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PHYSICAL ACOUSTICS

On Certain Characteristics of Ultrasound Attenuation in Suspensions of High-Molecular Oil Components

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Abstract—The paper presents experimental research data on the frequency and concentration dependences of additional ultrasound attenuation in mixtures of asphaltene in toluene. The results indicate that additional attenuation is determined by several different processes and has a relaxation nature. By juxtaposing the results to the data from several methods for studying similar model disperse systems, we show that changes in the concentration attenuation coefficient and its frequency dependence can provide additional information on structure transformations and phase transitions. The frequency dependence was measured in a range of 10–23 MHz. The concentration dependence was measured in the same frequency range from 0.1 to 10 wt %.

Keywords: disperse systems, high-molecular oil components, asphaltenes, supramolecular complexes, structure transformations, clusters, attenuation coefficient, relaxation theory, structural absorption

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INTRODUCTION

Interest in high-molecular compounds or oil components, so-called resinous-asphaltenic compounds (RACs), stems from both general challenges faced by petroleum chemistry and the needs of the oil-and-gas extraction and oil refining industries. The depletion of light crude reserves and increased energy consumption has lead to more active exploration of heavy crude and bituminous oil deposits, which have typically increased RAC contents. The highest-molecular part of RACs is represented by asphaltenes (mol. mass 300–1800 g/mol [1]), which, under normal conditions, are solid crystal-like substances that mix easily with aromatic hydrocarbons and precipitate as solid-phase particles with the addition of low-molecular *n*-alkanes. Asphaltene molecules are made of polycyclic aromatic or naphthene-aromatic rings that include heteroatoms (S, N, Cl, V, Ni, Fe, etc.) and pendent groups. Molecular diffusion measurements by time-resolved fluorescence depolarization and NMR spectroscopy showed the size of an asphaltene molecule to vary in the range of 1.2–2.4 nm [1]. Asphaltenes are characterized by polar molecules, considerable surface activity, and a propensity to form supramolecular complexes. During extraction, transport, and processing of feedstock, all of these properties cause various complications such as deposits on equipment surfaces and pipeline walls; sediments in the pore space of reservoirs; and reduced stability of water–oil emulsions to temperature, pressure, and variations in fluid composition that accompany technological processes. Determination of the conditions for the onset of structure formation and flocculation in model mixtures can reveal various ways to modify RAC properties, mitigate their negative impact, and use them more rationally. It is chiefly oil companies that are interested in solving problems related to RAC deposits and targeted alteration of feedstock properties, and they have long been funding various research in this direction. The main results and current notions about the nature of asphaltenes are systematized in rather detailed reviews [1, 2]. The authors point out that because many questions on the properties of resins and asphaltenes are debatable, and the available information is sometimes even controversial, no consensus has been reached on the structure transformation mechanisms for natural and model petroleum disperse systems.

This is because the properties of studied systems are influenced by many factors, such as the catagenesis of crude oil, the type of asphaltenes, the method of their separation, the time of contact with a flocculant, etc. Moreover, a significant part of the probing radiation is absorbed in the bulk of concentrated mixture samples, and structure formation processes are therefore studied mainly in thin films or weak mixtures, which makes the conclusions for a wider range of concentrations and the entire sample volume only hypothetical [1, 2]. Unresolved issues in the chemistry of high-molecular petroleum compounds require a variety of methods for analyzing and comparing data.