Research Article

Static foam stability and Nanoparticles effects on stability

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ABSTRACT

The purpose of this research work was to study the stability of static foam and the role of silica and TiO$_2$ nanoparticles (NP’s) in foam stability of nonionic surfactant Tween-20. Foam stability and Half-life of the foam were investigated and compared with and without using silica and TiO$_2$ NP’s. Combine effects of NP’s and ethanol on foam stability was also studied. For surfactant concentration 3 g L$^{-1}$, Half-life was 120 min for silica NP’s and for TiO$_2$ NP’s it was 78.2min.

KEYWORDS

Foam stability, Nanoparticles, Static Foam Behaviour, Volatile solvent.
1. INTRODUCTION
Foam stability depends on various parameters such as surface tension, temperature, rheological properties (surface viscosity and elasticity), liquid composition, pH, NP’s concentration, presence of volatile solvent etc. Overall, the foaming ability and foam stability are associated to (i) the presence of the surfactant in the liquid, (ii) the subsistence of dynamic conditions, (iii) high interfacial energy, and (iv) the rheological properties of materials, interfaces, and their exchanges in foam films [1-7].

The foaming power of surfactant systems are one of the generally main features for the formulation of detergents, cosmetics and other related products [8-9]. The Bartsch (shaking test) is the most generally applied simple tests for the foamability of surfactant solutions. In the Bartsch (shaking test) method, a definite amount of surfactant solution in presence or absents of NP’s is strongly shaken in a closed cylinder. The volume of the foam produced and the life time of either the entire or half the height of the foam formed is measured in this method [2], [10]. A surfactant molecule with rather low energy lies at the gas-liquid interface and reduces the surface tension [7]. Foam shows various applications in an industry, it used to overcome gas mobility challenges in petroleum reservoirs. Foam enhanced oil recovery [12-13]. Nonionic surfactants are used in dry fire-extinguishing agents [11]. Coated NP’s have been used to restore surface-active agents to stabilize gas–liquid [6], [14-16]. The mixture of NP’s and surfactants may suggest a new technique to produce stronger foams for gas mobility control. However, the use of NP’s to increase the stability of surfactant foam is still in the introductory stages [1], [17-18]. This surfactant contains both hydrophobic (nonpolar) and hydrophilic (polar) groups [12], [16], [19-22].

The objective of this work was to study surfactant foam stability in present of Silica and TiO$_2$ NP’s. Combined effect of volatile solvent and NP’s on foam stability were also studied.

2. MATERIALS AND METHODS
The surfactant Tween-20 (density 1.100–1.110g cm$^{-3}$ hydroxyl number 96-108, and saponification number 40-50, obtained from Merck), Ethanol, Double-distilled water, silica and TiO$_2$ NP’s (Collected from research lab).

2.1 Samples Preparations
Tween-20 surfactant (3g L$^{-1}$) was prepared in a conical flask then NP’s (0.01 g) was added. Then sonicate this solution for 10-15 mins.

2.2. Foamability test
Foamability is test for static foam, for measuring foam stability. Foaming power and foamability were measured by using Bratsch shaking test [8].

2.3 Half-Life test
The half-life of the foam was determined by measuring the decaying time of foam, from the maximum height of the foam ($i.e.$, $h_0$) to fall to its half [23-25]. Foam half-life tests were performed to certify that surfactants and nanoparticles could generate stable foams.
3. RESULTS AND DISCUSSION

It was found that, NP’s generally reduces the size of the bubbles (see figure 1) smaller size bubbles help them to increase the stability of the foam.

![Figure 1. Initial foam bubbles at time (t=0) absent and present of Silica NP’s](image)

Table 1 shows the results of foaming power of Tween-20 for silica and TiO$_2$ NP’s. It was found that, NP’s not contributing in increasing initial foam height hence maximum foam height was varies from 4.6 cm to 4.8 cm at t=0.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>0 min</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
<th>20 min</th>
<th>25 min</th>
<th>30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 g L$^{-1}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NP’s Absent</td>
<td>4.6</td>
<td>4.1</td>
<td>3.8</td>
<td>3.6</td>
<td>3.6</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>3 g L$^{-1}$</td>
<td>4.8</td>
<td>4.5</td>
<td>4.3</td>
<td>4.1</td>
<td>4.03</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>(Silica Nps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 g L$^{-1}$</td>
<td>4.6</td>
<td>4</td>
<td>4</td>
<td>3.6</td>
<td>3.4</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>(TiO$_2$ Nps)</td>
<td></td>
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</tr>
</tbody>
</table>

Volatile solvent generally increases the foam formation ability and in the same manners it increases the decaying rate from the top of the column. For static test, it was found (table 2) NP’s decreases the foaming power when it was used with volatile solvent (1ml ethanol +19 ml surfactant solution) but the result was reversed (table 3) for higher concentration of ethanol.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>0 min</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
<th>20 min</th>
<th>25 min</th>
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<tbody>
<tr>
<td>3 g L$^{-1}$</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NP’s Absent</td>
<td>5.2</td>
<td>4.6</td>
<td>4.4</td>
<td>4.3</td>
<td>4.2</td>
<td>4</td>
<td>3.7</td>
</tr>
<tr>
<td>3 g L$^{-1}$</td>
<td>4.5</td>
<td>4</td>
<td>3.8</td>
<td>3.5</td>
<td>3.4</td>
<td>3.2</td>
<td>3.1</td>
</tr>
</tbody>
</table>
NP’s Present

Table 3. Foaming power in absent and present of silica NP’s (0.01gm) with Ethanol (2ml) NP’s

<table>
<thead>
<tr>
<th>Concentration</th>
<th>0 min</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
<th>20 min</th>
<th>25 min</th>
<th>30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 g L⁻¹ NP’s Absent</td>
<td>4.1</td>
<td>3.8</td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>3 g L⁻¹ NP’s Present</td>
<td>4.6</td>
<td>4</td>
<td>3.6</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
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</tbody>
</table>

3.1. Foam Half-life
The half-life of the static foam for surfactant without nanoparticle and with nanoparticle were 60 min and 120 min, respectively at 3 g L⁻¹ surfactant concentration at room temperature. Also in case of TiO₂ the half-life was 78.6 min at 3g L⁻¹ (see figure 2). It means that the NP’s increases the foam stability.

![Figure 2](image)

**Figure 2.** Half-life of surfactant solution with or without Silica NP’s and TiO₂ NP’s

4. CONCLUSION
NP’s plays vital role in foam stability. Half-life of the static foam increases from 60min to 120 min when silica NP’s used while in case of TiO₂ NP’s, half-life increases from 60 min to 78.2 min. That shows that silica shows better performance than TiO₂. NP’s increases the foam stability and decreases the bubble size. Combine effect of NP’s and volatile solvent was studied. Optimize study is required for combine study of NP’s and volatile solvents.

5. ACKNOWLEDGEMENT
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6. REFERENCES


