Surface Energy of Water Propanol and Oil-Toluens Phases

Vladyslav A. Voloshynets1, Yevgen V. Kobylyansky2 and Igor V. Semeniuk3
1. Lviv Polytechnic National University, S. Bandery str. 12, Lviv, Ukraine
2. SC “MASMA”, Palladinaave., 46, Kyiv, Ukraine
3. JSC “T. Shevchenko URIPI”, V. Velykogo str., 4, Lviv, Ukraine

Received: August 01, 2014 / Accepted: August 28, 2014 / Published: November 10, 2014.

Abstract: The surface activity of heterogeneous systems from water solutions of propanol-1, propanol-2 and oil-toluens mixtures has been investigated. An interfacial surface energy on the verge of division of water propanol solutions and oil-toluens mixtures, calculated by Dzhirifalco-Gud equation and by stalagmomethric method, has been defined. It has been shown that Dzhirifalco-Gud equation can be applied for calculating of interfacial energy in heterogeneous system of water propanol solutions with oil-toluens mixtures on condition of variable values of empirical parameter $F$, calculated by experimental data.

Key words: Interphase energy, oil, water-propanol solution.

1. Introduction

The formation of over-alcaline plastic lubricating grease occurs in emulsion of II type composed from alcohol-water solution and oil-toluens mixture [1, 2]. In the oil toluens mixtures, the alcohol-water solutions form droplets of a nanometer size [3], serving as nanoreactors for interaction of calcium hydroxide with carbon oxide (IV): pro-fateric and pro-calcium carbonation. During the pro calcium carbonation, the nanoparticles forming the thixotropic nanosystems-highly functional over-alcaline lubricating grease, are created [4]. The effectiveness of the processes happening in nanoparticles and on interphases surfaces, firmness and stratification of these systems depend on the surface energy on the verge of division of organic and alcohol-water phases. For its proper estimation in indicated heterogeneous systems it is necessary to apply calculating and experimental methods. We have reported that according to experimental data concerning the surface tension in systems of water-methanol and water-ethanol solutions and oil-toluensmixtures, interphase oil tension-water-methanol and water-ethanol solutions, and calculations by Dzhirifalco-Gud equation it has been determined that water-methanol solutions have an advantage for nanoreactors for calcium hydroxide carbonation formation with over-alcaline lubricating grease creation [5]. It has also been shown that Dzhirifalco-Gud equation can be applied for calculating the interphase energy in these systems on condition of variable value of parameter $F$ by altering the alcohol concentration in the solution [5]. Simultaneously, the application of propanols for nanoreactors formation, in which at indicated mechanism over-alcaline lubricating grease are formed, and especially calculating and experimental determination of interphases tension between alcohol-water solutions and organic phase evoke interest.

The purpose of this work was investigation of...
interphase surface energy in heterogeneous systems formed from water propanol solutions and oil, toluen-smixtures.

2. Experiments

The calculation of interphase energy between two liquids is carried out by several ways. According to Antonov’s rule, it is defined as following:

$$\sigma_{12} = \sigma_2 - \sigma_1$$  \hspace{1cm} (1)

where, \(\sigma_1\) and \(\sigma_2\) are surface tension of liquids on the verge with air.

But this correlation is applied only in separate cases and does not have a universal character. The Dzhirifalco-Gud equation is applied more widely for calculating the interphase energy in various systems with two liquids which are not mixed.

Oil MS-20 (Table 1), distilled water, propanol-2 brand “lux” (ISO 4221), propanol-1 LAB-SCAN (Ireland), toluene (ISO 5789-78), neonol 9-10 (TS 38.103625-87), Vaseline oil of Chinese production (\(\eta = 1.477-1.481, \eta = 6.27-8.81 \text{ mm}^2/\text{s}, \text{concentration of aliphatic acids not more than 1\%}) have been used in experiments.

Surface tension on the verge with air has been defined by the method of bubble rushing by (Rebinder’s method), using a formula:

$$\sigma_x = \sigma_o \frac{P_x}{P_o}$$  \hspace{1cm} (2)

where, \(\sigma_x\) is surface tension of investigated solution; \(\sigma_o\) is surface tension of water or toluene; \(P_x\) is pressure at which the bubble has rushed by in the solution, mm a column of alcohol; \(P_o\) is pressure at which the bubble has rushed by in water or toluen, mm a column of alcohol.

The value of surface tension has been calculated by Eq. (2), using water for comparison in case of alcohol-water systems, and toluen in case of oil-toluens mixtures.

Methods of determining the surface tension have been tested on water solutions of neonol 9-10, surface tension of which determined during experiments was 33-34 mJ/m², which coincides with literary data [7].

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Characteristics of oil MS-20.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity ((\text{mm}^2/\text{s}))</td>
<td>Group carbohydrate composition (% mas.)</td>
</tr>
<tr>
<td>50 °C</td>
<td>100 °C</td>
</tr>
<tr>
<td>144.3</td>
<td>19.5</td>
</tr>
</tbody>
</table>

Interphase tension between organic and alcohol-water phases has been determined by stalagmotemetric method and calculated by Dzhirifalco-Gud equation [6],

$$\sigma_{12} = \sigma_1 + \sigma_2 - 2F\sqrt{\sigma_1\sigma_2}$$  \hspace{1cm} (3)

where, \(\sigma_1\) is surface tension of alcohol-water solutions on the verge with air; \(\sigma_2\) is surface tension of oil-toluens mixtures on the verge with air.

For measuring interphase tension on the verge of division of alcohol-water solutions-oil mixture a stalagmometer with capillary diameter 0.0005 m in which alcohol-water solution has been poured was used. A stalagmometer beak has been plunged into oil, drops have been formed and separated within two or more minutes. Oil mass before the experiment and after a fall of not less than five drops has been measured on analytical scale with accuracy 0.0002 g. Drops masses ranged from 0.0966 g to 0.1630 g. Interphase tension has been calculated by Eq. (4) [8].

$$m_{\text{drop}} = 2\pi \cdot r \cdot \sigma$$  \hspace{1cm} (4)

Methods of interphase tension determination have been tested on heterogeneous system vaseline oil-water. The value of interphase tension determined during our experiments was 120.8 mJ/m² what was close to literary data [9].

3. Results and Discussion

Isotherms of surface tension of propanol-1 and propanol-2 are similar (Fig. 1), since the surface tension of oil-toluens mixtures less depends on components concentration and lies within 28-30 mJ/m².

Interphase tension by Eq. (4) has been calculated accepting that value of empirical parameter \(F\) in Dzhirifalco-Gud equation is 0.5 and 1.2. In the last case
at certain concentration of alcohols negative values of surface energy have been received what contradicts the experimental fact of not mixing propanol-1, propanol-2 and their water solutions with oil. Taking this into consideration it has been adopted that maximum value of parameter $F$ in calculations is 1.

Calculation by Eq. (3) has been carried out using tables Excell and received dependencies have been presented in the following coordinates: surface tension-oil-toluens mixture-alcohol-water solution and interphase tension between organic and alcohol-water phases (Figs. 2-5).

Because of essential differences between calculated minimum and maximum values of the interphase tension on the verge of division of alcohol-water and oil-toluens phases (Figs. 2-5) the necessity to experimentally define this parameter by stalagmometric method has arisen.

The found values of the interphase tension (curve 1, Figs. 6 and 7) do not coincide with those calculated by Dzhirifalco-Gud equation (curve 2, Fig. 6 and 7).

The determined differences between defined and calculated quantities of interphase energy prove that values of parameter $F$ in Dzhirifalco-Gud equation are not constant and depend on propanol content in water solution. In accordance with determined interphase tensions on the verge water-propanol solution-oil, water-propanol solution-air and oil-toluens mixture-air the value of parameter $F$ has been calculated by Dzhirifalco-Gud equation (Fig. 8):

$$F = \frac{\sigma_1 + \sigma_2 - \sigma_{12}}{2\sqrt{\sigma_1 \sigma_2}}$$

(5)

The determined dependence of parameter $F$ on concentration of propanol-1 and propanol-2 indicates the changing of nature of interactions between oil system and alcohol-water solutions at changing of alcohol's content. In particular, the increase of $F$ with the increase of alcohol concentration is caused by the increase of disperse component in interactions between water-propanol and oil phases. The difference between
Dzhirifalco-Gud equation can be applied for calculation of interphase energy in heterogeneous systems of water-propanol solutions with oil-toluens mixtures on condition of variable values of empirical parameter $F$ calculated by experimental data.

![Surface Energy of Water Propanol and Oil-Toluens Phases](image)

**Fig. 4** Interphase surface energy in a system water-propanol-2 solution-oil-toluens mixture at values of empirical parameter $F = 1$.  

**Fig. 5** Interphase surface energy in a system water-ethanol solution-oil-toluens mixture at values of empirical parameter $F = 0.5$.  

maximum and minimum values of parameter $F$ for water-propanol solutions approximately corresponds to the difference of values of this parameter for water-ethanol solutions [5], which proves close values of their disperse interactions with oil-toluens phase.

**4. Conclusions**

According to the results of investigation the

![Surface Energy of Water Propanol and Oil-Toluens Phases](image)

**Fig. 6** Dependence of the interphase tension between water-propanol-1 solutions and oil MS-20 defined experimentally (1) and calculated by surface tensions on the verge with air according to Dzhirifalco-Gud equation at value of parameter $F = 0.66$ (2).

![Surface Energy of Water Propanol and Oil-Toluens Phases](image)

**Fig. 7** Dependence of the interphase tension between water-propanol-2 solutions and oil MS-20 defined experimentally (1) and calculated by surface tensions on the verge with air according to Dzhirifalco-Gud equation at value of parameter $F = 0.66$ (2).
The interphase tension on the verge of water-propanol and oil-toluens phases is less than on the verge of water-ethanol, water-methanol and oil-toluens phases [5], which gives certain advantage to methanol and ethanol for formation of thixotropy nanosystems during over alcaline lubricating grease formation. But simultaneously it should be noted that propanols water solutions can be used for formation of nanoreactors for thixotropy nanosystems synthesis.

References