云南大学学报（自然科学版） 2003，25（3）：283～292 CN 53 - 1045/ N ISSN 0258 - 7971
Journal of Yunnan University

Discovery of a vast amount of unknown actinomycetes from extreme environments in Xinjiang and Qinghai Province, China*

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Abstract: Soil and sediment samples were collected from saline and alkaline soil and lakes in Xinjiang and Qinghai Province, P. R. China. Halophilic, alkalophilic and psychrophilic actinomycetes and actinobacteria in these samples were isolated. The strains were identified by using cultural, physiological, biochemical, molecular biological procedures. One new family (*Yaniaceae*), two new genera (*Yania* and *Streptomonospora*) and eight new species of halophilic actinomycetes and actinobacteria, four new species of alkalophilic and one new species of psychrophilic actinomycetes were found. Basing on the research results that there is a very high density of new or unknown actinomycetes resources in the extreme environments in Xinjiang and Qinghai, China. It is inexorable that new species contains new genes, new metabolites, new activities, and must have new use. Actinomycetes under high salt and alkaline environments may be an important source for discovery of new drugs.

Key words: extreme environment; actinomycetes; actinobacteria
CLC number: Q 939.132 **Document code**: A **Article ID**: 0258 - 7971(2003)03 - 0283 - 10

Microorganisms under extreme environments have been attached a great attention owing to their producing various natural compounds and having special mechanism of adapting extreme environments[1]. But the research work on actinomycetes under extreme environments is very few[2]. There are wide saline and alkaline soils, salt lakes and snow-mountains in Xinjiang and Qinghai Provinces, China. Some results of a series of research on halophilic, alkalophilic and psychrophilic actinomycetes will be reported in this paper.

1 Materials and methods

1.1 Isolation of actinomycetes More than 200 soil and sediment samples were collected from salt and alkaline soil in Baicheng in Xinjiang, Aiding Lake and Xiao Lake in Xinjiang and Chaka Lake, Keke Lake in Qinghai, China. The actinomycetes were isolated with the following media by using dilution plates at 28 ℃ for 2 to 3 weeks.

(1) Starch-casein agar: Starch 10g, Casein 0.3 g, KNO_3 2g, $MgSO_4 \cdot 7H_2O$ 0.05 g, $K_2HPO_4 \cdot 3H_2O$ 2 g, $CaCO_3$ 0.02 g, $FeSO_4 \cdot 7H_2O$, NaCl 200 g, agar 20 g, water 1 000 mL, pH 7.2—7.4.

(2) Glycerol-Asparagine agar: L-Asparagine 1.0 g, glycerol 10.0 g, $K_2HPO_4 \cdot 3H_2O$ 2 g, trace salt ($FeSO_4 \cdot 7H_2O$ 0.1 g; $MnCl_2 \cdot 4H_2O$ 0.1 g; $ZnSO_4 \cdot 7H_2O$ 0.1 g; DW 100 mL) 1 mL, agar 20 g, water 1 000 mL, pH 7.0—7.4.

(3) Soil extract agar: Soil extract 1 000 mL

* **Received date**: 2003 - 03 - 23
Foundation item: This work is supported by the Ministry of Science and Technology, P. R. China (2001CCC00600), National Natural Science Foundation of China (30260004, 30270004), Yunnan Provincial Natural Science Foundation and International Science Cooperation (2002GH02).

(2 500 g soil in 2 500 mL water, 120 ℃ for 1 h, centrifuged, using clear extracts), meat extract 3 g, peptone 5 g, NaCl 200 g, agar 20 g, pH 7.0.

(4) Pridham argar (for isolation of actinobacteria): Starch 10 g, glycerol 10 g, $(NH_4)_2SO_4$ 2 g, $CaCO_3$ 2 g, K_2HPO_4 1 g, $MgSO_4 \cdot 7H_2O$ 1 g, NaCl 200 g, agar 15 g, pH 7.0.

1.2 Phenotypic characterization The media used for morphological studies were yeast extract-malt extract agar (ISP 2 medium) and glycerol-asparagine agar (ISP5 medium)[3] and the incubation time of the pure culture was 3—4 weeks. Morphological observation was made by using optical and electronic microscopy (Model EPMA-8705). Cultural and physiological characteristics were determined according to the methods proposed by Shirling & Gottlieb (1966)[3] and Williams et al.[4]. Color determinations were made by comparing the cultures with color chips from the ISCC-NBS COLOR CHARTS Standard Samples No. 2106 (Kelly, 1964)[5].

1.3 Chemotaxonomy Cell wall was purified and analyzed by the methods of Lechevalier & Lechevalier[6]. The procedures of Becker et al.[7] and Lechevalier & Lechevalier[6] were used for analyses of whole-cell chemical compositions.

1.4 16S rDNA sequencing The chromosomal DNA of these strains was isolated according to the procedure described by Hopwood et al.[8]. 16S rDNA was amplified by PCR using a PCR kit (Sino-American Biotechnology Co., Beijing), primer A8-27f (5′- AGAGTTTGATCCTGGCTCAG - 3′), and primer B 1 523—1 504 r(5′- TTAAGGAGGTGATCCAGCCGCA - 3′). The conditions used for thermal cycling were as the follows: denaturation at 95 ℃ for 5 min followed by 35 cycles consisting of denaturation at 95 ℃ for 1 min, primer annealing at 56 ℃ for 1 min, and primer extention at 72 ℃ for 3 min. At the end of the cycles, the reaction mixture was kept at 72 ℃ for 5 min and then cooled to 4 ℃. The 1.5 kb amplified 16S ribosomal DNA (rDNA) fragment was separated by agarose gel electrophoresis. The purified fragment was directly sequenced by using a *Taq* DyeDeoxy terminator Cycle Sequencing Kit (Applied Biosystems, Foster City, California), and analyzed with an ABI PRISMTM 377 DNA sequencer (Applied Biosystems, Inc.). Sequencing primers used included KMS098PB1r (5′- TAAGGAGGTGATCCAGCC - 3′), KMS098PDr (5′- GGGTTGCGCTCGTTG- 3′) and KMS098PCr (5′ - TCTGCGCATTTCACCGCTAC - 3′).

1.5 Sequence alignment and phylogenetic analysis The almost 16S rDNA full sequences of these extremophilic actinomycetes were aligned with representative sequences of related type strains from the GenBank database. The evolutionary tree, rooted with *Streptomyces megasporus* or other species as the out group, was inferred by using the neighbor-joining method[9] form the evolutionary distance data corrected by Kimura's 2 parameter model[10]. The topology of resultant tree was evaluated by bootstrap analysis[11] of the neighbor-joining method based on 1 000 resamplings. The ClustalX program[12] was used for multiple alignment and phylogenetic analysis. TreeView program[13] was used to display and edit phylogenetic trees.

2 Results and discussion

2.1 Growth of halophilic and halo-tolerant strains at different NaCl concentration and pH More than 200 halophilic or halo-tolerant actinomycetestrains were isolated from the samples collected from Xinjiang and Qinghai by using plate-dilution methods. NaCl concentration and pH range for growth of 40 strains is shown in Tab. 1. For most strains, NaCl concentration for growth was 0—20 %, and pH for growth was pH 6—10. 32 strains isolated from Qinghai were primarily identified by morphology and chemistry. The results show that 30 strains of them belong to *Nocardiopsis*, and the other two strains are *Streptomyces*. 8 strains isolated from Xinjiang have been identified using polyphasic taxonomic methods, and they belong to genus *Prauserella*, *Streptomonospora*, *Nocardiopsis* and *Saccharomonospora* respectively. We are surprised that 6 strains of the 8 strains are new genus or new species (Fig. 1).

Tab. 1 NaCl concentration and pH range for growth of 32 strains

Strains	Habitats	Amino acids of cell wall	Genus	NaCl concentration for growth/ %	pH for growth
YIM 90001	Xinjiang	*meso*-DAP	*Prauserella*	3 —20	6.0 —10.0
YIM 90002	Xinjiang	*meso*-DAP	*Streptomonospora*	5 —20	6.0 —10.0
YIM 90003	Xinjiang	*meso*-DAP	*Streptomonospora*	1 —20	6.0 —10.0
YIM 90004	Xinjiang	*meso*-DAP	*Nocardiopsis*	3 —20	6.0 —10.0
YIM 90005	Xinjiang	*meso*-DAP	*Prauserella*	0 —20	6.0 —10.0
YIM 90006	Xinjiang	*meso*-DAP	*Nocardiopsis*	3 —20	6.0 —10.0
YIM 90007	Xinjiang	*meso*-DAP, LL-DAP	*Saccharomonospora*	5 —20	6.0 —10.0
YIM 90010	Xinjiang	*meso*-DAP	*Nocardiopsis*	3 —20	6.0 —10.0
YIM 90012	Qinghai	*meso*-DAP	Nocardiopsis	0 —20	6.0 —10.0
YIM 90013	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90014	Qinghai	*meso*-DAP	*Nocardiopsis*	1 —20	6.0 —10.0
YIM 90015	Qinghai	*meso*-DAP	*Nocardiopsis*	3 —20	6.0 —10.0
YIM 90016	Qinghai	*meso*-DAP	*Nocardiopsis*	3 —20	6.0 —10.0
YIM 90017	Qinghai	LL-DAP	*Streptomyces*	0 —15	6.0 —10.0
YIM 90018	Qinghai	LL-DAP	*Streptomyces*	0 —15	6.0 —10.0
YIM 90021	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90022	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90023	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90024	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90025	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90026	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90027	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90028	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90029	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90030	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90031	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90032	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90033	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90034	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90035	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90036	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90037	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90038	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90039	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90040	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90041	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90042	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90043	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90044	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0
YIM 90045	Qinghai	*meso*-DAP	*Nocardiopsis*	0 —20	6.0 —10.0

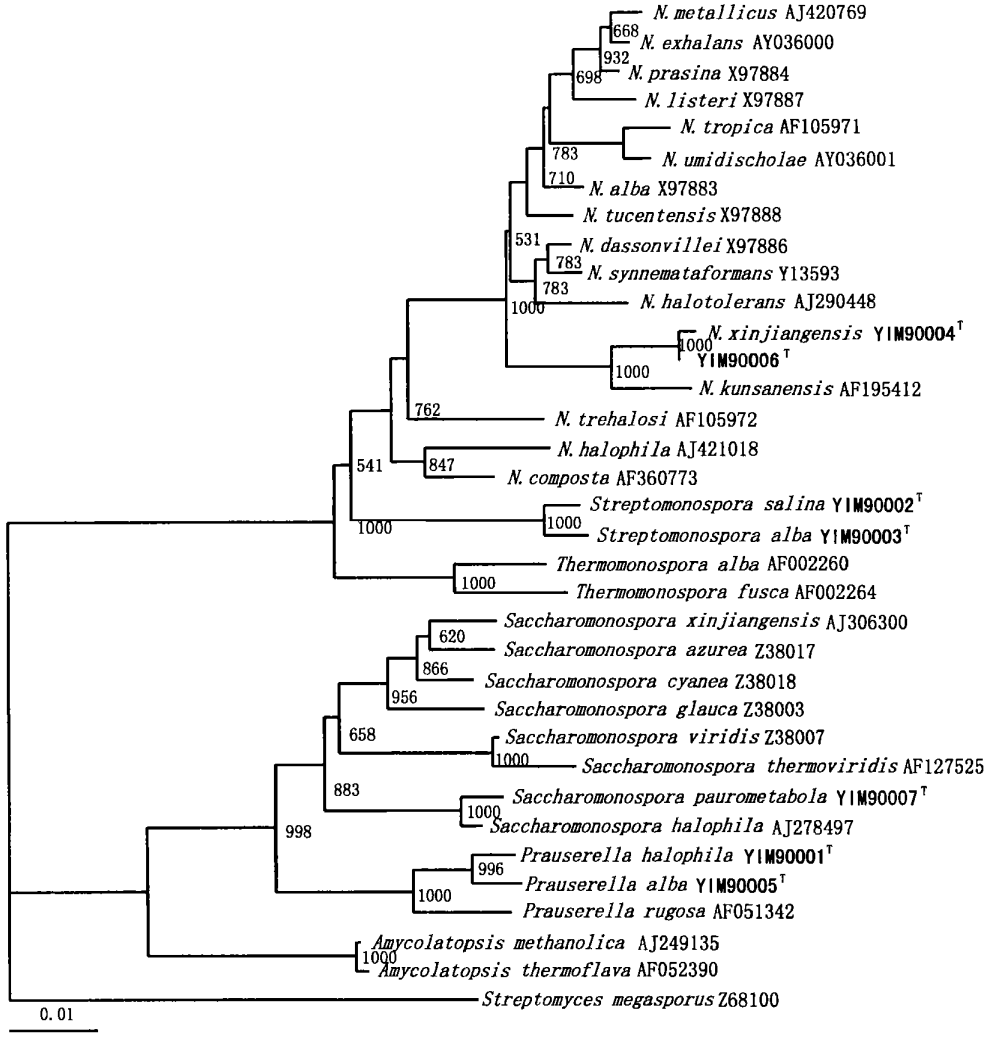

Fig. 1 Phylogenetic tree showing the relationships among halophilic actinomycete strains isolated fropm Xinjiang and Qinghai Provinces and relative species and other taxa downloaded from GenBank etc. based on 16S rDNA sequences. Numbers on branch nodes are bootstrap values (1 000 resamplings). The sequence of Streptomyces megasporus **was used as outgroup. Bar, 0.1 substitutions per nucleotide. N.** = Nocardiopsis**)**

More than 20 strains of halophilic or halo-tolerant actinobacteria were isolated. 15 strains of them were identified by using polyphasic taxonomic procedures. A new family, *Yaniaceae*, a new genus, *Yania* and species were discovered (Fig. 2).

2.2 Growth of alkalophilic or alkaline-tolerant strains at different pH 234 alkalophilic or alkaline-tolerant actinomycete strains were isolated from the soil samples collected from Xinjiang and Qinghai. Growth pH of 16 selected strains of them show in Tab. 2. 14 strains of the 16 grow well at pH 8.5—13, and belong to alkalophilic actinomycetes. Rest two strains can grow at pH 7.0. 12 strains of the 16 were identified by using polyphasic taxonomic procedures. Four new species of them were discovered. They are *Nocardiopsis lipasogena* sp. nov YIM80028^T, *Nocardiopsis oligotyphica* sp. nov YIM80034^T, *Nocardiopsis jiangbeiensis* sp. nov YIM80041^T and *Nocardiopsis frigoritoleransis* sp. nov YIM80045^T (Fig. 3).

In addition, we discovered another new species, *Streptomyces beijiangensis* sp. nov.[16] which grow well at 4—8 ℃. These new species has been published in Int. J. Syst. Evol. Microbiol. We believe based on the research results that there are a very high density of new or unknown actinomycetes un-

der extreme environments from Xinjiang and Qinghai Provinces, China.

Tab. 2 Optimum growth pH of alkaliphlic actinomycete isolates from Xinjiang

Strain	pH 7.0	pH 8.5	pH 9.5	pH 11.5	pH 13
80024	-	+ +	+ + +	+ + +	+ + +
80026	-	+ +	+ + +	+ + +	+ + +
80027	-	+ + +	+ + +	+ + +	+ + +
80028	+ + +	+ + +	+ + +	+ +	+-
80029	-	+ + +	+ + +	+ +	+ + +
80031	-	+ + +	+ + +	+ + +	+ +
80032	-	+ + +	+ + +	+ + +	+ +
80033	+ + +	+ + +	+ + +	+ +	+-
80034	-	+ + +	+ + +	+ +	+-
80035	-	+ + +	+ + +	+ +	+ +
80041	-	+ + +	+ + +	+ +	+ +
80045	-	+ + +	+ + +	+ +	+ +
80046	-	+ + +	+ + +	+ +	+ +
80048	-	+ + +	+ + +	+-	+ +
80049	-	+ + +	+ + +	+ + +	+ + +
80050	-	+ +	+ + +	+ + +	+ +

-:no growth; + :weak growth; + + :moderate growth; + + + good growth

We think based on these results that actinomycetes under extreme environments are an important source for bioactive metabolites. Now, we have isolated many other halophilic, alkalophilic and psychrophilic actinomyces from newly collected soil samples from Xinjiang and Qinghai for discovering other new and unknown actinomycetes and new compounds. By the line of new species, new genes, new products and new use, we are doing isolation and structure analysis of natural products produced by the new strains, and screening of useful genes for developing new leader compounds.

Description of all of these new family, genera and species is following as

Descroption of Yaniaceae **fam. nov.**

Yaniaceae (Yan. ia' ce. ae. M. L. fem. n. *Yania* type genus of the family; - *aceae* ending to denote a family; M. L. fem. pl. n. *Yaniaceae* the *Yaniaceae* family).

Description of Yania **gen. nov.**

Yania (Yan' ia. M. L. fem. n Yan named after Sun-Chu Yan, a Chinese microbiologist who made many contributions to actinomycete research work). Cells are non-motile, aerobic, Gram-positive, non-spore-forming cocci or oval and occurred singly or in clusters, about 0.4—0.6 μm in diameter. Oxidase-

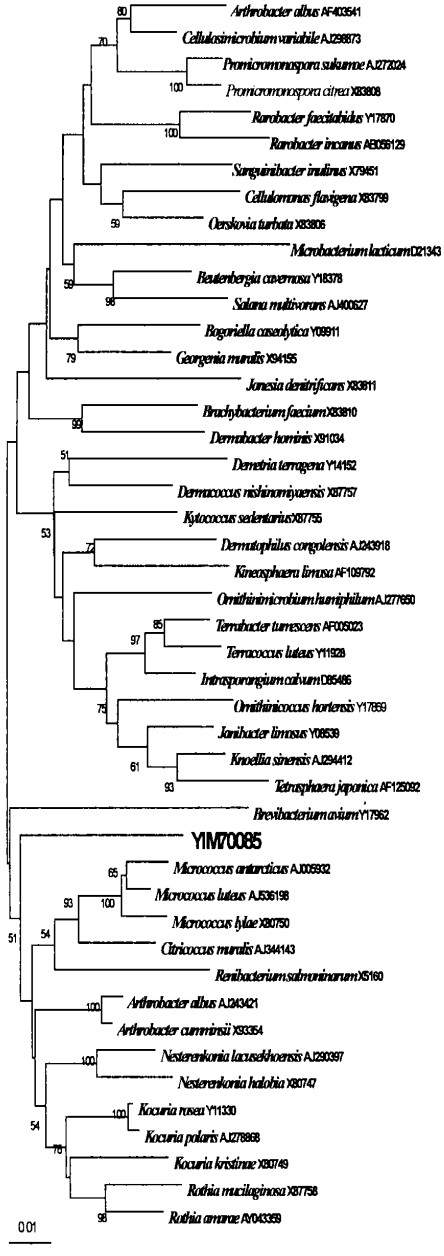

Fig. 2 Neighbour-joining tree showing the phylogenetic relationships among some alkalophilic actinobacteria strain YIM70085 and related type strains based on 16S rRNA gene

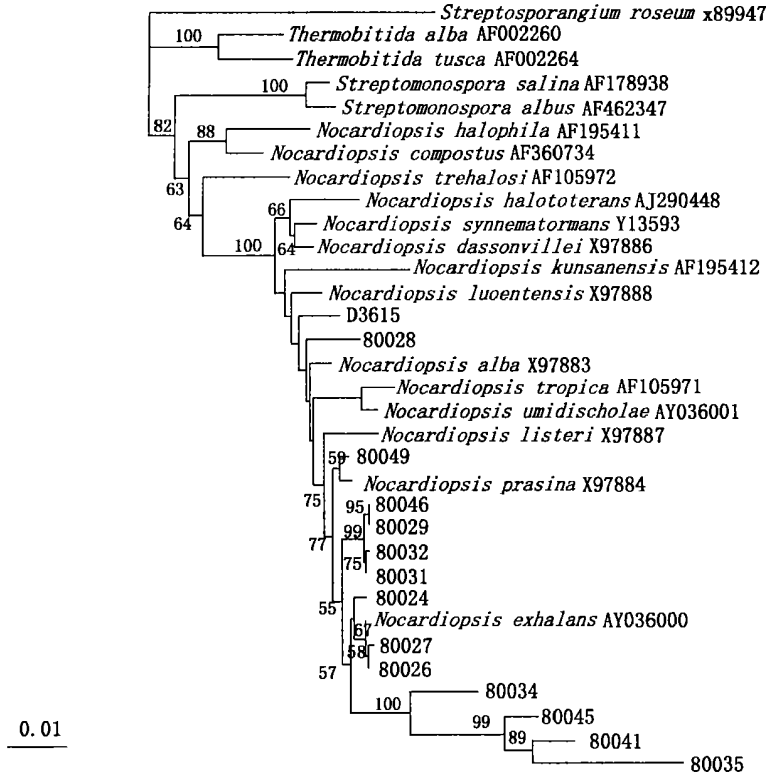

Fig. 3 Neighbour-joining tree showing the phylogenetic relationships among some alkalophilic actinomycete isolates and related type strains based on 16S rRNA gene sequences

negative and catalase-positive. The only and type species is *Yania halotolerans*.

Description of Yania halotolerans **sp. nov.**

Yania halotolerans (ha. lo. to'le. rans. Gr. n. *hals* salt; L. part. *tolerans* tolerating; N. L. pres. part. *halotolerans* referring to the ability to tolerate high salt concentrations). Cells are non-motile, aerobic, Gram-positive, non-spore-forming cocci or oval and occurred singly or in clusters, about 0.4—0.6 μm in diameter. Oxidase-negative and catalase-positive. Good growth occurs on Potato agar, Nutrient agar and modified Glycerol-Asparagine agar (ISP5) media. Poor growth on Yeast-Malt extract agar (ISP2) and no growth on Czapek agar, Oat meal agar (ISP3) and Inorganic-starch agar (ISP4) media. No soluble pigments are formed on all test media. The temperature range for growth is 10—40 ℃ with the optimum temperature of 28—30 ℃. Growth pH optimally between 7.0—8.0. The growth concentration range of NaCl, KCl, $MgCl_2 \cdot 6H_2O$ is 0—25 %, 0—20 %, 0—15 %, respectively. It is positive only for milk peptonization and urease, but negative for milk coagulation and nitrate reduction, gelatin liquefaction, growth in cellulose, H_2S and melanin production. Starch, Tween 20, Tween 40 and Tween 80 are not hydrolysed. Cells don't form indole, Methyl-red-negative and Voges-Proskauer-negative. Most of the range of carbon utilization could not be determined because of negative reactions caused by extremely poor growth in basal media except with sucrose and maltose. Isolated from a saline soil collected from Xinjiang Province, in the west of China. Type strain YIM70085^T, deposited in the Chinese Center of Type Culture Collection as strain CCTCC AA001023^T.

Description of Streptomonospora **gen. nov.**

Streptomonospora (Strep. to. mo. no. spo'ra Gr. adj. *streptos* pliant, bent; Gr. adj. *monos* single, solitary; Gr. fem. n. *spora*, a seed, sore; M. L. fem. n. *Streptomonospora* indicating that this organism

forms two type of spores, with wrinkled surfaces, on aerial mycelium and substrate mycelium). Gram-positive, aerobic organisms with branching hyphae. Non-fragmenting substrate mycelium present. The aerial mycelium, at maturity, forms short chains of non-motile spores; spores in short chains are oval-to rod-shaped with wrinkled surfaces. Substrate mycelium is extensively branched with non-fragmenting hyphae. Single, non-motile, oval to round spores are born on sporophores or dichotomously branched sporophores of substrate hyphae. Peptidoglycan contains *meso*-diaminopimelic acid as diagnostic diamino acid. Cell walls contain galactose or galactose plus arabinose. The phospholipid pattern is complex, consisting of phosphatidylglycerol, phosphatidylethanolamine, phosphatidylcholine and phosphatidylinositol; diphosphatidylglycerol, methylphosphatidylethanolamine, and phosphatidylserine may occur. The menaquinone composition may depend upon the growth medium and consists mainly of menaquinones with nine or ten isoprenoid chains and a varying degree of hydrogenation: i. e. a combination of one or more representative(s) of the series [MK-9 (H_2), (H4), (H6), (H8)] plus [MK-10 (H_2), (H4), (H6), (H8)]. The DNA base composition ranges from 69 to 71 mol % G + C (HPLC). Phylogentically a neighbour of *Nocardiopsis*, *Thermobifida* and *Actinomadura*. The type species is *Streptomonospora salina* (YIM90002^T).

Description of Streptomonospora salina **sp. nov.**[14]

Streptomonospora salina (sa. li'na. L. adj. *salina*, salted, saline). Aerial mycelium is well developed but not fragmented. Colonies are white on most media. Two-type spores with wrinkly surfaces are borne on aerial mycelium and substrate mycelium respectively. No diffusible pigmentis produced, but melanin is produced. *Streptomonospora salina* utilizes glucose, sucrose, maltose, arabinose, raffinose, starch, glycerol, mannitol and histidine. It is positive for starch hydrolysis, malanin production and negative for milk coagulation, milk peptonization, growth in cellulose, H_2S production and gelation liquefaction. Optimum growth occurs in media supplemented with salt at concentration of 15 % (*w*/v) at 28 ℃ and pH 7.0. Isolated from hypersaline habitats (a salt lake in China). The type strain is strain YIM90002^T (= CCTCC 99003^T = CCRC 16284^T).

Description of Streptomonospora alba **sp. nov.**

Streptomonospora alba ('al. ba. L. adj. *alba*, white color). Aerial mycelium and substrate mycelium are well developed but not fragmented on most media. The white aerial mycelium formed short chains of spores at maturity, which are straight to flexuous, spores are oval-to cylindrical-shaped (0.4—0.7 μm × 0.8—1.6 μm) with wrinkled surfaces and they are non-motile. Single round to oval spores are born on substrate mycelium. Grows well on most test media but no diffusible pigment is produced. Color of the substrate mycelium was white (ISP 4, ISP 5, Czapek's agar), gray white (ISP 3), moderate orange yellow (ISP 2), deep orange yellow (potato agar) or brilliant orange yellow (nutrient agar). The diagnostic diamino acid of peptidoglycan is *meso*-diaminopimelic acid while galactose and arabinose are cell wall sugars. The predominant menaquinone is MK-9 (H4) (glucose-yeast extract grown cells), while MK-10 (H_2), MK-9 (H_8) and MK-10 (H_4) are found in vitamin-enriched ISP2 medium. Major phospholipids are phosphatidylglycerol, phosphatidylethanolamine, phosphatidylinositol, diphosphatidylglycerol, methylphosphatidylethanolamine, phosphatidylserine, phosphatidylcholine and an unidentified phospholipid. Catalase positive, oxidase negative. Growth in medium supplemented with NaCl between 5 % and 25 % (w/v), optimum growth between 10 %—15 % NaCl (w/v) at 28 ℃ and pH 7.0. Nitrate reduction positive, starch hydrolysis and production of melanin negative. The range of carbon utilization could not be determined because of negative reactions caused by extremely poor growth in basal media. The G + C content of DNA is 74.4 mol % (HPLC). Isolated from soil in hypersaline habitats, Xinjiang Province, western China. The type strain is strain YIM90003^T, deposited in the Chinese Center of

Type Culture Collection as strain CCTCC AA001013^T (= DSM 44588^T) .

Description of Prauserella halophila **sp. nov.**

Prauserella halophila (ha. lo. phi 'la , M. L. adj. *halophila* salt-loving , referring to the ability to grow at high NaCl conecntration) . Gram-positive and aerobic. The substrate mycelia are fragmented and the aerial mycelia are well developed on most test media. The aerial mycelia formed long spore chains with branched short or long spore chains at maturity , which are straight to flexuous and spores are non-motile. No diffusible pigment is produced. The range of carbon and nitrogen utilization of strain YIM90001^T is wide. It is positive for milk peptonization , gelatin liquefaction and urease production , but negative for nitrate reduction , milk coagulation , growth in cellulose , H_2S and melanin production and starch hydrolysis. The cell walls of strain YIM90001^T contain *meso*-DAP and trace amounts of LL-DAP. The whole-cell hydrolysates mainly contain galactose , xylose and arabinose. The G + C contents of DNA of strain YIM90001^T is 65. 8 mol %. Optimum growth occurs on Czapek medium supplemented with salt at a concentration of 10 % —15 % (w/ v) at 28 ℃ and pH 7. 0. It was isolated from soil in hypersaline habitats , in the west of China. The type strain is strain YIM90001^T , deposited in the Chinese Center of Type Culture Collection as strain CCTCC AA001015^T (= DSM44617^T) .

Description of Nocardiopsis xinjiangensis **sp nov.** [15]

Nocardiopsis xinjiangensis sp nov. (Xinjiang en. sis M. L adj *Xinjiangensis* pertaining to Xinjiang , a province of west China where the samples were collected) . On most tested medium the fragmented substrate and aerial mycelia are well developed. Short spore chains were born on the aerial mycelium are composed of rod-shaped spores with smooth surface. No diffusible pigment. Whole-cell hydrolysates contain the cell wall diamino acid , *meso*-DAP and the whole-cell sugars including glucose , ribose , xylose , arabinose and galactose. The predominant menaquinones are MK-10 (H_2 , H_4) and the diagnostic phospholipids are phosphatidylglycerol and phosphatidylinostole. Utilizes cellobiose , galactose , alanine , proline and serine but not glucose , xylose , maltose , mannitol , raffinose , rhamnose , sucrose. Gelatin liquefaction , urease activity and melanin production are positive. Milk coagulation , milk peptonization , starch hydrolysis , nitrate reduction and H_2S production are negative. Its optimal growth temperature is 28 ℃; optimal salt concentration for growth is 10 % and the optimal pH is 7. 2. The G + C content of DNA is 74. 3 mol %. The species was isolated from the saline habitats in the west of China. The type strain is YIM90004^T (= CCRC16285^T = CCTCC AA99004^T = DSM44589^T) .

Description of Prauserella alba **sp. nov.**

Prauserella alba ('al. ba. L. adj. *alba* , white color) . The substrate mycelia are fragmented and the aerial mycelia are well developed on Czapek media. The aerial mycelia formed long spore chains with branched short or long spore chains at maturity , which were straight to flexuous and spores were non-motile. No diffusible pigment is produced. It can utilize almost all test carbon and nitrogen sources. It is positive only for milk peptonization , gelatin liquefaction , but negative for nitrate reduction , milk coagulation , growth in cellulose , H_2S and melanin production , starch hydrolysis and urease production. The cell walls of strain YIM90005^T contain *meso*-DAP and trace amounts of LL-DAP and DD-DAP. The whole-cell hydrolysates mainly contain galactose , xylose and arabinose and Madurose. The predominant menaquinones of strain YIM90005T are MK-9 (H_2) , MK-10 (H_2) , MK-9 (H_6) , MK-8 (H_6) and MK-9 (H_4) and the diagnostic phospholipids are phosphatidylethanolamine , phosphatidylcholine. The G + C contents of strain YIM90005^T is 66. 7 mol %. Optimum growth occurs in Czapek media supplemented with salt at a concentration of 10 % (*w/ v*) at 28 ℃ and pH 7. 0. It was isolated from soil in hypersaline habitats , in the west of China. The type strain is strain YIM90005^T , deposited in the Chinese Center of Type Culture Collection as strain CCTCC AA001016^T (= DSM44590^T) .

Saccharomonospora paurometabola **sp. nov.**

Saccharomonospora paurometabola sp. nov. (pau. ro. me. ta. bo'la Gr. adj, *paurus* little; Gr. adj. *metabolus* changeable; M. L. fem. adj. *paurometabola* little changeable, referring to the poor utilization of carbon sources). Aerial mycelium well developed on Yeast-Malt extract agar (ISP 2), Glycerol-Asparagine agar (ISP 5), Nutrient agar and Czapek's agar; moderate on Oatmeal agar (ISP 3) and poor on inorganic salt-starch agar (ISP 4), and Potato agar. White aerial mycelium on all media, except for a green-yellow mycelium on Nutrient agar. Sporulation is good on media ISP2, ISP5, Nutrient agar and Czapek's agar; moderate on ISP3 and poor on ISP4. The substrate mycelium is well developed on most test media. The color is deep orange-yellow (ISP2), light yellow-brown (nutrient agar), light yellow orange (Potato agar), or white (ISP4, ISP5, Czapek's agar), Non-motile single spores with smooth or wrinkled surface born on aerial mycelium, some single spores born on substrate mycelium. The optimum growth temperature is between 35 ℃ and 37 ℃. The optimum growth concentration of NaCl is 10 %. The cell wall of strain YIM90007^T contains *meso*-diaminopimelic acid. Whole-cell hydrolysates mainly contain galactose, arabinose and ribose. The only menaquinones are MK-9(H_2) (10 %) and MK-9(H_4) (90 %), and the phospholipids are phosphatidylinositol, phosphatidylglycerol, diphosphatidylglycerol, phosphatidylethanolamine and hydroxyphosphatidyl ethanolamine. The predominant cellular fatty acids are C16 : 0 (20. 7 %), iso-C16 : 0 (11. 2 %), cyclo17 : 0 and C18 : 1cis9 (13. 3 %); smaller amounts (> 1 %) are iso-C15 : 0 (1. 0 %), iso-C16 : 1 (1. 1 %), iso-C17 : 0 (1. 2 %), iso-C17 : 1 (1. 4 %), anteiso-C17 : 0 (3. 1 %), C16 : 1 (4. 4 %), C18 : 0 (3. 0 %), C18 : 1cis (31. 0 %), 2-hydroxy-anteiso-C15 : 0 (4. 8 %), and 2-hydroxy-iso-C16 : 0 (1. 7 %). The DNA G + C content is 71 mol %. Isolated from saline soil collected from Xinjiang Province, in the west of China. Type strain YIM90007^T (= CCTCC AA001018^T = CCRC16315^T = DSM 44619^T).

Description of Streptomyces beijiangensis **sp. nov.** [16]

Streptomyces beijiangensis (bei. jiang. en'sis. N. L. adj. *Beijiangensis* pertaining to beijiang, a place in Xinjiang province in western China). Aerial mycelium and substrate mycelium are well developed. Aerial mycelium at maturity forms long chains of spores that are straight to flexuous or occasionally Retinaculiaperti and are non-motile. Good growth on most media. Optimum growth temperature is between 8 and 20 ℃. Diffusible pigment is not produced. The color of colonies is medium-dependent. Glucose, galactose and glycerol are utilized and lactose, mannose, inulin, acetate and oxalate are not utilized. Nitrate reduction and urease are positive reaction. Diagnostic amino acid of peptidoglycan is L-D2pm. Whole-cell hydrolysates contain glucose and small quantities of xylose, galacotse and arabinose. The predominant menaquinones are MK-9(H_6) and MK-9(H_8) and phosphatidylethanolamine is the diagnostic phospholipid. Predominant cellular fatty acids are 15 : 0 anteiso, 16 : 0 iso and 17 : 0 cyclo. The strain was isolated from soil collected from Beijiang, western China. The type strain is strain YIM6^T (= CCTCC 99005^T = AS 4. 171 8^T = DSM 41794^T).

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新疆青海极端环境发现大量未知放线菌*

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摘要: 从新疆、青海的重盐碱地区、盐湖采集样品, 分离其中的嗜盐、嗜碱及低温放线菌. 研究了它们在几种盐的不同浓度, 不同 pH 条件下的生长情况. 利用多相分类程序进行鉴定, 发现嗜盐放线菌、放线细菌的新科 1 个(*Yaniaceae*), 新属 2 个(*Yania* and *Streptomonospora*), 新种 8 个, 嗜碱放线菌新种 4 个, 低温放线菌新种 1 个. 对其中部分新种、新属做了描述. 认为新疆、青海的重盐碱地区蕴藏着大量的未知放线菌资源; 新菌种必然有新基因, 新产物, 新活性和新用途, 是药物开发的重要来源.

关键词: 极端环境; 放线菌; 放线细菌

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