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Effect of Different Chemicals Compounds upon the Surface of Heavy Crude Oil

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Abstract*: Heavy crude oil is one of the unconventional crude oil which is difficult to recovery by conventional methods. High viscosity of heavy crude oil is reduced by the usage of steam in thermal recovery processes. Chemical flooding practices were fewer in heavy oil field compared to thermal flooding due to the low reactivity of chemicals on high dense crude oil. In this research article, different chemical compounds were tested on the heavy crude oil in both ambient and hot water conditions. The chemical compound prepared in the ambient temperature of water has no effect on heavy crude oil. On the contrary, heavy crude oil gave response to the chemicals made up of hot water. The chemical compounds namely surfactants, solvents and some salts happened to change the surface of heavy crude oil in turn influence the recovery rate. The analysis is useful for the testing and selecting of specific chemical compound which will react with heavy crude oil and improve the production.

Keywords: Chemical Flooding, Heavy Crude Oil, Solvents, Surfactants, Thermal Recovery and Viscosity

I. INTRODUCTION

Heavy crude oil has the characteristics of high density, viscosity, stickiness as their physical properties. The chemical characteristics of heavy crude oil are asphaltenes, resins, saturates and aromatics along with the high sulphur content and small amount of Nickel and Vanadium. Heavy crude oil is unconventional oil due to its difficulty in recovery and production processes. Table 1. gives the physical properties of heavy crude oil namely ˚API, density, viscosity ranges [1, 2].

Table 1. Physical properties of heavy crude oil [3]

	˚API	Density	Viscosity
Heavy crude oil	10˚- 22˚	920-1000	100-10000

Heavy crude oil recovery becomes tough due to its high viscosity and adhesiveness. In most of the petroleum companies, heavy crude oil is recovery by enhanced oil recovery as their primary or secondary recovery processes. The main enhanced oil recovery used for the heavy oil recovery is thermal recovery which uses heat effect to reduce the viscosity of heavy crude oil and helps in production. The thermal recovery methods used in the heavy oil are classified as steam based In-situ combustion and hot water flooding. Steam based recovery are dived into steam injection, Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD) [3, 4].

A chemical recovery method of heavy crude oil is rarely carried out due to the chemical inefficiency and lack of bonding with the unreactive heavy oil. The different chemical recovery methods are surfactant flooding, polymer flooding and alkaline flooding. In surfactant flooding any suitable surfactant such as anionic, cationic or non-ionic is flooded in the reservoir, which helps to reduce the interfacial tension between the crude oil and rocks or crude oil and water for the production of crude oil [5, 6].

In polymer flooding, appropriate polymers namely polyarcylamides (PAM) and xanthan gum (biopolymer) is applied in the crude oil well in order to increase the viscosity of water and improve the sweep efficiency. Alkaline flooding is an effective flooding process where the reservoirs have acidic conditions and some of the alkali such as sodium hydroxide and sodium carbonates are used. Alkaline flooding is not advised for the carbonate reservoirs due to abundant calcium ion which leads to the precipitation of hydroxide present in sodium hydroxide [7, 8].

In this research article, heavy crude oil was subjected to different chemicals namely salts, acids, surfactants, aromatics and saturates. The investigation helps to observe the changes on the surface of the heavy crude oil by the selected chemicals.

II. MATERIALS AND METHODS

A. Materials Required

Heavy crude oil was collected from the Western part of the Indian oil field for the investigation purposes. The laboratory chemicals were selected mainly salts, surfactants, acids, aromatics and saturates.

Chosen chemicals were Sodium Bicarbonate, Sodium Hydroxide, Sodium Chloride, Sodium Carbonate, Sodium Lauryl Sulphate (SLS), Triton X-100, Potassium Dihydrogen Orthophosphate, Calcium Sulphate, Barium Sulphate, Polyethylene Glycol, Diethyl Ether, 2-Chloro Phenol, Formaldehyde, Benzoic Acid, Barium Chloride and Acetone. Table 2. gives the picked chemicals and their corresponding structure and formula.

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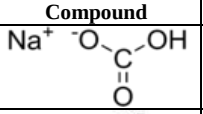
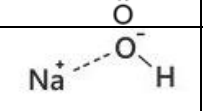
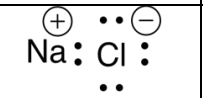
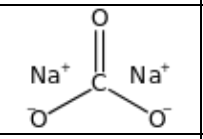
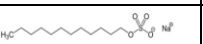
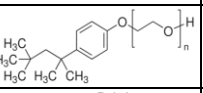
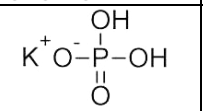
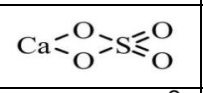
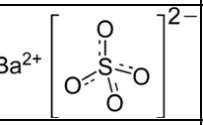
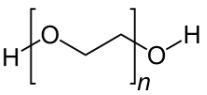
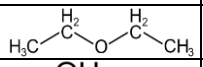
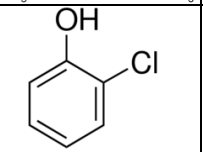
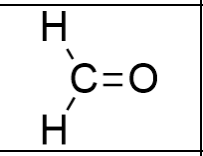
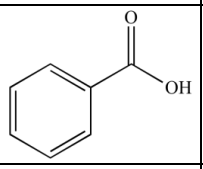
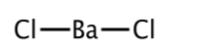
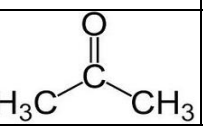
Table 2. Specifications of selected chemicals

Name of the Chemicals	Chemical Formula	Structure of the Chemical Compound	Mol. Mass (g/mol)
Sodium Bicarbonate	$NaHCO_3$		84.01
Sodium Hydroxide	NaOH		39.99
Sodium Chloride	NaCl		58.44
Sodium Carbonate	Na_2CO_3		105.98
Sodium Lauryl Sulphate (SLS)	$NaC_{12}H_{25}SO_4$		288.37
Triton X-100	$C_{14}H_{22}O(C_2H_4O)_n$ (n = 9-10)		647
Potassium Dihydrogen Orthophosphate	KH_2PO_4		136.08
Calcium Sulphate	$CaSO_4$		136.14
Barium Sulphate	$BaSO_4$		233.38
Polyethylene Glycol	$C_{2n}H_{4n+2}O_{n+1}$		18.02 + 44.05*n*
Diethyl Ether	$C_4H_{10}O$		74.12
2-Chloro Phenol	C_6H_5ClO		128.56
Formaldehyde	CH_2O		30.03
Benzoic Acid	$C_7H_6O_2$		122.12
Barium Chloride	$BaCl_2$		208.23
Acetone	C_3H_6O		58.08

B. Methodology

Selected chemicals were taken in specific concentration and mixed with water. Twice the same concentrations of each chemical were taken and mixed in hot water as well as ambient water (28 ˚C) separately. Same amount of heavy crude oil was used throughout the experimentation. The heavy oil was subjected to chemicals in both ambient water and hot water conditions.

III. RESULTS AND DISCUSSION

Heavy crude oil was investigated with the each chemical in ambient and hot conditions. Table 3. shows positive and negative sign of the chemicals in ambient water on heavy crude oil reaction. The chemical concentration in the ambient temperature showed no sign of phase change, viscosity reduction or heavy oil separation.

Heavy crude oil recovery at 28 ˚C chemical solution becomes a difficult condition and there will be no change in the surface of the heavy crude oil. The experimentation with the ambient temperature helps to avoid the reservoir treatment of chemical compounds at 28 ˚C which has no effect on the heavy oil.

Now, the experiment was conducted with the chemicals in hot water individually on heavy crude oil. Table 4. shows positive and negative sign of the chemicals in hot water on heavy crude oil reaction. Heavy crude oil found to show reaction on hot water with certain chemicals. The investigation results on heavy oil confirm that the selected surfactants, some salts and solvents can be applied in the crude oil recovery process.

Table 3. Effect of chemicals in ambient water (28 ˚C) on heavy crude oil

Name of the Chemicals	Density of chemicals (g/cm^3)	Reaction of Heavy crude oil and chemical
Sodium Bicarbonate	2.100	—
Sodium Hydroxide	2.13	—
Sodium Chloride	2.16	—
Sodium Carbonate	2.22	—
Sodium Lauryl Sulphate (SLS)	1.05	—
Triton X-100	1.07	—
Potassium Dihydrogen Orthophosphate	2.34	—
Calcium Sulphate	2.32	—
Barium Sulphate	4.5	—
Polyethylene Glycol	1.126	—
Diethyl Ether	0.713	—
2-Chloro Phenol	1.26	—
Formaldehyde	0.815	—
Benzoic Acid	1.27	—
Barium Chloride	3.86	—
Acetone	0.784	—

— means no reaction between chemicals and heavy crude oil
† means there is a reaction between chemicals and heavy crude oil

The selected surfactant reacts with heavy crude oil in the hot water conditions in other to reduce the surface tension and the particles tried to form an emulsion with the crude oil. Most of the solvents chosen were capable of reacting with heavy crude oil and many researches are being carried out in the field of heavy oil recovery by the injection of hot water with solvent. The influence of solvents and surfactants on the crude oil were fair than the salts and alkaline solutions.

Table 4. Effect of chemicals in hot water (80 ˚C) on heavy crude oil

Name of the Chemicals	Density of chemicals (g/cm^3)	Reaction of Heavy crude oil and chemical	Observations
Sodium Bicarbonate	2.100	—	Solution completely mixed with water but no reaction with the heavy oil
Sodium Hydroxide	2.13	—	No reaction between NaOH and heavy oil
Sodium Chloride	2.16	—	Deposition of salt on the surface of heavy oil
Sodium Carbonate	2.22	—	No reaction between NaOH and heavy oil
Sodium Lauryl Sulphate (SLS)	1.05	†	A few particles of heavy oil responded to the SLS
Triton X-100	1.07	†	A few particles of heavy oil responded to the Triton X-100
Potassium Dihydrogen Orthophosphate	2.34	†	A few particles of heavy oil responded to the KH_2PO_4
Calcium Sulphate	2.32	—	Calcium sulphate compounds got separated on addition of hot water
Barium Sulphate	4.5	—	Deposition of salt on the surface of heavy oil
Polyethylene Glycol	1.126	†	A few particles of heavy oil responded to the Polyethylene Glycol
Diethyl Ether	0.713	†	A few particles of heavy oil responded to the Diethyl Ether
2-Chloro Phenol	1.26	†	A few particles of heavy oil responded to the 2-Chloro Phenol
Formaldehyde	0.815	†	A few particles of heavy oil responded to the Formaldehyde
Benzoic Acid	1.27	—	Benzoic Acid compounds got separated on addition of hot water
Barium Chloride	3.86	—	No reaction between Barium Chloride and heavy oil
Acetone	0.784	—	No reaction between Acetone and heavy oil

— means no reaction between chemicals and heavy crude oil
† means there a reaction between chemicals and heavy crude oil

IV. CONCLUSION

Heavy crude oil is a high thick-viscous crude oil and recovery rate can be increased by the use of thermal enhanced oil recovery method. Several thermal methods apply heat effect through steam which reduces the viscosity of crude oil. The steam applied into the reservoir was generated either on the surface or sub-surface. The chemical enhanced oil recovery methods are used only in particular regions due to its slight reactivity with the heavy crude oil.

The investigation was carried out to give impression of the selected chemicals reaction with the heavy crude oil. The results of the experiments helps to find that the chemicals mixed with ambient water have no effect in the heavy crude oil. On the other hand, the same chemicals in hot water showed a positive response on the same amount of heavy crude oil. The selected chemicals particularly surfactants, solvents and some salts observed to react with heavy crude oil while other chemicals has no reaction with crude oil or separated in the preparations with hot water. The study assists in chemical flooding processes of heavy crude oil.

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