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Effect of temperature on field latex preservation and potential of membrane fouling from latex serum*

ผลกระทบของอุณหภูมิต่อการรักษาสภาพน้ำยางสดและศักยภาพของการเกิดฟาวลิ่งจากการกรองซีรัมน้ำยาง

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Abstract

This research focuses on the effect of temperature on stability of field latex with chemical conditioning and potential of membrane fouling when filtering latex serum. Difference of temperature was studied and observed at 30 °C and 50 °C. High temperature could induce the coagulation of latex particles faster than low temperature. The addition of sodium dodecyl (lauryl) sulfate (SDS) had a good effective chemical for stabilization and preservation field latex which could expand storage time to 36 h and 17 h for 30 °C and 50 °C of incubation temperature. Microfiltration lab scale unit with plane organic membrane was used to evaluate membrane fouling potential when filtering latex serum with and without adding SDS. Latex serum with SDS conditioning showed higher αW values than without SDS addition. αW values of any SDS concentration when filtering latex serum from 40%DRC and 50%DRC of latex suspension were not quite different which were the values in the range of 5.66 $\times 10^{12}$ m^{-2} to 8.50 $\times 10^{12}$ m^{-2}. The filtration of latex serum from 60%DRC with SDS conditioning obtained 8 times of αW values, about 14.2 $\times 10^{12}$ m^{-2} to 25.5 $\times 10^{12}$ m^{-2}, higher than without conditioning.

Keywords: field latex, latex serum, resistance coefficient, membrane fouling

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* The objective of this research is to study the effect of temperature on stability of field latex with chemical conditioning and potential of membrane fouling when filtering latex serum.

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บทคัดย่อ

งานวิจัยนี้มุ่งเน้นไปที่การศึกษาผลของอุณหภูมิต่อความมีเสถียรภาพของตัวอย่างน้ำยางสดที่มีการปรับสภาพและไม่ปรับสภาพด้วยสารเคมี รวมถึงการศึกษาศักยภาพการเกิดฟาวลิ่งเมื่อกรองซีรัมน้ำยาง โดยที่ผลของอุณหภูมิต่อความมีเสถียรภาพของตัวอย่างน้ำยางสดนั้นได้ทำการศึกษาที่ 30 และ 50 องศาเซลเซียส ซึ่งจากการศึกษาพบว่าอุณหภูมิที่สูงกว่านำไปสู่การจับตัวรวมกันเป็นกลุ่มก้อนของอนุภาคยางเร็วกว่าการศึกษาที่อุณหภูมิต่ำกว่า และพบว่าการเติมสารลดแรงตึงผิวประจุลบชนิด SDS (sodium dodecyl (lauryl) sulfate) ส่งผลบวกต่อเสถียรภาพและการรักษาสภาพของตัวอย่างน้ำยางสด ซึ่งสามารถช่วยยืดระยะเก็บรักษาได้ถึง 36 ชั่วโมงสำหรับการทดสอบที่อุณหภูมิ 30 องศาเซลเซียส และ 17 ชั่วโมงสำหรับการทดสอบที่อุณหภูมิ 50 องศาเซลเซียส ในขณะที่ชุดทดสอบไมโครฟิลเตรชันระดับห้องปฏิบัติการร่วมกับเยื่อกรองแบบแผ่นถูกนำมาใช้เพื่อศึกษาศักยภาพการเกิดฟาวลิ่งเมื่อกรองซีรัมน้ำยางร่วมกับการเติมและไม่เติม SDS ผลการศึกษาพบว่าค่าสัมประสิทธิ์ความต้านทานของซีรัมน้ำยางที่ผ่านการปรับสภาพด้วย SDS มีค่าสูงกว่าในตัวอย่างที่ไม่มีการเติม SDS และพบว่าความเข้มข้นของการเติม SDS ไม่ส่งผลอย่างชัดเจนต่อค่าสัมประสิทธิ์ความต้านทานเมื่อกรองซีรัมน้ำยางที่เตรียมจาก 40%DRC และ 50%DRC ของตัวอย่างน้ำยาง โดยพบว่าอยู่ในช่วง 5.66 $\times 10^{12}$ m^{-2} ถึง 8.50 $\times 10^{12}$ m^{-2} และเมื่อกรองซีรัมน้ำยางที่เตรียมจาก 60%DRC ของตัวอย่างน้ำยางร่วมกับการปรับสภาพด้วย SDS ส่งผลให้ค่าสัมประสิทธิ์ความต้านทานมีค่าสูงกว่า 8 เท่า เมื่อเปรียบเทียบกับสภาวะที่ไม่มีการปรับสภาพใดๆ โดยพบค่าอยู่ในช่วง 14.2 $\times 10^{12}$ m^{-2} ถึง 25.5 $\times 10^{12}$ m^{-2}

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Introduction

Para rubber is a one crop economy of Thailand. Field latex from rubber tree is added ammonia for preservation and stabilization before sending to produce concentrated latex commonly using centrifugation which has dry rubber content (DRC) approximately 60%. In addition, before storage its stability is also preserved by further adding ammonia and other chemicals (Tekasakul and Tekasakul 2006; Jawjit et al., 2015). However, temperature change is one of parameters a effecting on latex stability. After centrifugation process giving a part of skim latex contained the smallest latex particles with a low DRC in the range of 4-8%. In generally, latex particles from skim latex were recovered by sulphuric acid coagulation. Latex serum is a by-product of this step containing a small part of uncoagulated latex and soluble compound such as sugars, proteins, mineral ions and humic matter (Abrahama et al., 2009; Sakdapipanich and Rojruthai 2012). Such latex serum is discharged as serum wastewater without recovering valued product from them. Membrane separation seems easily suitable process for latex serum clarification. However membrane fouling is still limitation of its application. The prediction of membrane fouling potential should be evaluated to be a

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reference values. This work aims to (i) study effect of temperature on field latex stability with chemical conditioning and (ii) evaluate the potential of membrane fouling in microfiltration of latex serum conditioning by using the cake filtration model.

Materials and Methods

Experiment of temperature on coagulation time of latex particles

Field latex (30-35% DRC) was harvested from rubber tree in Songkhla province. Field latex sample was prepared for four conditioning (i) field latex (ii) field latex with 8-8.5 of pH value by adding HCl (hydrochloric acid) and (iii) field latex with 1% of sodium dodecyl (lauryl) sulfate (SDS) and a pH adjustment HCl addition in the range of 8-8.5. In this study SDS was added for preservation purposes. Incubator shaker was used to obtain constant temperature during tests which was study at 30 ˚C and 50 ˚C. The physical observation and conductivity were monitored the stability reduction of field latex with time.

Membrane fouling potential test

Concentrated latex obtained from concentrated latex factory in Songkhla province. Samples were prepared different concentrated latex dilution by deionized water for 40%, 50% and 60% of DRC, respectively. Then latex particles in latex suspension samples were separated by 2% of acetic acid obtaining latex serum of 30%, 40% and 50% from such latex suspension samples. Latex serum from this step contained a small amount of uncoagulated latex. The obtained latex serum was adjusted pH value in the range of 7-8 by ammonium hydroxide (NH_4OH) addition and added SDS at concentration of 0.05%, 0.1%, 0.3%, 0.5%, 1% and 2%, respectively. These samples were used as feed suspensions (100 mL) for filterability tests to evaluate membrane fouling potential. Microfiltration lab scale unit, volume 200 mL, with 0.22 µm of plane organic membrane was used in these experiments. Permeate of latex serum during filtration test was collected to get the cumulated volume of filtrate under constant transmembrane pressure (TMP) 1 bar without any mixing. Figure 1 and Figure 2 showed a schematic diagram of the experimental set-up and gave some membrane characteristics in Table 1.

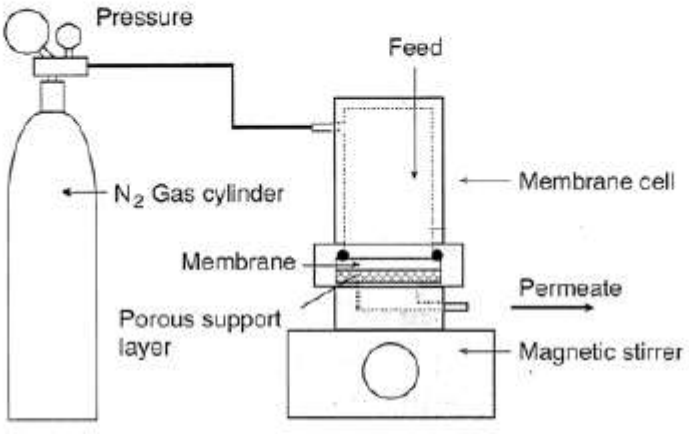
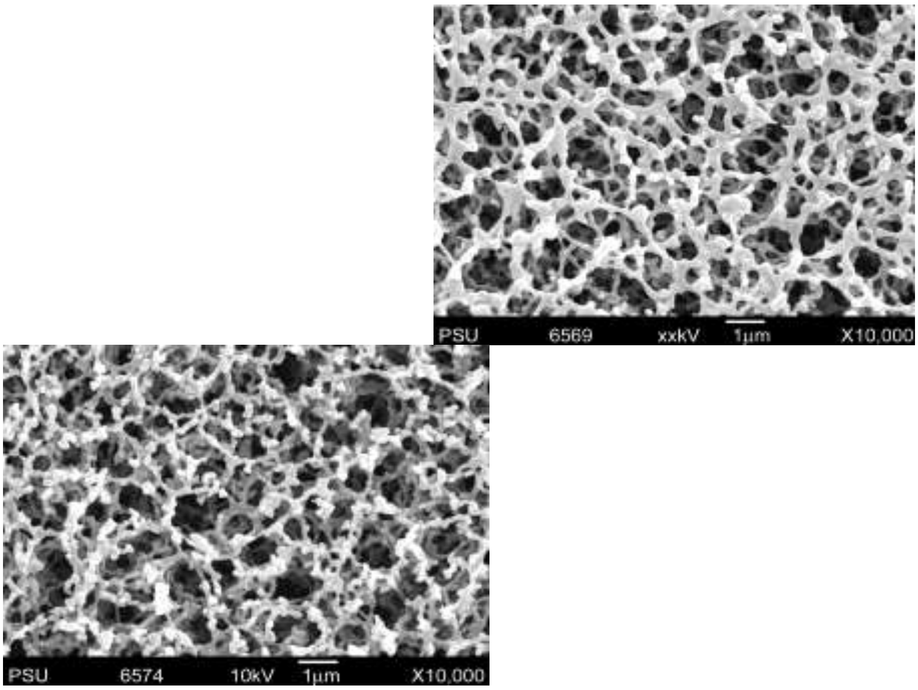


Figure 1 Schematic diagram of the experimental microfiltration lab scale unit and plan organic membrane (GSWP 04700)



Effective layer

Support layer

Figure 2 SEM analysis of plan organic membrane (GSWP 04700)

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Table 1 Membrane characteristics

Characteristics	GSWP 04700 membrane
Type	Plane
Membrane material	Mixed cellulose ester
Dimension (mm,diameter)	47
Filtration area (cm^2)	11.9
Pore size (µm)	0.22
Porosity (%)	75
Thickness (µm)	180
Water permeability (20°C, 1 bar) ($l.\ hr^{-1}.m^{-2}$)	10,800
Membrane resistance R_m (m^{-1})	2.5×10^6

The cumulated volumes of filtrate and filtration time were collected to calculate and analyze the resistance coefficient (αW) by using cake filtration theory. Slope of linear plot between t/V and V was used to calculate and replace into the Equation 1. V is cumulated volume of filtrate (m^3); t is filtration time (s); µ is dynamic viscosity (Pa.s); α is specific resistance ($m.kg^{-1}$); W is particle concentration ($kg.m^{-3}$); TMP is transmembrane pressure (Pa); R_m is initial membrane resistance (m^{-1}) and Ω is membrane area (m^2) (Ognier et al., 2002; Sridang et al., 2006; Sridang et al., 2008).

$$\frac{t}{V} = \frac{\mu \times \alpha \times W}{2 \times \Delta P \times \Omega^2} \times V + \frac{\mu \times R_m}{\Delta P \times \Omega} \quad (1)$$

Results and discussion

Effect of temperature on latex particles coagulation

Effect of temperature on the coagulation time of field latex particles was studied in the condition of without SDS and with SDS addition. Figure 3 pointed out that the result of initial conductivity value of field latex showed in the range of 2.72-8.18 mS/cm, 6.64-9.64 mS/cm of field latex for pH value of 8-8.5 by adding HCl and 6.83-9.81 mS/cm of 1% of SDS addition.

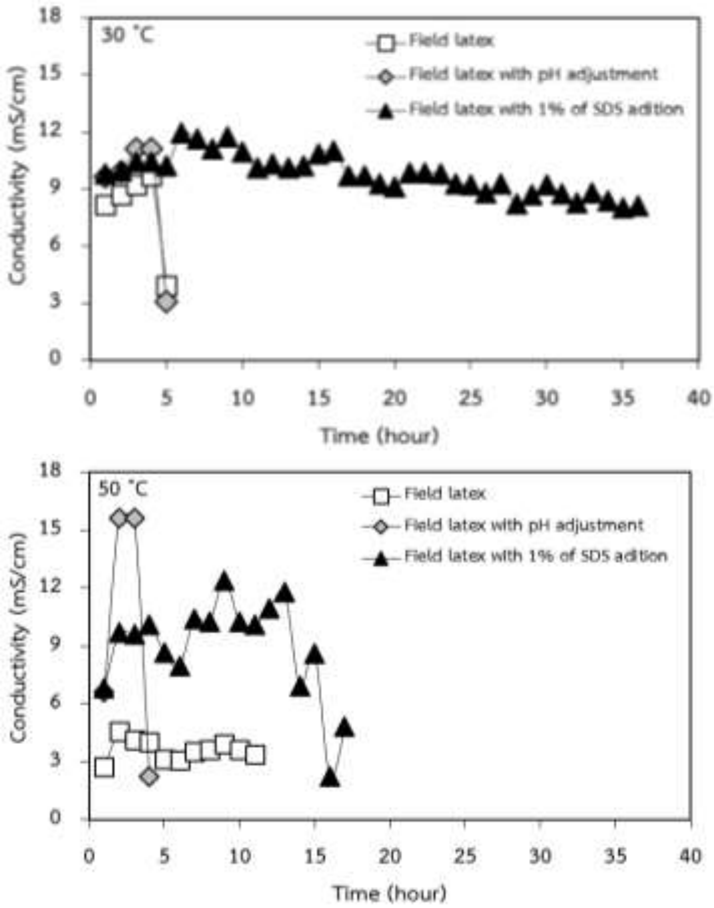

Figure 3 Conductivity value vs. coagulation time at 30 ˚C and 50 ˚C

It was found that latex particles of both conditions (with and without pH adjustment in field latex) had a large coagulation after incubation at 30 ˚C about 5 h, presenting conductivity value in the range of 3.10-3.94 mS/cm. For incubation at 50 ˚C a large coagulation of latex particles was observed in sample with pH adjustment after 4 h of operation time and giving 2.22 mS/cm of conductivity value. After 11 h of operation time latex particles of field latex without any condition obtained 3.39 mS/cm of conductivity value and found colloids destabilization as a large coagulation forming like a tofu as shown in Figure 4 a) and b). In case of condition with 1% SDS addition, flocculation/coagulation of latex particles was observed after operation time of 36 h and 17 h for 30 ˚C and 50 ˚C of temperature incubation (Figure 4 c)). The conductivity value appeared in the range of 4.81-8.11 mS/cm. It showed that lower temperature had a positive effect on colloids stabilization. Moreover, addition of 1% SDS could extend the time of colloids stabilization. This was probably due to SDS addition gave the excessive negative charges while latex particle also had a negative surface charges, so SDS and

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latex particles were pushed together which induced to keep colloids status and extend the storage time (Sridang et al., 2012).

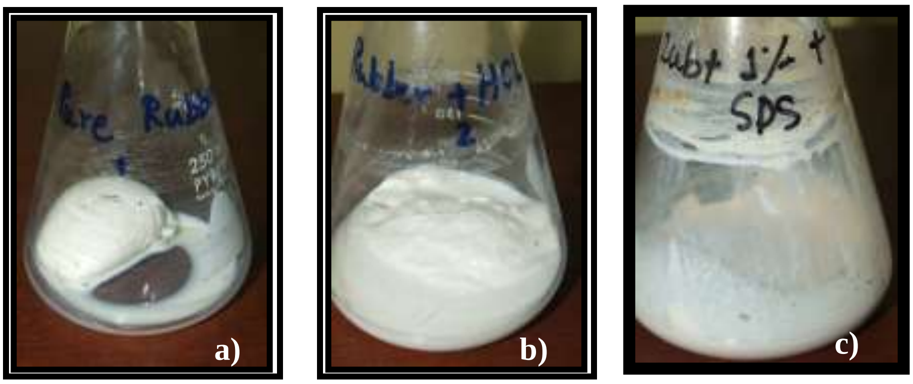

Figure 4 Destabilization and coagulation of latex particles (a) field latex b) field latex with pH adjustment and c) field latex with 1% of SDS addition)

Membrane fouling potential of latex serum filtration

The filterability tests were conducted in a lab scale unit equipped with a plane organic membrane and constantly operated at 1 bar of TMP. The evolution of t/V vs. V and the resistance coefficient (αW) during latex serum filtration with different condition are shown in Figure 5, Figure 6, and Table 2.

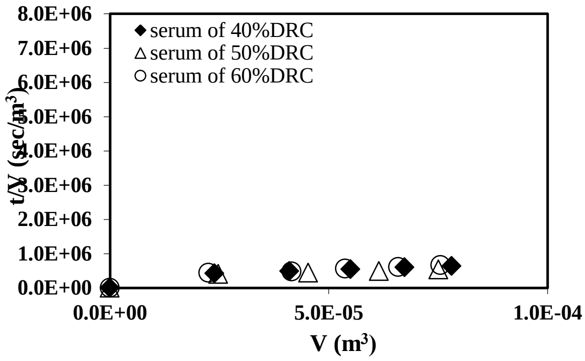

Figure 5 Evolution of t/V vs. V (filterability) for latex serum.

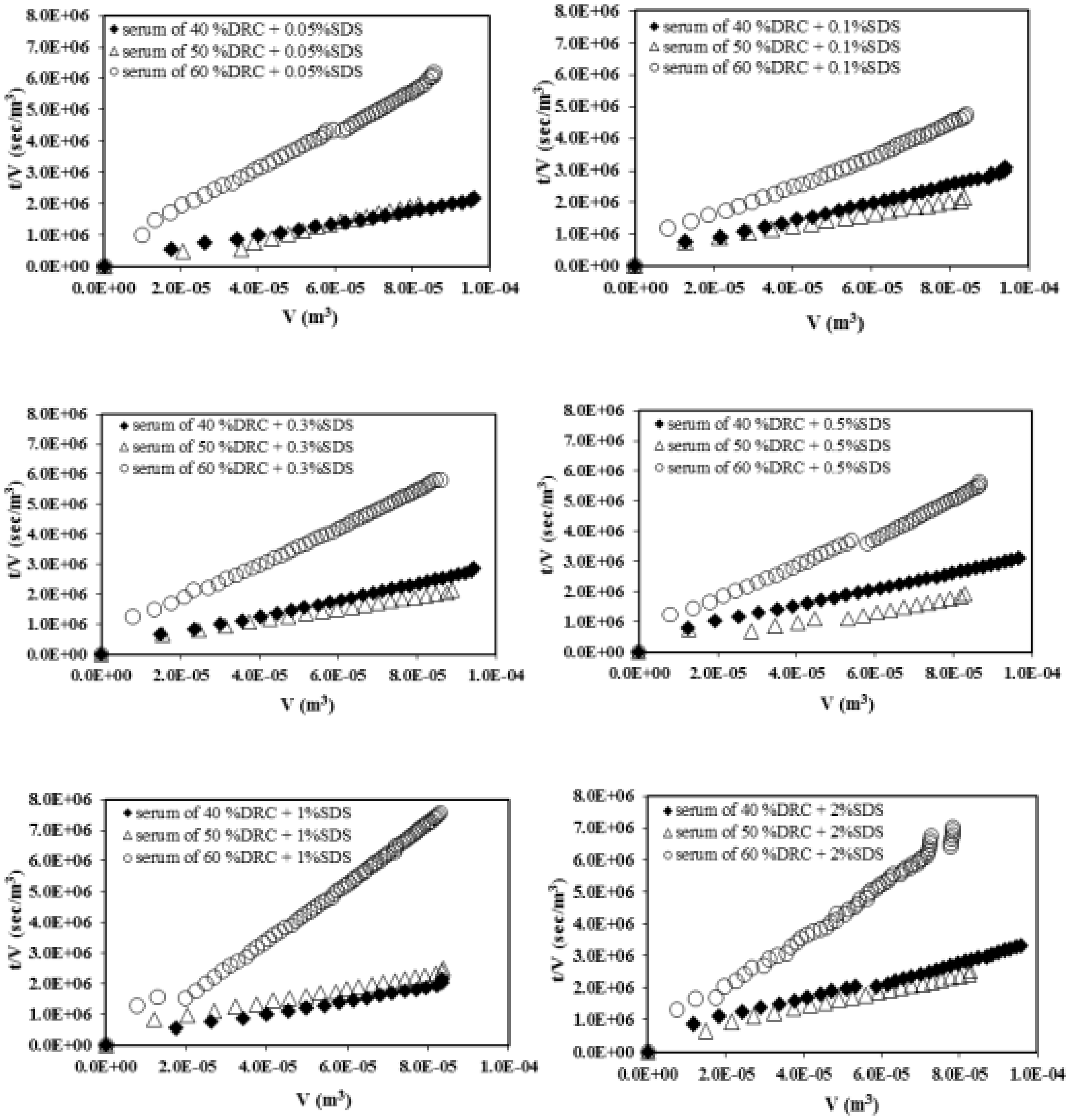

Figure 6 Evolution of t/V vs. V (filterability) for different condition of latex serum.

The filtration of latex serum without any condition and with SDS addition pointed out the different influence of hydrualic resistance. It was found that the linear plot of t/V with V in the condition of SDS addition was rapidly increased when comparing with no SDS addition, especially latex serum from concentrated latex suspensions (60% DRC). The rapid increase of linear graph at the beginning of filtration occurred from cake deposition (Sridang et al., 2008). When considering the value of αW, it was found that αW values after filtering latex serum (from 40%, 50% and 60%DRC of latex suspension and no adding SDS) were found in the close values which were about $1.98x10^{12}$, $1.70x10^{12}$ and $2.27x10^{12}$ m^{-2}. For chemical conditioning with SDS addition in latex serum, αW values were not quite different in any SDS concentration tested (in the range of 5.66 $x10^{12}$ m^{-2} to 8.50 $x10^{12}$ m^{-2}) and showed about 3-4 times higher than without chemical conditioning, except at 60%DRC of latex suspension. αW values of latex serum from 60%DRC of latex suspension when adding SDS were about 14.2 $x10^{12}$ m^{-2} to 25.5 $x10^{12}$ m^{-2} which were 8 times higher than without conditioning. This was probably due to the occurrence of film layer from adding SDS formed on membrane surface which induced hardly penetrate of latex serum to membrane.

Latex serum from 60%DRC of latex suspension in the condition of adding SDS showed high impact on increasing of αW values. This implied that residual uncoagulated latex and soluble fraction in latex serum were larger than pore sizes of membrane which could not penetrate or pass through them and led deposit on membrane surface as cake/biogel formation on membrane. Although, this study found that SDS conditioning of latex serum induced higher αW values than without SDS addition. However, chemical conditioning with adding SDS of skim latex suspension in previous study showed effective to stabilize latex particles in a part of latex serum which prevented the occurrence of coagulated latex particles. It also presented the positive result in terms of permeate flux control and αW values. This was the effect of SDS addition gave the excessive negative charges and could be attributed to the localized latex particles and structure, polarity and hydrophobicity of environment in micelles (Sridang et al., 2012; Thongmak et al., 2012).

Table 2 The value of αW obtained for latex serum tested.

Condition	αW of latex serum (*10^{12}, m^{-2})		
	40%DRC	50%DRC	60%DRC
Without SDS addition	1.98	1.70	2.27
0.05%SDS	5.66	8.50	17.0
0.1%SDS	8.50	5.66	14.2
0.3%SDS	8.50	5.66	17.0
0.5%SDS	8.50	5.66	17.0
1%SDS	5.66	5.66	25.5
2%SDS	8.50	8.50	22.7

Conclusions

The different temperature on stability of field latex with chemical conditioning pointed out that high temperature led to coagulation of latex particles in 17 hours. Field latex with SDS addition could preserve stability of field latex and expand storage time for both temperatures tested when comparing with no chemical conditioning. For the study of membrane fouling potential when filtering latex serum showed that latex serum with SDS conditioning induced higher αW values than without SDS addition. Concentration of SDS was not influence on αW values for filtration of latex serum from 40%DRC and 50%DRC of latex suspension. It showed higher 3-4 times than without chemical conditioning. While αW values of latex serum from 60%DRC of latex suspension were 8 times higher than without conditioning. Although the addition of SDS had a negative effect on filterability of latex serum, but latex serum quality still remained preserved if latex particles recovery is operated by acid coagulation from skim latex.

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