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Short Note

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A new *p*-terphenyl derivative from fruiting bodies of the basidiomycete *Sarcodon laevigatum*

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A new metabolite with *p*-terphenyl core, named sarcodan **(1)**, together with three known *p*-terphenyl metabolites **(3, 4, 5)** represented as Fig. 1, was isolated from the fruiting bodies of the basidiomycete *Sarcodon laevigatum*. The structures of these compounds were elucidated by spectroscopic and chemical methods.

The chemical investigation of *p*-terphenyls as one class of the pigments of mushrooms began in 1877. The isolation of polyporic acid, atromentin and thelephoric acid marked the start of the chemical investigation of fungal pigments. The elucidation of the structures of polyporic acid and atromentrin by KÖGL represented a significant advance in organic chemistry (TURNER *et al.* 1971, 1983).

It has been reported that some *p*-terphenyls exhibit significant biologically activities, e.g., potent immunosuppressants, neuroprotective, anticoagulant, specific 5-lipoxygenase inhibitory, and cytotoxic activities (KAMIGAUCHI *et al.* 1998, KHANNA *et al.* 1965, TAKAHASHI *et al.* 1992, BURTON *et al.* 1959, CALI *et al.* 2004). *p*-Terphenyls are also reported to have attractive antioxidant activities. Curtisians A–D and curtisians I–Q, isolated from *Paxillus curtissii* showed strong antioxidant activities against lipid peroxidation, *ca.* 10–20 times that of vitamin E (YUN *et al.* 2000, QUANG *et al.* 2003, QUANG *et al.* 2003). Betulinan A and B, isolated from *Lenzites betulina* showed potent antioxidant activities against lipid peroxidation (LEE *et al.* 1996). The antioxidant activities of ten natural *p*-terphenyls obtained from the fruiting bodies of three edible mushrooms (*Thelephora ganbajun, Thelephora aurantiotincta, Boletopsis grisea*) indigenous to China were evaluated in comparison with BHA and α-tocopherol by the DPPH radical-scavenging method (HU *et al.* 2001a, 2001b, 2003, LIU *et al.* 2004). Because of their promising biological activities, *p*-terphenyls have generated strongly increasing research interests. In addition, *p*-terphenyls are easily synthesized in comparison with other type of complex natural products since *p*-terphenyls contain fewer chiral centers or no chiral center. It is also interesting to note that some edible mushrooms often taken as favored food are rich in *p*-terphenyls. This is a sign that the toxicity of *p*-terphenyls is low, at least for some of them. All these properties are interesting for the drug discovery from this type of natural products.

Sarcodon leavigatum is a mushroom belonging to the family Thelephoraceae. In continuation of our studies on basidiomycete-derived bioactive secondary metabolites, the chemical constituents of the mushroom *Sarcodon laevigatum* from Yunnan, China has been investigated. This report describes the structural elucidation of a new compound, named sarcodan **(1)**, including three known *p*-terphenyls **(3, 4, 5)**.

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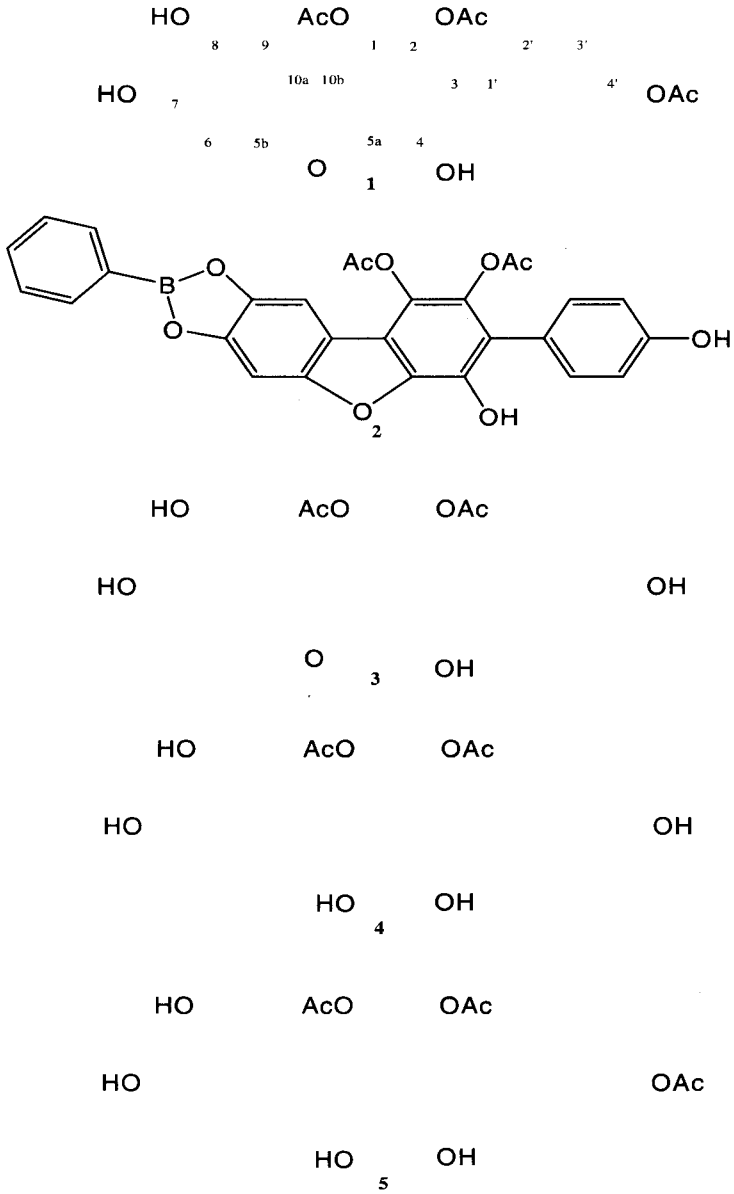

Fig. 1
The structures of compounds **1**–**5**

The entire freshly collected fruiting bodies of *S. laevigatum* (dry weight 320 g) were immersed in 95% EtOH and left at room temperature for three days. Then the EtOH extract was decanted and evaporated *in vacuo*. The residue was extracted with MeOH. The extract (25 g) was fractionated by column chromatography (silica gel, eluted with $CHCl_3$/MeOH 9:1, 8:2, 7:3, v/v). The fraction eluted by $CHCl_3$/MeOH (8:2, v/v) was submitted to further purification by Sephadex LH-20 chromatography. Elution with MeOH yielded compounds **1** (20 mg), **3** (15 mg), **4** (35 mg), and **5** (50 mg).

Sarcodan (**1**) was obtained as white amorphous powder. – UV/vis (MeOH): λ_{max} (lg ε) = 220 nm (4.23), 206 nm (4.65). – IR (KBr): 3421 (OH), 2934, 2094, 1751, 1627, 1431, 1371, 1218, 1133, 924, 597 cm^{-1}. – ^1H and ^{13}C NMR (CD_3OD) see Table 1. – HR-ESI-MS: *m/z* 465.0826 (calcd. for $C_{24}H_{17}O_{10}$ 465.0821). FAB-MS (neg.): *m/z* 465 (100) $[M-1]^-$.

Preliminary ^1H and ^{13}C NMR analysis of **1**, as well as IR and UV data, showed marked similarity with *p*-terphenyl derivative **3** except for an additional acetoxy group (TAKAHASHI *et al.* 1992). Complete high-field NMR analysis (400 MHz for ^1H), including two dimen-

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Table 1
^{1}H and ^{13}C NMR (CD_3OD) data of Sarcodan (**1**)

	δ C	δ H	^{1}H-^{1}HCOSY selected	HMBC selected
1	129.7			
2	137.2			
3	121.2			
4	139.0			
5a	144.2			
5b	152.6			
6 (CH)	99.4	7.06 (s)		
7	148.4			H-9
8	143.9			H-6
9 (CH)	107.3	7.13 (s)		
10a	114.9			H-6
10b	120.0			H-9
1′	132.2			H-3′,5′
2′,6′	132.9	7.36 (dd, 1.4, 6.8)	H-3′,5′	
3′,5′	122.4	7.16 (dd, 1.4, 6.8)	H-2′,6′	
4′	151.7			
1-$COCH_3$	170.1, 20.1	2.43 (s)		
2-$COCH_3$	170.4, 20.3	1.97 (s)		
4′-$COCH_3$	171.3, 20.9	2.29 (s)		H-3′,5′

sional experiments (^{1}H, ^{1}H-COSY, HSQC, HMBC) was performed on **1**. These data, aided by DEPT, allowed the complete signal assignments reported in the Experimental Section (see Table 1).

It was apparent that compound **1** contained a *p*-terphenyl nucleus bearing oxygenated functions at the same position as in compound **3**. In addition to the *p*-terphenyl resonances, **1** showed signals attributable to two acetoxy groups located at C-2′ and C-3′. This was confirmed by the HMBC correlations of the oxygen-bearing quaternary carbons with the acetate methyl groups. When **1** was treated with phenylboronic acid and the reaction mixture was examined directly by FAB-MS (neg.) in MNBA, an ion observed at *m/z* 704 ($[M + 154]^-$) indicated the formation of a phenylboronate **2**, which implied the presence of a pair of vicinal OH groups. Another acetoxy group was connected with C-4′ which was confirmed by the HMBC correction of H-3′, 5′ with acetoxy carbon.

Reaction of 1 with phenylboronic acid

1 (5 mg) in acetone (10 ml) and phenylboronic acid (5 mg) were refluxed at 50 °C for 6 h, and then evaporated. The crude residue was directly measured with FAB-MS (neg.): *m/z* 704 (100) $[M + 154]^-$.

Comparison of the physicochemical properties with the reported data allowed to identify compounds **3**, **4** and **5**, isolated from the same fungus, as 1,2-diacetoxy-3-(4′-hydroxyphenyl)-4,7,8-trihydroxy-dibenzofuran (TAKAHASHI *et al.* 1992) and 2′,3′-diacetoxy-3,4,4″,5′,6′-pentahydroxy-*p*-terphenyl and 2′,3′,4″-triacetoxy-3,4,5′,6′-tetrahydroxy-*p*-terphenyl (GERACI *et al.* 2000).

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References

BURTON, J. F. and CAIN, B. F., 1959. Antileukamic activity of polyporic acid. Nature, **184**, 1326–1327.

CALI, V., SPATAFORA, C. and TRINGALI, C., 2004. Sarcodonins and sarcoviolins, bioactive polyhydroxy *p*-terphenyl pyrazinediol dioxide conjugates from fruiting bodies of basidiomycete *Sarcodon leucopus*. Eur. J. Org. Chem., 592–599.

GERACI, C., NERI, P., PATERNO, C., RPCCO, C. and TRINGALI, C., 2000. An unusual nitrogenous terphenyl derivative from fruiting bodies of the basidiomycete *Sarcodon leucopus*. J. Nat. Prod., **63**, 347–351.

HU, L., GAO, J. M. and LIU, J. K., 2001a. Unusual poly(phenyl acetyloxy)-substituted 1,1′:4′,1″-terphenyl derivatives from fruiting bodies of the basidiomycete *Thelephora ganbajun*. Helv. Chim. Acta, **84**, 3342–3349.

HU, L. and LIU, J. K., 2001b. Two novel phenylacetoxylated *p*-terphenyls from *Thelephora ganbajun* Zang. Z. Naturforsch, **56c**, 983–987.

HU, L. and LIU, J. K., 2003. *p*-Terphenyls from the basidiomycete *Thelephora aurantiotincta*. Z. Naturforsch, **58c**, 452–454.

KAMIGAUCHI, T., SAKAZAKI, R., NAGASHIMA, K., KAWAMURA, Y., YASUDA, Y., MATSUSHIMA, K., TANI, H., TAKAHASHI, Y., ISHII, K., SUZUKI, R., KOIZUMI, K., NAKAI, H., IKENISHI, Y. and TERU, Y., 1998. Terprenins, novel immunosupressants produced by *Aspergillus cadidus*. J. Antibiot., **51**, 445–450.

KHANNA, J. M., MALONE, M. H., EULER, K. L. and BRADY, L. R., 1965. Anticoagulant from *Hydnellum diabolus*. J. Pharm. Sci., **54**, 1016–1020.

LEE, I. K., YUN, B. S., CHO, S. M., KIM, W. G., KIM, J. P., RYOO, I. J., KOSHINO, H. and YOO, I. D., 1996. Betulinans A and B, two benzoquinone compounds from *Lenzites betulina*. J. Nat. Prod., **59**, 1090–1092.

LIU, J. K., HU, L., DONG, Z. J. and HU, Q., 2004. DPPH radical scavenging activity of ten natural *p*-terphenyl derivatives obtained from three edible mushroom indigenous to China. Chemistry & Biodiversity, **1**, 601–605.

QUANG, D. N., HASHIMOTO, T., NUKADA, M., YAMAMOTO, I., TANAKA M. and ASAKAWA, Y., 2003. Antioxidant activity of custisians I-L from the inedible mushroom *Paxillus curtisii*. Planta Medica, **69**, 1063–1066.

QUANG, D. N., HASHIMOTO, T., NUKADA, M., YAMAMOTO, I., TANAKA, M. and ASAKAWA, Y., 2003. Curtisians M–Q: five novel *p*-terphenyl derivatives from the mushroom *Paxillus curtisii*. Chem. Pharm. Bull., **51**, 1064–1067.

TAKAHASHI, A., KUDO, R., KUSANO, G. and NOZOE, S., 1992. 5-Lipoxygenase inhibitors isolated from the mushroom *Boletopsis leucomelas* (Pers.) frayod. Chem. Pharm. Bull., **40**, 3194–3196.

TURNER, W. B. and ALDERIDGE, D. C., 1971, 1983. Fungal Metabolites (Vol. 1 1971; Vol. 2 1983). Academic Press, New York.

YUN, B. S., LEE, I. K., KIM, J. P. and YOO, I. D., 2000. Curtisians A and D, new free radical scavengers from the mushroom *Paxillus curtisii*. J. Antibiot., **53**, 114–122.

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