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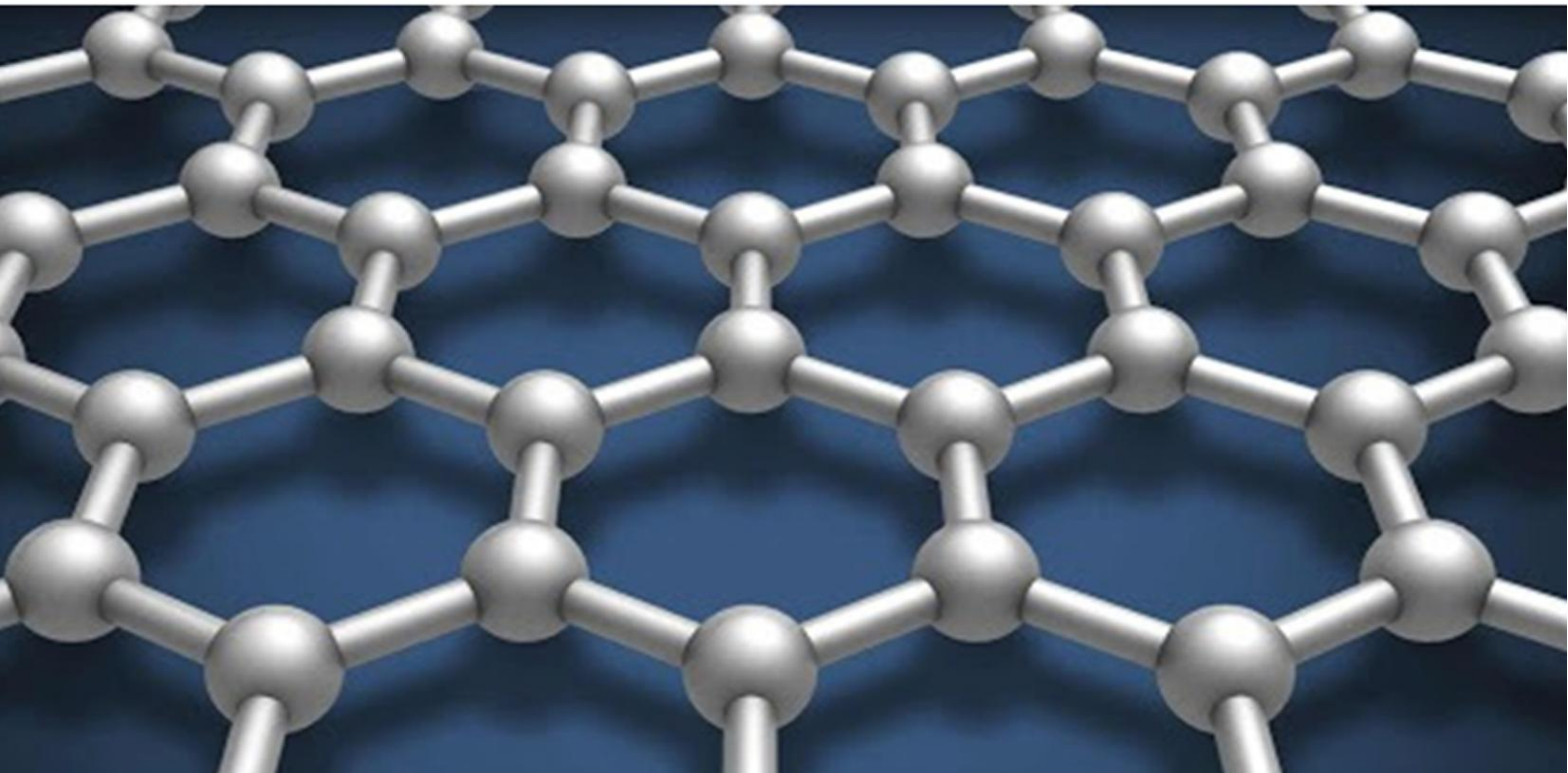
O‘zbekiston

Kompozitsion Materiallar

Ilmiy-texnikaviy va amaliy jurnali



Узбекский научно-технический и производственный журнал

Композиционные материалы

Qalmoqir konining tarkibida oltin bo‘lgan oksidlangan rudalarini eritish tajribalaridan olingan ma’lumotlarga asoslanib, asosiy texnologik ko‘rsatkichlar, eritish mahsulotlarining kimyoviy tarkiblari, shuningdek, oltin, kumush va misning fazalar bo‘yicha taqsimlanishi o‘rganilganda o‘xshash ekanligi aniqlandi. Oltin tarkibli shteynlarda mis miqdori 3,43-5,45 foiz oralig‘ida bo‘ldi.

Shteynlardagi mis va kumush miqdorining o‘zgarishi ularning konsentratsiyasiga sezilarli ta’sir ko‘rsatmadi. 1250˚C haroratda tarkibida mas. %: 53,1-56,3 SiO_2, 19,77-20,32 CaO, 12,12-12,77 Al_2O_3, 0,79-1,77 MgO, shlaklardagi mis miqdori 0,1%, oltin esa 0,128-0,145 g/t ga tengligi aniqlandi.

Shunday qilib, o‘tkazilgan tajribaviy eritish natijalariga asoslanib, sulfidli mis konsentratlaridan oltin tarkibli qaysar xomashyolarni eritishda (boyitishsiz: yanchish, flotatsiya va boshqalar) shteyn hosil qiluvchi flyus sifatida foydalanish shlak fazasida misning minimal miqdorida shteynda nodir metallarning samarali konsentratsiyasi shakllanadi, ushbu texnologik parametrlar bilan "Olmaliq KMK" AJ Mis eritish zavodining yallig‘ qaytaruvchi pechida sulfidli mis konsentratlarini shteynga eritish mumkin.

Xulosa. O‘tkazilgan tajribaviy eritish natijalariga asoslanib, sulfidli mis konsentratlaridan oltin tarkibli qaysar xomashyolarni eritishda (boyitishsiz, yanchish, flotatsiya va boshqalar) shteyn hosil qiluvchi flyus sifatida foydalanish toshqol fazasida misning minimal miqdorida shteynda nodir metallarning samarali konsentratsiyasini ta’minlashi aniqlandi, bu texnologik parametrlar bilan "Olmaliq KMK" AJ Mis eritish zavodining yallig‘ qaytaruvchi pechida sulfidli mis konsentratlarini shteynga eritish mumkin.

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RHEOLOGICAL CHARACTERIZATION OF SULFANOL-BASED SURFACTANT SYSTEMS

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Abstract. This study evaluates the rheological properties of Sulfanol-based surfactant solutions used in drilling and enhanced oil recovery (EOR) operations. Sulfanol solutions were prepared at concentrations of 0.1%, 0.3%, 0.5%, 1.0%, and 2.0%, and their viscosity was measured across shear rates ranging from 1–300 s^{-1} at temperatures of 25, 40, 60, and 80 °C. The results showed pronounced shear-thinning behavior at concentrations above 0.5%, where viscosity decreased from 9.8 mPa·s (10 s^{-1}) to 4.6 mPa·s (300 s^{-1}) for the 1.0% solution. Temperature caused a clear thinning effect, with viscosity of the 0.5% solution dropping from 5.9 mPa·s (25 °C) to 2.9 mPa·s (80 °C). Flow model analysis confirmed non-Newtonian behavior with flow indices $n < 1$ and increasing consistency coefficients (K) with concentration.

Keywords: Sulfanol, rheology, shear-thinning fluids, enhanced oil recovery, drilling fluids

Introduction. Surfactant-based chemical systems play a crucial role in modern oil extraction technologies, particularly in enhanced oil recovery (EOR), well stimulation, and drilling fluid engineering. Among these surfactants, *Sulfanol*-a petroleum-derived anionic surfactant-has gained wide industrial acceptance due to its strong surface activity, high emulsifying capacity, and ability to significantly reduce interfacial tension between oil and water phases. These characteristics make

Sulfanol an effective reagent for improving the displacement efficiency of crude oil, stabilizing drilling muds, and cleaning wellbore surfaces from paraffin, resin, and asphaltene deposits [1].

The performance of Sulfanol-containing systems in subsurface environments is primarily governed by their rheological behavior, which determines flow characteristics, suspension stability, and the capacity to transport solids and fluids under varying pressure–temperature conditions. Understanding the rheology of Sulfanol-based formulations is therefore essential for optimizing their application in drilling operations, enhancing sweep efficiency during water flooding, and ensuring stable fluid circulation in wellbores [3].

Despite the widespread industrial use of Sulfanol, comprehensive rheological investigations of its solutions under operational conditions remain limited. Variations in concentration, salinity, temperature, and shear rate can greatly influence viscosity, flow index, structural stability, and thixotropic behavior of Sulfanol-containing fluids. These parameters directly affect pumping requirements, wellbore cleaning efficiency, and overall technological performance.

Therefore, this study aims to systematically evaluate the rheological properties of Sulfanol solutions and Sulfanol-modified drilling fluids, providing insights into their flow behavior and operational applicability. The results will contribute to the development of optimized formulations for improved oil recovery and drilling efficiency [4].

Materials and Methods

Materials. Commercial petroleum-derived anionic surfactant *Sulfanol* (industrial grade) was used as the primary reagent in this study. The surfactant was supplied in liquid form with an active substance content of 40–45%. All solutions were prepared using distilled water. Sodium chloride (NaCl), calcium chloride ($CaCl_2$), and magnesium chloride ($MgCl_2$) (analytical grade, Sigma-Aldrich) were used to investigate the effect of salinity on rheological behavior.

To evaluate the influence of temperature, the solutions were examined within the range of 25–80 °C, which corresponds to typical conditions encountered during drilling and enhanced oil recovery (EOR) processes. Different concentrations of Sulfanol (0.1%, 0.3%, 0.5%, 1.0%, and 2.0% w/v) were prepared to study concentration-dependent rheological responses.

Rheological Measurements. Rheological properties were measured using a rotational rheometer equipped with a cone-and-plate geometry (Brookfield DV3T or equivalent), ensuring accurate control of shear rate and temperature. The following parameters were investigated: Apparent viscosity (η), shear stress (τ), shear rate ($\dot{\gamma}$), flow behavior index (n), consistency coefficient (K), thixotropy loop area

Measurements were performed at shear rates ranging from 1 to 300 s^{-1}. Each sample was equilibrated at the target temperature for 10 minutes prior to testing. For each condition, three parallel measurements were taken, and the average value was recorded.

Results and Discussion. The rheological analysis demonstrated that the viscosity and flow characteristics of Sulfanol-based systems strongly depend on surfactant concentration, salinity, and temperature. At low concentrations (0.1–0.3%), Sulfanol exhibited near-Newtonian flow, whereas higher concentrations (>0.5%) resulted in pronounced shear-thinning behavior. The increase in apparent viscosity is attributed to enhanced micelle formation and structural interactions within the aqueous phase.

Table 1.

Apparent viscosity (mPa·s) of Sulfanol solutions at different concentrations and shear rates

Concentration (%)	10 s^{-1}	50 s^{-1}	100 s^{-1}	300 s^{-1}
0.1	2.1	1.8	1.7	1.6
0.3	3.4	2.8	2.5	2.2
0.5	5.9	4.1	3.5	3.1
1.0	9.8	6.7	5.4	4.6

The data in Table 1 clearly show that viscosity decreases with increasing shear rate, confirming the pseudo-plastic (shear-thinning) nature of concentrated Sulfanol solutions. This behavior is beneficial for drilling and EOR operations, as high viscosity at low shear rates improves suspension stability, while reduced viscosity at high shear rates facilitates pumping and circulation.

Increasing Sulfanol concentration enhances intermolecular interactions and leads to formation of elongated micellar structures that resist deformation at low shear rates. As the shear rate increases, these structures align in the flow direction, resulting in a measurable drop in viscosity.

Fitting the rheological data to the Ostwald–de Waele model yielded flow behavior indices ($n < 1$) for all concentrations above 0.5%, confirming non-Newtonian pseudo-plastic behavior. Meanwhile, the consistency coefficient (K) increased proportionally with Sulfanol concentration, indicating improved structural integrity and flow resistance at low shear rates.

3. Разработка и технология получения композиционных материалов

4. Прикладные, экономические и экологические аспект применения композиционных материалов

5. Методы исследовании, приборов и оборудований композиционных материалов