Journal of Petroleum Science and Engineering 196 (2021) 107990

Contents lists available at ScienceDirect

Journal of Petroleum Science and Engineering

journal homepage: http://www.elsevier.com/locate/petrol

Low-field NMR-relaxometry as fast and simple technique for in-situ determination of SARA-composition of crude oils

Vladimir Y. Volkov [a,d], Ameen A. Al-Muntaser [a,b,**], Mikhail A. Varfolomeev [a,b,*], Nailia M. Khasanova [c], Boris V. Sakharov [c,d], Muneer A. Suwaid [a,b], Richard Djimasbe [a,b], Ranel I. Galeev [c], Danis K. Nurgaliev [c]

[a] Department of Petroleum Engineering, Kazan Federal University, Kazan, 420008, Russia
[b] Department of Physical Chemistry, Kazan Federal University, Kazan, 420008, Russia
[c] Institute of Geology and Petroleum Technologies, Kazan Federal University, Kazan, 420008, Russia
[d] State Research Center for Applied Microbiology&Biotechnology, Obolensk, 142279, Russia

ARTICLE INFO

Keywords:
Low field NMR relaxation
SARA analysis
Heavy oil
Light oil
Group composition

ABSTRACT

In this study a new, fast and simple method based on low field NMR-relaxometry for in-situ determination of SARA (saturates, aromatics, resins and asphaltenes) composition of crude oils was proposed. This method was tested on 22 samples of crude oils with a wide range of SARA-composition and API gravity values (4.6–42.0°), including extra-heavy, heavy, medium and light crude oils. Results obtained by low-field nuclear magnetic resonance (LF-NMR) were compared with conventional SARA analysis method (ASTM D 4124). Comparison shows good coincidence between SARA values determined by LF-NMR and conventional method data for heavy fractions of asphaltenes and resins (R^2 is equal to 0.98 and 0.91, respectively) and for the sum of light fractions including saturates and aromatics ($R^2 = 0.96$). However, comparison for saturated and aromatic compounds separately gave low correlation coefficients ($R^2 \leq 0.61$ and 0.27, respectively) and relatively soaring standard deviation for individual correlations for saturates and aromatics (8.18 and 9.20). Consequently, LF- NMR relaxation as an alternative method for studying the composition of crude oil allows the determination of asphaltenes, resins and the sum of light fractions (saturates and aromatics) without their extraction (in-situ), which greatly simplifies and accelerates conventional chromatographic analysis. This method can be successfully applied for different types of crude oils with a wide range of API gravity and viscosity values.

1. Introduction

SARA fractionation is one of the most common techniques for characterizing crude oils and as a prediction method for asphaltene stability of reservoir fluids at the pressure depletion or mixing of different fluids (Kharrat et al., 2007; Rudyk, 2018). Moreover, SARA composition of crude oils presents important information for the production, transportation, processing and refining processes (Wu et al., 2012). In addition, the technique of SARA fractionation has been used for long time as a good method for evaluation the performance of different experimental processes such as the process of oxidation and upgrading of crude oils (Al-Muntaser et al., 2020; Kok and Gul, 2013; Kök and Gul, 2013; Varfolomeev et al., 2016; Yuan et al., 2018). Currently, asphaltene precipitation by alkanes with further usage of open column liquid chromatography (conventional SARA separation) is the most widely used technique to separate and to determine SARA fractions of crude oils. Moreover, according to the SARA fractions solubility in solvents with different polarity and their affinity for absorption on solid granular packing columns, such as, alumina, natural clays and silica gel in which ASTM D 4124 standard is most commonly used (Fan et al., 2002; Kharrat et al., 2007; Wu et al., 2012) Jewel et al. were the first researchers who worked out this type of SARA analysis method (Jewell et al., 1971). Development of other approaches was the focus of later studies for evolution of determination of SARA composition (Ashoori et al., 2017; Chaffin et al., 1996; Félix et al., 1987; Grizzle and Sablotny, 1986; Miller, 1982; Radke et al., 1984; Suatoni and Swab, 1975). It should be noted that, despite some features of this technique such as separated SARA fractions, which can be further studied, it has

* Corresponding author. Department of Petroleum Engineering, Kazan Federal University, Kazan, 420008, Russia.
** Corresponding author. Department of Petroleum Engineering, Kazan Federal University, Kazan, 420008, Russia.
E-mail addresses: almuntaser.ameen@gmail.com (A.A. Al-Muntaser), mikhail.varfolomeev@kpfu.ru, vma.ksu@gmail.com (M.A. Varfolomeev).

https://doi.org/10.1016/j.petrol.2020.107990
Received 29 February 2020; Received in revised form 14 August 2020; Accepted 26 September 2020
Available online 9 October 2020