Nocardia inohanensis sp. nov., *Nocardia yamanashiensis* sp. nov. and *Nocardia niigatensis* sp. nov., isolated from clinical specimens

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Comparative 16S rDNA studies on six strains of actinomycete isolated from clinical specimens revealed that they belong to the genus *Nocardia* and are closely related to *Nocardia seriolae*, *Nocardia otitidiscaviarum*, *Nocardia uniformis*, *Nocardia pseudobrasiliensis* and *Nocardia crassostreae*. However, the novel organisms consistently formed a clade distinct from that of the five latter species. Determination of DNA–DNA relatedness indicated that these strains could be classified under three novel species. Based on their phenotypic and phylogenetic characters, three novel species of the genus *Nocardia* are established: *Nocardia inohanensis* sp. nov. for IFM 0092^T (=NBRC 100128^T=JCM 11891^T=DSM 44667^T), *Nocardia yamanashiensis* sp. nov. for IFM 0265^T (=NBRC 100130^T=JCM 11893^T=DSM 44669^T) and *Nocardia niigatensis* sp. nov. for IFM 0330^T (=NBRC 100131^T=JCM 11894^T=DSM 44670^T), IFM 0260, IFM 0636 and IFM 0833.

The genus *Nocardia* was proposed by Trevisan (1889) with the type species *Nocardia asteroides*. Many taxonomic studies (e.g. Schaal & Reuterberg, 1978; Orchard & Goodfellow, 1980) have reported that clinical isolates of *N. asteroides* are taxonomically heterogeneous. Clinical efforts to define specific subgroups of the species have been frustrated by the absence of readily available and reproducible testing methods (Wallace *et al.*, 1995). Identification of subgroups of *N. asteroides* using phenotypic characters is largely unsuccessful when applied in the clinical laboratory. Many taxonomically ambiguous strains of *Nocardia* from clinical samples have been classified as *N. asteroides*. Recently, an identification method using drug susceptibility patterns was reported (Kiska *et al.*, 2002; Roth *et al.*, 2003). Identification with phylogenetic characters alone causes taxonomic confusion, but these simple methods are readily available.

Six strains from clinical specimens were initially identified as *N. asteroides* in our laboratory; however, the strains were found to have distinctive characters such as the ability to degrade hypoxanthine. Based on phylogenetic criteria, the

taxonomic position of these strains was determined and this revealed that these organisms consistently formed a distinct clade that was closely affiliated with *Nocardia seriolae*, *Nocardia otitidiscaviarum*, *Nocardia uniformis*, *Nocardia pseudobrasiliensis* and *Nocardia crassostreae*. From phenotypic and phylogenetic characters, coupled with data from genomic DNA–DNA relatedness levels, we propose the inclusion of these strains within the three novel species *Nocardia inohanensis* sp. nov., *Nocardia yamanashiensis* sp. nov. and *Nocardia niigatensis* sp. nov.

Strains IFM 0260, IFM 0265^T, IFM 330^T, IFM 0636 and IFM 0833 were isolated from skin abscesses from Japanese patients. Strain IFM 0260 was isolated in 1986 from a 63-year-old male treated with corticosteroids, strain IFM 0265^T was isolated in 1987 from a 30-year-old female patient, strain IFM 330^T was isolated in 1990 from a 30-year-old male with systemic lupus erythematoses treated with corticosteroids, strain IFM 0636 was isolated in 1996 from a 53-year-old male with systemic lupus erythematoses treated with corticosteroids and strain IFM 0833 was isolated in 1998 from a 68-year-old male. Strain IFM 0092^T was an isolate that has been kept in our laboratory since 1965 (originally isolated from a patient in Mexico by Ochoa Ochoa).

Strains IFM 0092^T, IFM 260, IFM 0265^T, IFM 330^T, IFM 0636, IFM 0833, *N. seriolae* IFM 0286^T, *N. uniformis* IFM 0856^T and *N. otitidiscaviarum* IFM 0239^T were cultured on Muller–Hinton II (MH; Difco) slants with 1 % glucose and

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Abbreviation: MH, Mueller–Hinton II.

The DDBJ accession numbers for the 16S rDNA sequences of *N. inohanensis* IFM 0092^T, *N. yamanashiensis* IFM 0265^T and *N. niigatensis* IFM 0260, 0330^T, 0636 and 0833 are respectively AB092560–AB092565.

1 % glycerol for 1 week at 30 °C (25 °C for *N. seriolae*). Strains IFM 0092^T, IFM 260, IFM 0265^T, IFM 330^T, IFM 0636 and IFM 0833 were cultured on MH plates with 1 % glucose and 1 % glycerol for 1 week at 30 °C for colonization. The isolated strains were cultured on brain heart infusion (BHI; Difco) broth with 0.1 % glucose and 0.1 % glycerol for 5 days at 30 °C for DNA sequencing and on BHI broth with 2 % glucose and 2 % glycine for 3 days at 30 °C (25 °C for *N. seriolae*) for DNA–DNA hybridization. Morphological observations under a scanning electron microscope (model S-5200; Hitachi) were made on cultures grown on MH agar with 0.2 % glucose or humic acid/MOPS/gellan gum (HMG) medium (Suzuki *et al.*, 2000) at 30 °C for 7–10 days. For scanning electron microscopy, cultures were fixed in 2 % osmium tetroxide vapour *in situ* at 25 °C for 24 h, dehydrated with ethanol and t-butanol and then freeze-dried. Each specimen was coated with osmium using an Osmium Plasma Coater OPC 80N (NLE Nippon Laser & Electronics Lab).

Decomposition of adenine, casein, hypoxanthine, tyrosine, urea and xanthine and survival at 50 °C for 8 h were examined by using the methods of Gordon *et al.* (1974). Acid production from adonitol, arabinose, erythritol, galactose, glucose, inositol, maltose, mannose, rhamnose and sorbitol, utilization of citrate and gluconate and growth at 37 and 45 °C were determined by the modified method of Poonwan *et al.* (1995). Isolated strains were tested for their ability to grow in MH agar with 0.2 % glucose with each antibiotic TRIDISK (Eiken) at 32 °C for 2 or 3 days (Mikami & Yazawa, 1989).

Whole-cell hydrolysates were analysed for diaminopimelic acid (DAP) isomers using TLC (Staneck & Roberts, 1974). Whole-cell sugars were prepared as reported elsewhere (Lechevalier & Lechevalier, 1980) and analysed by TLC (Miyadoh, 2001). Mycolic acids were prepared as reported by Minnikin *et al.* (1980). Menaquinones were extracted from freeze-dried biomass (500 mg) and analysed as described by Chun & Goodfellow (1995).

A 1 ml aliquot of *Nocardia* broth culture was centrifuged at 12 000 r.p.m. for 10 min. The pellet was resuspended in 200 µl TE buffer, 250 µl GPT reagent (6 M guanidine thiocyanate dissolved in 50 mM Tris/HCl, pH 8.3) and 450 µl Tris-buffered phenol (pH 8.0). The tube was placed in a boiling water bath for 15 min and extracted with 250 µl chloroform/isoamyl alcohol (24:1, v/v). After 10 min centrifugation at 12 000 r.p.m., the aqueous phase (~500 µl) was transferred to a fresh tube. The aqueous phase was mixed with 500 µl 100 % isopropanol and 50 µl 3 M sodium acetate and microcentrifuged at 12 000 r.p.m. for 15 min at 4 °C before the supernatant was decanted. Traces of GPT reagent were removed by addition of 500 µl ice-cold 70 % ethanol to the nucleic acid pellet and samples were centrifuged at 12 000 r.p.m. for 5 min at 4 °C. The ethanol was then removed and the pellet dried under a vacuum for 20 min. The pellet was finally resuspended in 50 µl TE.

A nearly complete 16S rRNA gene sequence was determined for each isolated strain. The 16S rDNA was amplified by PCR and sequenced using the prokaryotic 16S rDNA universal primers 8F (5'-AGAGTTTGATCCTGGCTCAG-3') and 691R (5'-ACCGCTACACCAGGA-3'), 520F (5'-CAGCAGCCGCGGTAATAC-3') and 1100R (5'-GG-GTTGCGCTGTTG-3') and 926F (5'-AAACTCAAAGGA-ATTGACGG-3') and 1542R (5'-ACAAAGGAGGTGATC-3') in three separate reactions. PCR was performed with a DNA thermal cycler (TaKaRa) using 35 cycles of denaturation at 94 °C for 60 s, primer annealing at 60 °C for 60 s and primer extension at 72 °C for 120 s. PCR products were purified with Centri-Sep columns (Princeton Separations). DNA sequences were determined with an automatic sequence analyser (ABI PRISM 3100; PE Applied Biosystems) using a dye terminator cycle-sequencing kit (PE Applied Biosystems).

Species related to the novel isolates were identified by performing a sequence database search using BLAST. Sequence data for related species were retrieved from GenBank. Nucleotide substitution rates (K_{nuc} values) were calculated (Kimura & Ohta, 1972) and phylogenetic trees were constructed by the neighbour-joining method (Saitou & Nei, 1987). The statistical significance of the tree topology was evaluated by a bootstrap analysis of the sequence data with CLUSTAL W software (Thompson *et al.*, 1994). The DNAML program in the PHYLIP package version 3.5c (Felsenstein, 1985) was used for maximum-likelihood analysis, with the default transition/transversion ratio of 2.000000. Sequence similarity values were determined by visual comparison and manual calculation.

For DNA base composition analysis and DNA–DNA hybridization, DNA was isolated as described by Saito & Miura (1983) with modifications. DNA base compositions were estimated by HPLC (Tamaoka & Komagata, 1984) and levels of DNA–DNA relatedness were determined by the method of Ezaki *et al.* (1989) using photobiotin and a microplate format.

The morphological and chemotaxonomic characters of the six novel isolates are consistent with their assignment to the genus *Nocardia* (Goodfellow, 1998; Goodfellow *et al.*, 1999). All six isolates contained galactose and arabinose as characteristic whole-cell sugars in addition to meso-DAP as the predominant cell wall diamino acid. In addition, they all contained mycolic acids that co-migrated (R_f value of about 0.47) with those extracted from marker *Nocardia* strains. The major menaquinone of the six isolates was MK-8(H_{4ω-cycl}). 16S rDNA sequences were determined for all six strains, IFM 0092^T (1442 bp), IFM 0260 (1499 bp), IFM 0265^T (1414 bp), IFM 0330^T (1405 bp), IFM 0636 (1493 bp), IFM 0833 (1492 bp), and a database search demonstrated that the strains belong to the suborder *Corynebacterineae* and the family *Nocardiaceae* (Stackebrandt *et al.*, 1997).

The physiological properties of strains IFM 0092^T, IFM

Table 1. Phenotypic properties that distinguish the novel strains from type strains of *Nocardia* species

Strains: 1, *N. inohanensis* sp. nov. IFM 0092^T; 2, *N. yamanashiensis* sp. nov. IFM 0265^T; 3, *N. niigatensis* sp. nov. IFM 260, IFM 0330^T, IFM 0636 and IFM 0833; 4, *N. abscessus* DSM 44432^T; 5, *N. africana* DSM 44491; 6, *N. asteroides* ATCC 19247^T; 7, *N. brasiliensis* ATCC 19296^T; 8, *N. brevicatena* DSM 43024^T; 9, *N. beijingensis* JCM 10666^T; 10, *N. carnea* DSM 43397^T; 11, *N. cerradoensis* DSM 44546^T; 12, *N. crassostreae* ATCC 70418^T; 13, *N. cummidelens* DSM 44490; 14, *N. cyriacigeorgica* DSM 44484^T; 15, *N. farcinica* ATCC 3318^T; 16, *N. flavorosea* JCM 3224^T; 17, *N. fluminea* DSM 44488; 18, *N. ignorata* DSM 44496; 19, *N. nova* JCM 6044^T; 20, *N. otitidiscaviarum* NCTC 1934^T; 21, *N. paucivorans* DSM 44386^T; 22, *N. pseudobrasiliensis* ATCC 51512^T; 23, *N. salmonicida* JCM 4826^T; 24, *N. seriolae* JCM 3360^T; 25, *N. soli* DSM 44488^T; 26, *N. transvalensis* DSM 43405^T; 27, *N. uniformis* JCM 3224^T; 28, *N. vaccinii* DSM 43285^T; 29, *N. veterana* DSM 44445^T; 30, *N. vinacea* JCM 10302^T. Data were taken from Albuquerque de Barros *et al.* (2003), Gürtler *et al.* (2001), Hamid *et al.* (2001), Kinoshita *et al.* (2001), Maldonado *et al.* (2000), Yassin *et al.* (2000, 2001a, b), Wang *et al.* (2001) and this study. Characters are scored as: +, positive; –, negative; w, weak; (+), positive after 1 month; v, variable; ND, no data available.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Decomposition of:																														
Adenine	–	–	–	–	–	–	–	–	–	–	–	ND	–	–	–	–	–	ND	–	–	–	+	–	–	–	–	–	–	–	–
Casein	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–
Hypoxanthine	+	+	W	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	+	+	–	–	+
Tyrosine	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	+	–	–	–	+	–	–	–
Urea	+	+	V	ND	–	–	–	–	–	–	–	–	–	ND	–	+	–	ND	–	+	ND	+	–	–	–	+	+	–	ND	+
Xanthine	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–
Utilization of:																														
Adonitol	–	–	–	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arabinose	–	–	–	–	ND	–	–	ND	ND	ND	–	ND	ND	–	–	ND	ND	–	–	–	–	ND	–	ND	ND	–	ND	+	ND	ND
Erythritol	–	–	–	–	ND	–	–	ND	ND	ND	–	ND	ND	–	–	ND	ND	–	–	–	–	ND	–	ND	ND	+	ND	–	ND	ND
Galactose	–	–	–	–	ND	–	+	ND	ND	ND	–	ND	ND	–	–	ND	ND	–	+	–	–	ND	+	ND	ND	+	ND	+	ND	ND
Glucose	+	+	+	+	ND	+	+	ND	ND	ND	+	ND	ND	–	+	ND	ND	+	+	+	–	ND	+	ND	ND	+	ND	+	ND	ND
Inositol	+	+	V	–	ND	–	+	ND	ND	ND	–	ND	ND	–	–	ND	ND	–	–	+	–	ND	–	ND	ND	–	ND	–	ND	ND
Maltose	–	–	V	+	ND	–	+	ND	ND	ND	ND	ND	ND	–	+	ND	ND	+	–	–	–	ND	–	ND	ND	+	ND	–	ND	ND
Mannose	(+)	+	–	ND	ND	–	–	ND	ND	ND	+	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rhamnose	–	–	–	+	–	–	–	+	+	–	+	ND	–	–	+	–	+	–	–	–	–	–	–	–	+	+	–	+	+	–
Sorbitol	–	–	–	–	–	–	–	–	+	+	+	ND	–	ND	–	–	–	ND	+	–	–	+	+	–	–	+	–	–	ND	+
Citrate	+	+	–	+	–	+	+	–	+	–	–	–	–	–	–	–	+	–	–	–	–	+	+	+	–	–	–	–	–	ND
Gluconate	–	+	–	ND	ND	ND	ND	ND	ND	ND	–	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Growth at 37 °C	+	+	+	ND	+	+	+	+	ND	+	ND	–	ND	ND	+	+	ND	ND	+	+	ND	+	–	–	–	+	+	+	ND	+
Growth at 45 °C	–	–	–	–	+	–	+	–	–	–	–	–	–	ND	+	+	–	ND	–	+	ND	–	–	–	–	–	–	–	+	–
Susceptibility to:*																														
Imipenem ^a	+++	+++	–	+	+++	+++	–	ND	+++	+++	ND	ND	+++	+++	+++	ND	ND	ND	+++	–	+++	+++	+++	ND	+++	+++	ND	ND	+++	+++
Tobramycin ^a	+++	+	+++	+++	+	+++	+++	ND	+++	+++	ND	ND	+++	+++	–	ND	ND	ND	–	+	+++	+++	+++	ND	+++	–	ND	ND	–	+++
Kanamycin ^b	+++	+++	+++	++	+++	+	–	ND	+++	+++	ND	ND	–	–	–	ND	ND	ND	–	+++	+++	–	+	ND	–	–	ND	ND	++	–

*Scored as: *a*, growth at 10 (+++), 5 (++) or 2.5 (+) mg per disc or no growth with 2.5 mg per disc (–); *b*, growth at 30 (+++), 10 (++) or 5 (+) mg per disc or no growth with 5 mg per disc (–).

Fig. 1. Scanning electron micrographs of strain IFM 0092^T (a) grown on HMG agar and strains IFM 0265^T (b) and IFM 0330^T (c) grown on MH agar with 0.2% glucose at 30 °C for 7 days. Bars, 2 µm.

Fig. 2. Phylogenetic tree derived from 16S rDNA sequences created using the neighbour-joining method and K_{nuc} values. Numbers on the tree indicate bootstrap values for branch points; only values above 40% are indicated. The tree was unrooted and *Rhodococcus equi* was used as an outgroup.

0260, IFM 0265^T, IFM 0330^T, IFM 0636 and IFM 0833 are shown in Table 1. Susceptibility testing of clinical isolates of *Nocardia* to antimicrobials is useful in grouping organisms. Strains IFM 0260, IFM 0330^T, IFM 0636 and IFM 0833 were negative for imipenem, which is very characteristic. The six strains were found to have the ability to decompose hypoxanthine, which is also characteristic. Fig. 1 shows cells of strains IFM 0092^T, IFM 0265^T and IFM 0330^T under a scanning electron microscope.

It was clear from phylogenetic trees (Figs 2 and 3) that the six strains could be divided into two clusters. Strains IFM 0092^T and IFM 0265^T comprised one cluster and the remaining strains, IFM 0260, IFM 0330^T, IFM 0636 and IFM 0833, made another cluster. *Nocardia* sp. DSM 40872 and *Nocardia* sp. DSM 43399 are novel, unnamed strains of the genus *Nocardia* (Roth *et al.*, 2003). From a BLAST search, these novel strains were closely related to the six isolated strains. Sequence similarity among IFM 0260, IFM 0330^T, IFM 0636 and IFM 0833 was 99.6–99.9 %. This is very high, and is sufficient to indicate that these four strains belong to the same species. The sequence similarity between IFM 0092^T and IFM 0265^T was 99.0 % (14 base differences). The closest neighbour of IFM 0092^T amongst species with validly published names was *N. uniformis*, with 97.5 % sequence similarity (34 differences). The closest neighbours of IFM 0265^T and IFM 0330^T were respectively *N. otitidiscaviarum* (97.7 % similarity; 35 differences) and *N. seriolae* (97.8 %

similarity; 31 differences). We therefore checked the similarity of these strains based on DNA–DNA hybridization with *N. seriolae* IFM 0286^T, *N. otitidiscaviarum* IFM 0239^T and *N. uniformis* IFM 0856^T (Table 2). DNA–DNA relatedness among the four isolates IFM 0260, IFM 0330^T, IFM 0636 and IFM 0833 was >80 % and relatedness to other species with validly published names was <41 %, showing that these strains represent a single novel species. Strains IFM 0092^T and IFM 0265^T formed a cluster and the sequence similarity between the two strains was 99.0 %; however, DNA–DNA hybridization values (40–44 %) showed that strains IFM 0092^T and IFM 0265^T could each represent a novel species (Table 2).

In conclusion, the six isolated strains can be divided into three novel species of *Nocardia*. These three novel species and other *Nocardia* species were differentiated by biochemical phenotypes. From these studies on phenotypic characters and also the phylogenetic analysis, the names *Nocardia inohanensis* sp. nov., *Nocardia yamanashiensis* sp. nov. and *Nocardia niigatensis* sp. nov. are proposed.

Description of *Nocardia inohanensis* sp. nov.

Nocardia inohanensis (in.o.han.en'sis. N.L. fem. adj. *inohanensis* pertaining to Inohana, Chiba, Japan, where the type strain was identified).

Fig. 3. Phylogenetic tree derived from 16S rDNA sequences using maximum-likelihood analysis. The tree was unrooted and *Rhodococcus equi* was used as an outgroup.

Table 2. Levels of DNA–DNA relatedness among the six novel *Nocardia* strains and related type strains

Strain	1	2	3	4	5	6	7	8	9
1. IFM 0092 ^T	100	40	20	21	32	28	33	23	22
2. IFM 0265 ^T	44	100	24	29	19	22	29	25	27
3. IFM 0260	14	22	100	98	95	97	44	17	24
4. IFM 0330 ^T	10	21	99	100	92	95	42	20	25
5. IFM 0636	11	18	93	93	100	92	37	18	24
6. IFM 0833	23	18	94	88	90	100	36	18	23
7. <i>N. seriolae</i> IFM 0286 ^T	13	20	38	41	29	31	100	18	33
8. <i>N. otitidiscaviarum</i> IFM 0239 ^T	7·7	13	16	20	14	14	14	100	33
9. <i>N. uniformis</i> IFM 0856 ^T	17	8·2	15	22	18	16	16	19	100

Colonies are greyish-tan to tan. Cells show typical *Nocardia* micromorphology: branched vegetative mycelium that fragments into bacteroid, rod-shaped, non-motile elements. Aerial mycelium is only visible microscopically. No soluble pigment produced. Short chains of conidia can be seen on the tips of aerial mycelium. Gram-positive and partially acid-fast, as determined by the modified Kinyoun method (1 % sulfuric acid decolorization). Colonies are 0·6–1·3 mm in diameter after 7 days at 30 °C on MH medium with 0·2 % glucose. Glucose, inositol and citrate are utilized, but not adonitol, arabinose, erythritol, galactose, maltose, mannose, rhamnose, sorbitol or gluconate. Hypoxanthine and urea are decomposed, but not adenine, casein, tyrosine or xanthine. Grows at 37 °C but not at 45 °C. The G + C content of DNA is 69·3 mol%.

The type strain, strain IFM 0092^T (= NBRC 100128^T = JCM 11891^T = DSM 44667^T), was isolated from clinical material.

Description of *Nocardia yamanashiensis* sp. nov.

Nocardia yamanashiensis (ya.ma.na.shi.en'sis. N.L. fem. adj. *yamanashiensis* pertaining to Yamanashi prefecture of Japan, the source of the type strain).

Colonies are greyish-tan to tan. Cells have typical *Nocardia* micromorphology: branched vegetative hyphae that fragment into bacteroid, rod-shaped to coccoid elements. Aerial hyphae are sparse on most media used and are visible microscopically. Gram-positive and partially acid-fast, as determined by the modified Kinyoun method (1 % sulfuric acid decolorization). Colonies are 1·0–1·9 mm in diameter after 7 days at 30 °C on MH medium with 0·2 % glucose. Glucose, inositol, citrate and gluconate are utilized, but not adonitol, arabinose, erythritol, galactose, maltose, mannose, rhamnose or sorbitol. Hypoxanthine and urea are decomposed, but not adenine, casein, tyrosine or xanthine. Grows at 37 °C but not at 45 °C. The G + C content of DNA is 69·2 mol%.

The type strain, strain IFM 0265^T (= NBRC 100130^T = JCM 11893^T = DSM 44669^T), was isolated from clinical material.

Description of *Nocardia niigatensis* sp. nov.

Nocardia niigatensis (ni.i.gat.en'sis. N.L. fem. adj. *niigatensis* pertaining to Niigata, Japan, the source of the isolate).

Colonies are orange-tan to greyish-tan. Cells have typical *Nocardia* micromorphology: branched vegetative hyphae that fragment into oval to rod-shaped elements. Aerial mycelium is sparse and white and has a patchy distribution. Short chains of conidia may be found on the aerial mycelium. Faint brown soluble pigment produced. Gram-positive and partially acid-fast, as determined by the modified Kinyoun method (1 % sulfuric acid decolorization). Colonies are 1·5–3·2 mm in diameter after 7 days at 30 °C on MH medium with 0·2 % glucose. Glucose is utilized, but not adonitol, arabinose, erythritol, galactose, maltose, mannose, rhamnose, sorbitol or citrate. Hypoxanthine is weakly decomposed, but not adenine, casein, tyrosine or xanthine. Grows at 37 °C but not at 45 °C. The G + C content of DNA is 68·8–69·5 mol%.

The type strain is strain IFM 0330^T (= NBRC 100131^T = JCM 11894^T = DSM 44670^T). Strains have been isolated from clinical material.

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