

## Conference Paper

# Dielectric Properties and Substantiation of Electromagnetic Technologies for Oil Sludge Processing

Eldar Rinatovich Abdeev<sup>1</sup>, Minikhan Abuzarovich Fatykhov<sup>2</sup>, Rail Idiatovich Saitov<sup>1</sup>, Rinat Gazizyanovich Abdeev<sup>1</sup>, and Lenart Minnehanovich Fatykhov<sup>2</sup>

<sup>1</sup>Bashkir State University, Ufa, Russia

<sup>2</sup>Bashkir State Pedagogical University named after Akmulla, Ufa, Russia

## Abstract

In the process of reception, storage and preparation of oil for processing, significant volumes of oil-containing sludge are formed, which are not only a source of pollution, but also a valuable hydrocarbon feedstock. Long-term storage of oil with water, contact with atmospheric oxygen, and the presence of solid particles hydrophobized with asphalt-resinous and paraffinous substances contribute to the formation of "intermediate layers" in these sludges, which are ultra-stable oil-water emulsions. It is proposed to use the energy of the electromagnetic field of the high and microwave ranges when developing a technology for the destruction of oil-water emulsions. After analyzing the composition of the oil sludge, experimental studies were conducted of the dielectric loss tangent  $\text{tg}^{\delta\delta}$  of oil with the addition of sand and paraffin, depending on the frequency of electromagnetic oscillations in the range of 30 - 160 MHz and temperature in the range of 25 - 80 ° C using the cumeter method. Studies have shown that two technologies for the disposal of oil sludge are possible: HF and UHF methods. To assess the effectiveness of their application, it is necessary to conduct experimental studies of the dielectric properties of oil sludge.

**Keywords:** oil sludge, oil sludge disposal, oil storage, oil-water emulsions, electromagnetic field.

Corresponding Author:

Eldar Rinatovich Abdeev  
air@bgutmo.ru

Published: 31 December 2020

Publishing services provided by  
Knowledge E

© Eldar Rinatovich Abdeev  
et al. This article is distributed  
under the terms of the [Creative  
Commons Attribution License](#),  
which permits unrestricted use  
and redistribution provided that  
the original author and source  
are credited.

Selection and Peer-review under  
the responsibility of the  
TECHNOGEN-2019 Conference  
Committee.

In the process of reception, storage and preparation of oil for processing at oil producing and oil refining enterprises, significant volumes of oil-containing sludge are generated, which are not only a source of pollution, but also a valuable hydrocarbon feedstock. [1]. Long-term storage of oil with water, contact with atmospheric oxygen, and the presence of solid particles hydrophobized with asphalt-resinous and paraffinous substances contribute to the formation of "intermediate layers" in these sludges, which are ultra-stable oil-water emulsions. [2].

The high stability of such emulsions creates special difficulties in the process of processing oil sludge with a high content of asphalt-resin-paraffin substances. The choice of optimal methods for the destruction of ultra-stable oil-water emulsions depends on

## OPEN ACCESS

many factors, in particular, on the composition and properties of the produced products. By influencing these factors and the nature of the relationship between paraffins, resins and asphaltenes, it is possible to control the structure formation of asphalt-resin-paraffin substances in the produced fluid, and consequently, the disposal of oil sludge. In recent years, the use of high-frequency (HF) and ultra-high-frequency (UHF) electromagnetic fields has become very promising. The choice of the above ranges is justified by the fact that for a water-oil emulsion, the dielectric parameters that determine the interaction of the field with the medium have two dispersion regions in the HF and UHF regions. The dispersion in the HF region is due to the polarization of the polar oil components (asphaltenes, resins), and the UHF region due to the polarization of water molecules. This fact makes it possible to use the energy of the electromagnetic field of the HF and UHF ranges when developing the technology for the destruction of water-oil emulsions.

The presence of the first maximum in the frequency change of the dielectric loss tangent characterizes the absorption of electromagnetic field energy by the medium and allows predicting the resonant interaction of objects with an HF electromagnetic field, i.e. when the frequency of the electromagnetic field is equal to the frequency at which the dielectric loss tangent has a maximum, the field energy is most intensively absorbed by the polar components of the medium, forming armor shells on the surface of water drops. Therefore, there arise intensive thermodynamic and hydrodynamic effects and molecular bond strength between the dipole molecules shell will decrease. This in turn will weaken the strength of the entire shell, which will lead to the destruction of the oil-water emulsion.

The presence of the second maximum in the frequency change of the dielectric loss tangent allows predicting the resonant interaction of the emulsion with a UHF electromagnetic field. In this case, the main energy is absorbed by the aqueous phase concentrated in globules coated with an armor shell. As a result, volumetric heat sources arise in the water globules, due to which they are intensely heated, leading to the destruction of the armor shell.

Thus, the interaction of oil sludge material with an electromagnetic field is determined by the nature of the dependence of its dielectric properties on frequency, temperature and pressure. These dependencies can only be determined experimentally.

Oil sludge is not a simple mixture of asphaltenes, resins and paraffins, but is a complex structured system with a distinct core of asphaltenes and a sorption-solvation layer of oil resins. Asphalt-resinous substances are heterocyclic compounds of a complex hybrid state, which include nitrogen, sulfur, oxygen and metals.

In the process of cleaning wells and pipelines from asphalt-resin-paraffin deposits, oil sludges are formed by standard methods that are hazardous to the environment. Table 1

presents the properties of the investigated samples of oil sludge, selected under these conditions. As can be seen from table 1, oil sludge also contains mechanical impurities, in particular sand.

TABLE 1: Properties of oil sludge samples.

Parameters	Object	
	East - Pass field, Kogalymneftegaz, oil sludgeA23	Oil sludgeSuzun-Vankor interfield pipeline
Asphaltenes, %	4	1
Resins, %	9	12
Paraffins, %	27	41
Mechanical impurities, %	1,4	5
Oil residue with water, %	58,6	41
ASPO melting point, °C	53, 6	61
Paraffin Melting Point, °C	54	63

The analysis shows that the dielcometric method, based on the peculiarities of the interaction of an HF EMF of low power with inhomogeneous media, is an informative method for determining the conditions for the effective action of powerful high-frequency and ultra-high-frequency electromagnetic fields on oil sludge. To this end, experimental studies were conducted of the dielectric loss tangent  $\text{tg}^{\delta\delta}$  of oil with the addition of sand and paraffin, depending on the frequency of electromagnetic oscillations in the range of 30 - 160 MHz and temperature in the range of 25 - 80 ° C using the cumeter method (Figures 1 - 3).

The dependence of  $\text{tg}^{\delta\delta}$  of the studied media on the frequency of electromagnetic oscillations obeys the laws characteristic of polar liquids. Since the same mass was maintained in the measuring cell, for oil with sand  $\text{tg}^{\delta}$  depends on the amount of sand - the larger the mass of sand, the less  $\text{tg}^{\delta\delta}$  of the mixture.

Approximating the data presented in Figure 3, we can set the crystallization temperature of paraffin from the extremum value  $\text{tg}^{\delta}$ . For example, for oil with the addition of paraffin, it equals  $53 \pm 1$  ° C, oil sludge Yak 3-7 -  $58 \pm 1$  ° C, oil sludge Ach3 -  $56 \pm 1$  ° C. Moreover, with increasing temperature, the medium  $\text{tg}^{\delta}$  increases. These experimental data show the need for heating oil sludge to temperatures of 60 ° C and to evaluate the values of the tangent of the dielectric loss angle of oil sludge.

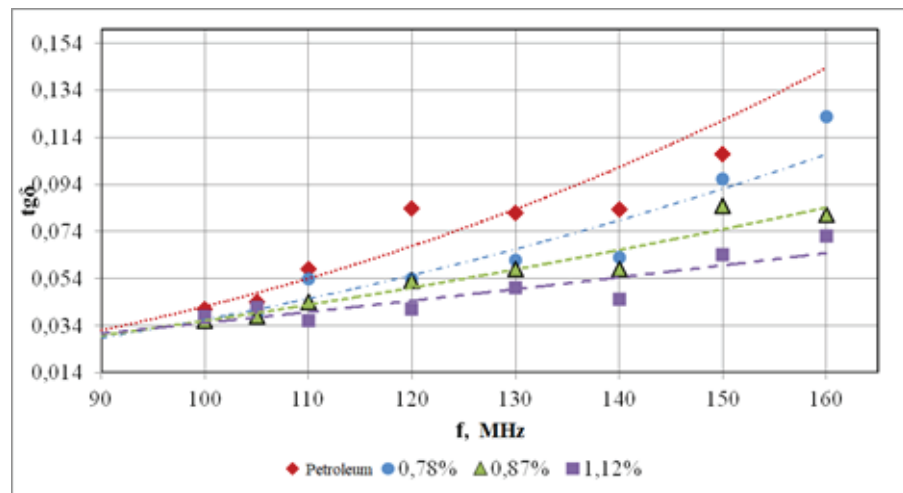


Figure 1: The dependence of the tangent of the dielectric angle losses of oil and sand mixtures

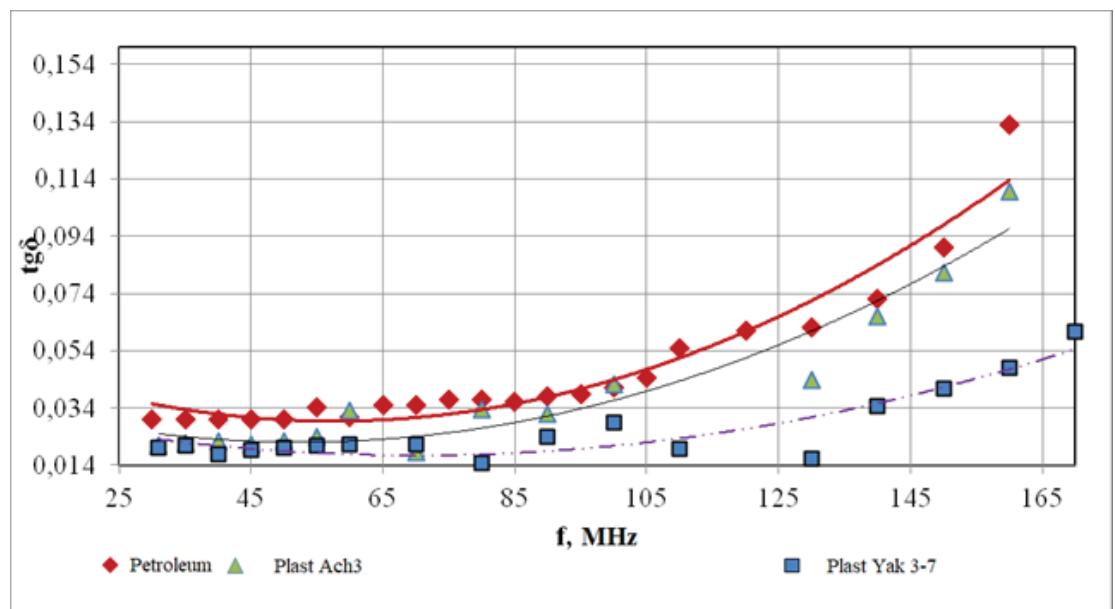
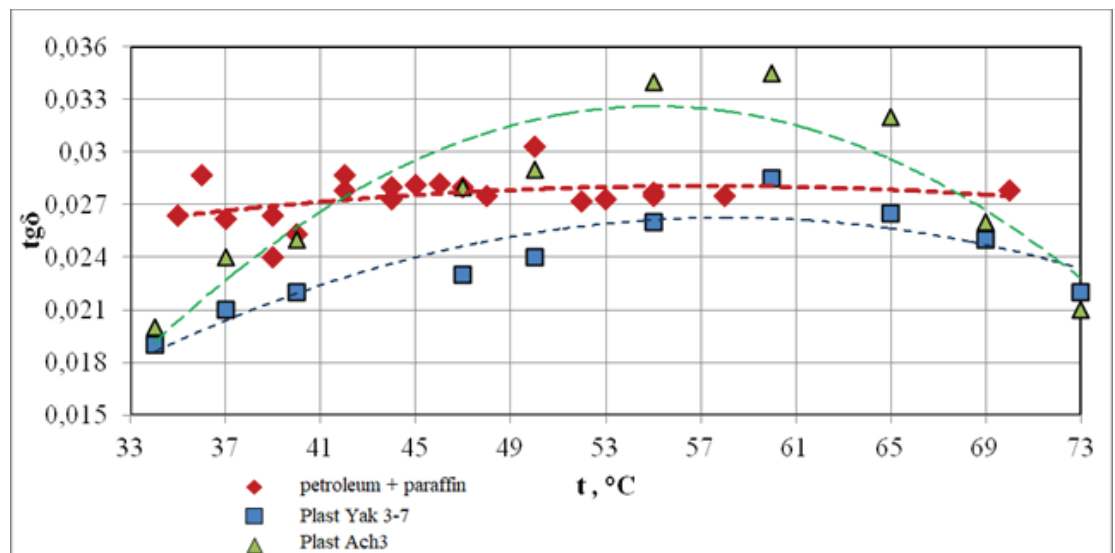


Figure 2: The dependence of the tangent of the dielectric loss angle of oil and oil sludge samples from the frequency of electromagnetic oscillations

## 1. Conclusion

Thus, two technologies for the disposal of oil sludge are possible: HF and UHF methods. To assess the effectiveness of their application, it is necessary to conduct experimental studies of the dielectric properties of oil sludge.

*This work was supported by the RFBR grant No. 18-29-24178*



**Figure 3:** The dependence of the tangent of the dielectric loss angle of oil with an additional paraffin content at a frequency of 35 MHz

## References

- [1] Antipin, Y.V., Valeev, M.D. and Syrtlanov, A.S. (1987). *Prevention of Complications in the Production of Waterlogged Oil*. Ufa: Bashk. Prince published, p. 168.
- [2] Pozdnyshev, G.N. (1982). *Stabilization and Destruction of Emulsions*. Moscow: Subsoil, p. 232.