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5-ACYL-2*H*-PYRAN-2-ONES IN THE SCHMIDT REACTION: MIGRATION OF THE PYRAN-2-ONE RING[#]

Franc Požgan, Maja Krejan, Slovenko Polanc, and Marijan Kočevar*

Faculty of Chemistry and Chemical Technology, University of Ljubljana, Aškerčeva 5, SI-1000 Ljubljana, Slovenia, e-mail: marijan.kocevar@fkkt.uni-lj.si

Abstract – The Schmidt reaction of the 5-acyl-2*H*-pyran-2-ones (**1a–f**) using NaN_3/H_2SO_4 was investigated. The reaction proceeded with complete regioselectivity in the 5-acetyl series to give the corresponding 5-acetylamino derivatives (**2a–c**) *via* pyran-2-one ring migration. In contrast, the reaction applied to the 5-benzoyl-2*H*-pyran-2-ones (**1d–f**) led to the formation of both regioisomers, (**2d–f**) and (**3d–f**). The latter resulted from the phenyl shift in this reaction and were obtained as minor products. The 3,5-diacylamino-2*H*-pyran-2-ones (**2a**) and (**2d**) were selectively debenzoylated at position 3.

INTRODUCTION

The reaction of carbonyl compounds with hydrazoic acid, known as the Schmidt reaction, is a convenient method for the synthesis of a wide variety of nitrogen-containing compounds.[1] The application of cyclic ketones in this reaction is of particular interest because it represents a direct and efficient one-step method to lactams of different ring sizes;[2] this is in contrast to the related Beckmann reaction,[3] which initially requires the preparation of an appropriate oxime. We have previously reported the expansion of a fused cyclohexenone ring of 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2,5-diones with an –NH– group using sodium azide or trimethylsilyl azide in an acidic medium affording pyrano[3,2-*c*]azepine derivatives as the major products, accompanied by a smaller quantity of their regioisomers, pyrano[3,2-*b*]azepines.[4] The regiochemistry of the rearrangement turned out to be temperature dependent, but the methylene-chain (being part of a fused cyclohexenone ring) migration in all cases dominated over the migration of the pyran-2-one ring. Similarly, cyclopenta[*b*]pyran-2,5-diones regioselectively gave pyrano[3,2-*c*]pyridines *via* the alkyl group (6-C) shift. The most widely accepted mechanism for the Schmidt reaction involves the

[#] Dedicated to Dr. Satoshi Ōmura, The Kitasato Institute, and Kitasato Institute for Life Sciences, Kitasato University, on the occasion of his 70th birthday.

formation of *syn*- and *anti*-iminodiazonium ions, followed by the migration of the *anti* substituent with the loss of molecular nitrogen.[5] However, the observed regioselectivity in the cycloalkenone-fused pyran-2-ones[4] was the opposite to that in the series of alkyl aryl ketones, where the aryl groups migrate preferentially.[1] Similar results to those we obtained with the fused pyran-2-ones[4] were also observed in some other heterocyclic systems, like quinolones[6] and flavanones.[7]

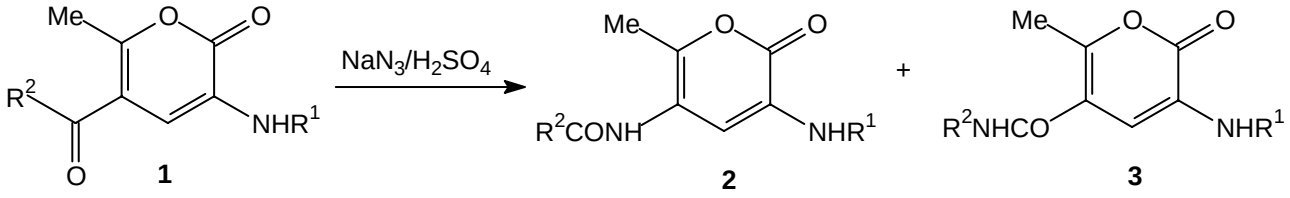
RESULTS AND DISCUSSION

Previous reports of the Schmidt reaction of fused pyran-2-ones[4] and alkyl aryl ketones[1] prompted us to undertake an investigation of the –NH– group insertion adjacent to the carbonyl moiety of the 5-acyl-2*H*-pyran-2-ones (**1**)[8] (for the synthesis of **1b**,**c**,**e**, and **f**, see EXPERIMENTAL). Having in mind that the Schmidt reaction of the cycloalkenone-fused pyran-2-ones preferentially gave products resulting from an alkyl group migration,[4] and in order to check the possibility of the pyran-2-one ring migration, we decided to investigate the rearrangement of the non-fused 5-acyl-2*H*-pyran-2-ones (**1)**. If in these cases the pyran-2-one ring was to migrate preferentially, the corresponding 3,5-diamino substituted 2*H*-pyran-2-ones (**2**) would be obtained as our target compounds. To the best of our knowledge, they would be the first known compounds with such a substitution pattern and, therefore, might serve as synthons for the synthesis of different novel heterocyclic derivatives. For the preparation of compounds (**2**) we have also taken into consideration the Beckmann reaction, which in some cases complemented the Schmidt reaction,[9] but in our particular case this was not a realistic option. This is because our previous results have shown that 5-acyl-2*H*-pyran-2-ones react with hydroxylamine at the acyl group and at the 6-C of the pyran-2-one ring to give isoxazole derivatives.[10] On this basis, the preparation of the corresponding oximes from 5-acyl-2*H*-pyran-2-ones would be impossible.

However, when 5-acetyl-2*H*-pyran-2-ones (**1a**–**c**) were allowed to react with hydrazoic acid, generated *in situ* from NaN_3 and H_2SO_4, the 5-acetylamino-2*H*-pyran-2-one derivatives (**2a**–**c**) were isolated as the sole products in good-to-excellent yields (Table 1, Runs 1–3). No traces of their regioisomers (**3a**–**c**) and/or other products were detected in the ^{1}H NMR spectra and the TLCs of the crude products. The structures (**2a**–**c**) were assigned by means of their ^{1}H NMR spectra, which showed singlets for the newly incorporated amide protons as well as for the methyl groups of the 5-acetylamino unit, thus indicating that they were not coupled. Additional evidence for the structures of the 5-acetylamino derivatives (**2a**–**c**) was obtained from their MS spectra, in which the peaks arising after the elimination of the MeCO group from their parent structures were observed.

The Schmidt reaction applied to the 5-benzoyl-2*H*-pyran-2-ones (**1d**–**f**) resulted in the formation of both regioisomers, the 5-benzoylamino derivatives (**2d**–**f**) and the *N*-phenyl-2*H*-pyran-5-carboxamides (**3d**–**f**), in the approximate ratio 4:1 (Table 1, Runs 4–6). In order to distinguish between the isomeric products and

to establish the mode of the carbon shift (5-C of the pyran-2-one ring *vs.* Ph) it was necessary to investigate the 2D NMR spectra and the MS spectroscopic fragmentation patterns of the regioisomers (**2d**–**f**) and (**3d**–**f**). Thus, considering the compound (**2e**), the two- and three-bond ^{1}H, ^{13}C connectivities, obtained from the HMBC measurement, supported the 5-benzoylamino-2*H*-pyran-2-one structure. Namely, the amide proton of the **2e** correlates with the 4-C, 5-C and 6-C atoms of the pyran-2-one ring, whereas the amide proton of the isomer (**3e**) correlates with *ortho* carbon atoms of the phenyl group. The MS analyses of the compounds (**2d**–**f**) exhibited the characteristic fragments of *m*/*z* of 105 (PhCO) with an intensity of 100%, whereas in the MS spectra of their regioisomers (**3d**–**f**), peaks for the fragments M^{+}–PhNH were observed. On the basis of these analyses it could be concluded that the Schmidt reaction applied to the 5-benzoyl-2*H*-pyran-2-ones (**1d**–**f**) afforded the 5-benzoylamino derivatives (**2d**–**f**) as the major products and the *N*-phenylcarboxamides (**3d**–**f**) as the minor ones.



a: R^1 = COPh, R^2 = Me
b: R^1 = H, R^2 = Me
c: R^1 = COMe, R^2 = Me
d: R^1 = COPh, R^2 = Ph
e: R^1 = H, R^2 = Ph
f: R^1 = COMe, R^2 = Ph

Scheme 1

Table 1: Reaction conditions and yields of products (**2**) and (**3**).

Run	Substrate **1**	Conditions (temperature, react. time after NaN_3 addition)	Products (overall yield, %)
1	**1a**	–10 to 0 °C, 3 h + rt, 2 h	**2a** (98)
2	**1b**	–10 to 0 °C, 3 h + rt, 2 h	**2b** (96)
3	**1c**	–10 to 0 °C, 3 h + rt, 2 h	**2c** (86)
4	**1d**	–10 to 0 °C, 3 h + rt, 2 h	**2d**/**3d** 3.5/1[a] (99)
5	**1e**	–10 to 0 °C, 3 h + rt, 2 h	**2e**/**3e** 3.9/1[a] (87)
6	**1f**	–10 to 0 °C, 3 h + rt, 2 h	**2f**/**3f** 3.7/1[a] (72)
7	**1b**	32–35 °C, 2 h	**2b** (86)
8	**1e**	32–35 °C, 2 h	**2e**/**3e** 3.6/1[a] (92)

[a]The product ratio was determined on the basis of the ^{1}H NMR spectrum of the crude mixture of the isomers.

In our previous investigation we showed that the regioselectivity of the Schmidt reaction was dependent on

the temperature.[4b] In this study we performed reactions of the substrates (**1b**) and (**1e**) at around 35 °C, but no significant change in the regiochemistry was observed (Table 1, Runs 7 and 8). Thus, **2b** was again obtained as the sole product and the ratio **2e**/**3e** did not change significantly.

We believe that the observed regioselectivity in the Schmidt rearrangement of the 5-acyl-2*H*-pyran-2-ones (**1a**–**f**) can be explained by the pathway outlined in Figure 1. The determining step is probably the formation of the iminodiazonium ion (**4**), whose *anti*-configured isomer (with its two relatively stable rotameric forms **4A** and **4B**) seems to be more stable than its *syn* isomer would be (because of the bulky 2*H*-pyran-2-one ring in comparison to the smaller Me and Ph groups). As a consequence, the *anti* group (the 2*H*-pyran-2-one ring) of the intermediate (**4**) would migrate preferentially, with the concomitant extrusion of nitrogen, thus leading to the formation of the compounds (**2a**–**f**) as the major regioisomers. The differences in stability between the *syn* and *anti* isomers (**4**) are more pronounced with the 5-acetyl derivatives (**1a**–**c**) than with the 5-benzoyl derivatives (**1d**–**f**)**,** and, therefore, the expected regioselectivity is higher with the acetyl derivatives.

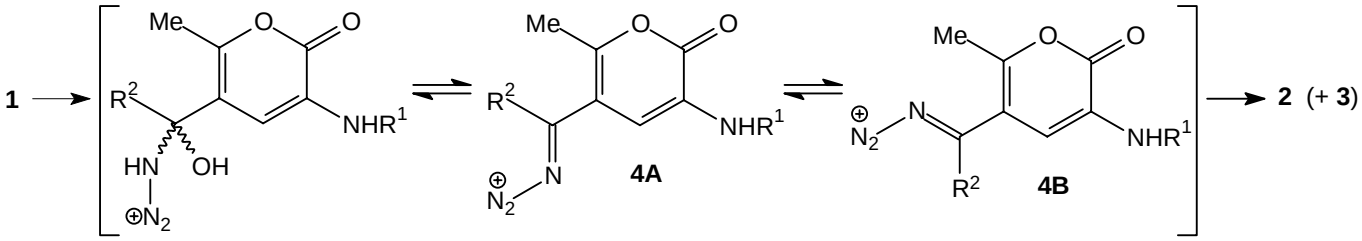


Figure 1

For comparison, the previously observed regiochemistry in the Schmidt reaction of the cycloalkenone-fused pyran-2-ones[4] can be attributed to the transition-state factors rather than to the equilibrium populations of the iminodiazonium ions (**5**). In accordance with the previous investigation,[6,7] the following has to be taken into consideration: the lone-pair delocalization of the pyran oxygen atom would inhibit the pyran-2-one ring migration by increasing the double-bond character between 4a-C and 5-C in the intermediate (**5**); on the other hand, it would also enhance the alkyl migration by stabilizing the carbocation (**6**) (Figure 2).

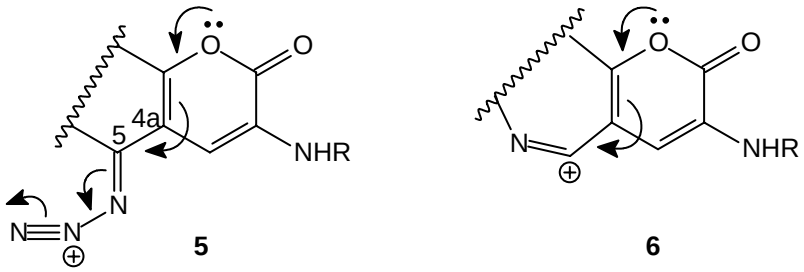
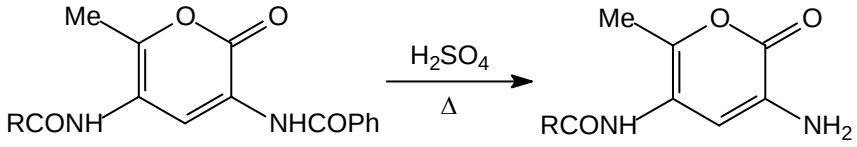


Figure 2

In order to demonstrate the synthetic potential of the 3,5-diacylamino-2*H*-pyran-2-ones, the compounds (**2a**) and (**2d**) were heated for 2 h in concentrated sulfuric acid at 70–75 °C. The reaction resulted in the

selective deprotection of the 3-amino group, yielding the corresponding 5-acylamino-3-amino2*H*-pyran-2-ones (**2b**) and (**2e**) in 79% and 82% yields, respectively (Scheme 2).



2a: R = Me
2d: R = Ph

2b: R = Me
2e: R = Ph

Scheme 2

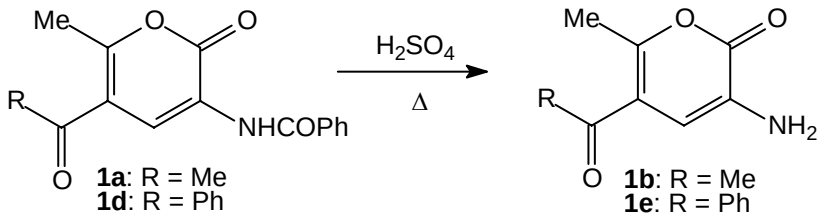
In conclusion, we have presented an application of the Schmidt reaction with respect to the 5-acyl-2*H*-pyran-2-ones (**1**), which preferentially led to the formation of the 3,5-diamino substituted 2*H*-pyran-2-ones (**2**) as a result of the pyran-2-one moiety migration. Thus, in the 5-acetyl series, the corresponding 5-acetylamino derivatives (**2a**–**c**) were obtained as sole products, whereas the 5-benzoyl analogues afforded a mixture of the 5-benzoylamino derivatives (**2d**–**f**) and the *N*-phenylcarboxamides (**3d**–**f**) in the approximate ratio 4:1. The 3-benzoylamino group of derivatives (**2**) can be deprotected in hot sulfuric acid, while the 5-acylamino groups are much more stable.

EXPERIMENTAL

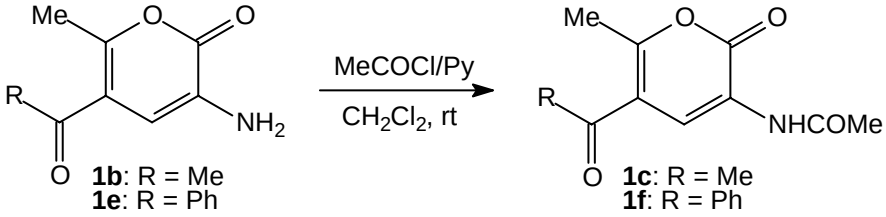
Melting points were determined on a Kofler micro hot stage, and are uncorrected. ^{1}H and ^{13}C spectra were recorded at 29 °C in DMSO-d_6 with a Bruker Avance DPX 300 spectrometer, using TMS as an internal standard. ^{13}C NMR spectra are referenced against the central line of DMSO-d_6 at δ = 39.5 ppm. IR spectra were obtained with a Bio-Rad FTS 3000 MX spectrophotometer. MS spectra were recorded with a VG-Analytical AutoSpec Q instrument. Elemental analyses (C, H, N) were performed with a Perkin-Elmer 2400 CHNS/O Analyzer. TLC was carried out on Fluka silica-gel TLC-cards. Column chromatography was carried out with Fluka silica-gel 60 (220–440 mesh).

Synthesis of the starting compounds (1b,c,e,f):

General procedure for the synthesis of 1b,e. A mixture of 10 mmol of 2*H*-pyran-2-one (**1a** or **1d**) and 10 mL of concentrated sulfuric acid was heated for 2 h at 70–75 °C. After cooling, the solution was added to ~80 g of ice; the separated benzoic acid was filtered off and washed with a small amount of water. The filtrate was neutralized with solid $NaHCO_3$, and the water layer was extracted with CH_2Cl_2 (3×60 mL). The collected organic layers were dried over anhydrous Na_2SO_4, filtered and evaporated to dryness to give product (**1b** or **1e**).



General procedure for the synthesis of 1c,f. To a mixture of 5 mmol of amine (**1b** or **1e**) in pyridine (0.45 mL, 5.56 mmol) and CH_2Cl_2 (15 mL) acetyl chloride (0.4 mL, 98%, 5.56 mmol) in CH_2Cl_2 (2 mL) was slowly added at rt. The reaction mixture was stirred at the same temperature for 1 h, after which it was evaporated. After the addition of water (10 mL), the product (**1c** or **1f**) was separated by filtration and washed with a small amount of water.



Yields, analytical and spectroscopic data of products (1b,c,e,f):

5-Acetyl-3-amino-6-methyl-2*H*-pyran-2-one (1b): yield 90%, mp 105–106.5 °C (petroleum ether/EtOAc); IR (KBr) ν_{max}/cm^{-1}: 3466, 3407, 3348, 1726, 1674, 1626, 1585; ^1H NMR (300 MHz): δ 2.399 (s, 3H, Me), 2.403 (s, 3H, Me), 5.34 (s, 2H, NH_2), 6.72 (s, 1H, 4-H); ^{13}C NMR (75.5 MHz): δ 18.8, 29.5, 109.5, 117.3, 131.3, 153.8, 158.7, 196.6; MS *m/z* 167 (M^+, 100%). Anal. Calcd for $C_8H_9NO_3$: C, 57.48; H, 5.43; N, 8.38. Found: C, 57.62; H, 5.52; N, 8.66.

***N*-(5-Acetyl-6-methyl-2-oxo-2*H*-pyran-3-yl)acetamide (1c):** yield 95%, mp 150–152 °C (EtOH); IR (KBr) ν_{max}/cm^{-1}: 3335, 1717, 1678 br, 1618, 1542 br; ^1H NMR (300 MHz): *δ* 2.12 (s, NHCO*Me*), 2.43 (s, 3H, COMe), 2.50 (s, 3H, Me), 8.55 (s, 1H, 4-H), 9.67 (s, 1H, NH); ^{13}C NMR (75.5 MHz): *δ* 19.5, 23.7, 29.4, 116.3, 122.3, 124.7, 157.3, 161.2, 170.1, 195.8; MS *m/z* 209 (M^+, 34), 167 (100). Anal. Calcd for $C_{10}H_{11}NO_4$: C, 57.41; H, 5.30; N, 6.70. Found: C, 57.55; H, 5.35; N, 6.60.

3-Amino-5-benzoyl-6-methyl-2*H*-pyran-2-one (1e): yield 95%, mp 111–113 °C (EtOH/H_2O); IR (KBr) ν_{max}/cm^{-1}: 3461, 3349, 1707, 1658, 1626, 1588; ^1H NMR (300 MHz): *δ*2.13 (s, 3H, Me), 5.40 (s, 2H, NH_2), 6.34 (s, 1H, 4-H), 7.56 (m, 2H, Ph), 7.68 (m, 1H, Ph), 7.78 (m, 1H, Ph); ^{13}C NMR (75.5 MHz): *δ* 17.9, 109.6, 117.1, 128.7, 129.2, 131.3, 133.2, 137.2, 151.4, 159.0, 193.8; MS *m/z* 229 (M^+, 100), 105 (97). Anal. Calcd for $C_{13}H_{11}NO_3$: C, 68.11; H, 4.84; N, 6.11. Found: C, 68.02; H, 4.96; N, 6.32.

***N*-(5-Benzoyl-6-methyl-2-oxo-2*H*-pyran-3-yl)acetamide (1f):** yield 98%, mp 216–218 °C (EtOH) (lit.,[11] mp 217–219 °C).

General procedure for the Schmidt reaction:

To a mixture of the 5-acyl-2*H*-pyran-2-one derivative (**1**) (2–12 mmol) in $CHCl_3$ (20 mL/1 mmol of substrate) and concentrated sulfuric acid (1 mL/1 mmol of substrate) in an ice/NaCl bath (temperature of the reaction mixture about –10 to 0 °C) or in a water bath at 32–35 °C an excess of sodium azide (6 mmol/1 mmol of substrate) was added portion-wise during 15 min; the reaction mixture was further stirred for the time and at the temperature as specified in Table 1. After the addition of ice and water (~30 g/1 mmol of substrate) the mixture was neutralized with solid $NaHCO_3$ and the water layer was extracted with $CHCl_3$ (3×15 mL/1 mmol of substrate). The collected organic layers were dried over anhydrous Na_2SO_4 to give products (**2a**–**c**) or a mixture of products (**2d**–**f**) and (**3d**–**f**). In the case of **2b** or **2c**, the solid residue, obtained after the evaporation of the water layer, was extracted with hot chloroform (**2b**) or hot acetone (**2c**), yielding an additional amount of the product. Products (**2d**–**f**) and (**3d**–**f**) were separated by column chromatography with EtOAc/petroleum ether (1:1) as the eluant. The isolated yields from the mixtures of products were as follows: **2d** (40%), **2e** (43%), **2f** (39%), **3d** (20%), **3e** (22%), **3f** (25%).

Preparation of compounds (2b) and (2e) from (2a) and (2d): A mixture of 2 mmol of **2a** (**2d**) and 2 mL of concentrated sulfuric acid was heated for 2 h at 70–75 °C. After cooling, the solution was added to ~20 g of ice; the separated benzoic acid was filtered off and washed with a small amount of water. The filtrate was neutralized with solid $NaHCO_3$ and the water layer was extracted with CH_2Cl_2 (3×15 mL). The collected organic layers were dried over anhydrous Na_2SO_4, filtered and evaporated to dryness to give the product (**2b**) in a 52% yield (**2e**, 82% yield). An additional amount of **2b** (27%) was extracted with hot chloroform from the solid residue obtained after evaporation of the water layer.

Analytical and spectroscopic data of products (2) and (3):

***N*-[5-Acetylamino-6-methyl-2-oxo-2*H*-pyran-3-yl]benzamide (2a):** mp 204–206 °C (H_2O/MeOH); IR (KBr) ν_{max}/cm^{-1}: 3401, 3270, 1720, 1670, 1656, 1522; ^{1}H NMR (300 MHz): δ2.02 (s, 3H, Me), 2.17 (s, 3H, Me), 7.57 (m, 3H, Ph), 7.92 (m, 2H, Ph), 8.03 (s, 1H, 4-H), 9.48 (s, 1H, NH), 9.51 (s, 1H, NH); ^{13}C NMR (75.5 MHz): δ 15.9, 22.7, 115.7, 121.7, 127.5, 128.5, 130.5, 132.1, 133.5, 151.1, 158.2, 165.7, 168.9; MS *m/z* 286 (M^+, 28), 244 (74), 105 (100). Anal. Calcd for $C_{15}H_{14}N_2O_4$: C, 62.93; H, 4.93; N, 9.79. Found: C, 63.03; H, 4.97; N, 9.76.

***N*-(3-Amino-6-methyl-2-oxo-2*H*-pyran-5-yl)acetamide (2b):** mp 177–180 °C (1,4-dioxane); IR (KBr) ν_{max}/cm^{-1}: 3443, 3357, 3269, 1719, 1645, 1626, 1570, 1520; ^{1}H NMR (300 MHz): δ1.96 (s, 3H, MeCO), 2.02 (s, 3H, Me), 5.18 (s, 2H, NH_2), 6.30 (s, 1H, 4-H), 9.19 (s, 1H, NH); ^{13}C NMR (75.5 MHz): δ 15.2, 22.8, 112.4, 116.5, 131.3, 142.5, 159.3, 168.6; MS *m/z* 182 (M^+, 100), 140 (31). HRMS Calcd for $C_8H_{10}N_2O_3$: 182.0691, found: 182.0700.

***N*-[3-Acetylamino-6-methyl-2-oxo-2*H*-pyran-5-yl]acetamide (2c):** mp 244–246 °C (EtOH); IR (KBr)

ν_{max}/cm^{-1}: 3254, 1732, 1663, 1584, 1521 br; ^{1}H NMR (300 MHz): δ 1.99 (s, 3H, Me), 2.10 (s, 3H, Me), 2.11 (s, 3H, Me), 8.08 (s, 1H, 4-H), 9.40 (s, 1H, NH), 9.53 (s, 1H, NH); ^{13}C NMR (75.5 MHz): δ 15.8, 22.6, 23.7, 115.6, 122.2, 127.0, 149.6, 157.9, 168.8, 169.9; MS *m/z* 224 (M^+, 42), 182 (100), 140 (94). Anal. Calcd for $C_{10}H_{12}N_2O_4$: C, 53.57; H, 5.39; N, 12.49. Found: C, 53.69; H, 5.53; N, 12.30.

***N*-[3-Benzoylamino-6-methyl-2-oxo-2*H*-pyran-5-yl]benzamide (2d):** mp 265–267 °C (EtOH/DMF); IR (KBr) ν_{max}/cm^{-1}: 3412, 3271 br, 1721, 1672, 1645, 1524; ^{1}H NMR (300 MHz): δ 2.23 (s, 3H, Me), 7.60 (m, 6H, two Ph), 7.96 (m, 4H, two Ph), 8.11 (s, 1H, 4-H), 9.58 (s, 1H, 3-N*H*COPh), 10.00 (s, 1H, 5-N*H*COPh); ^{13}C NMR (75.5 MHz): δ 16.2, 115.6, 121.8, 127.6, 127.7, 128.4, 128.5, 131.2, 131.9, 132.1, 133.46, 133.50, 152.4, 158.3, 165.78, 165.80; MS *m/z* 348 (M^+, 12), 105 (100). Anal. Calcd for $C_{20}H_{16}N_2O_4$: C, 68.96; H, 4.63; N, 8.04. Found: C, 68.73; H, 4.63; N, 8.03.

***N*-(3-Amino-6-methyl-2-oxo-2*H*-pyran-5-yl)benzamide (2e):** mp 259–261 °C (H_2O/EtOH); IR (KBr) ν_{max}/cm^{-1}: 3449, 3338, 3250 br, 1702, 1638, 1549; ^{1}H NMR (300 MHz): δ 2.08 (s, 3H, Me), 5.26 (s, 2H, NH_2), 6.37 (s, 1H, 4-H), 7.55 (m, 3H, Ph), 7.94 (m, 2H, Ph), 9.74 (s, 1H, NH); ^{13}C NMR (75.5 MHz): δ 15.4, 112.7, 116.4, 127.5, 128.4, 131.5, 131.7, 133.9, 143.6, 159.3, 165.6; MS *m/z* 244 (M^+, 49), 105 (100). Anal. Calcd for $C_{13}H_{12}N_2O_3$: C, 63.93; H, 4.95; N, 11.47. Found: C, 63.82; H, 5.09; N, 11.26.

***N*-[3-Acetylamino-6-methyl-2-oxo-2*H*-pyran-5-yl]benzamide (2f):** mp 225–227 °C (MeOH/DMF); IR (KBr) ν_{max}/cm^{-1}: 3328, 1716, 1690, 1653, 1518; ^{1}H NMR (300 MHz): δ 2.11 (s, 3H, NHCO*Me*), 2.17 (s, 3H, Me), 7.58 (m, 3H, Ph), 7.96 (m, 2H, Ph), 8.16 (s, 1H, 4-H), 9.60 (s, 1H, N*H*COMe), 9.94 (s, 1H, N*H*COPh); ^{13}C NMR (75.5 MHz): δ 16.0, 23.7, 115.6, 122.3, 127.3, 127.6, 128.4, 131.8, 133.5, 150.6, 157.9, 165.7, 170.0; MS *m/z* 286 (M^+, 13), 105 (100). HRMS Calcd for $C_{15}H_{14}N_2O_4$: 286.0954, found: 286.0961. Anal. Calcd for $C_{15}H_{14}N_2O_4$×¼ H_2O: C, 61.96; H, 5.03; N, 9.63. Found: C, 62.10; H, 5.01; N, 9.68.

3-Benzoylamino-6-methyl-2-oxo-*N*-phenyl-2*H*-pyran-5-carboxamide (3d): mp 205–207 °C (MeOH/DMF); IR (KBr) ν_{max}/cm^{-1}: 3418, 3275, 1724, 1674, 1651, 1523; ^{1}H NMR (300 MHz): δ 2.45 (s, 3H, Me), 7.12 (m, 1H, Ph), 7.36 (m, 2H, Ph), 7.60 (m, 5H, Ph), 7.95 (m, 2H, Ph), 8.22 (s, 1H, 4-H), 9.71 (s, 1H, N*H*COPh), 10.38 (s, 1H, Ph-N*H*); ^{13}C NMR (75.5 MHz): δ 18.2, 114.4, 119.9, 121.9, 124.0, 127.6, 128.5, 128.7, 129.1, 132.1, 133.4, 138.6, 158.1, 158.2, 163.2, 165.9; MS *m/z* 348 (M^+, 31), 256 (12), 105 (100). Anal. Calcd for $C_{20}H_{16}N_2O_4$: C, 68.96; H, 4.63; N, 8.04. Found: C, 68.95; H, 4.66; N, 8.35.

3-Amino-6-methyl-2-oxo-*N*-phenyl-2*H*-pyran-5-carboxamide (3e): mp 209–211 °C (H_2O/MeOH); IR (KBr) ν_{max}/cm^{-1}: 3464 br, 3347 br, 1705, 1651; ^{1}H NMR (300 MHz): δ 2.29 (s, 3H, Me), 5.39 (s, 2H, NH_2), 6.46 (s, 1H, 4-H), 7.09 (m, 1H, Ph), 7.33 (m, 2H, Ph), 7.65 (m, 2H, Ph), 10.20 (s, 1H, NH); ^{13}C NMR (75.5 MHz): δ 17.3, 109.5, 115.4, 119.7, 123.7, 128.6, 131.5, 138.8, 148.6, 159.1, 164.3; MS *m/z* 244 (M^+, 83), 152 (100). Anal. Calcd for $C_{13}H_{12}N_2O_3$: C, 63.93; H, 4.95; N, 11.47. Found: C, 63.76; H, 4.99; N, 11.30.

3-Acetylamino-6-methyl-2-oxo-*N*-phenyl-2*H*-pyran-5-carboxamide (3f): mp 202–204 °C

(MeOH/DMF); IR (KBr) ν_{max}/cm^{-1}: 3335, 3269, 1712, 1687, 1655, 1524 br; ^1H NMR (300 MHz): δ2.13 (s, 3H, NHCO*Me*), 2.38 (s, 3H, Me), 7.11 (m, 1H, Ph), 7.35 (m, 2H, Ph), 7.65 (m, 2H, Ph), 8.28 (s, 1H, 4-H), 9.70 (s, 1H, N*H*COMe), 10.33 (s, 1H, Ph-N*H*); ^{13}C NMR (75.5 MHz): δ 18.0, 23.7, 114.6, 119.9, 122.5, 124.0, 124.7, 128.7, 138.6, 156.0, 157.8, 163.4, 170.1; MS *m/z* 286 (M^+, 37), 194 (12), 93 (100). HRMS Calcd for $C_{15}H_{14}N_2O_4$: 286.0954, found: 286.0960.

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