




# Selection of an Efficient Solvent for Asphalt-Resin-Paraffin Deposits Using Model and Actual Field Samples

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**Abstract.** Optimizing chemical reagents for paraffin deposit control is essential for improving oil production efficiency. This study presents a comparative analysis of three solvents: a volatile commercial reagent, a novel in-house formulation, and a commercial aromatic-based product. Their performance was evaluated based on dissolution kinetics and effectiveness against both standard paraffin and actual field deposits using complementary testing methodologies.

The results revealed substantial differences in solvent behavior. The in-house developed reagent demonstrated superior performance, achieving high efficiency rapidly for complex deposits. While the commercial aromatic-based product eventually reached comparable ultimate efficiency, it exhibited significantly slower dissolution kinetics with a noticeable induction period. The third commercial reagent showed considerably lower overall effectiveness.

Technical and regulatory assessment identified further limitations of the commercial aromatic-based product, including reliance on expensive imported components and absence of key performance parameters in its specifications. Although possessing certain advantageous properties like low corrosivity, its slow action and regulatory concerns limit practical applicability. Consequently, the proprietary in-house developed reagent emerges as the most promising candidate, warranting further investigation and development for oilfield applications.

**Keywords:** asphalt-resin-paraffin deposits (ARPD), paraffin, efficiency of dissolving, solvesso, solvent

## 1. Introduction

Oil production during the late stages of field development faces a number of technological challenges, among which the problem of asphalt-resin-paraffin deposits (ARPD) holds a central position. These complex multicomponent systems form on the internal surfaces of production tubing, flow lines, and field pipelines due to changes in

thermobaric conditions and the disruption of the oil's colloidal equilibrium [1, 2]. The accumulation of ARPD leads to a reduction in flow area, increased hydraulic resistance, malfunctions in electric submersible pump (ESP) systems, and, consequently, significant economic losses associated with unscheduled shutdowns and costly workovers [3]. Within the operational context of Tatneft PJSC, minimizing failures of downhole pumping equipment caused by ARPD is a key objective in the program for reducing operational expenditures. The most common method for combating these deposits involves periodic treatments of wells and field pipelines with specialized chemical solvents [4].

Consequently, the development and search for new, more efficient, and cost-effective reagents is a pressing task. An adequate assessment of their potential requires a comprehensive approach that considers not only the final outcome (completeness of dissolution) but also the process kinetics, which is particularly crucial for optimizing well treatment protocols [5]. The objective of this research is to identify the compositional bases that provide solvents with the necessary efficacy and to determine ways to mitigate the shortcomings inherent in commercial samples.

## 2. Experimental section

### 2.1. Investigated Reagents

For the comparative testing, Reagent № 1 was selected—a commercial solvent widely used in the region, serving as one of the benchmark samples. However, it is characterized by a sharp odor and negative feedback from personnel working with it. This is likely associated with its chemical nature, which, according to open sources, is based on a composition of highly volatile aromatic solvents.

Based on this data, two reagents were developed. Reagent № 2 is a laboratory-synthesized reagent representing a balanced mixture of light aliphatic and aromatic hydrocarbons, synergistically enhanced with a combination of non-ionic surfactants. Reagent № 3 is a laboratory sample positioned as a multi-functional solvent for combating oil-sludge deposits. Its composition includes dearomatized and aromatic solvents, such as Solvesso, a non-ionic surfactant, and other components.

### 2.2. Test Methods

For a comprehensive evaluation of the reagents, two complementary methodologies based on the widely recognized "basket method" were employed to characterize their effects on different ARPD components.

**Standard Dissolution Methodology Using Paraffin Grade P-2.** This method is designed to evaluate a reagent's capacity to disrupt the crystalline paraffin matrix, which constitutes the structural framework of most deposits. The testing procedure involved dissolving a standardized sample of paraffin wax Grade P-2, conforming to GOST 23683-2021, with a mass of  $0.450 \pm 0.005$  g. The dissolution was carried out in a solvent at a constant mass ratio of 70:1 (solvent to paraffin), maintained at a temperature of 20°C

in a thermostated water bath, as illustrated in Fig. 1. The key efficacy criterion was the time to complete dissolution of the sample, determined by visual observation.

**Advanced Testing Methodology for Native ARPD under Static Conditions.** Given that actual deposits represent complex conglomerates, a methodology accounting for process kinetics was developed for adequate assessment. The test objects were native ARPD samples extracted from the well. Laboratory analysis determined their component composition as follows: paraffins – 33.15%, asphaltenes – 7.44%, resins – 11.23%, which is typical for deposits in this region.

**Sample Preparation:** The ARPD sample is melted in a water bath at 80°C until complete homogenization, poured into special cylindrical molds, and solidified at room temperature.

**Specimen Preparation:** The solidified deposits are cut into cylindrical specimens weighing 0.451 g, which are placed in individual mesh baskets, as shown in Fig. 2.

**Solvent Preparation:** 31.57 g of the test solvent is poured into chemical beakers and pre-thermostated at 20°C for at least 10 minutes.



Fig. 1. Paraffin P-2 Samples in Tested Solvents



Fig. 2. Native ARPD Sample of Required Mass

**Test Initiation:** The basket containing the specimen is immersed in the solvent, and the experiment start time is recorded.

**Cyclic Measurement:** At hourly intervals, the specimen is extracted, dried to remove residual solvent from the mesh basket, weighed on an analytical balance, and returned to the same beaker containing the test solvent.

**Test Completion:** The cycle is repeated until constant mass or complete dissolution of the ARPD is achieved. The dissolution efficiency is calculated using equations (1).

$$\eta = (m_0 - m_i)/m_0 * 100 \%, \quad (1)$$

where  $m_0$  is the initial mass of the native ARPD,  
 $m_i$  is the mass of the sample after  $i$  hours from the start of the test. Constructing kinetic curves enables analysis of not only the final result but also the process dynamics, including the presence of an induction period and the rate of efficiency accumulation.

### 3. Results and discussion

#### 3.1. Comparative Analysis of Paraffin Grade P-2 Dissolution

Testing on the model system - paraffin grade P-2 - demonstrated fundamental differences in the reagents' mechanisms of action. Commercial Reagent #1 and Reagent № 2 showed high and comparable efficiency, completely dissolving the sample within 51 and 59 minutes respectively. Such rapid kinetics indicate effective penetration of solvent molecules into the paraffin crystal lattice and its subsequent destruction. Thus, laboratory Reagent № 2 achieves the same properties as commercial Reagent № 1, but also replicates the same disadvantages related to strong odor and high volatility. Elimination of this disadvantage through the use of highly aromatic hydrocarbons like Solvesso in Reagent № 3 drastically reduces its efficiency in this test. The complete dissolution time exceeds 5 hours, making its application for operational paraffin plug removal technologically impractical. This can be explained by specific features of its formulation: despite containing a powerful dearomatized component, its effect is likely neutralized by other constituents that don't contribute to rapid destruction of the paraffin matrix, possibly being oriented toward asphaltene dispersion instead. It should also be noted that components of Reagents № 1 and № 2 (C5-C7 fractions) are more readily available on the market than Solvesso.

#### 3.2. Identify Kinetics and Efficiency of Paraffin P-2 Dissolution in Reagent № 3

Given that Reagent № 1 and Reagent № 2 rapidly dissolve the model paraffin sample compared to Reagent № 3, the kinetics of Reagent № 3 were additionally investigated under both static and dynamic conditions at a paraffin-to-solvent ratio of 1:70. Test results presented in Fig. 3 show that during the first 2 hours of the experiment under dynamic conditions at 1000 rpm, paraffin dissolution occurs twice as fast as under static conditions. However, complete dissolution was not achieved even after 4 hours, whereas for Reagents № 1 and № 2 this parameter is less than 1 hour. We suggest this result is associated with the content of Solvesso as the main component in Reagent № 3's composition, which is less effective against paraffin structures compared to the C5-C7 fractions present in Reagents № 1 and № 2.

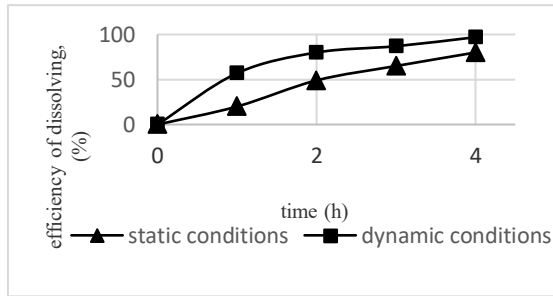


Fig. 3. Efficiency of Reagent No 3 on Paraffin P-2

### 3.3. Kinetics and Efficiency of Native ARPD Dissolution

The results obtained from testing with actual deposits are presented in Fig. 4 and Fig. 5.

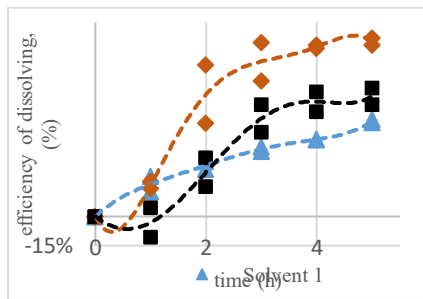


Fig. 4. Results of Testing with Native ARPD



Solvent 1                      Solvent 2                      Solvent 3

Fig. 5. Baskets with residual undissolved ARPD after 4 hours

Reagent No 1 demonstrated the worst performance among all samples. The dissolution efficiency increased at an almost linear rate and reached approximately 50% over the 5-hour experiment. The absence of a distinct plateau on the curve suggests that even

with prolonged exposure, the ultimate efficiency would remain substantially lower than that of samples № 2 and № 3. A comparative analysis of the data obtained for paraffin P-2 and native ARPD clearly demonstrates that evaluating a reagent's efficacy based on a single type of deposit can be misleading.

Reagent № 2 confirmed its high efficacy. Its kinetic curve was characterized by a steep initial ascent, indicating a high initial dissolution rate. Efficiency reached 48-78% within just 2 hours, and the process reached a plateau corresponding to 88% deposit dissolution by 4 hours. This dynamic is ideal from a technological standpoint, as it enables a high result to be achieved within a timeframe comparable to a typical well treatment cycle. Reagent № 2 demonstrated versatility, performing effectively on both pure paraffin and actual field deposits, attributable to its balanced formulation.

Reagent № 3 demonstrated fundamentally different kinetics. A pronounced induction period was observed, with efficiency not exceeding 5% during the first hour. This behavior may be associated with swelling of the ARPD sample prior to the active dissolution of the paraffin component. Although the final dissolution result is comparable to that of Reagent № 2, as confirmed by Fig. 5 after 4 hours from the test start.

#### 4. Conclusion

The following conclusions were drawn from the conducted laboratory tests: The methodology involving hourly monitoring of sample mass dynamics serves as an informative tool for the comparative assessment of not only the ultimate efficiency but also the dissolution kinetics of ARPD solvents. Despite its efficacy against Grade P-2 paraffin, Reagent № 1 demonstrates the opposite result when applied to actual wellbore deposits. Furthermore, this solvent contains low-boiling-point fractions, which creates uncomfortable and unsafe working conditions for personnel during field applications. Reagent № 2, formulated with C5-C7 fractions, exhibits properties of a fast-acting universal solvent, demonstrating significantly faster dissolution rates for both pure paraffin and complex wellbore deposits. While such a solvent is advantageous for rapid action, its application is constrained by the low boiling points and high volatility of its light fractions. Reagent № 3 contains a highly aromatic hydrocarbon (Solvesso) in its formulation, rendering it safer compared to other solvents in this series and suitable for cleaning deposit from tank internal surfaces where processing speed is not a critical factor. However, this solvent demonstrated critically low paraffin dissolution rates, which constitutes a fundamental limitation for its approval for field pilot trials. Reagent № 2 demonstrated the highest potential for industrial application, showing the optimal combination of high dissolution rate and completeness for both model substances and native deposits, coupled with lower production costs. It is recommended to conduct extended trials, including evaluation of its dispersing capacity, corrosivity, material compatibility, and ultimately, field pilot tests to validate the laboratory findings under actual operating conditions.

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