Supplementary Materials

Microbial corrosion behavior of pipeline steels in simulation environment of natural gas transportation pipeline

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Table S1 shows the pipeline corrosion conditions of shale gas fields in two blocks in southwest China (southern Sichuan). The corrosion parameters selected for this work are also from the Changning block. From the table, it can be seen that 20~70℃ is the operating temperature range of the gas field pipeline. The subject of this work is to study the corrosion behaviour of microorganisms in natural gas gathering and transportation pipelines. In order to reflect the influence of microorganisms on the corrosion behaviour, it is crucial for the study of microbial corrosion to maintain a high activity level of microorganisms. In this work, three temperatures of 20°C, 40°C and 60°C were selected within the pipeline operating temperature range for SRB culture and the growth curve of SRB was obtained using a spectrophotometer. The results are presented in Figure S1. It can be seen from the figure that the growth of SRB is obviously inhibited at 60°C, and the bacterial growth at 20°C is not as good as that at 40°C. Therefore, 40°C is chosen as the operating temperature of the corrosion test, which not only corresponds to the actual corrosion conditions, but also avoids low bacterial activity, which affects the accuracy of the test.

Table S1 Corrosion environment table of Changning and Weiyuan shale gas blocks in southern Sichuan

item		Changning block	Weiyuan block
Flowback Liquid Components	SRB content (per/mL)	Up to 13,000	1150~7500
	TGB content (per/mL)	Up to 9.5	/
Service Condition	Temperature (°C)	20~70	
	Maximum pressure (MPa)	4~8.5MPa	6.4MPa
	Velocity of flow (m/s)	1.0	/

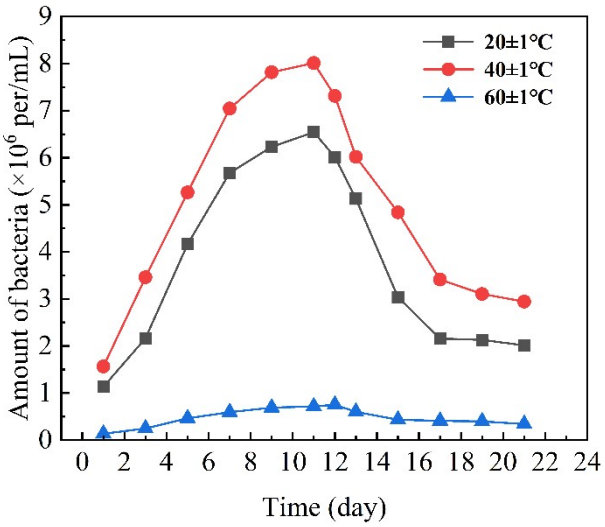

Figure S1. Growth curve of SRB in culture medium at different temperatures.

Table S2 EIS fitting parameters of X80 pipeline steels after corrosion in different microbial environments.

Group	Time (d)	R_s ($\Omega \cdot cm^2$)	Q_{bc} ($\Omega^{-1} \cdot cm^{-2} \cdot s^n$)	R_{bc} ($\Omega \cdot cm^2$)	Q_{dl} ($\Omega^{-1} \cdot cm^{-2} \cdot s^n$)	R_{ct} ($\Omega \cdot cm^2$)
Control	1	5.4800	/	/	1.645×10^{-2}	199.59
	3	4.8073	/	/	3.117×10^{-3}	80. 24
	6	6.6499	/	/	1.534×10^{-4}	92811
	9	38.878	/	/	3.656×10^{-4}	42544
	12	11.138	/	/	1.379×10^{-4}	49700
	15	13.092	/	/	6.083×10^{-5}	45141
SRB	1	4.5064	1.104×10^{-2}	6.9296	3.339×10^{-2}	929.31
	3	3.7152	1.769×10^{-2}	2.7584	4.257×10^{-2}	192.7
	6	4.3723	1.359×10^{-2}	6.9781	4.781×10^{-2}	321.23
	9	7.7396	1.623×10^{-4}	69.056	1.119×10^{-4}	6816

	12	8.9653	1.694×10^{-4}	167.76	6.570×10^{-5}	11266
	15	9.4464	1.249×10^{-4}	582.17	5.543×10^{-4}	6830.1
IOB	1	4.5777	4.880×10^{-4}	1.7603	1.051×10^{-2}	411.06
	3	8.9529	2.513×10^{-5}	14.043	1.468×10^{-4}	53434
	6	8.4708	3.234×10^{-5}	15.479	1.124×10^{-4}	91000
	9	9.7336	1.254×10^{-4}	50.457	7.638×10^{-5}	80134
	12	11.566	2.378×10^{-5}	10.832	1.306×10^{-4}	19197
	15	10.164	1.304×10^{-5}	16.945	4.599×10^{-5}	97593
SRB+IOB	1	5.8151	1.268×10^{-5}	6.5444	2.430×10^{-4}	9641.6
	3	9.0135	1.503×10^{-8}	1.2178	2.108×10^{-4}	25086
	6	9.1589	1.411×10^{-5}	10.839	6.950×10^{-5}	92438
	9	9.3000	1.054×10^{-4}	43.411	6.807×10^{-5}	56010
	12	10.378	2.226×10^{-5}	17.790	5.938×10^{-5}	58868
	15	11.0220	2.411×10^{-5}	22.955	3.147×10^{-4}	74958

Table S3 Polarization curve parameters of X80 pipeline steels after corrosion for 1, 6, 9 and 15 days in different microbial environments.

Time (d)	Group	β_a (mV)	β_c (mV)	E_{corr} (V, SCE)	i_{corr} (A/cm^2)
1	Control	101.41	113.51	-0.68475	2.7638×10^{-5}
	SRB	164.86	37.736	-0.75640	2.0242×10^{-5}
	IOB	105.31	80.059	-0.74381	1.8051×10^{-5}
	SRB+IOB	269.64	272.34	-0.18272	3.5020×10^{-6}
3	Control	133.69	94.479	-0.61597	3.1481×10^{-5}
	SRB	109.16	49.327	-0.74486	2.4340×10^{-5}
	IOB	491.89	152.07	-0.08091	1.8127×10^{-6}
	SRB+IOB	199.00	262.35	-0.13211	4.5975×10^{-6}
6	Control	382.06	124.17	-0.04826	7.5022×10^{-7}
	SRB	133.06	64.598	-0.71380	4.2788×10^{-5}
	IOB	594.85	124.19	-0.07453	8.9359×10^{-7}
	SRB+IOB	2949.3	172.40	-0.09358	1.6205×10^{-6}
9	Control	1263.0	158.87	-0.12305	2.2376×10^{-6}
	SRB	540.42	131.92	-0.09088	1.2852×10^{-6}
	IOB	548.15	122.97	-0.05038	8.2928×10^{-7}
	SRB+IOB	490.70	142.41	-0.05619	1.1666×10^{-6}
12	Control	678.59	110.00	-0.06281	4.7699×10^{-7}
	SRB	873.66	112.93	-0.07766	7.3328×10^{-7}

	IOB	502.79	148.51	0.05561	8.3947×10^{-7}
	SRB+IOB	612.01	52.947	0.34250	4.6417×10^{-7}
15	Control	880.46	118.98	0.10696	8.5838×10^{-7}
	SRB	670.20	202.19	0.11763	1.1128×10^{-7}
	IOB	510.55	117.25	0.15938	3.6799×10^{-7}
	SRB+IOB	658.62	119.64	0.15337	4.3987×10^{-7}