-2*H*-thiopyran-2-one or 3-bromo-4,5,6-triaryl-2*H*-thiopyran-2-one (1 g., 0.0029 mole) in dry toluene (15 ml.) was refluxed with phosphorus pentasulphide (3 g., 0.13 mole) for 5 hours. After washing the solution with 10% ammonium sulphide, drying (sodium sulfate) and evaporation, the 2*H*-thiopyran-2-thione separated in quantitative yield and was crystallized from benzene-petroleum ether (b.p. 60-80°) in deep red crystals.

Reaction of the 2*H*-Thiopyran-2-thiones **10j,m** with Piperidine.

A solution of **10j** or **m** (0.5 g., 0.0011 mole) in 90% methanol (15 ml.) was refluxed with piperidine (1 ml.) for 6 hours. On cooling, 3,4,5-triphenylthiophene-2-carboxypiperidide (**8j**) (60% yield), m.p. and mixed m.p. 196°, separated out.

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