Desulfatibacillum aliphaticivorans gen. nov., sp. nov., an n-alkane- and n-alkene-degrading, sulfate-reducing bacterium

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A novel marine sulfate-reducing bacterium, strain CV2803^T, which is able to oxidize aliphatic hydrocarbons, was isolated from a hydrocarbon-polluted marine sediment (Gulf of Fos, France). The cells were rod-shaped and slightly curved, measuring $0.6 \times 2.2\text{--}5.5\ \mu\text{m}$. Strain CV2803^T stained Gram-negative and was non-motile and non-spore-forming. Optimum growth occurred in the presence of $24\ \text{g NaCl l}^{-1}$, at pH 7.5 and at a temperature between 28 and 35 °C. Strain CV2803^T oxidized alkanes (from C₁₃ to C₁₈) and alkenes (from C₇ to C₂₃). The DNA G + C content was 41.4 mol%. Comparative sequence analyses of the 16S rRNA gene and dissimilatory sulfite reductase (*dsrAB*) gene and those of other sulfate-reducing bacteria, together with its phenotypic properties, indicated that strain CV2803^T was a member of a distinct cluster that contained unnamed species. Therefore, strain CV2803^T (= DSM 15576^T = ATCC BAA-743^T) is proposed as the type strain of a novel species in a new genus, *Desulfatibacillum aliphaticivorans* gen. nov., sp. nov.

INTRODUCTION

Several studies have demonstrated that anaerobic hydrocarbon oxidation is possible under different anoxic conditions. Microbial mineralization of hydrocarbons has been demonstrated with nitrate, ferric iron, sulfate and carbon dioxide as the terminal electron acceptor (Heider *et al.*, 1999; Spormann & Widdel, 2000; Zengler *et al.*, 1999; Zwolinski *et al.*, 2000). With sulfate as electron acceptor, the degradation of various aromatic hydrocarbons (Annweiler *et al.*, 2000; Meckenstock *et al.*, 2000; Wilkes *et al.*, 2000; Zwolinski *et al.*, 2000) and aliphatic hydrocarbons (Coates *et al.*, 1997; Caldwell *et al.*, 1998; Kropp *et al.*, 2000; So & Young, 2001) by microcosms or enrichment cultures has been reported. Some pure cultures of sulfate-reducing bacteria that degrade toluene (Rabus *et al.*, 1993; Beller *et al.*, 1996), xylene (Harms *et al.*, 1999) and naphthalene (Galushko *et al.*, 1999) have been described. Alkane oxidation by sulfate-reducing bacteria was reported by Novelli & ZoBell (1944) and Davis & Yarbrough (1966). However, these cultures were not preserved and the results were not confirmed (Spormann & Widdel, 2000). The first reported sulfate-reducing bacterium that was able to grow and

oxidize alkanes was '*Desulfobacterium oleovorans*' strain Hxd3 (Aeckersberg *et al.*, 1991). Later, isolation of a thermophilic sulfate-reducing bacterium, strain TD3, which mineralizes alkanes, was reported (Rueter *et al.*, 1994). Two strains of sulfate-reducing, alkane-degrading isolates were obtained more recently, strains Pnd3 (Aeckersberg *et al.*, 1998) and AK-01 (So & Young, 1999).

This paper describes a novel hydrocarbon-degrading, sulfate-reducing bacterium, strain CV2803^T, isolated from a polluted marine sediment (Gulf of Fos, France). This strain, which is able to oxidize n-alkanes and n-alkenes, is proposed as a representative of a novel species of a new genus, *Desulfatibacillum aliphaticivorans* gen. nov., sp. nov.

METHODS

Source of organisms and sampling. Strain CV2803^T was isolated from marine sediment of Canal Vieil cove (Lavera, Gulf of Fos, France), which has been polluted by petroleum refinery spills over a period of 15 years. Sediment samples were collected using a plastic core sampler capped with a butyl rubber stopper. Samples were stored at 4 °C until use.

Culture media, enrichment and isolation procedures

Microcosms and enrichment cultures. Microcosms were prepared in 250 ml screw-cap bottles sealed with butyl rubber stoppers. The

The GenBank accession numbers for 16S rRNA gene sequence and two dissimilatory sulfite reductase gene sequences of strain CV2803^T are respectively AY184360, AY215505 and AY215506.

sediment was added as a 25% (v/v) inoculum to 150 ml sea-water medium. Natural sea-water medium (filtered sea water supplemented with 0.2 g $\text{NH}_4\text{Cl l}^{-1}$) was prepared under N_2/CO_2 (90:10) according to the method of Pfennig *et al.* (1981). After sterilization, the medium was supplemented with the following (l^{-1}): 0.8 M NaHCO_3 , 30 ml; 0.1 M phosphate buffer (pH 7.2), 4 ml; 0.2 M $\text{Na}_2\text{S}_9\text{H}_2\text{O}$, 6 ml; vitamin V7 solution (Pfennig *et al.*, 1981), 1 ml; pH 7.0–7.2. The microcosms were then supplemented with 1-tetradecene (1.4 mM) as substrate and sodium dithionite (0.12 mM) as an additional reductant (Widdel & Bak, 1992). The bottles were incubated in a nearly horizontal position to maximize contact between the medium and hydrocarbon and to avoid contact between the hydrocarbon and the stopper (Aeckersberg *et al.*, 1991). The microcosms were incubated at 30 °C in the dark, without shaking.

Enrichment cultures were prepared from active microcosms by successive transfers to fresh sea-water medium. Enrichments were made in triplicate with duplicate sterile controls.

Isolation and maintenance of pure cultures. Pure cultures were obtained by repeated passage through a deep agar dilution series in natural sea-water medium (Pfennig & Trüper, 1981) with N_2/CO_2 in the gas phase, sodium octanoate (2 mM) as soluble substrate and sodium dithionite (0.12 mM). The final synthetic medium for maintenance and growth of pure cultures prepared under N_2/CO_2 (90:10) contained (l^{-1} distilled water): Na_2SO_4 , 3 g; KH_2PO_4 , 0.2 g; NH_4Cl , 0.3 g; NaCl , 15 g; $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, 2.8 g; KCl , 0.5 g; $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, 0.15 g; NaHCO_3 , 2 g; $\text{Na}_2\text{S}_9\text{H}_2\text{O}$, 0.3 g; vitamin V7 solution (Pfennig *et al.*, 1981), 1 ml; trace element solution SL12 (Overmann *et al.*, 1992), 1 ml; selenite/tungstate solution (Widdel & Bak, 1992), 1 ml; pH 7.0–7.2. Finally, the medium was supplemented with 1-tetradecene (1.4 mM) as substrate and sodium dithionite (0.12 mM).

Cellular structure and morphology. Microscopic observations and photomicrographs were made with a Zeiss photomicroscope, according to the method of Pfennig & Wägener (1986).

Endospore production was checked by microscopic observation in synthetic medium supplemented with 1 mM sodium octanoate plus a spore inducer (0.18 mM MnSO_4 , 0.5 g yeast extract l^{-1} , soil extract, beef meat extract or egg yolk) and also by growth in synthetic medium after exposure of cultures to a temperature of 80 °C for 20 min.

The Gram reaction was determined by Gram staining and by the KOH method (Buck, 1982).

Purity controls. The purity of cultures was checked by phase-contrast microscopy. In addition, cultures were transferred to oxygen-containing and anoxic sea-water medium containing glucose (3 mM) and yeast extract (0.5 g l^{-1}), as well as to AC medium (Difco).

Physiological tests. Temperature limits for growth was determined by culture incubation at 4–50 °C in synthetic medium. pH limits for growth was determined in the same medium adjusted to pH values between 5 and 9. The dependence of growth on NaCl concentration was determined in the synthetic medium containing 0.5 g $\text{MgCl}_2 \cdot 6\text{H}_2\text{O l}^{-1}$ with an NaCl concentration of 0–70 g l^{-1} . Sodium octanoate (2 mM) was used as substrate for these experiments.

Utilization of carbon sources and electron donors (sodium salts) was tested in synthetic medium under optimal growth conditions with substrate concentrations as given in the Results and Discussion. Electron acceptors were tested in sulfate-free synthetic medium using sodium octanoate (2 mM) as electron donor. Fermentative growth was also tested in sulfate-free synthetic medium.

Utilization of N_2 , ammonia, nitrate, glutamate or yeast extract as nitrogen source was conducted in N-free defined medium. Growth was followed through four consecutive transfers.

Vitamin requirements were determined by following a culture through four consecutive transfers in synthetic medium without vitamins.

All tests were performed in completely filled 25 ml screw-cap tubes, as described by Caumette *et al.* (1988). Growth was monitored by culture OD_{450} with a Spectronic model 20D⁺ spectrophotometer (Milton Roy) over a period of 15 days. At the end of the experiments, cultures were observed microscopically.

Hydrocarbon oxidation was tested in synthetic medium in bottles sealed with butyl rubber stoppers. Hydrocarbons were the sole substrate and were added at 250 p.p.m. organic carbon for aliphatic hydrocarbons (n-alkanes $\text{C}_5\text{--C}_{20}$; n-alkenes $\text{C}_7\text{--C}_{23}$) and 100 p.p.m. organic carbon for aromatic hydrocarbons (benzene, toluene, xylene, p-cymene, naphthalene and phenanthrene). To avoid toxicity of small alkanes and aromatic hydrocarbons, 2,2,4,4,6,8,8-heptamethylnonane was used as the carrier phase (Rabus *et al.*, 1993). Substrate utilization was followed by measuring sulfide concentrations in the assays and by comparing the results with concentrations obtained in sterile and positive controls (synthetic medium supplemented with 2 mM sodium octanoate).

Disproportionation of thiosulfate or sulfite was checked in synthetic medium without sulfate or organic electron donor. The only carbon source was carbon dioxide in the gas phase and the medium was supplemented with either thiosulfate or sulfite as energy source and electron acceptor (Bak & Pfennig, 1987). After incubation, disproportionation was assessed by the formation of sulfide and sulfate. Sulfate was assayed by adding a few drops of HCl and 5% BaCl_2 solution to a small volume of culture. Controls contained sulfate and CO_2/H_2 in the gas phase.

All growth tests were carried out in triplicate.

Quantitative growth experiments. Quantitative growth experiments on 1-tetradecene were carried out in Bellco tubes (25 ml) containing 12.5 ml synthetic medium with resazurin (1 mg l^{-1}), 1-tetradecene (5 μl) and sodium dithionite (0.12 mM) under N_2/CO_2 (90:10). Tubes were inoculated with 1.2 ml culture and sealed with Teflon-coated rubber stoppers (West Pharmaceutical Services) and aluminium crimp seals. Tubes were incubated under optimal growth conditions in the dark without shaking. Four assay replicates and two sterile controls replicates were analysed at the beginning and end of the experiment.

Chemical and biochemical analyses. Sulfide concentrations were determined colorimetrically by the methylene blue formation reaction (Cline, 1969) using a miniaturized method (final volume 900 μl). The exact sulfide contents of standards were determined by iodometric titration (Vogel, 1961). Sulfate analyses were performed using the turbidimetric method (Kolmert *et al.*, 2000) after removing sulfide by addition of zinc carbonate.

Tetradecene concentrations were determined by GC after extraction with pentane using 2,2,4,4,6,8,8-heptamethylnonane as internal standard. The GC (Chrompack CP9001) was equipped with a flame-ionization detector (300 °C) and a fused silica capillary column (10 m $\times$ 0.53 mm). The injector temperature was 270 °C. The column temperature was initially set at 80 °C and increased by 2 °C min^{-1} to 104 °C.

The presence of desulfovibrin was tested as described by Postgate (1984). The G+C content was determined at the Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH (DSMZ),

Braunschweig, Germany, according to a standard protocol described by Mesbah *et al.* (1989).

DNA extraction, PCR amplification and sequencing. Genomic DNA was extracted using the Wizard Genomic DNA purification kit (Promega), DNA extracts were stored at -20°C . The 16S rRNA gene was amplified with primers Fd1 (5'-AGAGTTTGATCCTGGCTCAG-3') and R6 (5'-TACGGTTACCTTGTTACGAC-3') (modified from Lane, 1991) and the following reaction conditions: 1 min at 94°C ; 30 cycles of 30 s at 94°C , 1 min at 55°C and 2 min at 72°C ; and a final extension of 10 min at 72°C . The dissimilatory sulfite reductase (*dsrAB*) gene was amplified with primers DSR1F (5'-ACSCACTGGAAGCACG-3') and DSR4R (5'-GTGTAGCAGT-TACCGCA-3') (Wagner *et al.*, 1998) and the following reaction conditions: 1 min at 94°C ; 45 cycles of 30 s at 94°C , 1 min at 45.7°C and 3 min at 72°C ; and a final extension of 10 min at 72°C . PCR products were cloned using the pGEM-T easy cloning kit (Promega). Clone libraries were screened by direct PCR amplification from a colony using the vector-specific primers SP6 (5'-ATTTAGGTGACACTATAGAA-3') and T7 (5'-TAATACGACTCACTATAGGG-3') and the following reaction conditions: 2 min at 96°C ; 40 cycles of 30 s at 94°C , 1 min at 55°C and 3 min at 72°C ; and a final extension of 10 min at 72°C . Plasmids containing inserts of the correct length were isolated using the Wizard Plus SV Minipreps DNA purification system (Promega) and sent for sequencing to Genome Express (Grenoble, France).

Phylogenetic analyses. The nucleotide sequence of the 16S rRNA gene and the amino acid sequence deduced from the nucleotide sequence of the *dsrAB* gene were aligned manually with reference sequences of various sulfate-reducing bacteria using the sequence alignment editor BIOEDIT (Hall, 1999). Reference sequences were obtained from the Ribosomal Database Project II (Maidak *et al.*, 2001), EMBL and GenBank (Benson *et al.*, 1999). Positions of sequence and alignment uncertainty were omitted from the analysis. Pairwise evolutionary distances based on 1278 unambiguous nucleotides (16S rRNA gene) and on 329 unambiguous amino acids (*dsrAB* gene) were respectively computed by the methods of Jukes & Cantor (1969) and Kimura (1980). Dendrograms were constructed using the neighbour-joining method (Saitou & Nei, 1987). Confidence in the tree topology was determined by bootstrap analysis using 100 resamplings of the sequences (Felsenstein, 1985).

RESULTS AND DISCUSSION

Microcosms, enrichment cultures and isolations

Hydrocarbon-polluted marine sediment of Canal Vieil cove had a strong smell of petroleum. Microcosms prepared from the black zone of the sediment and sea-water medium, supplemented with 1-tetradecene, showed a significantly higher sulfide concentration than the tetradecene-free control after 4 weeks of incubation (data not shown).

After three transfers, a sediment-free enrichment culture was obtained that grew with tetradecene as the only organic substrate in the presence of sulfate. From this enrichment culture, three strains were isolated with sodium octanoate as soluble substrate. Of the three pure strains obtained, two did not grow on tetradecene. The third isolate produced sulfide with 1-tetradecene as sole substrate. This isolate, strain CV2803^T, was used for further experiments. In purity controls, neither anaerobic nor aerobic contaminants were detected.

Morphology

Individual cells of strain CV2803^T stained Gram-negative. In young cultures grown with sodium octanoate, cells were rod-shaped ($0.6 \times 2.2\text{--}5.5\text{ }\mu\text{m}$), slightly curved and non-motile. When grown on 1-tetradecene, cells sometimes aggregated in clusters around hydrocarbon droplets. Endospores were not observed.

Physiology and other characteristics

Strain CV2803^T was mesophilic. Growth occurred between 15 and 40°C , with an optimum growth temperature of $28\text{--}35^{\circ}\text{C}$. Growth was possible at pH 6.6–7.8, with an optimum at pH 7.5. Growth was observed in $6\text{--}45\text{ g NaCl l}^{-1}$, with an optimum around 24 g NaCl l^{-1} .

Under optimal growth conditions, with sodium octanoate as carbon source and electron donor, the mean doubling time of strain CV2803^T was 16 h during exponential growth. Malate and pyruvate were not fermented. Sulfate (20 mM), sulfite (5 mM) and thiosulfate (10 mM) were used as electron acceptors, but elemental sulfur (0.8 g l^{-1}), nitrate (10 mM) and fumarate (10 mM) were not used. Thiosulfate and sulfite were not disproportionated. The strain utilized N_2 , NH_4Cl , glutamate and yeast extract as nitrogen sources, but not nitrate. Vitamins were not essential for growth. Desulfoviridin was absent.

Strain CV2803^T used the following substrates as electron donor and carbon source (mM, except where stated): H_2 /acetate (1 bar/10), formate (5), butyrate (5), valerate (5), octanoate (2), nonanoate (2), palmitate (5), stearate (2), pyruvate (10), fumarate (10) and crotonate (2). Slight growth was obtained with 10 mM acetate, propionate, malate or succinate. The strain was not able to grow on the following substrates (mM, except where stated): lactate (10), citrate (5), α -ketoglutarate (5), tartrate (2), glycolate (2), thioglycolate (2), acetone (5), methanol (10), ethanol (10), isopropanol (10), glycerol (10), glucose (5), fructose (5), gluconate (10), glycine (5), alanine (5), serine (5), threonine (10), lysine (10), cysteine (5), methionine (10), aspartate (5), glutamate (5), betaine (5), gallate (5), catechol (0.5), indole (0.25), phenol (0.5), benzoate (5), nicotinate (2), thioacetamide (2), peptone (0.5 g l^{-1}), Casamino acids (0.5 g l^{-1}) and yeast extract (0.5 g l^{-1}). Optimum growth occurred with crotonate, octanoate, nonanoate and valerate. Chemolithoautotrophic growth was possible with H_2 as electron donor and carbon dioxide as carbon source.

Strain CV2803^T was able to oxidize C_{13} to C_{18} n-alkanes and C_7 to C_{23} n-alkenes. Growth on aromatic hydrocarbons was not observed. Like strain CV2803^T, strains Hxd3 (Aeckersberg *et al.*, 1991), Pnd3 (Aeckersberg *et al.*, 1998) and AK-01 (So & Young, 1999) are able to oxidize alkanes and alkenes (Table 1). Strain TD3 (Rueter *et al.*, 1994), isolated from a hydrothermal site (Guaymas Basin), is the only thermophilic micro-organism among the hydrocarbon-degrading, sulfate-reducing bacteria. In contrast to the four previously mentioned strains, this strain is only able to oxidize alkanes.

Table 1. Main characteristics of sulfate-reducing bacteria physiologically or phylogenetically close to strain CV2803^T

Data for reference strains were taken from So & Young (1999) (AK-01), Aeckersberg *et al.* (1998) (Pnd3), Aeckersberg *et al.* (1991) (Hxd3) and Rueter *et al.* (1994) (TD3). +, Growth; –, no growth; (+), slight growth; NR, not reported. All strains were negative for aromatic hydrocarbon degradation.

Characteristic	CV2803 ^T	AK-01	Pnd3	Hxd3	TD3
Morphology	Rod	Rod	Rod	Rod	Curved rod
DNA G + C content (mol%)	41.4	57.0	NR	63.0	37.4
Desulfovibrin	–	–	NR	NR	–
Optimum temperature (°C)	28–35	26–28	30	28–30	60–65
Optimum pH	7.5	6.9–7.0	NR	NR	6.5–6.8
Optimum salinity (g NaCl l ^{–1})	24	10	NR	NR	21
Compound used as electron donor and carbon source:					
Formate	+	NR	+	–	NR
Acetate	(+)	(+)	–	–	–
Propionate	(+)	(+)	NR	–	–
Butyrate	+	(+)	NR	(+)	NR
Fatty acids	C ₄ –C ₁₈	C ₄ –C ₁₆	C ₃ –C ₁₈	C ₁₀ –C ₁₈	C ₄ –C ₁₈
Lactate	–	(+)	NR	–	–
Dicarboxylic acids	+	+	NR	–	–
H ₂ /CO ₂	+	+	NR	–	–
Ethanol	–	NR	–	–	–
Hydrocarbon degradation:					
Alkanes	C ₁₃ –C ₁₈	C ₁₃ –C ₁₈	C ₁₄ –C ₁₇	C ₁₂ –C ₂₀	C ₆ –C ₁₆
Alkenes	C ₇ –C ₂₃	C ₁₅ , C ₁₆	C ₁₆	C ₁₄ , C ₁₆ , C ₁₇	–

In contrast to strain CV2803^T, strains TD3 and Hxd3 were unable to use carboxylic acids as sole substrates and they were not able to grow autotrophically (Table 1). Physiological comparisons between strain CV2803^T and strain Pnd3 are not easy to make because many characteristics of strain Pnd3 have not been determined. The physiological properties of strain AK-01 are very similar to those of strain CV2803^T. Both are able to utilize a similar range of fatty acids and other carboxylic acids and to grow autotrophically (Table 1). Their optimum temperature and pH for growth are nearly identical. In contrast, the optimum salinity for growth of strain AK-01 (10 g NaCl l^{–1}) is lower than that of strain CV2803^T (24 g NaCl l^{–1}). Interestingly, the strains differed by more than 15% when comparing DNA G + C content determined by HPLC (57 mol% for strain AK-01 and 41.4 mol% for strain CV2803^T).

1-Tetradecene degradation balance

1-Tetradecene was oxidized completely by strain CV2803^T. After 41 days incubation, 8.3 mM sulfide was produced, 10.5 mM sulfate was consumed and 0.98 mM tetradecene was oxidized. Thus, per 1 mM tetradecene, 8.5 mM sulfide was produced and 10.7 mM sulfate was consumed. This is close to the expected theoretical value of 10.5 mM sulfate consumed per mM tetradecene oxidized, according to the following equation:

In sterile controls, no loss of tetradecene was detected during incubation.

Phylogenetic analyses

Analysis of the almost complete sequence (1278 bp) of the 16S rRNA gene of strain CV2803^T revealed that the novel isolate grouped within the family *Desulfobacteraceae* in the δ -*Proteobacteria*. Strain CV2803^T was phylogenetically closely related (99.4% identity) to a group of unnamed

Fig. 1. Phylogenetic tree based on similarities of 16S rRNA gene sequences of strain CV2803^T and its relatives. Bar, 2 substitutions per 100 nt.

Fig. 2. Phylogenetic tree based on similarities of *dsrAB* gene sequences of strain CV2803^T and its relatives. Bar, 5 substitutions per 100 nt.

alkane-oxidizing strains, S2550 and S2552 (Myhr *et al.*, 2002), Pnd3 and AK-01. The most closely related species was *Desulfosarcina variabilis* (92.9% identity) (Fig. 1). The phylogenetic position of strain CV2803^T within the family *Desulfobacteraceae* was supported by *dsrAB* sequence analyses (329 amino acids), indicating a close relationship to strain AK-01. As shown by 16S rRNA sequence analyses, strain CV2803^T was closely related to strain AK-01 (Fig. 2). Since cultures and *dsrAB* sequences of strains S2550, S2552 and Pnd3 were not available, they could not be included in the comparison.

Strains AK-01, Pnd3, S2550 and S2552 have not been named and are not available from culture collections. Based on the genetic and physiological differences from existing described genera, it is proposed that strain CV2803^T represents a novel species in a new genus, *Desulfatibacillum aliphaticivorans* gen. nov., sp. nov.

The other strains that fall into the same cluster (Fig. 1) may represent other species in this genus. A clear conclusion can only be drawn by a more detailed physiological investigation and DNA–DNA hybridization of all strains belonging to this cluster.

Description of *Desulfatibacillum* gen. nov.

Desulfatibacillum (De.sul.fa.ti.ba.cil'lum. L. pref. *de* from; N.L. n. *sulfas* sulfate; L. neut. n. *bacillum* rod; N.L. neut. n. *Desulfatibacillum* a sulfate-reducing rod).

Mesophilic, sulfate-reducing bacteria that stain Gram-negative. Rod-shaped cells without spores. Desulfoviridin is not detected. Organic substrates are completely oxidized. Fatty acids, C₄ dicarboxylic acids, alkanes and alkenes are used as substrates. The type species is *Desulfatibacillum aliphaticivorans*.

Description of *Desulfatibacillum aliphaticivorans* sp. nov.

Desulfatibacillum aliphaticivorans (a.li.pha.ti.ci.vo'rans. N.L. adj. *aliphaticus* aliphatic; L. part. adj. *vorans* devouring,

digesting; N.L. neut. part. adj. *aliphaticivorans* aliphatic hydrocarbon-devouring).

Cells are slightly curved rods (0.6 × 2.2–5.5 µm). Growth occurs at 15–40 °C (optimum 28–35 °C) and pH 6.6–7.8 (optimum pH 7.5). Growth occurs at NaCl concentrations of 6–45 g l⁻¹ (optimum 24 g NaCl l⁻¹). Sulfate, sulfite and thiosulfate are used as electron acceptors. H₂, pyruvate, C₄ dicarboxylic acids, acetate, propionate, C₄ to C₁₈ fatty acids and butanol serve as electron donors. Able to grow autotrophically. Alkanes (C₁₃ to C₁₈) and alkenes (C₇ to C₂₃) are oxidized. No vitamins are required. The DNA G + C content of the type strain is 41.4 mol% (HPLC).

The type strain, CV2803^T (=DSM 15576^T = ATCC BAA-743^T), was isolated from hydrocarbon-polluted marine sediment of Canal Vieil cove (Gulf of Fos, France).

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