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Biodegradation of Paraffin in Crude Oil: Prevention of Wax Deposition

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Microorganisms were obtained by separation and purification experiment from waxy oil production wells in Jilin oil field. The paraffin-degrading strain was identified as *Bacillus sp.*. After microbial treatment, the paraffin degradation rate could reach to 79.3 %, the paraffin prevention rate could reach to 68.4 %, the reduction rate of crude oil viscosity was 56.1 %, the oil freezing point reduced by 5.5 ºC and the reduction rate of culture surface tension was 46.3 %. By analyzing the data, the paraffin-degrading strain has better effect on microbial prevention of wax deposition.

Key Words: Microorganisms, Degradation, *Bacillus sp.*, Crude oil.

INTRODUCTION

High molecular weight hydrocarbons (> C_{40}) are important constituents of petroleum and can cause problems related to crystallization and deposition of paraffin waxes during production and transportation[1,2]. During the production of crude oil, the escape of dissolved gases and expansion makes the oil temperature is reduced, resulting in the precipitation of wax crystals, which deposited on the pipeline, which severely impact crude oil production[3,4]. Therefore, the implementation of the measures of removal paraffin is the primary means to ensure the normal production of oil well[5,6].

Mechanisms of microbial paraffin-removal include direct degradation of higher molecular weight alkanes (paraffin), production of fatty acids together with other microbial metabolites, which can act as paraffin solvents and dispersants and the production of biosurfactants and gases[7-9]. These mechanisms can lead to reduced viscosity, pour points, as well as cloud points of crude oil[10]. Microbial treatment has many outstanding advantages *i.e.*, simple construction, low operating costs, the role of a long cycle does not affect the quality of the oil strata without any damage[11].

In this work, microorganisms were obtained by separation and purification experiment from waxy oil production wells in Jilin oil field. We aim to study the degradation and prevention rate of paraffin after microbial treatment and the change of crude oil viscosity, freezing point using the microbial treatment.

EXPERIMENTAL

Isolation and selection of microorganism: Microorganisms were screened from waxy oil production in Jilin oil field. Experiment of identification showed that the paraffin-degrading strain was identified to *Bacillus sp.*.

Paraffin degradation: Marine mineral culture (100 mL) was sterilized by autoclaving at 121.3 ºC for 20 min. After sterilization, waxes (3 g) and the paraffin-degrading strain (2 mL) were added to the sterilized culture medium in the asepticmanipulationroom. The system was operated at the following parameters temperature 45 ºC, pH = 7.2, salinity 5000 mg/L. The incubation periods were 7, 14, 21, 28 d. The degradation rates of paraffin were measured respectively.

Paraffin inhibition: The method of effect evaluation was according to SY/T6300-1997. By controlling the temperature difference in crude oil and paraffin tube (crude oil was controlled at temperature 45 ºC, paraffin tube was controlled at temperature 30 ºC), circulating pump was operated for 28 days, which made paraffin deposit on the paraffin tube, then the paraffin tube was frozen to 25 ºC. The prevention rates of paraffin were measured before microbial treatment and after microbial treatment.

Viscosity and freezing point measurement: Mixed bacteria liquid (100 mL) with crude oil (100 mL) in the conical flask, then operated at the following parameters temperature 45 ºC, the incubation period was 10 days. After 10 days, crude oil was dehydrated. A rotating viscometer (NDS-8S) set at

50 ºC and 12 s^{-1} shear rate was used to measure the viscosity of crude oil. The dehydration of crude oil after microbial treatment was used to measure freezing point by cryoscopic method.

Surface tension measurement: Marine mineral culture (100 mL) was sterilized by autoclaving at 121.3 ºC for 20 min. After sterilization, crude oil (3 g) and 2 % (v/v) of bacteria liquid were added to the sterilized culture medium in the aseptic manipulation room. The system was operated at the following parameters temperature 45 ºC, pH = 7.2, salinity 5000 mg/L, the incubation period was 7 days. After 7 days, surface tensiometer (XZD-3) was used to measure the surface tension.

RESULTS AND DISCUSSION

The photo of scanning electron microscope for the paraffin-degrading strain is shown in Fig. 1.

Degradation and prevention rate of paraffin: The degradation rate of paraffin is shown in Table-1 and the prevention rate of paraffin is shown in Table-2. As shown in Tables 1 and 2, the degradation rate of paraffin could reach to 79.3 %, the prevention rate of paraffin could reach to 68.4 % after the paraffin-degrading strain treatment. Thus it could be seen that the paraffin-degrading strain has better effect on microbial prevention of wax deposition.

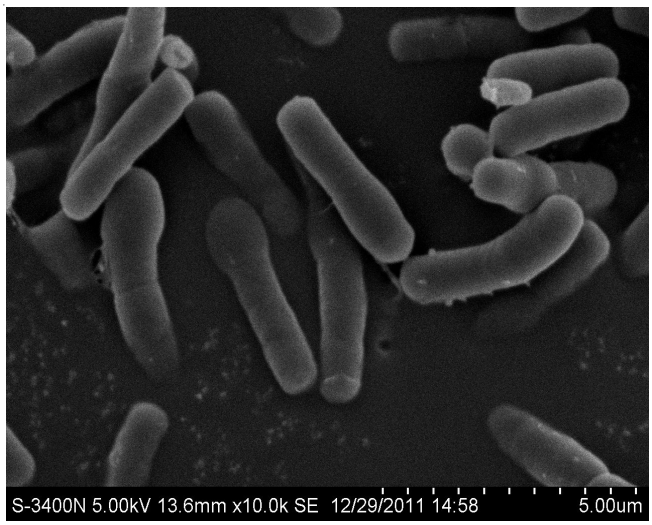

Fig. 1. Scanning electron microscope graphs for the paraffin-degrading strain (×10.0 k)

TABLE-1
DEGRADATION RATE OF PARAFFIN AFTER THE PARAFFIN-DEGRADING STRAIN TREATMENT

Degradation time (d)	0	7	14	21	28
Quality of wax before degradation (g)	3.00	3.00	3.00	3.00	3.00
Quality of wax after degradation (g)	3.00	2.02	1.55	1.19	0.62
Degradation rate of paraffin (%)	0	32.7	48.3	60.3	79.3

Change of viscosity and freezing point: The change of viscosity and freezing point are shown in Tables 3 and 4. As shown in Tables 3 and 4, the reduction rate of crude oil viscosity was 56.1 % and the crude oil freezing point reduced by 5.5 ºC after the paraffin-degrading strain treatment. The reasons were likely to be that organic solvent was produced in the metabolism of the microbe, crude oil was diluted by the organic solvent and biological surfactant was produced in the metabolism of the microbe, crude oil was emulsified.

Change of surface tension: The change of surface tension is shown in Table-5. As shown in Table-5, the reduction rate of surface tension was 46.3 % after the paraffin-degrading strain treatment. The reducing reason of surface tension was that biological surfactant was produced in the metabolism of the microbe.

Conclusion

Microorganisms were obtained by separation and purification experiment from waxy oil production wells in Jilin Oilfield. The paraffin-degrading strain was identified as *Bacillus sp*.

The paraffin-degrading strain has better effect on microbial prevention of wax deposition, the degradation rate of paraffin

TABLE-2
PREVENTION RATE OF PARAFFIN AFTER MICROBIAL TREATMENT

Bacterial strain	Weight difference of paraffin tube after 28 days (g)		Prevention rate of paraffin (%)
	Before microbial treatment	After microbial treatment	
Paraffin-degrading strain	0.57	0.18	68.4

TABLE-3
CRUDE OIL VISCOSITY BEFORE AND AFTER MICROBIAL TREATMENT

Bacterial strain	Crude oil viscosity (mPa·s)		The reduction rate of viscosity (%)
	Before microbial treatment	After microbial treatment	
Paraffin-degrading strain	46.7	20.5	56.1

TABLE-4
CRUDE OIL FREEZING POINT BEFORE AND AFTER MICROBIAL TREATMENT

Bacterial strain	Crude oil freezing point (ºC)		Reduction of freezing point (ºC)
	Before microbial treatment	After microbial treatment	
Paraffin-degrading strain	30.9	25.4	5.5

TABLE-5
CHANGE OF SURFACE TENSION BEFORE AND AFTER MICROBIAL TREATMENT

Bacterial strain	Surface tension ($mN \cdot m^{-1}$)		The reduction rate of surface tension (%)
	Before microbial treatment	After microbial treatment	
Paraffin-degrading strain	45.8	24.6	46.3

could reach to 79.3 %, the prevention rate of paraffin could reach to 68.4 % after the paraffin-degrading strain treatment.

The paraffin-degrading strain has better effect on reducing crude oil viscosity and freezing point, the reduction rate of crude oil viscosity was 56.1 % and the crude oil freezing point reduced by 5.5 ºC after the paraffin-degrading strain treatment.

The paraffin-degrading strain has better effect on reducing culture surface tension, the reduction rate of surface tension was 46.3 % after the paraffin-degrading strain treatment.

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