colloids and interfaces

Editorial

Colloids and Interfaces in Oil Recovery

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The role of surface and colloid chemistry in the petroleum industry is of great importance to the many current and future challenges confronting this sector. Even though according the latest BP Energy Outlook (https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-energy-outlook-2019.html) alternative, more sustainable energy sources are making increasing contributions to global energy needs, crude oil output will nevertheless continue at least at the present level for decades to come. This increases the pressure on producers to recover crude oil more economically and with increasing environmental consideration. Therefore, the oil industry continues to work on many fronts towards improving procedures for extracting and processing these valuable resources.

The oil price has always been a key determinant for technological developments in oil recovery. For example, the high price of a barrel of crude oil in the 1970s and early-1980s stimulated the development of surfactant-based enhanced oil recovery (EOR) technology, as well as encouraging the pursuit of heavy oils and natural bitumen.

However, the fall in the oil price in the mid-1980s saw research into new technology decline, as extraction of incremental oil from conventional reservoirs, as well as heavy oil requiring unconventional methods, became uneconomic. Not until the early-2000s did the prospect of $100/barrel oil prices encourage oil producers to revisit the development of new technologies, based on improved physicochemical and geological understandings of the nature of crude oil reservoirs. One particular feature of this was that heavy oil and bitumen exploitation using mining and energy-intensive steam-based technologies increased in importance. In parallel with research into heavy oils, further research continued into conventional oil production. Thus, the past two decades have seen the development of more sophisticated approaches directed at improving the incremental recovery of conventional oil, with emphasis on oil/water/rock interfacial chemistry. Applied to crude oil reservoirs, studies have shown that rock wettability can be favorably influenced to aid oil recovery during waterflooding through the application of nanoparticles or by controlling the ionic composition of the water.

Therefore, the contents of this volume, contributed by an international group of researchers, address different aspects of oil recovery, emphasizing colloidal and interfacial aspects relevant to contemporary issues. Original research articles and reviews are included, with a focus on improving oil recovery, considering physical, chemical and microbial approaches as applied to conventional and heavy oils, as well as to natural bitumen.

Low salinity waterflooding (LSW), applicable to conventional oil recovery, was critically reviewed by Derkani et al. [1], focusing specifically on carbonate reservoirs. These authors provide evidence which confirms the benefits of LSW in improving recovery. They conclude that it is possible that no one mechanism is exclusively responsible for the effects seen, but rather, several of the reviewed mechanisms could be involved. In focusing on one specific mechanism, Taylor and Chu [2] explored the interfacial role of Ca^{2+} ions in LSW. Although a part of this investigation was in error, due to an inappropriate source of Ca^{2+} ions being used (Taylor et al. [3]), it nevertheless highlights that the coordination modes of Ca^{2+} ions are potentially relevant to crude oils, thereby warranting further research.

The roles of interfacial properties, and wettability in particular, on droplet displacement from surfaces were reviewed by Tangparitkul et al. [4] with reference to the action of different interfacially-active materials, including surfactants and nanoparticles (and derived nanofluids). Oil displacement mechanisms were considered in the presence of the different systems. Martins et al. [5] considered the specific effect of *n*-alcohols on the properties of asphaltene films at air/water and toluene/water interfaces, as these relate to crude oil emulsions formed during recovery.

Telles da Cruz et al. [6] demonstrated the possibility of modifying solid wettability through the use of cyclodextrins (CDs). The toroidal shapes of CDs create the ability for these supramolecular compounds to form inclusion complexes with linear hydrocarbons, producing what the authors term "pseudo-surfactants" and increasing the water-wettability of an initially hydrophobic C_{18}-modified quartz surface.

Two contributions consider sweep efficiency during waterflooding in porous media. In their study, Skauge et al. [7] firstly reviewed polymer flow in porous media, and followed that by introducing new rheological data from in-situ linear core-flood experiments. Significantly, it was found that the presence of oil reduced the apparent viscosity of the polymer solution. In the second contribution on this topic, Yeh and Juárez [8] demonstrated the use of a randomly close-packed porous micromodel, pre-saturated with silicone oil (viscosity = 5 cSt) to simulate the flow of polymer (polyvinylpyrrolidone) and surfactant (sodium dodecyl sulfate) solutions.

The remaining contributions focus on specific aspects of heavy oil and bitumen recovery. At the present time, heavy oil and natural bitumen amount to approximately 70% of global oil reserves. The physical properties of these resources, as well as the geology of the reservoirs, make the cost of recovery higher than for conventional oils. Particular emphasis is centered on cost and emissions reduction associated with recovery. Extending the requirement to improve sweep efficiency, in this case for the unfavorable mobility ratios associated with high viscosity heavy oils, Telmadarreie and Trivedi [9] investigated the application of surfactant and surfactant/polymer foams, in which they identified advantages in the presence of polymer. Various aspects of the interfacial chemistry involved in steam-based recovery methods were considered by Taylor [10], and how these might be improved with regard to efficiency of oil displacement under the high temperature conditions required to mobilize high viscosity oils. In a further development, Shibulal et al. [11] demonstrated the application of microbial EOR using two indigenous strains of *Bacillus* spp. isolated from soil contaminated with heavy crude oil from an Omani oilfield. In core tests, additional recoveries of around 8–10% were obtained.

At the outset, the aim of this Special Issue was to highlight the breadth of colloidal and interfacial applications in oil recovery, acknowledging the inevitability that the contributions could only be a snapshot of contemporary research. It is hoped that this has been achieved, at least in some small measure.

Conflicts of Interest: The author declare no conflict of interest.

References

1. Derkani, M.H.; Fletcher, A.J.; Abdallah, W.; Sauerer, B.; Anderson, J.; Zhang, Z.J. Low Salinity Waterflooding in Carbonate Reservoirs: Review of Interfacial Mechanisms. *Colloids Interfaces* **2018**, *2*, 20. [CrossRef]
2. Taylor, S.E.; Chu, H.T. Metal Ion Interactions with Crude Oil Components: Specificity of Ca2+ Binding to Naphthenic Acid at an Oil/Water Interface. *Colloids Interfaces* **2018**, *2*, 40. [CrossRef]
3. Taylor, S.E.; Chu, H.T.; Isiocha, U.I. Addendum: Taylor, S.E. Metal Ion Interactions with Crude Oil Components: Specificity of Ca2+ Binding to Naphthenic Acid at an Oil/Water Interface. *Colloids Interfaces* **2018**, *2*, 54. [CrossRef]
4. Tangparitkul, S.; Charpentier, T.V.J.; Pradilla, D.; Harbottle, D. Interfacial and Colloidal Forces Governing Oil Droplet Displacement: Implications for Enhanced Oil Recovery. *Colloids Interfaces* **2018**, *2*, 30. [CrossRef]
5. Martins, R.G.; Martins, L.S.; Santos, R.G. Effects of Short-Chain n-Alcohols on the Properties of Asphaltenes at Toluene/Air and Toluene/Water Interfaces. *Colloids Interfaces* **2018**, *2*, 13. [CrossRef]

6. Da Cruz, A.F.T.; Sanches, R.D.; Miranda, C.R.; Brochsztain, S. Evaluation of Cyclodextrins as Environmentally Friendly Wettability Modifiers for Enhanced Oil Recovery. *Colloids Interfaces* **2018**, *2*, 10. [CrossRef]
7. Skauge, A.; Zamani, N.; Jacobsen, J.G.; Shiran, B.S.; Al-Shakry, B.; Skauge, T. Polymer Flow in Porous Media: Relevance to Enhanced Oil Recovery. *Colloids Interfaces* **2018**, *2*, 27. [CrossRef]
8. Yeh, H.-L.; Juárez, J.J. Waterflooding of Surfactant and Polymer Solutions in a Porous Media Micromodel. *Colloids Interfaces* **2018**, *2*, 23. [CrossRef]
9. Telmadarreie, A.; Trivedi, J.J. Static and Dynamic Performance of Wet Foam and Polymer-Enhanced Foam in the Presence of Heavy Oil. *Colloids Interfaces* **2018**, *2*, 38. [CrossRef]
10. Taylor, S.E. Interfacial Chemistry in Steam-Based Thermal Recovery of Oil Sands Bitumen with Emphasis on Steam-Assisted Gravity Drainage and the Role of Chemical Additives. *Colloids Interfaces* **2018**, *2*, 16. [CrossRef]
11. Shibulal, B.; Al-Bahry, S.N.; Al-Wahaibi, Y.M.; Elshafie, A.E.; Al-Bemani, A.S.; Joshi, S.J. Microbial-Enhanced Heavy Oil Recovery under Laboratory Conditions by Bacillus firmus BG4 and Bacillus halodurans BG5 Isolated from Heavy Oil Fields. *Colloids Interfaces* **2018**, *2*, 1. [CrossRef]