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Wastewater Treatment with Acoustic Separator
音響放射力を用いた排液の浄水

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1. Introduction

Bitumen and crude oil produced from oil sands are a major energy source. However, the production of oil sands affects environmental and health issues including the issue of water. Oil sands contain between 8 and 14 wt% bitumen with significant amounts of undesirable things such as coarse sands and clays. About 3.0 m^3 of water is required to extract 1.0 m^3 of crude oil from oil sands [1]. After the extraction process, the contaminated water, called OSPW (Oil Sands Process-affected Water), is discharged and stored in tailings ponds. OSPW in the ponds may impact the aquatic environment, and should be purified [2]. Cost reduction of water treatment would make OSPW treatment familiar and ordinary, and thus the aquatic environment could be kept as is.

Several water treatment options of various efficiencies have been proposed for OSPW [3]. It is widely accepted that a treatment train composed of several treatment steps will be required to achieve water quality suitable for discharge to the environment. This would include primary treatment to remove suspended solids (clays, oil droplets, etc.) that could comprise coagulation, flocculation and settling. Reducing the chemical doses required for coagulation would contribute to operational cost reduction for OSPW treatment because these chemicals are a cost factor in the treatment.

Acoustic separating technique which induces self-assembly phenomena of the suspended matters is one candidate method to reduce the chemical amount. In this report, a batch-system separation based on acoustic separation is demonstrated with a small scale acoustic separator

2. Materials and methods

Acoustic separator was manufactured in a cylindrical acryl resin tube as shown in Fig.1 whose length and internal diameter were 150 and 20 mm, respectively. The cylindrical acryl was sandwiched between a PZT piezoelectric transducer and an aluminum reflector. OSPW from a northern Alberta tailings pond was used as a model sample (COD (Chemical Oxygen Demand): 256 mg/L, Turbidity: 408 NTU, Oil: 10 mg/L). By measuring the transmittance of a He-Ne laser (λ = 640 nm) through the sample, COD in the sample was estimated with the calibration curve of COD to the transmittance.

In this report, “required settling time”, which was defined as the time at which the COD reached the environmental criterion (< 200 mg/L), was used to evaluate the acoustic separtor perfromance.

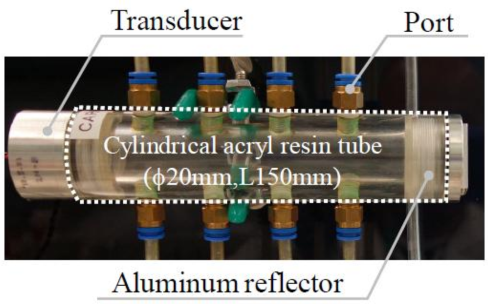

Fig. 1 Prototype acoustic separator. Transducer: PZT (Resonance frequency: 2.17 MHz)

3. Results and Discussion

The effect of $FeCl_3$ dose on COD reduction with ultrasound treatment is shown in Fig.2. The acoustic separator was operated at frequency of 2.17 MHz with power of 26.5 W/cm^2. Ultrasound was applied to the sample for 30 seconds. Little change in COD was observed in the sample that did not receive a $FeCl_3$ dose as shown in Fig.2 (a). However, the trend of COD vs settling time shifted downward when the $FeCl_3$ dose was increased. This result indicates that the required settling time could be reduced by increasing the $FeCl_3$ dose.

Fig.2 (b) shows the effect of $FeCl_3$ dose on the required settling time. As mentioned above, the required settling time was observed to decrease with increasing $FeCl_3$ dose. By using the acoustic separator, the required settling time of the sample dosed with $FeCl_3$ of 500 mg/L was shortened from 10 minutes to 1 minute. Based on these results, it can be estimated that a sample coagulated with a 160 mg/L $FeCl_3$ dose and subjected to US at the frequency, power and duration used in these tests would require the same settling time as a sample dosed with 500 mg $FeCl_3$/L that was not sonicated. This result indicates that for a given settling time, coagulant dose could be reduced considerably by applying the acoustic separator in the OSPW treatment.

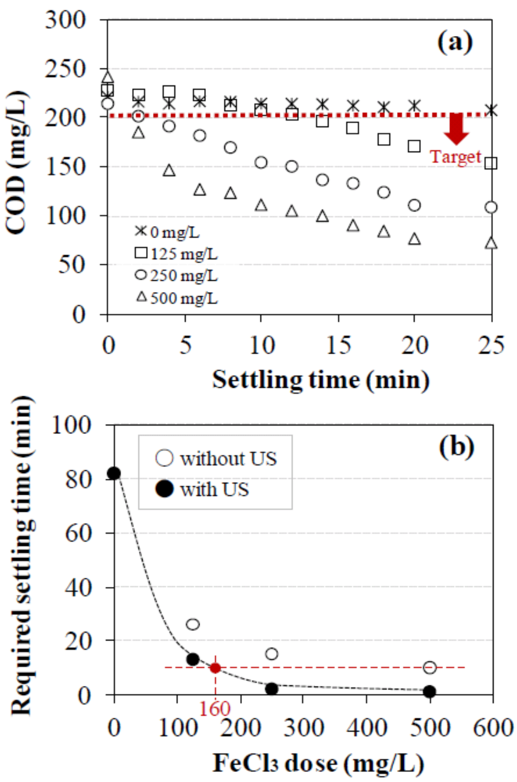

Fig. 2 Dependence of COD on $FeCl_3$ dose. (a) COD change as function of settling time in sonicated samples (frequency of 2.14 MHz with power of 26.5 W/cm^2 for 30 seconds), (b) Required settling time at which COD becomes lower than the target value of 200 mg/L vs $FeCl_3$ dose.

Fig.3 shows the schematic diagram of the treatment mechanism in coagulation and flocculation with acoustic separation. Large flocs are formed in the following two steps; 1) Coagulation and 2) Flocculation. Destabilization of the suspended matter occurs during the coagulation. Acoustic radiation force can only manipulate suspended matter in the sample, not destabilize it. Therefore, if surface potentials on the suspended matter were high, the matters were not flocculated by applying the acoustic separator. To treat a suspension containing suspended matters whose surface potentials are high, a coagulants such as $FeCl_3$ would be required to destabilize the suspended matters. It has also been reported that the potentials of the suspended matters in OSPW are high [4]. That explains why acoustic separator alone could not reduce the COD as shown in Fig. 2. Only flocculation of the suspended matter was enhanced by applying the acoustic separator. Therefore, destabilization by means of a coagulant will be required when acoustic separator will be applied to the OSPW treatment.

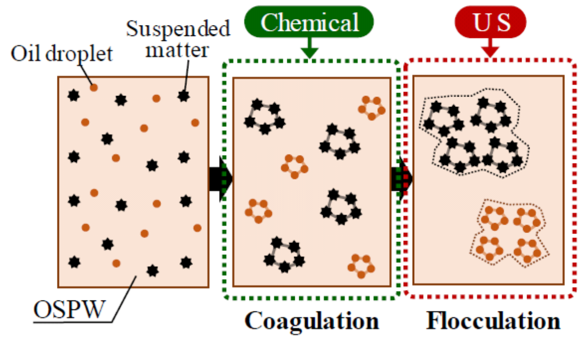

Fig. 3 Schematic diagram of coagulation and flocculation effect of $FeCl_3$ and Ultrasound (US)

4. Conclusion

Applying acoustic separator to the batch use OSPW treatment, the required settling time which is the time that the COD reduces to the environmental criterion (< 200 mg/L) could be shortened from 10 minutes to 1 minute. Shortening the required settling time results in the capital expenditure reduction because the tank of a water treatment facility can be smaller. Moreover, for a given settling time, the required $FeCl_3$ dose was much lower when acoustic separation was used. For a 10 minute settling time, acoustic separation could reduce the $FeCl_3$ dose from 500 mg/L to 160 mg/L, which would result in a reduction of operating expenditure.

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