Recent Advances in
Petrochemical Science
ISSN: 2575-8578

Juniper Publishers
key to the Researchers

Review Article
Volume 1 Issue 5 - June 2017
DOI: 10.19080/RAPSCI.2017.01.555574

Recent Adv Petrochem Sci

Anionic Surfactant Adsorption: Insight for Enhanced Oil Recovery

Abbas AH, wan Sulaiman WR*, ZaidiJaafar M and AugustineAja A

Department of Petroleum Engineering, University of Technology, Malaysia, Malaysia

Submission: March 22, 2017, **Published:** June 19, 2017

***Corresponding author:** Wan Sulaiman WR, Department of Petroleum Engineering, Faculty of Chemical and Energy Engineering, UniversitiTeknologi Malaysia, UTM Skudai, 81310 Johor Bahru, Malaysia, Email: r-wan@petroleum.utm.my

Abstract

Surfactant flooding is a known enhanced oil recovery technique used in the oil and gas industry for decades. The primary principle of surfactant flooding is to reduce interfacial tension, wettability between the oil, water and rock, a lot of attention on research has been devoted to this area of study but the problem is the economical factor due to the high rate of surfactant loss to rock formation and clay minerals, as a result of surfactant retention. This paper therefore, is to review the basic concepts of surfactant nature, minerology, electorlyte, temperature and pH as future guide lines in addressing the surfactant losses due to the adsorption.

Keywords: Anionic surfactant; Adsorption; Miner logical; Salinity; pH; Temperature

Introduction

Oil is the most used nonrenewable source of energy in the world and this has led to the study of new processes for exploration and production of oil reservoirs. Oil and gas industry has invested heavily in increasing the recovery and productivity of reservoirs, mainly in processes of enhanced oil recovery (EOR) [1,2]. The enhanced recovery methods are processes that seek an additional recovery from the reservoirs, after their natural energy is depleted [3,4]. These methods have been developed with the objectives of producting more hydrocarbon than that provided just by the natural energy of the reservoir. It consist of the of thermal, microbial, hydrocarbon gas injection, and chemical injection, which consist mainly of the injection of fluids such as; alkali, surfactants and polymer into the reservoir to move the oil the oil to the well bore [5].

Surfactant flooding is a CEOR process that involves the injection of one or more Surfactant into the reservoir with the aim of lowering the interfacial tension between the oil and the water present in the reservoir [6-9]. These will lead to the pressure gradient across the oil droplets to exceed the retaining capillary force. The presence of surfactant between water and oil tend to re arrange the distribution between the two phases [10-12]. Surfactant system used for sandstone reservoirs comprise mainly of anionic surfactants [13], the use of Surfactnt in CEOR practice is quit challenging, if not well design could lead to the following; transport failure (Filtration and plugging), Chemical instability, Surfactant retention, and Adsorption on rock [14-20].

Adsorption phenomena refers to the collection of molecules on the external surface or internal surface of solids or liquids [21,22]. During the flooding process, the surfactant molecules tend to aggregate on the surface of rock which lower the initial concentration needed for lowering the interfacial tension (IFT). The amount of surfactant adsorbed depends on various parameters such as; types of surfactant used, the mineralogy and the morphological characteristics of the rock, presence of co-surfactants and alcohol, impurities, the nature of electrolytes existing in the solution , reservoir temperature and the pH of the reservoir [23-26].

Chemical EOR (CEOR) has been under the spotlight for decades and has attracted academic researcher attention particularly in the area of reservoir applications [5,6]. Several studies have in the past attempted to address the chemical flood challenges by studying these mechanisms responsible for the adsorption of the chemicals in order to preserve the concentration of effective groups during flooding [7].

This paper therefore, is to review the basic concepts of the aforementioned parameter for future guide line in addressing the surfactant losses due to the adsorption. The focus is on the effect of certain parameters on the anionic surfactant adsorption such as surfactant nature, minerology, electorlyte, temperature and pH.

Effect of anionic surfactant nature

The purity of anionic surfactants, hydrocarbon chain and functional groups all these conditions play a rule in surfactant adsorption. Anionic surfactant purity is not much of a concern to the oil and gas industry but however, it is a concern for colloids. Several reports states that the effect of the functional groups play an important role in the structure of the adsorbed layers depending on the packing of the molecules, which in turn depends on the mutual repulsion. For isomeric surfactants with the same functional group, the comparison of adsorption behaviour remains the same and strongly depends on the charge of the functional group [27-29]. As a result, surfactants with longer hydrocarbon chains has a much greater driving force for the aggregation, it shows that anionic surfactant with longer chain has direct relationship with aggregate on the rock surface [28].

Effect of mineralogy

Sandstone reservoir consists of different minerals the dominant are Sand-quartz, feldspar and clay minerals. The clay minerals vary based on the sandstone depositional environment, they include; kaolinite, illite, montmorillonite and chlorite. Several authors have attempted to address the effect of clay minerals presence on the adsorption of anionic surfactant with single adsorbent [30,31] or clay fraction effect [20]. They reported that the kaolinite mineral has the highest adsorption [32], the impact of mineral surface area also affect adsorption, even with the negative ions [33]. Sanchez et al. [33], investigated the effect of clay minerals structure and surfactant nature on adsorption, very few researchers have studied the effect of montmorillonite and illite as single adsorbent on the anionic surfactant [34]. All the results show that electrostatic bond between the kaolinite mineral and the anionic surfactant as the dominant adsorption mechanism and very weak hydrogen bond with the other clay mineral.

Effect of Salinity

The presence of free salt ions is one of the reasons for increased adsorption. The presence of sodium chloride (NaCl) and calcium chloride (CaCl2) in the solutions of anionic surfactants (NP4S, NP10S, NP25S, oxyethylenic) affects the adsorption of anionic surfactants on quartz and kaolin sample. Addition of salts increases the amount of anionic surfactants adsorbed on the solid surfaces [35]. Bera et al. [23] studied the Anionic surfactant, Sodium dodecylsulphate (SDS) (with 98% purity), they reported that, increasing the salinity of the solution, increased the adsorption of SDS on the sand surface, this is due to low electrostatic repulsion between the adsorbed surfactant species. Also, increase in the surfactant concentration, led to increase in adsorption on the surface of sand particles until it reaches the saturation point. Just recently, Yekeen et al. [36] investigated the adsorption of sodium dodecyl sulfate (SDS) on kaolinite at various surfactant concentration and added electrolyte (NaCl, CaCl2 and AlCl3), using the surface tension technique and two phase titration method. They concluded that, the adsorption of SDS by kaolinite increases with increasing concentration of NaCl and CaCl2. Indicating that the effect of monovalent ions increases the adsorption. However, the presence of divalent ions and tri-valent ions make the surfactant solubilisation less and causes surfactant precipitation.

Effect of Temperature

Early investigations of the temperature dependence of adsorption from solution indicated that adsorption decreases with increase in temperature [37,38]. Since adsorption is an exothermic process, the lower the temperature, higher the adsorption. However, interference from surfactant thermal decomposition should be eliminated for successful interpretation of the effect of temperature on adsorption. Mineral dissolution at elevated temperatures has caused sulfonate precipitation. Use of sulfonates as additives may require the addition of co surfactants and sequestering agents to improve surfactant solubility [39, 40].

Effect of pH

The effect of pH has a major role to play in adsorption, the charge of the rock surface is dependent on the pH. When the pH of an aqueous solution is lower than 6, the solid surface become more positive due to the adsorption of protons from the solution on to charged sites. The low pH will tend to increase the adsorption of anionic surfactants which is carrying the negative sign [41-43].

Conclusion

Considering the great variability of different surfactant types, anionic surfactant remains favorable for CEOR especially for sand stone reservoirs. The soil mineralogical composition, formation water total dissolved ions and reservoir temperature reported may affect the surfactant stability and adsorption in the practical field. The reported consideration need to be understood under different physicochemical conditions to avoid the surfactant losses and enabling the project to be economically feasible. This losses need to be eliminate which will led to open door for developing efficient anionic surfactant and processing schemes for oil recovery.

References

1. Aleklett K, Mikael H, Kristofer J, Michael L (2010O) the peak of the oil age–analyzing the world oil production reference scenario in world energy outlook 2008. Energy Policy 38(3): 1398-1414.
2. Hite JR, Maynard L, Ira Kuhlman M, Fair WB (2012) Managing Risk in EOR Projects. in SPE Latin America and Caribbean Petroleum Engineering Conference. Society of Petroleum Engineers, p. 7.

How to cite this article: Abbas A, wan S W, ZaidiJaafar M, Augustine A A. Anionic Surfactant Adsorption: Insight for Enhanced Oil Recovery. Recent Adv Petrochem Sci. 2017; 1(5): 555574. DOI: 10.19080/RAPSCI.2017.01.555574.

3. Latil M (1980) Enhanced oil recovery. Technip, pp. 252.

4. Lake LW (1989) Enhanced oil recovery. In: Cliffs NJ, Prentice Hall (Eds.), World Cat.

5. Thomas S (2006) Chemical EOR: The Past-Does It Have a Future? (Russian). Society of Petroleum Engineers, p. 49.

6. Sheng J (2010) Modern chemical enhanced oil recovery: theory and practice. Gulf Professional Publishing, USA.

7. Pope GA (2007) Overview of chemical EOR. In Presentation: casper eor workshop.

8. Schramm LL (2000) Surfactants: fundamentals and applications in the petroleum industry. Cambridge University Press, pp. 1-22.

9. Park S, Lee ES, Sulaiman WRW (2015) Adsorption behaviors of surfactants for chemical flooding in enhanced oil recovery. Journal of Industrial and Engineering Chemistry 21: 1239-1245.

10. Gogarty W (1976) Status of surfactant or micellar methods. Journal of Petroleum Technology 28(1): 93-102.

11. Cullum D (1994) Introduction to surfactant analysis. Springer.

12. Myers D (2005) Surfactant science and technology. (3rd edn), John Wiley & Sons, USA.

13. Hirasaki GJ, Miller CA, Puerto M (2008) Recent advances in surfactant EOR. in SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers, USA, pp. 35.

14. Howe AM (2014) Visualising surfactant enhanced oil recovery. Colloids and Surfaces A: Physicochemical and Engineering Aspects.

15. Gogoi SB (2011) Adsorption-desorption of surfactant for enhanced oil recovery. Transport in porous media 90(2): 589-604.

16. Salter SJ (1977) the influence of type and amount of alcohol on surfactant-oil-brine phase behavior and properties. in SPE Annual Fall Technical Conference and Exhibition. Society of Petroleum Engineers.

17. Graciaa A (1987) Partitioning of nonionic and anionic surfactant mixtures between oil/micro emulsion/water phases. SPE Reservoir Engineering 2(3): 305-314.

18. Ahmadi MA, Shadizadeh SR (2015) Experimental investigation of a natural surfactant adsorption on shale-sandstone reservoir rocks: Static and dynamic conditions. Fuel 159: 15-26.

19. Curbelo FD, Santanna VC, Neto EL, Dutra TV, Dantas TN, et al. (2007) Adsorption of nonionic surfactants in sandstones. Colloids and Surfaces A: Physicochemical and Engineering Aspects 293(1): 1.

20. Amirianshoja T, Radzuan J, Kamal Idris A, Rahmani O (2013) A comparative study of surfactant adsorption by clay minerals. Journal of Petroleum Science and Engineering 101: 21-27.

21. Dabrowski A (2001) Adsorption-from theory to practice. Adv Colloid Interface Sci 93(1): 135-224.

22. Desta MB (2013) Batch sorption experiments: Langmuir and Freundlich isotherm studies for the adsorption of textile metal ions onto Teff Straw (Eragrostis tef) agricultural waste. Journal of Thermodynamics, p. 6.

23. Bera A, Mandal A (2015) Micro emulsions: a novel approach to enhanced oil recovery: a review. Journal of Petroleum Exploration and Production Technology 5(3): 255-268.

24. Wilson M, Wilson L, Patey I (2014) The influence of individual clay minerals on formation damage of reservoir sandstones: a critical review with some new insights. Clay Minerals 49(2): 147-164.

25. Alvarado V, Manrique E (2010) Enhanced oil recovery: an update review. Energies 3(9): 1529-1575.

26. Sheng JJ (2015) Status of surfactant EOR technology. Petroleum 1(2): 97-105.

27. Scamehorn J, Schechter R, wade WH (1982) Adsorption of surfactants on mineral oxide surfaces from aqueous solutions: I: Isomerically pure anionic surfactants. J. Colloid Interface Sci 85(2): 463-478.

28. Bera A, Kumar T, Ojha K (2013) Adsorption of surfactants on sand surface in enhanced oil recovery: isotherms, kinetics and thermodynamic studies. Applied Surface Science 284: 87-99.

29. Mao X , Jiang R, Xiao W, Yu J (2015) Use of surfactants for the remediation of contaminated soils: a review. J Hazard Mater 285: 419-435.

30. Muherei MA, Junin R (2009) Equilibrium adsorption isotherms of anionic, nonionic surfactants and their mixtures to shale and sandstone. Modern Applied Science 3(2): 158.

31. Li H, Sheng G, Teppen BJ, Johnston CT, Boyd SA, et al. (2003) Sorption and desorption of pesticides by clay minerals and humic acid-clay complexes. Soil Science Society of America Journal 67(1): 122-131.

32. Lv W (2011) Static and dynamic adsorption of anionic and amphoteric surfactants with and without the presence of alkali. Journal of Petroleum Science and Engineering 77(2): 209-218.

33. Sánchez-Martín M, Dorado MC, del Hoyo C, Rodríguez-Cruz MS (2008) Influence of clay mineral structure and surfactant nature on the adsorption capacity of surfactants by clays. J Hazard Mater 150(1): 115-123.

34. Hower WF (1970) Adsorption of surfactants on montmorillonite. Clays Clay Miner 18(97105): 97-105.

35. Nevskaia D, Guerrero-Ruız A, Lopez Gonzalez JDP (1998) Adsorption of polyoxyethylenic nonionic and anionic surfactants from aqueous solution: Effects induced by the addition of NaCl and CaCl2. J Colloid Interface Sci 205(1): 97-105.

36. Yekeen N, Manan MA, Idris AK, Samil AM (2017) Influence of surfactant and electrolyte concentrations on surfactant Adsorption and foaming characteristics. Journal of Petroleum Science and Engineering 149: 612-622.

37. Groves T, Bowden S, Jones W (1947) Quantity of adsorbent and temperature as factors in adsorption from solution. Recueil des Travaux Chimiques des Pays-Bas 66(10): 645-654.

38. Somasundaran P, Fuerstenau D (1973) Heat and entropy of adsorption and association of long-chain surfactants at the alumina-aqueous solution interface. Transactions, p. 252.

39. Ziegler VM (1988) Laboratory investigation of high temperature surfactant flooding. SPE reservoir engineering 3(02): 586-596.

40. Ziegler VM, Handy LL (1981) Effect of temperature on surfactant adsorption in porous media. Society of Petroleum Engineers Journal 21(02): 218-228.

41. Amyx JW, Bass DM, Whiting RL (960) Petroleum reservoir engineering: physical properties. McGraw-Hill College, p. 610.

42. Hanna H, Somasundaran P (1977) Physico-chemical aspects of adsorption at solid/liquid interfaces. II. Mahogany sulfonate/berea sandstone, kaolinite. Academic Press, New York, USA.

43. Shahs DO (1981) Surface phenomena in enhanced oil recovery. In: Dinesh O Shah (Ed.), Springer US, ISBN: 978-1-4757-0337-5.

How to cite this article: Abbas A, wan S W, ZaidiJaafar M, Augustine A A. Anionic Surfactant Adsorption: Insight for Enhanced Oil Recovery. Recent Adv Petrochem Sci. 2017; 1(5): 555574. DOI: 10.19080/RAPSCI.2017.01.555574.

DOI: 10.19080/RAPSCI.2017.01.555574