# Reactions of Methoxynaphthalenes with Active Methylene Compounds in the Presence of Manganese(III) Acetate

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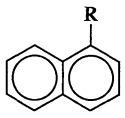
(Received September 12, 1990)

The reaction of methoxynaphthalenes with malonamide in the presence of magnanese(III) acetate gives 2-acetoxy-2-(1-naphthyl)propanediamides and 2-hydroxy-2-(1-naphthyl)propanediamides. It was found that the propanediamidation reaction did occur when naphthalenes have electron-donating substituents, such as a methoxyl group. The reactions of methoxynaphthalenes with ethyl 3-oxobutanoate, 2-cyanoacetamide, and malononitrile in the presence of manganese(III) acetate also yielded the corresponding substituted naphthalenes, ethyl 2-(acetoxymethyl)naphtho[2,1-*b*]furan-1-carboxylates, and/or a 4-methylene-1(4*H*)-naphthalenone. The reaction mechanisms are discussed.

Although the reactions of alkenes with active methylene compounds in the presence of manganese(III) acetate have been well documented,[1] the reaction of aromatic substrates with manganese(III) acetete–active methylene compounds has received less attention than alkenes, probably because of the lower reactivity of the aromatic compounds towards the reagents. The authors have reported that the reactions of naphthalenes, anthracene, and other aromatic substrates with tris(2,4-pentanedionato)manganese(III), and with malonic acid in the presence of manganese(III) acetate,[2] gave diacetylmethylated arenes[3] and formylated arenes,[4] respectively. Citterio et al.[5,6] have also reported that the reactions of alkoxynaphthalenes with diethyl malonates, ethyl 3-oxobutanoate and ethyl 2-cyanoacetate in the presence of manganese(III) acetate gave aromatic substitution products. In view of the potential synthetic utility of these reactions, which could functionalize aromatic compounds, we then investigated the reactions involved in incorporating other carbonyl functions into naphthalenes and other aromatic substrates. We describe here the reactions of methoxy-substituted naphthalenes with malonamide, ethyl 3-oxobutanoate, 2-cyanoacetamide, and malononitrile in the presence of manganese(III) acetate.

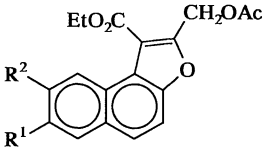
## Results

2,7-Dimethoxynaphthalene (**1a**) was selected as an aromatic substrate in a reaction aimed at optimizing the reaction conditions since the reaction products could be readily separated and characterized by spectroscopic methods. The reaction of **1a** with malonamide in the presence of manganese(III) acetate gave an acetate (**2a**) as the major product after purification on preparative TLC. The $^1$H NMR spectrum of **2a** ($C_{17}H_{18}N_2O_6$ based on elemental analysis and $M^+$=346 in the MS spectrum) exhibited an AB ($\delta_A$=7.24 and $\delta_B$=7.86, $J_{AB}$=8.79 Hz) and an ABC spin system ($\delta_A$=7.03, $\delta_B$=7.42, $\delta_C$=7.78, $J_{AB}$=2.20, $J_{AC}$=7.89, $J_{BC}$=0 Hz) due to aromatic protons. The $J$ value for the AB spin system indicated the presence of H-3 and H-4. The peaks at $\delta$=2.38 (3H, singlet), 3.76 (3H, singlet), and 3.79 (3H, singlet) are assigned to an acetoxyl group and two methoxyl groups, respectively. There are four peaks at $\delta$=6.86, 7.87, 7.95, and 9.66 assigned to two $NH_2$, which disappeared upon deuteration. The IR spectrum showed absorptions at 1685 and 3100—3500 cm$^{-1}$ due to amide functions. These spectral properties indicate the structure of 2-acetoxy-2-(2,7-dimethoxy-1-naphthyl)-propanediamide for **2a**. There was a minor product (**3a**) which showed an $^1$H NMR spectrum similar to that of **2a**, except for the presence of a hydroxyl group and

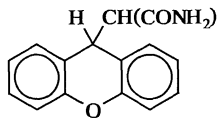


**1** : R=H
**2** : R=C(OAc)($CONH_2$)$_2$
**3** : R=C(OH)($CONH_2$)$_2$
**4** : R=C(OAc)($COCH_3$)$CO_2Et$
**7** : R=C(OAc)(CN)$CONH_2$

**a** : 2,7-(OMe)$_2$
**b** : 4-OMe
**c** : 2-OMe
**d** : 2,6-(OMe)$_2$
**e** : 4,6-(OMe)$_2$
**f** : 6,7-(OMe)$_2$



**5a** : $R^1$=H, $R^2$=OMe
**5c** : $R^1$=$R^2$=H
**5d** : $R^1$=OMe, $R^2$=H



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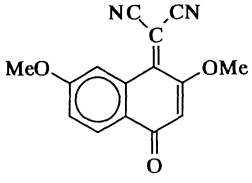


**8**

Fig. 1.

Table 1. Reactions of Methoxynaphthalenes with Active Methylene Compounds in the Presence of Manganese(III) Acetate in Acetic Acid[a]

| Entry | Substrate | Active methylene | Molar ratio[b] | Time | Composition of products (%)[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | min | Substrate | Acetate | Alcohol | Furan | Others |
| 1 | **1a** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1a** ( 4) | **2a** (52) | **3a** (19) | | |
| 2 | **1a** | $CH_2(CONH_2)_2$ | 1:8:8[d] | 3 | | **2a** (61) | **3a** ( 7) | | |
| 3 | **1b** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1b** ( 3) | **2b** (38) | **3b** (10)[e] | | |
| 4 | **1c** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1c** ( 5) | **2c** (55) | **3c** ( 9)[e] | | |
| 5 | **1d** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1d** (15) | **2d** (37) | **3d** ( 9) | | |
| 6 | **1e** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1e** ( 6) | **2e** (17) | **3e** ( 8)[e] | | |
| 7 | **1f** | $CH_2(CONH_2)_2$ | 1:8:8 | 3 | **1f** (19) | **2f** (35) | **3f** (22) | | |
| 8 | **1a** | $CH_3COCH_2CO_2Et$ | 1:4:12 | 15 | **1a** ( 4) | **4a** (46) | | **5a** ( 2) | |
| 9 | **1c** | $CH_3COCH_2CO_2Et$ | 1:4:12 | 5 | | **4c** (49) | | **5c** (12) | |
| 10 | **1d** | $CH_3COCH_2CO_2Et$ | 1:4:12 | 3 | | **4d** (19) | | **5d** (11) | |
| 11 | **1a** | $NCCH_2CONH_2$ | 1:8:8 | 3 | | **7a** (25) | | | |
| 12 | **1a** | $CH_2(CN)_2$ | 1:8:8 | 3 | **1a** (44) | | | | **8** (9) |

a) The reactions were carried out at the reflux temperature. b) Substrate : active methylene compound : Mn(III). c) Isolated yield based on the amount of substrate added. d) $Ac_2O$ (2 $cm^3$) was added. e) Yield was estimated from the $^1H$ NMR spectra.

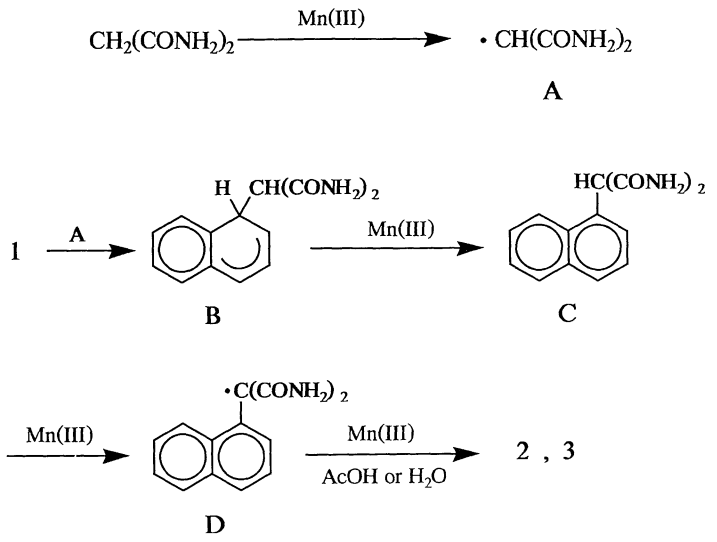
the absence of an acetoxyl group. The structure was then assigned to be 2-hydroxy-2-(2,7-dimethoxy-1-naphthyl)propanediamide (**3a**) (Fig. 1).

The reaction was carried out at various molar ratios of **1a**: malonamide: manganese(III); we found that the reaction at a molar ratio of 1:8:8 at the reflux temperature for 3 min gave the maximum yield for **2a** (Table 1, Entry 1). The reactions were then examined for 1-methoxynaphthalene (**1b**), 2-methoxynaphthalene (**1c**), 2,6-dimethoxynaphthalene (**1d**), 1,7-dimethoxynaphthalene (**1e**), and 2,3-dimethoxynaphthalene (**1f**) at a molar ratio of 1:8:8 at reflux temperature for 3 min. The results are shown in Table 1. The 2-hydroxy derivatives were not always obtained as a pure substance because of contamination with the acetates. The yields of some 2-hydroxy derivatives (**3b**, **3c**, **3e**) were estimated from the intensities of the hydroxyl group in **3** and the acetoxyl group in **2**, which are well separated from the other signals in their $^1H$ NMR spectra. In order to prevent the formation of the 2-hydroxy derivative (**3a**), a reaction was conducted which added acetic anhydride. The yield of **2a** was slightly improved (by 9%) at the expense of **3a**; the yield of which was lowered by 12% (Entry 2). It was shown that an aromatic ring having a methoxyl group in naphthalene is always active towards the reaction, except for **1f** (2,3-dimethoxynaphthalene). In the case of **1f**, the propanediamide moiety is introduced into the unsubstituted ring. The reaction of unsubstituted naphthalene with manganese(III) acetate–$CH_2(CONH_2)_2$ gave a small amount of products along with the unchanged material. The products could not be characterized. The reactions of anthracene and pyrene also gave a complex mixture which could not be identified.

We then looked into the reactions of 2,7-dimethoxynaphthalene (**1a**), 2-methoxynaphthalene (**1c**), and 2,6-dimethoxynaphthalene (**1d**), with ethyl 3-oxobutanoate in the presence of manganese(III) acetate that gave ethyl 2-acetoxy-2-(1-naphthyl)-3-oxobutanoates (**4a**, **4c**, **4d**) and ethyl 2-(acetoxymethyl)naphtho[2,1-*b*]-furan-1-carboxylates (**5a**, **5c**, **5d**) (Entries 8—10). The isolated yield of **4c** (ethyl 2-acetoxy-2-(2-methoxy-1-naphthyl)-3-oxobutanoate) was better than the yield (20%) reported by Citterio et al.,[5] who obtained **4c** in a reaction at 80 °C. The IR and $^1H$ NMR spectra of compound **5d**, which has a molecular formula $C_{19}H_{18}O_6$ (analysis and $M^+$=342), indicated the presence of 1,2,6-trisubstituted naphthalene, a methoxy group ($\delta$=3.90 (3H, s)), an ethoxycarbonyl group (1710 $cm^{-1}$, $\delta$=4.50 (2H, q) and $\delta$=1.45 (3H, t)), an acetoxyl group (1732 $cm^{-1}$, $\delta$=2.12 (3H, s)), and a methylene group ($\delta$=5.52 (2H, s)). The $^{13}C$ NMR spectrum showed two methylene groups at $\delta$=58.297, 61.374 that finally confirmed the structure of ethyl 2-(acetoxymethyl)-7-methoxynaphtho[2,1-*b*]furan-1-carboxylate for **5d**. The structures of **5a** and **5c** were similarly determined on the basis of the presence of acetoxymethyl group in their $^1H$ NMR spectra. The reactions of **1a** with 2-cyanoacetamide, and malononitrile in the presence of manganese(III) acetate at a molar ratio of 1:8:8 at reflux temperature were also carried out (Entries 11, 12). The products were found to be 2-acetoxy-2-cyano-(2,7-dimethoxy-1-naphthyl)acetamide (**7a**) and 4-(dicyanomethylene)-3,6-dimethoxy-1(4*H*)-naphthalenone (**8**). The yields were rather poor and much of the unchanged **1a** was recovered in the reaction of malononitrile.

## Discussion

It has been reported that diacetylmethylation using tris(2,4-pentanedionato)manganese(III) (abbreviated [Mn(acac)$_3$]) is effective when the ionization potential of the aromatic compound is lower than 8.28 eV.[3] The reaction could be accounted for in terms of a radical reaction initiated by the diacetylmethyl radical, ·CH-

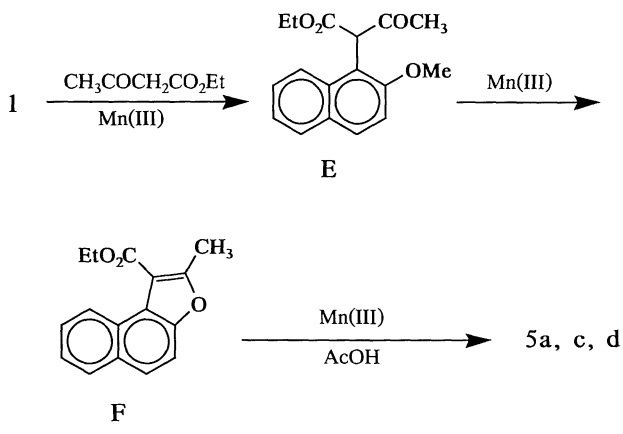



Scheme 1.

$(COCH_3)_2$, which is formed by the thermal decomposition of [Mn(acac)3], and subsequently attacks the aromatic nucleus, followed by further oxidation by [Mn(acac)3] to give products.[3] In an analogy to the above-mentioned mechanism, the reaction of aromatic compounds with malonamide in the presence of manganese(III) acetate could be envisaged as being initiated by a propanediamide radical, $\cdot CH(CONH_2)_2$ (**A**), which is formed by an interaction with manganese(III) acetate and $CH_2(CONH_2)_2$. In an attempt to obtain information concerning the complex formation between Mn(III) and $CH_2(CONH_2)_2$ though the visible spectra of manganese(III) acetate in AcOH were taken in both the presence and absence of three equivalents of $CH_2(CONH_2)_2$ at room temperature, no appreciable change could be observed. However, the formation of **A** was substantiated by the fact that xanthene gave a 2-(9-xanthenyl)propanediamide (**6**) in 81% yield when treated with manganese(III)–$CH_2(CONH_2)_2$ (Fig. 1). The propanediamide radical (**A**) seems to have an electrophilic nature as well as do $\cdot CH_2CO_2H$ and other radicals which have carbonyl functions attached to the radical carbon. Thus, **A** attacks the $\alpha$-position in naphthalenes to give radicals (**B**), which could be subsequently oxidized with excess manganese(III) acetate present in the oxidation system to give 2-(1-naphthyl)propanediamide (**C**). Compound **C** could not be isolated, probably because **C** has a hydrogen on a tertiary carbon which may more easily be oxidized than the methylene group in $CH_2(CONH_2)_2$ to give radical (**D**). Radical (**D**) is further oxidized to a corresponding cation, which takes up either an acetate ion or water to yield **2** and **3**, respectively (Scheme 1). The acetate (**2a**) was fairly stable and could not be hydrolyzed, even with 50% aqueous acetic acid containing a small amount of hydrochloric acid at room temperature for 12 h. It is therefore reasonable to assume that **3a** was not formed from **2a** by hydrolysis during the work-up but, rather, was formed from the intermediate **D** and water contained in the reaction medium.

The formation of ethyl 2-(acetoxymethyl)naphtho-[2,1-*b*]furan-1-carboxylates (**5a**, **5c**, and **5d**) in the reactions of methoxynaphthalenes (**1a**, **1c**, and **1d**) with ethyl 3-oxobutanoate reveals another interesting feature of the reaction. The removal of the methoxyl group has been observed in the reactions of 2-hydroxy-2′-methoxybenzophenones with manganese(III) acetate that yielded 9-xanthenones,[7] and in the reaction of **1c** (2-methoxynaphthalene) with dimethyl malonate.[6] The formation of **5a**, **5c**, and **5d** could be accounted for by the fact that the substituted product (**E**) was cyclized to give **F**, which was subsequently acetoxylated with manganese(III) acetate (Scheme 2). The intermediates, **E** and **F**, could not be isolated from the reaction mixture, probably because we were using excess manganese(III) acetate (1:12 molar equivalent ratio).

The reactions of **1a** (2,7-dimethoxynaphthalene)




Scheme 2.

with 2-cyanoacetamide and malononitrile could also be accounted for by similar mechanisms initiated with the $\cdot CH(CN)CONH_2$ and $\cdot CH(CN)_2$ radical, respectively. The low yields are probably due to the less reactive nature of 2-cyanoacetamide and malononitrile than malonamide towards manganese(III) acetate.

It can thus be concluded that a radical substitution reaction occurred only at the $\alpha$-position and that the substitution reaction occurs at the unsubstituted nucleus in the case of **1f** (2,3-dimethoxynaphthalene) that may be due to a steric hindrance caused by the two methoxyl groups at the C-2 and C-3 position. It should be emphasized that this new direct incorporation of $C_3$ and $C_4$ units using manganese(III) acetate–active methylene compounds takes place in the electron-rich aromatic compounds having such an electron-donating group as the methoxyl group. These reactions could be utilized in organic syntheses.

## Experimental

**Measurements.** All the $^1H$ and $^{13}C$ NMR spectra were taken with JNM PMX-60SI (60 MHz), JNM EX-90 (90 MHz for $^1H$ and 22.4 MHz for $^{13}C$), and JNM GX-400 (400 MHz) FT NMR spectrometers with tetramethylsilane used as the internal standard. The IR spectra were measured on a JASCO A-102 IR spectrometer. The mass spectra were obtained on a JMS-DX303 HF mass spectrometer using a direct-insertion probe at an ionizing voltage of 70 eV. The melting points were determined with a Yanagimoto micro-melting point apparatus.

**Materials.** Methoxynaphthalenes (**1a—f**) were synthesized by the methylation of the corresponding naphthols with dimethyl sulfate. The other aromatic compounds were commercially available. Manganese(III) acetate was prepared by a method described in the literature.[8]

**Reaction of Aromatic Compounds with Malonamide in the Presence of Manganese(III) Acetate.** The typical procedure for the reaction of aromatic compounds with malonamide in the presence of manganese(III) acetate was as follows. To a heated solution of an aromatic compound (1 mmol) and malonamide (8 mmol) in acetic acid (30 $cm^3$), manganese(III) acetate (1.98 g, 8 mmol as Mn(III)) was added. The reaction mixture was heated under reflux until the dark-brown color of the solution turned opaque white. The solvent was then removed in vacuo, and the residue triturated with 2 M (1 M=1 mol $dm^{-3}$) hydrochloric acid (50 $cm^3$), followed by extraction with ethyl acetate. The solvent was removed again in vacuo and the products separated on a silica-gel plate while eluting with chloroform. Yields are summarized in Table 1.

**Products. 2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)propanediamide (2a):** Mp 184.5—185.5 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1685, 1726 ($-CONH_2$), 1755 (-OAc), 3100—3500 ($-NH_2$) $cm^{-1}$ ; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.38 (3H, s, -OAc), 3.76 (3H, s, $-OCH_3$) 3.79 (3H, s, $-OCH_3$), 6.86 (1H, s, NH), 7.03 (1H, dd, $J$=7.89, 2.20 Hz, H-6), 7.24 (1H, d, $J$=8.79 Hz, H-3), 7.42 (1H, d, $J$=2.20 Hz, H-8), 7.78 (1H, d, $J$=7.89 Hz, H-5), 7.86 (1H, d, $J$=8.79 Hz, H-4), 7.87 (1H, s, -NH), 7.95 (1H, s, -NH), and 9.66 (1H, d, -NH); MS $m/z$ (rel intensity)=346 [$M^+$] (100), 285 (100), 255 (44), 215 (67), 199 (51), and 185 (87). Found: C, 58.85; H, 5.25; N, 8.06%. Calcd for $C_{17}H_{18}O_6N_2$: C, 58.95; H, 5.24; N, 8.09%.

**2-Hydroxy-2-(2,7-dimethoxy-1-naphthyl)propanediamide (3a):** Mp 211—214 °C (from ethyl acetate); IR(KBr) $\nu$ 1705 ($-CONH_2$), 3100—3500 ($-NH_2$, -OH) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=3.80 (3H, s, $-OCH_3$) 3.82 (3H, s, $-OCH_3$), 6.07 (1H, br. s, -OH), 6.86—8.12 (4H, br. 2×$-NH_2$), 7.07 (1H, dd, $J$=8.6, 2.0 Hz, H-6), 7.26 (1H, d, $J$=9.0 Hz, H-3), 7.51 (1H, d, $J$=2.2 Hz, H-8), 7.81 (1H, d, $J$=8.6 Hz, H-5), and 7.88 (1H, d, $J$=9.0 Hz, H-4). Found: C, 59.30; H, 5.29; N, 9.30%. Calcd for $C_{15}H_{16}N_2O_5$: C, 59.20; H, 5.30; N, 9.21%.

**2-Acetoxy-2-(4-methoxy-1-naphthyl)propanediamide (2b):** Mp 196.5—197.5 °C (from chloroform–ethyl acetate); IR (KBr) $\nu$ 1682 ($-CONH_2$), 1763 (-OAc), 3100—3500 ($-NH_2$) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.34 (3H, s, OAc), 3.97 (3H, s, $-OCH_3$), 6.95 (1H, d, $J$=8.43 Hz, H-3), 7.01 (1H, s, -NH), 7.38 (1H, d, $J$=8.42 Hz, H-4), 7.47—7.54 (2H, m, H-6, H-7), 7.70 (1H, s, -NH), 8.02 (1H, s, -NH), 8.10—8.12 (1H, dd, H-5), 8.20—8.22 (1H, dd, H-8), and 10.25 (1H, s, -NH); MS $m/z$ (rel intensity) 316 [$M^+$] (13), 272 (13), 255 (37), 231 (19), and 185 (100). Found: $m/z$ 316.1054. Calcd for $C_{16}H_{16}O_5N_2$: M, 316.1059.

**2-Acetoxy-2-(2-methoxy-1-naphthyl)propanediamide (2c):** Mp 205 — 206 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1691 ($-CONH_2$), 1766 (-OAc), 3100 — 3500 ($-NH_2$) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.08 (3H, s, OAc), 3.82 (3H, s, $-OCH_3$), 7.30 — 7.45 (7H, m, 2×$-NH_2$, 3×arom. H), 7.81 — 7.83 (1H, dd, H-5), 7.93 (1H, d, $J$=8.79 Hz, H-4), and 8.35 — 8.37 (1H, dd, H-8). Found: C, 60.66; H, 5.14; N, 8.86%. Calcd for $C_{16}H_{16}O_6N_2$: C, 60.75; H, 5.10; N, 8.86%.

**2-Acetoxy-2-(2,6-dimethoxy-1-naphthyl)propanediamide (2d):** Mp 199 — 200 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1690 ($-CONH_2$), 1730 (-OAc), 3100 — 3500 ($-NH_2$) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.37 (3H, s, -OAc), 3.74 (3H, s, $-OCH_3$), 3.83 (3H, s, $-OCH_3$) 6.87 (1H, s, -NH), 7.10 (1H, dd, $J$=9.53, 2.93 Hz, H-7), 7.30 (1H, d, $J$=2.57 Hz, H-5), 7.37 (1H, d, $J$=8.80 Hz, H-3), 7.72 (1H, s, -NH), 7.85 (1H, d, $J$=7.89 Hz, H-4), 7.96 (1H, d, $J$=9.16 Hz, H-8), 8.31 (1H, s, -NH), and 9.65 (1H, s, -NH). Found: C, 58.81; H, 5.24; N, 8.06%. Calcd for $C_{17}H_{18}O_6N_2$: C, 58.95; H, 58.24; N, 8.09%.

**2-Hydroxy-2-(2,6-dimethoxy-1-naphthyl)propanediamide (3d):** Mp 228 — 230 °C (from ethyl acetate); IR(KBr) $\nu$ 1670, 1687 ($-CONH_2$), 3100 — 3500 ($-NH_2$, -OH) $cm^{-1}$; MS $m/z$ (rel intensity)=304 [$M^+$] (46), 261 (49), 215 (100), 201 (18), and 157 (23). Found: $m/z$ 304.1032. Calcd for $C_{15}H_{16}O_5N_2$: M, 304.1059.

**2-Acetoxy-2-(4,6-dimethoxy-1-naphthyl)propanediamide (2e):** Mp 187—188 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1690, 1712 ($-CONH_2$), 1730 (-OAc), 3100—3500 ($-NH_2$) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.33 (3H, s, -OAc),3.86 (3H, s, $-OCH_3$), 3.97 (3H, s, $-OCH_3$), 6.90 (1H, d, $J$=8.06 Hz, H-2), 6.98 (1H, s, -NH), 7.18 (1H, d, $J$=9.15 Hz, H-8), 7.19 (1H, dd, $J$=9.16, 2.93 Hz, H-7), 7.39 (1H, d, $J$=8.06 Hz, H-3), 7.51 (1H, d, $J$=2.93 Hz, H-5), 7.59 (1H, s, -NH), 7.74 (1H, s, -NH), and 9.86 (1H, s, -NH). Found: C, 58.66; H, 5.28; N, 8.00%. Calcd for $C_{17}H_{18}O_6N_2$: C, 58.95; H, 5.24; N, 8.09%.

**2-Acetoxy-2-(6,7-dimethoxy-1-naphthyl)propanediamide (2f):** Mp 215—216 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1680 ($-CONH_2$), 1738 (-OAc), 3100—3500 ($-NH_2$) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=2.21 (3H, s, -OAc),

3.82 (6H, s, 2×-$OCH_3$), 7.13—7.34 (2H, m, H-3, -NH), 7.32 (1H, s, H-5), 7.51—7.53 (1H, dd, H-2), 7.67 (1H, s, H-8), 7.75—7.79 (1H, dd, H-4), 7.92 (2H, s, 2×-NH), and 8.20 (1H, s, -NH); MS *m/z* (rel intensity) 346 [$M^+$] (70), 304 (44), 285 (100), 261 (100), 216 (100), and 188 (90). Found: *m/z* 346.1141. Calcd for $C_{17}H_{18}O_6N_2$: M, 346.1165.

**2-Hydroxy-2-(6,7-dimethoxy-1-naphthyl)propanediamide (3f):** Mp 229.5—230.5 °C (from chloroform–ethyl acetate); IR(KBr) $\nu$ 1680 (-$CONH_2$), 3100—3500 (-NH, -OH) $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$) $\delta$=3.81 (3H, s, -$OCH_3$) 3.87 (3H, s, -$OCH_3$), 6.21 (1H, s, -OH), 7.25 (1H, t, $J$=7.33 Hz, H-3), 7.27—7.29 (1H, dd, H-2), 7.28 (1H, s, -NH), 7.31 (1H, s, H-5), 7.58 (1H, s, -NH), 7.62 (1H, s, H-8), 7.70—7.73 (1H, dd, H-4), and 7.93 (2H, s, -$NH_2$). MS *m/z* (rel intensity) 304 [$M^+$] (100), 285 (34), 261 (100), 216 (100), and 188 (100). Found: *m/z* 304.1050. Calcd for $C_{15}H_{16}O_5N_2$: M, 304.1069.

**Reaction of Xanthene with Malonamide in the Presence of Manganese(III) Acetate.** To a heated solution of xanthene (1 mmol) and malonamide (8 mmol) in acetic acid (30 $cm^3$), manganese(III) acetate (8 mmol as Mn(III)) was added. The reaction mixture was heated under reflux for 1 min. The solvent was removed under reduced pressure and the residue treated with 2 M hydrochloric acid (50 $cm^3$). The precipitate was collected and recrystallized from a mixture of chloroform and ethyl acetate to give 9-xanthenone (11%) and 2-(9-xanthenyl)propanediamide (**6**) (81%): Mp 281—282 °C; IR(KBr) $\nu$ 1675 (-$CONH_2$), 3100—3500 (-$NH_2$) $cm^{-1}$; $^1H$ NMR (60 MHz, DMSO-$d_6$) $\delta$=3.10 (1H, d, $J$=10.8 Hz, >CH-), 4.60 (1H, d, $J$=10.8 Hz, >CH-), and 6.87—7.41 (12H, m, 2×-$NH_2$, arom. H). Found: C, 67.81; H, 5.05; N, 9.84%. Calcd for $C_{16}H_{14}O_3N_2$: C, 68.07; H, 5.00; N, 9.92%.

**Reactions of Methoxynaphthalenes (1a, 1c, and 1d) with Ethyl 3-Oxobutanoate in the Presence of Manganese(III) Acetate.** A mixture of a methoxynaphthalene (1 mmol), ethyl 3-oxobutanoate (4 mmol), and manganese(III) acetate (12 mmol for Mn(III)) in acetic acid (30 $cm^3$) was heated under reflux until the dark-brown color of the solution turned colorless. The reaction mixture was poured into water (50 $cm^3$) and then extracted with chloroform (50 $cm^3$). The chloroform and the unchanged ethyl 3-oxobutanoate was removed under reduced pressure; the residue was then chromatographed on a silica-gel plate while eluting with chloroform. The products were further purified by repeated TLC or by recrystallization.

**Products. Ethyl 2-Acetoxy-2-(2,7-dimethoxy-1-naphthyl)-3-oxobutanoate (4a):** Liquid; IR($CHCl_3$) $\nu$ 1720, 1743, 1750 (>C=O) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$) $\delta$=1.28 (3H, t, $J$=7.0 Hz, -$OCH_2\underline{CH_3}$), 2.20 (3H, s, -$COCH_3$), 2.28 (3H, s, -$COCH_3$), 3.83 (3H, s, -$OCH_3$) 3.87 (3H, s, -$OCH_3$), 4.30 (2H, q, $J$=7.0 Hz, -$O\underline{CH_2}CH_3$), 6.98 (1H, dd, $J$=9.0, 2.0 Hz, H-6), 7.10 (1H, d, $J$=9.0 Hz, H-3), 7.42 (1H, d, $J$=2.0 Hz, H-8), 7.62 (1H, d, $J$=9.0 Hz, H-4 or H-5), and 7.74 (1H, d, $J$=9.0 Hz, H-5 or H-4). MS *m/z* (rel intensity) 374 [$M^+$] (8), 332 (19), 289 (13), and 215 (100). Found: *m/z* 374.1330. Calcd for $C_{20}H_{22}O_7$: M, 374.1366.

**Ethyl 2-(Acetoxymethyl)-8-methoxynaphtho[2,1-*b*]furan-1-carboxylate (5a):** Mp 92—93 °C (from ethanol); IR ($CHCl_3$) $\nu$ 1717 (-$CO_2Et$), 1742 (-OAc) $cm^{-1}$; $^1H$ NMR (90 MHz, $CDCl_3$) $\delta$=1.463 (3H, t, $J$=7.03 Hz, -$OCH_2\underline{CH_3}$), 2.148 (3H, s, -OAc), 3.996 (3H, s, -$OCH_3$) 4.511 (2H, q, $J$=7.03 Hz, -$O\underline{CH_2}CH_3$), 5.559 (2H, s, -$CH_2$-), 7.170 (1H, dd, $J$=9.09, 2.49 Hz, H-7), 7.474 (1H, d, $J$=9.09 Hz, H-4 or H-5), 7.735 (1H, d, $J$=9.09 Hz, H-5 or H-4), 7.826 (1H, d, $J$=9.09 Hz, H-6), and 8.691 (1H, d, $J$=2.49 Hz, H-9). MS *m/z* (rel intensity) 342 [$M^+$] (100), 283 (20), 255 (33), 254 (24), and 253 Found: *m/z* 342.1085. Calcd for $C_{19}H_{18}O_6$: M, 342.1104.

**Ethyl 2-Acetoxy-2-(2-methoxy-1-naphthyl)-3-oxobutanoate (4c):** Mp 146—147 °C (from ethanol); IR($CHCl_3$) $\nu$ 1720, 1742, 1750 (>C=O) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$) $\delta$=1.28 (3H, t, $J$=7.0 Hz, -$OCH_2\underline{CH_3}$), 2.20 (3H, s, -$COCH_3$), 2.28 (3H, s, -$COCH_3$), 3.91 (3H, s, -$OCH_3$), 4.17 (2H, q, $J$=7.0 Hz, -$O\underline{CH_2}CH_3$), 7.27 (1H, d, $J$=9.0 Hz, H-3), 7.87 (1H, d, $J$=9.0 Hz, H-4), and 7.3—8.2 (4H, m, H-5—H-8). MS *m/z* (rel intensity) 344 [$M^+$] (21), 302 (63), 260 (17), 259 (22), 256 (23), 229 (18), 214 (27), 187 (27), 186 (26), and 185 (100). Found: C, 66.23; H, 5.84%. Calcd for $C_{19}H_{20}O_6$: C, 66.27; H, 5.85%.

**Ethyl 2-(Acetoxymethyl)naphtho[2,1-*b*]furan-1-carboxylate (5c):** Colorless liquid; IR($CHCl_3$) $\nu$ 1722 (-$CO_2Et$), 1745 (-OAc) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$) $\delta$=1.46 (3H, t, $J$=7.0 Hz, -$OCH_2\underline{CH_3}$), 2.13 (3H, s, -OAc), 4.53 (2H, q, $J$=7.0 Hz, -$O\underline{CH_2}CH_3$), 5.56 (2H, s, -$CH_2$-), 7.4—8.1 (5H, m, H-4—H-8), and 9.15 (1H, m, H-9). MS *m/z* (rel intensity) 312 [$M^+$] (95), 270 (38), 269 (28), 253 (22), 225 (30), 224 (30), and 223 (100). Found: *m/z* 312.1002. Calcd for $C_{18}H_{16}O_5$: M, 312.0998.

**Ethyl 2-Acetoxy-2-(2,6-dimethoxy-1-naphthyl)-3-oxobutanoate (4d):** Liquid; IR($CHCl_3$) $\nu$ 1725, 1745, 1760 (>C=O) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$) $\delta$=1.29 (3H, t, $J$=7.0 Hz, -$OCH_2\underline{CH_3}$), 2.20 (3H, s, -$COCH_3$), 2.29 (3H, s, -$COCH_3$), 3.87 (6H, s, 2×-$OCH_3$), 4.33 (2H, q, $J$=7.0 Hz, -$O\underline{CH_2}CH_3$), 7.0—7.2 (2H, m, H-5, H-7), 7.22 (1H, d, $J$=9.0 Hz, H-3), 7.73 (1H, d, $J$=9.0 Hz, H-4), and 8.00 (1H, d, $J$=10.0 Hz, H-8). MS *m/z* (rel intensity) 374 [$M^+$] (36), 332 (66), 217 (31), 216 (21), and 215 (100). Found: *m/z* 374.1356. Calcd for $C_{20}H_{22}O_7$: M, 374.1366.

**Ethyl 2-(Acetoxymethyl)-7-methoxynaphtho[2,1-*b*]furan-1-carboxylate (5d):** Mp 112—113 °C (from ethanol); IR ($CHCl_3$) $\nu$ 1710 (-$CO_2Et$), 1732 (-OAc) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$), $\delta$=1.45 (3H, t, $J$=7.0 Hz, -$OCH_2\underline{CH_3}$), 2.12 (3H, s, -OAc), 3.90 (3H, s, -$OCH_3$), 4.50 (2H, q, $J$=7.0 Hz, -$O\underline{CH_2}CH_3$), 5.52 (2H, s, -$CH_3$-), 7.18 (1H, d, $J$=2.0 Hz, H-6), 7.21 (1H, dd, $J$=8.2, 2.0 Hz, H-8), 7.53 (1H, d, $J$=9.0 Hz, H-4 or H-5), 7.62 (1H, d, $J$=9.0 Hz, H-5 or H-4), and 9.00 (1H, d, $J$=8.2 Hz, H-9); $^{13}C$ NMR (22.4 MHz, $CDCl_3$) $\delta$=14.246 (1C, -$CH_2\underline{C}H_3$), 20.705 (1C, -$OCO\underline{C}H_3$), 55.269 (1C, -$OCH_3$), 58.297 (1C, -$CH_2$-), 61.370 (1C, -$CH_2$-), 107.868 (1C, =CH-), 112.239 (1C, =CH-), 114.730 (1C, =C-), 118.266 (1C, =CH<), 120.130 (1C, =C<), 122.845 (1C, =C<), 126.754 (1C, =CH-), 127.500 (1C, =CH-), 132.766 (1C, =C<), 151.502 (1C, =C<), 155.798 (1C, =C<), 156.947 (1C, =C<), 164.033 (1C, -$O\underline{C}OCH_3$), and 170.313 (1C, -$\underline{C}OOEt$). MS *m/z* (rel intensity) 342 [$M^+$] (88), 300 (19), 283 (20), 253 (100), and 215 (44). Found: C, 66.64; H, 5.27%. Calcd for $C_{19}H_{18}O_6$: C, 66.66; H, 5.30%.

**Reactions of 2,7-Dimethoxynaphthalene (1a) with 2-Cyanoacetamide and Malononitrile in the Presence of Manganese(III) Acetate.** Reactions of **1a** with the active methylene compounds in the presence of manganese(III) acetate were carried out in a manner similar to that of malonamide at a molar ratio of 1:8:8.

**Products. 2-Acetoxy-2-cyano-2-(2,7-dimethoxy-1-naphthyl)acetamide (7a):** Mp 169 °C (from ethanol); IR($CHCl_3$) $\nu$ 1708 (-$CONH_2$), 1765 (-OAc), 2230 (C≡N) $cm^{-1}$; $^1H$ NMR

(400 MHz, $CDCl_3$) $\delta$=2.15 (3H, s, -OAc), 3.84 (3H, s, $-OCH_3$), 3.94 (3H, s, $-OCH_3$), 7.08 (1H, dd, $J$=8.79, 2.20 Hz, H-6), 7.31 (1H, d, $J$=8.80 Hz, H-3), 7.46 (1H, d, $J$=2.20 Hz, H-8), 7.81 (1H, d, $J$=8.79 Hz, H-5), 7.93 (1H, d, $J$=8.79 Hz, H-4), 8.18 (1H, s, -NH), and 8.39 (1H, s, -NH). MS $m/z$ (rel intensity) 328 [$M^+$] (21), 301 (10), 285 (9), 242 (39), 226 (13), and 215 (100). Found: C, 62.21; H, 4.89; N, 8.52%. Calcd for $C_{17}H_{16}O_5N_2$: C, 62.19; H, 4.91; H, 8.53%.

**4-Dicyanomethylene-3,6-dimethoxy-1(4*H*)-naphthalenone (8):** Mp 166—167 °C (from ethanol); IR($CHCl_3$) $\nu$ 1618 (C=C), 1676 (>C=O), 2220 (C≡N) $cm^{-1}$; $^1H$ NMR (60 MHz, $CDCl_3$) $\delta$=3.95 (3H, s, $-OCH_3$) 3.98 (3H, s, $-OCH_3$), 6.84 (1H, s, =CH-), 7.20 (1H, dd, $J$=9.0, 2.4 Hz, H-7), 7.72 (1H, d, $J$=2.4 Hz, H-5), and 8.73 (1H, d, $J$=9.0 Hz, H-8). Found: C, 67.55; H, 3.89; N, 10.55%. Calcd for $C_{15}H_{10}O_3N_2$: C, 67.66; H, 3.79; N, 10.52%.

The authors wish to thank Mr. Yasunori Sudoh of Taiho Pharmaceutical Co., Ltd., Tokushima, for his assistance in measuring the mass spectra.

## References

1) W. J. de Klein, "Reactions with Manganese(III) Acetate," in "Organic Syntheses by Oxidation with Metal Compounds," ed by W. J. Mijs and C. R. H. J. de Jonge, Plenum Press, New York (1986), pp. 261—314.

2) W. E. Fristad and S. S. Hershberger, *J. Org. Chem.*, **50**, 1026 (1985). The formula of manganese(III) acetate has been reported to be $[Mn_3O(OAc)_6(OAc)(HOAc)]5H_2O$, where all manganese are in the state of Mn(III).

3) H. Nishino, *Bull. Chem. Soc. Jpn.*, **59**, 1733 (1986).

4) H. Nishino, K. Tsunoda, and K. Kurosawa, *Bull. Chem. Soc. Jpn.*, **62**, 545 (1989).

5) A. Citterio, D. Fancelli, R. Santi, A. Pagani, and S. Bonsignore, *Gazz. Chim. Ital.*, **118**, 405 (1989).

6) A. Citterio, R. Santi, T. Fiorani, and S. Strologo, *J. Org. Chem.*, **54**, 2703 (1989).

7) S. Ueda and K. Kurosawa, *Bull. Chem. Soc. Jpn.*, **50**, 193 (1977).

8) P. Andrulis, Jr., M. J. S. Dewar, R. Dietz, and R. Hunt, *J. Am. Chem. Soc.*, **88**, 5473 (1966).