Stability of nano-oil by pH control in stationary conditions

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ABSTRACT - The purpose of this study is to investigate the stability of nano-oil by pH control in stationary conditions. The nano-oil was prepared by dispersing an optimal composition of 0.5 vol.% 70 nm hexagonal boron nitride (hBN) nanoparticles in SAE 15W-40 diesel engine oil by sonication technique. Hydrochloric (HCl) acid and Sodium Hydroxide (NaOH) were used as a dispersing agent to determine the stability of the dispersion. The dispersion stability was evaluated by using the sedimentation method with the help of Ultra Violet-Visible (UV-Vis) spectrophotometer. It was demonstrated that the suspension in the alkaline region with a pH value of 11 to 13 was stable over the period of 60 days.

1. INTRODUCTION

The study of nanomaterials has attracted a great interest in the recent years, due to their remarkable applications concerning several realms of science. Nanotechnology has the potential to create several fresh materials and devices with a vast range of applications, such as in medicine, electronics, biomaterials and energy production [1]. On the other hand, dealing with nanopowders is a complicated issue and a very difficult one, mainly because of their toxicity and propensity to agglomeration as a result of their high surface area. Therefore, study of the stability of nanoparticles in liquid solution is essential.

Stabilization is achieved through absorption of stabilizing molecules on the pigment surface, so that repulsive forces prevent other particles from approaching close enough for the attractive van der Waals forces to cause agglomeration. There are two principal mechanisms for the stabilization of pigmented dispersions [2]: (a) Electrostatic stabilization (b) Steric stabilization. However, this study only focuses on the electrostatic stabilization. Classic colloidal science explains electrostatic stabilization in terms of an electrical double-layer. A charge is generated on the pigment surface, and a more diffuse cloud of oppositely charged ions develops around it. As two particles approach each other the charge effectively provides a barrier to closer particle interactions. Stabilization increases along with the thickness of this layer.

Even though the stability of nanoparticles is the key issue for its application, there are limited studies on estimating the stability of a suspension. Therefore, the aim of this study is to further investigate the stability of nano-oil by pH control in stationary conditions using both qualitative and quantitative analyses.

2. METHODOLOGY

Nano-oil, used in this study, was prepared by dispersing an optimal composition of 0.5 vol.% 70 nm hBN in SAE 15W-40 diesel engine oil using ultrasonic homogenizer for 20 minutes. The optimal composition was determined from the previous work [3].

The pH of the suspension was adjusted to a desired value of 1 to 13 with the addition of dispersing agent 0.1M HCl or 0.1M NaOH. The dispersion stability was evaluated for 60 days. The stability of the dispersion was determined using the sedimentation method by observing the nanoparticles formed at the bottom of the bottle. Moreover, UV-Vis spectrophotometer measurements were used to quantitatively characterize the colloidal stability of the dispersions. The sample was hold by a glass cuvette with 1 mm thickness. At 200 – 900 nm wavelengths, the UV–Vis spectrophotometer measures the absorption of liquid and is used to analyze various dispersions in the fluid [4]. The degree of absorbance is proportional to the amount of the particles per unit volume, so that it can denote the dispersion stability of the particles in the solution.

3. RESULTS & DISCUSSION

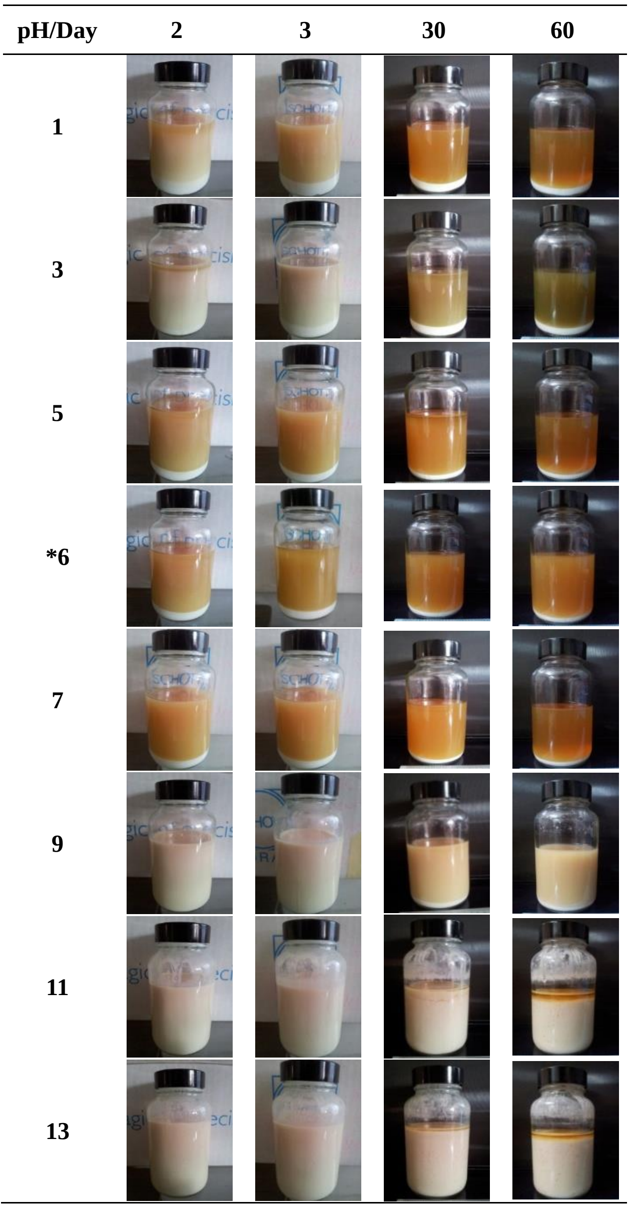
Table 1 shows the sedimentation time during which a white layer of hBN nanoparticles is formed at the bottom of the bottle. Formation of the above mentioned layer is shown in Figure 2, where it was taken after the suspension was kept at room temperature for 2, 3, 30 and 60 days. As can be seen from Figure 2, decreasing the pH value gave rise to the reduction of stability time and hBN nanoparticles formed at the bottom of the bottle over a period of 60 days. However, at pH value of 11 to 13 (alkaline region), the nanoparticles were well dispersed in the oil.

The above qualitative analysis was supported by the absorbency of nano-oil with time using UV-Vis spectrophotometer at 600 nm wavelength, as shown in Figure 3. The absorbency should be greater if the dispersion of nanoparticles is better. After 60 days, the absorbency of nano-oil at pH values of 11 to 13 was still stable. However, below than a pH value of 9, the absorbency decreases about 60 – 80%.

Table 1 Stability time of hBN nanoparticles suspensions with different pH values

pH	1	3	5	*6	7	9	11	13
Stability [day]	2	2	2	2	2	30	60	60

*The pH value of suspension without dispersing agent



*The pH value of suspension without dispersing agent

Figure 1 Photo of formation of hBN nanoparticles layer over time in different pH values

The higher absorption of UV radiations in suspension stabilized by NaOH, confirmed the higher efficiency of electrostatic repulsive force. This behavior is attributed to the fact that the absorbed ions in electrostatic mechanism form a charged layer around the particles preventing aggregation. Adsorption of OH- ion (in the alkaline region) on the particles surface increases the repulsive force and results in the lengthening of the distance between particles or increases the thickness of the electrical double-layer, which causes an electrostatic stability.

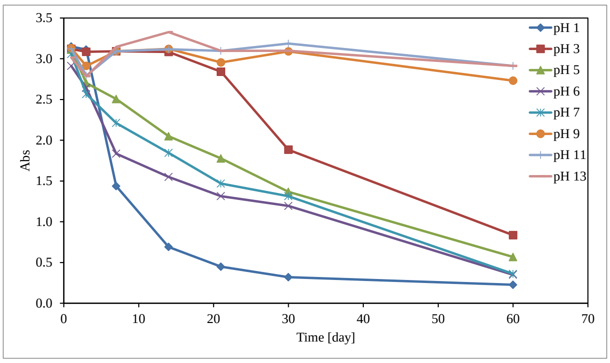


Figure 2 UV-Vis absorption of nano-oil in different pH values (wavelength = 600 nm)

4. CONCLUSIONS

In conclusion, the stability of the hBN nanoparticles in SAE 15W-40 diesel engine oil increases in the alkaline region with pH value of 11 – 13. The suspension was stable over the period of 60 days, as compared with the suspension in the acidic region. This is due to the electrostatic mechanism, which increases the repulsive force and results in thicken the electrical double-layer that provides stability.

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