JOURNAL OF NATURAL PRODUCTS

NOTE

pubs.acs.org/jnp

Sesquiterpene and Xanthone Derivatives from the Sea Fan-Derived Fungus *Aspergillus sydowii* PSU-F154

Kongkiat Trisuwan,[†] Vatcharin Rukachaisirikul,[*,†] Morakot Kaewpet,[†] Souwalak Phongpaichit,[‡] Nongporn Hutadilok-Towatana,[§] Sita Preedanon,[⊥] and Jariya Sakayaroj[⊥]

[†]Department of Chemistry and Center for Innovation in Chemistry, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand

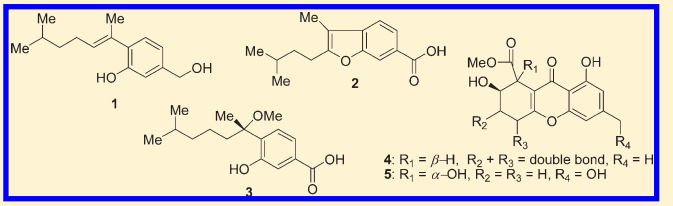
[‡]Natural Products Research Center and Department of Microbiology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand

[§]Department of Biochemistry, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand

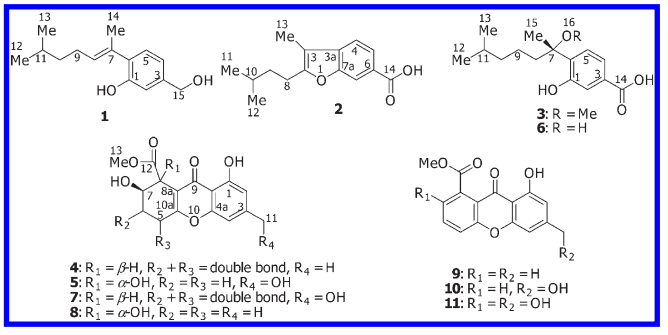
[⊥]National Center for Genetic Engineering and Biotechnology (BIOTEC), Thailand Science Park, Klong Luang, Pathumthani 12120, Thailand

Supporting Information

ABSTRACT: Three new sesquiterpenes, named aspergillusenes A (**1**) and B (**2**) and (+)-(7*S*)-7-*O*-methylsydonic acid (**3**), and two new hydrogenated xanthone derivatives, named aspergillusones A (**4**) and B (**5**), were isolated from the sea fan-derived fungus *Aspergillus sydowii* PSU-F154 together with 10 known compounds. Their structures were identified on the basis of spectroscopic data. The isolated compounds were evaluated for their antioxidant activity.



Many biologically active secondary metabolites have been isolated from the genus *Aspergillus*.[1] During our ongoing search for biologically active metabolites from marine-derived fungi, the broth EtOAc extract of *Aspergillus sydowii* PSU-F154, isolated from a gorgonian sea fan of the genus *Annella*, exhibited antioxidant activity in the 1,1-diphenyl-2-picrylhydrazyl (DPPH$^{\bullet}$) scavenging assay. Investigation of the EtOAc extract led to the isolation and structure determination of three new sesquiterpenes, aspergillusenes A (**1**) and B (**2**) and (+)-(7*S*)-7-*O*-methylsydonic acid (**3**), and two new hydrogenated xanthone derivatives, aspergillusones A (**4**) and B (**5**), along with 10 known compounds, including one sesquiterpene (**6**), two hydrogenated xanthones (**7**, **8**), five xanthones (including **9**−**11**), one diketopiperazine alkaloid, and one phenol. Their antioxidant activity was examined with the DPPH$^{\bullet}$ assay.



All compounds were purified using various chromatographic techniques, and their structures were elucidated by interpretation of spectroscopic data, including IR, UV, NMR, and MS. For the 10 known compounds, the structures were confirmed by comparison of the ^{1}H and ^{13}C NMR data with those previously reported. They were identified as (+)-(7*S*)-sydonic acid (**6**),[2] (7*R*,8*R*)-AGI-B4 (**7**),[3] (7*R*,8*R*)-α-diversonolic ester (**8**),[4,5] methyl 8-hydroxy-6-methyl-9-oxo-9*H*-xanthene-1-carboxylate (**9**),[6] sydowinins A (**10**) and B (**11**),[7] pinselin,[8] methyl 1,6-dihydroxy-3-methyl-9-oxo-9*H*-xanthene-1-carboxylate,[9] (11*S*,14*S*)-cyclo(L-Trp-L-Phe),[10] and orcinol.[11]

Aspergillusene A (**1**) was isolated as a colorless gum with the molecular formula $C_{15}H_{22}O_2$ assigned from HREIMS data. The UV spectrum displayed absorption bands at 228 and 270 nm, characteristic of an aromatic chromophore. The IR spectrum exhibited absorption bands for hydroxy and double-bond functionalities at 3313 and 1635 cm^{-1}, respectively. The ^{1}H NMR spectrum (Table 1) showed characteristic signals for three aromatic protons of a 1,2,4-trisubstituted benzene [δ_H 7.07 (d, J = 7.8 Hz), 6.92 (d, J = 1.5 Hz), and 6.87 (dd, J = 7.8 and 1.5 Hz)], an isopentyl moiety [δ_H 2.32 (q, J = 7.2 Hz), 1.60 (m), 1.34 (m), and 0.93 (d, J = 6.6 Hz)], one hydroxy proton (δ_H 5.69, brs), one olefinic proton of a trisubstituted double bond (δ_H 5.55, tq, J = 7.2 and 1.2 Hz), one hydroxymethyl group (δ_H 4.62, s), and one methyl group (δ_H 1.98, d, J = 1.2 Hz). Three aromatic protons

Received: May 2, 2011
Published: June 30, 2011

Table 1. ^{1}H and ^{13}C NMR Data for Aspergillusenes A (1) and B (2) and (+)-(7*S*)-7-*O*-Methylsydonic Acid (3)

	1		2		3	
position	δ_C	δ_H m (*J*, Hz)	δ_C	δ_H m (*J*, Hz)	δ_C	δ_H m (*J*, Hz)
1-OH	152.1, C	5.69, brs			156.1, C	8.96, s
2	113.8, CH	6.92, d (1.5)	158.8, C		118.6, CH	7.49, s
3	141.1, C		110.0, C		129.9, C	
3a			135.6, C			
4	118.6, CH	6.87, dd (7.8, 1.5)	118.2, CH	7.37, d (8.1)	121.2, CH	7.49, d (8.5)
5	128.5, CH	7.07, d (7.8)	124.2, CH	7.89, d (8.1)	127.5, CH	7.03, d (8.5)
6	130.5, C		135.6, C		133.8, C	
7	131.6, C		112.7, CH	8.04, s	83.0, C	
7a			153.2, C			
8	132.1, CH	5.55, tq (7.2, 1.2)	24.5, CH_2	2.67, t (7.5)	39.8, CH_2	1.77, m
						1.75, m
9	26.4, CH_2	2.32, q (7.2)	36.9, CH_2	1.55, m	21.6, CH_2	1.27, m
						1.05, m
10	38.6, CH_2	1.34, m	27.7, CH	1.49, m	39.0, CH_2	1.05, m
11	27.8, CH	1.60, m	22.3, CH_3	0.86, d (6.0)	27.8, CH	1.42, m
12	22.5, CH_3	0.93, d (6.6)	22.3, CH_3	0.86, d (6.0)	22.5, CH_3	0.75, d (6.5)
13	22.5, CH_3	0.93, d (6.6)	7.8, CH_3	2.10, s	22.5, CH_3	0.75, d (6.5)
14	17.9, CH_3	1.98, d (1.2)	172.0, C		169.4, C	
15	65.1, CH_2	4.62, s			22.2, CH_3	1.55, s
16					50.6, CH_3	3.16, s

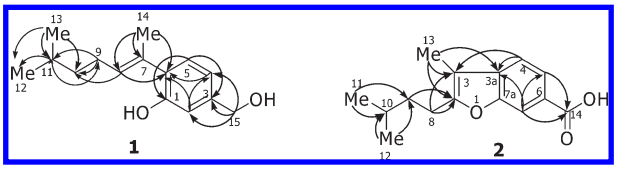


Figure 1. Selected HMBC correlations for compounds **1** and **2**.

resonating at δ_H 7.07, 6.92, and 6.87 were assigned as H-5, H-2, and H-4, respectively, on the basis of their multiplicities, coupling constants, and ^{3}J HMBC correlations: H-2/C-4 (δ_C 118.6) and C-6 (δ_C 130.5); H-4/C-2 (δ_C 113.8) and C-6; H-5/C-1 (δ_C 152.1) and C-3 (δ_C 141.1) (Figure 1). The substituent at C-1 of the 1,2,4-trisubstituted benzene ring was identified as a hydroxy group according to the chemical shift of C-1. The hydroxymethylene protons, H_2-15 (δ_H 4.62), showed HMBC correlations with C-2, C-3, and C-4, suggesting that the hydroxymethyl unit was located at C-3 of the benzene ring. Signal enhancement of H-2 and H-4 after irradiation of H_2-15 in the NOEDIFF experiment supported the assigned location. The isopentyl unit was established according to the following $^{1}H-^{1}H$ COSY and HMBC correlations: H_2-10 (δ_H 1.34)/H_2-9 (δ_H 2.32) and H-11 (δ_H 1.60); H-11/H_3-12 (δ_H 0.93) and H_3-13 (δ_H 0.93); H_2-9/C-10 (δ_C 38.6) and C-11 (δ_C 27.8); H-11/C-9 (δ_C 26.4), C-12, and C-13; and H_3-13/C-10, C-11, and C-12. In the $^{1}H-^{1}H$ COSY spectrum, the methylene protons, H_2-9, of the isopentyl unit showed a cross-peak with the olefinic proton, H-8 (δ_H 5.55), which was further coupled with the methyl protons, H_3-14 (δ_H 1.98), with a small coupling constant of 1.2 Hz. These data as well as the HMBC correlations of H_3-14 with C-7 (δ_C 131.6) and C-8 (δ_C 132.1) established a 2-substituted 6-methyl-2-heptenyl fragment. This fragment was attached at C-6 of the benzene ring on the basis of the HMBC correlations of H-8 and H_3-14 with C-6. The configuration of the double bond in the heptenyl unit was assigned as *E* according to signal enhancement of H_2-9 upon irradiation of H_3-14 in the NOEDIFF experiment. Therefore, aspergillusene A had the structure **1**.

Aspergillusene B (**2**), a colorless gum, had the molecular formula $C_{15}H_{18}O_3$, which was determined by HREIMS. The UV spectrum revealed the presence of a benzofuran chromophore at 219, 250, 266, 295, and 303 nm.[12] The IR spectrum was similar to that of **1** with an additional absorption band for a carbonyl group of a carboxylic acid at 1721 cm^{-1}. A carbonyl resonance at δ_C 172.0 in the ^{13}C NMR spectrum (Table 1) supported the IR data. The ^{1}H NMR spectrum (Table 1) was similar to that of **1**. The differences were the downfield shift of all aromatic protons, H-4 (δ_H 7.37), H-5 (δ_H 7.89), and H-7 (δ_H 8.04), and the disappearance of signals for olefinic, hydroxy, and hydroxymethyl protons in **2**. In the ^{13}C NMR spectrum, the replacement of the hydroxymethyl carbon in **1** with the carboxyl carbonyl carbon, C-14 (δ_C 172.0), in **2** revealed that the hydroxymethyl group in **1** was oxidized to the carboxylic acid in **2**. The ^{3}J HMBC correlations of H-5 and H-7 with C-14 (Figure 1) confirmed the assignment. In addition, the 2-substituted 6-methyl-2-heptenyl side chain and 1-OH in **1** formed an ether linkage between C-2 (δ_C 158.8) and C-7a (δ_C 153.2) in **2** to form a benzofuran moiety. The HMBC correlations of the methyl protons, H_3-13 (δ_H 2.10), with C-2, C-3 (δ_C 110.0) and C-3a (δ_C 135.6) and those of H_2-8 (δ_H 2.67) with C-2 and C-3 established the location of the methyl and isopentyl groups at C-3 and C-2 of the benzofuran unit, respectively. Consequently, aspergillusene B (**2**) was assigned as a cyclized benzofuran derivative of **1**.

(+)-(7*S*)-7-*O*-Methylsydonic acid (**3**) was obtained as a colorless gum. The molecular formula was assigned as $C_{16}H_{24}O_4$ through analysis of its HREIMS spectrum. The UV (230 and

dx.doi.org/10.1021/np200374j |*J. Nat. Prod.* 2011, 74, 1663–1667

Table 2. ^{1}H and ^{13}C NMR Data for Aspergillusones A (4) and B (5)

	4		5	
position	δ_C	δ_H m (*J*, Hz)	δ_C	δ_H m (*J*, Hz)
1-OH	160.3, C	12.30, s	160.7, C	11.97, s
2	112.4, CH	6.63, brs	108.9, CH	6.76, s
3	147.2, C		151.0, C	
4	107.5, CH	6.71, brs	104.3, CH	6.94, s
4a	155.6, C		156.0, C	
5	123.0, CH	6.45, d (10.0)	26.0, CH_2	2.96, m
				2.87, m
6	137.8, CH	6.61, dd (10.0, 5.0)	24.2, CH_2	2.31, m
				2.21, m
7	65.2, CH	4.87, m	72.7, CH	4.09, dd
				(10.5, 4.0)
8	44.9, CH	4.29, d (3.5)	76.0, C	
8a	110.1, C		117.0, C	
9	181.0, C		180.0, C	
9a	108.9, C		116.8, C	
10a	158.5, C		167.2, C	
11	22.4, CH_3	2.41, brs	64.4, CH_2	4.76, brs
12	170.9, C		172.0, C	
13	52.8, CH_3	3.73, s	53.3, CH_3	3.85, s

283 nm) and IR (3400 and 1720 cm^{-1}) absorption bands revealed the presence of a benzoic acid.[2] Its ^{1}H NMR data (Table 1) were comparable with those of **6**[2] except for an additional signal for a methoxy group (δ_H 3.16, s). The presence of the methoxy group was supported by a resonance at δ_C 50.6 in the ^{13}C NMR and DEPT spectra. A HMBC correlation from the methoxy protons, H_3-16 (δ 3.16), to C-7 (δ_C 83.0) revealed the replacement of the hydroxy group in **6** with the methoxy group in **3**. The observed specific rotation of **3**, $[\alpha]^{20}_D$ +2 (*c* 1.9, MeOH), which correlated well with that of **6**, $[\alpha]^{20}_D$ +2.7 (*c* 2.3, MeOH), indicated that C-7 in **3** has the *S* configuration, identical to that of **6**. Therefore, **3** was identified as a methyl ether derivative of **6**.

Aspergillusone A (**4**) was obtained as a colorless gum with $[\alpha]^{25}_D$ −1 (*c* 0.4, MeOH). The UV and IR spectra were almost identical to those of **7**.[3] The HREIMS data supported the molecular formula $C_{16}H_{14}O_6$, one oxygen atom less than that of **7**. The ^{1}H and ^{13}C NMR data (Table 2) of **4** were comparable to those of **7** except for the appearance of a signal for the aromatic methyl group (δ_H 2.41 and δ_C 22.4) in **4**, instead of the hydroxymethyl signal (δ_H 4.67 and δ_C 64.3) in **7**. The location of the methyl group at C-3 (δ_C 147.2) was confirmed by the HMBC correlations of the methyl protons, H_3-11, with C-2 (δ_C 112.4), C-3 and C-4 (δ_C 107.5) as well as signal enhancement of H-2 (δ_H 6.63) and H-4 (δ_H 6.71) upon irradiation of H_3-11 in the NOEDIFF experiment. The relative configuration of ring A in **4** was assigned as *trans*, identical to that of **7** according to their similar coupling constants (**4**: $J_{6,7}$ = 5.0 Hz and $J_{7,8}$ = 3.5 Hz; **7**: $J_{6,7}$ = 4.8 Hz and $J_{7,8}$ = 3.6 Hz). Irradiation of H-7 in the NOEDIFF experiment did not affect signal intensity of H-8, supporting their *trans* orientation. The observed specific rotation of **4** was almost identical to that of **7**, $[\alpha]^{25}_D$ −1.6 (*c* 0.4, MeOH),[3] indicating that they have the same absolute configuration at C-7 and C-8. Consequently, aspergillusone A (**4**) was the 11-deoxy derivative of **7**.

The molecular formula of aspergillusone B (**5**) was established by analysis of its HREIMS data as $C_{16}H_{16}O_8$. The UV and IR spectra were almost identical to those of **8**.[4] Its ^{1}H NMR spectrum (Table 2) differs from that of **8**[5] by the replacement of the aromatic methyl signal in **8** with a hydroxymethyl signal (δ_H 4.76, brs) in **5**. The HMBC correlations of the hydroxymethyl protons, H_2-11 (δ_H 4.76), with C-2 (δ_C 108.9), C-3 (δ_C 151.0), and C-4 (δ_C 104.3) as well as signal enhancement of both H-2 (δ_H 6.76) and H-4 (δ_H 6.94) upon irradiation of H_2-11 in the NOEDIFF experiment supported the attachment of the hydroxymethyl group at C-3. The coupling constants of 10.5 and 4.0 Hz between H-7 (δ_H 4.09) and H_{ab}-6 (δ_H 2.31 and 2.21) showed the pseudoaxial position of H-7, identical to that (H-7, δ_H 4.08, dd, *J* = 10.5 and 3.5 Hz) in **8**, thus suggesting the same relative configuration. The configurations of both C-7 and C-8 were proposed as *R*, identical to that of **8**, on the basis of above data and the same signs of their specific rotations: **5**, $[\alpha]^{25}_D$ −46.3 (*c* 0.2, $CHCl_3$); **8**, $[\alpha]^{25}_D$ −22.6 (*c* 0.23, $CHCl_3$).[4] Accordingly, aspergillusone B (**5**) was determined as the 1-hydroxy derivative of **8**.

The isolated compounds **1**−**3**, **7**−**11**, and (11*S*,14*S*)-cyclo-(L-Trp-L-Phe) were subjected to a DPPH$^{\bullet}$ assay. Among them, only the dihydroxanthone **7** showed antioxidant activity, with an IC_{50} value of 17 μM, while the remaining compounds were inactive. This dihydroxanthone derivative (**7**), however, was much less effective than the standard butylated hydroxyanisole (IC_{50} = 0.13 μM). The dihydroxanthone **7** and the xanthone **11** are structurally similar, with three hydroxy groups being at the same positions (C-1, C-7, and C-11). However, **7** differed from **11** in the absence of a double bond at the C7−C8 position, indicating that the planar structure in **11** might decrease the antioxidant activity.

Investigation of the sea fan-derived fungus *A. sydowii* PSU-F154 led to the isolation of 15 compounds, including three new sesquiterpenes (**1**−**3**) and two new dihydroxanthones (**4**, **5**). The xanthone derivatives have a right-hand ring structurally similar to the co-isolated orcinol. So far, there have been only two reports on compounds of this type isolated from marine-derived *Aspergillus* spp.[13,14] Furthermore, only five phenolic bisabolane sesquiterpenes, for example, **6**, have been obtained from a marine-derived *Aspergillus* sp.[15] Consequently, compounds **1**−**3** are new members of bisabolane-type sesquiterpenes and are derived via the same biosynthetic pathway as the co-occurring metabolite **6**.

EXPERIMENTAL SECTION

General Experimental Procedures. Optical rotations were measured on a JASCO P-1020 polarimeter. Ultraviolet spectra (UV) were measured in MeOH with an UV-160A Shimadzu spectrophotometer. Infrared spectra (IR) were recorded on a Perkin-Elmer 783 FTS 165 FT-IR spectrometer. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ on a 300 or 500 MHz Bruker FTNMR Ultra Shield spectrometer using tetramethylsilane (TMS) as an internal standard. Mass spectra were obtained on a MAT 95 XL mass spectrometer (Thermo Finnigan). Solvents for extraction and chromatography were distilled at their boiling point range prior to use except for EtOAc and light petroleum, which were analytical grade reagents. Thin-layer chromatography (TLC) and precoated TLC (PTLC) were performed on silica gel GF_{254} (Merck). Column chromatography (CC) was carried out on silica gel (Merck) type 100 (70−230 Mesh ASTM) with a gradient system of MeOH−CH_2Cl_2, on Sephadex LH-20 with MeOH, or on reversed-phase silica gel C-18 with a gradient system of MeOH−H_2O, or as otherwise stated.

Fungal Material and Identification. The marine-derived fungus *A. sydowii* PSU-F154 was isolated from a sea fan, *Annella* sp., collected from the coastal area in Suratthani Province, Thailand, in 2006. This fungus was deposited as PSU-F154 at the Department of Microbiology, Faculty of Science, Prince of Songkla University, and as BCC 28785 at the National Center for Genetic Engineering and Biotechnology (BIOTEC) Culture Collection, Thailand.

The fungus PSU-F154 was identified on the basis of its morphological and molecular characteristics. Colonies on potato dextrose agar at 25 °C grew slowly, reaching 20−25 mm in diameter after 7 days, velvety to rather floccose. Colony color is blue-green and edge of colony is white. Conidiophores are upright, simple, terminating in a globose conidial head bearing phialides, which are the characteristics of the genus *Aspergillus*.[16] The analysis of the DNA sequences of the internal transcribed spacer (ITS1-5.8S-ITS2) regions of its rRNA gene revealed that the PSU-F154 ITS sequence (GenBank accession no. JN123448) matched with three *A. sydowii* sequences from GenBank (HQ637369, FR733849, and FR733845) with sequence identity of 99.7%, respectively. This sea fan-derived fungus was then identified as *A. sydowii*.

Fermentation, Extraction, and Isolation. The EtOAc extract from the culture broth was prepared using the same procedure described previously.[17] The broth EtOAc extract was obtained as a brown gum in 1.7 g. It was fractionated over Sephadex LH-20 to give five fractions (A−E). Separation of fraction B (573.6 mg) using Sephadex LH-20 CC afforded four fractions (B1−B4). Fraction B2 (501.3 mg) was further purified by CC over reversed-phase silica gel to give five fractions (B21−B25). Compound **5** (1.0 mg) was obtained from fraction B21 (23.5 mg) after purification by silica gel CC followed by PTLC with 40% EtOAc−light petroleum. Separation of fraction B22 (45.2 mg) using silica gel CC gave three fractions. The third fraction (4.7 mg) was further purified by PTLC using 1% MeOH−CH_2Cl_2 as a mobile phase to furnish **8** (3.1 mg). Fraction B24 (61.1 mg) was separated by CC over silica gel to give **1** (8.4 mg) and **2** (4.0 mg). Purification of fraction B25 (4.8 mg) by PTLC with 40% EtOAc−light petroleum yielded **3** (2.9 mg) and **6** (1.2 mg). Compound **4** (1.1 mg) was obtained from fraction B3 (57.3 mg) after purification by silica gel CC followed by PTLC with 10% EtOAc−CH_2Cl_2. Purification of fraction B4 (5.1 mg) by PTLC using 5% EtOAc−light petroleum afforded **10** (3.3 mg). Fraction C (630.1 mg) was separated using CC over reversed-phase silica gel to furnish six fractions (C1−C6). Fraction C1 (69.0 mg) was further purified by silica gel CC to give three fractions. The second fraction contained orcinol (3.0 mg). Purification of fraction C3 (26.3 mg) using CC over silica gel yielded (11*S*,14*S*)-cyclo-(L-Trp-L-Phe) (6.2 mg). Compound **9** (2.8 mg) was obtained from fraction C5 (35.6 mg) after purification with silica gel CC. Fraction D (269.6 mg) was subjected to CC over silica gel to afford six fractions (D1−D6). Fraction D2 (8.2 mg) was further purified by PTLC using 30% EtOAc−light petroleum to furnish pinselin (0.9 mg). Compound **7** (3.4 mg) was obtained from fraction D4 (7.3 mg) after purification by PTLC with 40% EtOAc−light petroleum. Fraction D6 contained **11** (20.0 mg). Fraction E (169.5 mg) was further purified by CC over silica gel using a gradient of EtOAc−light petroleum to afford three fractions (E1−E3). Fraction E2 (8.3 mg) after purification on PTLC with 10% EtOAc−CH_2Cl_2 yielded methyl 1,6-dihydroxy-3-methyl-9-oxo-9*H*-xanthene-1-carboxylate (1.2 mg).

Aspergillusene A (**1**): colorless gum; UV (MeOH) λ_{max} (log ε) 228 (3.10), 270 (3.21) nm; FT-IR (neat) ν_{max} 3313, 1635 cm^{-1}; ^1H NMR (300 MHz) and ^{13}C NMR (75 MHz) data, see Table 1; HREIMS *m*/*z* 234.1622 $[M]^+$ (calcd for $C_{15}H_{22}O_2$, 234.1620).

Aspergillusene B (**2**): colorless gum; UV (MeOH) λ_{max} (log ε) 219 (4.20), 250 (4.01), 266 (3.81), 295 (3.65), 303 (3.10) nm; FT-IR (neat) ν_{max} 3312, 1721, 1623 cm^{-1}; ^1H NMR (300 MHz) and ^{13}C NMR (75 MHz) data, see Table 1; HREIMS *m*/*z* 246.1254 $[M]^+$ (calcd for $C_{15}H_{18}O_3$, 246.1256).

(+)-(7S)-7-O-Methylsydonic acid (**3**): colorless gum; $[\alpha]^{20}_D$ +2 (*c* 1.9, MeOH); UV (MeOH) λ_{max} (log ε) 230 (3.73), 283 (3.15) nm; FT-IR (neat) ν_{max} 3400, 1720, 1659 cm^{-1}; ^1H NMR (500 MHz) and ^{13}C NMR (125 MHz) data, see Table 1; HREIMS *m*/*z* 280.1675 $[M]^+$ (calcd for $C_{16}H_{24}O_4$, 280.1675).

Aspergillusone A (**4**): colorless gum; $[\alpha]^{25}_D$ −1 (*c* 0.4, MeOH); UV (MeOH) λ_{max} (log ε) 220 (4.13), 263 (3.81), 292 (3.79), 304 (3.15) nm; FT-IR (neat) ν_{max} 3380, 1745, 1681, 1653 cm^{-1}; ^1H NMR (500 MHz) and ^{13}C NMR (125 MHz) data, see Table 2; HREIMS *m*/*z* 284.0685 $[M - H_2O]^+$ (calcd for $C_{16}H_{12}O_5$, 284.0681).

Aspergillusone B (**5**): colorless gum; $[\alpha]^{20}_D$ −46.3 (*c* 0.2, $CHCl_3$); UV (MeOH) λ_{max} (log ε) 230 (3.71), 280 (3.30), 320 (3.10) nm; FT-IR (neat) ν_{max} 3400, 1725, 1697, 1649 cm^{-1}; ^1H NMR (500 MHz) and ^{13}C NMR (125 MHz) data, see Table 2; HREIMS *m*/*z* 336.0842 $[M]^+$ (calcd for $C_{16}H_{16}O_8$, 336.0845).

(+)-(7S)-Sydonic acid (**6**): $[\alpha]^{23}_D$ +2.0 (*c* 2.0, MeOH).

(7R,8R)-AGI-B4 (**7**): $[\alpha]^{25}_D$ −1.0 (*c* 0.4, MeOH).

(7R,8R)-α-Diversonolic ester (**8**): $[\alpha]^{23}_D$ −47.6 (*c* 0.2, $CHCl_3$).

Biological Activity. The DPPH radical scavenging assay was carried out according to Yen and Hsieh.[18] The IC_{50} value was recorded by reading the sample concentration that produced 50% scavenging of those radicals. Butylated hydroxyanisole displayed an IC_{50} value of 0.13 μM.

■ ASSOCIATED CONTENT

Supporting Information. ^1H and ^{13}C NMR spectra for new compounds (**1**−**5**). This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*Tel: +66-74-288-435. Fax: +66-74-558-841. E-mail: vatcharin.r@psu.ac.th.

■ ACKNOWLEDGMENT

V.R. thanks the Office of Higher Education Commission and the Thailand Research Fund for the TRF Senior Research Scholar (Grant No. RTA5180007). K.T. thanks the Thailand Research Fund through the Royal Golden Jubilee Ph.D. Program (Grant No. PHD/0109/2550) and the Center for Innovation in Chemistry (PERCH-CIC) for a scholarship. The Graduate School and Faculty of Science, Prince of Songkla University, are acknowledged for partial support.

■ REFERENCES

(1) Saleem, M.; Ali, M. S.; Hussain, S.; Jabbar, A.; Ashraf, M.; Lee, Y. S. *Nat. Prod. Rep.* **2007**, *24*, 1142–1152.

(2) Kudo, S.; Murakami, T.; Miyanishi, J.; Tanaka, K.; Takada, N.; Hashimoto, M. *Biosci. Biotechnol. Biochem.* **2009**, *73*, 203–204.

(3) Kim, H. S.; Park, I. Y.; Park, Y. J.; Lee, J. H.; Hong, Y. S.; Lee, J J. *J. Antibiot.* **2002**, *55*, 669–672.

(4) Holker, J. S.; O'Brien, E.; Simpson, T. J. *J. Chem. Soc., Perkin Trans. 1* **1983**, *7*, 1365–1368.

(5) Nicolaou, K. C.; Li, A. *Angew. Chem., Int. Ed.* **2008**, *47*, 6579–6582.

(6) Shao, C.; Wang, C.; Wei, M.; Gu, Y.; Xia, X.; She, Z.; Lin, Y. *Magn. Reson. Chem.* **2008**, *46*, 1066–1069.

(7) Hamasaki, T.; Sato, Y.; Hatsuda, Y. *Agric. Biol. Chem.* **1975**, *39*, 2341–2345.

(8) Yamazaki, M.; Okuyama, E. *Chem. Pharm. Bull.* **1980**, *28*, 3649–3655.

(9) Hamasaki, T.; Kimura, Y. *Agric. Biol. Chem.* **1983**, *47*, 163–165.
(10) Kimura, Y.; Tani, K.; Kojima, A.; Sotoma, G.; Okada, K.; Shimada, A. *Phytochemistry* **1996**, *41*, 665–669.
(11) Monde, K.; Satoh, H.; Nakamura, M.; Tamura, M.; Takasugi, M. *J. Nat. Prod.* **1998**, *61*, 913–921.
(12) Trofast, J. *Phytochemistry* **1978**, *17*, 1359–1361.
(13) Wu, Z.-J.; Ouyang, M.-A.; Tan, Q.-W. *Pest Manag. Sci.* **2009**, *65*, 60–65.
(14) Lee, Y. M.; Li, H.; Hong, J.; Cho, H. Y.; Bae, K. S.; Kim, M. A.; Kim, D.-K.; Jung, J. H. *Arch. Pharm. Res.* **2010**, *33*, 231–235.
(15) Wei, M.-Y.; Wang, C.-Y.; Liu, Q.-A.; Shao, C.-L.; She, Z.-G.; Lin, Y.-C. *Mar. Drugs* **2010**, *8*, 941–949.
(16) Barnett, H. L.; Hunter, B. B. *Illustrated Genera of Imperfect Fungi*; Prentice-Hall, Inc.: The American Phytopathological Society, USA., 1998.
(17) Trisuwan, K.; Rukachaisirikul, V.; Sukpondma, Y.; Preedanon, S.; Phongpaichit, S.; Sakayaroj, J. *Phytochemistry* **2009**, *70*, 554–557.
(18) Yen, G.-C.; Hsieh, C.-L. *Biosci. Biotechnol. Biochem.* **1997**, *61*, 1646–1649.