

鞘氨醇单胞菌研究进展

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摘要 鞘氨醇单胞菌属(*Sphingomonas*)是1990年才重新划分的一个新属,由于其特有的生态分布与代谢特征,已引起了环境微生物学者的重视.本文综述了鞘氨醇单胞菌的细胞结构与功能,以及生态分布与代谢特征方面的研究进展.鞘氨醇单胞菌具有特殊的细胞结构,最显著的是细胞膜用鞘脂糖代替了脂多糖,这使其与传统意义上的革兰氏阴性菌具有显著区别.鞘氨醇单胞菌耐受贫营养的代谢机制使其在自然界中有着极强的生命力和广泛的分布,某些菌株具有细胞膜上的高分子通道与大质粒,能够降解高分子有机污染物[尤其是多环芳烃(PAHs)].这些特性使得鞘氨醇单胞菌在环境污染治理与生物技术领域具有广阔的应用前景.图2表1参65

关键词 鞘氨醇单胞菌;鞘脂糖;贫营养菌;高分子通道;多环芳烃降解

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Progress in Research of *Sphingomonas* *

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Abstract The genus *Sphingomonas* was established by Yabuuchi *et al.* in 1990, and since then it has been the focus of microbiology researchers because of its special ecological distribution and metabolism. This paper provides a review on the cytoarchitecture, relational functions, ecological distribution and metabolism of *Sphingomonas*. The genus is characterized by an outer membrane that contains glycosphingolipids instead of lipopolysaccharide, which makes it different from the traditional Gram-negative aerobic bacteria. The distribution of *Sphingomonas* has not been systematically studied, but it is known that it widely occurs because of its metabolic mechanism able to endure poor nutrients. Some of its species have a macromolecule transport/depolymerization system and degradative plasmids, which enable them to degrade refractory compounds, particularly polycyclic aromatic hydrocarbons (PAHs). *Sphingomonas* has been extensively applied for disposition of environmental pollution and in the field of biotechnology. Fig 2, Tab 1, Ref 65

Keywords *Sphingomonas*; glycosphingolipid; ligotrophic; macromolecule transport system; biodegradation of polycyclic aromatic hydrocarbons

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鞘氨醇单胞菌由于其具有某些生理特征(如含大质粒,可降解多环芳烃类化合物,产生黄色素等)以前曾被归于假单胞菌属(*Pseudomonas*)或黄杆菌属(*Flavobacterium*)中.1990年,Yabuuchi等通过研究16S rRNA的核苷酸序列,胞内脂质中出现的特殊鞘糖脂和辅酶Q的主要类型,首次提出这是一类新的细菌属——鞘氨醇单胞菌属(*Sphingomonas*);并描述了该属4株菌的化学分类及系统发育特征^[1].此后,许多鞘氨醇单胞菌新种被科学家们相继发现.鞘氨醇单胞菌在地球上分布极其广泛,在各种水体、土壤、大气以及极端环境中都有其存在的踪影.它们具有耐受极端贫营养条件、利用各种简单分子、降解复杂有机物的能力,某些种属还能产生有价值的生物高分子(如 β -胡萝卜素、结冷胶);它们又是一类致病菌,能引起植物根部或动物伤口的感染.

1 鞘氨醇单胞菌基本特征

鞘氨醇单胞菌从属于 α -变形杆菌纲,鞘氨醇单胞菌目,鞘氨醇单胞菌科.该属与相关菌属系统进化关系如图1,属内各模式菌株的系统发育关系如图2.属于异养、好氧的革兰氏阴性菌,但其细胞膜组成不同于一般的革兰氏阴性好氧菌(如假单胞菌)特有的脂多糖,而是鞘脂糖^[2],这是所有鞘氨醇单胞菌都具有的重要特征.鞘脂糖的种类有:18~21碳直链饱和二氢鞘氨醇、单不饱和二氢鞘氨醇和含环丙烷的二氢鞘氨醇^[1].此外,辅酶Q10带有10个类异戊二烯单元支链的苯醌作为呼吸传递链的电子载体.细胞内未检测到由酯或氨基连接的3-羟基脂肪酸.许多种都有鞭毛,大部分能产黄色素(类胡萝卜素).该属模式种为少动鞘氨醇单胞菌(*S. paucimobilis*)^[1].

2 鞘氨醇单胞菌细胞结构与功能

2.1 细胞膜中的鞘脂糖与T细胞识别^[3,4]

革兰氏阴性菌细胞膜中的脂多糖是一种细菌内毒素,会刺激机体免疫反应.鞘脂糖作为脂多糖的替代物也会引起这种反应,而且这种刺激反应已用于研究人体免疫T细胞对生物抗原的反应过程.以前对人体免疫T细胞性状的研究方式比较

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单一,主要是通过非经典的 MHC (主要组织相容性复合体) I 类分子——CD1d 携带的人工合成糖脂类抗原 (即 α -半乳糖酰基鞘氨醇) 去激发其免疫活性,从而研究免疫反应过程.但这种糖脂有效性非常有限, T 细胞对真实的生物抗原反应是否

一样还存在争议,科学家们一直在寻找新的 CD1d 结合糖脂来刺激 T 细胞活性.最近研究发现,老鼠和人类的 T 细胞能够识别鞘氨醇单胞菌的鞘脂糖,引起免疫反应,这使得人们能够更深入研究 T 细胞功能,从而方便确定更多疾病的治疗方法.

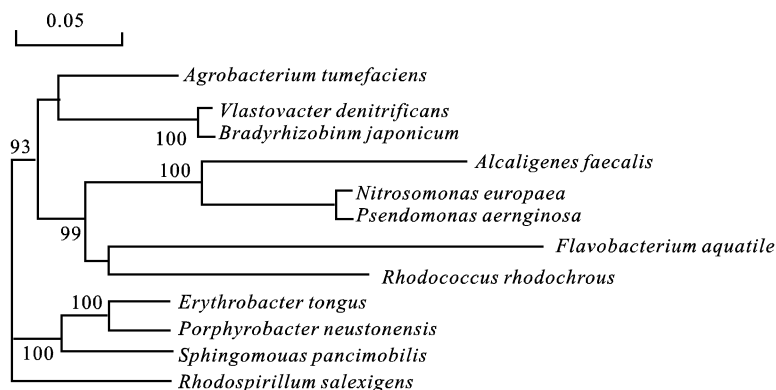


图1 鞘脂单胞菌与相关菌属的无根系统发育树

Fig. 1 Unrooted phylogenetic tree of *Sphingomonas* and related genera

基于所选模式种的部分 16S rDNA 序列分析,通过 DNAMAN 程序来排列 DNA 序列,并构建发育树,用最大可能法来计算基因距离.节点上显示 bootstrap 值,比例线指示进化距离.下同.

基因库的登录号分别是:鞘脂单胞菌属, U37337;土壤杆菌属, M11223;产碱菌属, M22508;红球菌属, X70295;假单胞菌属, D11236;黄杆菌属, AM230485;慢生根瘤菌属, S46916;芽生杆菌属, X66025;亚硝化单胞菌属, AJ245759;红螺菌属, M59070;紫杆菌属, L01785;赤杆菌属, M59062. The phylogenetic tree is constructed based on selected type species 16S rDNA sequence analysis and DNA sequencing by using DNAMAN programs. Genetic distances were calculated using method of Maximum Likelihood. Bootstrap values are shown at nodes. The scale bar indicates substitutions per site. The same below.

Accession numbers of GenBank: *Sphingomonas paucimobilis* strain ATCC 29837, U37337; *Agrobacterium tumefaciens* DSM 30105, M11223; *Alcaligenes faecalis*, M22508; *Rhodococcus rhodochrous*, X70295; *Pseudomonas aeruginosa*, D11236; *Flavobacterium aquatile*, AM230485; *Bradyrhizobium japonicum*, S46916; *Blastobacter denitrificans* strain LMG 8443, X66025; *Nitrosomonas europaea*, AJ245759; *Rhodospirillum rubrum* DSM 2132, M59070; *Porphyrobacter neustonensis* ACM 2844, L01785; *Erythrobacter longus* ATCC 33941, M59062

2.2 细胞膜上的高分子通道

部分鞘氨醇单胞菌细胞膜上具有高分子通道,已发现能降解高分子藻酸盐的鞘氨醇单胞菌 A1,即通过“超级通道”——细胞膜表面上的坑、周质藻酸盐绑定蛋白以及内膜 ATP 绑定盒式传输蛋白——结合藻酸盐,再由细胞内的降解酶系降解^[5,6].通过电镜观察,发现加入藻酸盐前后,细胞表面和膜结构发生了动力学的变化,其中最显著的是细胞膜表面嘴型深坑的形成^[5].将 A1 的完整细胞转变成原生质体,细胞表面蛋白就以泡囊形式从外膜上释放出来,共有 7 种蛋白,分别是: p1 ~ p4,外膜转运蛋白; p5, p6,鞭毛蛋白; p7,脂蛋白.与其他细菌鞭毛蛋白形成鞭毛不同, A1 细菌鞭毛蛋白 (p5, p6) 的功能是作为藻酸盐的受体或细胞表面结构的调节蛋白^[6].

2.3 大质粒与高分子降解

2.3.1 芳香化合物 鞘氨醇单胞菌降解芳香化合物的能力与其大质粒有关,质粒上的开放阅读框编码大量运输和降解芳香化合物 (如萘、联苯、甲苯、二甲苯、甲酚、氧芴等) 的酶类^[7,8].也有实验表明,与降解有关的基因不仅位于细菌质粒上,还位于细菌的染色体上,不同地层的鞘氨醇单胞菌其降解芳香化合物的基因位于不同的地方,地表菌株基因定位于染色体上,而地下菌株在质粒上^[9].

表 1 列出了近期报道的鞘氨醇单胞菌的降解底物,大部分为多环芳香烃和杂环衍生物.其中,木质素是一种在生物圈中含最多芳香化合物的混合物,其降解是地球碳循环的关键的一

步.

鞘氨醇单胞菌对芳香化合物的降解机制是依次在芳环上加氧,形成醛、酮或醇类中间体,而后开环裂解,如 *Sphingomonas* sp. RW1 降解氧芴 (二苯环化合物),首先是对邻近醚键的目标位进行加氧,形成二氢二醇 (不稳定的半缩醛中间体),再生成 2,2',3'-三羟联苯,被间位裂解,再生成水杨酸 (单苯化合物),由儿茶酚间位分裂途径或龙胆酸盐途径进一步降解^[25].另一种降解机制是其它能源存在下,通过共代谢作用进行降解,如 *Sphingomonas* sp. LB126 对菲与萤葱的共代谢,就是利用降解菲的能量生长,同时加氧酶可作用于萤葱,使之一起被降解^[39].芳基化合物的降解一般发生在上述的有氧条件下,也可以发生在缺氧条件 (硝酸盐、硫酸盐还原条件) 下,这对环境污染物的治理是非常有利的^[40].

2.3.2 聚乙烯醇 聚乙烯醇 (PVA) 是一类水溶性的人造聚合物,广泛运用于粘合剂、包装纸、纺织品工业等.但聚乙烯醇作为工业废水中主要的污染物之一,在环境中并不容易降解.几乎所有能利用聚乙烯醇的细菌都不能单独以聚乙烯醇为碳源和能源生长,而是通过两种或两种以上菌种进行协同代谢,有两类代谢模式:第一类是两种 (或两种以上) 菌种共同代谢 PVA^[41];另一类是某种菌代谢 PVA,而另一种菌提供生长因子,如吡咯喹啉醌 (Pyrroloquinoline quinone, PQQ)^[36].从韩国某处纺织厂分离筛选出一组 PVA 降解菌,首次发现了一株鞘氨醇单胞菌新种能够和另一株菌协同代谢 PVA,其代谢模式

为鞘氨醇单胞菌降解 PVA, 另一株菌产生 PQQ 或 PQQ 类似物, 协同代谢的最适温度是 30 ~ 35 °C, 最适 pH 是 8.0, 最有效的氮源是 NH_4^+ [36].

另一篇文献报道, 鞘氨醇单胞菌代谢聚乙烯醇的水解酶

(OPH) 和脱氢酶存在于细胞周质中. 其中水解酶属于丝氨酸-水解酶家族, 水解氧化的 PVA 和 p-硝基苯醋酸盐, 但不水解单酮和二酮 [37].

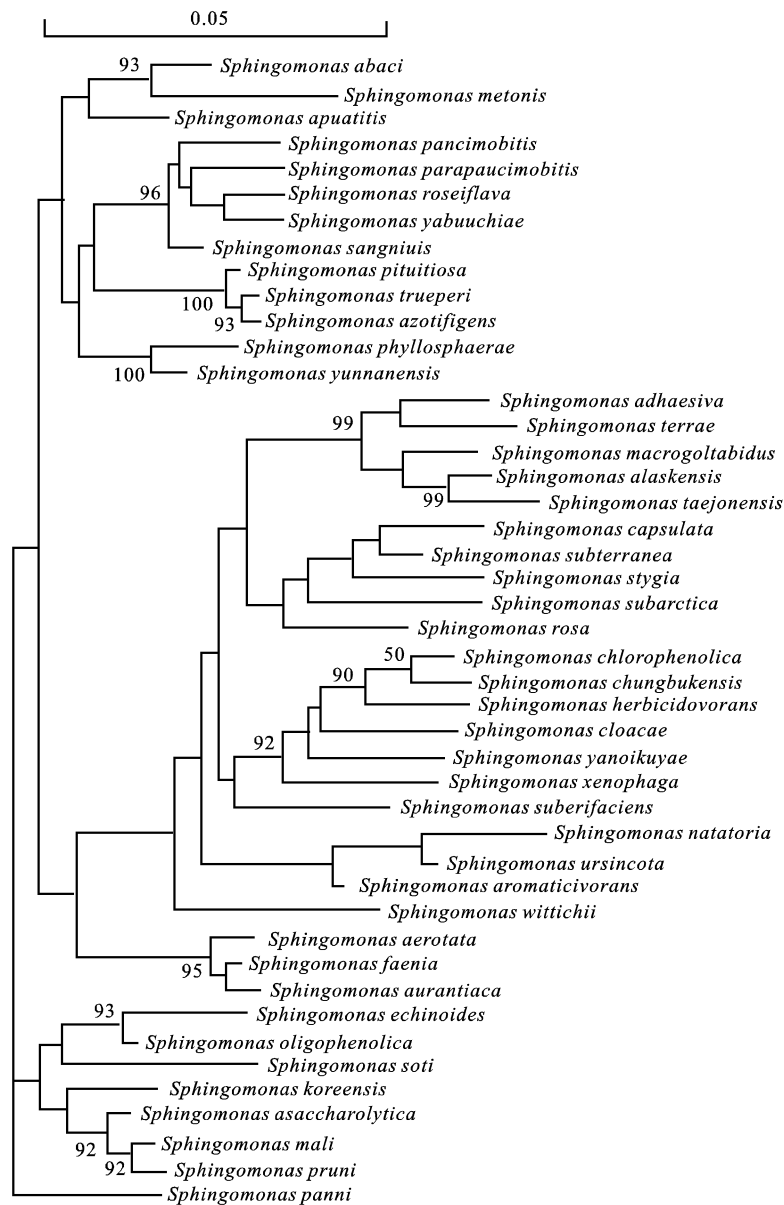


图 2 鞘脂单胞菌属 45 种模式菌株的无根系统发育树

Fig. 2 Unrooted phylogenetic tree of type strains of 45 *Sphingomonas* species

基因库的登陆号 (Accession numbers of GenBank): *S. abaci* strain C42, AJ575817; *S. adhaesiva* NBRC 15099, D13722; *S. aerolata* strain NW12, AJ429240; *S. alaskensis* strain RB2256, AF378795; *S. aquatilis* strain JSS7, AF131295; *S. aromaticivorans* SMCC F199, U20756; *S. asaccharolytica* NBRC 15499, Y09639; *S. aurantiaca* strain MA101, AJ429236; *S. azotifigens* strain NBRC 15497, AB217471; *S. capsulata* NBRC 12533, D16147; *S. chlorophenolica* strain ATCC 33790, X87161; *S. chungbukensis* strain DJ77, AF159257; *S. cloacae* strain S-3, AB040739; *S. echinoides* strain ATCC 14820, AB021370; *S. faenia* strain MA-olki, AJ429239; *S. herbicidovorans* DSM 11019, AB022428; *S. koreensis* strain JSS26, AF131296; *S. macrogoltabidus* NBRC 15033, D13723; *S. mali* NBRC 15500, Y09638; *S. melonis*, AB201254; *S. natatoria* ATCC 35951, X73043; *S. oligophenolica*, AB018439; *S. panni* strain C52, AJ575818; *S. parapaucimobilis* NBRC 15100, D13724; *S. paucimobilis* strain ATCC 29837, U37337; *S. phyllosphaerae* strain FA2, AY453855; *S. pituitosa* strain EDIV, AJ243751; *S. pruni* NBRC 15498, Y09637; *S. rosa* strain ATCC 51837, D13945; *S. roseiflava* strain MK341, D84520; *S. sanguinis* NBRC 13937, D13726; *S. soli* strain T5-04, AB166883; *S. stygia* strain B0712, AB025013; *S. subarctica* HAMBI 2110, X94102; *S. suberifaciens* NBRC 15211, D13737; *S. subterranea* strain B0478, AB025014; *S. taejonensis* strain JSS54, AF131297; *S. terrae* NBRC 15098, D13727; *S. trueperi* LMG 2142, X97776; *S. ursincota* strain KR-99, Y10677; *S. wittichii* strain DSM 6014, AB021492; *S. xenophaga* strain BN6, X94098; *S. yabuuchiae* strain A1-18, AB071955; *S. yanoikuyae* NBRC 15102, D13728; *S. yunnanensis* strain YIM 003, AY894691

表 1 鞘氨醇单胞菌的降解底物
Table 1 Refractory compounds degraded by *Sphingomonas*

除草剂 Herbicide	2,4-二氯苯氧基乙酸 2,4-dichlorophenoxyacetic acid	<i>Sphingomonas</i> sp. ^[10]
	五氯苯酚 Pentachlorophenol	<i>S. chlorophenolica</i> RA2 ^[11] <i>S. chlorophenolica</i> ATCC 39723 ^[12]
	手性 (RS)-2-[(4-氯-2-甲基苯基)氧]丙酸 (mecoprop) (RS)-2-(4-chloro-2-methylphenoxy) propionic acid)	<i>S. herbicidovorans</i> MH ^[13]
	苯基脲类除草剂 Phenylurea herbicide isoproturon	<i>Sphingomona</i> sp. ^[14]
染料类 Dyes	偶氮染料 Azo dyes	<i>Sphingomona</i> sp. strain BN6 ^[15]
农药类 Pesticide	六氯化苯(六六六)及其 α -, β -, γ -取代物 Hexachlorocyclohexane and α -, β -, γ -hexachlorocyclohexane	<i>S. paucimobilis</i> strain B90 ^[16] <i>S. paucimobilis</i> UT26 ^[17]
	苯并环丙烯 6,7-dihydro-5H-benzocycloheptene	<i>S. yanoikuyae</i> ^[18]
其他芳基化合物 Other aromatics	脱氢松香酸 (DhA) 及氯化物 Dehydroabietic acid and chlorinated dehydroabietic acids	<i>Sphingomonas</i> sp. ^[19, 20]
	阿魏酸 Ferulic Acid	<i>S. paucimobilis</i> SYK-6 ^[21]
	木质素 Lignin	<i>S. paucimobilis</i> SYK-6 ^[22]
	联苯化合物 Biphenyl	<i>S. paucimobilis</i> SYK-6 ^[23]
	萘-2-磺酸盐 Naphthalene-2-sulfonate	<i>S. xenophaga</i> BN6 ^[24]
	氧(杂)芑 (CDD), 氧芑 (DF) Dibenzo-p-dioxins, dibenzofuran	<i>S. wittichii</i> RW1 ^[25] <i>Sphingomona</i> sp. strain HH19k ^[26]
	氯代苯酚, 壬基苯酚 Chlorophenol, nonylphenol	<i>Sphingomona</i> sp. strain TTNP3 ^[27] <i>S. xenophaga</i> Bayram ^[28]
	苯氧基烷酸 Phenoxyalkanoic acid	<i>S. herbicidovorans</i> MH ^[29]
	菲 Phenanthrene	<i>Sphingomonas</i> sp. ^[30, 31]
	二苯醚及其氟代, 氯代, 溴代物 Diphenyl ether and its monohalogenated derivatives	<i>Sphingomona</i> sp. SS3 ^[32]
	呋喃 Carbofuran	<i>Sphingomona</i> sp. strain CF06 ^[33]
	1,2-二氢萘 1,2-dihydronaphthalene	<i>S. yanoikuyae</i> ^[34]
多聚物类 Polymer	天门冬氨酸多聚物 Poly-aspartic acid	<i>Sphingomonas</i> sp. ^[35]
	聚乙烯醇 Polyvinyl alcohol (PVA)	<i>Sphingomonas</i> sp. ^[36, 37]
	聚乙烯乙二醇 Polyethylene glycol	<i>S. terrae</i> ^[38]

2.4 主要产物与生物技术应用

2.4.1 β -胡萝卜素 β -胡萝卜素和类胡萝卜素广泛存在自然界中,作为维生素 A 的前体,具有抗氧化作用,可淬灭与清除机体内产生的自由基;提高人体免疫能力,还能预防癌症和减缓癌症的发展.类胡萝卜素的天然来源主要是水果、蔬菜、酵母的提取物等;细菌作为类胡萝卜素的生产在现有生产工艺中较少^[42].

大部分鞘氨醇单胞菌产生的黄色素都是类胡萝卜素.某实验室通过筛选土壤中的类胡萝卜素产生菌,找到一株鞘氨醇单胞菌新种,它能积累 1.7 mg 类胡萝卜素/g(细胞干重),其中 β -胡萝卜素占 29%.而它的突变株在最佳条件能够生产 5.7 mg 类胡萝卜素/g(细胞干重), β -胡萝卜素的积累达到 89%^[42].

2.4.2 结冷胶 结冷胶是少动鞘氨醇单胞菌(*S. paucimobilis*)产生的胞外多糖,类似于黄原胶,但具有比其他微生物多糖更优良的物理化学特性.如结冷胶的水溶液的黏度是黄原胶的 5.5 倍;其固体凝胶与琼脂相比,用量少(0.25% 是用量能达到琼脂 1.5% 的凝胶强度),透明度高,热稳定性好,耐受更广的 pH、温度和盐度条件,经改良后的胶体强度可增加 4 倍足以抵抗高压灭菌^[43, 44].

结冷胶在细胞内合成,分泌到细胞外,其合成途径尚无定论,可能途径是细菌通过糖酵解途径和糖醛酸途径将葡萄糖等单体转变成各种活性前体,这些前体物质再聚合成结冷胶^[45].

3 鞘氨醇单胞菌生态分布与特征

3.1 水体

3.1.1 海洋超微细菌 已有文献报道,在北太平洋深处发现鞘氨醇单胞菌的广泛分布,其中, *Sphingomonas* strain RB2256 是海洋贫营养超微细菌的代表菌^[46~50].它们有着特殊的代谢调控机制以适应海洋多变的环境(尤其是营养物缺乏的环境),能够高效地调整自身的生长速率来抵抗许多不利的环境变化.实验发现,在供给营养物发生变化时,细胞生长速率变化很大,而细胞大小却变化很小,并且从营养物不足到营养物过量剧烈变化时,最大的生长速率能够在短时间之内达到,说明蛋白质合成是组成性调控的^[46].进一步研究发现,细菌在生长对数期和稳定期的蛋白含量变化可达 70 倍,表明蛋白合成的基因调节是非常高效的^[47].通过蛋白合成速度和细胞蛋白含量与核糖体含量比较发现,核糖体合成与蛋白合成不是直接相连的,核糖体的功能不仅限于翻译成为蛋白质,进一步的结论还须实验证明^[47].

3.1.2 藻类与珊瑚杀手 由于氮、磷等营养元素大量进入水体,引起有害藻类的过量繁殖,水体的生态环境受到破坏.鞘氨醇单胞菌广泛存在于各种水体中,同时也是海洋中的优势菌群,所以具有消除藻类的生长机制.实验证实,鞘氨醇单胞菌通

过产生微囊藻毒素酶将微囊藻毒素(一种较普遍的藻毒素)降解成小分子多肽和氨基酸^[51],而且还能分泌一种五肽的活性物质杀灭毒藻^[52]。

在防治藻类过度繁殖的同时,鞘氨醇单胞菌却又是海洋中另外一些生物的杀手。在美国佛罗里达州的暗礁上发现了一种导致珊瑚大面积死亡的微生物,经分析它会放出一种毒素,这种毒素不光对珊瑚有杀伤力,而且对许多物种都有毒力,经分析是一种鞘氨醇单胞菌新种^[53]。

3.1.3 自来水系统的分布与生物腐蚀 鞘氨醇单胞菌还从许多贫营养淡水环境中分离出来,如矿泉水^[54],自来水系统^[55, 56]。这些细菌的生长常常引起各种腐蚀。近来研究报道,某大厦的供水系统管道腐蚀由微生物引起的,从水中分离出两种微生物,分别是假单胞菌属和鞘氨醇单胞菌属;两种菌都能在它们的细胞壁中积累铜,引发生物腐蚀的阳极反应^[56]。

3.2 土壤

3.2.1 土壤中有毒物质的降解 鞘氨醇单胞菌是清理土壤中有毒物质最有效的微生物类群之一,由于其大质粒上携带了许多能降解苯系及杂环物质的酶系基因,在受有毒物质污染的土壤中,鞘氨醇单胞菌随毒物的空间分布而分布。如农田常用苯基尿素类除草剂(异丙隆 IPU)残留于土壤中,并随地表和地下水向土壤深层迁移。在英国沃里克郡某处土壤中检测 IPU 的生物降解情况,发现 IPU 的生物降解率存在空间上的变化,这种空间变化是降解微生物(*Sphingomonas* sp.)和土壤 pH 共同作用的结果^[14]。

3.2.2 对植物的感染 鞘氨醇单胞菌的细胞膜是用含糖醛酸的鞘脂糖代替脂多糖,而鞘脂糖一般只存在于植物和动物细胞膜内。这种化学组成可能使它们能与植物高效地结合,也使得哺乳动物的 T 细胞能够识别它们的鞘脂糖。

很多文献报道了从土壤中植物的根际分离出来的鞘氨醇单胞菌,它们跟植物的联系非常密切,可以在根际分泌糖类营养物,促进植物吸收^[57];又可通过引起植物根部的感染的方式入侵植物体内(类似根瘤菌);还可促进植物抵抗多种植物病原菌,比如对引起黄萎病的真菌(*Verticillium dahliae*)有拮抗作用^[58]。加拿大科学家从水稻根际和根茎上分离出了 4 种抗植物病害的细菌,其中包括 *S. trueperi*,它们能够有效地抵抗植株病原体感染。实验发现,接种了这些菌后,植株高度和大米干重明显提高了,从而植物生长得以促进^[59]。

3.2.3 氮循环的调节 从加拿大的水稻根际和根茎上分离出的 *S. trueperi* 含有固氮基因,能够将乙炔还原成乙烯^[60]。在法国某个生物实验室里,通过好氧与厌氧条件的交替从废水中分离出 *S. adhaesiva*,具有好氧反硝化能力^[61]。鞘氨醇单胞菌属某些菌株具有固氮和脱氮特征,它们在自然界中的广泛存在预示着该属菌株在维持自然界的氮平衡方面起着重要作用。

3.3 空气

从俄罗斯空间实验室取回的空气样品中分离纯化微生物,通过表型特征、基因型特征和 16S rRNA 基因序列分析,获得了鞘氨醇单胞菌的新种 *S. yabuuchiae*^[62]。鞘氨醇单胞菌在空气中的分布可能是由于耐受贫营养特征,第二可能是因为它们能利用空气中人们还不知道某些化学物质或辐射能。

鞘氨醇单胞菌在空气中(也包括水体中)的存在会造成哺

乳动物的感染性疾病。如在医院的病房里,少动鞘氨醇单胞菌(*S. paucimobilis*)会通过感染伤口进入人体而引起各种炎症、败血症等感染性疾病。

4 讨论

虽然没有系统调查,但鞘氨醇单胞菌分布非常广泛。从陆地到河流海洋,从地层深处^[9, 63]到空气中^[58, 59],从南极^[50]到赤道附近^[64],都遍布着鞘氨醇单胞菌属的成员。它们又与人们的生活息息相关,不管是土壤植物根系、自来水管中,还是医院空气和排水系统中,都有它们的存在。鞘氨醇单胞菌能够在广泛的环境中存在,原因有以下几点:一、鞘氨醇单胞菌能够耐受高度贫营养环境和恶劣环境,它们有着特殊的代谢调控机制以适应多变的环境(尤其是营养物缺乏的环境),能够高效调整自身的生长来抵抗许多不利的环境变化,如饥饿^[46, 47],高温^[46],乙醇^[46],过氧化氢^[46, 48],紫外线^[49],严寒^[50]等。已有文献表明,56℃ 高温,25 mmol/L 过氧化氢,20% 乙醇^[46],紫外线直接照射^[49]以及南极洲 1 m 厚冰层下的海水中^[50]都发现鞘氨醇单胞菌的生存,而且生长细胞和休止细胞有着一样的抗性。最近一项研究调查了鞘氨醇单胞菌对无营养环境的适应能力,发现其蛋白和 RNA 的合成是高度调节的,从而对饥饿能够直接反应^[47]。二、能够利用的底物广泛,从多环芳烃类化合物、聚乙烯醇等高聚物到简单无机物 N₂,都能利用。作者实验室的研究也发现,在长期运行的氨生物氧化实验装置中,也发现鞘氨醇单胞菌大量存在,说明它们能够在贫营养的自养环境中生长和繁殖。

有学者推测,鞘氨醇单胞菌可能借用了真核生物的基因,形成类似于真核细胞的酸性糖类细胞外膜表面,而不是类似于假单胞菌的多聚糖粘液,因此它们能够入侵植物体内与植物共生^[65],并能够起到拮抗植物致病真菌的作用;也能够被哺乳动物 T 细胞识别,感染动物引发各种炎症。

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