

Research Article

Impact of *N,N'*-Methylene-*bis*-Morpholine on the Preservation of Natural Rubber Latex

Liguang Zhao,^{1,2,3} Ruishen Fan,¹ Peng Li,⁴ Li Ding,^{1,2} Yazhong Song,^{1,2} Jianwei Li,^{1,3} Yuekun Wang,^{1,3} Tuo Dai,^{1,3} Dayu Deng,^{1,5} and Hongxing Gui^{1,2} 

¹Rubber Research Institute, Chinese Academy of Tropical Agricultural Sciences, Haikou, China

²Hainan Engineering Research Center of Natural Rubber Cultivation and Processing, Haikou, China

³Hainan Provincial Key Laboratory of High Performance Natural Rubber Material Engineering, Haikou, China

⁴The Fourth Production Plant of Changqing Oilfield Company, Yulin, China

⁵Hainan University, Haikou, China

Correspondence should be addressed to Hongxing Gui; guihongxing@263.net

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Natural rubber latex (NRL) preserved by high ammonia (HA) presents substantial pollution issues despite its good all-around properties. Cleaning preservation of NRL is critical in the modern rubber industry. In this study, NRL was preserved using *N,N'*-methylene-*bis*-morpholine (MBM), and the impact of MBM on the preservation and characteristics of NRL was investigated. The results showed that when the MBM dose was greater than 0.15 wt%, the volatile fatty acid value (VFA No.) and viscosity value of fresh NRL were lower, and it could be stored for longer than 5 days without losing stability. Furthermore, MBM demonstrated a favorable preservation effect on concentrated NRL (CNRL). To be effective, MBM must be administered at a dosage greater than 0.3 wt%. The mechanical stability test (MST) and VFA No. of the low-ammonia (LA)-CNRL prepared by MBM combined with ammonia were somewhat lower, whereas the viscosity value was greater. The research showed that the dose of lauric acid soap needs to be increased to improve the stability of ultra-LA-CNRL made by MBM-ammonia composite preservation. After pre-vulcanization treatment, the stability of LA-CNRL preserved by MBM-ammonia composite was drastically reduced. As the stabilizer dose was increased, the CNRL viscosity value decreased, whereas the MST and heat stability improved. The LA-CNRL vulcanized film has excellent mechanical properties similar to HA-CNRL. Furthermore, the infrared spectrum of the LA-CNRL raw rubber film was similar to that of the HA-CNRL film. The thermal degradation curve and characteristic temperature were also similar to that of the HA film. The study indicates that MBM has an outstanding preservation effect on fresh NRL and LA-CNRL, and the findings constitute a significant step forward in the development of the CNRL sector.

1. Introduction

Natural rubber latex (NRL) is a versatile substance used in impregnated, sponge, and pressing items in our daily life [1]. The *Hevea brasiliensis* laticifer produces NRL [2], a white slurry liquid. In addition to rubber hydrocarbons, it contains carbohydrates, proteins, lipids, acetone solubles, and water solubles [3]. These non-rubber components have a considerable influence on the NRL properties [4]. It is quite easy to get infected and produce a large number of bacteria once the NRL pours out of the rubber tree [5]. Bacteria and enzyme degra-

dation products will destroy the protective coating of NRL particles, reducing their stability [6, 7]. Furthermore, the formation of fatty acids, which neutralize alkaline substances and decrease pH value [8], reduces particle repulsion [9–11], resulting in adhesion and aggregation development between rubber particles. Furthermore, it can reduce latex colloid stability, causing fast solidification and rot of NRL [12, 13]. Bacteria are the primary cause of NRL solidification [6, 14]. NRL corruption will have a substantial influence on rubber quality and manufacturing efficiency; thus, preservatives must be used throughout production to keep NRL stable.

Preservatives have two purposes: they keep latex stable and fluid and they keep NRL fresh. The basic functions of preservatives are antibacterial, antiseptic, and enhancing stability [15, 16]. In addition to preserving the stability of NRL for a long time, NRL preservative does not affect the structure of rubber and does not affect processing or product performance. Surfactants can increase latex colloidal stability and reduce the surface tension between the two phases [17–19]. Ammonia–tetramethylthiuram disulfide (TMTD) and zinc oxide (ZnO), which have an excellent preservation effect, have long been utilized to preserve latex in manufacturing [20, 21]. The high volatility of ammonia and the stimulation of the respiratory system caused by the large dosage are harmful to the health of the employees. It contributes to serious pollution issues [22]. Cleaning and preserving NRL are recognized as essential in the rubber industry. The production of concentrated NRL (CNRL), that is, low-ammonia (LA) and ammonia-free, has become an urgent problem that has to be tackled right away in the CNRL processing and NRL products sectors as environmental problems gain prominence [23].

NRL preservation has been the topic of research and testing since the 1950s. Zinc sulfate, ammonium carbonate, formaldehyde, urea, methylamine, hydroxylamine, sodium pentachlorophenol, boric acid, 8-hydroxyquinoline, and chitosan have all been employed to keep NRL stable [15, 16, 24]. Numerous NRL preservatives have been introduced in recent years. Aziana et al. [25] applied streptomycin sulfate to preserve NRL; Zuhainis et al. [26] utilized a biological surfactant to keep latex stable; and Pastore [27] used plant tannin to preserve NRL. Although the majority of research was conducted in labs, certain discoveries have been applied in small-scale production, such as when LA, ammonia-free CNRL was produced in Malaysia utilizing 2-[(hydroxymethyl) amino] ethanol [24] preservation. Food preservatives, such as sodium tripolyphosphate, sodium citrate, and sodium benzoate, were used by some Chinese manufacturers. However, the cost, toxicity, and preservation effect of the aforementioned research achievements have prevented their widespread promotion and application.

The author, who has some expertise and has conducted an extensive study on NRL preservation technology, has developed two preservation systems based on hexahydrotriethylhomotriazine and benproisothiazoline, which, when employed in production, have a significant influence on CNRL preservation. However, the high cost of these systems limits the future promotion of their usage. *N,N'*-Methylenebis-morpholine (MBM) [28], a fast and efficient broad-spectrum, sustained-release formaldehyde fungicide that inhibits microbial growth and reproduction and prevents spoiling and odor generation, is ideal for usage in a variety of moist conditions. MBM is widely used in water-based systems, such as adhesives, paper pulp, leather, coatings, detergents, metalworking fluids, and detergents. MBM has several advantages, including extended endurance, moderate odor, and little skin irritation, and it has received a lot of interest in a variety of application fields. In this study, MBM was used as a primary fungicide to preserve fresh NRL. After that, LA-CNRL was preserved using MBM, ammonia, and

potassium laurate. The effect of MBM on NRL performance during processing and storage was examined.

2. Experimental

2.1. Materials

2.1.1. Primary Materials. Fresh NRL from plantations in Hainan province, China, was used for this study. Industrial grade MBM was provided by Shandong Yusuo Chemical Technology Co., Ltd., Linyi, China.

2.1.2. Preparation of Fresh NRL Samples. A specified quantity of fresh NRL was split into six equal parts, and then appropriate preservatives (ammonia, MBM, and Na_2CO_3 were 10 wt% solution, and TMTD/ZnO was a 25 wt% colloid) were added utilizing the formulation in Table 1. The preservative dose was calculated using the latex mass fraction. Samples A1 through A6 were labeled and kept at room temperature after thorough shaking. The TMTD/ZnO composite formula is made up of 68.9 parts soft water, 0.1 parts sodium hydroxide (NaOH), 15.0 parts TMTD, 15.0 parts zinc oxide (ZnO), 1.0 parts sodium methylene dinaphthalene sulfonate, and 0.1 parts NaOH, for a total of 100.0 parts.

2.1.3. Preparation of CNRL Samples. The fresh NRL sample was preserved by 0.25% ammonia before being processed to be CNRL. And then, the samples B1–B5 and C1–C9 were prepared according to Tables 2 and 3 and the preservation methods. The contents of ammonia, MBM, and 10 wt% lauric acid soap solution are shown in Tables 2 and 3. The preservative dosage was calculated using the CNRL mass. Samples B1–B5 and C1–C9 were thoroughly shaken. The samples were kept at room temperature and tested every month.

2.1.4. Preparation of the CNRL Raw Rubber Film. A suitable amount of CNRL was poured into a clean glass dish for leveling. The glassware was then dried in an oven at 60°C until the natural rubber (NR) film turned clear.

2.1.5. Preparation of the Pre-Vulcanized CNRL. CNRL was diluted to 50 wt% in a clean beaker in a water bath at 40°C while vulcanizing agent dispersion was added. The mixture was stirred at 60°C. The degree of curing was determined by the chloroform value method to fabricate the pre-cured CNRL. The formula of vulcanizing compound (dry base and mass fraction) was CNRL 100, sulfur 1, KOH 0.1, pereg-al-O 0.1, ZDC 0.5, and ZnO 0.4.

2.1.6. Preparation of the Vulcanized CNRL Film. An appropriate dosage of pre-vulcanized latex was placed into a clean glass dish for leveling and dried at room temperature before being removed and immersed in deionized water for 24 hours before being removed and heated in an oven at 80°C for 6 hours. The prepared film was removed, and the label was sealed for further use.

2.2. Measurement and Methods

2.2.1. Tests for CNRL. The volatile fatty acid value (VFA No.) of CNRL was determined according to International Organization

TABLE 1: Preservation formula of fresh NRL.

Sample	Ammonia (%)	TMTD-ZnO (%)	MBM (%)	Na ₂ CO ₃ (%)
A1	0.25	—	—	—
A2	0.25	0.04	—	—
A3	—	—	0.1	0.1
A4	—	—	0.15	0.1
A5	—	—	0.2	0.1
A6	—	—	0.25	0.1

Note. “—” indicates not addition; the dosage of preservative is measured by the wet weight of latex.

TABLE 2: Preservation formula of concentrated NRL.

Sample	Ammonia (%)	MBM (%)	Potassium laurate (%)
B1	0.7	—	0.05
B2	0.25	0.25	0.05
B3	0.25	0.3	0.05
B4	0.25	0.35	0.05
B5	0.25	0.4	0.05

for Standardization (ISO) 506:2020, the viscosity value of CNRL according to ISO 1652:2011, and the mechanical stability test (MST) of CNRL according to ISO 35:2004, and pH values of CNRL and pre-vulcanized CNRL were determined according to ISO23497:2019.

2.2.2. Mechanical Properties. Tensile strength, elongation at break, and fixed extension stress of vulcanized rubber film were determined according to ISO 1421:2016. The tear strength of vulcanized rubber film was determined according to ISO 34-2:2015. The hardness of vulcanized rubber film was determined according to ISO 48-4:2018.

2.2.3. Particle Size of CNRL. One milliliters of CNRL sample was absorbed with a disposable plastic straw, and the NRL was mixed uniformly in 100 mL of deionized water. The size and distribution of rubber particles were determined using a laser scattering particle size distribution analyzer LA-960S (HORIBA, Kyoto, Japan), and the reference area of particle size was selected. The refractive index of rubber particles was 1.388. A dispersant was water with a refractive index of 1.333.

2.2.4. FTIR Spectroscopy Analysis of CNRL Raw Rubber Film. A TENSOR 27 Fourier infrared spectrometer was used to test the samples. Fourier-transform infrared spectroscopy (FTIR) spectra were acquired in the range of 4000–370 cm⁻¹ with 32 scans at 4 cm⁻¹ resolution.

2.2.5. Thermogravimetric Analysis of Raw Rubber Film. The sample of raw CNRL rubber film sample was ground into particles, and about 10 mg of the sample was placed in a crucible. The sample was examined using an STA449 thermogravimetric analyzer in a nitrogen atmosphere (flow rate = 50 mL/minutes). Thermogravimetric analysis (TGA)

TABLE 3: Optimized formula of concentrated NRL preservation system.

Sample	Ammonia (%)	MBM (%)	Potassium laurate (%)
C1	0.7	—	0.04
C2	0.15	0.3	0.04
C3	0.15	0.3	0.08
C4	0.25	0.3	0.04
C5	0.25	0.3	0.08
C6	0.15	0.35	0.04
C7	0.15	0.35	0.08
C8	0.25	0.35	0.04
C9	0.25	0.35	0.08

Note. “—” denotes no addition; the dosage of the preservative is measured by the wet weight of latex.

was performed in the range of 25–600°C with a heating rate of 10°/minutes.

2.2.6. Determination of Low-Temperature Characteristics of Raw Rubber Film. The glass transition temperature (T_g) of CNRL raw rubber film was measured by differential scanning calorimetry. Measurements were made in the temperature range from -90°C to 100°C with a heating rate of 10°/minutes.

3. Results and Discussion

3.1. Preservation Effect of MBM on the Fresh NRL. The preservation effect of MBM in fresh NRL was investigated in this section. Figure 1(a) depicts the variations in VFA No. of fresh NRL prepared using various preservation systems. The preservation time of fresh latex preserved with 0.25 wt% ammonia water alone was relatively short, as shown in Figure 1(a), and the VFA No. of the NRL grows fast, exceeding the standard significantly after 2 days. At the moment, ammonia+TMTD/ZnO of the A2 sample was commonly used to prepare CNRL, and the preservation effect was good, with the VFA No. of fresh NRL remaining less than 0.06 after 5 days of storage. The VFA No. of fresh NRL samples preserved by MBM reduced as the MBM dose increased. When the MBM preservative dosage was greater than 0.15 wt%, the VFA No. of fresh NRL was lower than that of A2 NRL, and the preservation effect reached the present ammonia + TMTD/ZnO system preservation level.

Figure 1(b) shows the change in viscosity of fresh NRL samples obtained using various preservation systems. The viscosity value of fresh NRL is highly correlated with the VFA No. of NRL (Figure 1(b)). In general, the viscosity of NRL with a poor preservation effect is ropiness. The preservation effect of fresh NRL preserved by A1 alone with ammonia is poorer in Figure 1(b), and the viscosity value increases rapidly after 2 days. Using ammonia+TMTD/ZnO, the viscosity of fresh NRL of A2 is maintained at a low level for 5 days. Except for the A3 sample, the viscosity of MBM-preserved fresh NRL is lower than that of A2 preserved with ammonia+TMTD/ZnO, which may be

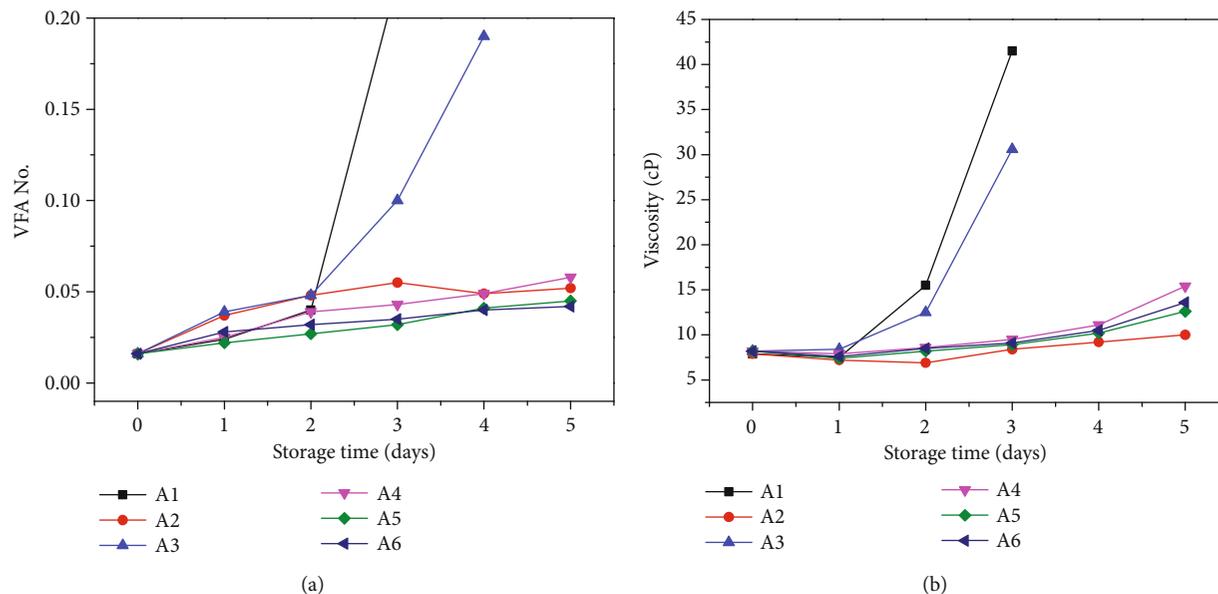


FIGURE 1: Properties versus the storage time of the fresh NRL: (a) VFA No. and (b) viscosity.

attributed to the increased basicity of ammonia + TMTD/ ZnO preserved NRL.

3.2. Effect of MBM on the Preservation of CNRL. The variations in VFA No. of CNRL samples preserved by MBM–ammonia combination with high ammonia (HA) are shown in Figure 2(a). The VFA No. of B1 CNRL preserved by HA is rather low, and the preservation effect is excellent. The VFA No. of CNRL samples reduces as the MBM dose increases and the preservation effect improves. When the MBM dose is less than 0.3 wt%, the preservation effect is significantly poorer, and the VFA No. exceeds 0.06 after 180 days.

The variations in viscosity values of CNRL samples preserved by MBM–ammonia combined preservation and HA are shown in Figure 2(b). The viscosity value of CNRL preserved with the B1 HA sample is reduced. The viscosity value decreases during storage and becomes typically stable later on. When the MBM dose in the MBM–ammonia composite preservation CNRL is less than 0.3 wt%, the preservation effect is weak, and the viscosity value tends to rise over time. When the MBM dosage exceeds 0.3 wt%, the viscosity of the MBM–ammonia composite preservation CNRL decreases as the MBM dose increases.

The variations in MST of CNRL samples preserved by MBM–ammonia combined preservation and HA are shown in Figure 2(c). The MST of B1 HA-preserved CNRL grows significantly, as does the enhanced range. When the MBM dose is less than 0.3 wt%, the MST of CNRL preserved by the MBM–ammonia compound is extremely low. When the MBM dose is greater than 0.3 wt%, the MST of CNRL is greater than 650 seconds after 90 days of storage, and the increasing rate is also higher in the later period, essentially approaching the level of HA-CNRL, and the preservation effect improving. When the MBM dose is less than 0.3 wt%, the MST of CNRL grows slowly, the increased range is also smaller, and the subsequent storage duration

has a significant downward trend, which is highly correlated with the preservation effect.

Figure 2(d) shows the pH variations of CNRL samples preserved by MBM–ammonia combined preservation and HA. The sample B1 HA-preserved CNRL has a rather high pH with a small drop. The pH of LA-CNRL preserved by the MBM–ammonia compound is lower and decreases more significantly. The pH value of CNRL increases as the MBM dose is increased. The pH value decreases somewhat when the MBM dosage exceeds 0.3 wt%.

3.3. Regulation of Stable System of LA-CNRL. Figure 3(a) shows the variations in VFA No. of MBM–ammonia CNRL in various stable systems with combined preservation and HA preservation. The VFA No. of CNRL at 0.35 wt% MBM dosage is significantly lower than that at 0.3 wt% MBM dosage in LA-CNRL samples with different MBM preservation systems. The ammonia and lauric acid soap contents of the preservation system have a specific effect on the value of VFA No. When the dose of ammonia and lauric acid soap is increased, the value of VFA No. decreases. Lauric acid soap has a greater stabilizing effect on CNRL VFA No. than ammonia water at the right dosage.

Figure 3(b) shows the change in the viscosity value of CNRL preserved with different stable systems of MBM–ammonia and HA. The latex viscosity value of the sample with an MBM dosage of 0.35 wt% in the LA-CNRL samples of the MBM–ammonia composite preservation system is much lower than that of the sample with the MBM dosage of 0.3 wt%. The amount of ammonia and lauric acid soap in the preservation system influences the viscosity value, and the viscosity value decreases as the ammonia and lauric acid soap dosage increases. The stabilizing effect of ammonia on the viscosity value of CNRL is better than that of lauric acid soap at the exact dose.

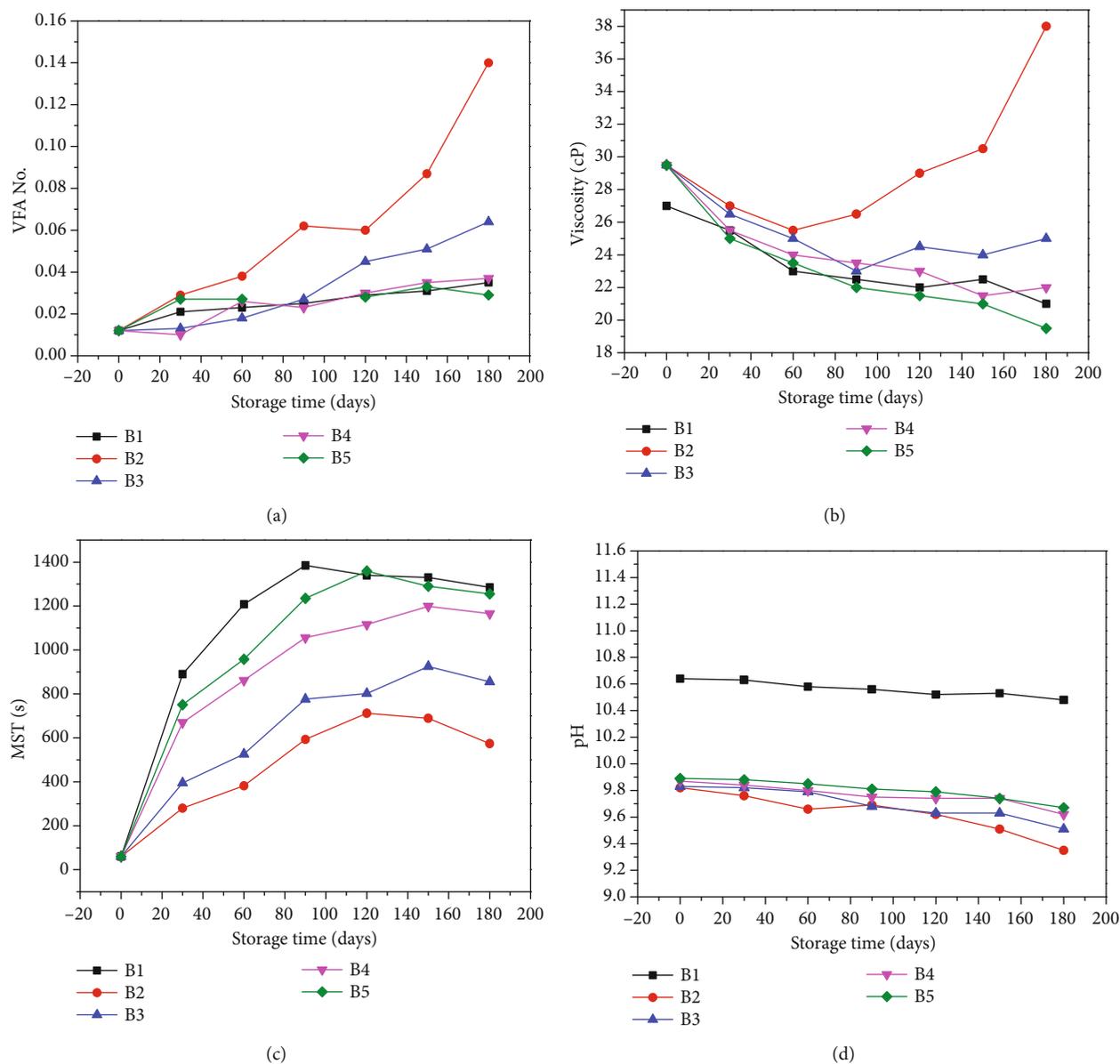


FIGURE 2: Properties versus the storage time of the CNRL: (a) VFA No.; (b) viscosity; (c) MST; and (d) pH.

Figure 3(c) depicts the changes in MST of CNRL preserved with different stable systems of MBM–ammonia and HA. The MST of CNRL with 0.35 wt% MBM dosage is substantially greater than that of MBM dosage with 0.3 wt% among the LA-CNRL samples with various MBM preservation combinations. Ammonia and lauric acid soap contents in the preservation system have a specific effect on the MST, and the MST is also greater when the ammonia and lauric acid soap levels are higher. The improvement in MST of CNRL is mostly attributable to lauric acid soap, whereas ammonia has a weaker effect on MST.

Figure 3(d) shows the change in the pH value of MBM–ammonia CNRL under different stability systems combined and HA preservation. The initial pH values in LA-CNRL samples with different MBM preservation combinations indicate no change when the MBM dose is from 0.3 wt% to 0.35 wt%. However, due to the difference in storage effect,

the pH value of 0.35 wt% latex is more stable in the latter storage period. The content of ammonia and lauric acid soap in the preservation system has a specific effect on the pH value, with the pH value increasing as the ammonia and lauric acid soap dose increases. The effect of ammonia is primarily responsible for the increase in the pH value of CNRL; however, lauric acid soap has minimal influence on the increase in pH value.

3.4. Stability of Pre-Vulcanized CNRL. Figure 4 depicts the change in viscosity of pre-vulcanized CNRL prepared by composite preservation of different stable systems of MBM–ammonia and HA throughout storage. LA-CNRL has a higher initial viscosity value following pre-vulcanization than HA-CNRL. The viscosity of pre-vulcanized CNRL varies dramatically during storage. The viscosity of HA pre-vulcanized CNRL increases somewhat

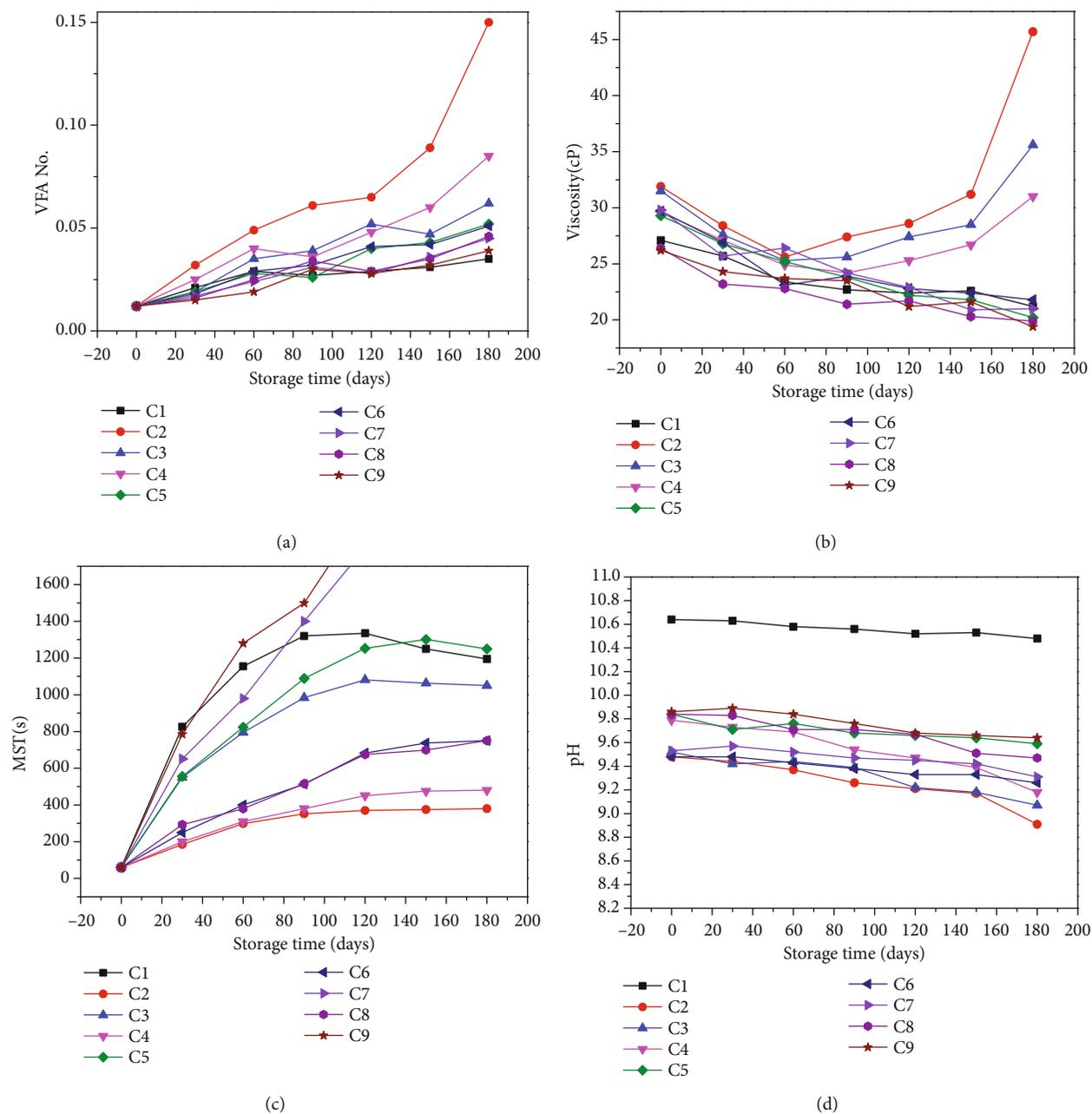


FIGURE 3: Properties versus the storage time of LA-CNRL: (a) VFA No.; (b) viscosity; (c) MST; and (d) pH.

in the early stage of parking and tends to remain steady with a minor increase in the latter stage. However, the viscosity of LA pre-vulcanized CNRL increases during the parking and accelerates in the later parking period, resulting in poor stability. The stability of the system and the viscosity value of MBM-ammonia composite preservation LA pre-vulcanized CNRL are greatly affected. The greater the ammonia and lauric acid soap dose, the lower the viscosity value, and the stronger the impact of lauric acid soap. More stabilizers should be added to LA-CNRL to maintain the viscosity stability of pre-vulcanized CNRL.

Table 4 summarizes the findings of stability tests on pre-vulcanized CNRL prepared by composite preservation of

MBM-ammonia in different stable systems and CNRL with HA. The pH of HA pre-vulcanized CNRL samples is greater than the pH of MBM-ammonia composite preserved LA-CNRL samples. The HA pre-vulcanized CNRL MST is somewhat lower. The LA pre-vulcanized CNRL MST difference is considerable, and it is mostly influenced by the amount of lauric acid soap used. The heat stability of HA pre-vulcanized CNRL is average, with just a tiny difference between it and LA pre-vulcanized CNRL.

3.5. Mechanical Properties. The physical and mechanical properties of vulcanized rubber films prepared using a fraction of MBM-ammonia composite preservation and HA-CNRL are shown in Table 5. The four vulcanized film

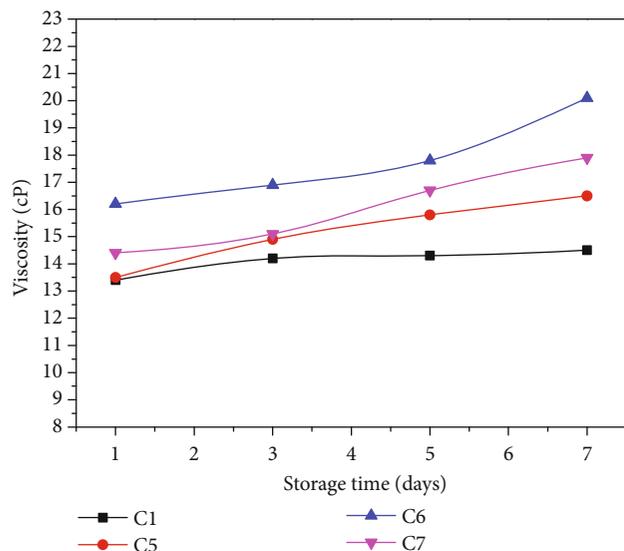


FIGURE 4: Viscosity changes of pre-vulcanized CNRL.

TABLE 4: Stability of pre-vulcanized CNRL.

Sample	pH value	MST (seconds)	Thermal stability (seconds)
C1	10.15	355	56
C5	9.42	487	64
C6	9.31	296	59
C7	9.35	438	55

TABLE 5: Physical and mechanical properties of the vulcanized film.

Sample	300% fixed extension stress (MPa)	Elongation at break (%)	Tensile strength (MPa)	Tear strength (kN/m)	Hardness (Shore A)
C1	1.16	998.5	26.32	45.14	28
C5	1.15	1012.4	26.78	41.54	26.5
C6	1.15	1025.6	27.31	45.30	27
C7	1.14	985.2	26.05	40.12	27

samples have similar strengths with little variation. The fixed elongation stress of MBM-ammonia composite preserved LA-CNRL is lower than that of HA-CNRL at 300% fixed elongation stress, and the hardness of the vulcanized rubber film is likewise lower. The elongation at the break of the sample of MBM-ammonia preserved LA-CNRL vulcanized film is greater as a result. Furthermore, MBM-ammonia composite preservation LA-CNRL vulcanized film tear strength is lower when compared with HA-CNRL, which may be due to the soft film.

3.6. Particle Size and Distribution. The rubber particle size distributions of two CNRL samples of C6 MBM-ammonia compound preserved latex and C1 HA-preserved latex are shown in Figure 5. The two CNRL samples have identical rubber particle size distribution ranges. The peak for sample C1 has a lower intensity on the particle size distribution

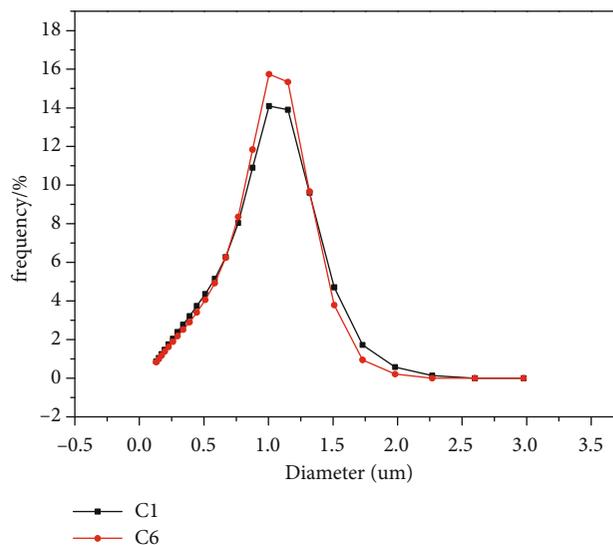


FIGURE 5: Particle size distributions of CNRL rubber particles.

curve, whereas the peak for sample C6 is somewhat more intense and has a narrower distribution. Furthermore, the content of large rubber particles in the range of 1.25–2.5 μm in the C6 sample is rather low. Overall, the particle size distribution curves of the two CNRL samples are quite similar, with just minor differences.

Table 6 displays the rubber particle size data of relevant CNRL samples. The characteristic parameters of the rubber particle size distribution of the two CNRL samples are almost identical, with little deviation. The D_{90} particle size of C1 HA-CNRL is larger and more significant, which is consistent with the particle size distributions shown above. The C6 LA-CNRL sample has fewer large rubber particles.

3.7. FTIR Spectroscopy Analysis of the Raw Rubber Film.

Figure 6 depicts the FTIR spectra of two CNRL raw rubber film samples. The spectra of MBM-preserved LA-CNRL samples and HA-preserved samples show no significant change in peak frequency or intensity, and the peaks appear mostly at the characteristic value of the wave number. The C=C double bond stretching vibration peak of NR is at 1650 cm^{-1} , and the bending vibration peak is at 833 cm^{-1} . The stretching vibration peaks of $-\text{CH}_3$ and $-\text{CH}_2$ are at 2956 and 2855 cm^{-1} , respectively, whereas their bending vibration peaks appear at 1445 and 1375 cm^{-1} . MBM-preserved NR has the same chemical structure as HA-preserved NR. MBM composite preservative has no negative impact on the NR structure.

3.8. Thermogravimetric Analysis of Raw Rubber Film.

Figure 7 depicts the TGA curves of the two CNRL raw rubber films. In the early stage, the thermal degradation curve of the raw rubber film of the LA-CNRL sample preserved by MBM is the same as the CNRL sample preserved by HA. Nevertheless, at the later stage, there are some differences in the residue content of the two samples. The HA sample has a larger residue content, and the degradation curves of

TABLE 6: Characteristics of particle size distributions of CNRL rubber particles.

Sample	Intermediate diameter (μm)	Average diameter (μm)	Frequency diameter (μm)	D_{10} (μm)	D_{90} (μm)
C1	0.8215	0.8012	0.9526	0.2826	1.2660
C6	0.8351	0.8001	0.9532	0.2951	1.2280

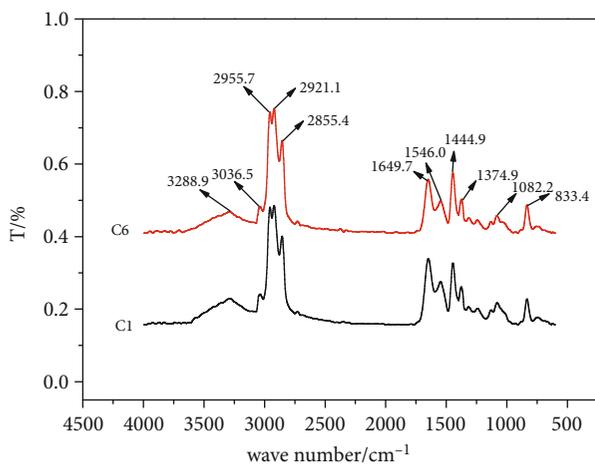


FIGURE 6: The FTIR spectra of CNRL raw rubber film samples.

the two samples are nearly identical. The thermal stability of the film is unaffected by the MBM-preserved latex.

The initial degradation temperature (T_0), semi-degradation temperature ($T_{50\%}$), maximum central degradation temperature (T_p), and termination degradation temperature (T_f) of the two CNRL raw rubber film samples during thermal degradation are shown in Table 7. The characteristic temperature of the LA-CNRL film prepared by MBM-ammonia composite preservation was the same as that of HA preservation, as shown by the change in the degradation curve in Figure 7. Overall, there is little difference; hence, MBM does not affect the thermal stability of CNRL raw rubber film.

The glass transition temperature (T_g) is part of the characteristic temperatures of polymers with high elasticity and glass transition. Table 7 displays the T_g of two CNRL raw rubber film samples. T_g is the temperature node of the relaxation phenomenon from a frozen to thawed state in the amorphous part of the polymer molecular chain from the standpoint of molecular structure. As shown in Table 7, the T_g of the C6 sample of MBM is somewhat lower than that of the HA-preserved CNRL sample of C1 among the two LA-CNRL samples. Overall, the difference between the two samples is quite small, indicating that MBM has a minor effect on rubber T_g .

4. Conclusions

MBM has a good preservation effect on fresh NRL. When the MBM dose is larger than 0.15 wt%, fresh NRL can be

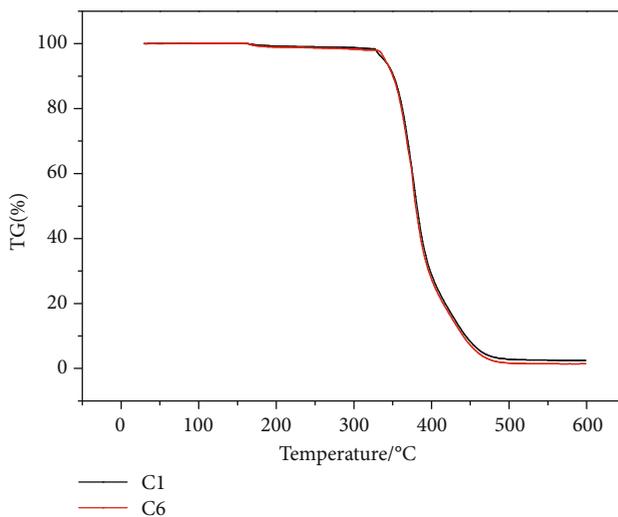


FIGURE 7: TGA curve of CNRL raw rubber film samples.

TABLE 7: Degradation temperature and T_g of CNRL raw rubber film samples.

Sample	T_0 ($^{\circ}\text{C}$)	$T_{50\%}$ ($^{\circ}\text{C}$)	T_p ($^{\circ}\text{C}$)	T_f ($^{\circ}\text{C}$)	T_g ($^{\circ}\text{C}$)
C1	352.42	381.29	379.46	408.88	-64.65
C6	352.59	378.87	379.10	405.69	-64.10

securely kept for more than 5 days. The viscosity value and VFA No. of fresh NRL are low, and both are comparable with the present ammonia + TMTD/ZnO composite preservation system. MBM has also a positive impact on CNRL preservation. When the combined dosage of MBM exceeded 0.3 wt%, the VFA No. of LA-CNRL is lower and similar to that of HA-CNRL, and the MST is higher while the viscosity value is lower. Combined to the regulation of the stable system, the stability of ultra-LA-CNRL prepared by MBM preservation is low, and it is essential to appropriately increase the dose of laurate soap to enhance the stability and overall performance of CNRL. Furthermore, there are minor differences in the size and dispersion of rubber particles. The stable system has a substantial effect on the stability of MBM-ammonia preserved LA pre-vulcanized CNRL. The viscosity value decreases as the stability dosage increases, while the MST and heat stability improve. The mechanical properties of the vulcanized film samples prepared from HA-CNRL and LA-CNRL are almost equivalent. The material research results show that when compared with CNRL preserved by HA and MBM-ammonia composite preservation, NRL's infrared spectrum structure, thermal weight loss capabilities, and glass transition temperature are unaffected.

Data Availability

The raw/processed data required to reproduce these findings cannot be shared at this time due to technical or time limitations.

Conflicts of Interest

The author(s) declare(s) that they have no conflicts of interest.

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