Microbe-derived aromatic polyketides toward MRSA infection: current advances and perspectives

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Table S1. Other bioactivity of aromatic polyketides from microorganism.

Depsidones and benzophenones					
Compounds	**Sources**	**Anti-MRSA**		**Other bioactivates**	**Isolation Ref.**
		Strains	**MICs (μg/mL)**		
Folipastatin (**1**)	*Aspergillus unguis* PSU-MF16, PSU-RSPG199, PSU-RSPG204,	MRSA	1.0	**1** and **2**: antibacterial activity against *S. aureus* and *B. subtilis* [1, 2] antifungal activity against *C. neoformans* [3] antimalarial activity against *P. falciparum* [4] moderate cytotoxicity against Vero, KB, and MCF-7 [4] inhibit forskolin-stimulated chloride secretion in T84 cells (IC_{50} = 2.0 and 0.5 μM) [2] Sterol O-acyltransferase (SOAT) 1 and 2 isozymes inhibition [5] **2**: anti-phytopathogenic activity against *A.brassicicola* and *C. acutatum* [6]	2-4
Emeguisin A (**2**) (7-chlorofolipastatin)	*Aspergillus unguis* PSU-MF16, PSU-RSPG199, PSU-RSPG204,	MRSA	0.5		2-4
2-Chlorounguinol (**3**)	*Aspergillus unguis* PSU-MF16, PSU-RSPG199, PSU-RSPG204, IB151	MRSA	8.0	antibacterial against *S. aureus*, *M. gypseum,* and *P. aeruginosa* [4,7] antifungal activity against *C. neoformans* and *C. albicans* [3] sterol O-acyltransferase (SOAT) 1 and 2 isozymes inhibition [5] inhibition of xanthine oxidase and aromatase activities [8] larvicidal activity [7] anti-phytopathogenic activity against *A. brassicicola* and *C. acutatum* [6] interaction with penicillin-binding protein 2a (PBP2a) [9]	2-4, 9
2,4-Dichlorounguinol (**4**)	*Aspergillus unguis* PSU-RSPG204	MRSA	4.0	antibacterial activity against *S. aureus* (MIC = 4.0 μg/mL) [2] antifungal activity against *C. albicans* (MIC = 8.0 μg/mL) [2]	2
Mollicellin H (**5**)	*Chaetomium* sp. Eef-10	MRSA N50	6.21	antibacterial against SA (MIC = 5.14 μg/mL) [10] cytotoxicity against HepG2 (IC_{50} = 6.83 μg/mL) [10]	10
Mollicellin S (**6**)	*Chaetomium brasiliense* SD-596	clinical isolate MRSA	6.25	antibacterial against *S. aureus* (MIC = 6.25 μg/mL) [11]	11
Nidulin (**7**)	*Aspergillus unguis* PSU-MF16, PSU-RSPG204, DLEP2008001, IB151	MRSA	4.0	**7-9**: antibacterial activity against *S. aureus, B. subtilis,* and *B. cereus* [3] inhibition of xanthine oxidase and aromatase activities [8] weak anti-cancer activities HuCCA-1, HepG2, A549, MOLT-3 cancer cell line [8] larvicidal activity [7] DNA-damage repair capacity-defective *E. coli* [12] anti-phytopathogenic activity against *A. brassicicola* and *C. acutatum* [6] **7**: anti-A*β* aggregation activity [13] stimulate AKT-dependent glucose uptake in 3T3-L1 adipocytes [14] **8:** antifungal against *C. neoforman* (MIC = 1.0 μg/mL) [3] inhibition of LPS-induced NF-κB activation in Raw264.7 macrophages [15] antimalarial activity against *Plasmodium falciparum via* targeting quinone oxidoreductase (PfMQO) enzyme [16] transmembrane protein 16A (TMEM16A) inhibitor [17]	2, 3, 7
Nornidulin (**8**)	*Aspergillus unguis* PSU-MF16, PSU-RSPG199, PSU-RSPG204, DLEP2008001, GXIMD 02505	MRSA	2.0		2-4, 15
Aspergillusidone C (2,7-dichlorounginol) (**9**)	*Aspergillus unguis* PSU-MF16, *Aspergillus unguis* PSU-RSPG204	MRSA	1.0		2-4

				inhibition of cystic fibrosis transmembrane conductance regulator (CFTR)-mediated intestinal chloride secretion in T84 cells [18] **8** and **9**: antimicrobial activity against *M. variabilis*, *M. jannaschii*, and *V. pelagius* [15] **9:** antifungal against *M. gypseum* (MIC = 2.0 μg/mL) [3]	
Aspersidone (**10**)	*Aspergillus unguis* PSU-RSPG199, PSU-RSPG204	MRSA	0.5	antibacterial against SA and BC [2, 6] cytotoxicity against Vero (IC_{50} = 16.7 μM) [2] anti-phytopathogenic activity against *A. brassicicola* and *C. acutatum* [6]	[2]
Spiromastixone F (**11**)	*Spiromastix* sp. MCCC 3A00308	ATCC 33591 MRSA (12-33)	1.72 1.72		[19]
Spiromastixone H (**12**)	*Spiromastix* sp. MCCC 3A00308	ATCC 33591 MRSA (12-33)	1.72 3.44		[19]
Spiromastixone G (**13**)	*Spiromastix* sp. MCCC 3A00308, SCSIO F190	ATCC 33591 MRSA (12-33) MRSA	1.78 3.55 2.0	**11-14**: antibacterial activity against *S. aureus*, *B. thuringiensis* and *B. subtilis* (MIC = 0.125-4.0 μg/mL) [19]	[19, 21]
Spiromastixone J (**14**)	*Spiromastix* sp. MCCC 3A00308, SCSIO F190	ATCC 33591 MRSA (12-33) MRSA MRSA T144 MRSA 1530	0.96 1.91 1.0 0.96 0.96	**11**: Inhibit foam cell formation promoted via regulation the efflux and uptake of cholesterol through upregulating the PPARγ-ABCA1/G1and downregulating the scavenger receptors CD36 and SR-A [20] **13-16**: antibacterial activity against *S. aureus*, *E. faecalis*, *M. luteus*, *S. simulans*, *E. faecium*, *E. gallinarum*, and *B. subtilis* (MIC = 0.125-32.0 μg/mL) [21]	[19, 21]
Spiromastixone I (**15**)	*Spiromastix* sp. MCCC 3A00308, SCSIO F190	MRSA	2.0		[19, 21]
Spiromastixone E (**16**)	*Spiromastix* sp. MCCC 3A00308, SCSIO F190	MRSA	4.0		[19, 21]
Spiromastixone P (**17**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	3.26 3.26		
Spiromastixone T (**18**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.0 1.0		
Spiromastixone V (**19**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	3.89 3.89		
Spiromastixone X (**20**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.94 3.89	**17-27**: antibacterial activity against VRE CAU360 and CAU378 (MIC = 1.0-16.0 μM) [22]	[22]
Spiromastixone Y (**21**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.94 1.94		
Spiromastixone Z (**22**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.15 1.15		
Spiromastixone Z1 (**23**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	0.29 0.29		

Spiromastixone Z2 (**24**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	0.58 0.58		
Spiromastixone Z3 (**25**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.31 1.31		
Spiromastixone Z4 (**26**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	1.15 1.15		
Spiromastixone Z5 (**27**)	*Spiromastix* sp. MCCC 3A00308	MRSA T144 MRSA 1530	5.22 5.22		
Penibenzophenone C (**28**)	*Penicillium* sp.	ATCC 33951	3.12	antibacterial against *S. aureus* (MIC = 6.25 μg/mL) [23]	[23]
Penibenzophenone D (**29**)	*Penicillium* sp.	ATCC 33951	6.25	antibacterial against *S. aureus* (MIC = 12.5 μg/mL) [23] antifungal against *C. albicans* (MIC = 25.0 μg/mL) [23]	[23]
Penibenzophenone E (**30**)	*Aspergillus fumigatus* H22	MRSA	1.25	antibacterial against *S. aureus* and *B. cereus* (MIC = 25.0 μg/mL) [23] antifungal against *C. albicans* (MIC = 25.0 μg/mL) [23]	[24]
Sulochrin (**31**)	*Aspergillus fumigatus* H22	MRSA	1.25	anti-HCV activity [25] inhibited eosinophil degranulation, activation, and chemotaxis [26] inhibited VEGF-induced tube formation of HUVEC cells [27] cytotoxic activity against L5178Y with an IC_{50} value of 5.1 μM [28] inhibitions of CDK-2, TOP-2, and MMP-13 [28] α-glucosidase inhibitory effect [29]	[24]
Pestalone (**32**)	*Pestalotiopsis* sp. ZJ-2009-7-6 *Pestalotiopsis trachicarpicola* SCJ551	MRSA (30740) MRSA (ATCC 6538)	6.25 5.0	Antibacterial against *B. megaterium, M. lysodeikticus* [30], *S. aureus, and* VSE (MIC = 0.078, 6.25, 5.0, and 2.5 μg/mL) [31] synergistic activity with meropenem against MRSA [32]	[30, 31]
SB87-Cl (**33**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	2.5	Antibacterial against *S. aureus and* VSE (MIC = 2.5 and 1.25 μg/mL) [31] cytotoxicity against A549, Hela, HepG2, MCF-7, and Vero (IC_{50} = 2.9, 2.1, 3.9, 4.6, and 2.4 μM) [31]	[31]
Pestalotinone A (**34**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	2.5	**34**-**38**: Antibacterial against SA, VSE, and VRE (MIC = 1.25-10.0 μg/mL) [31] **34**-**37**: selected moderate cytotoxicity against A549, Hela, HepG2, MCF-7, and Vero with IC_{50} values ranging 7.1 to 29.6 μM **38**: cytotoxicity against A549, Hela, HepG2, MCF-7, and Vero (IC_{50} > 5 0 μM) [31]	[31]
Pestalotinone B (**35**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	1.25		[31]
Pestalotinone C (**36**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	2.5		[31]
Pestalotinone D (**37**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	5.0		[31]

Pestalachloride B (**38**)	*Pestalotiopsis trachicarpicola* SCJ551	MRSA (ATCC 6538)	1.25		[31]
Microsphaerin D (**39**)	*Microsphaeropsis* sp. (strains F2076 and F2078)	MRSA (ATCC 33591)	0.5	antibacterial against SA, *E. faecalis*, *S. pneumoniae, B. subtilis,* and *M. catarrhalis* (MIC = 1.3, 1.3, 3.6, 3.0, and 1.3 μM) [33] cytotoxicity against CHO, HepG2, MRC5, and HEK293 (IC_{50} = 9.0, 25.0, 13.0, and 20.0 μM) [33]	[33]
Castochrin (**40**)	*Alternaria longissima*	ATCC 700787	2.0	**40-42**: weak mammalian cell cytotoxicity effects against pancreatic cancer cells (MIA PaCa-2) with IC_{50} values of 50.8, 30.3, and 29.3 μM, respectively [34] **42**: inhibition of Aβ_{42} aggregation with an IC_{50} value of 0.99 μM [35] inhibition in *Toxoplasma gondii* [36]	[34]
Dioschrin (**41**)	*Alternaria longissima*	ATCC 700787	3.2		[34]
Polluxochrin (**42**)	*Alternaria longissima*	ATCC 700787	2.9		[34]
Benzoisochromanequinones (BIQs)					
Strepoxepinmycin C (**43**)	*Streptomyces* sp. XMA39	ATCC 43300	6.0	**43-45**: antibacterial against *E. coil* and CA (MIC = 2.0-8.0 μg/mL) [37] cytotoxicity against PC and HCT-116 (**43**: IC_{50} = 16.0 and 4.4 μM), (**44**: IC_{50} = 19.0 and 2.9 μM), (**45**: IC_{50} = 0.015 and 0.043 μM) [37] **43** and **45**: ROCK 2 protein kinase inhibitor, (IC_{50} = 9.0 and 0.011 μM) [37] **45**: inhibits TNFα-promoted inflammatory reaction in human synovial fibroblasts [38] AKT selective kinase inhibitor alkylate a regulatory loop cysteine [39 40]	[37]
Strepoxepinmycin D (**44**)	*Streptomyces* sp. XMA39	ATCC 43300	3.0		[37]
Medermycin (Lactoquinomycin) (**45**)	*Streptomyces* sp. XMA39	ATCC 43300	0.25		[37]
G15-F (**46**)	*Streptomyces albolongus* CA-186053	MRSA	2.0-4.0	-	[41]
Lactoquinomycin A (**47**)	*Streptomyces bacillaris* MBTC38 *Streptomyces albolongus* CA-186053	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300 MRSA	0.25 0.50 0.25 0.25 0.25 2.0-4.0	antibacterial against *S. aureus*, *B. subtilis*, *C. xerosis* with MIC values of 1.55–3.13 μg/mL [41, 42] intercalated into double-stranded DNA and damaged DNA repair [41, 42]	[41, 42]
Lactoquinomycin B (**48**)	*Streptomyces bacillaris* MBTC38	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300	4.0 8.0 4.0 4.0 4.0	antibacterial against *S. aureus* and *B. subtilis* with MIC values of 5.0 and 10.0 cytotoxicity against K562, P388, and L1210 (IC_{50} = 0.12-0.20 μg/mL) [43]	[42]
N-Methyl lactoquinomycin A (**49**)	*Streptomyces bacillaris* MBTC38	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300	1.0 1.0 1.0 0.5 0.5	-	[42]

Menoxymycin A (**50**)	*Streptomyces bacillaris* MBTC38	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300	2.0 2.0 1.0 0.5 1.0	antitumor [44]	[42]
Xiakemycin A (**51**)	*Streptomyces* sp. CC8-201	ATCC 33591 MRSA (12-33)	4.0 8.0	antibacterial against SA, MSSE, MRSE, VSE, and VRE (MIC values ranging from 2.0 to 8.0) [45] cytotoxicity against A549, HepG2, MCF-7, HCT-116 cell p53 wt cells, SH-SY5Y, and PC-3 (IC_{50} = 2.77, 1.54, 1.82, 0.98, 0.59, 0.55, and 0.43 μM) [45] the potent inhibition mechanism on tumor cells was due to degradation of AKT protein and low endogenous p53 levels [46] induction of apoptosis in human hepatoma HepG2 cells [47]	[45]
Enceleamycin A (**52**)	*Amycolatopsis* sp. MCC0218	MRSA_3B MRSA_6B MRSA_9B MRSA_10B	4.0 4.0 4.0 4.0	**52** and **53**: antibacterial against SA, *S. epidermidis*, *B. cereus*, *B. subtilis*, *M. luteus*, and *L. monocytogenes* (MIC = 2.0-8.0 and 8.0-16.0 μg/mL) [48] Anticancer activities against HFF-1, A549, Hela, and triple-negative breast cancer (TNBC) MDA-MB-231 cells with an IC_{50} values of 1.25-7.60 μg/mL [49]	[48]
Enceleamycin C (**53**)	*Amycolatopsis* sp. MCC0218	MRSA_6B MRSA_10B	8.0 8.0	**52**: the anticancer mechanism on TNBC cells was by targeting the AKT2 signaling pathway [49]	[48]
Napyradiomycins (NPDs)					
Naphthomevalin (**54**)	*Streptomyces* sp. CPCC 203577	ATCC 33591	4.0	**54**: antibacterial against MSSA, MSSE, and VSE (MIC = 8.0, 4.0, and 16.0 μg/mL) [50] **54-56**: cytotoxicity against SF-268, MCF-7, NCI-H460, and HepG-2 with IC_{50} were above 20 μM [51]	[50]
4-Dehydro-4a-dechloronapyradiomycin A1 (**55**)	*Streptomyces* sp. CA-271078	MB 5393	4.0-8.0		[52]
3-Chloro-6,8-dihydroxy-8-lapachone (**56**)	*Streptomyces* sp. CA-271078	MB 5393	0.5-1.0		[52]
Napyradiomycin D1 (**57**)	*Streptomyces* sp. CA-271078	MB5393	5.74-11.48	**57-62**: cytotoxicity against HepG2 (IC_{50} =14.9-40.1 μM) [53]	[53]
Napyradiomycin A2a (**58**)	*Streptomyces* sp. CA-271078	MB5393	5.95-11.91		[53]
Napyradiomycin A2b (**59**)	*Streptomyces* sp. CA-271078	MB5393	5.95-11.91		[53]
Napyradiomycin B2 (**60**)	*Streptomyces* sp.CA-271078	MB5393	1.58-3.17		[53]
Napyradiomycin B4 (**61**)	*Streptomyces* sp. CA-271078	MB5393	6.55-13.10		[53]
Napyradiomycin B5 (**62**)	*Streptomyces* sp. CA-271078	MB5393	6.86-13.73		[53]

A80915A (**63**)	*Streptomyces* sp. CNQ-525	ATCC 33591 clinical isolate c-44 clinical c-88 USA300 (UAMS 1182) USA300 (TCH 1516)	1.0-2.0 3.0 1.5-3.0 1.5-3.0 2.0	**63** and **64**: antibacterial against MSSA, NRS70, Sanger 252, NRS100, VRSA, GISA, and Hetero-GISA (MIC = 0.5-5.0) [54] **63**: inhibition of gastric (H^+-K^+)-ATPase [55]	54
A80915B (**64**)	*Streptomyces* sp. CNQ-525	ATCC 33591 clinical isolate c-44 clinical c-88 USA300 (UAMS 1182) USA300 (TCH 1516)	2.0 1.5 1.5 1.0-3.0 1.0-2.0		54
Chlorinated dihydroquinone 1 (**65**)	*Actinomycetes* CNQ-525	MRSA	1.95	**65-67**: antibacterial against VREF (MIC = 1.95-3.9 μg/mL) [56] cytotoxicity against HCT-116 (IC_{50} = 0.97-2.4 μg/mL) [56]	56
Chlorinated dihydroquinone 3 (**66**)	*Actinomycetes* CNQ-525	MRSA	1.95		56
Chlorinated dihydroquinone 4 (**67**)	*Actinomycetes* CNQ-525	MRSA	1.90		56
Tetracyclic polyketides					
Tetracyclines					
Spirohexaline (**68**)	*Paecilomyces* sp. CMB-MF010 *Penicillium brasilianum* FKI-3368	AUS-RBWH-MRSA-02 clinical isolate MRSA K24 clinical isolate MRSA	1.30 6.25 6.25	**68-70**: antibacterial against VRE (MIC = 3.1,1.1, and 0.04 μM) [57] **68**: cytotoxicity against NCI-H460, KB3-1, SW620, and Jurkat (IC_{50} = 11.3, 6.3, 16.7, and 44.3 μM) [57] **68** and **69**: inhibit undecaprenyl pyrophosphate (UPP) synthase (IC_{50} = 4.0 and 9.0 μM) [58] **69** and **70**: antibacterial against SA, QRSA, *B. subtilis*, *B. cerues*, *M. luteus*, *S. pneumoniae*, *E. faecium*, *E. faecalis*, *S. epidermidis*, *S. typhinurium*, and *A. calcoaceticus* (MIC = 0.06-8.0 μg/mL) [59] cytotoxicity against NCI-H460, KB3-1, and SW620 (IC_{50} = 0.6-2.5 μM) [57] **69**: fungicidal activities to several agricultural pathogenic bacteria and insecticidal activity to *Plutella xylostella* [60]	57, 58, 61
Viridicatumtoxin A (**69**)	*Paecilomyces* sp. CMB-MF010 *Penicillium brasilianum* FKI-3368 *Penicillium* sp. FR11	AUS-RBWH-MRSA-02 clinical isolate MRSA K24 CCARM 3167 CCARM 3506	0.38 0.78 0.25 0.25		57-59, 61
Viridicatumtoxin B (**70**)	*Paecilomyces* sp. CMB-MF010 *Penicillium* sp. FR11	AUS-RBWH-MRSA-02 CCARM 3167 CCARM 3506	0.08 0.5 0.5		57, 59
Viridicatumtoxin C (**71**)	*Paecilomyces* sp. CMB-MF010	AUS-RBWH-MRSA-02	0.98	**71-73**: antibacterial against VRE (MIC = 1.5-4.8 μM) [57] cytotoxicity against NCI-H460, KB3-1, and SW620 (IC_{50} = 9.2-17.4, 20.7-30, > 30, and 4.1-6.0 μM) [57]	57
Viridicatumtoxin D (**72**)	*Paecilomyces* sp. CMB-MF010	AUS-RBWH-MRSA-02	5.48		57
Viridicatumtoxin E (**73**)	*Paecilomyces* sp. CMB-MF010	AUS-RBWH-MRSA-02	1.87		57
Previridicatumtoxin (**74**)	*Paecilomyces* sp. CMB-MF010	AUS-RBWH-MRSA-02	2.50		57

Tetracenomycins					
Tetarimycin A (**75**)	Heterologous expression of an environmental DNA	MRSA (USA300)	0.78	-	[62]
Mersaquinone (**76**)	*Streptomyces* sp. HDN154193	MRSA	1.9	**76-79**: antibacterial against *P. species*, *M. phlei*, *B. subtilis*, and MRCNS (MIC = 1.0-16.0, 1.9-3.9, 1.9-3.9, and 1.9 μg/mL) [63]	[63]
Bitetracenomycin A (**77**)	*Streptomyces* sp. HDN154193	MRSA	1.9		[63]
(+)-Bitetracenomycin B (**78**)	*Streptomyces* sp. HDN154193	MRSA	1.9		[63]
(−)-Bitetracenomycin B (**79**)	*Streptomyces* sp. HDN154193	MRSA	1.9		[63]
Phenyltetracenoid polyketides					
Fasamycin-type					
Fasamycin A (**80**)	Heterologous expression of an environmental DNA	MRSA (USA300)	3.1	**80** and **81**: antibacterial against *B. subtilis*, SA, *B. subtilis*, and *E. faecalis* (MIC = 0.8-6.25 μg/mL) [64] Inhibit FabF in type II fatty acid biosynthesis [65]	[64]
Fasamycin B (**81**)	Heterologous expression of an environmental DNA	MRSA (USA300)	6.25		[64]
Fasamycin C (**82**)	*Streptomyces* sp. KIB-1414	MRSA	6.25	**82** and **83**: antibacterial against MSSA, *E. coli* and *E. coli* NR698 (MIC = 2.0-16.0 μg/mL) [66] **82**: inhibition of *E. coli* Topo IV and *S. aureus* gyrase with IC_{50} values of 25.5 and 23.3 μM **83**: inhibition of *E. coli* Topo IV, *S. aureus* gyrase, *M. mazei* Topo VI, and Human Topo II*α*, and Human Topo II*β* with IC_{50} values of 6.4, 5.7, 3.4, 26.2, and 50.0 μM [66] displayed a high barrier to resistance of MSSA and MRSA (a barrier to resistance experiment for 40 days) [66] **82-89**: antibacterial against SA and *E. coli* with MIC = 3.13-12.5 μg/mL, *B. subtilis* with MIC = 3.13-50.0 μg/mL [67]	[67]
Fasamycin E (**83**)	*Streptomyces* sp. KIB-1414	MRSA	1.56		[67]
Fasamycin G (**84**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Fasamycin H (**85**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Fasamycin I (**86**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Fasamycin J (**87**)	*Streptomyces* sp. KIB-1414	MRSA	1.56		[67]
Fasamycin K (**88**)	*Streptomyces* sp. KIB-1414	MRSA	6.25		[67]
2,9-Methoxy-fasamycin C (**89**)	*Streptomyces* sp. KIB-1414	MRSA	1.56		[67]
Fasamycin R (**90**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5	**90** and **91**: antibacterial against SA, VRE, and VSE (MIC = 0.6-2.5 μg/mL) [68] cytotoxicity against A549, Hela, HepG2, MCF-7, and Vero (IC_{50} = 2.5-16.5 μM) [68]	[68]
Fasamycin S (**91**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	0.6		[68]

Fasamycin L (**92**)	*Streptomyces formicae* KY5	ATCC BAA-1717	2.0		[69]
Fasamycin M (**93**)	*Streptomyces formicae* KY5	ATCC BAA-1717	4.0		[69]
Fasamycin N (**94**)	*Streptomyces formicae* KY5	ATCC BAA-1717	2.0	**92**: displayed a high barrier to resistance of MSSA and MRSA (a barrier to resistance experiment for 40 days) [66]	[69]
Fasamycin O (**95**)	*Streptomyces formicae* KY5	ATCC BAA-1717	2.0	inhibition of *E. coli* Topo IV and *S. aureus* gyrase with IC_{50} values of 9.2 and 4.7 [66]	[69]
Fasamycin P (**96**)	*Streptomyces formicae* KY5	ATCC BAA-1717	4.0	**92-96**: Antibacterial against MSSA (MIC = 2.0-4.0 μg/mL) [69] against *E. coli*, *E. coli* NR698, MSSA, *B. subtilis*, VSE, and VRE with MIC values of 2.0-16.0 μg/mL [66]	[69]
Fasamycin Q (**97**)	*Streptomyces formicae* KY5	ATCC BAA-1717	4.0		[69]
Naphthacemycin B_1 (**98**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	>8		[70]
Naphthacemycin B_2 (**99**)	*Streptomyces* sp. KB-3346-5, N12W1565	clinical isolates 22 strains clinical isolate MRSA K24	8 8		[70, 71]
Naphthacemycin B_3 (**100**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	8	**98-101**: enhanced the anti-MRSA activity of imipenem (ratio = 128-512 folds) [70] **99**: Inhibition of protein-tyrosine phosphatase (PTP1B) [71]	[70]
Naphthacemycin B_4 (**101**)	*Streptomyces* sp. KB-3346-5, KIB-1414	clinical isolates 22 strains clinical isolate MRSA K24 MRSA	8 8 3.13	**101**: Antibacterial against SA, *B. subtilis*, and *E. coli* (MIC = 1.56-6.25 μg/mL) [67]	[67, 70]
Naphthacemycin B_5 (**102**)	*Streptomyces* sp. N12W1565	MRSA	1.6	**102** and **103**: antibacterial against *B. subtilis* and *E. coli* (MIC = 1.0 and 4.8 μg/mL for **102**; MIC = 12.1 and >100 μg/mL for **103**) [72]	[72]
Naphthacemycin B_7 (**103**)	*Streptomyces* sp. N12W1565	MRSA	8.4	inhibition of protein-tyrosine phosphatase (PTP1B) [71]	[72]
Accramycin A (**104**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.3 1.25	antibacterial against SA, VRE, and VSE (MIC = 1.3 μg/mL) [68] cytotoxicity against A549, Hela, HepG2, MCF-7, and Vero (IC_{50} = 3.3-7.1) [68]	[68, 73]
Accramycin E (**105**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.25		[73]
Accramycin I (**106**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5		[73]
Streptovertimycin A (**107**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	2.5		[74]
Streptovertimycin B (**108**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	2.5	**105-128**, antibacterial against MSSA, VRE, and VSE (MIC = 0.63-10.0 μg/mL) [74] Selectively showed cytotoxicity against A549, Hela, HepG2, MCF-7 (IC_{50} = 1.7-17.6 μM), and Vero (IC_{50} = 2.8- 18.9 μM) [74]	[74]
Streptovertimycin C (**109**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	2.5		[74]
Streptovertimycin D (**110**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	1.25		[74]
Streptovertimycin E (**111**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	2.5		[74]

Streptovertimycin F (**112**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	2.5	[74]
Streptovertimycin G (**113**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	0.63	[74]
Streptovertimycin H (**113**)	*Streptomyces morookaense* SC1169	MRSA (no. 11646)	5.0	[74]
Streptovertimycin J (**115**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5	[73]
Streptovertimycin M (**116**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.25	[73]
Streptovertimycin N (**117**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5	[73]
Streptovertimycin O (**118**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	5.0	[73]
Streptovertimycin P (**119**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.25	[73]
Streptovertimycin R (**120**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.25	[73]
Streptovertimycin S (**121**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.25	[73]
Streptovertimycin T (**122**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5	[73]
Streptovertimycin X (**123**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	5.0	[68]
Streptovertimycin Z_2 (**124**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	5.0	[68]
Streptovertimycin Z_3 (**125**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.3	[68]
Streptovertimycin Z_4 (**126**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.3	[68]
Streptovertimycin Z_5 (**127**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	1.3	[68]

Streptovertimycin U (**128**)	*Streptomyces morookaense* SC1169	MRSA (No.11646)	2.5		[68]
Naphthacemycin A-type					
Naphthacemycin A_1 (**129**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	> 8.0	**129-135**: enhanced the anti-MRSA activity of imipenem (ratio = 128-512 fold) [70]	[70]
Naphthacemycin A_2 (**130**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	8.0		[70]
Naphthacemycin A_3 (**131**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	8.0		[70]
Naphthacemycin A_4 (**132**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	4.0		[70]
Naphthacemycin A_5 (**133**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	2.0		[70]
Naphthacemycin A_6 (**134**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	2.0		[70]
Naphthacemycin A_7 (**135**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates	2.0		[70]
Naphthacemycin A_8 (**136**)	*Streptomyces* sp. KB-3346-5	22 clinical isolates MRSA (70) MRSA KB 362 MRSA KB 363 MRSA Mu50 Linezolid resistant-6	2.0 2.0 1.0 2.0 2.0 4.0	**136** and **137**: antibacterial against MSSA, *S. epidermidis*, *K. rhizophila*, *E. faecalis, E. faecalis,* and *E. faecium* (MIC = 0.5-4.0 μg/mL) [70] **137**: inhibitory activities of Entamoeba histolytica cysteine synthase (EhCs) [75] cytotoxicity against MRC-5 cells [70]	[70]
Naphthacemycin A_9 (**137**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains MRSA (70) MRSA KB 362 MRSA KB 363 MRSA Mu50 Linezolid resistant-6	4.0 1.0 1.0 1.0 2.0 2.0		[70]
Naphthacemycin A_{10} (**138**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	2.0	-	[70]
Naphthacemycin A_{11} (**139**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	1.0	-	[70]
Formicamycin-type					
Formicamycin A (**140**)	*Streptomyces* sp. KIB-1414	MRSA	1.56	**140-143**, **145**, and **148-150:** antibacterial against VSE and VRE with MIC values of 2.0-16.0 μg/mL [66] **140-147**: showed antibacterial against SA, *B. subtilis,* and *E. coli* with MIC ranging from 0.39 to 12.5 μg/mL [67]	[67]
Formicamycin B (**141**)	*Streptomyces* sp. KIB-1414	MRSA	1.56		[67]
Formicamycin C (**142**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]

Formicamycin E (**143**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Formicamycin F (**144**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Formicamycin G (**145**)	*Streptomyces* sp. KIB-1414	MRSA	0.20		[67]
Formicamycin N (**146**)	*Streptomyces* sp. KIB-1414	MRSA	6.25		[67]
Formicamycin O (**147**)	*Streptomyces* sp. KIB-1414	MRSA	3.13		[67]
Formicamycin J (**148**)	*Streptomyces formicae* KY5	ATCC BAA-1717	4.0	**148**-**150**: antibacterial against MSSA (MIC = 2.0-4.0 μg/mL) [69] **148**: displayed a high barrier to resistance of MSSA and MRSA (a barrier to resistance experiment for 40 days) [66] inhibition of *E. coli* Topo IV, *S. aureus* gyrase, and *M. mazei* Topo VI with IC_{50} values of 6.0, 7.1, and 11.9 μM [66]	[69]
Formicamycin R (**149**)	*Streptomyces formicae* KY5	ATCC BAA-1717	2.0		[69]
Formicamycin S (**150**)	*Streptomyces formicae* KY5	ATCC BAA-1717	3.0		[69]
Naphthacemycin C-type					
Naphthacemycin C_1 (**151**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	>8.0	-	[70]
Naphthacemycin C_2 (**152**)	*Streptomyces* sp. KB-3346-5	clinical isolates 22 strains	>8.0	-	[70]
Angucyclines					
Nocardiopsistin B (**153**)	*Nocardiopsis* sp. HB-J378	MRSA	3.12	-	[76]
Nocardiopsistin D (**154**)	*Nocardiopsis* sp. HB-J378	MRSA	0.098	antibacterial against VRSA, *E. faecium*, and *B. cereus* (MIC = 0.031-0.063 μg/mL) [77]	[77]
Nocardiopsistin E (**155**)	*Nocardiopsis* sp. HB-J378	MRSA	3.125	-	[77]
Homophenanthroviridone (**156**)	*Micromonospora echinospora* SCSIO 04089	MRSA (shhs-A1)	2.0	antibacterial against MSSA, *B. thuringensis*, *B. subtilis,* and *M. luteus* (MIC = 2.0-4.0 μg/mL) [78] cytotoxic against SF-268, MCF-7, and HepG2 (IC_{50} = 5.4, 6.8, and 1.4 μM) [78]	[78]
Mayamycin (**157**)	*Streptomyces* sp. HB202	ATCC 33593	1.25	antibacterial against MSSA, *B. epidermidis*, *B. subtilis, D. hominis*, *K. pneumoniae, P. aeruginosa, S. epidermidis, S. lentus* and *X. campestris* (MIC = 0.31-8.4 μg/mL) [79] cytotoxic against HepG2, HT-29, GXF251L, LXF529L, MAXF401NL, MEXF462NL, PAXF1657L, and RXF486L (IC_{50} = 0.13-0.29 μM) [79]	[79]
Jadomycin TFAL (**158**)	*Streptomyces venezuelae* ISP5230 cultured with	MRSA	3.0	antibacterial against *S. warneri* and VRE, (MIC = 3.0 and 12.0 μg/mL) [80]	[80]

	*N*ε-Trifluoroacetyl-L-lysine				
Nocardiopsistin F (**159**)	*Nocardiopsis* sp. HB-J378	MRSA	0.195	-	[77]
Yangpumicin A (**160**)	*Micromonospora yangpuensis* DSM 45577	MRSA	$<1.0\times10^{-6}$	**160-162**: antibacterial against MSSA (MIC = 1.0-2.0×10^{-6} μg/mL), *E. coli* (MIC = 1.28 ×10^{-4}, 3.2×10^{-5}, and 0.032 μg/mL) [81]	[81]
Yangpumicin F (**161**)	*Micromonospora yangpuensis* DSM 45577	MRSA	$<1.0\times10^{-6}$		[81]
Yangpumicin G (**162**)	*Micromonospora yangpuensis* DSM 45577	MRSA	2.0×10^{-6}		[81]
Sealutomicin A (**163**)	*Nonomuraea* sp. MM565M-173N2	MRSA No.5 MRSA No.17	0.0125 0.0125	**163-166**: antibacterial against MSSA, VISA, VRE, *E. coli*, *E. cloacae*, *K. pneumoniae*, *P. aeruginosa*, and *A. baumannii* (MIC = 0.0063-6.4 μg/mL) [82]	[82]
Sealutomicin B (**164**)	*Nonomuraea* sp. MM565M-173N2	MRSA No.5 MRSA No.17	0.4 0.4		[82]
Sealutomicin C (**165**)	*Nonomuraea* sp. MM565M-173N2	MRSA No.5 MRSA No.17	1.6 0.8		[82]
Sealutomicin D (**166**)	*Nonomuraea* sp. MM565M-173N2	MRSA No.5 MRSA No.17	0.8 0.4		[82]
Vineomycin A_1 (**167**)	*Streptomyces* sp. A6H	MRSA	4.0	antibacterial against MSSA (MIC = 4.0 μg/mL) [83]	[83]
Xanthones					
Polycyclic xanthones					
Cervinomycin A_2 (**168**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.5 0.5	**168-172**: antibacterial against *E. faecalis* and *E. faecium* (MIC = 0.016-1.0 μg/mL) cytotoxicity against SW1990, PC3, and H1299 (**168**: IC_{50} = 0.7, 1.3, and 2.5; **169-172**: IC_{50} = 0.1×10^{-3}- 0.01 μM) [84] **168**: inhibitory activity against anaerobic bacteria, such as *Clostridium perfringens*, *Peptococcus prevotii*, and *Bacteroides fragilis* [85]	[84]
Cervinomycin B_1 (**169**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.06 0.06		[84]
Cervinomycin B_3 (**170**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.016 0.008		[84]
Cervinomycin B_2 (**171**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.06 0.12		[84]
Cervinomycin B_4 (**172**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.25 0.12		[84]
Cervinomycin C_1 (**173**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.25 0.25	**173-176**, antibacterial against MSSE, MSSA, *E. faecalis*, and *E. faecium* (MIC = 0.016-4.0 μg/mL) [86] cytotoxicity against HCT116 and BxPC-3 with IC_{50} = 0.9–801.0 nM [86]	[86]

Cervinomycin C_3 (**174**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.03 0.03		[86]
Cervinomycin C_2 (**175**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.12 0.25		[86]
Cervinomycin C_4 (**176**)	*Streptomyces* sp. CPCC 204980	ATCC 33591 MRSA (16-30)	0.12 0.12		[86]
Citreamicin *ε* (**177**)	*Streptomyces vinaceus*	ATCC 43300 Clinical isolate (1137)	0.13 0.25	**177** and **178**: Antibacterial against *S. aureus*, *E. faecium*, *S. pneumoniae*, *H. influenzae*, and *M. catarrhalis* (MIC = 0.06-4.0 μg/mL) [87] cytotoxicity against HepG2 and normal human dermal fibroblast (NHDF) with CC_{90} = 0.1-2.4 μg/mL[87]	[87]
Citreamicin *δ* (**178**)	*Streptomyces vinaceus*	ATCC 43300 Clinical isolate (1137)	0.5 2.0	**177A** and **B**: Citreamicin *ε* A and B, two diastereomers, potent cytotoxic activity against HeLa and HepG2 cells with IC_{50} values ranging from 30 to 100 nM., induced caspase-3-dependent apoptosis through generating reactive oxygen species [88] Citreamicin *ε* A and B, showed different apoptotic effects on PtK2 cells with IC_{50} values of 0.086 and 0.025 μM [89] induced cell apoptosis and activated the NF-κB pathway with different rate (**177B** more faster) [89]	[87]
Citreaglycon A (**179**)	*Streptomyces caelestis*	ATCC 43300	8.0	antibacterial against *S. haemolyticus* and *B. subtillis* (MIC = 8.0 μg/mL) [90]	[90]
Citreamicin *θ*A (**180**)	*Streptomyces caelestis*	ATCC 43300	0.25	**180** and **181**: Antibacterial against *S. haemolyticus, S. aureus* and *B. subtillis* (MIC = 0.25-1.0 μg/mL) [90] cytotoxicity against HeLa with IC_{50} = 0.055 and 0.072 μg/mL [90]	[90]
Citreamicin *θ*B (**181**)	*Streptomyces caelestis*	ATCC 43300	0.25		[90]
Neocitreamicin I (**182**)	*Nocardia pseudobrasiliensis* G0655	MRSA NRS1 MRSA NRS2 MRSA NRS71	0.5 0.12 0.12	**182** and **183**: antibacterial against *E. faecalis* and *B. subtillis* (MIC = 0.06-1.25 μg/mL) [91]	[91]
Neocitreamicin II (**183**)	*Nocardia pseudobrasiliensis* G0655	MRSA NRS1 MRSA NRS2 MRSA NRS71	1.0 0.5 0.5		[91]
Xantholipin B (**184**)	*Streptomyces flocculus* CGMCC 4.1223 WJN-1	MRSA Mu50	0.025	**184** and **185**: antibacterial against *B. mycoides* and *M. smegmatis* (**184**: MIC = 0.08; **185**: MIC = 5.0 μg/mL) [92] antifungal against *C. albicans* and *C. sake* (MIC = 0.08-1.3 μg/mL) [92] cytotoxicity against KB, HL-60, BGC-803, A549, and MCF-7, (IC_{50} = 0.0088-0.43 μM) [92] **185**: inhibitor of HSP47 gene expression [93]	[92]
Xantholipin (**185**)	*Streptomyces flocculus* CGMCC 4.1223 WJN-1	MRSA Mu50	0.025		[92]
Kebanmycin A (**186**)	*Streptomyces* sp. SCSIO 40068	MRSA shhs-A1 MRSA 1862 MRSA 669 MRSA991	0.125 0.125 0.5 0.5	**186-190**: Antibacterial against *S. aureus* and *B. subtilis* (MIC = 0.125-4.0 μg/mL) [94] cytotoxicity against HepG2 (IC_{50} = 0.25-31.0 μM) and MCF-7 (IC_{50} = 0.12-4.1 μM) [94]	[94]

Kebanmycin B (**187**)	*Streptomyces* sp. SCSIO 40068	MRSA shhs-A1 MRSA 1862 MRSA 669 MRSA991	2.0 1.0 2.0 2.0		[94]
Kebanmycin C (**188**)	*Streptomyces* sp. SCSIO 40068	MRSA shhs-A1 MRSA 1862 MRSA 669 MRSA991	0.5 1.0 2.0 2.0		[94]
FD-594 (**189**)	*Streptomyces* sp. SCSIO 40068	MRSA shhs-A1 MRSA 1862 MRSA 669 MRSA991	2.0 1.0 2.0 1.0		[94]
FD-594 aglycon (**190**)	*Streptomyces* sp. SCSIO 40068	MRSA shhs-A1 MRSA 1862 MRSA 669 MRSA991	8.0 4.0 8.0 8.0		[94]
Dimeric xanthones					
Xanthoquinodin A_1 (**191**)	*Chaetomium globosum* 7s-1	MRSA	0.5	**191-193**: antibacterial against *S. aureus* and *B. cereus* (MIC = 0.22-1.75 μM) [95] antimalarial with IC_{50} of 2.55-6.29 μM [95] anti-*Mycobacterium tuberculosis* (TB) with IC_{50} of 87.39 μM [95] cytotoxicity against KB, MCF-7 and NCI-H187 (IC_{50} = 0.98–18.40), Vero (IC_{50} = 1.78-3.86 μM) [95] **191**: inhibition in *Toxoplasma gondii* [36] inhibitory effects against *M. genitalium*, *C. parvum*, *T. vaginalis*, and *P. falciparum* with EC_{50} values from 0.13 to 5.2 μM [96] anticoccidial [97]	[95]
Xanthoquinodin A_3 (**192**)	*Chaetomium globosum* 7s-1	MRSA	1.0		[95]
Xanthoquinodin B_9 (**193**)	*Chaetomium globosum* 7s-1	MRSA	0.5		[95]
7,8-Dideoxygriseorhodin C (**194**)	*Streptomyces* sp. 1425S.R.1a.1	ATCC® 43300™	0.08-0.12	-	[98]
Jugione A (**195**)	*Penicillium shearii* CMB-STF067	AUS-RBWH-MRSA-01	2.4	**195-197**: antibacterial against *S. aureus* and *E. faecalis* (IC_{50} = 1.8-6.6 μM) [99] **195**: antifungal against *C. albicans* with an IC_{50} value of 4.1 μM [99] anticancer activities against SW620 and NCI-H460 with IC_{50} values of 9.8 and 9.0 μM [99]	[99]
Jugione B (**196**)	*Penicillium shearii* CMB-STF067	AUS-RBWH-MRSA-01	6.4		[99]
Jugione D (**197**)	*Penicillium shearii* CMB-STF067	AUS-RBWH-MRSA-01	3.7		[99]
Subplenone A (**198**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	0.5 0.25	**198**, **199** and **201-207**: antibacterial against *S. aureus, E. faecalis, E. faecium,* and *S. epidermidis* (MICs = 0.125-16.0 μg/mL) [100] **200**: antibacterial against *S. aureus* and *S. epidermidis* (MIC = 2.0 and 1.0 μg/mL) [100]	[100]
Subplenone B (**199**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	1.0 0.5		[100]

Subplenone C (**200**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	4.0 2.0		100
Subplenone D (**201**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	1.0 0.5		100
Subplenone E (**202**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	0.5 0.25		100
Subplenone F (**203**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	1.0 0.5		100
Subplenone G (**204**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	0.5 0.25		100
Subplenone H (**205**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	0.5 0.5		100
Subplenone I (**206**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	4.0 4.0		100
Subplenone J (**207**)	*Subplenodomus* sp. CPCC 401465	MRSA 43300 MRSA 700698	1.0 0.5		100
Penicixanthone G (**208**)	*Penicillium purpurogenum* SC0070	MRSA	0.4	antibacterial against *S. aureus* and *S. dysenteriae* (MIC = 0.4 and 6.3 μg/mL) [101] cytotoxicity against A549, Hela, and HepG2 (IC_{50} = 0.3-0.6 μM), Vero (IC_{50} > 50.0 μM) [101]	101
Neosartorin (**209**)	*Aspergillus fumigatiaffinis*	MRSA Mu50 MRSA 25697	8.0 8.0	antibacterial against *S. aureus, S. pneumoniae*, *S. pyogenes*, and *B. subtilis* (MIC = 4.0-8.0 μg/mL) [102] antitumor against Hela and THP-1 cell lines (IC_{50} = 12.0-32.0 μg/mL), no cytotoxicity against Balb/3T3 at 68.0 μg/mL [102]	102
Anthraquinones					
Polycyclic anthraquinones					
5-Hydroxy ericamycin (**210**)	*Actinoplanes* sp. 4731	ATCC 43300 MRSA (1137)	0.016 <0.06	antibacterial against *S. aureus, S. epidermis*, *E. faecalis*, *S. pneumoniae*, *S. pyogenes*, and *S. agalactiae* (MIC = 0.004-0.06 μg/mL) [103] antibacterial against *E. faecium*, *H. influenzae*, *H. parainfluenzae*, and *E. coli* (MIC = 0.25-4.0 μg/mL) [103] cytotoxicity against normal human dermal fibroblast cell and HepG2 (CC_{90} = 4.7 μg/mL) [103]	104
Arenimycin (**211**)	*Salinispora arenicola* CNR-647	MRSA (5158) MRSA (5085) MRSA (5167) MRSA (5177) MRSA (5218)	0.53 1.03 0.13 0.05 1.00	antibacterial against rifampin and methicillin-resistant SA, Coagulase-negative *Staphylococcus, S. aureus*, *S. saprophyticus*, *E. faecalis*, *E. faecium*, and *M. bacille* (MIC = 0.05-1.0 μg/mL) [103]	103

(-)-Anthrabenzoxocinone (BE-24566B) (**212**)	*Streptomyces* sp. MA6657	MRSA mac*R* (COL, MB5393)	2.0	**212-214**: antibacterial against *S. aureus*, *S. pneumoniae*, *E. faecalis*, *E. faecium*, and *E. coli* (MIC = 0.5-2.0 μg/mL) [105] **213**: induction of cell cycle arrest, apoptosis, and autophagy in non-small cell lung cancer through targeting inhibition of the PI3K/AKT/mTOR pathway [106] potential Inhibitors of SARS-CoV-2 Main Protease (M^{pro}) [107] **214**: induction of *Staphylococcus aureus* FASII [105] endothelin binding inhibitor [108]	
(+)-Anthrabenzoxocinone (1.264-C) (**213**)	*Streptomyces* sp. MA6657	MRSA mac*R* (COL, MB5393)	0.5		105
(-)-Bischloroanthrabenzoxocinone (L-755805) (**214**)	*Streptomyces* sp. MA6657	MRSA mac*R* (COL, MB5393)	1.0		105
Zunyimycin A (**215**)	*Streptomyces* sp. FJS31-2	Clinical isolates (08301) and (161231380)	6.89 8.36	antibacterial against *E. faecalis,* 4 strains of *E. faecalis* clinical isolates, and *B. subtilis* (**215** and **216**: MIC = 12.81-33.43 μg/mL; **217**: MIC = 3.75-8.14 μg/mL) [109] **217**: enhances immunity and improves cognitive impairment through changing intestinal flora diversity and SCFAs [110] induces apoptosis of lung cancer cells through an AKT-related mechanism [111]	109
Zunyimycin B (**216**)	*Streptomyces* sp. FJS31-2	Clinical isolate (08301)	7.88		109
Zunyimycin C (**217**)	*Streptomyces* sp. FJS31-2	Clinical isolates (08301) (161222330) (161231380) (170108317) (161231350)	3.75 8.14 4.07 4.07 4.07		109
Enduracyclinone A (**218**)	*Nonomuraea* sp. ID40491	MRSA L3864 MRSA L3797	0.03 0.03	Antibacterial against *S. aureus*, *S. hemolyticus*, *S. intermedius*, *S. pyogenes*, *S. pneumoniae*, *E. faecium*, *P. acnes*, and *C. difficile* (MIC = 0.0005-4.0 μg/mL) [112] inhibition of peptidoglycan and DNA syntheses of *S. aureus* [112]	112
TLN-05220 (**219**)	*Micromonospora echinospora* ssp. *challisensis* NRRL 12255	ATCC 700699	0.016	**219** and **220**: antibacterial against *S. aureus*, *S. pneumoniae*, *E. faecalis*, and *C. difficile* (MICs = 0.016-2.0 μg/mL) [113] **219**: showed cytotoxicity against MCF-7, HCT-116, NCL-H460, and K-562 (IC_{50} = 0.09-4.62 μM), PC-3 (IC_{50} < 0.01 μM) [113] **219: s**howed a narrow therapeutic index and pharmacokinetics unsuitable for i.v./i.p. dosing in PC-3 nude mouse in vivo studies [113]	113
TLN-05223 (**220**)	*Micromonospora echinospora* ssp. *challisensis* NRRL 12255	ATCC 700699	0.125		113
Dimeric anthraquinones					
Lincolnenin A (**221**)	*Streptomyces lincolnensis* ACM-4234	MRSA	1.14	**221** and **222**: antibacterial against *S. aureus*, *C. diphtheria*, *S. epidermis,* and *E. faecalis* (MIC_{99} = 0.5-3.5 μM) antimycobacterial against *Mycobacterium tuberculosis* H37Ra with MIC_{99} of 0.9 and 1.7 μM [114] **222**: inhibition of SARS-CoV-2 main protease (M^{pro}) with an IC_{50} value of 12.026 μM, anti-inflammatory and anti-oxidant property [115]	114
Setomimycin (**222**)	*Streptomyces lincolnensis* ACM-4234	MRSA	0.7		114
Skyrin (**223**)	*Talaromyces wortmanii*	MRSA	8.0	**223** and **224**: antibacterial against *S. epidermidis* and *S. pneumoniae* (MIC_s = 4.0-8.0 μg/mL) [116] **223**: antitumor through upregulating death receptor 5 (TNFRSF10B) and reversing TRAIL resistance [117] DNA-protective effects on non-cancerous human cells [118]	116
Rugulosin A (**224**)	*Talaromyces wortmanii* *Penicillium radicum* FKI-3765-2	MRSA	8.0 0.125		116, 122 121

	Talaromyces sp. WHUF04072			antioxidant [119] a receptor-selective glucagon antagonist [120] **224**: antibacterial against *S. aureus* NEWMAN and *S. aureus* ATCC25923 (MICs = 0.25 and 0.125 μg/mL) [116] disrupted cell membrane integrity and permeability by inducing elevated levels of intracellular ROS [121]	
Parengyomarin A (**225**)	*Parengyodontium album*	ATCC700699	0.22	**225-227**: Antibacterial against *S. aureus* (MIC_s = 0.39-3.12 μM) [123] **227**: anti-tumor activity against Cal27, Kyse510, HCC38, A2789, and MDA-MB-231 with IC_{50} of 0.2-2.6 μM [124]	[123]
Parengyomarin B (**226**)	*Parengyodontium album*	ATCC700699	0.89		[123]
Torrubiellin B (**227**)	*Parengyodontium album*	ATCC700699	1.69		[123]
Bisanthraquinone derivative 1 (**228**)	*Streptomyces* strain # N1-78-1	ATCC 43300	0.08	**228** and **229**: Antibacterial against VRE (IC_{50} = 2.0 and 12.0 μM) [125] cytotoxicity against HCT-116 (IC_{50} = 3.3 and 5.6 μM) [125]	[125]
Bisanthraquinone derivative 2 (**229**)	*Streptomyces* strain # N1-78-1	ATCC 43300	0.2		[125]
Mycopyranone (**230**)	*Phialemoniopsis* sp. MSX61662	USA300 LAC strain AH1263	≤6.25	Molecular docking indicated that **230** binds to the FtsZ (tubulin-like) protein in the same pocket as viriditoxin (**2**), suggesting that **230** targets bacterial cell division [126]	[126]
Vioxanthin (**231**)	*Aspergillus elegans* KUFA0015	MRSA 66/1	0.5	**231** and **232**: Antibacterial against *S. aureus* and *E. faecalis* (MICs = 1.0-8.0 μg/mL) [127] **231**: an effective inhibitor of MPT/protein thiol oxidation [128] **232**: antibacterial against *C. albicans* (MIC = 6.25 μg/mL) [129] cytotoxicity against A2780 human ovarian carcinoma cells (IC_{50} = 5.0 μM) [130] inhibition of *in vitro* SUMOylation with IC_{50} value of 10.2 μM [131] anti-dormant mycobacterial activity [132]	[127]
Viomellein (**232**)	*Aspergillus elegans* KUFA0015	MRSA 66/1	2.0		[127]
Biemodin (**233**)	*Talaromyces wortmanii*	MRSA	8.0	antibacterial against *S. epidermidis* and *S. pneumoniae* (MIC = 16.0 μg/mL) [116]	[116]
Other anthraquinones					
Urnucratin A (**234**)	*Urnula craterium*	MRSA MW2	2.0	**234** and **235**: antibacterial against *S. aureus, E. faecium*, *E. faecalis,* and *S. pyogenes* (MICs = 0.5-8.0 μg/mL) [133]	[133]
Urnucratin B (**235**)	*Urnula craterium*	MRSA MW2	8.0		[133]
Chlororesistoflavin A (**236**)	*Streptomyces* sp. strain EG32	MRSA	0.25	-	[134]
Chlororesistoflavin B (**237**)	*Streptomyces* sp. strain EG32	MRSA	2.0		[134]
Resistoflavin (**238**)	*Streptomyces* sp. strain EG32	MRSA	0.25		[134]
Cladosporol B (**239**)	*Cladosporium* sp. TMPU1621	ATCC43300	3.12	antiproliferative and proapoptotic effects against HT-29 cell [135], inhibition of adipogenesis in 3T3-L1 preadipocytes as peroxisome proliferator-activated receptor gamma (PPARγ) agonist [136] inhibit HT-29 cell proliferation by inducing robust G0/G1-phase arrest and upregulating p21waf1/cip1 [135] anti-breast cancer against α-estrogen receptor [137]	[138]

(+)-Cercosporin (**240**)	*Septoria pistaciarum* Caracc. ATCC 22201	ATCC 33591	5.0	antibacterial against *S. aureus* (MIC = 2.5 μg/mL) [139] antiplasmodial activity against chloroquinesensitive (D6) clone and chloroquineresistant (W2) clone, (IC_{50} = 1.08 and 1.62 μM) [139] phytotoxic activity to bentgrass (*A. stolonifera*) and lettuce (*L. sativa* cv. L., iceberg) antileishmanial activity (IC_{50} = 1.14 μM) [139] cytotoxicity to SK-MEL, KB, BT-549, SK-OV-3, LLC-PK_{11}, and Vero (IC_{50} = 3.6-10.8 μM) [139]	[139]
Resistomycin (**241**)	*Streptomyces* sp. EG32	MRSA	0.125	Antimicrobial activities against *B. subtilis*, *S. aureus*, *S. epidermis*, *E. faecalis*, *K. pneumonia*, *Salmonella typhi*, *Escherichia coli*, and *Shigella* sp. with MIC values of 8-45 μg/mL [140] suppresses prostate cancer cell growth by instigating oxidative stress, mitochondrial apoptosis, and cell cycle arrest [141] inhibits Wnt/β-catenin signaling to induce the apoptotic death of human colorectal cancer cells [142] inhibits the growth of triple negative breast cancer cells through induction of apoptosis and mitochondrial dysfunction [143] attenuates triple-negative breast cancer progression by inhibiting E3 ligase Pellino-1 and inducing SNAIL/SLUG degradation [144] Induced apoptosis and cycle arrest in human hepatocellular carcinoma cells by activating p38 MAPK pathway [145] TRAIL resistance-overcoming activity [146]	[134]
Chromomycin A_9 (**242**)	*Streptomyces microflavus* MBTI36	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300 ATCC 700787 ATCC 700788	0.13 0.13 0.13 0.13 0.13 0.13 0.13	**242**-**245**, antibacterial activities to *S. aureus*, MSSA, *E. faecium*, *E. faecalis*, and *S. enterica*, with MIC values ranging from 0.03 to 0.5 μg/mL[147]	[147]
Chromomycin A_P (**243**)	*Streptomyces microflavus* MBTI36	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300 ATCC 700787 ATCC 700788	0.25 0.25 0.13 0.06 0.13 0.25 0.25		[147]
Chromomycin A_2 (**244**)	*Streptomyces microflavus* MBTI36	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300 ATCC 700787 ATCC 700788	0.13 0.13 0.06 0.06 0.06 0.25 0.13		[147]

Chromomycin A_3 (**245**)	*Streptomyces microflavus* MBTI36	CCARM 3089 CCARM 3090 CCARM 3634 CCARM 3635 ATCC 43300 ATCC 700787 ATCC 700788	0.13 0.13 0.13 0.13 0.13 0.13 0.13		[147]
Mutactimycin E (**246**)	*Amycolatopsis* strain 17128	ATCC 43300 MRSA (1137)	8.0 8.0	antibacterial activities to *S. aureus*, *S. pneumoniae, E. faecium*, and *M. catarrhalis* (MICs = 1.0-8.0 μg/mL) [148]	[148]
Emodin (**247**)	*Penicillium citrinum* PSU-F51	MRSA	4.0	anticancer, hepatoprotective, antiinflammatory, antioxidant, anti-allergic, neuroprotective, immunosuppressive, anti-osteoporotic, anti-diabetic, anti-metastasis, and antivirus activity [149] antibacterial activity against *M. tuberculosis* with MIC value of 0.9 μM [149] hepatotoxicity, kidney toxicity and reproductive toxicity [150]	[149]
Aspetritone A (**248**)	*Aspergillus tritici* SP2-8-1	ATCC 43300 ATCC 1.12409	7.53 7.63	antibacterial against *V. vulnificus*, *V. rotiferianus*, *and V. campbellii* (MICs = 15.6, 31.2, and 15.5 μg/mL) [151] cytotoxicity to HeLa, A549, and Hep G2 (IC_{50} = 2.7, 3.1, and 3.9) [151]	[151]
Lateropyrone (**249**)	The co-culture of *Aspergillus nidulans* and *Streptomyces rapamycinicus*	MRSA 25697	2.0-4.0	antibacterial against *B. subtilis*, *S. aureus*, *S. pneumoniae*, and *E. faecalis* (MICs = 2.0-8.0 μg/mL) [152]	[152]
f13102B (**250**)	Fungus strain F-13102	MS 16526	8.0	antibacterial against *S. aureus*, *B. subtilis*, and *E. coli* (MICs = 4.0-16.0 μg/mL) [153]	[153]

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