The Formulation of Foaming Agents from Palm Oil Fatty Acid and Performance Test on Peat Fires

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Foaming agents from palm oil as one example of palm oil downstream products can reduce water surface tension and create foams to be used to extinguishing fires on peatlands. This research is aimed at obtaining the best foaming agent formula from sodium laurate and potassium palmitate as the result of fatty acid saponification and finding the information on the performance of foaming agent formulas applied to extinguishing fires on peatlands at a laboratory scale. The result of the performance test on the best foaming agent formula is one using 15% sodium laurate and 3% potassium palmitate. The result of the application test shows that the addition of 3.33 wt% of foaming agents to well-sourced water yields foams that can extinguishing fires on peatlands and saves water by 9.89 wt% while giving a shorter fire-fighting time.

Key Words
Foaming agent, Palm oil, Peatland, Extinguishing fire

1. Introduction

Foaming agents are liquid preparations that can be used to create foams to extinguishing fires on peatlands. Foaming agent formulas constitute preparations that will be used to reduce water surface tension and create foams. Foams serve to cover the burning peat surface so as to interrupt the oxygen circulation, and the foam liquids can easily penetrate into the peat pores. Foaming agents can be made through the saponification process utilizing the raw materials of palm oil fatty acid using the potassium and sodium hydroxide reactants.

The fatty acid contents in palm oil that are potential to be made into foaming agents are lauric, oleic, and palmitic acids. The said three components have different characteristics in creating foams to extinguishing fires. Firefighting substances based on sodium oleate, potassium palmitate and laurate applied to extinguishing fires on civilian buildings and to reduce the level of intoxication of water organisms by 10 to 30 times lower compared with synthetic firefighting substances.

Sodium palmitate and oleate as a raw material that renders the foaming-creating ratio of 1:8 with the foams lasting 345 hours when applied on fighting fuel-caused fires. Environmentally friendly fire fighting foams from the substances of potassium laurate, potassium oleate, and sodium oleate to be used for forest fire fighting purposes.

Fire fighting foaming agents from potassium palmitate, their power to create foams reach 193-215 vol% and the foams created by them can last up to 2-3 days.

This research builds on the result of the research predecessor, aimed at finding the best composition from potassium palmitate and sodium laurate as a raw material to make foaming agents and obtaining the information on the performance of foaming agent formulas applied to extinguishing peatland fires at a laboratory scale. Sodium laurate and potassium palmitate are formulated to produce
foaming agent formulas, from which the best foaming agent concentrates are selected to be applied for peatland firefighting purposes. The selection of raw materials from the best result of the saponification of fatty acid from the preliminary research, namely, sodium laurate and potassium palmitate was expected to render significant influence on the characteristics of foaming agents deemed able to extinguishing peat fires.  

The most important parameters in foaming agents for the application of peat firefighting are, among others, foam volume, foam age, surface tension, interfacial tension, viscosity, and contact angle. With the said parameters, foaming agents could create lots of foams; foam bubbles were not easily broken and could reduce the surface tension so that the foam solution could penetrate into the peat pores.  

2. Experimental

The raw materials of the preparations of foaming agents to be applied for peatland fire fighting purposes were chosen from the result of the saponification of palm oil fatty acid conducted at “Surfactant and Bioenergy Research Center, Bogor Agricultural University (SBRC-IPB)” Sodium laurate can form a high foam, but the age of the foam is low, while potassium palmitate can form the low foam, but its age is upper. The combination of these two materials is expected to produce foaming agents that have better foam forming properties so that the foam produced has a good performance in extinguishing peat fires.

The ingredients consist of sodium laurate and potassium palmitate (see Fig. 1), the concentration of each ingredient is 10-20 wt% and 3-9 wt% using 9 variations of experimental formula. This research was started with the formulation of foaming agents from sodium laurate and potassium palmitate as the result of the saponification obtained by the previous researchers and carried on to select the best formula.

The formulation was carried out by mixing both substances with distilled water for 60 minutes, the rotation speed was 300 rpm, and the mixing temperature was 70°C. The responses from the formulation covered the ability to create foams, foam age, surface tension, interfacial tension, contact angle, and viscosity.  

The next research stage was the performance test of the best foaming agent formula for the application of peatland fire fighting purposes at a laboratory scale. Fig. 2 represents the peatland sample taken from the peatland in Sontang Village, Rokan Hulu Regency, Riau Province. Peat sample dried in the oven at a temperature of 105°C for 48 hours, sample before being dried (3 kg), and after being dried (1.5 kg) with a water content of 12.42 wt%. The air after being dried was then entered into the burning reactor, where it was burned for 3 - 4 hours at a temperature of 350-600°C.  

The burning of the peat in the reactor was started from the above surface (0.01 m²) using the heat from an electricity source of 80-100 W electrical power as the fire trigger. The burning in each experiment was done 3 times with the peat temperature in experiment 1 (concentration 1%) was 340-520°C, this temperature was the optimal temperature for the fire fighting to begin. In experiment 2 (concentration 3%), the temperature at which the fire fighting began was 384-541°C, in experiment 3 (concentration 6%), the temperature for the fire fighting was 390-545°C.  

These temperatures were the middle-category
temperatures because peat in some regions could reach temperatures approaching 700°C when burning\(^{13-16}\).

In experiment 1, the fire was extinguishing with as many as 3 times of spray. For each spray, as much as 25 g of a foaming agent solution was used. The first spray directly reduced the temperature down to 316°C. After the 3rd minute, the temperature in the thermocouple rose to 347°C, so the 2nd spray was applied and the temperature dropped to 242°C. But at the 9th minute, the temperature went up to 268°C, so the 3rd spray was administered. After the 15th minute, the peat temperature kept going down, this indicating that the fire was completely extinguishing. The fire would usually recur after it is extinguishing at an interval of about 15 minutes\(^6\). Then in experiments 2 and 3 the fire was extinguishing 2 times, each using a foaming agent solution as much as 23.11 g and 22.67 g for one spray. The use of a foaming agent solution to extinguishing the fire in each experiment for one running amounted to 73 g, 66 g, and 64 g.

After the peat was evenly burning, it was then extinguishing using the foams that were sprayed onto all of the reactor surfaces. The foam is produced by the foaming agents that were mixed with water and entered into a foam-generating bottle. The foam agent concentration used was 1, 3 and 6 wt%\(^{16,17}\). Fig. 3 shows the reactor used to burn the peat sample.

After the peat fire was extinguishing, there was observed a change in temperature at the surface and inside of the reactor. The change in the temperature was recorded with a digital thermocouple; this parameter was to find out if the fire fighting was successful or if there were still fire flames on the peat. Besides the change in temperature, the use of fire fighting media was also recorded to find out the volume of the foaming agent formula and water used to extinguishing the peat fires\(^{11}\).

The final stage was the application of peat fire fighting using well-sourced water without the addition of foaming agents; the method utilized was the same as in the fire-fighting procedure using a foaming agent solution. The difference in the use of a foaming agent solution and well-sourced water was meant to find out about the efficiency of peat fire fighting using the said two substances\(^{19}\).

At this stage, the burning of the peat was conducted the same way as that in the research stage preceding; that is, the burning in each experiment was done 3 times applying the same volume. The peat temperature in experiment 1 was 519-561°C, the temperature in experiment 2 was 459-500°C, and that in experiment 3 was 380-397°C.

The peat burning in experiment 1 was extinguishing with well-sourced water 4 times of spray. The first spray used 25 g. The much water used in experiment 1 was believed to be caused by the high heat, thus making it difficult for the water to penetrate into the peat pores. The 2nd, 3rd, 4th spray also used 25 g each. Then the burning in experiment 2 was extinguishing 3 times and that in experiment 3 was fought 2 times. That is, the water volume was limited, making it easily evaporate before penetrating deep inside the peat\(^{18}\).

3. Results and Discussion

Dwelling on the result of the measurement of responses to the formulation of foaming agents rendered in Table 1, the best formula was formula 7 with the concentration of sodium laurate reaching 15 wt% and potassium palmitate being 3 wt%. With the response of the most-foam volume totaling 8.37mL, the foams could last 6 days, the lowest interfacial and surface tensions were 0.47 and 0.026 N/m, the contact angle was 13.32º, and the viscosity was 0.007 Pa.s.

The best formula was mixed with well-sourced water to produce foams to be used to extinguishing the fire of the peat that was burned in the burning reactor\(^2\).\(^{19}\).

Besides the said advantages, formula 7 did not easily thicken during its storage of several months like other
formulas as can be seen in Fig. 4.

Fig. 5 shows the graph illustrating the change in peat fighting temperatures in the experiment at a laboratory scale. The picture shows an average of 3 times of experiment for each experiment with a different foaming agent concentration.

Fig. 6 shows the graph of the use of foaming agents as a raw material to create foams to be used to extinguishing the peat fire in the reactor. The picture illustrates that the higher the foaming agent concentration got, the lower the used solution volume became. And the increased temperature of the burning peat caused the use of the foaming agent solution to increase too.

This almost resembled the procedure of peat fire fighting using water: The higher the temperature got, the more the use of water became. Fig. 7 shows the graph of the change in the temperature of the peat fire fighting procedure using water. From the picture it can be seen that in experiment 3 the burning was extinguishing 2 times, this was believed to be caused by the lower temperature so that the peat burning could be cooled with water.

The use of water as a firefighting medium can be
there was observed a difference in the use of the foaming agent solution and water as media to extinguishing peat fires. From Fig. 9 it can be seen that the use of water was 7.6 L/m², while the use by the previous researcher was 7.02 L/m². The difference was believed to exist because of the different kinds of peat used for the experiment, so that this affected the heating temperature produced. The kind of peat used by the previous researcher produced a temperature of 200-450 °C at the time of fire fighting, while that used in this research produced a temperature of 340-545 °C. The use of the foaming agent solution by the previous researcher was 3.6 L/m², while that used in this research was 6.3 L/m². This relatively huge difference was believed to be caused by not only the different kind of peat but also the different foaming agent formula substance used to increase its performance.

Fig. 10 shows the difference in fire-fighting time between well-sourced water and foaming agent solutions.

From the experiment, it can also be seen that the water found it hard to penetrate into some of the peat surfaces probably because it did not properly burn, but this was hard to detect. That part was the reactor corner that tended to receive the heat circulation not very optimally so that the part did not burn. If spraying was to be attempted to the said part, the water volume had to be adequate to wet the peat.

From the results of research on the performance of foaming agents and water as peat firefighting media,

seen in Fig. 8. From the picture, it can be seen that the higher the peat burning temperature got, the more the use of water turned out.

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The fire fighting went faster using the foaming agent solution than using well-sourced water by 15 minutes. This relatively big difference allowed the peat fire to be extinguishing faster and the smoke haze negative impacts to be minimized.

4. Conclusion

The best foaming agent formula in this study was using 15 wt% sodium laurate and 3 wt% potassium palmitate. From the performance test, it can be concluded that the foaming agent produced can extinguishing peat fires on the surface and inside the peat pile. Besides that, from the result of the test adding water to the foaming agent by 3.33 wt%, we can save water by 20.07 wt% and shorten the firefighting time by 15 minutes compared with when we use just water. The formula produced still needs development to get a better foaming agent formula. The use of digital thermocouples as temperature detectors at reactor performance is less optimal because the recording is done manually, so further research is needed to develop reactor performance using adequate equipment.

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