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[1]Yubin Zhang,
master student, e-mail: 1940390250@qq.com
[1]*Hongbin Yang,
PhD, Associate Professor,
e-mail: hongbinyang@upc.edu.cn
[2]Miao Li,
master student, e-mail: 519630341@qq.com
[1]Haizhuang Jiang,
doctoral student, e-mail: 2737353467@qq.com
[1]Ruichao Wang,
doctoral student, e-mail: wang_rchao@163.com
[1]Luyao Xing,
master student, e-mail: xly2841010053@163.com
[1]Haocong Li,
master student, e-mail: 1244243374@qq.com
[1]Shuhe Zhang,
master student, e-mail: 1009383847@qq.com
[1]Liang Peng,
master student, e-mail: 1539552876@qq.com
[1]Xin Chen,
master student, e-mail: xin_baobei77@163.com
[1]Haobin Shi,
master student, e-mail: 2842117353@qq.com
[1]*Wanli Kang,
Professor, e-mail: kangwanli@upc.edu.cn

[1]School of Petroleum Engineering, China University of Petroleum (East China), Qingdao, PR China
[2]Qingdao Huizhi Oilfield Service Company Limited, Qingdao, PR China

STUDY ON THE INFLUENCE FACTORS OF DEMULSIFIER ON OIL-WATER INTERFACE

Abstract

Natural surfactants such as gum and asphaltene in crude oil can form stable emulsions. Emulsions can cause significantly harm to crude oil storage, processing, product quality and equipment. Therefore, oilfield crude oil must undergo demulsification before being exported. However, conventional demulsifiers are difficult to dehydrate at low temperatures and the mechanism of action of low-temperature demulsifiers on oil-water interfaces is not clear. Therefore, this paper focused on the three low-temperature demulsifiers AR101, AR902, and AE405 selected from the Y block in X region, and used the interfacial rheological system of the interfacial tension meter to explore the low-temperature demulsification mechanism from the changes in oil-water interfacial tension. The results indicate that interfacial tension has a certain impact on crude oil demulsification, and the lower the interfacial tension value, the better the demulsification effect. As the concentration of the demulsifier increases, the interfacial tension value first decreases and then remains stable, indicating the existence of an optimal concentration that minimizes the interfacial tension. As the demulsification temperature increases, the interfacial tension between oil and water decreases, and the time required to reach stability becomes shorter, resulting in faster demulsification speed and better effectiveness. By studying the mechanism of low-temperature demulsification, theoretical guidance is provided for the on-site application of demulsifiers in oil fields.

Key words: emulsion, low temperature demulsifier, interfacial tension, interface rheology, oil-water interfacial tension.

Introduction

Chemical demulsification is the application of a chemical reagent to alter the oil-water interface, which can lower it. The characteristics of the interfacial facial mask are changed through the reaction of chemical reagents to make the interfacial facial mask thinner, so that the droplets are more likely to coalesce and demulsify [1–3]. This method is the easiest to apply in emulsion breaking methods and also the most optimal reaction method. The demulsification temperature of conventional crude oil demulsifiers used in most oil fields is 55–60C°, which can basically meet the requirements of crude oil dehydration. At present, the mining of Y block in X area has entered the three highs stage, and the properties of the extracted fluid have changed greatly. At the same time, in order to save costs, the gathering and transportation system does not heat the produced liquid in summer, which causes the temperature of most settling tanks in the gathering and transportation stations to drop to 26–30C°. As a result, the effectiveness of conventional crude oil demulsifiers has deteriorated, and the speed of oil-water separation has slowed down. Conventional demulsifiers can no longer meet the needs of oil fields [4–6].

The conventional demulsifier is difficult to dewater at low temperature, which is mainly because the viscosity of emulsion increases as the dehydration temperature of crude oil decreases, demulsifier molecules are difficult to disperse in crude oil, and the migration speed from oil phase to oil-water interface facial mask slows down. Low temperature demulsifiers with good performance can compensate for the shortcomings of conventional demulsifiers and effectively solve the problem of decreased demulsification effect caused by lower demulsification temperature and shorter demulsification time [7–10]. To solve the problem of poor demulsification effect caused by shortened demulsification time and reduced demulsification temperature in Y block of X area in recent years, the selected low-temperature demulsification system is further explored from the perspective of oil-water interface properties to provide theoretical guidance for oilfield field applications.

Materials and Methods

Dehydrated crude oil and formation water in Block Y of X area, with basic properties shown in Tables 1 and 2; Low temperature demulsifiers AR101, AR902, AE405; Sodium chloride, calcium chloride, analytical grade; China National Pharmaceutical Group Chemical Reagent Co., Ltd; Kerosene; Distilled water, self-made in the laboratory.

Table 1 – Basic properties of crude oil

Saturates/%	aromatics/%	resin/%	asphaltene/%
76.39	18.06	3.57	1.98

Table 2 – Basic properties of formation water

Ion concentration/ (mg/L)	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+
6510.23	123.27	2948.58	119.98	80.1	42.49	3195.81

The TX-500C interfacial tension meter (Biao Wei, America) was used to measure the changes in oil-water interfacial tension at different demulsifiers and demulsification temperatures, based on the rotating droplet method.

Results and Discussion

The influence of demulsifier types on oil-water interfacial tension

The changes in oil-water interfacial tension of demulsifiers AR101, AR202, and AR401 at a concentration of 100 mg/L at 35C° were shown in Figure 1.

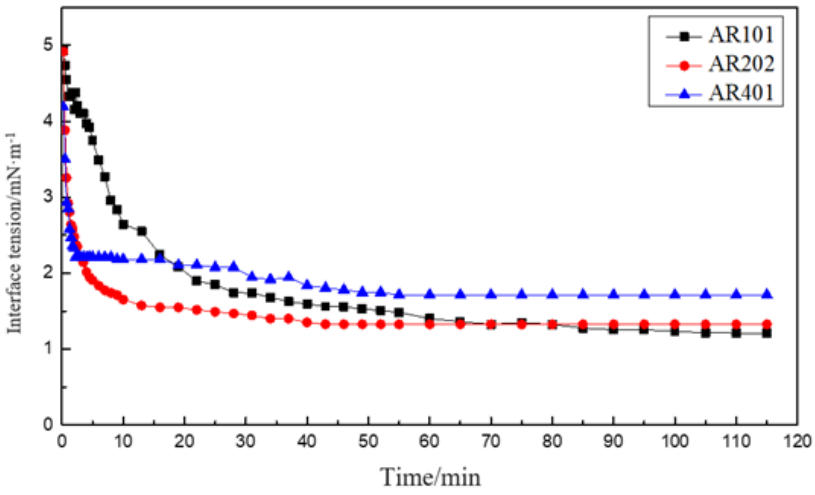

Figure 1 – Dynamic interfacial tension curve of demulsifier solution and crude oil

From Figure 1, it could be seen that after adding different demulsifiers, the interfacial tension between oil and water decreased, and the decrease was fast in the early stage, slow in the later stage, and gradually tended to stabilize. This indicates that in the early stage, the demulsifier can quickly adsorb on the oil-water interface through diffusion, effectively reducing the interfacial tension. The slowing down trend of the later curve indicates that the adsorption of demulsifier molecules at the oil-water interface has reached equilibrium, and the interfacial tension has decreased to the lowest.

Table 3 – Comparison of demulsification effects of different demulsifiers at 35C°

Type	Dehydration rate /%	Dehydration rate	Cleanliness of aqueous phase	Interface uniformity
AR101	95.66	1	2	2
AR202	83.52	2	2	1
AR401	52.15	2	2	3

According to Table 3, there is a corresponding relationship between interfacial tension and the performance of demulsifiers, that is, the lower the interfacial tension value, the faster the demulsification speed of crude oil emulsions, and the higher the dehydration rate.

Effect of demulsifier concentration on oil-water interfacial tension

The relationship between oil-water interfacial tension and time was measured at concentrations of 50, 100, 150, 200, and 300 mg/L of AR101 at 35 C°, as shown in Figure 2. As shown in the figure, with the increase of concentration, the interfacial tension of the demulsifier first decreased, and after reaching 150 mg/L, the downward trend slowed down and tended to stabilize.

Match the stable value of interfacial tension with the dehydration rate one by one in Figure 3. It can be seen that the interfacial tension between oil and water did not simply decrease with increasing concentration. there existed an optimal concentration that minimized the interfacial tension. As shown in the figure, before the concentration of the demulsifier reaches 150 mg/L, the interfacial tension decreased with the increase of demulsifier concentration. This indicates that at low concentrations,

as the concentration increases, the amount of surface active substances adsorbed on the oil-water interface increases and the interfacial tension decreases; After reaching 150 mg/L, increasing the concentration of the demulsifier resulted in an increase in interfacial tension. This indicates that when the concentration is too high, the surfactant self assembles to form micelles, resulting in a decrease in the effective adsorption capacity at the oil-water interface and a slight increase in interfacial tension.

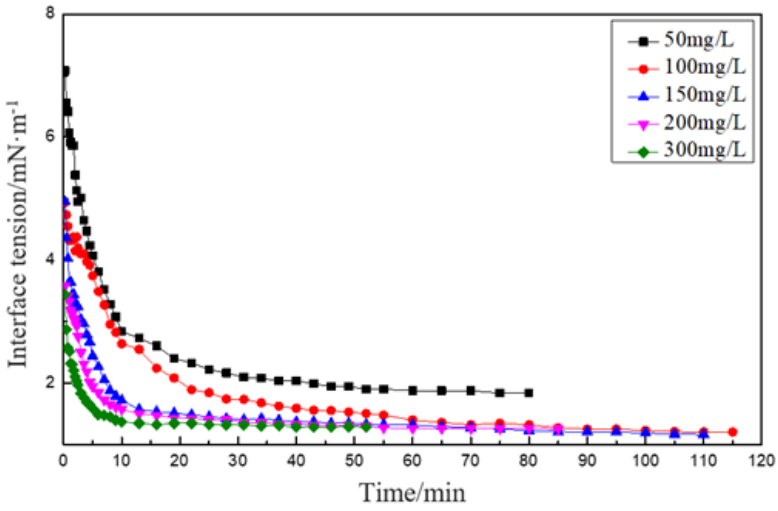

Figure 2 – Dynamic interfacial tension curves of demulsifier solutions with different concentrations and crude oil

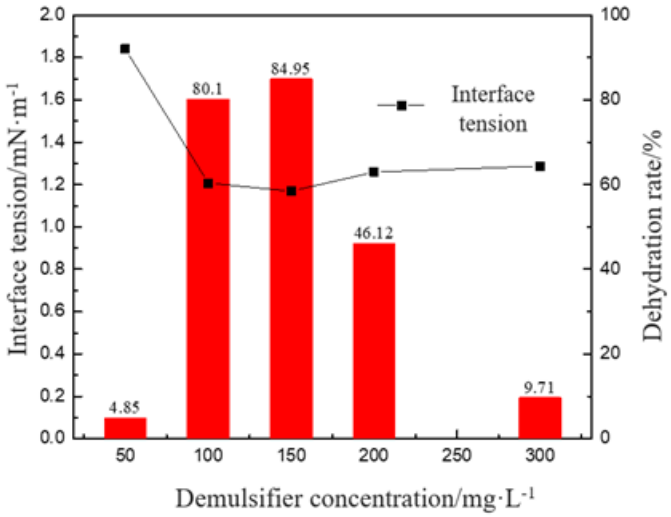

Figure 3 – Corresponding relationship between oil-water interfacial tension and dehydration rate at different concentrations

In summary, there is a corresponding relationship between dehydration performance and interfacial tension, and it is a process of first increasing and then decreasing, that is, the dehydration rate is highest when the emulsifier concentration reaches the optimal concentration.

Effect of demulsifier temperature on oil-water interfacial tension

The relationship between oil-water interfacial tension and temperature was measured at a concentration of 100mg/L for AR101, as shown in Figure 4.

From Figure 4, it could be seen that as the demulsification temperature increased, the interfacial tension between oil and water decreased. And the higher the temperature, the shorter the time required to reach a stable value.This is because as the temperature increases, the molecular motion becomes

more intense, and the demulsifier can adsorb more quickly to the oil-water interface. At the same time, the adsorption amount also increases, replacing more of the original film-forming substances and rapidly reducing the interfacial tension to a lower value. The corresponding relationship between dehydration rate and temperature was shown in Table 4, which proves that the higher the temperature, the lower the interfacial tension, the faster the corresponding demulsification speed, and the higher the dehydration rate.

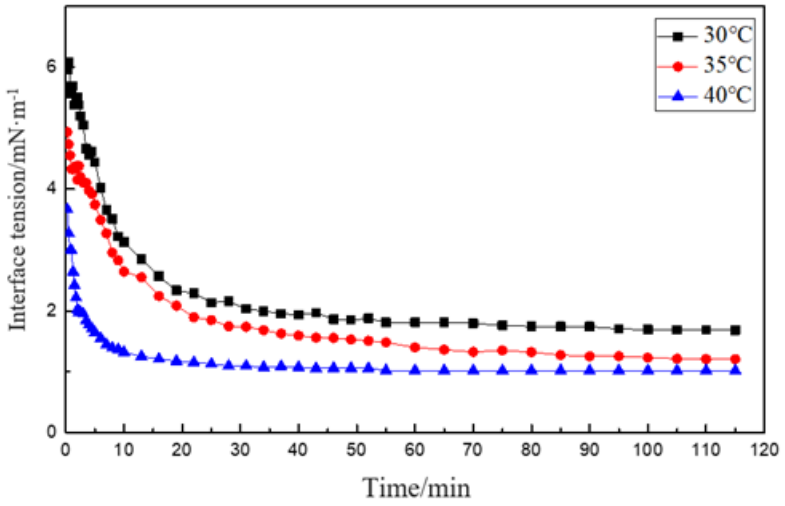

Figure 4 – Temperature dependent curve of oil-water interfacial tension

Table 4 – Relationship between dehydration rate and temperature

Evaluating indicator	Temperature		
	30C°	3C°	40C°
Dehydration rate /%	93.33	95.66	96.32
Dehydration speed	2	1	1

Conclusion

(1) Different demulsifiers can reduce the interfacial tension between oil and water, and the decrease is fast in the early stage, slow in the later stage, and gradually tends to stabilize. The main reason is that the adsorption of demulsifier molecules at the oil-water interface in the later stage has reached equilibrium, and at this point, the interfacial tension has been reduced to the lowest.

(2) The lower the interfacial tension value, the higher the dehydration rate of crude oil emulsion. As the concentration of the demulsifier increases, the interfacial tension decreases; After the concentration increases to a certain value, the interfacial tension remains stable and no longer decreases, so there is an optimal concentration for the use of emulsifiers.

(3) The increase in demulsification temperature leads to a decrease in the interfacial tension between oil and water, and the higher the temperature, the shorter the time required to reach a stable value, resulting in a faster demulsification rate.

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[1]Юбинь Чжан,
магистрант, e-mail: 1940390250@qq.com
[1]*Хонгбин Ян,
PhD, қауымдастырылған профессор, e-mail: hongbinyang@upc.edu.cn
[2]Мяо Ли,
магистрант, e-mail: 519630341@qq.com
[1]Хайчжуан Цзян,
докторант, e-mail: 2737353467@qq.com
[1]Руйчао Ван,
докторант, e-mail: wang_rchao@163.com
[1]Луяо Синь,
магистрант, e-mail: xly2841010053@163.com
[1]Хаоконг Ли,
магистрант, e-mail: 1244243374@qq.com,
[1]Шухэ Чжан,
магистрант, e-mail: 1009383847@qq.com
[1]Лян Пэн,
магистрант, e-mail: 1539552876@qq.com
[1]Синь Чэнь,
магистрант, e-mail: xin_baobei77@163.com
[1]Хаобин Ши,
магистрант, e-mail: 2842117353@qq.com
[1]*Ванли Канг,
профессор, e-mail: kangwanli@upc.edu.cn

[1]Мұнай инженериясы мектебі, Қытай мұнай университеті (Шығыс Қытай),
Циндао қ., ҚХР
[2]Циндао Хуэйжи мұнай сервистік компаниясы, Циндао қ., ҚХР

ДЕЭМУЛЬГАТОРДЫҢ МҰНАЙ-СУ ФАЗАЛАРЫНЫҢ БӨЛІНУ ШЕКАРАСЫНА ӘСЕР ЕТЕТІН ФАКТОРЫН ЗЕРТТЕУ

Аңдатпа

Шикі мұнайдағы табиғи беттік-белсенді заттар – сағыз және асфальтендер тұрақты эмульсиялар түзе алады. Эмульсиялар шикі мұнайды сақтау, өңдеу, өнім сапасы мен жабдықтың жұмысына айтарлықтай зиян келтіруі мүмкін. Сондықтан мұнай кен орындарында шикі мұнай экспортталмас бұрын демульсияландыруы қажет. Алайда, дәстүрлі демульгаторларды қолдану төмен температураларда сусыздандыруда қиындық

тудырады, ал төмен температуралы демульгаторлардың мұнай-су интерфейстеріне әсер ету механизмі жеткілікті деңгейде зерттелмеген. Осы мақалада X аймағындағы Y блогынан алынған үш төмен температуралы демульгатор – AR101, AR902 және AE405 зерттеліп, төмен температуралық демульгация механизмін зерттеу үшін мұнай-су фазааралық керілуінің өзгерісіне негізделген әдіс пайдаланылды. Бұл мақсатта фазааралық керілу өлшегіш пен фазааралық реологиялық жүйе қолданылды. Зерттеу нәтижелері шикі мұнайды демульсиялауға фазааралық кернеудің белгілі бір әсері бар екенін көрсетті. Фазааралық кернеу мәні неғұрлым төмен болса, демульсиялау әсері соғұрлым жақсы болатыны анықталды. Демульгатордың концентрациясы артқан сайын фазааралық керілу мәні алдымен төмендейді, кейін тұрақты күйге өтеді. Бұл фазааралық керілуді төмендететін оңтайлы концентрацияның бар екенін көрсетеді. Сонымен қатар, демульсия температурасы артқан сайын мұнай мен су арасындағы фазааралық керілу азаяды, ал тұрақтылыққа жету үшін қажетті уақыт қысқарады. Бұл өз кезегінде демульсия жылдамдығы мен тиімділігінің артуына ықпал етеді. Бұл зерттеу төмен температуралы демульгирлеу механизмін терең түсінуге ықпал етіп, мұнай кен орындарында демульгаторларды тиімді қолдануға арналған теориялық негіздерді ұсынады.

Тірек сөздер: эмульсия, төмен температуралы деэмульгатор, фазааралық керілу, фазааралық керілу реологиясы, мұнай-су фазааралық керілу.

[1]Юбинь Чжан,
магистрант, e-mail: 1940390250@qq.com
[1]*Хонгбин Ян, PhD,
ассоциированный профессор, e-mail: hongbinyang@upc.edu.cn
[2]Мяо Ли,
магистрант, e-mail: 519630341@qq.com
[1]Хайчжуан Цзян,
докторант, e-mail: 2737353467@qq.com
[1]Руйчао Ван,
докторант, e-mail: wang_rchao@163.com
[1]Луяо Синь,
магистрант, e-mail: xly2841010053@163.com
1Хаоконг Ли,
магистрант, e-mail: 1244243374@qq.com
[1]Шухэ Чжан,
магистрант, e-mail: 1009383847@qq.com
[1]Лян Пэн,
магистрант, e-mail: 1539552876@qq.com
[1]Синь Чэнь,
магистрант, e-mail: xin_baobei77@163.com
[1]Хаобин Ши,
магистрант, e-mail: 2842117353@qq.com
[1]*Ванли Канг,
профессор, e-mail: kangwanli@upc.edu.cn

[1]Школа нефтяной инженерии, Китайский нефтяной университет (Восточный Китай), г. Циндао, КНР
[2]Циндаоская Хуейжи нефтяная сервисная компания, г. Циндао, КНР

ИССЛЕДОВАНИЕ ФАКТОРОВ ВЛИЯНИЯ ДЕЭМУЛЬГАТОРА НА ПОВЕРХНОСТЬ РАЗДЕЛА ФАЗ НЕФТЬ-ВОДА

Аннотация

Природные поверхностно-активные вещества, такие как камедь и асфальтен, содержащиеся в сырой нефти, могут образовывать устойчивые эмульсии. Эмульсии могут нанести значительный ущерб хранению, переработке сырой нефти, качеству продукции и оборудованию. Поэтому перед отправкой на экспорт нефть с нефтяных месторождений должна подвергаться деэмульгированию. Однако обычным деэмульгаторам

трудно обезвоживать нефть при низких температурах, и механизм действия низкотемпературных деэмульгаторов на поверхности раздела нефть – вода неясен. Поэтому в данной статье основное внимание было уделено трем низкотемпературным деэмульгаторам: AR101, AR902 и AE405, выбранным из блока Y в области X, и использовалась межфазная реологическая система измерителя межфазного натяжения для изучения механизма низкотемпературной деэмульгации на основе изменений межфазного натяжения нефть – вода. Результаты показывают, что поверхностное натяжение оказывает определенное влияние на деэмульгацию сырой нефти и чем ниже значение поверхностного натяжения, тем лучше эффект деэмульгации. По мере увеличения концентрации деэмульгатора величина межфазного натяжения сначала уменьшается, а затем остается стабильной, что указывает на наличие оптимальной концентрации, которая минимизирует межфазное натяжение. С повышением температуры деэмульгирования межфазное натяжение между маслом и водой уменьшается и время, необходимое для достижения стабильности, сокращается, что приводит к увеличению скорости деэмульгирования и повышению эффективности. Изучая механизм низкотемпературной деэмульгации, мы даем теоретические рекомендации по применению деэмульгаторов на нефтяных месторождениях на месте.

Ключевые слова: эмульсия, низкотемпературный деэмульгатор, межфазное натяжение, реология межфазного натяжения, межфазное натяжение нефть – вода.

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