

Supplementary information

The incredible story of the ophiobolin A and sphaeropsidin A: Two fungal terpenoids from wilt-inducing phytotoxins to promising anticancer compounds

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Content

Table 1

Table 2

Table 1 Ophiobolin A, its natural and analogs (“: identical data to the entry immediately above)

First subgroup			
Compound	Fungal producer	Activity	Ref.
Ophiobolin A (1 , OPhA)	<i>Ophiobolus miyabeanus</i>	Phytotoxic	15
	<i>Helminthosporium orizae</i>	Not reported	17
	<i>Bipolaris</i> and <i>Aspergillus Drechslera</i> genera	Other biological activities	5
	<i>Drechslera gigantea</i>	Phytotoxic and weed biocontrol	51
	<i>Helminthosporium gramineum</i> subsp. <i>echinochloae</i> and <i>Curvularia lunata</i>	“	52
		Anticancer	54, 55, 56, 57
	<i>H. gramineum</i>	Inhibitors of calmodulin	37
		Antiproliferative	53
		Antifungal	44
	<i>Helminthosporium sp.</i>	Inhibition of photosynthesis	63
	<i>Bipolaris sorghicola</i>	Phytotoxic	64
	<i>Drechslera maydis</i>	“	66
	<i>Cochliobolus heterostrophus</i>	Not reported	69
	<i>Aspergillus</i> section <i>Usti</i>	Cytotoxic and antimalarial	71
		Cytotoxic	77
Ophiobolin B (3 , SphB)	<i>O. miyabeanus</i>	Not reported	17
	<i>D. gigantea</i>	Phytotoxic	51
	<i>C. heterostrophus</i>	Not reported	71
	<i>Aspergillus</i> section <i>Usti</i>	Cytotoxic	77
6- <i>epi</i> -ophiobolin A (4)	<i>D. gigantea</i>	Phytotoxic	50
	<i>Helminthosporium sp.</i>	Inhibition of photosynthesis	63
	<i>Bipolaris sorghicola</i>	Phytotoxic	64
	<i>D. maydis</i>	“	66
	<i>C. heterostrophus</i>	Not reported	71
3-Anhydro-6- <i>epi</i> -ophiobolin A (5)	<i>D. gigantea</i>	Phytotoxic	50
	<i>Helminthosporium sp.</i>	Inhibition of photosynthesis	63
	<i>Bipolaris sorghicola</i>	Phytotoxic	64
	<i>D. maydis</i>	“	66
	<i>C. heterostrophus</i>	Not reported	71
	<i>Bipolaris sp.</i>	Inhibition of HMG-CoA Inhibition of lipopolysaccharide (LPS)- induced nitric oxide production	85
Ophiobolin I (6)	<i>D. gigantea</i>	No toxic	50
	<i>C. heterostrophus</i>	Not Reported	71
Ophiobolin J (7)	<i>D. gigantea</i>	Phytotoxic	51
	<i>Drechslera orizae</i>	“	66
	<i>Bipolaris sp.</i>	Inhibition of HMG-CoA Inhibition of lipopolysaccharide (LPS)- induced nitric oxide production	85
Ophiobolin E (8)	<i>D. gigantea</i>	Not toxic	51
8- <i>epi</i> -Ophiobolin J (9)	<i>D. gigantea</i>	Not toxic	51
	<i>Bipolaris sp.</i>	Inhibition of HMG-CoA Inhibition of lipopolysaccharide (LPS)- induced nitric oxide production	85
Ophiobolin C (10 , SphC)	<i>Bipolaris zizanie</i>	Not reported	58
	<i>D. maydis</i>	Phytotoxic	66
	<i>Aspergillus</i> section <i>Usti</i>	Cytotoxic	77
	<i>Aspergillus flocculosus</i>	“	80
Ophiobolin D (11)	<i>Cephalosporium caerulens.</i>	“	59,60
Ophiobolin F (12)	<i>B. maydis</i>	“	61

		"	77
Ophiobolin A lactone (13)	<i>Cochliobolus miyabeanus</i>	Not reported	62
	<i>C. heterostrophus</i>	Not reported	69
3-Anhydrophiobolin A (14)	<i>Heliminthosporium sp.</i>	Inhibition of photosynthesis	31
	<i>B. sorghicola</i>	Phytotoxic	64
	<i>D. maydis</i>	"	66
	<i>C. heterostrophus</i>	Not Reported	69
	<i>Aspergillus sp.</i>	"	71
Ophiobolin G (15)	<i>Aspergillus ustus</i>	Antibiotic	87
		Not reported	65
		"	64
	"	Cytotoxic	79
Ophiobolin H (16)	<i>A. ustus</i>	Antibiotic	64,65
	<i>A. section Usti</i>	Cytotoxic	77
	<i>A. ustus</i>	"	79
	<i>Aspergillus sp.</i>	Not reported	87
		Cytotoxic	80
25-Hydroxyphiobolin I (17)	<i>D. sorghicola</i> and <i>D. maydis</i>	Phytotoxic	66
6- <i>epi</i> -Ophiobolin I (18)	<i>D. orizae</i>	"	67
	<i>A. ustus</i>	Cytotoxic	79
8-Deoxyphiobolin J (19)	"	"	"
Ophiobolin K (20)	<i>A. ustus</i>	Nematocidal	68
	<i>A. section Usti</i>	Cytotoxic	77
	<i>A.ustus</i>	"	79
	<i>Aspergillus sp.</i>	Not reported	80
6- <i>epi</i> -Ophiobolin K (21)	"	"	"
Ophiobolin L (22)	<i>C. heterostrophus</i>	Not reported	69
6- <i>epi</i> -Ophiobolin L (23)	"	"	"
Ophiobolin B lactone (24)	"	"	"
Ophiobolin M (25)	"	Nematocidal activity	70
6- <i>epi</i> -Ophiobolin M (26)	"	"	"
6- <i>epi</i> -Ophiobolin C (27)	"	"	"
18,19-Dihydrophiobolin C (28)	"	"	"
6- <i>epi</i> -3-Anhydrophobolin B (29)	"	Not reported	71
6- <i>epi</i> -Ophiobolin N (30)	<i>Emericella varicolor</i>	Not reported	72
	<i>A. section Usti</i>	"	77
	<i>Aspergillus insuetus</i>	Antibiotic	81
	<i>Aspergillus sp.</i>	Cytotoxic	87
	<i>Aspergillus flocculosus</i>	"	80
6- <i>epi</i> -Ophiobolin G (31)	<i>E. varicolor</i>	Not reported	72
	<i>A. section Usti</i>	"	77
	<i>A. insuetus</i>	Antibiotic	81
	<i>Apergillus sp.</i>	Cytotoxic	87
	<i>A. flocculosus</i>	"	80
5 α ,6 α -Ophiobolin H (32)	<i>A. ustus</i>	Not reported	74
	"	"	78
	<i>A. insuetus</i>	Antibiotic	81
	<i>Aspergillus sp.</i>	Not reported	87
5- <i>O</i> -Methyl-5 α ,6 α -ophiobolin H (33)	<i>A. ustus</i>	Not reported	74
5- <i>O</i> -Methylphiobolin H (34)	"	"	"
(6 α)-21,21 <i>O</i> -Dihydrophiobolin G (35)	<i>A. ustus</i>	"	"
	<i>A. insuetus</i>	"	74
	<i>A. calidoustus</i>	"	81
	<i>Aspergillus sp.</i>	Inhibition of lipopolysaccharide (LPS)-	83

		induced nitric oxide productionI	87
18,19-Dihydro-18,19-dihydroxyophiobolin G (36)	<i>A. ustus</i>	"	74
			78
	<i>A. insuetus</i>	"	81
Ophiobolin O (37)	<i>A. ustus</i>	Antiproliferative	75
Ophiobolin P (38)	<i>Ulocladium</i> sp.	Antibiotic	76
	<i>Aspergillus</i> sp.	Not reported	87
Ophiobolin Q (39)	<i>Ulocladium</i> sp.	Not toxic	76
	<i>Aspergillus</i> sp.	Inhibition of lipopolysaccharide (LPS)-induced nitric oxide productionI	87
Ophiobolin R (40)	<i>Ulocladium</i> sp.	Not toxic	76
	<i>Aspergillus calidoustus</i>	Not reported	83
Ophiobolin S (41)	"	"	"
Ophiobolin T (42)	"	Antibiotic and cytotoxic	"
Ophiobolin U (43)	<i>A. section Usti</i>	Not reported	77
	<i>A. ustus</i>	Antibiotic and zootoxic	78
	<i>Aspergillus</i> sp.	Inhibition of lipopolysaccharide (LPS)-induced nitric oxide productionI	87
Ophiobolin V (44)	<i>A. ustus</i>	Antibiotic and zootoxic	78
Ophiobolin W (45)	"	"	"
(6 α)-21-Deoxyophiobolin G (46)	"	"	"
(6 α)-16,17-Dihydro-21-deoxyophiobolin G (47)	"	"	"
Ophiobolins X, (48)	"	Not reported	79
	<i>Aspergillus</i> sp.	"	87
Ophiobolin Y (49)	"	"	"
Ophiobolin Z (50)	"	Cytotoxic	"
21-Deoxyophiobolin K (51)	"	"	"
21- <i>epi</i> -Ophiobolin O (52)	"	"	"
21- <i>epi</i> -Ophiobolin Z (53)	"	"	"
14,15-dehydro-6- <i>epi</i> -ophiobolin K (54)	<i>A. flocculosus</i>	"	80
14,15-dehydro ophiobolin K (55)	"	"	"
14,15-dehydro-6- <i>epi</i> -ophiobolin G (56)	"	"	"
14,15-dehydro-ophiobolin G (57)	"	"	"
14,15-dehydro-(<i>Z</i>)-14-ophiobolin G (58)	"	"	"
(6 <i>R</i>)-16,17,21,21 <i>O</i> -Tetrahydroophiobolin G (59)	<i>A. insuetus</i> SD-512	Antibiotic	81
(6 <i>R</i>)-16,17-Dihydroophiobolin H (60)	"	"	"
(5 <i>S</i> ,6 <i>S</i>)-16,17-Dihydroophiobolin H (61)	"	Not reported	"
α - <i>epi</i> -18,19-Dihydro-18-methoxy-19-hydroxyophiobolin P (62)	<i>Aspergillus</i> sp.	"	82
β - <i>epi</i> -18,19-Dihydro-18-methoxy-19-hydroxyophiobolin P (63)	"	"	"
Ophiobolin P1 (64)	<i>A. calidoustus</i>	"	83
5,6-Di- <i>epi</i> -Ophiobolin H (65)	"	"	"

Second subgroup

Compound	Fungal producer	Activity	Ref.
Halorosellinic acid (66)	<i>Halorosellinia oceanica</i>	Antimalarial	84
Bipolarin A (67)	<i>Bipolaris</i> sp.	Not reported	85
Bipolarin B (68)	"	Antibiotic	"

		Antimalarial	
Bipolarin C (69)	"	Not reported	"
Bipolarin D (70)	"	Antibiotic	"
		Antimalarial	
Bipolarin E (71)	"	Antibiotic	"
		Antimalarial	
Bipolarin F (72)	"	Antibiotic and antifungal	"
Bipolarin G (73)	"	Not Reported	"
Bipolarin H (74)	"	"	"
Bipolaricins A (75)	<i>Bipolaris</i> sp.	Not reported	86
Bipolaricins B (76)	"	Inhibition of HMG-CoA	"
Bipolaricins C (77)	"	"	"
Bipolaricins D (78)	"	Not reported	"
Bipolaricins E (79)	"	"	"
Bipolaricins F (80)	"	"	"
Bipolaricins G (81)	"	"	"
Bipolaricins H (82)	"	"	"
Bipolaricins I (83)	"	"	"
Asperophiobolin A (84)	<i>Aspergillus</i> sp.	Not Reported	87
Asperophiobolin B (85)	"	"	"
Asperophiobolin C (86)	"	"	"
Asperophiobolin D (87)	"	"	"
Asperophiobolin E (88)	"	"	"
Asperophiobolin F (89)	"	"	"
Asperophiobolin G (90)	"	"	"
Asperophiobolin H (91)	"	Inhibition of lipopolysaccharide (LPS)- induced nitric oxide production Inhibition of <i>Mycobacterium tuberculosis</i> protein tyrosine phosphatase B	"
Asperophiobolin I (92)	"	Inhibition of lipopolysaccharide (LPS)- induced nitric oxide production	"
Asperophiobolin J (93)	"	"	"
Asperophiobolin K (94)	"	Not reported	"
Bipolarolide A (95)	<i>Bipolaris</i> sp.	Inhibition of HMG-CoA reductase	88
Bipolarolide B (96)	"	Not reported	"
Bipolarolide C (97)	"	Not reported	"
Bipolarolide D (98)	"	Not reported	"
Bipolarolide E (99)	"	Not reported	"
Bipolarolide F (100)		Antifungal	
Bipolarolide G (101)	"	Not reported	"
Ophiobotriol (102)	"	"	"
Drophiobiolin A (103)	<i>D. gigantea</i>	Phytotoxic Cytotoxic	90
Drophiobiolin B (104)	"	"	"
Maydispenoid A (105)	<i>Bipolaris maydis</i>	Inhibitory activity of monoclonal antibodies Suppression murine splenocytes proliferation	91

Table 2 Spheropsidin A and its natural analogs “: identical data to the entry immediately above)

Compound	Fungal producer	Activity	Ref.
Saphaeropsidin A (2, SphA)	<i>Diplodia cupressi</i>	Phytotoxic	115
	<i>Aspergillus chevalieri</i>	Antibiotic	114
	<i>Tubercularia sp. TF5</i>	Not reported	118
	<i>Smardaea sp.</i>	Cytotoxicity and inhibition (MDA-MB-231) migration	119
	<i>Diplodia africana</i>	Phytotoxic	121
	<i>Aspergillus sp.</i>	Cytotoxicity	173
	<i>Diplodia quercivora</i>	Phytotoxic, antifungal, zootoxic	125
	<i>Diplodia corticola</i>	Not reported	131
	<i>Botryospheria loricina</i>	Induction of quinone reductase	133
	<i>Aspergillus candida</i>	Cytotoxic	134
	<i>Diplodia olivarum</i>	Phytotoxic and antifungal	135
	<i>Diplodia globulosa</i>	Phytotoxic, antifungal, zootoxic	136
	Sphearopsidin B (135)	<i>D. cupressi</i>	Phytotoxic
<i>Aspergillus chevalieri</i>		Antibiotic	114
<i>Tubercularia sp. TF5</i>		Not reported	118
<i>B. loricina</i>		Induction of quinone reductase	133
Sphearopsidin C (136)	<i>D. cupressi</i>	Phytotoxicity	112
	<i>D. quercivora</i>	Phytotoxic, antifungal, zootoxic	124
	<i>D. olivarum</i>	No activity	135
	<i>D. globulosa</i>	No activity	136
Sphearopsidin D (137)	<i>D. cupressi</i>	Phytotoxic	112
Sphearopsidin E (138)	<i>D. cupressi</i>		112
Sphearopsidin F (139)	<i>D. cupressi</i>		112
Diplopyrmarane (140)	<i>D. quercivora</i>	Phytotoxic, antifungal, zootoxic	125
Sphearopsidin G (141)	<i>D. corticola</i>	Zootoxic	132
	<i>D. olivarum</i>	“	135
16-O- α -D-Tetraacetylglucopyranosyl hymatoxin C (142)	<i>Tubercularia sp.</i>	Not reported	118
Xylopimarane (143)	<i>Xylaria sp.</i>	Cytotoxic	173
Aspergiloid E (144)	<i>Aspergillus sp.</i>	Cytotoxic	122
	<i>Aspergillus porosus</i>	“	174
Aspewentin A (145)	<i>Aspergillus wentii</i>	Zootoxic	175
		Antibiotic	176
Aspewentin B (146)	“	Zootoxic	175
Aspewentin C (147)	“	“	“
Aspewentins D (148)	“	Antibiotic and antifungal	176
Aspewentins E (149)	“	Not reported	“
Aspewentins F (150)	“	Antibiotic and antifungal	“
Aspewentins G (151)	“	“	“
Aspewentins H (152)	“	“	“
Aspewentins I (153)	“	Antibiotic	177
Aspewentins J (154)	“	“	“
Aspewentins K (155)	“	Not reported	“
Aspewentins I (156)	“	“	“
Aspewentins M (157)	“	Antifungal	“
Aspewentins N (158)	<i>Aspergillus sp.</i>	Cytotoxic	178
Aspewentins O (159)	“	Not reported	“
Aspewentins P (160)	“	Cytotoxic	“
Aspewentins Q (161)	“	“	“
Aspewentins R (162)	“	Not Reported	“
Botryosphin A (163)	<i>B. loricina</i>	“	133
Botryosphin B (164)	“	Induction of quinone reductase	“

Botryosphin C (165)	“	Not reported	“
Botryosphin D (166)	“	Induction of quinone reductase	“
Botryosphin E (167)	“	Not reported	“
Botryosphin F (168)	“	“	“
Taichunin D (169)	<i>Aspergillus taichungensis</i>	No Toxic	180
Botryosphins G (170)	<i>B. laricina</i>	NO inhibition and quinone reductase	179
Botryosphins H (171)	“	“	“
Botryosphins I (172)	“	Not reported	“
