Effect of temperature and type of dispersant on treating oil spills

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Abstract. Dispersant is a chemical surfactant which can break down an oil from the water surface. Therefore, dispersant can be used to treating oil spills. The effectiveness of dispersant as oil emulsifier can be influenced by the temperature of the environment and concentration of oil and dispersant. This paper shows the influence of temperature variations, dispersant types and layers of sea water on oil spills by testing the light absorbance using spectrophotometer UV-Vis. The results of the experiments show that the biggest light absorbance occurs on the water surface at temperatures of 26°C with area absorbing of 82.15 abs. Meanwhile, the smallest light absorbance is at temperatures of 16°C with wide absorbance 25.72 abs on the type of dispersant soluble. Wide light absorbance total greatest namely 26°C temperatures on the type of soluble with wide absorbance total 133.49 on three points of layers of water.

1. Introduction

Indonesia is a maritime country that has thousand of islands with a very wide sea territories. Indonesia has area reached 3.977 miles between the Indian Ocean and Pacific Ocean with land area of 1.922.570 km² and the area of the sea 3.257.483 km² [1]. It makes Indonesia have natural resources such as oil and gas. The industry activities of oil and gas can become a source of pollution at the sea such as oil spills. When the oil spilled at the sea, oil will spread on the surface of the water which formed a thin layer called oil slick [2]. Oil spills can be treated by giving a dispersant so it can breaks into the size of water column. Giving a dispersant on oil spills can be influenced by various factors such as the concentration of oil, the energy to mix the dispersant with the oil such as waves, the temperature of the environment, types of surfactant’s molecule and oil ties to the water of the sea. The spread of oil spills was also influenced by the temperature of the water of the sea and the properties of oil itself. Temperatures have an important role to salinity and the stability of emulsion on oil. The sea water with low temperature increase oil and dispersant viscosity. When the oil becomes more viscose, the energy needed to mix the oil and dispersant increased [3]. At high temperatures, solubility of dispersant in sea water will tend to increase so that the temperature rise of water can reduce the viscosity and speed up the process of oil dispersion so that the oil slick on the surface of the water of the sea will gone. It can be use to determine the level of effectiveness of dispersant in different temperatures where testing the clarity of the water can be tested with spectrophotometer UV-Vis. Dispersant is a method of treating oil spills that is often used by the company in dealing with pollution at the sea, so the testing in the laboratory scale is expected to help the ability dispersion relatively better on the crude oil and processed oil.
2. Literature Review

Dispersant is a chemical substances mixture of emulsion substances (surfactant) and solvent so it can break down oil into small particles so that the surface of the oil layer became larger and easy to dispersion in the water. By adding a dispersant, the viscosity between oil and water is reduced so the waves can break a layer of oil into a small droplets [2]. At some of oil spills at the sea, the oil will dispersed naturally into water column. It releases them due to the viscosity grade on each of the different oil where oil with low viscosity more easily to dispersed naturally compared with oil with high viscosity [4].

Effectivity of dispersant can be reviewed by knowing by comparing the light absorbance and wavelength from testing with spectrophotometer UV-Vis. Area under the curve light absorbance vs. wavelength, where samples of the experiment from the wavelengths done on the ratio of 340-400nm using trapezoidal rule calculation, based on the formula (1) [5]:

\[
\text{Area} = \frac{(\text{Abs}_{340} + \text{Abs}_{370})30}{2} + \frac{(\text{Abs}_{370} + \text{Abs}_{400})30}{2}
\]  

(1)

Where the \text{Abs}_{340}, \text{Abs}_{370}, and \text{Abs}_{400} are the absorbances measured at wavelength 340, 370, and 400 nm, respectively. Area can show the effectiveness of dispersant.

A spectrophotometer can measure the intensity of light as a function of the color spectrum (light waves). An important feature of spectrophotometer namely spectral bandwidth (range of color spectrum that can be transmitted through samples tested), the percentage of the sample transmission and range of distric from absorption of samples. Using the appliance spectrophotometer, spectrophotometry measurements involving electronic energy is big enough on the molecule analyzed, so spectrophotometer UV-Vis used more for quantitative analysis compared qualitative research. The spectrum UV-Vis very useful for measuring quantitatively.

3. Methodology and Materials

The first phase of this experiment is looking for a literature that is derived from the theory, research and journals that have been there before. Samples are testing using spectroscopy to obtain data required to analyzed. The type of appliance spectrophotometry used a spectrophotometer UV-VIS in wavelength 340 nm, 370 nm and 400 nm. The data is in the form of temperatures, light absorbance, the speed of the dispersion, and other data. If all data needed has been achieved then the analysis can be started by connecting the data into a parameter. The outward from this research is expected to be a reference in the use of dispersant on the process of treating oil spills at the sea.

3.1. Sample Preparation

The preparation of the samples that will be tested in this research is based on the needs of the data retrieval and restrictions that determined. The sample used in this research are dispersant and oil. The election of the type of oil for a sample of the experiment using MESLU-crude oil. Dispersant used as samples are OSD MAXI-CLEAN 2 and the OSD NEO-CHEM M-405.

![Figure 1](image-url.jpg)

**Figure 1.** (a) MESLU-Crude Oil Dispersant. (b) NEO-CHEM M-405, (b) MAXI CLEAN-2.
3.2. Experimental Set-Up

Dispersant and crude oil taken using pipette and then poured into the beaker glass which filled with a sea water. Then the mixture diluted with magnetic stirrer which functions as the energy that work on the system as a replacement for the waves by set the frequency of the vibrations on the low frequency in order to produce a homogeneous mixture. After the oil has been dispersed, setting the temperature of each of the beaker glass done with the oven and cooler bag to achieve the temperature target.

After that, sample from the mixture taken using a syringe at the top, middle and bottom layer and then placed in a cuvette. The use of syringes aimed to sampling in each layer more precise so that the data obtained has a high accuracy. Cuvette placed into the spectrophotometer UV-Vis for testing of light absorbance. On this experiment, data taken directly by using the acquisition of data that is connected to the computer. The data then recorded in accordance with temperature and a specified time.

4. Results and Discussion

4.1. Graph of Light Absorbance and Temperatures at Layers of Sea Water (Dispersant A)

![Graphs of light absorbance and temperatures at different layers of sea water for Temperatures of 16°C, 26°C, and 36°C.](image-url)

*Figure 2. Dispersant A at Temperature (a) 16°C (b) 26°C and (c) 36°C.*

Figure 2 shows each layer of water in each of the temperature variations have different absorbance level of light, therefore it can be proved that the temperature can affect the level of light absorbance on each layer of water. In this analysis, light absorbance will be divided into 3 layers, namely top layer, middle layer and bottom layer.

Emulsion occurred in a period of one to two days. In the analysis of light absorbance on a layer of water, it can be seen that the trend that occurred in the middle layer and bottom layers are same. The graph of light absorbance by dispersant soluble in water at temperature 16°C shows that the light absorbance of water layer shows value <0.25 abs by shooting UV with the wavelength of 340 nm.
The light absorbance on the bottom layer shows the value of 0.034 abs on the first three hours and increase until oil dispersed for 24 hours. For light absorbance on the middle layer has higher level compared with the bottom layer which is 0.052 abs and increase until oil dispersed for 24 hours. The top layer have different trends on the first six hours when oil dispersed. On the graph shows reduced light absorbance and increase until oil dispersed for 24 hours. The value of the light absorbance on the top layer is 0.227 abs, where the value has the difference about 0.2 abs with the bottom layer of water. But the value of light absorbance on the top layer after oil dispersed for 6 hours have values that are almost the same as the middle layer. It shows the stability of the emulsion is very low on each layer of water.

At temperatures 26⁰ C, light absorbance on each layer has a different trends, where the layers of the surface of the water has a higher value compared with the middle layer and bottom layer about 1.0 abs, therefore it can be seen that the emulsion which happens have a good stability

Oil dispersing at temperature 36⁰ C have the same trends in each layer of water. In the first three hours on the top layer has the difference value of absorbance about 0.2 abs with middle layer and bottom layer of water. The trend of the graph on the middle layer of water at temperatures 36⁰ C have the same characteristics with middle layer at temperatures 26⁰ C, where the value of light absorbance is lower than the top layer and the bottom of the water. This happened because of the higher temperatures increase from dispersant solubility in water and temperatures of oil spills, reducing the viscosity of oil. Decline in oil viscosity resulted in an increase in the effectiveness of the performance of dispersant.

4.2. Graph of Light Absorbance and Temperatures at Layers of Sea Water (Dispersant B)

![Graphs](a) Temperatur 16⁰ C (b) Temperatur 26⁰ C (c) Temperatur 36⁰ C

**Figure 3.** Dispersant B at Temperature (a) 16 C (b) 26 C and (c) 36 C

Dispersing of crude oil with dispersant insoluble in water at temperature 16 C shows the same trends in each layer of water. Based on the figure 3, the graphs shows a significant difference in the first three
hours dispersing. The top layer of water has the light absorbance value 0.1229 abs, where the value of the absorbance have differences about 0.04 abs with middle layer and bottom layer of water. Changes in the level of turbidity in the upper layers of the water does not appear on the figure 4, but the results of the testing with spectrophotometer UV-VIS indicates that there is a change in the value of absorbance on each layer. After dispersing for three hours, the value of light absorbance on each layer up until dispersing for 24 hours having the result in the range of 0.07 - 0.1 abs.

The same thing happened on dispersing crude oil at temperature 26 C. The difference of light absorbance in the top layers with the middle layer and bottom layer about 0.06 abs. The level of turbidity decline at the time of dispersing 24 hours. In the first three hours of dispersing, top layers the water has the value of the light absorbance of 0.2645abs.

On dispersing crude oil at temperature 36 C, the value of the light absorbance on the top layer of the water on the first three hours is 0.3422 abs, where there are differences value of light absorbance about 0.1 abs with the middle layer and bottom layer of water.

4.3. Area of Light Absorbance of Dispersed Oil

In this research, the experiment done to correlate the phenomenon of light absorbance with the concentration of oil. As can be seen on figure 4, each layer has a different area on each temperatures. Based on the graph, the top layer of dispersant soluble in water at temperature 26 C have the biggest area of light absorbance 82.15 abs, whereas the smallest area of light absorbance at temperature 16⁰ C with value 25.72 abs.

| Dispersant Types | Absorbance |
|-----------------|------------|
|                 | 36 C | 26 C | 16 C |
| A               | 119,84 | 133,49 | 51,42 |
| B               | 125,32 | 101,54 | 52,55 |

Table 1 is a data from the area total on each temperatures of each type of dispersant. The largest area total of light absorbance is at temperatures 26 C with type of dispersant soluble in water with value 133.49 abs. This can happened due to the stability of the emulsifier substances, therefore the process of emulsion that occurs on when the oil dispersed more effective. The value of the area total of light absorbance which is not much different occur at temperature 36 C, both on the type of dispersant insoluble and soluble in the water with absorbance area each are 125.32 abs and abs 119.84. The high temperatures will reduce the viscosity of dispersant and crude oil to increase the performance of dispersant as the substance of oil emulsifier.
5. Conclusions
Oil dispersed caused by emulsification by emulsifier substances such as dispersant. Temperature can affect the effectiveness of dispersant. Area of light absorbance can represent in the determination of the effectiveness of dispersant. Light absorbance on each layer of the water on the oil dispersed has a different value. This is caused by the process of emulsion by emulsifier substances such as dispersant that mixed into crude oil. Area of light absorbance can be a reference to measure the effectiveness performance of dispersant. The larger an area then the effectiveness of the performance of dispersant getting better due to the level of turbidity is lower. The top layer of dispersant soluble in water at temperature 26°C have the biggest area of light absorbance about 82.15 abs, but the smallest area of light absorbance occurs at temperature 16°C by 25.72 abs. Largest area total of light absorbance found at the temperature of 26°C with types of dispersant soluble in water by 133.49 abs while the smallest area total area of light absorbance found at temperature 16°C with types of dispersant soluble in water by 51.42 abs. Based on the experiment that has been done, dispersant soluble in water at temperatures 26°C has the most effectiveness. But the temperature of 36°C still have a high enough of absorbance value, therefore it can be said dispersant can work effectively on the temperature range of 26°C - 36°C.

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7. References
[1] National Geographic. Panjang Garis Pantai. http://nationalgeographic.co.id/berita/2013/10/terbaru-panjang-garis-pantai-indonesia-capai-99000-kilometer (accessed on November 19, 2016)
[2] Pancadewi Y 1990 Depok. Pengaruh Variasi Komposisi Dispersan dan Unsur Nitrogen Terhadap Proses Biodegradasi Tumpahan Minyak Bumi.
[3] Clayton J R Payner J R and Farlow J S 1993 Oil Spill Dispersants. Mechanism of Action and Laboratory Test CRC Press, Inc, Boca Raton, Florida p. 113
[4] The International Tanker Owner Pollution Federation Limited (ITOPF). The Use of Chemical Dispersant To Treat Oil Spills. United Kingdom.
[5] Desphande N, Chandrasekar S, Sorial G Dispersant Effectiveness On Oil Spills – Impact of Environmental Factors Cincinnati, Ohio.