Manganese(III)-Mediated Direct Introduction of 3-Oxobutanamides into Methoxynaphthalenes

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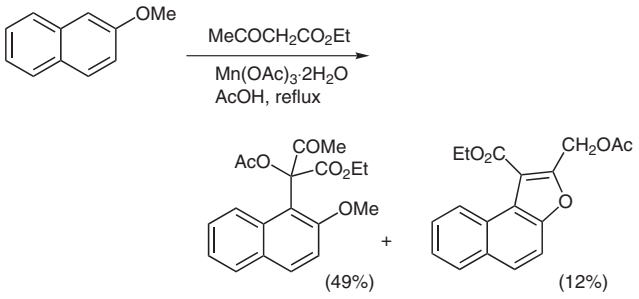
Abstract: The oxidation of methoxynaphthalenes with manganese(III) acetate in the presence of *N*-aryl-3-oxobutanamides gave the directly 3-oxobutanamide-substituted methoxynaphthalenes in moderate to good yields along with small amounts of naphtho[2,1-*b*]furans and benzo[*e*]indolinones. The optimized reaction conditions and the mechanism for the formation of the products are discussed.

Key words: oxidations, manganese, radicals, aromatic substitutions, cyclizations

The redox radical process is an important tool for the formation of the carbon–carbon bond in organic synthesis.[1] Manganese(III) acetate is well known as a mild one-electron oxidant and widely used to construct the carbon–carbon bond using oxidatively formed carbon radicals.[2] Accordingly, the intramolecular oxidative free-radical cyclization or annulation[2d,e] and intermolecular addition[2b,c,f] using manganese(III) acetate have been extensively investigated. In recent years, our research group has developed various manganese(III) based oxidative reactions,[2b,3] and we[4] and other groups[5] have found that the reaction of aromatic substrates with active methylene species, such as malonic acids, malonates, malonamide, α-cyanoacetamide, malononitrile, β-keto esters, and β-diketones gave various interesting functionalized products. For example, the reaction of methoxynaphthalenes with ethyl 3-oxobutanoate afforded substituted products in moderate yields together with a small amount of naphtho[2,1-*b*]furans (Scheme 1).[4c] Dimethyl malonate also gave similar results.[5a] Since the naphthofuran skeleton is found in a wide range of natural and unnatural compounds, which exhibit important biological and pharmacological activities,[6] it is worthwhile to explore the possible manganese(III) acetate mediated oxidation of methoxy-substituted naphthalenes with *N*-aryl-3-oxobutanamides, which are expected to develop an efficient method for the preparation of functionalized naphtho[2,1-*b*]furans or benzo[*e*]indolinones. Therefore, we initially examined the reaction using *N*-phenyl-3-oxobutanamide, which gave a complex product distribution and a poor yield of the expected cyclization products. However, by changing the reaction conditions, the directly 3-oxobutanamide-substituted naphthalenes were unexpectedly formed in fairly good yields. In general, 2-substituted 1,3-dicarbonyl compounds are versatile intermediates in organic synthesis.[7] In addition, the manganese(III) acetate based oxidation showed an efficient method for the alkylation of 1,3-dicarbonyl compounds.[4,5,8] In view of the potential synthetic utility of this approach and as a continuation of our interest in the development of efficient synthetic methodologies using manganese(III) acetate, we scrutinized the direct introduction of 3-oxobutanamides into methoxynaphthalenes.



Scheme 1

Based on our previously related research experience,[4b,c] 2,7-dimethoxynaphthalene (**1a**) was selected as an aromatic substrate for the reaction aimed at optimizing the reaction conditions since the obtained products could be readily separated and characterized. The reaction of **1a** with *N*-phenyl-3-oxobutanamide (**2a**) in the presence of manganese(III) acetate was examined in boiling acetic acid since manganese(III) acetate is only soluble in hot carboxylic acid (Scheme 2).[4d] A mixture of **1a** and **2a** in a molar ratio of 1:2 was heated in glacial acetic acid, and manganese(III) acetate (6 equiv) was added just before refluxing (Method A). The reaction was complete within 1 minute similar to the previously reported result,[4c,5a] and the 3-oxobutanamide-substituted naphthalene **3aa**, naphtho[2,1-*b*]furan **4aa**, and benzoindolinone **5aa** were obtained in 18, 23 and 7% yield, respectively (Table 1, entry 1). To overcome the lower conversion of the starting material **1a**, an excess amount of manganese(III) acetate was used (Table 1, entries 2, 3). As a result, **1a** was completely consumed when 12 equivalents of the oxidant were added. However, the total yield of the products was only slightly improved (a 9% increase in yield).[9] It seemed that the use of a large amount of the oxidant resulted in the self-oxida-

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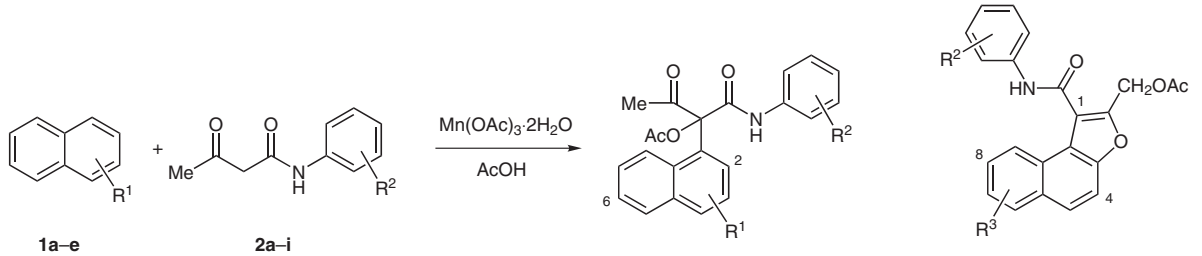


1a–e **2a–i** **3** **4** **5**

1a: R^1 = 2,7-$(MeO)_2$
1b: R^1 = 2,6-$(MeO)_2$
1c: R^1 = 2-MeO
1d: R^1 = 1,7-$(MeO)_2$
1e: R^1 = 1-MeO

2a: R^2 = H
2b: R^2 = 2'-Cl
2c: R^2 = 4'-Cl
2d: R^2 = 2'-MeO
2e: R^2 = 4'-MeO
2f: R^2 = 2'-O_2N
2g: R^2 = 2'-Me
2h: R^2 = 4'-Me
2j: R^2 = 4'-F

3aa: R^1 = 2,7-$(MeO)_2$, R^2 = H
3ab: R^1 = 2,7-$(MeO)_2$, R^2 = 2'-Cl
3ac: R^1 = 2,7-$(MeO)_2$, R^2 = 4'-Cl
3ad: R^1 = 2,7-$(MeO)_2$, R^2 = 2'-MeO
3ae: R^1 = 2,7-$(MeO)_2$, R^2 = 4'-MeO
3af: R^1 = 2,7-$(MeO)_2$, R^2 = 2'-NO2
3ag: R^1 = 2,7-$(MeO)_2$, R^2 = 2'-Me
3ah: R^1 = 2,7-$(MeO)_2$, R^2 = 4'-Me
3ai: R^1 = 2,7-$(MeO)_2$, R^2 = 4'-F
3ba: R^1 = 2,6-$(MeO)_2$, R^22 = H
3ca: R^1 = 2-MeO, R^2 = H
3da: R^1 = 4,6-$(MeO)_2$, R^2 = H
3ea: R^1 = 4-MeO, R^2 = H

4aa, **5aa**: R^2 = H, R^3 = 8-MeO
4ab, **5ab**: R^2 = 2'-Cl, R^3 = 8-MeO
4ac, **5ac**: R^2 = 4'-Cl, R^3 = 8-MeO
4ad, **5ad**: R^2 = 2'-MeO, R^3 = 8-MeO
4ae, **5ae**: R^2 = 4'-MeO, R^3 = 8-MeO
4af, **5af**: R^2 = 2'-NO_2, R^3 = 8-MeO
4ag, **5ag**: R^2 = 2'-Me, R^3 = 8-MeO
4ah, **5ah**: R^2 = 4'-Me, R^3 = 8-MeO
4ai, **5ai**: R^2 = 4'-F, R^3 = 8-MeO
4ba, **5ba**: R^2 = H, R^3 = 7-MeO
4ca, **5ca**: R^2 = R^3 = H
4da: R^2 = H, R^3 = 9-MeO

Scheme 2

tion of **1a** as well as the formation of a dimer or trimer of **2a**.[5a,10]

In order to improve the conversion of **1a**, we adopted the high-dilution conditions of **2a** toward the oxidant (Method B). To a heated solution of **1a** and **2a** in a molar ratio of 1:0.3 in glacial acetic acid was added manganese(III) acetate (6 equiv) just before refluxing, and then another portion of **2a** (1.0 equiv) dissolved in AcOH was dropwise added through a dropping funnel. The oxidant was consumed in 2 minutes and the substituted product **3aa** was preferentially produced in 63% yield along with **4aa** and **5aa** in 14% and 8% yields, respectively (Table 1, entry 4). When the reaction was carried out at 70 °C, a maximum yield of **3aa** (79%) was achieved (Table 1, entry 5).

This result encouraged us to apply the process using other *N*-aryl-3-oxobutanamides **2b–i** because of the good selectivity of **2a** in the formation of the directly substituted product **3aa**. The reaction of **1a** with *N*-(2-chlorophenyl)- (**2b**), *N*-(4-chlorophenyl)- (**2c**), *N*-(2-methoxyphenyl)- (**2d**), *N*-(4-methoxyphenyl)- (**2e**), *N*-(2-nitrophenyl)- (**2f**), *N*-(2-methylphenyl)- (**2g**), *N*-(4-methylphenyl)- (**2h**), and *N*-(4-fluorophenyl)-3-oxobutanamide (**2i**) gave the corresponding substitution products **3ab–3ai** in good yields together with a small amount of the addition products **4ab–4ai** and **5ab–5ai**, respectively (Table 1, entries 6–13). Use of 2,6-dimethoxy- (**1b**), 2-methoxy- (**1c**), 1,7-dimethoxy- (**1d**), and 1-methoxynaphthalene (**1e**) instead of **1a** also afforded similar products (Table 1, entries 14–17).

The mechanism for the formation of three products **3**, **4**, and **5** could be explained as follows. Analogous to the previously reported oxidative radical reaction pathway,[4,11] the manganese(III)-3-oxobutanamide enolate complex **2′** is formed by the ligand-exchange reaction of manganese(III) acetate with the *N*-aryl-3-oxobutanamides **2** during the first stage. The electron-deficient enolate complex **2′** would interact with the electron-rich methoxynaphthalenes **1** to afford an electron donor–acceptor-like complex **A**,[11] followed by a one-electron transfer to give radical **B**, which should be easily oxidized by manganese(III) to yield the intermediate cation **C**. It was expected that the aromatization process accompanied by deprotonation should be fast, giving the substitution product **D**. Since product **D** still has an active methine proton, product **D** should be oxidized by an excess amount of manganese(III) acetate to give **3** (Scheme 3, path a).[4c] On the other hand, the intermediate cation **C** could be intramolecularly attacked by the acetyl oxygen or amide nitrogen. The O-cyclization followed by elimination of methanol would give the naphthofuran **F**, which would then be converted into acetoxymethylnaphthofuran **4** via the benzyl-type oxidation (path b).[4c] On the other hand, when the amide nitrogen would attack intramolecularly at the positive charge in cation **C**, a benzoindolinone **H** would be produced, and the hydroxybenzoindolinone **5** would be eventually obtained by further oxidation (path c).

Table 1 Reaction of Methoxynaphthalenes **1a–e** with 3-Oxobutanamides **2a–i** in the Presence of $Mn(OAc)_3·2H_2O$[a]

Entry	1	2	Molar ratio[b]	Temp (°C)	Time (min)	Recovery (%)	Product(s) (Yield, %)[c]		
1[d]	**1a**	**2a**	1:2:6	reflux	1	30	**3aa** (18)	**4aa** (23)	**5aa** (7)
2[d]	**1a**	**2a**	1:2:8	reflux	1	14	**3aa** (17)	**4aa** (25)	**5aa** (12)
3[d]	**1a**	**2a**	1:3:12	reflux	1	–	**3aa** (22)	**4aa** (19)	**5aa** (16)
4[e]	**1a**	**2a**	1:1.3:6	reflux	2	4	**3aa** (63)	**4aa** (14)	**5aa** (8)
5[e]	**1a**	**2a**	1:1.2:6	70	2	7	**3aa** (79)	**4aa** (5)	**5aa** (5)
6[e]	**1a**	**2b**	1:1.2:6	70	2	9	**3ab** (76)	**4ab** (1)[f]	**5ab** (11)[f]
7[e]	**1a**	**2c**	1:1.2:6	70	2	10	**3ac** (70)	**4ac** (4)	**5ac** (9)
8[e]	**1a**	**2d**	1:1.2:6	70	2	9	**3ad** (59)	**4ad** (trace)	**5ad** (15)
9[e]	**1a**	**2e**	1:1.2:6	70	2	37	**3ae** (30)	**4ae** (3)	**5ae** (trace)
10[e]	**1a**	**2f**	1:1.2:6	70	2	5	**3af** (69)	**4af** (trace)	**5af** (12)
11[e]	**1a**	**2g**	1:1.2:6	70	2	12	**3ag** (53)	**4ag** (19)	**5ag** (trace)
12[e]	**1a**	**2h**	1:1.2:6	70	2	10	**3ah** (51)	**4ah** (8)	**5ah** (9)
13[e]	**1a**	**2i**	1:1.2:6	70	2	14	**3ai** (60)	**4ai** (13)	**5ai** (15)
14[e]	**1b**	**2a**	1:1.2:6	70	3	24	**3ba** (35)	**4ba** (9)	**5ba** (4)
15[e]	**1c**	**2a**	1:1.2:6	70	2	14	**3ca** (35)	**4ca** (15)	**5ca** (12)
16[e]	**1d**	**2a**	1:1.2:6	70	2	21	**3da** (28)	**4da** (9)	–
17[e]	**1e**	**2a**	1:1.2:6	70	2	13	**3ea** (67)	–	–

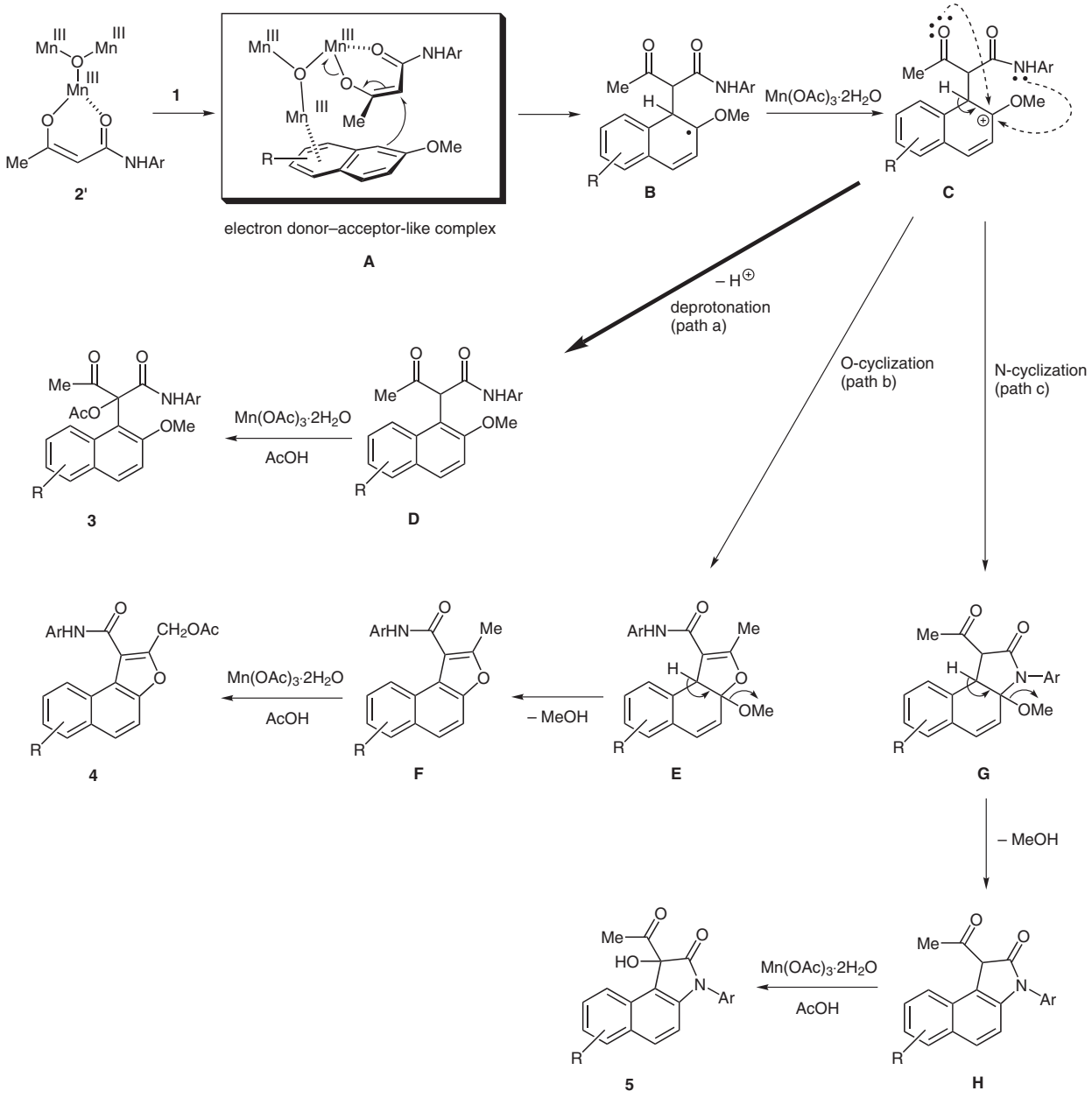
[a] The reaction was carried out in glacial AcOH.
[b] **1**:**2**:$Mn(OAc)_3·2H_2O$.
[c] Isolated yield based on the amount of the added methoxynaphthalene **1**.
[d] The reaction was conducted using Method A described in the experimental section.
[e] The reaction was carried out using Method B mentioned in the experimental section.
[f] An intractable mixture of **4ab** and **5ab** was obtained and the yield was estimated on the basis of the integration of the NH and OH peaks in the ^1H NMR spectrum.

In conclusion, we have developed an efficient way to directly prepare the 3-oxobutanamide-substituted naphthalenes **3** by the oxidation of methoxynaphthalenes **1** with manganese(III) acetate by controlling the proportion of the 3-oxobutanamides **2** in the reaction mixture at 70 °C. The reaction is very simple and the reaction times are very short. Although it was difficult to improve the yield of **3**, this is an interesting procedure to prepare heterocyclic compounds using the functionalized naphthalenes **3**. Further studies on the synthesis of functionalized heterocyclic compounds using **3** are now in progress.

The NMR spectra were recorded using a JNM AL300 FT NMR spectrometer at 300 MHz for ^1H and at 75 MHz for ^{13}C with tetramethylsilane as the internal standard. The chemical shifts are given in δ values (ppm) and the coupling constants in Hz. The IR spectra of the neat samples were measured using the KBr disc or $CHCl_3$ solution by a Shimadzu 8400 FT IR spectrometer and expressed in cm^{-1}. The EI MS spectra were recorded by a Shimadzu QP-5050A gas chromatograph-mass spectrometer at an ionizing voltage of 70 eV. The elemental analyses were performed at the Instrumental Analysis Center of Kumamoto University, Kumamoto, Japan. $Mn(OAc)_2·4H_2O$ was purchased from Wako Pure Chemical Ind., Ltd. $Mn(OAc)_3·2H_2O$ was prepared according to the method described in the literature.[12] Methoxynaphthalenes **1a–e** were prepared by the methylation of the corresponding naphthols using dimethyl sulfate in anhyd acetone in the presence of anhyd K_2CO_3.

Oxidation of Methoxynaphthalenes 1 with Manganese(III) Acetate in the Presence of *N*-Aryl-3-oxobutanamides 2; Compounds 3aa, 4aa, and 5aa; Typical Procedure (Table 1, Entry 1)

Method A: To a heated solution of 2,7-dimethoxynaphthalene (**1a**; 188 mg, 1 mmol) and *N*-phenyl-3-oxobutanamide (**2a**; 354 mg, 2 mmol) in glacial AcOH (25 mL) was added $Mn(OAc)_3·2H_2O$ (1.608 g, 6 mmol) was added just before refluxing. The reaction was complete within 1 min when the dark-brown color of the solution turned clear red. The mixture was then cooled to r.t., and the solvent was removed in vacuo. The residue was triturated with aq 2 M (1 M = 1 mol dm^{-3}) HCl (30 mL) followed by extraction with $CHCl_3$ (3 × 20 mL). The combined organic extracts were washed with sat. aq $NaHCO_3$ (2 × 20 mL) and H_2O (2 × 20 mL), dried ($MgSO_4$), and concentrated to dryness. The products were separated by silica gel TLC (Wako B-10) by eluting with $CHCl_3$, and **3aa** (76 mg, 18%; R_f = 0.22), **4aa** (89 mg, 23%; R_f = 0.43), and **5aa** (24 mg, 7%; R_f = 0.33) were obtained together with recovered **1a** (56 mg, 30%; R_f = 0.73). The products were further purified by recrystallization



Scheme 3

from appropriate solvents. Entries 2 and 3 in Table 1 were carried out with this method.

Method B (Table 1, Entry 4): A mixture of 2,7-dimethoxynaphthalene (**1a**; 188 mg, 1 mmol), *N*-phenyl-3-oxobutanamide (**2a**; 35.4 mg, 0.2 mmol), and glacial AcOH (18 mL) was placed in a three-necked flask equiped with a condenser and a dropping funnel. To the heated solution was added $Mn(OAc)_3·2H_2O$ (1.608 g, 6 mmol) just before refluxing, and then another portion of **2a** (177 mg, 1 mmol) dissolved in glacial AcOH (7 mL) was dropwise added within 2 min. The mixture was cooled to r.t., and the solvent was removed in vacuo. The residue was worked up by the same procedure as described for Method A to give the products **3aa** (333 mg, 79%), **4aa** (21 mg, 5%), and **5aa** (17 mg, 5%) along with recovered **1a** (13 mg, 7%). Entries 5–17 in Table 1 were carried out by this method at 70 °C.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-phenyl-3-oxobutanamide (3aa)

Colorless needles (from MeOH); mp 161.5–162 °C.

IR (KBr): 3427, 3389, 1768, 1730, 1701 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.43 (1 H, s, NH), 7.78 (1 H, d, *J* = 9.0 Hz, H-5), 7.66–7.63 (2 H, m, H-4, H-8), 7.47 (2 H, d, *J* = 8.1 Hz, H-2′, H-6′), 7.26 (2 H, td, *J* = 7.8, 1.8 Hz, H-3′, H-5′), 7.08–6.99 (3 H, m, H-3, H-6, H-4′), 3.87 (3 H, s, OCH_3), 3.79 (3 H, s, OCH_3), 2.35 (3 H, s, $COCH_3$), 2.25 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 199.2, 168.3, 164.5, 158.1, 155.8, 137.4, 134.3, 132.2, 130.1, 128.9, 125.8, 124.5, 119.8, 116.7, 115.8, 110.9, 104.1, 89.6, 56.2, 55.0, 26.3, 21.1.

MS: *m*/*z* = 421 (M^+, 12%).

Anal. Calcd for $C_{24}H_{23}NO_6$: C, 68.40; H, 5.50; N, 3.32. Found: C, 68.20; H, 5.46; N, 3.25.

2-Acetoxy-*N*-(2′-chlorophenyl)-2-(2,7-dimethoxy-1-naphthyl)-3-oxobutanamide (3ab)
Colorless needles (from MeOH); mp 166–166.5 °C.

IR (KBr): 3373, 3346, 1759, 1730, 1707 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 9.09 (1 H, s, NH), 8.35 (1 H, dd, *J* = 1.5, 8.1 Hz, H-6′), 7.82 (1 H, d, *J* = 8.7 Hz, H-5), 7.67 (1 H, d, *J* = 9.3 Hz, H-4), 7.61 (1 H, s, H-8), 7.34 (1 H, dd, *J* = 1.5, 8.1 Hz, H-3′), 7.23 (1 H, t, *J* = 8.1 Hz, H-5′), 7.11 (1 H, d, *J* = 9.0 Hz, H-6), 7.05–6.99 (2 H, m, H-3, H-4′), 3.92 (3 H, s, OCH_3), 3.81 (3 H, s, OCH_3), 2.37 (3 H, s, $COCH_3$), 2.30 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 198.0, 168.1, 164.8, 158.4, 155.5, 134.3, 134.0, 132.4, 132.3, 130.3, 129.0, 127.7, 125.7, 124.8, 122.8, 116.9, 115.7,110.8, 103.8, 56.2, 55.1, 26.4, 21.1.

Anal. Calcd for $C_{24}H_{22}ClNO_6$: C, 63.23; H, 4.86; N, 3.07. Found: C, 63.12; H, 4.81; N, 3.09.

2-Acetoxy-*N*-(4′-chlorophenyl)-2-(2,7-dimethoxy-1-naphthyl)-3-oxobutanamide (3ac)
Colorless microcrystals (from $CHCl_3$–Et_2O); mp 198–199 °C.

IR (KBr): 3361, 1761, 1722, 1693 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.39 (1 H, s, NH), 7.69 (1 H, d, *J* = 8.7 Hz, H-5), 7.59 (1 H, s, H-8), 7.56 (1 H, d, *J* = 8.7 Hz, H-4), 7.32 (2 H, dd, *J* = 2.1, 9.0 Hz, H-2′, H-6′), 7.13 (1 H, d, *J* = 8.7 Hz, H-3′ or 5′), 7.11 (1 H, d, *J* = 8.7 Hz, H-5′ or 3′), 6.97 (1 H, d, *J* = 8.7 Hz, H-6), 6.92 (1 H, dd, *J* = 2.7, 8.7 Hz, H-3), 3.77 (3 H, s, OCH_3), 3.72 (3 H, s, OCH_3), 2.23 (3 H, s, $COCH_3$), 2.15 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 199.1, 168.4, 164.6, 158.3, 155.4, 135.9, 133.9, 132.3, 130.2, 129.3, 128.8, 125.6, 121.1, 116.7, 115.5, 110.7, 104.2, 89.2, 56.2, 55.0, 26.2, 21.0.

Anal. Calcd for $C_{24}H_{22}ClNO_6$: C, 63.23; H, 4.86; N, 3.07. Found: C, 63.26; H, 4.95; N, 3.07.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-(2′-methoxyphenyl)-3-oxobutanamide (3ad)
Colorless needles (from MeOH); mp 177–177.5 °C.

IR (KBr): 3382, 1759, 1728, 1699 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 9.11 (1 H, s, NH), 8.30 (1 H, d, *J* = 7.8 Hz, H-5), 7.80 (1 H, d, *J* = 8.4 Hz, H-4), 7.65 (1 H, dd, *J* = 1.5, 9.0 Hz, H-6′), 7.53 (1 H, s, H-8), 7.10 (1 H, dd, *J* = 1.5, 9.0 Hz, H-3′), 7.06–6.84 (4 H, m, H-3, H-6, H-4′, H-5′) 3.91 (3 H, s, OCH_3), 3.84 (3 H, s, OCH_3), 3.73 (3 H, s, OCH_3), 2.39 (3 H, s, $COCH_3$), 2.27 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 198.0, 167.9, 164.5, 158.3, 155.8, 148.1, 133.9, 132.1, 130.2, 127.1, 125.7, 124.2, 121.1, 119.7, 116.7, 116.6, 111.1, 110.1, 103.8, 90.4, 56.3, 55.9, 54.9, 26.7, 21.2.

Anal. Calcd for $C_{25}H_{25}NO_7$: C, 66.51; H, 5.58; N, 3.10. Found: C, 66.15; H, 5.51; N, 3.04.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-(4′-methoxyphenyl)-3-oxobutanamide (3ae)
Colorless microcrystals (from MeOH); mp 162–162.5 °C.

IR (KBr): 3357, 1767, 1715, 1689 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.29 (1 H, s, NH), 7.81 (1 H, d, *J* = 8.7 Hz, H-5), 7.67 (1 H, d, *J* = 9.0 Hz, H-4), 7.60 (1 H, s, H-8), 7.39 (2 H, d, *J* = 9.0 Hz, H-2′, H-6′), 7.10 (1 H, d, *J* = 8.7 Hz, H-3), 7.01 (1 H, dd, *J* = 2.7, 8.7 Hz, H-6), 6.82 (2 H, d, *J* = 9.0 Hz, H-3′, H-5′), 3.89 (3 H, s, OCH_3), 3.79 (3 H, s, OCH_3), 3.76 (3 H, s, OCH_3), 2.36 (3 H, s, $COCH_3$), 2.26 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 198.8, 168.3, 164.4, 158.3, 156.6, 155.7, 134.1, 132.2, 130.4, 130.2, 125.7, 121.6, 116.7, 116.3, 114.1, 111.0, 104.1, 89.8, 56.3, 55.4, 55.1, 26.5, 21.1.

Anal. Calcd for $C_{25}H_{25}NO_7$: C, 66.51; H, 5.58; N, 3.10. Found: C, 66.34; H, 5.53; N, 3.09.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-(2′-nitrophenyl)-3-oxobutanamide (3af)
Yellow microcrystals (from MeOH); mp 205.5–206.5 °C.

IR (KBr): 3335, 1759, 1730, 1705 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 11.25 (1 H, s, NH), 8.76 (1 H, dd, *J* = 1.2, 8.4 Hz, H-3′), 8.18 (1 H, dd, *J* = 1.5, 8.4 Hz, H-6′), 7.83 (1 H, d, *J* = 9.0 Hz, H-5), 7.68 (1 H, d, *J* = 9.0 Hz, H-4), 7.60 (1 H, td, *J* = 8.4, 1.5 Hz, H-5′), 7.54 (1 H, s, H-8), 7.15 (1 H, td, *J* = 8.4, 1.5 Hz, H-4′), 7.13 (1 H, d, *J* = 8.7 Hz, H-3), 7.01 (1 H, dd, *J* = 2.4, 9.0 Hz, H-6), 3.95 (3 H, s, OCH_3), 3.80 (3 H, s, OCH_3), 2.42 (3 H, s, $COCH_3$), 2.37 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.1, 168.4, 166.0, 158.5, 155.6, 136.5, 135.9, 134.2, 133.9, 132.5, 130.4, 125.8, 125.6, 123.6, 122.1, 116.7, 114.9, 110.8, 103.7, 90.1, 56.1, 55.0, 26.5, 21.1.

Anal. Calcd for $C_{24}H_{22}N_2O_8$: C, 61.80; H, 4.75; N, 6.01. Found: C, 61.65; H, 4.69; N, 6.00.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-(2′-methylphenyl)-3-oxobutanamide (3ag)
Colorless needles (from MeOH); mp 160–161 °C.

IR (KBr): 3358, 3161, 1759, 1725, 1695 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.41 (1 H, s, NH), 7.92 (1 H, d, *J* = 7.5 Hz, H-5), 7.81 (2 H, m, *J* = 8.7 Hz, H-8, H-4), 7.67 (1 H, d, *J* = 9.0 Hz, H-6′), 7.17–6.98 (5 H_{arom}, m), 3.91 (3 H, s, OCH_3), 3.85 (3 H, s, OCH_3), 2.35 (3 H, s, $COCH_3$), 2.30 (3 H, s, $COCH_3$), 2.14 (3 H, s, CH_3).

^{13}C NMR ($CDCl_3$): δ = 199.7, 168.8, 164.2, 158.3, 155.0, 135.7, 134.2, 132.2, 130.3, 130.1, 127.8, 126.7, 125.8, 124.7, 121.6, 116.9, 116.1, 110.5, 104.6, 89.3, 56.0, 55.2, 26.2, 21.1, 17.3.

Anal. Calcd for $C_{25}H_{25}NO_6$: C, 68.95; H, 5.79; N, 3.22. Found: C, 69.03; H, 5.59; N, 3.31.

2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-*N*-(4′-methylphenyl)-3-oxobutanamide (3ah)
Colorless needles (from MeOH); mp 169–170 °C.

IR (KBr): 3396, 1771, 1715, 1695 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.32 (1 H, s, NH), 7.80 (1 H, d, *J* = 9.3 Hz, H-5), 7.66 (1 H, d, *J* = 9.0 Hz, H-4), 7.60 (1 H, d, *J* = 2.4 Hz, H-8), 7.36 (2 H, d, *J* = 8.4 Hz, H-2′, H-6′), 7.09 (2 H, d, *J* = 8.7 Hz, H-3′, H-5′), 7.08 (1 H, d, *J* = 9.0 Hz, H-3), 7.01 (1 H, dd, *J* = 2.4, 9.0 Hz, H-6), 3.90 (3 H, s, OCH_3), 3.78 (3 H, s, OCH_3), 2.36 (3 H, s, $COCH_3$), 2.28 (3 H, s, $COCH_3$), 2.26 (3 H, s, CH_3).

^{13}C NMR ($CDCl_3$): δ = 199.3, 168.2, 164.3, 158.3, 155.8, 134.7, 134.3, 134.1, 132.2, 130.2, 129.5, 125.8, 119.9, 116.8, 116.3, 111.0, 104.1, 90.0, 56.4, 55.1, 26.5, 21.3, 20.8.

Anal. Calcd for $C_{25}H_{25}NO_6$: C, 68.95; H, 5.79; N, 3.22. Found: C, 69.03; H, 5.65; N, 3.22.

2-Acetoxy-*N*-(4′-fluorophenyl)-2-(2,7-dimethoxy-1-naphthyl)-3-oxobutanamide (3ai)
Colorless microcrystals (from MeOH); mp 127–129 °C.

IR (KBr): 3381, 3309, 1757, 1718, 1684 cm^{-1}.

^1H NMR ($CDCl_3$): δ = 8.44 (1 H, s, NH), 7.80 (1 H, d, *J* = 8.7 Hz, H-5), 7.68 (1 H, s, H-8), 7.67 (1 H, d, *J* = 9.0 Hz, H-4), 7.44 (1 H, d, *J* = 8.7 Hz, H-2′ or H-6′), 7.43 (1 H, d, *J* = 8.7 Hz, H-6′ or H-2′), 7.08 (1 H, d, *J* = 9.3 Hz, H-3), 7.02 (1 H, dd, *J* = 2.4, 9.0 Hz, H-6), 6.97 (1 H, d, *J* = 8.7 Hz, H-3′ or H-5′), 6.94 (1 H, d, *J* = 8.7 Hz, H-5′ or H-3′), 3.89 (3 H, s, OCH_3), 3.82 (3 H, s, OCH_3), 2.34 (3 H, s, $COCH_3$), 2.26 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 199.2, 168.4, 164.6, 161.0, 158.3, 157.8, 155.5, 134.0, 133.3, 132.3, 130.2, 125.7, 121.8, 121.7, 116.7, 115.7, 115.4, 110.8, 104.2, 89.3, 56.2, 55.1, 26.2, 21.1.

Anal. Calcd for $C_{24}H_{22}FNO_6$: C, 65.60; H, 5.05; N, 3.19. Found: C, 65.72; H, 5.06; N, 3.42.

2-Acetoxy-2-(2,6-dimethoxy-1-naphthyl)-*N*-phenyl-3-oxobutanamide (3ba)

Colorless microcrystals (from MeOH); mp 180–181 °C.

IR (KBr): 3413, 1757, 1718 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.50 (1 H, s, NH), 8.19 (1 H, d, *J* = 9.6 Hz, H-8), 7.76 (1 H, d, *J* = 9.0 Hz, H-4), 7.47 (2 H, d, *J* = 8.4 Hz, H-2′, H-6′), 7.47 (2 H, t, *J* = 8.1 Hz, H-3′, H-5′), 7.20 (1 H, d, *J* = 9.0 Hz, H-3), 7.47 (1 H, dd, *J* = 2.7, 9.6 Hz, H-7), 7.04–7.09 (2 H, m, H-5, H-4′), 3.83 (6 H, s, OCH_3), 2.34 (3 H, s, $COCH_3$), 2.22 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 198.8, 168.3, 164.6, 156.0, 153.4, 137.4, 131.7, 131.2, 128.8, 127.6, 124.5, 119.9, 119.4, 117.6, 114.3, 89.4, 56.5, 55.1, 26.3, 21.1.

Anal. Calcd for $C_{24}H_{23}NO_6$: C, 68.40; H, 5.50; N, 3.32. Found: C, 68.07; H, 5.60; N, 3.24.

2-Acetoxy-2-(2-methoxy-1-naphthyl)-*N*-phenyl-3-oxobutanamide (3ca)

Colorless microcrystals (from MeOH); mp 163–164.5 °C.

IR (KBr): 3352, 1770, 1715, 1699 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.46 (1 H, s, NH), 8.19 (1 H, d, *J* = 8.4 Hz, H-8), 7.90 (1 H, d, *J* = 8.7 Hz, H-5), 7.79 (1 H, d, *J* = 8.1 Hz, H-4), 7.51–7.08 (8 H_{arom}, m), 3.91 (3 H, s, OCH_3), 2.35 (3 H, s, $COCH_3$), 2.25 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 198.6, 168.2, 164.7, 155.2, 137.3, 132.7, 132.5, 130.4, 129.0, 128.9, 127.1, 124.9, 124.7, 124.0, 120.0, 117.4, 113.8, 89.8, 56.6, 26.4, 21.3.

Anal. Calcd for $C_{23}H_{21}NO_5$: C, 70.58; H, 5.41; N, 3.58. Found: C, 70.66; H, 5.37; N, 3.68.

2-Acetoxy-2-(4,6-dimethoxy-1-naphthyl)-*N*-phenyl-3-oxobutanamide (3da)

Colorless microcrystals (from MeOH); mp 177–177.5 °C.

IR (KBr): 3341, 1751, 1716, 1683 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.79 (1 H, br s, NH), 8.52 (1 H, d, *J* = 9.6 Hz, H-8), 7.61 (1 H, d, *J* = 2.7 Hz, H-5), 7.42 (2 H, d, *J* = 7.5 Hz, H-2′, H-6′), 7.30–7.23 (4 H, m, H-7, H-2, H-3′, H-5′), 7.05 (1 H, t, *J* = 7.2 Hz, H-4′), 6.73 (1 H, d, *J* = 8.1 Hz, H-3), 3.99 (3 H, s, OCH_3), 3.92 (3 H, s, OCH_3), 2.36 (3 H, s, $COCH_3$), 2.32 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 203.5, 170.6, 164.4, 157.3, 155.9, 137.2, 128.8, 128.2, 127.5, 127.2, 124.5, 123.6, 121.2, 120.2, 119.5, 102.9, 101.1, 89.8, 55.5, 55.2, 26.9, 20.9.

Anal. Calcd for $C_{24}H_{23}NO_6$: C, 68.40; H, 5.50; N, 3.32. Found: C, 68.01; H, 5.47; N, 3.26.

2-Acetoxy-2-(4-methoxy-1-naphthyl)-*N*-phenyl-3-oxobutanamide (3ea)

Colorless microcrystals (from MeOH); mp 176–177 °C.

IR (KBr): 3307, 1746, 1719, 1698 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.77 (1 H, s, NH), 8.55 (1 H, d, *J* = 8.4 Hz, H-5), 8.33 (1 H, dd, *J* = 1.2, 7.8 Hz, H-8), 7.58 (1 H, t, *J* = 8.4 Hz, H-7), 7.52 (1 H, t, *J* = 8.1 Hz, H-6), 7.41–7.48 (3 H, m, H-2, H-2′, H-6′), 7.25 (1 H, t, *J* = 7.8 Hz, H-3′, H-5′), 7.05 (1 H, t, *J* = 8.1 Hz, H-4′), 6.76 (1 H, d, *J* = 8.4 Hz, H-3), 4.00 (3 H, s, OCH_3), 2.37 (3 H, s, $COCH_3$), 2.33 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 203.5, 170.6, 164.4, 157.0, 137.2, 132.1, 128.8, 127.4, 126.8, 126.4, 125.6, 124.6, 122.6, 121.1, 120.2, 102.4, 89.9, 55.6, 26.9, 21.0.

Anal. Calcd for $C_{23}H_{21}NO_5$: C, 70.58; H, 5.41; N, 3.58. Found: C, 70.51; H, 5.39; N, 3.54.

2-Acetoxymethyl-1-phenylcarbamoyl-8-methoxynaphtho[2,1-*b*]furan (4aa)

Colorless needles (from EtOH); mp 177–177.5 °C.

IR ($CHCl_3$): 3309, 3018, 1732, 1670 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.90 (1 H, s, NH), 8.07 (1 H, d, *J* = 2.7 Hz, H-9), 7.88 (2 H, d, *J* = 7.8 Hz, H-2′, H-6′), 7.78 (1 H, d, *J* = 9.0 Hz, H-6), 7.70 (1 H, d, *J* = 8.7 Hz, H-4 or H-5), 7.43 (1 H, d, *J* = 8.7 Hz, H-5 or H-4), 7.40 (2 H, t, *J* = 8.1 Hz, H-3′, H-5′), 7.18 (1 H, td, *J* = 7.5, 1.2 Hz, H-4′), 7.12 (1 H, dd, *J* = 2.7, 8.7 Hz, H-7), 5.37 (2 H, s, CH_2), 3.87 (3 H, s, OCH_3), 2.14 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 172.3, 162.4, 158.5, 152.9, 148.2, 138.6, 130.4, 129.1, 127.8, 125.4, 124.3, 119.7, 117.2, 109.0, 103.4, 58.9, 55.3, 20.8.

MS: *m*/*z* = 389 (M^+, 5%).

Anal. Calcd for $C_{23}H_{19}NO_5$: C, 70.94; H, 4.92; N, 3.60. Found: C, 70.79; H, 4.87; N, 3.60.

2-Acetoxymethyl-1-(4′-chlorophenylcarbamoyl)-8-methoxynaphtho[2,1-*b*]furan (4ac)

Colorless needles (from $CHCl_3$–Et_2O); mp 190–191 °C.

IR (KBr): 3240, 1740, 1647 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 10.08 (1 H, s, NH), 8.06 (1 H, d, *J* = 2.4 Hz, H-9), 7.85 (2 H, d, *J* = 8.7 Hz, H-2′, H-6′), 7.79 (1 H, d, *J* = 9.3 Hz, H-6), 7.72 (1 H, d, *J* = 8.7 Hz, H-5 or H-4), 7.44 (1 H, d, *J* = 8.7 Hz, H-4 or H-5), 7.36 (2 H, d, *J* = 8.7 Hz, H-3′, H-5′), 7.13 (1 H, dd, *J* = 2.7, 9.3 Hz, H-7), 5.36 (2 H, s, CH_2), 3.89 (3 H, s, OCH_3), 2.20 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 172.8, 162.1, 158.5, 153.4, 148.0, 137.1, 130.2, 129.4, 129.1, 127.8, 126.0, 120.9, 119.3, 119.0, 117.0, 109.1, 104.3, 58.9, 55.3, 20.9.

Anal. Calcd for $C_{23}H_{18}ClNO_5$: C, 65.18; H, 4.28; N, 3.30. Found: C, 65.06; H, 4.38; N, 3.26.

2-Acetoxymethyl-1-(4′-methoxyphenylcarbamoyl)-8-methoxynaphtho[2,1-*b*]furan (4ae)

Light yellow microcrystals (from EtOH); mp 165–167 °C.

IR (KBr): 3258, 1747, 1645 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.77 (1 H, s, NH), 8.12 (1 H, s, H-9), 7.82–7.79 (3 H, m, H-6, H-2′, H-6′), 7.73 (1 H, dd, *J* = 2.7, 9.3 Hz, H-4 or H-5), 7.46 (1 H, dd, *J* = 3.0, 8.7 Hz, H-5 or H-4), 7.14 (1 H, dd, *J* = 2.7, 8.7 Hz, H-7), 6.95 (1 H, dd, *J* = 2.7, 8.7 Hz, H-3′ or H-5′), 6.94 (1 H, dd, *J* = 3.0, 9.3 Hz, H-5′ or H-3′), 5.41 (2 H, s, CH_2), 3.90 (3 H, s, OCH_3), 3.83 (3 H, s, OCH_3), 2.20 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 172.8, 161.7, 158.5, 156.5, 153.6, 148.0, 131.8, 130.1, 129.4, 127.7, 126.1, 121.2, 119.7, 119.3, 117.1, 114.2, 109.2, 104.3, 58.9, 55.5, 55.4, 20.9.

Anal. Calcd for $C_{24}H_{21}NO_6$: C, 68.73; H, 5.05; N, 3.34. Found: C, 68.65; H, 5.09; N, 3.41.

2-Acetoxymethyl-8-methoxy-(2′-methylphenylcarbamoyl)naphtho[2,1-*b*]furan (4ag)

Colorless microcrystals (from EtOH); mp 207–209 °C.

IR (KBr): 3229, 1757, 1717 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.06 (1 H, br s, NH), 8.05 (1 H, d, *J* = 2.1 Hz, H-9), 7.93 (1 H, d, *J* = 7.8 Hz, H-3′), 7.83 (1 H, d, *J* = 8.7 Hz, H-6),

7.75 (1 H, d, *J* = 9.0 Hz, H-4 or H-5), 7.49 (1 H, d, *J* = 9.0 Hz, H-5 or H-4), 7.34–7.20 (3 H, m, H-4′, H-5′, H-6′), 7.14 (1 H, dd, *J* = 8.7, 2.1 Hz, H-7), 5.47 (2 H, s, CH_2), 3.85 (3 H, s, OCH_3), 2.39 (3 H, s, $COCH_3$), 2.16 (3 H, s, CH_3).

^{13}C NMR ($CDCl_3$): δ = 197.3, 174.1, 163.4, 161.6, 153.8, 140.7, 135.1, 131.3, 131.0, 130.6, 130.2, 127.6, 126.9, 125.3, 124.6, 121.5, 118.0, 110.5, 102.4, 90.0, 55.6, 22.6, 17.6.

Anal. Calcd for $C_{24}H_{21}NO_5$: C, 71.45; H, 5.25; N, 3.47. Found: C, 71.21; H, 5.29; N, 3.62.

2-Acetoxymethyl-8-methoxy-1-(4′-methylphenylcarbamoyl)naphtho[2,1-*b*]furan (4ah)
Colorless microcrystals (from EtOH); mp 197–199 °C.

IR (KBr): 3420, 3215, 1716, 1683 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.60 (1 H, s, NH), 8.15 (1 H, d, *J* = 2.4 Hz, H-9), 7.83 (1 H, d, *J* = 8.7 Hz, H-6), 7.72 (1 H, d, *J* = 9.3 Hz, H-4 or H-5), 7.61 (2 H, d, *J* = 8.7 Hz, H-2′, H-6′), 7.45 (1 H, d, *J* = 9.3 Hz, H-5 or H-4), 7.20 (2 H, d, *J* = 8.1 Hz, H-3′, H-5′), 7.14 (1 H, dd, *J* = 2.4, 8.7 Hz, H-7), 4.96 (2 H, s, CH_2), 3.82 (3 H, s, OCH_3), 2.37 (3 H, s, $COCH_3$), 2.17 (3 H, s, CH_3).

^{13}C NMR ($CDCl_3$): δ = 172.9, 162.7, 158.5, 156.7, 153.3, 148.2, 134.5, 130.5, 129.7, 128.9, 127.2, 126.1, 121.2, 119.9, 119.3, 117.1, 114.2, 109.5, 104.0, 57.3, 55.3, 31.0, 21.0.

Anal. Calcd for $C_{24}H_{21}NO_5$: C, 71.45; H, 5.25; N, 3.47. Found: C, 71.15; H, 5.31; N, 3.56.

2-Acetoxymethyl-1-(4′-fluorophenylcarbamoyl)-8-methoxynaphtho[2,1-*b*]furan (4ai)
Colorless microcrystals (from EtOH); mp 148–150 °C.

IR (KBr): 3283, 1736, 1695 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 10.01 (1 H, s, NH), 8.10 (1 H, d, *J* = 2.4 Hz, H-9), 7.90–7.68 (3 H_{arom}, m), 7.46–7.56 (2 H_{arom}, m), 7.18–7.08 (3 H_{arom}, m), 5.41 (2 H, s, CH_2), 3.90 (3 H, s, OCH_3), 2.21 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 172.3, 162.4, 158.5, 152.9, 148.2, 138.6, 130.4, 129.1, 127.8, 125.4, 124.3, 119.7, 117.2, 109.0, 103.4, 58.9, 55.3, 20.8.

Anal. Calcd for $C_{23}H_{18}FNO_5$: C, 67.81; H, 4.45; N, 3.44. Found: C, 67.72; H, 4.53; N, 3.36.

2-Acetoxymethyl-1-(phenylcarbamoyl)-7-methoxynaphtho[2,1-*b*]furan (4ba)
Colorless needles (from EtOH); mp 186–187 °C.

IR (KBr): 3263, 3242, 1749, 1647 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.92 (1 H, s, NH), 8.59 (1 H, d, *J* = 8.7 Hz, H-9), 7.87 (2 H, d, *J* = 8.1 Hz, H-2′, H-6′), 7.71 (1 H, d, *J* = 8.7 Hz, H-4 or H-5), 7.58 (1 H, d, *J* = 8.7 Hz, H-5 or H-4), 7.41 (2 H, t, *J* = 8.1 Hz, H-3′, H-5′), 7.12–7.22 (3 H_{arom}, m), 5.39 (2 H, s, CH_2), 3.91 (3 H, s, OCH_3), 2.19 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 172.3, 162.1, 156.9, 152.1, 148.3, 139.7, 138.5, 132.5, 129.1, 126.9, 125.5, 124.6, 119.9, 118.7, 112.2, 107.9, 58.9, 55.4, 21.1.

Anal. Calcd for $C_{23}H_{19}NO_5$: C, 70.94; H, 4.92; N, 3.60. Found: C, 70.87; H, 4.84; N, 3.46.

2-Acetoxymethyl-1-(phenylcarbamoyl)naphtho[2,1-*b*]furan (4ca)
Colorless microcrystals (from EtOH); mp 192–194 °C.

IR (KBr): 3273, 3190, 1750, 1651 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.90 (1 H, s, NH), 8.65 (1 H, d, *J* = 7.8 Hz, H-9), 7.87–7.89 (3 H_{arom}, m), 7.79 (1 H_{arom}, d, *J* = 8.4 Hz), 7.39–7.60 (5 H_{arom}, m), 7.16–7.23 (1 H, m, H-4′), 5.37 (2 H, s, CH_2), 2.18 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 182.8, 172.6, 164.7, 152.8, 138.2, 129.1, 128.0, 127.7, 127.0, 125.7, 125.1, 124.8, 124.6, 119.8, 111.7, 55.7, 20.9.

Anal. Calcd for $C_{22}H_{17}NO_4$: C, 73.53; H, 4.77; N, 3.90. Found: C, 73.39; H, 4.67; N, 3.88.

2-Acetoxymethyl-9-methoxy-1-(phenylcarbamoyl)naphtho[2,1-*b*]furan (4da)
Colorless needles (from EtOH); mp 177–177.5 °C.

IR (KBr): 3410, 1734, 1684 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.45 (1 H, br s, NH), 7.82–7.74 (3 H_{arom}, m), 7.62 (1 H, dd, *J* = 1.5, 9.0 Hz, H-6), 7.51 (1 H, d, *J* = 8.1 Hz, H-4 or H-5), 7.43–7.37 (3 H_{arom}, m), 7.15 (1 H, td, *J* = 1.5, 9.0 Hz, H-4′), 6.90 (1 H, d, *J* = 7.8 Hz, H-8), 5.33 (2 H, s, CH_2), 3.74 (3 H, s, OCH_3), 2.12 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 171.2, 163.3, 155.2, 152.8, 148.4, 138.7, 132.3, 129.1, 127.1, 125.2, 124.1, 121.5, 119.3, 119.1, 117.4, 112.6, 105.8, 58.0, 54.8, 20.9.

Anal. Calcd for $C_{23}H_{19}NO_5$: C, 70.94; H, 4.92; N, 3.60. Found: C, 70.67; H, 4.81; N, 3.5.

1-Acetyl-1-hydroxy-8-methoxy-3-phenyl-1*H*-benzo[*e*]indol-2(3*H*)-one (5aa)
Colorless needles (from EtOH); mp 192–193 °C.

IR (KBr): 3317, 2970, 1695, 1629 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.54 (1 H, s, OH), 8.13 (1 H, d, *J* = 2.4 Hz, H-9), 8.07 (1 H, d, *J* = 8.7 Hz, H-6), 7.75 (1 H, d, *J* = 9.0 Hz, H-4 or H-5), 7.58 (2 H, d, *J* = 8.4 Hz, H-2′, H-6′), 7.32 (2 H, t, *J* = 8.1 Hz, H-3′, H-5′), 7.26–7.01 (3 H, m, H-4 or H-5, H-7, H-4′), 3.99 (3 H, s, OCH_3), 1.92 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.5, 174.0, 163.4, 161.8, 161.6, 140.6, 137.0, 131.3, 130.2, 129.0, 124.8, 124.7, 119.9, 118.1, 110.5, 102.4, 89.8, 55.6, 22.6.

MS: *m*/*z* = 347 (M^+, 11%).

Anal. Calcd for $C_{21}H_{17}NO_4$: C, 72.61; H, 4.93; N, 4.03. Found: C, 72.47; H, 4.86; N, 3.97.

1-Acetyl-3-(4′-chlorophenyl)-1-hydroxy-8-methoxy-1*H*-benzo[*e*]indol-2(3*H*)-one (5ac)
Light yellow microcrystals (from EtOH); mp 244–247 °C.

IR (KBr): 3333, 1705, 1674 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.56 (1 H, s, OH), 8.12 (1 H, d, *J* = 2.7 Hz, H-9), 8.09 (1 H, d, *J* = 8.7 Hz, H-6), 7.76 (1 H, d, *J* = 9.0 Hz, H-4), 7.54 (2 H, d, *J* = 8.7 Hz, H-2′, H-6′), 7.29 (1 H, d, *J* = 9.0 Hz, H-5), 7.24 (2 H, d, *J* = 8.7 Hz, H-3′, H-5′), 7.13 (1 H, dd, *J* = 2.7, 8.7 Hz, H-7), 3.99 (3 H, s, OCH_3), 1.92 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.1, 174.0, 163.6, 161.8, 140.8, 135.6, 131.4, 130.3, 129.9, 129.1, 124.8, 121.2, 118.2, 110.5, 102.4, 89.6, 55.6, 22.7.

Anal. Calcd for $C_{21}H_{16}NO_4$: C, 66.06; H, 4.22; N, 3.67. Found: C, 65.62; H, 4.14; N, 3.66.

1-Acetyl-1-hydroxy-8-methoxy-3-(2′-methoxyphenyl)-1*H*-benzo[*e*]indol-2(3*H*)-one (5ad)
Colorless microcrystals (from EtOH); mp 147–148 °C.

IR (KBr): 3415, 1716, 1679 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 9.11 (1 H, s, OH), 8.36 (1 H, dd, *J* = 1.5, 8.1 Hz, H-6′), 8.15 (1 H, d, *J* = 2.7 Hz, H-9), 8.07 (1 H, d, *J* = 8.7 Hz, H-6), 7.74 (1 H, d, *J* = 8.7 Hz, H-5), 7.25 (1 H, d, *J* = 9.3 Hz, H-4),

7.11 (1 H, dd, *J* = 2.7, 8.7 Hz, H-7), 7.04 (1 H, dt, *J* = 1.5, 7.8 Hz, H-5′ or H-4′), 6.93 (1 H, dt, *J* = 1.5, 7.8 Hz, H-4′ or H-5′), 6.85 (1 H, dt, *J* = 1.2, 8.1 Hz, H-3′), 3.97 (3 H, s, OCH_3), 3.89 (3 H, s, OCH_3), 1.93 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 196.5, 173.8, 163.3, 161.6, 148.2, 140.2, 131.4, 130.1, 126.7, 124.7, 124.3, 121.1, 119.9, 118.0, 110.7, 110.4, 109.9, 102.4, 90.3, 55.9, 55.6, 22.0.

Anal. Calcd for $C_{22}H_{19}NO_5$: C, 70.02; H, 5.07; N, 3.71. Found: C, 69.72; H, 5.06; N, 3.61.

1-Acetyl-1-hydroxy-8-methoxy-3-(2′-nitrophenyl)-1*H*-benzo[*e*]indol-2(3*H*)-one (5af)
Yellow microcrystals (from EtOH); mp 198–199 °C.

IR (KBr): 3314, 1722, 1686 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 11.57 (1 H, s, NH), 8.85 (1 H, d, *J* = 8.4 Hz, H-3′), 8.20 (1 H, dd, *J* = 1.5, 8.4 Hz, H-6′), 8.13 (1 H, s, H-9), 8.12 (1 H, d, *J* = 8.7 Hz, H-6), 7.76 (1 H, d, *J* = 8.7 Hz, H-5), 7.65 (1 H, dt, *J* = 1.5, 8.7 Hz, H-5′), 7.37 (1 H, d, *J* = 8.7 Hz, H-4), 7.19 (1 H, dt, *J* = 0.9, 8.4 Hz, H-4′), 7.12 (1 H, dd, *J* = 2.1, 8.4 Hz, H-7), 3.96 (3 H, s, OCH_3), 1.96 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 194.5, 173.7, 164.9, 161.7, 140.5, 136.4, 136.1, 133.9, 131.3, 130.2, 125.8, 125.0, 123.9, 121.9, 118.3, 110.5, 102.3, 90.5, 55.6, 21.0.

Anal. Calcd for $C_{23}H_{18}N_2O_7$: C, 63.59; H, 4.18; N, 6.45. Found: C, 63.91; H, 3.97; N, 6.68.

1-Acetyl-1-hydroxy-8-methoxy-3-(4′-methylphenyl)-1*H*-benzo[*e*]indol-2(3*H*)-one (5ah)
Colorless microcrystals (from EtOH); mp 215.5–218 °C.

IR (KBr): 3344, 1701, 1672 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.46 (1 H, s, OH), 8.13 (1 H, d, *J* = 2.7 Hz, H-9), 8.06 (1 H, d, *J* = 8.7 Hz, H-6), 7.73 (1 H, d, *J* = 9.0 Hz, H-5), 7.46 (2 H, d, *J* = 8.4 Hz,, H-2′, H-6′), 7.22 (1 H, dd, *J* = 1.0, 8.7 Hz, H-7), 7.10–7.14 (3 H, m, H-4, H-3′, H-5′), 3.98 (3 H, s, OCH_3), 2.30 (3 H, s, $COCH_3$), 1.91 (3 H, s, CH_3).

^{13}C NMR ($CDCl_3$): δ = 197.1, 173.9, 163.3, 161.7, 140.5, 134.5, 134.3, 131.3, 130.2, 129.5, 124.7, 119.9, 118.1, 110.6, 110.5, 102.4, 89.8, 55.6, 22.6, 20.9.

Anal. Calcd for $C_{22}H_{19}NO_4$: C, 73.12; H, 5.30; N, 3.88. Found: C, 73.29; H, 5.22; N, 3.67.

1-Acetyl-3-(4′-fluorophenyl)-1-hydroxy-8-methoxy-1*H*-benzo[*e*]indol-2(3*H*)-one (5ai)
Colorless microcrystals (from EtOH); mp 177–177.5 °C.

IR (KBr): 3271, 1726, 1691 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.54 (1 H, s, OH), 8.12 (1 H, d, *J* = 2.7 Hz, H-9), 8.08 (1 H, d, *J* = 9.3 Hz, H-6), 7.75 (1 H, d, *J* = 9.3 Hz, H-5), 7.57–7.52 (2 H, m, H-2′, H-6′), 7.23 (1 H, d, *J* = 9.3 Hz, H-4), 7.13 (1 H, dd, *J* = 2.7, 9.0 Hz, H-7), 7.04–6.99 (2 H, m, H-3′, H-5′), 3.99 (3 H, s, OCH_3), 1.92 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.2, 173.7, 167.8, 163.5, 161.8, 140.7, 132.9, 131.3, 130.8, 128.8, 124.7, 121.8, 121.7, 118.2, 115.9, 115.5, 110.5, 102.4, 89.8, 55.6, 23.0.

Anal. Calcd for $C_{24}H_{22}FNO_6$: C, 65.60; H, 5.05; N, 3.19. Found: C, 66.45; H, 5.06; N, 3.63.

1-Acetyl-1-hydroxy-7-methoxy-3-phenyl-1*H*-benzo[*e*]indol-2(3*H*)-one (5ba)
Colorless microcrystals (from EtOH); mp 177–177.5 °C.

IR (KBr): 3414, 3325, 1724, 1680 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.64 (1 H, d, *J* = 8.7 Hz, H-9), 8.56 (1 H, br s, OH), 8.07 (1 H, d, *J* = 9.0 Hz, H-8), 7.58 (2 H, d, *J* = 7.5 Hz, H-2′, H-6′), 7.47–7.30 (3 H_{arom}, m), 7.21 (1 H, d, *J* = 2.7 Hz, H-6), 7.10–7.17 (2 H_{arom}, m), 4.00 (3 H, s, OCH_3), 2.02 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.5, 173.3, 172.2, 163.4, 157.5, 139.7, 136.8, 131.0, 129.0, 124.8, 124.5, 121.9, 119.9, 114.1, 111.5, 107.9, 89.8, 55.4, 22.8.

Anal. Calcd for $C_{21}H_{17}NO_4$: C, 72.61; H, 4.93; N, 4.03. Found: C, 72.57; H, 5.09; N, 4.14.

1-Acetyl-1-hydroxy-3-phenyl-1*H*-benzo[*e*]indol-2(3*H*)-one (5ca)
Colorless microcrystals (from EtOH); mp 192–193 °C.

IR (KBr): 3407, 1705, 1684 cm^{-1}.

^{1}H NMR ($CDCl_3$): δ = 8.74 (1 H, d, *J* = 7.5 Hz, H-2′, H-6′), 8.59 (1 H, s, OH), 8.16 (1 H, d, *J* = 8.7 Hz, H-9), 7.87 (1H, d, *J* = 8.1 Hz, H-6), 7.71 (1 H, t, *J* = 8.1 Hz, H-8 or H-7), 7.59 (1 H, d, *J* = 7.8 Hz, H-5), 7.52 (1 H, t, *J* = 7.2 Hz, H-7 or H-8), 7.41 (1 H, dd, *J* = 1.8, 8.7 Hz, H-4), 7.32 (2 H, t, *J* = 7.5 Hz, H-3′, H-5′), 7.12 (1 H, t, *J* = 7.8 Hz, H-4′), 1.93 (3 H, s, $COCH_3$).

^{13}C NMR ($CDCl_3$): δ = 197.5, 173.8, 163.3, 141.0, 136.8, 130.3, 129.6, 129.1, 129.0, 128.7, 126.0, 124.8, 123.2, 120.0, 113.7, 111.3, 89.8, 22.8.

Anal. Calcd for $C_{20}H_{15}NO_3$: C, 75.70; H, 4.76; N, 4.41. Found: C, 75.57; H, 4.72; N, 4.37.

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