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Recovery bitumen from asbuton with sodium tripolyphospate and SDBS surfactant as wetting agent

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Abstract. The objective of this research is to develop a more-environmental friendly method of bitumen extraction from Asbuton, which also has high rate of percentage recovery, by using a mixture of sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) and sodium dodecyl benzene sulfonate (SDBS) surfactant in several temperatures process. The extraction process itself has three steps of reactions, first is premixing, second is digesting and third is separating. Separated layer of bitumen after separation process will be analyzed to obtain bitumen percentage recovery during extraction. The purpose of premixing step is reducing viscosity of Asbuton by adding DEX up to 60 percent (w/w) of the total mass and then mixing it for 30 minutes. The digesting step is carried out by adding a mixture of DEX Asbuton with wetting agent. Wetting agent is a mixture solution of sodium dodecyl benzene sulfonate surfactant (SDBS) and $Na_5P_3O_{10}$ (NTP) in various concentration. This mixture is being stirred at 1500 rpm using controlled temperature at 60, 70, 80 0C for 30 minutes. We use various surfactant ratio of SDBS from 0.125%; 0.25%; 0.37%, 0.5% (w/w) to the total mass ratio, and for NTP ratio is 0.125%; 0.25%; 0.37%; 0.5% (w/w). Separation process is done by adding water to form three layers of solution, the top layer, DEX-bitumen solution, will be weighed and measured for its weight and density to obtain the percentage recovery of bitumen. It can be concluded that the combination of SDBS and NTP mixture as wetting agent, can bring better result on bitumen extraction from Asbuton asphalt. The highest percentage of bitumen recovery is 74.63% at 80ºC of temperature, and with SDBS concentration of 0.125% and $Na_5P_3O_{10}$ concentration of 0.25%.

1. Introduction

Asbuton (Asphalt Rock from Indonesia) is a mixture of bitumen and minerals with the highest composition is limestone. Asbuton is one type of natural asphalts which bitumen adheres directly to the mineral. Bitumen, which has form of highly viscous oil in normal condition, is one of the essential elements in asphalt's mixture and widely used as main component for building roads. The mixture itself consist of 95% aggregate and 5% bitumen, which bitumen serves as adhesive agent (thanks to natural viscosity of bitumen) and it makes asphalt has high degree of flexibility and excellent strength [1].

Asphalt demand in Indonesia continues to increase year by year, in line with the economic growth. Thousands kilometers of highway has been proposed and constructed to accelerate transportation of citizens and also daily needs between cities every day. With the asphalt's demand around 1.2 million tons per year, Indonesia still needs to import asphalt from foreign entities, because of domestic production in Indonesia can only produce around 300,000 tons of asphalt per year, mainly from oil-base product by Pertamina, it means the rest of it, still needs to be imported either by Pertamina or Government [2]. It is a very contrary fact, because Indonesia has known to has one of the biggest natural asphalt mine in the world, called Asbuton, located in Buton Island, Southeast Sulawesi, with the total number of reserve roughly around 660 million tons, and 132 million tons of them is pure bitumen. The bitumen reserve are vast and has potential to be explored, since it has not been explored efficiently.

Most of the research of bitumen extraction were using hot sodium hydroxide (NaOH) solution to separate bitumen and other materials from the soil. Addition of suitable caustic substances, mainly sodium hydroxide (NaOH), is useful to improve the release and recovery of bitumen [3]. But, in the other hand, sodium hydroxide (NaOH) can easily form caustic residue, which is dangerous to the environment and also difficult to eliminate [4]. Nowadays, several studies have tried to develop more environmental friendly method of extraction which have low caustic alkalis or alkali-free, such as sodium tripolyphosphate ($Na_5P_3O_{10}$ /NTP). Previous research has been conducted on the extraction process of bitumen using this kind of method, first, by addition of kerosene and sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) [5]. Other research, used YSFL agent, with low level of sodium hydroxide, provides bitumen extraction rate rise of up to 95% [6]. The using of sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) in bitumen extraction is to form interaction with polyvalent cations, such as calcium ions, and also reducing the adverse effect of molecular interactions, including natural surfactants, that are released in the aqueous phase of the bitumen during mixing process and helps increasing yield of extraction [7].

Material development for extracting bitumen is a very important step to obtain efficient process. Synthetic surfactants are usually added during the process to improve recovery of bitumen. Sodium dodecyl benzene sulfonate (SDBS) surfactant is the most efficient surfactant to reduce the interfacial tension on Asbuton up to 4 x 10-4 mN/m at 0.05% of concentration and pH of 11 [8]. The synergy effect between alkalis and small amounts of surfactant can reduce the interfacial tension between Brintnell oil and salt solution. For comparison, interface tension which was obtained at 100 ppm of surfactant and alkaline addition, is 0.01 dyn / cm, meanwhile, with the addition of alkali (only) the interfacial tension is about 0.07 - 0.1 dyn / cm. [9]. Impairment of interface tension will increase the value of recovery of bitumen.

The goal of this research is to develop a more-environmental friendly method of bitumen extraction from Asbuton, which also has high rate of percentage recovery, by using a mixture of sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) and sodium dodecyl benzene sulfonate (SDBS) surfactant in the process.

The independent variables in this study are concentration of sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP), concentration of sodium dodecyl benzene sulfonate (SDBS) and temperature of the process. These variables are used to determine its effect on the percentage recovery of bitumen from Asbuton.

2. Experimental

2.1. Experiment sample

Aspal Pulau Buton (Asbuton) is taken from Buton Island, Southeast Sulawesi, Indonesia, with bitumen content of 18,547 %. Extraction agent is the mixture of sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) and Sodium dodecyl benzene sulfonate (SDBS) surfactant. Asbuton is pre-destructed and screened with the size of 20-40 mesh. It was characterized by soxhlet extraction (By standart of SNI 03-3640-1994) using Trichloroethylene (TCE) as solvent to obtain bitumen content in asbuton. The basic chemicals which is used in these experiments are: Sodium Dodecylbenzene sulphonate and Sodium tripolyphosphate ($Na_5P_3O_{10}$ / NTP) (technical grades) and commercial DEX (Pertamina) as the diluent.

2.2. Separation method

Asbuton and DEX were mixed inside the reactor, with certain proportion and being agitated with low speed at various temperature. A separation agent was added to the mixer, heated and stirred for a certain time. The separation agent is a mixture of SDBS surfactant, sodium tripolyphosphate ($Na_5P_3O_{10}$

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/NTP) and water. The concentration of SDBS were 0.125%; 0: 25%; 0.375%; 0.5% (w/w ratio) while the concentration of sodium tripolyphosphate ($Na_5P_3O_{10}$ /NTP) were 0.125%; 0: 25%; 0.375%; 0.5% (w/w ratio). Temperature process were controlled at 60, 70 and 80°C. Next, for the separation process, water was added to the mixture to form three layers of solution. The upper layer was collected and measured in weight and density to determine percentage recovery of bitumen from sample, based on calibration curve which 1/ρ versus percentage concentration of bitumen in DEX.

3. Results and discussion

3.1. Effect of temperature on% bitumen recovery

Effect of temperature in percentage recovery of bitumen is shown in Figure 1.

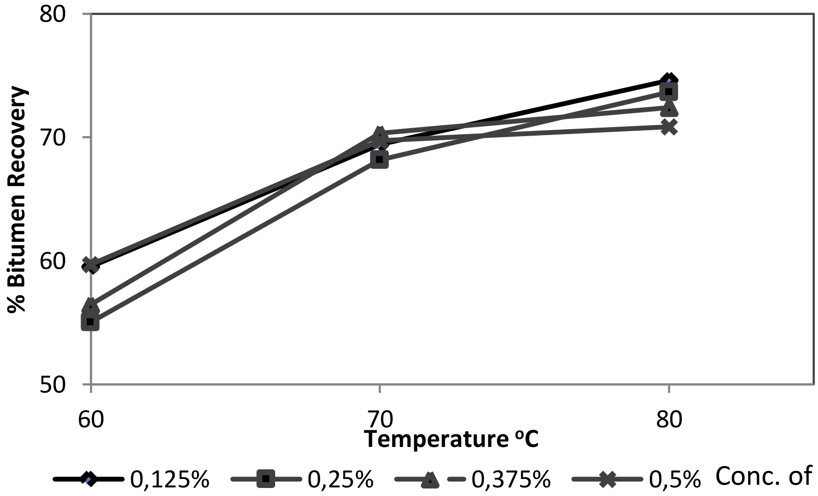

Figure 1. Effect of temperature on the percentage recovery of bitumen at 0.5% concentration of SDBS surfactant and various concentrations $Na_5P_3O_{10}$.

The decreasing viscosity is necessary and become an initial step for releasing bitumen from the Asbuton/mineral. Increasing temperature of process, along with addition of hydrocarbon solution (such as DEX), has an effect to reduce the viscosity and also enchance separation efficiency [10].

Currently, common temperature that is used in bitumen extraction process is around 50^{0}C. In this kind of situation, bitumen has known to flow easily, but, when we try to increase the temperature, viscosity of bitumen decreases significantly. The high temperature will change the interfacial tension between bitumen and water. It makes separation process become more easily and increases the yield [11].

Figure 1 also shows that increasing in temperature of process between 60°C to 80°C are able to increase percentage recovery of bitumen. DEX solution also was added as a diluent to reduce viscosity from sample.

3.2. Effect of SDBS surfactant concentration against percentage of bitumen recovery

Effect of SDBS surfactant against percentage recovery of bitumen is shown in Figure 2. Figure 2 shows increasing in concentration of SDBS surfactant will give reducing effect in percentage recovery of bitumen. The main purpose of surfactant addition to the mixture is to serve as wetting agent that will reduce the interfacial tension that occurs between *bitumen-dex* layer and mineral layer. Differences in density and also decreasing effect in interfacial tension, cause the *bitumen-dex* layer to move up, and the mineral layer drops down. This phenomenon is called as gravity separation.

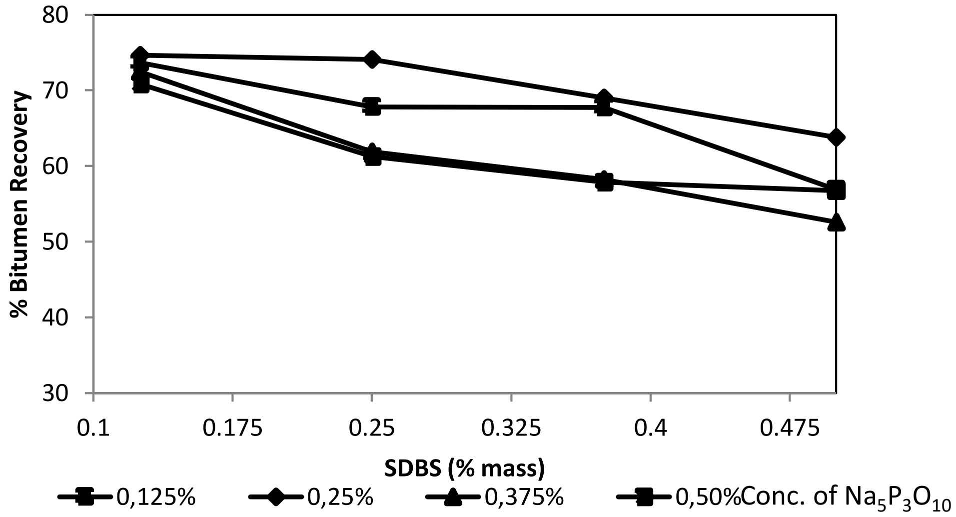

Figure 2. Effect of SDBS surfactant against percentage recovery of bitumen at 80°C with various concentrations of $Na_5P_3O_{10}$.

In general, the effect of surfactant addition will decrease interfacial tension until CMC (Critical Micelle Concentration) value has reached [12]. Surfactant concentration that exceeds the CMC value will result in formation of micelles and does not has any effect to decrease interfacial tension [13].

The CMC value of SDBS surfactant is strongly influenced by presence of electrolyte. With the presence of electrolyte ions, the CMC value is equal to $4x10^{-4}$ M, but, without the presence of electrolyte ions, The CMC value will be at 1.6×10^{-3} M [14]. However, at concentration of 1/10x CMC, SDBS lowers interfacial tension the most [15].

From the data of this research, variation of SDBS surfactant which is added, has already exceeded the CMC value of SDBS. It means, high concentrations of SDBS surfactants reduces the effectiveness of its work and reducing percentage recovery of bitumen [16].

3.3. Effect of Adding Sodium tripolyphosphate ($Na_5P_3O_{10}$/ NTP) against % bitumen recovery

The effect of adding Sodium tripolyphosphate ($Na_5P_3O_{10}$/NTP) against percentage recovery of bitumen is shown in Figure 3

Figure 3 shows increasing percentage recovery of bitumen in specific $Na_5P_3O_{10}$ concentration of 0.25% (w/w). However, after exceeding 0.25% (w/w) of $Na_5P_3O_{10}$ addition, percentage recovery tends to decrease. Natrium tripolyphosphate ($Na_5P_3O_{10}$) is an agent that is used to improve the efficiency of the separation of White rock's tar sand [17]. In general, $Na_5P_3O_{10}$ is not used as primary alkali to produce soap for interfacial tension reduction process, but being used in combination with other alkalies, such as sodium carbonate (Na_2CO_3) or sodium hydroxide (NaOH) to improve wetting power [18,19].

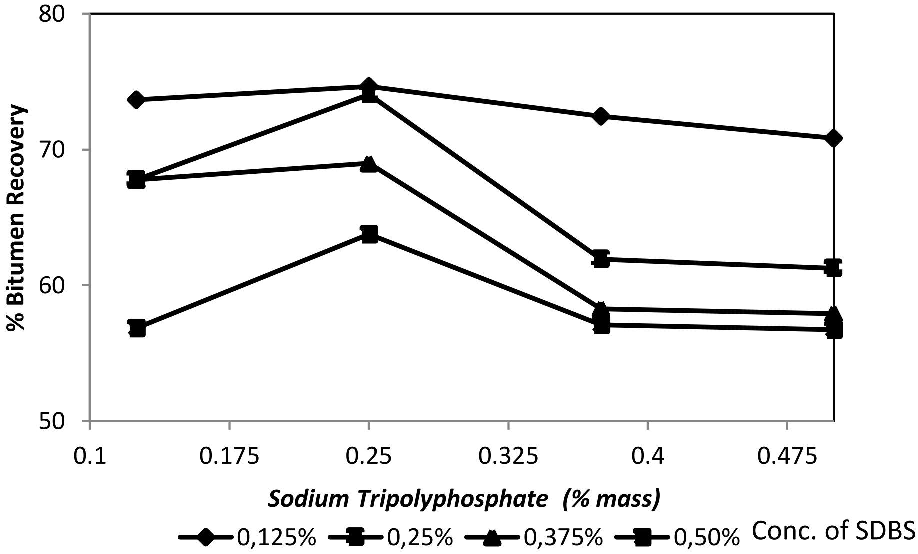

Figure 3. The effect of Na5P3O10 addition in various concentration against percentage recovery of bitumen at 80°C with various concentrations of SDBS surfactant.

$Na_5P_3O_{10}$ has ability as an extraction agent and can not lower interfacial tension significantly if used alone, but, in contrast, $Na_5P_3O_{10}$ is able to work well if working in combination with other substances. $Na_5P_3O_{10}$ also could minimize precipitation of divalent ion and change wetting ability along with emulsification during the process [20].

The buffer properties of $Na_5P_3O_{10}$ also keeping pH value not to increase, since pH value can affect the value of interfacial tension during reaction. The addition of $Na_5P_3O_{10}$ solution will raise the pH value and causes hydrolysis reaction, because of alkali and naphthenic acid, to produce soluble anionic surfactant during extraction process. The statement above explains that $Na_5P_3O_{10}$ can work properly, when being used together with other alkaline compounds [19]. Because of these properties, percentage recovery of bitumen does not show an increase with increasing concentration $Na_5P_3O_{10}$.

4. Conclusion

This study investigates the effect of several variables during extraction process to the percentage recovery of bitumen from asbuton, likes temperature, addition of SDBS surfactant, and also effect of $Na_5P_3O_{10}$ addition. The percentage of bitumen recovery increases along with increasing temperature during process. It looks that increasing of SDBS concentration to the mixture, from 0.125% to 0.5% will decrease bitumen recovery. It occurs since SDSB concentration already exceeds the CMC value and does not has any effect to decrease interfacial tension. The highest percentage of bitumen recovery is 74.63% at 80°C with the concentration of SDBS surfactant is 0.125%, and for $Na_5P_3O_{10}$ is 0.25%. Addition of $Na_5P_3O_{10}$ also helps extraction process of bitumen recovery but only at specific concentration at 0.25%.

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