Recent Advances in
Petrochemical Science
ISSN: 2575-8578

Juniper PUBLISHERS key to the Researchers

Mini Review
Volume 2 Issue 4 - July 2017
DOI: 10.19080/RAPSCI.2017.02.555592

Recent Adv Petrochem Sci

Experimental Study of Asphaltene Deposition: Short Review

Farhad Salimi*

Department of chemical engineering, Islamic Azad University of Kermanshah, Iran

Submission: June 15, 2017; **Published:** July 20, 2017

***Corresponding author:** Frahd Salimi, Department of chemical engineering, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran, Email: f.salimi@iauksh.ac.ir

Abstract

Asphaltenes are always present in crude oils, their instable form in oil could cause some problems. The asphaltene instability occurs due to variations in the pressure, temperature and composition. When asphaltene instability arises in oil, it deposits in the oil production, transportation, and processing stream. Finding the accurate place of this instability in oil pipes and reservoirs is of the most important. It should be mentioned that, the instability is not always considered as the prerequisite to create deposit in flow lines, because asphaltene flocs are carried out by the oil flow so they make no deposit. Therefore, assessing the behavior of asphaltene deposits in flow systems is necessary. To improve understanding and, hence, prediction of asphaltene deposition, several tests have been reported. Accordingly, asphaltene deposit in steel pipes with large diameter, capillary tubes, beds and Taylor-Couette cells can be mentioned. A capillary deposition test in long stainless steel capillaries has been used to investigate the tendency of a wide variety of oils to create deposits. In the capillary tube test, the measurement of pressure variations along the tube is utilized to assess the amount of deposit its. Findings of this section have been used to simulate asphaltene behavior in the reservoir porous media. Other tests have used pipe circular and a Taylor–Couette cell. They measure the amount of deposit indirectly by measuring temperature in different parts of the system. And their data are being used to develop simulators to predict the rate of growth of arterial asphaltene deposits under wellbore conditions.

Keywords: Asphaltene; Theoretical model; Deposition rates; Test loop; Laminar flow

Introduction

Generally, asphaltenes are part of the crude oil that is insoluble in normal alkanes (e.g., n-pentane and heptane) but soluble in aromatics (e.g., toluene and benzene). Also they have highest molecular weight and most polar oil components [1,2]. Asphaltenes composition, structure and stability are dependent on its source, and the type of solvent used for the extraction of oil [3-11]. Formation of asphaltene deposition during petroleum production causes several operational issues such as total or partial blocking of pipeline and wellbore, changes in wettability and some damages in equipment [12]. The flow assurance problem in the oil industry is identified as creating deposit in oil transfer pipes and oil reservoirs. The adsorption and deposition of asphaltenes on steel surface would restrict oil flow in the transportation pipelines [13,14]. The remediation of asphaltene problem would be very costly and in some cases it is considered as one of the designing parameters [15-18]. In many cases, the potential of organic solids depositions force the field managers to rely mostly on the chemical and mechanical remediation methods [19-22]. Asphaltene deposition in pipelines is a too complex and also depends on many parameters such as flow shear rate, surface type and characteristics, particle size and particle surface interactions [8]. Although, asphaltene precipitation in oil is a perquisite to create deposition but it is not enough and after precipitation, asphaltene particles need to approach the surface and stick to it to create asphaltene deposition, flow assurance problem, in the pipe lines. Therefore, better understanding of the mechanism of solid deposition is required for proper design treatments, including the effect of pressure, temperature, composition, additives and flow conditions. In the present research, a variety of laboratory methods of studying asphaltene deposition were assessed. Accordingly, designed and used laboratory apparatuses are stated and subsequently, each of them is described shortly.

Discussion

Tests of asphaltene deposition have been conducted primarily in two geometries: tubes of capillary (or a packed bed of beads) or larger dimensions and Taylor-Couette (TC) cells. Long capillary tubes, mainly of stainless steel, allow pressure measurements in a high surface area, low volume environment. In large diameter pipes, the asphaltene behavior is basically assessed by measuring temperature, pressure and sometimes amount of deposition directly. Therefore, the impact of concentration, flow and temperature on the asphaltene deposit in the pipe is studied. In tests with larger tubes wall temperatures were higher than the bulk temperature of the destabilized oil.

Capillary Tests

Brosetta et al. [23] developed the asphaltene capillary deposition test and established clearly that deposition occurs only when asphaltenes are unstable. They concluded that increasing molecular weight of asphaltene precipitant leads to the higher amount of deposition and also the rate of deposition increases with the distance from the deposition onset. Wang et al used a 100ft long stainless steel capillaries at low shear rates. They represented that, flow rate and length of capillary tube have no influence on the rate of deposition. They also showed that, by increasing the molecular weight of insoluble solvent the amount of deposition is more than the soluble solvent [11]. Hoepfner et al and Chai soon tornyotin et al investigated the deposition of asphaltenes in capillary tubes with different crude oils and nalkanes [24,25]. They have observed that asphaltene deposits are formed even at n-alkane concentrations below the point of instantaneous asphaltene aggregation detection. The results of Hoepfner et al. reveals that the main factor controlling asphaltene deposition is the concentration of insoluble asphaltenes present in a crude oil precipitant mixture and the instantaneous onset point is irrelevant to the deposition process.

Nabzar et al. [26] investigated the formation of asphaltene deposits in porous media and capillary tubes. The scaling relations between rate of deposit formation and flow rate were find to be independent of crude oil origin. They showed that there are two critical shear rates that affect deposit creation: at low shear rates up to first critical shear rate the deposition is in diffusion-controlled regime, whereas beyond the firsts critical shear rate to the second critical, the deposition of colloidal asphaltene is more sensitive to shear rate than the previous regime while both critical shear rates depend on stability of asphaltene in the mixture. Hashmi et al. [27] also studied asphaltene deposition in capillary tubes and observed similar behavior to Nabzar et al at high flow rates.

Bennett and Eskin et al. [28] introduced the asphaltene particle size as an important variable in the asphaltene deposition process, where an interplay between shear and adhesion forces on depositing asphaltenes will determine whether the asphaltene will adhere to the surface [4,28]. A new deposition apparatus, a packed bed of stainless steel beads, was designed and constructed to investigate asphaltene deposition. They observed that the asphaltene deposition rate increases linearly with the concentration of unstable asphaltenes and the asphaltene deposition process can be explained by a diffusion-limited deposition of nanoparticles [29].

Pipe-circular

Jamialahmadi et al. [5] investigated the mechanisms of deposition of flocculated asphaltene experimentally and theoretically under turbulence condition. The effects of oil velocity, flocculated asphaltene concentration and temperature on the rate of asphaltene deposition were investigated. Their results showed that the rate of asphaltene deposition increases with increasing flocculated asphaltene concentration and temperature while it decreases with increasing oil velocity. Salimi et al. [30] reported similar finding about asphaltene deposits in flow lines under smooth flow [9]. Shirdel et al. [31] studied the application of some particle deposition to predict published experimental data. Based on the studies performed, the authors concluded that the deposition models satisfactorily agree with experimental data and also applicable for modeling asphaltene deposition in crude oils as well as other particle deposition in gas flow streams. They also observed that increasing the flow velocity and decreasing the tubing surface temperature decreases the deposition rate significantly.

a novel experimental flow loop setup was designed by Khorram et al. [6] and constructed to carry out the turbulent flow of oil (Re up to ≈ 7500) through continuous measurements of pressure drop across the pipe. Their results showed that flow rate and asphaltene concentration are two most important factors in the rate of asphaltene deposition and decreasing them cause the attachment of asphaltene particles to the surface are decreased. One study using a fixed flow rate and changing ratios of heptane to two different petroleum fluids concluded that the amount of precipitating material is a strong contributor to the deposition behavior: when too little heptane was added to the petroleum fluid, very little deposition occurred; while the largest amount of heptane used, 50% by volume, generated the most deposition [25].

In larger metal pipes (24mm diameter), decreasing flow rate and increasing asphaltene content were both found to increase deposition, but the control parameters were varied only by a factor of two [32].

Furthermore, there is disagreement regarding the uniformity of deposition along the axial direction in a pipe. Evidence has been presented to suggest both that deposition is uniform throughout a given length of pipe and also that

How to cite this article: Farhad S. Experimental Study of Asphaltene Deposition: Short Review. Recent Adv Petrochem Sci. 2017; 2(4): 555592. DOI: 10.19080/RAPSCI.2017.02.555592

deposition occurs mainly near the pipe inlet [11,25]. A pipe-loop apparatus for investigation of oil stability was used to measure deposition thickness by salami et al. The effects of many factors such as oil type, oil temperature, oil velocity, inhibitors, and solvents on asphaltene deposition were investigated. Their findings showed that, the Heptane amount causes to deposition increase but the Toluene amount and the oil temperature have no influence on it and adding inhibitors decreased the rate of asphaltene deposition [8]. It should be pointed out that, even oil with stable CII will create deposition over a long time.

The TC apparatus was used to measure the asphaltene deposit and wax as a time function but the amount of asphaltene deposit was low, and deposit formation remained constant after a while. Results showed that, the oil still has constituents of deposit and if it uses again, the deposit will created by decreasing the pressure [33]. However, for oil with low asphaltene content, the amount of obtained asphaltene was a very small thus interpretation of tests was difficult. In order to overcome the limitation, later work was done with supplying fresh sample during the test. They found that shear has a significant impact on deposition in TC cell where the rate of asphaltene deposition is smaller at a pressure close to onset point than pressure close to bubble point of reservoir fluid [16].

Conclusion

In the present research, results of studying the asphaltene deposit as well as findings related to large diameter pipes, capillary tubes and sand bed apparatuses were assessed. Results showed that, experiments of capillary tubes were applicable to simulate the deposition of asphaltenes in porous media. The capillary tube results indicated that increasing amount of asphaltene precipitant leads to the higher amount of deposition and asphaltene deposits were formed even at n-alkane concentrations below the instantaneous onset point. Again, assessing the deposit in pipes with large diameter was applicable for wellbore simulation. Results of asphaltene deposition in large diameter pipes indicated that the increased flow rate of oil causes to decreased deposition. As the oil velocity increased, less deposition was noticed in this experimental study. Results of TC cell indicated that deposition tests can be performed on asphaltenic oils and the deposit wills create by decreasing the pressure.

References

1. Ali LH, Al-Ghannam KA (1981) Investigations into asphaltenes in heavy crude oils I Effect of temperature on precipitation by alkane solvents. Fuel 60(11): 1043-1046.
2. Hirschberg A, DeJong L, Schipper B, Meijer J (1984) Influence of temperature and pressure on asphaltene flocculation. Society of Petroleum Engineers Journal 24(3): 283-293.
3. De Boer R, Leerlooyer K, Eigner M, Van Bergen A (1995) Screening of crude oils for asphalt precipitation: theory, practice, and the selection of inhibitors. SPE Production & Facilities 10(1): 55-61.
4. Eskin D, Ratulowski J, Akbarzadeh K, Andersen S (2012) Modeling of asphaltene deposition in a production tubing. AIChE Journal 58(9): 2936-2948.
5. Jamialahmadi M, Soltani B, Müller-Steinhagen H, Rashtchian D (2009) Measurement and prediction of the rate of deposition of flocculated asphaltene particles from oil. International Journal of Heat and Mass Transfer 52(19): 4624-4634.
6. Khorram GA, Kharrat R, Soltani SB (2016) Investigation of the asphaltene deposition along the flow of the oil in tubing: Experimental study and a parametric analysis. Petroleum Science and Technology 34(10): 884-890.
7. Rassamdana H, Dabir B, Nematy M, Farhani M, Sahimi M, et al. (1996) Asphalt flocculation and deposition: I The onset of precipitation. AIChE Journal 42(1): 10-22.
8. Salimi F, Salimi J, Abdollahifar M (2016) Investigation of asphaltene deposition under dynamic flow conditions. Petroleum Science 13(2): 340-346.
9. Salimi F, Seftie MV, Ayatollahia S (2013) Experimental Investigation of the Effects of Different Parameters on the Rate of Asphaltene Deposition in Laminar Flow and Its Prediction Using Heat Transfer Approach. Journal of Dispersion Science and Technology 34(12): 1690-1696.
10. Soroush S, Pourafshary P, Vafaie-Sefti M (2014) A Comparison of Asphaltene Deposition in Miscible and Immiscible Carbon Dioxide Flooding in Porous Media. SPE EOR Conference at Oil and Gas West Asia. Society of Petroleum Engineers, pp. 10.
11. Wang J, Buckley JS, Creek JL (2004) Asphaltene deposition on metallic surfaces. Journal of dispersion science and technology 25(3): 287-298.
12. Islam M (1994) Role of asphaltenes on oil recovery and mathematical modeling of asphaltene properties. Developments in Petroleum Science 40: 249-298.
13. Mochida I, Zhao XZ, Sakanishi K (1988) Catalyst deactivation during the hydro treatment of asphaltene in an Australian brown coal liquid. Fuel 67(8): 1101-1105.
14. Faus FM, Grange P, Delmon B (1984) Influence of asphaltene deposition on catalytic activity of cobalt molybdenum on alumina catalysts. Applied catalysis 11(2): 281-293.
15. Akbarzadeh K, Eskin D, Ratulowski J, Taylor S (2011) Asphaltene deposition measurement and modeling for flow assurance of tubings and flow lines. Energy & Fuels 26(1): 495-510.
16. Akbarzadeh K, Ratulowski J, Lindvig T, Davies TL, Huo Z, et al. (2009) The importance of asphaltene deposition measurements in the design and operation of subsea pipelines. in SPE annual technical conference and exhibition. Society of Petroleum Engineers, p. 9.
17. Buckley JS (2012) Asphaltene deposition. Energy & Fuels 26(7): 4086-4090.
18. Hammami A, Ratulowski J (2007) Precipitation and deposition of asphaltenes in production systems: a flow assurance overview. in Asphaltenes, Heavy Oils, and Petroleomics, pp. 617-660.
19. Leontaritis KJ (2005) Asphaltene near-well-bore formation damage modeling. Journal of energy resources technology 127(3): 191-200.
20. Minssieux L (1997) Core damage from crude asphaltene deposition. in International Symposium on Oilfield Chemistry Society of Petroleum Engineers, p. 19.
21. Peramanu S, Clarke PF, Pruden BB (1999) Flow loop apparatus to study the effect of solvent, temperature and additives on asphaltene precipitation. Journal of Petroleum Science and Engineering 23(2): 133-143.

How to cite this article: Farhad S. Experimental Study of Asphaltene Deposition: Short Review. Recent Adv Petrochem Sci. 2017; 2(4): 555592. DOI: 10.19080/RAPSCI.2017.02.555592

22. Chang CL, Scott Fogler H (1996) Peptization and coagulation of asphaltenes in apolar media using oil-soluble polymers. Fuel Science and Technology International 14(1-2): 75-100.

23. Broseta D, Robin M, Savvidis T, Féjean C, Durandeau M, et al. (2000) Detection of asphaltene deposition by capillary flow measurements. in SPE/DOE Improved Oil Recovery Symposium. Society of Petroleum Engineers, p. 9.

24. Chaisoontornyotin W, Haji-Akbari N, Fogler HS, Hoepfner MP (2016) Combined Asphaltene Aggregation and Deposition Investigation. Energy & Fuels 30(3): 1979-1986.

25. Hoepfner MP, Limsakoune V, Chuenmeechao V, Maqbool T, Fogler HS, et al. (2013) A fundamental study of asphaltene deposition. Energy & Fuels 27(2): 725-735.

26. Nabzar L, Aguiléra M (2008) The Colloidal Approach A Promising Route for Asphaltene Deposition Modelling. Oil & Gas Science and Technology-Revue de l'IFP 63(1): 21-35.

27. Hashmi S, Loewenberg M, Firoozabadi A (2015) Colloidal asphaltene deposition in laminar pipe flow: Flow rate and parametric effects. Physics of Fluids 27(8): 083302.

28. Bennett CA (2012) A theory describing asphaltene adhesion fouling inside heat exchanger tubes. Heat Transfer Engineering 33(15): 1246-1250.

29. Vilas Bôas Fávero Cu, Hanpan A, Phichphimok P, Binabdullah K, Fogler HS, et al. (2016) Mechanistic Investigation of Asphaltene Deposition. Energy & Fuels 30(11): 8915-8921.

30. Salimi F, Ayatollahi S, Vafaie Seftie M (2017) An Experimental Investigation and Prediction of Asphaltene Deposition during Laminar Flow in the Pipes Using a Heat Transfer Approach. Iranian Journal of Oil & Gas Science and Technology 6(2): 17-32.

31. Shirdel M, Paes D, Ribeiro P, Sepehrnoori K (2012) Evaluation and comparison of different models for asphaltene particle deposition in flow streams. Journal of Petroleum Science and Engineering 84: 57-71.

32. Soltani SB, Rashtchian D, Tohidi B, Jamialahmadi M (2009) Integrated Modelling Methods for Asphaltene Deposition in Well string. Journal of the Japan Petroleum Institute 52(6): 322-331.

33. Zougari M, Jacobs S, Ratulowski J, Hammami A, Broze G, et al. (2006) Novel organic solids deposition and control device for live-oils: design and applications. Energy & Fuels 20(4): 1656-1663.

DOI: 10.19080/RAPSCI.2017.02.555592

How to cite this article: Farhad S. Experimental Study of Asphaltene Deposition: Short Review. Recent Adv Petrochem Sci. 2017; 2(4): 555592. DOI: 10.19080/RAPSCI.2017.02.555592