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# APPLICATION OF SURFACTANT COMPOSITIONS AND ALKALINE BUFFER SYSTEMS

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**Abstract:** In the development of physicochemical technologies, a clear trend has emerged toward endowing oil-displacing fluids with self-regulating properties, allowing them to maintain their functions in the reservoir for extended periods. One version of this trend has been realized, based on the concept of an oil-displacing fluid as a physicochemical system with negative feedback. These concepts formed the basis for the development of physicochemical principles for selecting surfactant compositions, taking into account the thermodynamic and kinetic parameters of the oil-rock-aqueous phase system, which influence oil displacement from a porous medium.

**Keywords:** organic solvents, ionic associates, cation, tetraphenylarsonium, tetraphenylphosphonium, triphenyl lead, ionic association, benzene, toluene, xylene.

**Introduction:** It is proposed to use alkaline buffer systems with a maximum buffer capacity in the pH range of 9.0–10.5 to provide negative feedback in oil-displacing compositions of ICH, allowing them to maintain and self-regulate a set of colloidal chemical properties optimal for oil displacement purposes [6]. The choice of alkaline buffer systems is due to the important role of physicochemical processes involving hydroxylions in the mechanism of oil displacement from the capillary-porous medium of the formation by aqueous solutions of surfactants. Such interactions include reactions of neutralization of acid groups, saponification of ester bonds, deprotonation of donor heteroatoms of heteroatomic compounds of oil, association of hydroxylions with aromatic fragments of molecules of oil components, influence on the structure of water and, thereby, on hydrophobic binding and conformational mobility of the hydrophobic parts of the surfactant. These interactions reduce interfacial tension and viscosity at the oil-water interface, increase water wettability of the reservoir rock, and reduce surfactant losses due to adsorption on the rock.

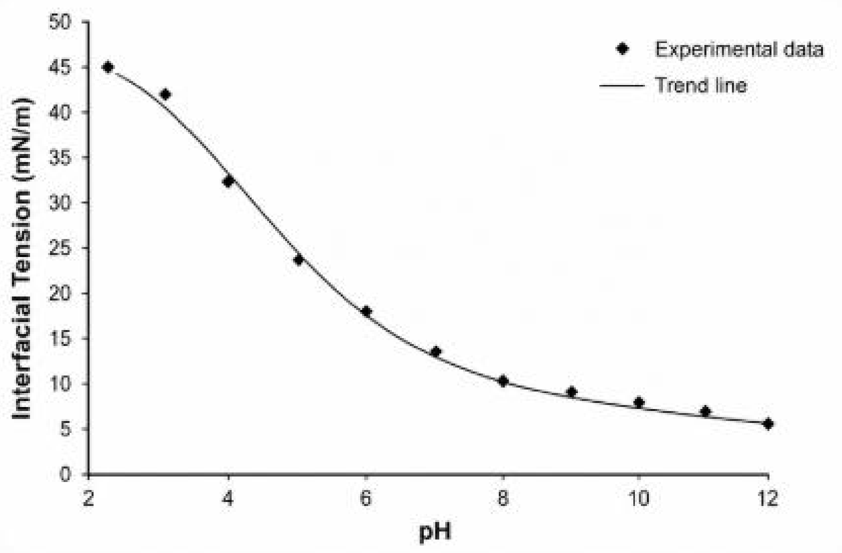
Systematic studies of the effect of pH and ionic strength of aqueous electrolyte solutions on the interfacial tension of oils and their fractions have led to the development of an electrocapillary model of the interfacial layer, according to which it possesses the properties of an ion-exchange membrane, representing an amphoteric adsorption layer for natural oil surfactants.

**A literature review of the topic.** The model explains the extreme nature of the dependence of interfacial tension of oils on aqueous phase pH by the existence of an electrical double layer (EDL), which arises from the ionization of ionogenic groups of natural oil surfactants—heteroatomic compounds found in resins and asphaltenes. The model allows us to relate the component composition of oil to the physicochemical parameters of the interfacial layer that determine the mechanism of oil displacement by aqueous solutions: interfacial tension, adsorption of natural surfactants in the oil, and the composition and concentration of electrolytes in the aqueous phase. Within this model, the dependence of the interfacial tension of oil s on the pH of the aqueous phase is expressed by the equation

$$\mathbf{s = s_i + bJ^2\,[lg(a_{H^+} + KI) - pH_i]^2 - cJ^4[lg(a_{H^+} + KI) - pH_i]^4 - G_0RTln(1 + K_aI)}$$

where pHi is the isoionic point of the interfacial layer (pH of the maximum of the curve s – pH); si is the interfacial tension at the isoionic point; b is the integral capacitance of the DEL; c is the parameter characterizing the dependence of the integral capacitance of the DEL on its potential; ; an+ is the activity of hydrogen ions of the aqueous phase; K is the ion-exchange equilibrium constant for the interfacial membrane; I is the ionic strength of the aqueous phase; Ka is the adsorption constant of electrolyte ions in the interfacial layer; G0 is the limiting adsorption of electrolyte ions in the interfacial layer; R is the universal gas constant; T is the temperature; J = 2.303RT/F; F is the Faraday number. Figure 1 shows, as an example, the calculated and experimental dependence of the interfacial tension on pH for oil from the Sovetskoye field, formation AB1-2, at the boundary with an aqueous electrolyte solution with a constant ionic strength.

**Results:** The most promising for industrial application at oil fields are ICN compositions based on surfactants and an ammonia buffer system formed by ammonia and ammonium nitrate—inexpensive industrial products with a virtually unlimited raw material base. A distinctive feature of ICN compositions is that their components are integral parts of the geochemical cycles of nitrogen, carbon, and oxygen. This ensures their environmental acceptability and versatility: the components serve as a food source for indigenous reservoir microflora, natural indicators and tracers of filtration flows in the reservoir, etc. These are fire-resistant fluids with a freezing point of –33 … –55 °C. ICN compositions provide a 10–20% increase in displacement efficiency. They can be used over a wide range of reservoir temperatures and formation waters, in the development of low-permeability and heterogeneous formations. During oil displacement with ICH compounds, the mobility of the filtered fluid increases by 3-7 times, indicating the potential for significantly increasing the injectivity of injection wells during bottomhole formation treatment. Specific surfactant losses (adsorption) on core material during oil displacement are 0.2-0.6 mg/g.



Dependence of the interfacial tension of oil at the boundary with an aqueous electrolyte solution with constant ionic strength
(I = 0.1 mol/kg water) on pH: 1 – experiment, 2 – model.

Field tests revealed the stimulating effect of ICH compositions on the development of reservoir microflora. Components of the ammonia buffer system are integral to the geochemical nitrogen cycle and provide additional nitrogen nutrition for anaerobic and aerobic microorganisms in the trophic chains of the microbial biocenosis of the oil reservoir. Studies of microbiological processes conducted at injection sites showed that the number of denitrifying and heterotrophic microorganisms, including Pseudomonas and Actinomices, was significantly higher than at control sites. The number of sulfate-reducing bacteria in the extracted waters of the test sites was significantly lower than in the injected and extracted waters of the control sites.

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