Development of Correlation Between Potassium Hydroxide Number and Conductivity of Concentrated Natural Rubber Latex

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ABSTRACT: Increase in the ion concentration in the medium was found to increase conductivity and potassium hydroxide number (KOH No) in natural rubber latex (NRL). Addition of long chain fatty acids can increase the ion concentration in the medium and stability of NRL. A series of concentrated natural rubber latex samples from three different areas with different soils and climatic conditions were tested for the parameters such as KOH No and conductivity. They have been measured over a period of 62 days, upon addition of soap to natural rubber latex concentrate. The result showed that there was a strong positive linear correlation between conductivity and KOH No. The regression equation to express the relationship between the variables has also been found. J Appl Polym Sci 107: 1066–1070, 2008

Key words: NRL; MST; KOH No; conductivity

INTRODUCTION

Potassium hydroxide number (KOH No) has been a long used test for characterization of latex but determination was found to be a lengthy and complicated procedure. On the other hand from the industrial point of view, it needs a simple and quicker method to investigate KOH No. because investigations consume considerable time and intricate procedure requires skilled workers to be employed. Hence, necessity for effortless and a faster method has become a requirement of the era.

KOH No and conductivity are highly influenced by the ionic concentration present in natural rubber latex (NRL). Further, in the past KOH No had been one of the well-known properties to check the quality of NRL. However, electrical conductivity measurement of lattices for being a simple property to measure has been a subject of interest for serving as a useful index of quality.[1–3]

The chemical constitution of ammonia-preserved NRL after storage differs considerably from that of the fresh, NRL. The overall concentration of ions present in the aqueous phase tends to increase with the storage time.[4,5] Long chain fatty acids in NRL develop gradually with time and attain to a maximum and tend to become constant at a stage. There can be different changes in latex system during this period which is called maturation. KOH No is one of the measurements of quality of the latex and therefore it is important to quantify KOH No. in NRL.

Cook and Sekar[1] have confirmed that specific conductivity increases both with volatile fatty acid No (VFA No) and KOH No. Recent study by Silva and Walpalage[6] has confirmed the latter. According to Cook and Sekar, there is a significant linear relationship between specific conductivity and VFA No of latex concentrate. Further, they have shown that conductivity of a fully preserved latex increases on storage even when a VFA of latex remains unaltered. As such high conductivity in given latex is not solely caused by a high VFA content. Madge[2] suggests that long chain fatty acid ammonium soap contribute more to KOH No than to conductivity and it seems likely that there may be a direct relationship between VFA No and conductivity in freshly ammoniated field latex, where long chain soap have not usually been formed to any greater extent.

In this study, the relationship between KOH No and conductivity has been studied with a view to find a faster and easy method to measure KOH No by establishing a correlation between them in the form of an equation. In comparison to other similar studies,[1–3] a wide spectrum of ionic concentration was obtained by, dealing with natural rubber lattices of different types, addition of different levels of soap, and taking measurement at different time peri-

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TABLE I
Initial Values of Properties of NRL Used

	Laboratory test data		
Property	A	B	C
MST[a] (s)	35	25	25
KOH[b] No	–	0.596	0.85
VFA[c] No	0.015	0.032	0.071
TSC[d] (%)	61.9	62.07	59.05
DRC[e] (%)	60.24	60.46	57.50
Alkalinity	0.2	0.2	0.2

[a] Mechanical stability test.
[b] Potassium hydroxide number.
[c] Volatile fatty acid.
[d] Total solid content.
[e] Dry rubber content.

ods. Purpose of this article is to establish a correlation between conductivity and KOH No.

EXPERIMENTAL

Materials

For the purpose of this investigation, low ammonia Tetramethylthiuram disulfide preserved (LA-TZ) concentrated NRL from three different geographical areas (A, B, and C-low quality) were used. They were collected from leading latex manufactures at three different periods. The principal lattices characteristic are shown in Table I.

The ammonium laurate soap was prepared as an aqueous solution by neutralizing lauric acid with ammonium hydroxide. The ammonium hydroxide was of general purpose grade reagent supplied by Aldrich while lauric acid was a commercial grade reagent. Ammonium laurate was prepared as a 10% solution. The pH of the final soap solution was 10.0. Other materials used in this work were analytical grade wherever possible.

Preparation of latex samples

Original lattices were first strained through wire mesh to remove any coagulum particles. Lattices from area A and B were divided into four portions and C was divided into three portions. Required amounts of ammonium laurate were added to these samples as a 10% solution and corresponding molar levels per 100 g of latex were obtained. Latex samples were prepared according to the soap concentrations given in Table II. Each sample was placed in air-tight plastic containers having same capacity ensuring structure to be same. These samples were then stored under room temperature at (29 ± 1)°C for 4 days to allow for the attainment of equilibrium. Each sample was monitored for variation with time in conductivity and KOH No.

For areas A and B, all the samples were individually tested for 6-weeks maturation at intervals of 7 days and there after a lapse of 21 days. But for area C all the samples were individually tested during 5-weeks maturation at intervals of 7 day. Samples S11, S21, and S31 without added soap were the control samples of area A, B, and C, respectively.

Determination of properties

Mechanical stability time was determined with 55% TSC at 35°C by means of a Klaxon MST test apparatus operating at 14,000 rpm conforming to ISO 35 : 1995[E] procedure. KOH No was determined at room temperature and 30% TSC content by means of combined apparatus system containing pH meter, electrode, and magnetic stirrer. The test was carried out according to ISO 127 : 1995[E] procedure. Conductivity was determined at 25°C by means of a conductivity meter. TSC, DRC, Alkalinity, and VFA No were determined in accordance with ISO 124 : 1992, ISO 126 : 1974, ISO 125 : 1990, and ISO 506-1974 [E], respectively. Foaming height was determined by MST apparatus and a scale graduated in mm.

Results of Table I give properties in the latex system soon after it exuded the rubber tree. All the properties with different maturation periods are then compared with respect to these initial values. Changes in these properties give clear picture of the quality of latex.

RESULTS AND DISCUSSION

Variation of conductivity upon maturation and effect of soap

Figures 1–3 illustrate the change in conductivity values of samples of different areas treated with different soap levels. High conductivity increment was shown within first few days.

Conductivity is a composite quantity which attributes to the overall ionic strength and basically nature and concentration of all dissolved ionic species in the medium. Surface- active substances may be pres-

TABLE II
Samples Prepared to Investigate Property Variation with Storage Time

Area	Sample code	Soap concentration in moles/100 g of latex (weight/100 parts latex)
A	S11	No added soap
	S12	2.1×10^{-4} [0.046]
	S13	3.36×10^{-4} [0.073]
	S14	4.62×10^{-4} [0.100]
B	S21	No added soap
	S22	2.1×10^{-4} [0.046]
	S23	3.36×10^{-4} [0.073]
	S24	4.62×10^{-4} [0.100]
C	S31	No added soap
	S32	0.84×10^{-4} [0.018]
	S33	2.1×10^{-4} [0.046]

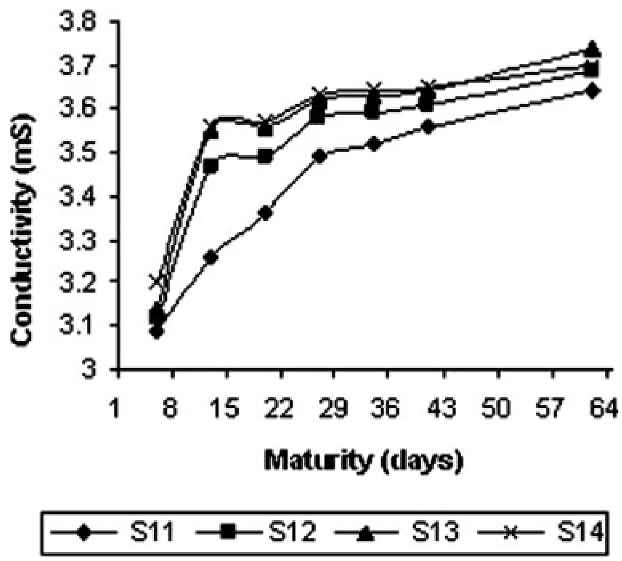

Figure 1 Effect of ammonium laurate soap on conductivity upon maturation of LA-TZ latex for area A.

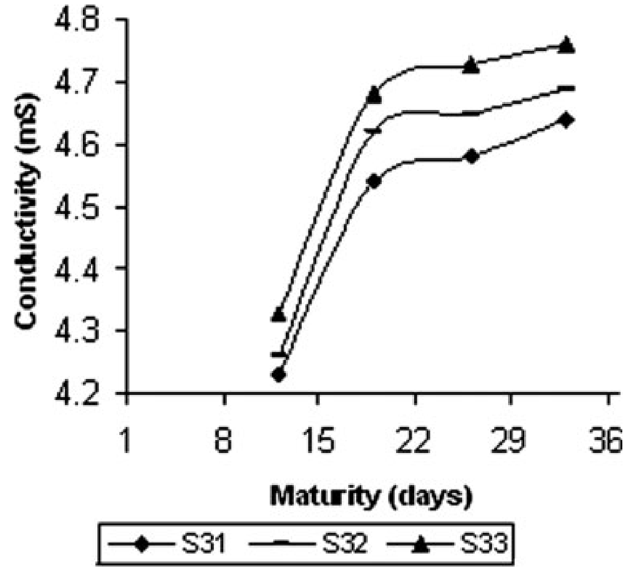

Figure 3 Effect of ammonium laurate soap on conductivity upon maturation of LA-TZ latex for area C.

ent as monomolecular form as well as micellar in the medium, whether these substances are ionized or not. According to Blackley,[7] contribution for the ionic strength from electrophoretic mobility of the rubber particle is usually assumed to be negligible. Dissolved ions in the aqueous phase are attributable for the conductivity.

Being a biological system NRL consists of nonrubber substances including phospholipids. Upon storage, these long chain molecules breakdown into long chain fatty acids and small species with time. One explanation for increase in ionic strength is usually attributed to this increased ion concentration in the medium as a result of mechanism of nonrubber breakdown.[7] On the other hand, increase in ionic strength is accompanied by added ammonium laurate to the medium.

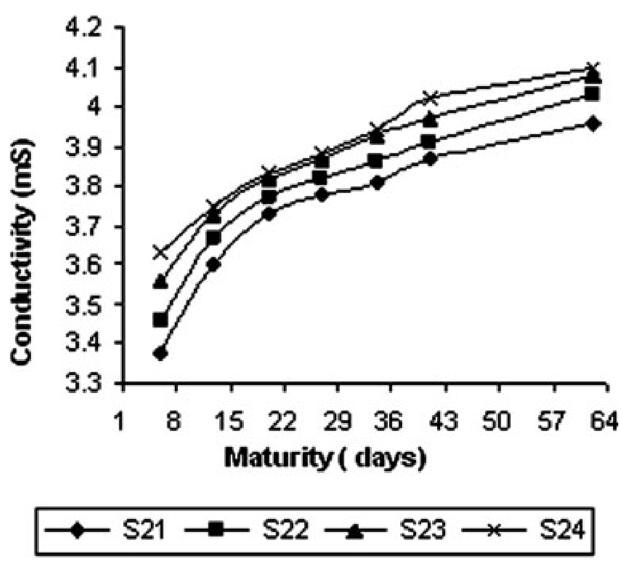

Figure 2 Effect of ammonium laurate soap on conductivity upon maturation of LA-TZ latex for area B.

According to Cook and Sekar,[1] presence of high VFA increase the ionic strength and hence electrical conductivity. But they have confirmed that conductivity of fully preserved latex increase on storage even when VFA remain unchanged. Therefore, high conductivity in given latex is not only caused by VFA.

In this work, conductivity was increased rapidly between 5 and 19 days in areas A, B, and 12–19 days in area C, respectively. Thereafter rate of increase tends to slow down. Lower results for C may be due to the different soil and climatic condition in the area. Results suggest that lipid hydrolysis offering ions to the medium contribute for the rapid increase in ionic strength within the first few days. Part of these higher fatty acids may adsorb on to the surface displacing some proteins to the medium.[8] These proteins may have released some acids increasing the ionic strength of the medium.

It appears that after first few days, conductivity of all samples tend to follow a plateau. These results suggest that the ion concentration in the medium try to maintain maximum ion concentration achieved. It can be suggested that consumption of lipids slowed down the hydrolysis and hence the medium tends to become stable by attaining to an equilibrium state.

Increase in conductivity with respect to the soap addition is due to the increased ionic strength of the aqueous phase brought about by added soap anions and their equivalent cations with respect to the level of soap. These alterations of ionic concentration in samples from all three areas are prominent with

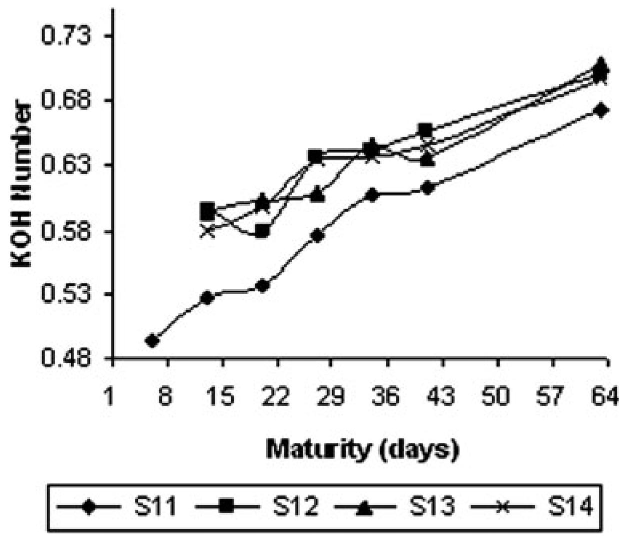

Figure 4 Effect of ammonium laurate soap on KOH No. upon maturation of LA-TZ latex for area A.

respect to the control samples of respective areas. Further adsorption of these anions may have displaced some proteins which donate some acids to the medium.

Variation of KOH No upon maturation and effect of soap

Figures 4–6 illustrate the change in KOH No values of samples of different areas treated with different soap levels. According to the analysis, KOH No of the samples increase during storage, ensuring many acid radicals formation. As reported by Bateman,[9] many acids such as phosphoric acid, amino acid, oxalic acid, succinic acid, fumaric acid, oxaloacetic acid, tartaric acid have been reported to be present in latex serum.

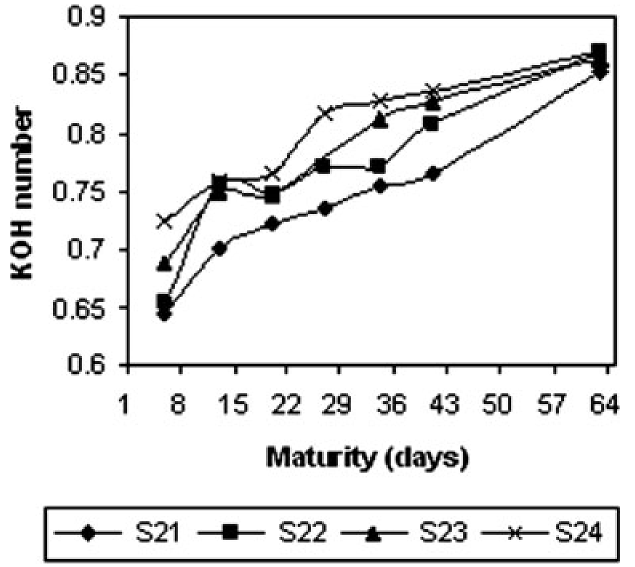

Figure 5 Effect of ammonium laurate soap on KOH No. upon maturation of LA-TZ latex for area B.

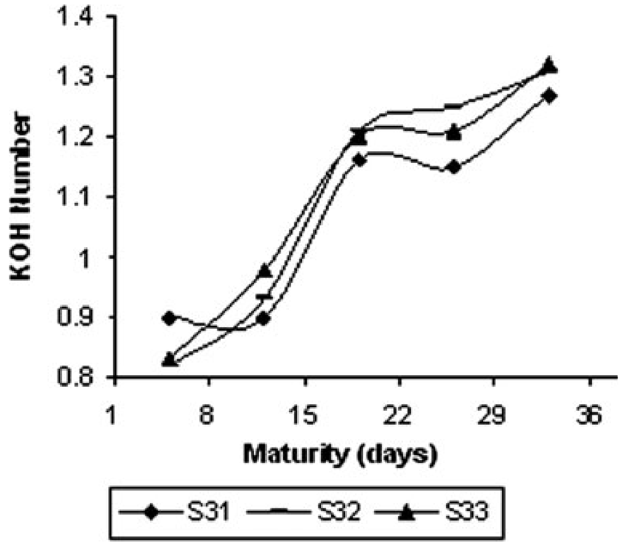

Figure 6 Effect of ammonium laurate soap on KOH No. upon maturation of LA-TZ latex for area C.

Results showed that rate of KOH increment were more rapid between 5 and 19 days for area C and 5–12 days for areas A and B. Explanation for this rapid increment can bring about as the rapid hydrolysis of lipids offering higher fatty acid and other acid radicals to the medium. These surface active agents may have adsorbed to the particle surface displacing some proteins or short chain fatty acids. These proteins may have positively contributed for the acidity development via protein hydrolysis releasing some amino acids to the medium. This additional increment in acid radicals in the serum may have contributed to the rapid increase in KOH No.

KOH No variation with respect to the soap addition is not significant. But still there is little variation in acidity development with respect to soap level in each area because of the increased acid radicals in the medium.

Correlation between conductivity and KOH No

The work and results in this study show similar pattern of variation of ionic strength in the medium and hence a relationship between KOH No. and conductivity is possible.

Statistical analysis was made to establish the correlations between the variables.

Correlation was made irrespective of areas, soap concentrations, and maturity. Correlation coefficient (R^2) value between conductivity (x) and KOH No (y) is 0.9615 (Fig. 7).

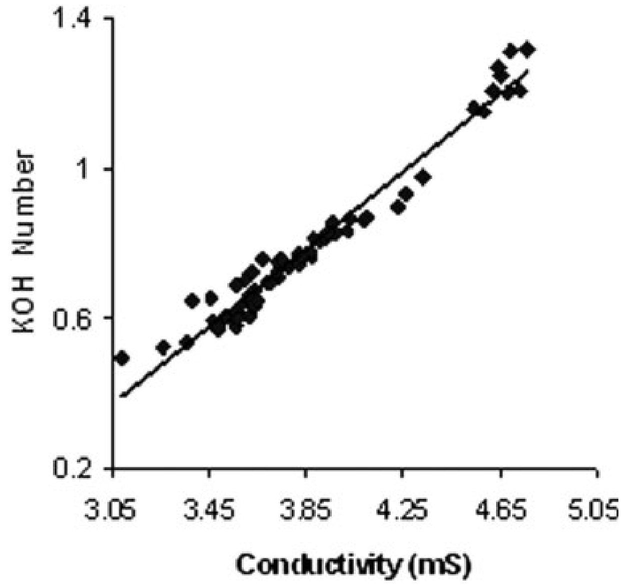

Figure 7 Correlation between conductivity and KOH No.

The regression equation is

$$y = 0.517 \times - 1.2073$$

where

$$3.09 \text{ mS} < x < 4.8 \text{ mS}$$

$$0.493 < y < 1.32$$

KOH No variation upon storage is highly influenced by lipid hydrolysis and ultimate development of acid radicals in the medium. Increment in ionic strength resulting conductivity variation with time is very similar to lipid hydrolysis offering ions to the medium. It is suggested that this similarity between acid radical formation and ion generation in the medium tends to form a linear correlation between these two properties.

Further study was carried out to develop relationship between soap level and foaming height, and conductivity and VFA No. However strong positive correlation is not visible between these properties. Results show that, when the time of agitation is increased prior to measure foaming height, the strength of the relationship in the correlation further decreases. However, there is a moderate positive linear correlation between conductivity and VFA No.

CONCLUSION

Correlation coefficient (R^2) value between conductivity and KOH No indicates that there is a strong positive linear relationship between conductivity and KOH No. The proposed relation can be applied to specified range of KOH No. Hence, it has become necessary that number of natural rubber latex have to be examined to adopt of this correlation as a general rule.

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