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How to Prepare Natural Rubber Latex (NRL) for Dipped Goods Production

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ABSTRACT: In order to make the production of dipped goods from natural rubber latex (NR) possible and of high quality, a creaming process is usually carried out. This process concentrates the latex by increasing its dry rubber content (DRC), total solids content (TSC) and mechanical stability time (MST). These are the three most important parameters in latex manufacturing science and technology. Three creaming agents were used. These are A. Sodium alginate (SA), B. Tamarind seed powder (TSP) and C. Cassava starch from cassava processing effluent (CPE). Excellent results were obtained, with the starch achieving the best result even though it is new. It was observed that after creaming, the DRC of the concentrated NR latex increased from 28.50% to about 64.50%, while the TSC increased from 30.40% to about 65.70%. It was observed that the MST increased with increasing incubation time. The concentrated latex, i.e. cream-coloured concentrated NR latex (CCNRL), is therefore suitable for the manufacture of dipped articles such as balloons, tubes, catheters, teething rings, suction cups, liners, balls, rubber bands, foams, mattresses, pillows, mackintoshes, condoms and gloves. However, the fresh field latex NR (FNRL) is not suitable unless it is creamed or centrifuged to increase its DSC, TSC and MST.

Keywords: Creaming, concentrated, latex, dipped goods, starch, polysaccharide

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INTRODUCTION

The natural rubber liquid exuded from the chopped rubber tree is typically insufficient for the creation of goods such as balloons, balls, tubes, foams, mattresses, pillows, elastic bands, teethers, catheters, condoms, and hand gloves. Latex is a flowing milky white liquid that is used to make natural rubber. Much of the world's natural rubber is generated industrially from the latex of the particular species Heveabrasiliensis (Suksup et al., 2017). The natural rubber latex (NRL) derived from the Heveabrasiliensis tree is a colloid, with a mainly rubber dispersed phase and a water serum dispersion medium (Shera and Siby, 2017). The rubber ingredient (the elastic component of the NRL) is primarily cis - 1, 4 - polyisoprene and is the primary cause for the rubber tree's utility (Shera and Siby, 2017).

As a result, NRL is defined as a colloidal system of micron-sized rubber particles (or molecules) dispersed in an aqueous serum (Yumae et al., 2010). Fresh NRL has a dry rubber content (DRC) of 30-40% (Table 1). Smitthipong et al., 2004; Smitthipong et al., 2008).

Fresh NRL's physical and chemical composition is affected by parameters like as species, genotype, fertilizer quality, season (wet or dry), and tapping system (Suksup et al., 2017). Because fresh NRL contains a variety of beneficial ingredients such as proteins, carbs, fats, phospholipids, minerals, and so on, it is susceptible to contamination by microorganisms (Vallat et al., 2014 and Smitthipong 2014).

These microorganisms devour the non-rubber ingredients and subsequently produce the volatile fatty acid (VFA), which causes the latex particles to destabilize. This phenomenon is straightforward and may be explained as follows: latex molecules are negatively charged, but the release of VFA by microorganisms' results in the creation of acid molecules or positively charged ions or particles that are H+ groups (positively charged).

The reaction between the OH groups (negatively charged) and the H^+ groups (positively charged) causes the natural rubber latex to destabilize or coagulate. "Auto-

Table 1: The composition of fresh natural rubber latex (FNRL). (Smitthipong 2004, 2008).

Component	% by weight
Rubber particles (DRC)	27 – 35
Total solids content (TSC)	35 – 40
Protein	2 – 3
Lipids	0.1 – 0.5
Sugars	1 – 2
Ash content	0.5 – 1.0
pH	10.35
magnesium content, mglc	258
alkalinity (ammonia)	1
VFA number	0.04

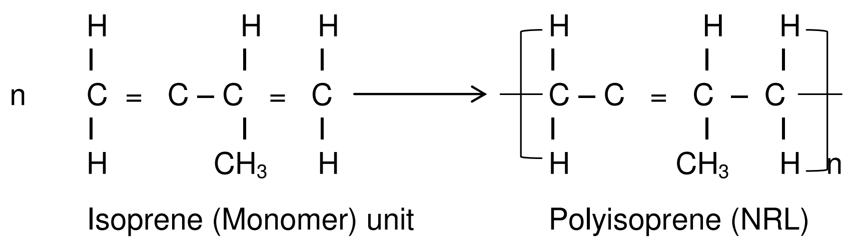

Figure 1: Structure of natural rubber latex(NRL).

coagulation" is the name given to this process. To avoid auto-coagulation, ammonia solution is typically used to neutralize the VFA in the latex and maintain latex stability.

The ammonia functions as a buffer, preserving the latex until it is ready for use (Suksup et al., 2017). Fresh NRL can be turned into concentrated NRL to maintain the continuous quality of concentrated NRL and produce economic value for latex shipping.

The fact that natural rubber (NR) refers to dry rubber, such as sheets, blocks, or crepes, but NRL is an adequately stabilized, usually concentrated, liquid form of rubber solution. Because dry rubber is so prevalent, the term natural rubber (NR) is frequently used to refer to both types of raw materials. Latex has expanded in importance in recent years, with output increasing dramatically. In 2018, the global output of NR and NRL (natural rubber) was 13.8 million tonnes (Rzymski et al., 2013, Sowcharoensuk, 2022).

According to Jack et al., (2022), NRL has several special qualities as an elastomer that make it relevant in numerous industries, including as the creation of dipped products such as hand gloves, balloons, condoms, catheters, and many medical devices. Foamed latex is utilized in the production of mattresses, pillows, and footwear. Latex is used as a backing in carpets and in sticky binders (Suksup et al. 2017).

According to Wei et al. (2022), NRL is a colloidal mixture of a water-based serum phase and a solid rubber phase. The rubber produced from Heveabrasiliensis is a cis - 1, 4 - polyisoprene polymer. Polymer chains of this type can range in length from 1,000 to 3,000 isoprene units. Latex particles contain a very particular organization of rubber molecules. Rubber particles are spherical or pear-shaped core-shell structures having a polymer core (inside) suspended by a thin "shell" of phospholipids and protein.

There are two levels in D.C Blackley's model: an inner shell of phospholipids and an outer shell of proteins. Proteins and phospholipids, on the other hand, are more prone to be combined. Many other scientists have corroborated the surface's mixed structures, which have been depicted more precisely in subsequent research (Nowamawat et al., 2011).

According to Sakdapipanich (2006) and Terachiwin et al. (2005), each polymer chain has two distinct terminal groups: and terminal linked with phosphate groups associated with phospholipids and - terminal linked with protein, which play critical roles in forming the distinct structures of NRL particles.

Natural rubber latex (NRL) particles have a bimodal diameter size distribution, and rubber particles can be divided into small rubber particles (SRPs) with an average particle size of 10 - 250 nm and large rubber particles (LRPs) with an average particle size of 250 - 3,000nm, or 2.5 - 3.0 x 10-7nm (Sririn et al., 2018; Singh et al., 2018; Hill, 2018; Subroto et al., 2001; Joseph, 2013) (Figure 1). The bimodal size distribution appears differently in different types of lattices (fresh latex, concentrated latex, and PVL) and varies after processing, such as centrifugation or clarifying (Santipanusopon et al., 2009, and Solomez et al., 2014). Concentrated natural rubber latex (CNRL) comprises around 60% rubber and is used to make items such as foam rubber, pillows, mattresses, elastic bands, gloves, tubes, balloons, condoms, and so on (Smitthipong et al., 2016).

CNRL is a vital basic material with numerous applications. Evaporation, electro-decantation, centrifuging, and creaming are all methods for producing CNRL. The evacuation of water is accomplished by floating a double-walled cylindrical vessel and a hollow iron roller in latex into a partially evacuated chamber. In electro-decantation, positive electrodes are immersed in latex, resulting in a mixture of positives that float to the latex's surface. Centrifuging involves placing the latex in a centrifuge and then centrifuging it to remove some of the water in order to improve the dry rubber content (DRC) of the latex (Suksup et al. (2017).

The centrifugation technique for CNRL is well established and widely utilized in commercial applications. It normally entails the use of large, expensive machinery as well as a chemical compound called tetra methyl thiuramdisulphide (TMTD) to maintain and vulcanize the NRL. Because of the presence of nitrosamine, TMTD is a carcinogen (Suksup et al., 2017).

Creaming is another way of preparing CNRL. Creaming is a chemical procedure that combines creaming agent and fresh NRL and allows for phase separation (rubber fractions and serum). Creaming agents are commonly used to improve creaming efficiency. Cream concentrated natural rubber latex (CCNRL) was produced successfully using creaming agents such as sodium carboxymethyl cellulose (CMC), locust bean gum (LBG), tamarind seed powder (TSP), casein, sodium alginate, aluminium alginate, ammonium alginate, and cassava process effluents (CPE) (Yumae et al., 2010).

Creaming is a chemical process that involves the insertion of creaming agents and aids into vessels containing field latex in order to accelerate the phase separation process. It is the principle utilized for concentrating field latex to higher concentrations and is based on the variations in specific gravity between water (1.0) and rubber polymer (0.9) molecules. The creaming effect is caused by the creation of a loose network between creaming agent molecules absorbed on the surface of the particles and those dissolved in the serum.

The buoyancy of the clusters causes them to break free from the network. Because the specific gravity of rubber particles is lower than that of serum, latex tends to cream. The creaming rate (or settling rate), which is usually higher in the scattered phase than in the continuous phase, can be approximated using Stokes' equation, as illustrated in equation (1).

$$V = 2r^2 (p - e_0) \; g / gm \text{……………………equation(1)}$$

Where v is the creaming (settling) rate, r is the diameter of the rubber particles, e is the density, e_0 is the density of the dispersion medium, n is the viscosity of dispersion medium (continuous phase) and g is the local acceleration due to gravity (Shera *and* Siby, 2017).

The DRC, non-rubber solids (NRS), total solids contents (TSC), mechanical stability time (MST), volatile fatty acid number (VFA), potassium hydroxide (KOH) number, magnesium content ash content, and chloroform number alkalinity are latex properties that are important to dipped goods producers. Latex concentrated (CNRL) is a non-Newtonian fluid whose viscosity reduces with increasing shear rate (Van Wazer et al., 1966).

Due to the salts that are dissolved in the aqueous phase, NRL exhibits a detectable electrical conductivity (Gazeley et al., 1988). CNRL is combined with other compounding chemicals to create latex goods. Vulcanizing agents, accelerators, activators, fillers, and other specific additives like solids or liquids that may or may not be water soluble are examples of compounding ingredients.

In order to prepare latex compounds, CNRL is typically combined with solutions, dispersions, or emulsions of various compounding materials. According to Shera and Siby, (2017), the compounded latex is maintained for 24 hours or a day to mature. After maturity, the compounded latex is used to create the products. Shape, leach, dry, bead, vulcanize, dust, dip, and batching are a few examples of such product preparation steps (Shera and Siby, 2017).

In most cases, the items can be made straight from the latex compound. To make elastic bands, balloons, and other products, prevulcanized latex is occasionally utilized. Prevulcanized NRL resembles unvulcanized latex in appearance, but the former retains the latter's natural fluidity, comparable latex particle size distribution, and stable colloidal properties (Porter et al., 1992; Nurulhuda, 2014).

Two steps in the standard procedure can be shortened by using prevulcanized latex. This is both cost-effective and cost-beneficial. If field latex can be utilized directly to generate dipped goods and articles, farmers can produce these items locally. This study's objective is to determine how regional farmers can make cream concentrated NR latex without using complex machinery. Therefore, we develop a straightforward, affordable, and environmentally friendly technique that creates cream concentrated latex using water-based chemicals instead of expensive or extravagant equipment, such as sodium alginate, tamarind seed powder (TSP), cassava processing effluents (CPE), etc.

The primary properties of cream concentrated latex were examined using several procedures, including alkalinity, TSC, DRC, magnesium number, potassium number, and so on. Except for the fact that the TSC and DRC of the creamed latex were significantly higher than those of the fresh natural latex, there were no significant differences in results between fresh natural rubber latex

Table 2: The properties of fresh field NR latex and centrifuged concentrated latex.

Materials	Parameters (%)	Sources
Fresh natural rubber latex	TSC 38.47	RRIN, Nigeria
(FNRL)	DRC 28.28	RRIN, Nigeria
Centrifuged natural rubber	TSC 62.00	RRIN, Nigeria
latex (CNRL)	DRC 60.00	RRIN, Nigeria

(FNRL) and cream concentrated natural rubber latex (CNRL).

MATERIALS AND METHODS

Materials

The Rubber Research Institute of Nigeria (RRIN) graciously and generously provided fresh natural rubber latex (FNRL). Table 2 shows the parameters of FNRL. Sodium alginate was purchased from Rotex chemicals firm in Benin city, while tamarind seed powder (TSP) and cassava processing effluents were obtained locally from the market and cassava processing facilities in Benin city, Nigeria. Rotex chemicals in Benin City provided the ammonia solution. Ammonia is commonly used as a latex preservative to protect it from microbial attack and to ensure long-term stability while preventing latex auto-coagulation.

Preparation of cream concentrated latex using sodium alginate, tamarind seed powder (TSP) and cassava processing effluent (CPE)

In 100mL of distilled water, 3g of sodium alginate, tamarind seed powder, and cassava processing effluent (creaming agents) were dissolved. Various amounts of each solution (1, 2, 3, 4, and 5ml) were poured into beakers containing 25ml of latex and constantly swirled or agitated for 30 - 60 minutes.

The combinations were incubated for three days at temperatures ranging from 28 to 32 degrees Celsius. After the first day, it was discovered that the latex had divided into two layers. Over several days and perhaps weeks, the rubber particles (the cream phase) gradually drifted up. When the separation was finished, the aqueous serum phase was removed, leaving only the upper rubber portion.

Characterization of the fresh natural rubber latex (FNRL) and the cream concentrated natural rubber latex (CCNRL)

The total solids content (TSC), (ISO, 124)

Put 2g of latex into the dish and weigh it to the nearest 0.1m: following that, place the dish in the oven at 105± 5^{o}C. Allow it to sit for 2 hours. After the test portion has lost its whiteness, remove it. Remove the dish from the oven and allow it to cool to room temperature.

The dry rubber content (DRC) (ISO, 126)

In a dish, put 10 ±1g of latex concentrate. Add 20gldm-^{3} of acetic acid, rotate the dish slowly, and when the serum is clear, collect any coagulated rubber particles by rubbing them with the main bulk. Soak the coagulated rubber in numerous water changes until the water is no longer acidic to litmus paper, and then soak it for about 5 minutes after the water has stopped flowing. Dry the sheet at 70 degrees until all white patches are gone.

The Alkalinity test (%) (ISO, 125)

To prevent coagulation, a test portion of latex is titrated with acid to pH 6 in the presence of a stabilizer, either electrometrically or visually with methyl red. The alkalinity is determined by the amount of acid necessary.

The volatile fatty acid (or VFA) tests (ISO, 506)

A portion of the test is coagulated with ammonium sulphate, and a portion of the resultant serum is isolated and acidified with sulphic acid. Titration of the distillate with a standard volumetric barium hydroxide solution determines the volatile acids present in the test portion of the acidified serum.

The mechanical stability time (MST) (ISO, 35)

A sample of latex is diluted to 55% by mass total solids content and vigorously agitated. The time necessary to initiate visible flocculation is measured and used to assess mechanical stability.

RESULTS AND DISCUSSION

The addition of creaming agent to fresh field natural rubber latex (FFNRL) results in the formation of two layers. The creaming phenomenon refers to this segregation or two layer separation. The cream concentrated NR latex (CCNRL) occupies the top layer. In order to protect this top layer, 0.6% ammonia was added to it. The lower layer portion is the serum, which was separated from the creamed latex by gravity in

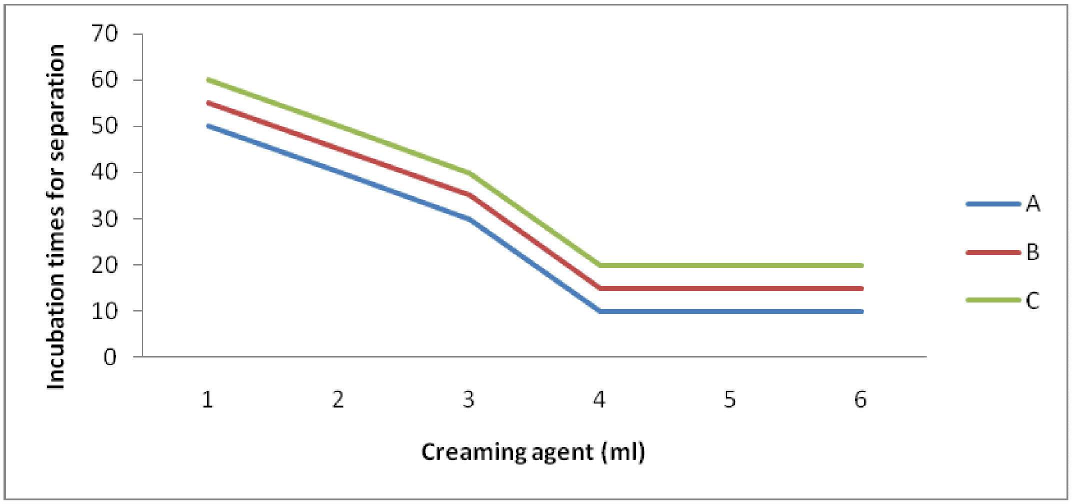

Figure 2: The relationship between quantity of creaming agent and incubation time.

Table 3: The characteristics of fresh NR latex and cream concentrated NR latex.

Parameters	Fresh NR Latex (%)	Creamed concentrated NR Latex (%)
Total solids content (TSC)	38.00	46.32 – 47.00
Dry rubber content (DRC)	28.00	45.00 – 45.50
Alkalinity	0.68	0.15
Volatile fatty acid (VFA)	0.044	0.033

addition to the activity creaming agents and aids.

The quantity of creaming agent for the preparation of cream concentrated NR latex (CCNRL)

Figure 2 shows varying concentrations of creaming agents at 1,2,3,4, and 5ml in 25ml of fresh natural rubber latex. In order to observe the advancement of the creaming process, several incubation times were used. Figure 004 depicts the relationship between the incubation times and the quantity of creaming agents.

We discovered that when the amount of creaming agent used increases, the incubation time reduces. As a result, we discovered that the optimal amount of creaming agent in fresh natural rubber latex at 25ml was 4ml. This ideal value will be utilized in the next sections. This is consistent with the findings of Supkup et al. (2014) who discovered a similar result for latex creaming using only sodium alginate as the creaming agent in 2017.

Where A = Sodium alginate (SA)
B = Tamarind seed powder (TSP)
C = Cassava processing effluents (CPE)
The three creaming agents all showed good quality; with cassava being the best of the three followed by tamarind and sodium alginate was the least.

The excellent properties of cream concentrated natural rubber latex (CCNRL)

The characteristics of fresh natural rubber latex were determined using the creaming method with A (sodium alginate) (SA), B (tamarind seed powder) (TSP), and C (cassava processing effluent) (CPE). TSC and DRC of CCNRL were clearly greater than those of fresh natural rubber latex (FNRL).

This demonstrates that the creaming agents (A, B, and C) improved the efficiency with which the rubber particles were separated from the serum solution. There were no significant differences in alkalinity or VFA between the FNRL and CCNRL. The CCNRL was incubated for 72 hours, or three days, and then for seven days with 4ml of creaming agents, A,B, and C, respectively. The alkalinity level in VFA is shown in (Table 3).

In the latex is an indication of degradation of latex by micro-organisms. The result from the (Table 3) implies that both types of latex are in good condition.

The effect of the incubation times on the total solids content (TSC) and the dry rubber content (DRC) of CNRL and NRL

Figure 3 depicts the TSC and DRC values of cream concentrated NR latex as a function of incubation time. The TSC and DRC values of cream concentrated NR latex grew in the first month and then plate used with a constant value after a prolonged duration of incubation time. TSC values are always greater than DRC values. This is due to the fact that TSC incorporates both rubber and non-rubber components. The DRC values, on the other hand, only represent rubber components.

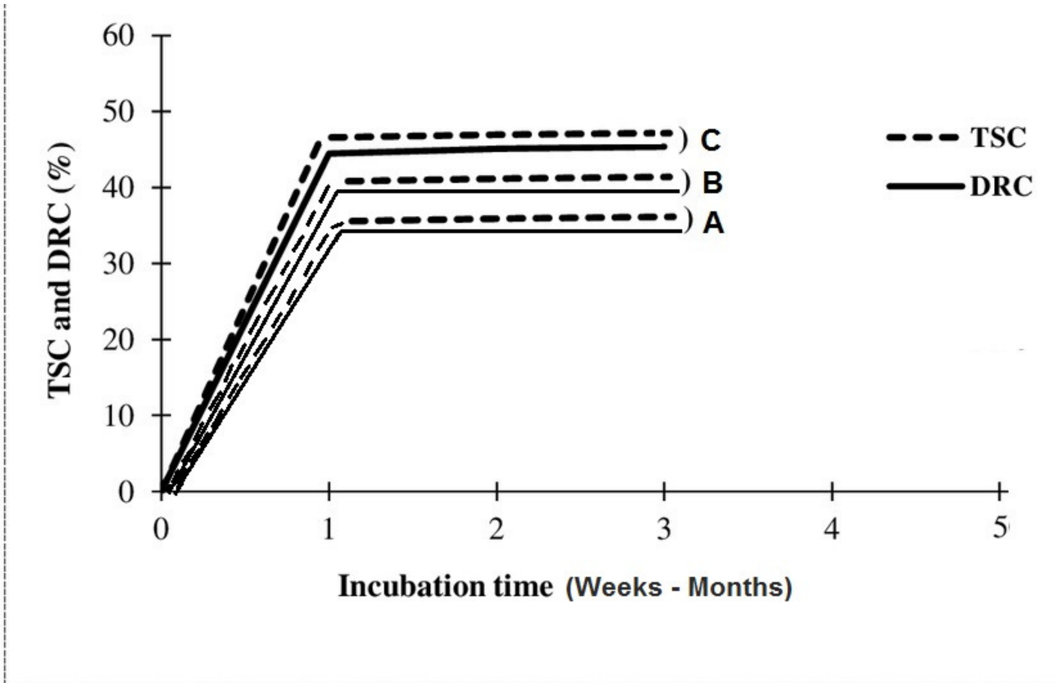

Figure 3: The relationship between TSC and DRC of cream concentrated NR latex and incubation time.

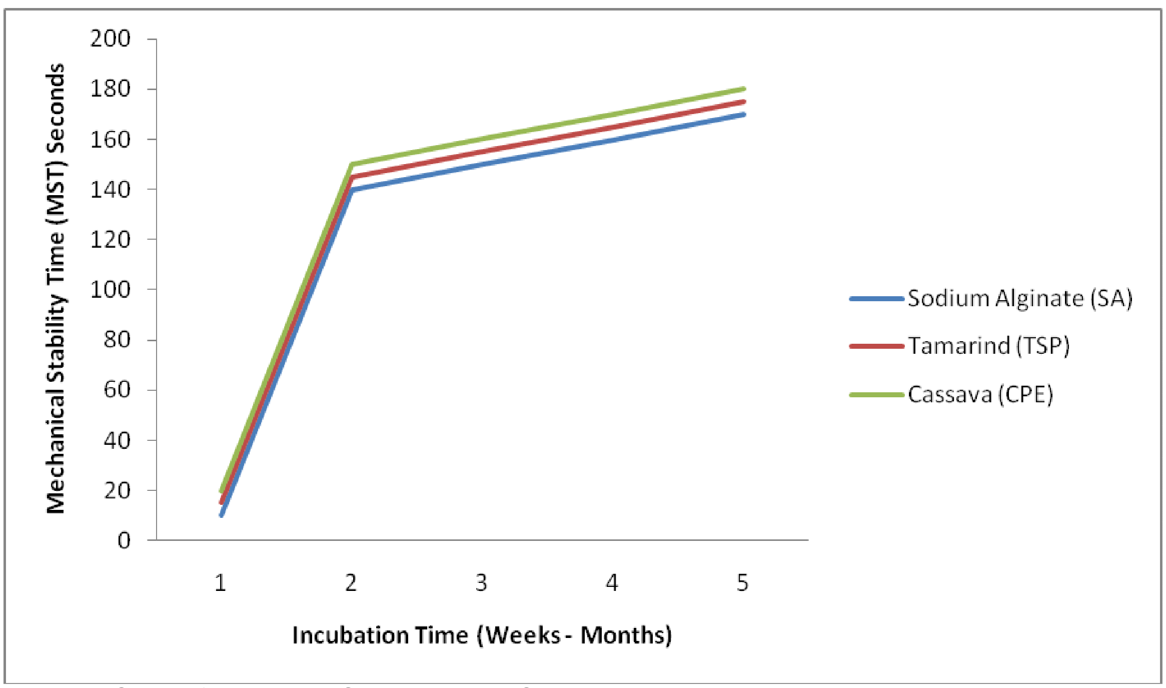

Figure 4: Graph of Mechanical Stability Time (MST) against Incubation Time

The effects of the incubation times on mechanical stability of cream concentrated NR latex (CCNRL)

Mechanical stability times (MST) are often a result of incubation times. The CCNRL exhibits increasing values, as shown in Figure 4. These values typically increased as incubation times (storage time) increased. MST often refers to the latex's stability prior to the commencement of auto-coagulation. MST increases with storage time due to an increase in fatty acid soaps from phospholipid hydrolysis and the buffer ammonia solution used as a preservative (Gorton et al., 1972).

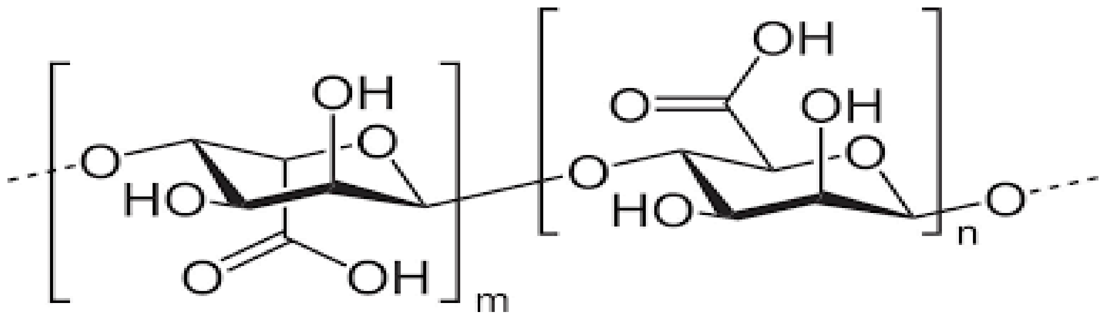

Figure 5: The structural formula of sodium alginate (SA)

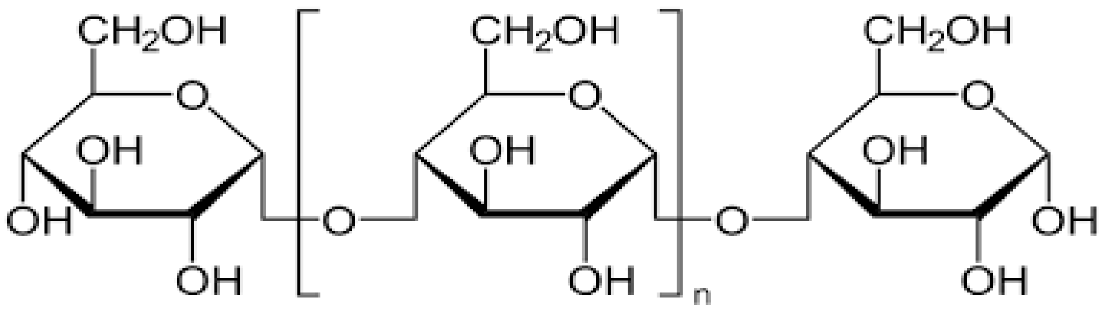

Figure 6: The structural formula of starch (TSP and CPE)

Roslim et al (2014) discovered that MST was a function of the duration of storage or incubation times. Their research also revealed that longer incubation durations resulted in greater MST levels. It was discovered that the fatty acid soap is absorbed at the surface of the rubber particles, resulting in the formation of hydration layers that coat the rubber particles.

This finding is consistent with the findings of Tarachiwin and Sakdapipanich, (2005), Sriring et al. (2018), and Nowamawat et al. (2011). As stated by numerous writers, this has a good impact on improving the colloidal stability of the latex and thereby enhancing the MST. The graph for the various creaming agents and the MST of the corresponding cream concentrated latex is shown in (Figure 5).

The molecular model of the creaming process

Cassava processing effluent (CPE), Tamarind seed powder (TSP), B, and sodium alginate (SA) was used. Polymers derived from polysaccharides that are utilized as creaming agents often have a high degree of polarity (the hydroxyl groups, - OH) and sequences of mannuronic and galuronic residues from β - d - mannuronic acid (M) and -1- guluronic acid (G) monomers. Tamarillo and cassava starch are composed of -1, 4 - glucosidic and -1, 6 - glucosidic residues and sinkases from amylose and amylopectin with several hydroxyl groups, - OH as well as sodium alginate, with all three creaming agents (A,B, and C) being polysaccharides. As a result, they exhibit good gelling, chelating, and viscosity increasing capabilities (pub chem, chem book, www.sciencedirect.com, and www.europa.eu.epsa.journal).

Shuren (2000) wrote extensively on the enormous potential of cassava starch for domestic food and industrial applications, with a focus on the polymer sector.

As illustrated in (Figure 6), the creaming agents A, sodium alginate (SA), B, tamarind seed powder (TSP), and C, cassava processing effluent (CPE), molecules covered the surface of the rubber particles. The absorption of creaming agent molecules on the surfaces of the rubber molecules frequently results in extended incubation times. The branches, which are segments of the creaming agent molecules, are frequently interlaced, mixed, entwined, and entangled with the adjoining rubber molecules (Figure 6).

This causes the rubber molecules to expand and grow in size. The higher the molecular weight of the creaming polymer, which has a large number of negatively charged hydroxyl groups (OH-), the higher the viscosity of the cream condensed NR latex and hence the sluggish and slow movement of the rubber molecules. This is one of the findings of Singh (2018) and Yu et al., (2017).

Conclusion

Cream concentrated natural rubber latex (CCNRL) is produced by creaming NR fresh field latex (FNRL). The method was successful in creating cream-concentrated NR latex. A, sodium alginate (SA), B, tamarind seed powder (TSP), and C, cassava processing effluent (CPE) were used as creaming agents in the experiment. TSP use has been mentioned in numerous literatures and has been practiced in some countries such as India. However, the utilization of cassava processing effluent (or starch) is novel and has received little attention in the literature. Sodium alginate is extremely common and widely used.

The usage of cassava starch, however, produced excellent results. Sodium alginate and tamarind powder were inferior to cassava starch. Overall, compared to fresh field NR latex, creaming increased the TSC and DRC for CCNRL. Longer incubation durations resulted in a noticeable improvement in the MST of the cream-concentrated NR latex. This concentrated NR latex can be used to make foams, mattresses, pillows, condoms, hand gloves, tubes, balloons, teethers, and suckers, which are all considered dipped goods.

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