Advisory Circular No.2016/11

Manufacture of Latex Crepe

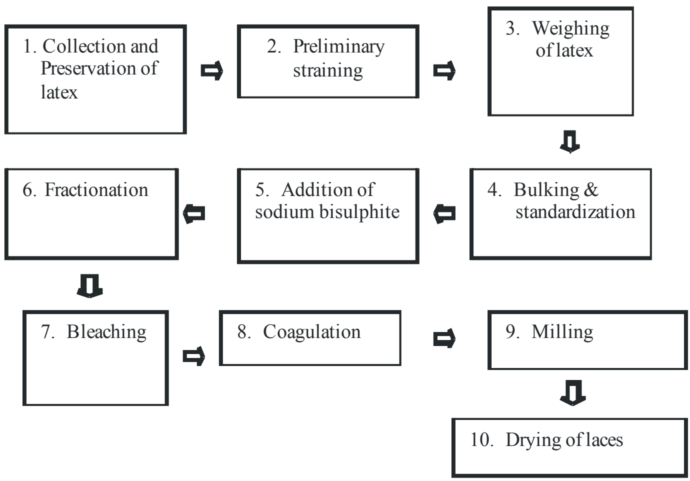
Rubber Research Institute
of Sri Lanka

MANUFACTURE OF LATEX CREPE RUBBER

Introduction

Latex crepe rubber is the purest form of natural rubber available in the market and it is manufactured by coagulating natural rubber (NR) field latex. Sri Lanka is the world's largest producer of high quality latex crepe rubber. This is also known as pale crepe due to its, white colour. Latex crepe rubber is one of the raw materials for dry rubber based products, especially non black applications, pharmaceutical and surgical rubber appliances and rubber product contacted with food.

All important steps in the manufacturing process of latex crepe are shown in Fig. 1.



Fractionation and bleaching are the two main steps that in the production of water white coloured latex crepe. Based on the way these two processing steps used (*i.e.* fractionation and bleaching), latex crepe rubber can be divided into several grades. Table 1 shows each grade of latex crepe and their general applications.

Table 1. Latex crepe grades and their applications

Grade	Processing method	Applications
Fractionated bleached (FB)	Both fractionation and bleaching steps	Adhesive tapes, gums and glues and stickers pad
Fractionated unbleached (FUB)	Fractionation only and no bleaching step	Catheter tubes, blood tubing and other surgical appliances, infant teething rings
Un-fractionated un-bleached (UFUB)	Neither fractionation nor bleaching steps carried out	Bright colour products
Yellow fraction (YF	Yellow fraction removed from NR latex is processed into YF	For making hard vulcanized substances such as rice huller roller surfaces

1. Collection and preservation of latex

Collection of field latex should be carried out under carefully controlled and hygienic conditions in order to produce high quality and pure white coloured crepe rubber. Natural rubber field latex tends to auto coagulate (pre-coagulation) within a few hours after tapping due to acid formation by bacteria on non rubber substances (carbohydrates, proteins and lipids). Therefore, it is important to preserve the field latex against pre-coagulation until it is processed into crepe rubber.

1.1 Recommended methods

Field latex is collected from the tree into cleaned coconut shells or collecting cups, introduced by the Rubber Research Institute, made out of thermoplastics. It is important to make sure that the field latex is not contaminated with dirt during the collection.

The use of anticoagulant, a chemical used to preserve latex in short term, is necessary to ensure that field latex remains stable until it is processed. The most commonly used anticoagulant in crepe rubber manufacture is sodium sulphite (Na2SO3), commercially available as a white powder of purity 90% - 98%. It is not stable under tropical conditions and, therefore, it should be stored in an air tight container.

Recommended strength of stock solution of sodium sulphite is 3.3% by weight. Stock solution is made by dissolving 1 kg of powder in 30 L of water and 300 ml from this stock solution is sufficient for 20 L of latex (0.05% on latex). Freshly prepared solutions should be used since the strength of the solution decreases during the storage.

Ammonia as an anticoagulant should never be used in the manufacture of pale crepe since it imparts a yellowish colour to the laces

2. Preliminary straining

Once the field latex is brought to the factory (or to the collection centre), the latex should be strained in order to remove lumps, bark shavings other foreign particles *etc.*

2.1 Recommended method

The latex is strained through a sieve fitted with monel (*i.e.* an alloy) metal mesh of 40 mesh size. Brass or iron mesh is not suitable for latex straining since contamination of copper and iron into latex affect the properties of crepe rubber produced.

3. Weighing of latex

Dry rubber content (DRC) of field latex is estimated by using a metrolac and the estimated DRC level is used to make payments to tappers and as guidance for dilution of latex prior to coagulation. The DRC estimated by the metrolac is not as accurate as the DRC determined by the laboratory method. However, estimation of DRC using the metrolac is the most convenient, rapid and reasonably accurate method used in the field.

The metrolac is a glass instrument which measures the density of latex. The instrument is graduated to give a direct reading of the rubber content of latex in grams per litre.

3.1 Recommended method

The latex should be diluted with two parts of water and mix them properly before making the estimation. All readings of the metrolac should be taken after ensuring that the instrument moves quite freely in the diluted sample of latex. After reading the metrolac, the dry weight of rubber in the latex can be obtained using the standard metrolac chart recommended by the RRISL.

4. Bulking and standardisation

It is important to bulk latex from all the divisions/ suppliers in a single tank unless there are unavoidable reasons. This is important to obtain an improved and uniform product. Bulking tanks are usually rectangular and their capacity should be such that it should be more than the total volume of the latex/ water mixture (*i.e.* the volume of the highest daily crop that is anticipated together with the volume of dilution water to be added in the standardization process).
It is essential to dilute the field latex to standard dry rubber content (DRC) in order to maintain the uniformity in appearance and the properties of latex crepe rubber.

4.1 Objectives of standardisation

- To obtain a uniform quality raw material
- To enable uniform distribution of chemicals
- To enable trapped air and any fermented gases to escape
- To obtain a softer coagulum, which leads to reduce the energy during the milling process, to improve the clarity of laces and for maximum removal of the non rubber substances during the milling process.

4.2 Recommended method

The recommended dilutions are:

- If a fraction is taken, latex should be diluted to a standard DRC of 21% in the bulking tank.
- If a fraction is not taken, latex should be diluted to a standard DRC of 15% in the bulking tank.

It is important to use good quality water to standardize NR latex. The water should be without colour and smell and should not contain high concentration of metal ions such as ion, manganese, copper and calcium. The use of inferior quality water will discolour and deteriorate the quality of the crepe rubber produced.

The volume of water required to dilute the latex to a standard DRC can be estimated using the equations given below.

$$V_T D_S = V_F D_F$$

$$V_W = V_T - V_F$$

V_T = Total volume of latex/water mixture

D_S = DRC of standardised latex

V_F = Volume of field latex

D_F = DRC of field latex

V_W = Volume of water required for dilution

5. Addition of sodium bisulphite/sodium metabisulphite

Sodium bisulphite ($NaHSO3$) or sodium metabisulphite ($Na2S2O3$), which is a white crystalline powder, is incorporated into latex as soon as the latex is brought to the factory.

5.1 Objective

This chemical is added to field latex in order to prevent the darkening of pale crepe due to enzymatic reactions. Delay in incorporating the chemical would result in discoloured (i.e. dark coloured) crepe rubber.

5.2 Recommended dosage

This chemical should be added to the latex at the rate of 5g/kg of dry rubber (maximum) and it should be in the form of diluted solution. When latex from different divisions arrives separately, the calculated amount of the chemical should be added accordingly.

This quantity may be reduced:

- If substantial quantity of sodium sulphite has been added in the field
- If oxalic acid is partly used for the coagulation of latex

However, the addition of excess amount of this chemical than the recommended dosage delays the drying process and, as a result, it may cause discolouration of the crepe rubber.

6. Fractionation

Fractionation is a process aimed at removing most of the non rubber constituents including carotenoids and other pigments in the field latex and thereby improving the colour of the crepe rubber. The fractionation process also reduces the tendency of moisture absorption and mould growth since most of the non rubbers substances are removed. Fractionation is used to produce fractionated bleached (FB) and fractionated unbleached (FUB) grades of crepe rubber.

6.1 Recommended methods

Fractionation can be done by either manually or mechanically. Two methods can be used to remove the fraction from field latex.

a. Manual method

In this method, latex is agitated by manually. The procedure for manual agitation is as follows

- Standardise the latex to a 21% DRC initially.
- Add sodium bisulphite.
- Stir the latex briskly, for 20 min. periods with an interval of about 10-15 min. in between.
- While stirring, dip one's hand, a finger or a clean plank of wood into the latex occasionally in order to find out whether the yellow particles are forming.
- When the yellow particles in latex are visible on the palm of the hand or the surface of the dipped item, dilute latex to 15 % DRC and allow the mixture to remain undisturbed for about 10 minutes followed by stirring gently until yellow particles form bigger clots.

b. Mechanical method

In this method, latex is agitated by mechanically. The procedure for mechanical agitation is as follows:

- Standardise the latex to 15% DRC.
- Add sodium bisulphite.
- Pass compressed air through the latex for a period 10 minutes at 20 minutes interval by means of perforated pipes immersed in the latex
- Collect the destabilized particles (seen as clots) mixed with the froth on the surface.
- Continue the above step until no particles appear on froth.

After the removal of the yellow fraction, allow latex (white fraction) to flow into coagulation tanks through a 60 mesh strainer. The yellow fraction removed from the NR field latex is processed into Yellow Fraction (YF) grade of crepe rubber.

7. Bleaching

Bleaching agent is added to fraction removed latex (*i.e.* white fraction) in order to improve the colour of latex crepe.

7.1 Objective

Although most of yellow pigments are removed by fractionation process, it is necessary to use a bleaching agent to bleach the remaining yellow (carotenoids) pigments in the fraction removed latex.
The bleaching agent used in latex crepe manufacturing is sodium para toluene thiophenate (an aromatic mercaptan), which is commercially available in several trade names such as Nexo-bleach, Rupepa, Poly bleach and RPA -4.

7.2 Recommended dosage

The strength of the commercially available bleaching agent is 35 40%. The stock solution is prepared by adding 10 parts of water soluble bleaching agent with 190 parts of water, resulting in 200 ml of 5% of bleaching agent solution. About 2-3 litres of the stock solution of the bleaching agent is sufficient for 100 kg DRC (i.e. 100-150g strong bleaching agent per 100 kg of dry rubber). The amount needed can vary depending on the colour of latex, fractionation etc, and, therefore it should be decided by the factory staff using their experience and by doing small scale trials. However, in most cases the dose required is much less than the upper limit of the above dose range and is very close to the lower limit.
The addition of this bleaching agent in excess does not further improve the colour of laces, but may lead to storage softening and dull appearance.

8. Coagulation

After addition of the bleaching agent, an acid is added to coagulate the rubber particles in the latex. The coagulation of rubber particles by addition of acid is due to reduction in pH value of latex. Rubber particles in the field latex coagulate at the pH between 4.4 - 4.8.

Formic acid is the most preferred and commonly used coagulant for the manufacture of latex crepe rubber.

8.1 Recommended dosage

The strength of the formic acid commercially available is generally 85% and it should be diluted and added to the latex as 1% solution.

The 1% stock solution can be prepared by mixing:
1 part of 85% strong acid + 84 parts of water = 1% formic acid solution

Latex is coagulated by the addition of formic acid at the rate of 3.5-4.5 ml of 85% strong formic acid per kg of rubber (i.e. 350-450 ml of 1% solution per kg of rubber). Exact amount of acid depends on various factors such as amount of anticoagulant used, clone, and quality of water and the time of coagulation. However, excess amount than the recommended level of acid should not be incorporated as the coagulum becomes harder and resulting in milling difficulties.

9. Milling

Rubber coagulum is milled into thin laces using two roll mills. The following types of two roll mills are used to manufacture latex crepe rubber.

- Horizontally grooved rollers (macerators)
- Smooth rollers

9.1 Objectives

Milling of rubber is carried out:

- To expel the serum out from the coagulum
- To remove non rubber substances by through washing
- To convert the coagulum into thin lace form

9.2 Recommended method

The recommended mills and number of mill passes for the manufacture of latex crepe is given in Table 2.

Table 2. *Milling programme for the manufacture of latex crepe*

Type of mill	Type of roller surface grooving	Number of mill passes	Gear ratio	Effects of rollers
Macerator	Horizontal	5	1:1.25	Blanketing and washing the coagulum
Smooth roller	Smooth	1	1:1.8	Preparation of thin laces
Blanket roller	Horizontal	2	1:1	Dry blanketing

Following procedure is generally used for the manufacture of latex crepe.

- Coagulum is divided into slices not exceeding 10 cm in thickness.
- These slices are passed 5 times in the straight grooved mill, under a good water spray to wash out the non rubber substances.
- Laces are then passed once through the smooth mill to obtain a thin lace.
- The thickness of a lace is such that the weight of the lace should be 600-700 g (dry rubber) per square meter.
- After drying, the laces should be spread on a table to examine for colour and dirt contamination. About seven of these mats are placed one over the other to overlap and folded to form long strip of laces of three layers.
- The above preformed strips are passed through the dry blanketing mill to get a blanket of 22-25 mm in thickness.
- The blankets are then allowed to cool for at least five hours.
- The roller nip is adjusted to get a final blanket thickness of approximately 18.
- These blankets are then cut to a standard size. This will depend on the buyers' requirements, but the normal size is 540 x 720 mm.
- Packing is done into 50kg bales or to the size required by the buyers.

10. Drying of laces

- Generally, crepe rubber drying is carried out with warm air in a drying tower operated at 34 0C for three days.

10.1 Objectives

- To remove remaining moisture
- To retard mould growth
- To facilitate transport.

10.2 Recommended operation of drying tower

It is advisable to keep all the doors and windows open while the laces are being loaded to the warm air drying chamber and firing of the boiler started before the loading is completed. After the loading is completed, all windows and doors should be shut but top air ventilator is kept fully open during the first 3-4 hours and thereafter it is kept partially open in order to maintain the temperature at 34 0C. Inlet air ducks should be checked and any blocks in them removed. If necessary they can be extended up to the radiators for efficient heat transfer to maintain the required temperature.

11. Defects in crepe rubber

Although latex crepe is manufactured by taking all precautions to obtain pure water white colour laces, crepe rubber can be discoloured due to various reasons. Following are the main types of discolouration.

- Enzymatic discolouration
- Yellow discolouration
- Storage discolouration
- Mould contamination.

Table 3 shows the possible reasons and preventive measures to be adopted for the control of main types of discolouration.

Table 3. *Possible reasons and preventive measures for the discolouration of latex crepe rubber*

Type of discolouration	Possible reasons	Preventive measures
Enzymatic discolouration	Oxidation of polyphenolic compounds in NR latex. Reactions are catalyzed by enzymes.	Addition of correct dosage of sodium bisulphate or sodium meta bisulphate at the correct time. Prevent any delays in processing. Prevent any delays in drying.
Yellow discolouration	Presence of carotenoid pigments in latex.	Removal of fraction from field latex. Addition of correct quantity of bleaching agent.
Storage discolouration	Reaction of amine compounds present in latex with metal ions.	Use of good quality water
Mould contamination	Fungal growth in rubber laces	Ensure the drying of laces within three days. Prevent loft drying. Dried laces should be stored in a clean and dry place.

In addition to the main discolouration types, following types of discolouration may also occur;

- Reddish brown discolouration due to metal ions such as ion (Fe).
- Dull/yellowish colour which appears 24 weeks, after manufacture due to bacterial contamination of latex.
- Dull appearance of laces due to direct exposure to sunlight, use of inadequately cooled mills and high temperature in drying towers.
- Yellow steaks on laces due to processing of pre-coagulated latex.

12. Average specifications

Although latex crepe is sold on visual grading, Rubber Research Institute of Sri Lanka has now introduced average specifications for latex crepe rubber. Fractionated bleached crepe rubber (FB) could be easily produced to conform to the specifications given in Table 4.

Table 4. *Average specifications for latex crepe rubber*

Property	**Specifications**
Dirt content % (w/w)	0.02 (max)
Volatile matter content % (w/w)	0.5 (max.)
Ash content % (w/w)	0.20 (max.)
Initial plasticity number (Wallace units)	30 (min)
Plasticity Retention Index (PRI)	60 (min)
Nitrogen content % (w/w)	0.35 (max)
Mooney viscosity ML 1 + 4@ 100 °C	75-85
Lobibond colour	1.5 (max)

Raw Rubber Process Development &
Chemical Engineering Dept.
Rubber Research Institute of Sri Lanka
Telawala Road
Ratmalana

January 2016