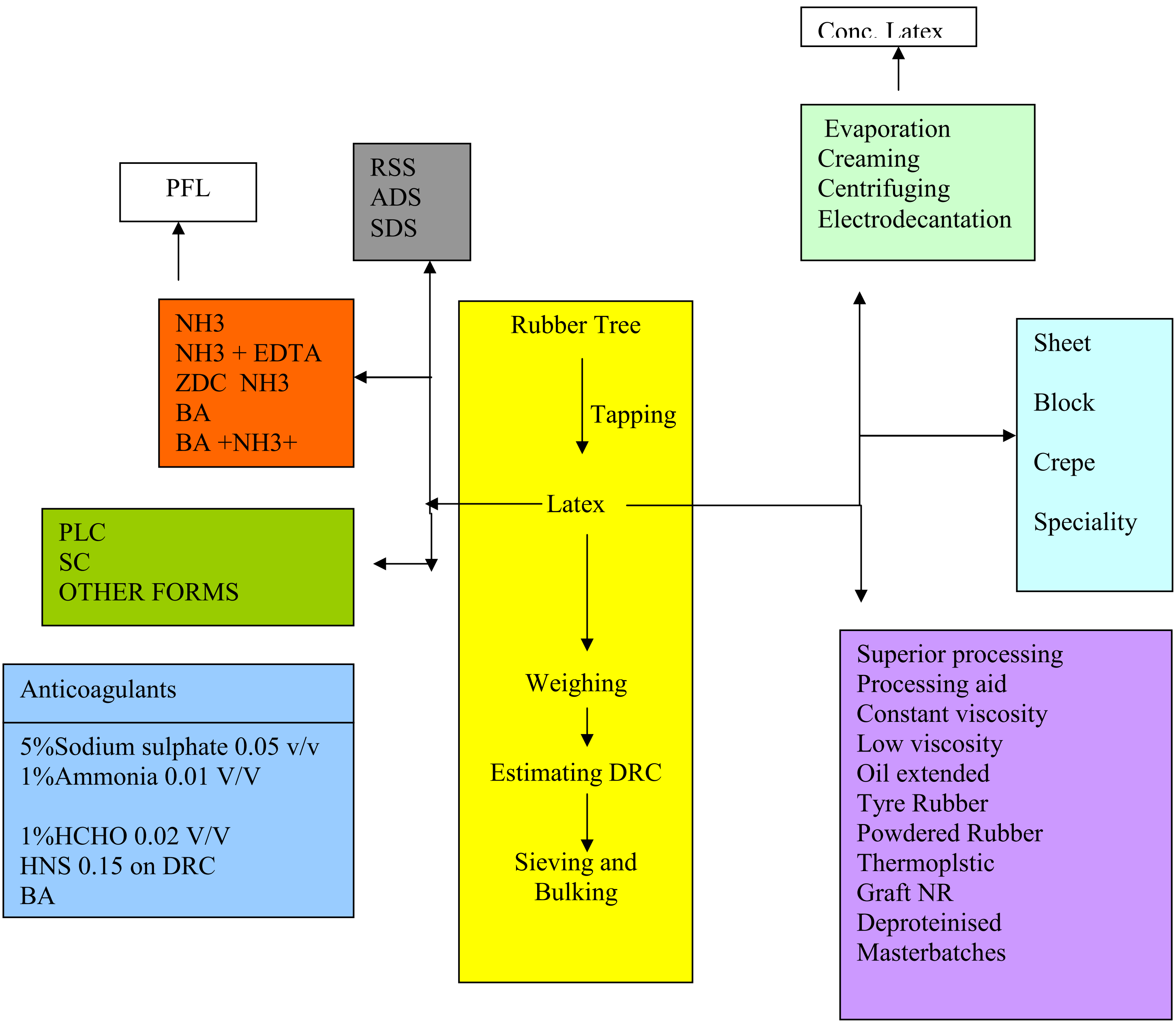
LATEX PROCESSING



Latex is produced in laticifer cells.

Laticifer -
- Single, non-articulated
- Compound, articulated

There are 12,500 species of laticiferous plants.
7,000 produce isoprene. (*Mostly they are mixed with resins*)

Hevea Brasiliensis- the best.
(These are with articulated laticiferous bark).
It gives better yield and superior rubber content.

A group of plants that has resulted from the vegetative propagation of an individual is a **clone.**

Average yield is 2000 kg to 3000 kg / ha

Latex yield simulation by chemicals:

- 2-amino- 3.5.6 – trichloropicolinic acid
- 2- chloroethyl phosphoric acid

(penetrate the bark and produce ethylene within the plant.)

Producers:

- Malaysia
- Indonesia
- Thailand
- India and China
- Srilanka

<u>Taping</u>

Latex is contained in capillary vessels that are in a sheath concentric with the outer bark. **2-3 mm thick zone**. **20 to 50 microns dia capillary vessel**

- Latex oozes out through a cut in the bark. Coagulates after 2-5 hours , due to evaporation (thus plugging)
- Half spiral method (S2, d2) ie. Half cut, taping every other day and S1, d4 method (full spiral cut, every fourth day)

General composition of latex:

Latex	(% wt)
Rubber	30 – 40
Protein	2.25
Ash	0.7 – 0.9
Resin	1 – 1.6
Sugar	1-1.5
Water	60- 70

Rubber	phase
Rubber	86
Water (hydration layer)	10
Proteins	1
Phospholipids	3

- Laticifer cells are arranged in concentric rings around and adjacent to cambium. (In the region called Phloem Fig. 6 of ref 1372)
- These are running parallel to the tree trunk and are interconnected at places.
- The contiguous wall of two adjacent laticifers becomes perforated in several places producing anastomoses which create a continuous network within each mantle.

The secondary phloem contains in addition to laticifer cells, sieve tubes, companion cells, parenchyma cell. Xylem and phloem connected by vascular rays.

New cells are formed by the cambial activity. Gradually the older phloem (and so the old laticifers) are pushed outward. Parenchyma cells, enclosing the laticier tubes becomes hardened.

Wood transport water and mineral from the root. It is supplied to the cambium area through vascular rays. Ie. Wood participate in supplying laticiferous tissue water , mineral and also sugar that are precursor of the synthesis of rubber (As the wood also accumulates reserves, mainly of starch) ie. Starch is accumulated in axial parenchyma cells (Fig. 13 and 16 of ref 1372)

Lutoids

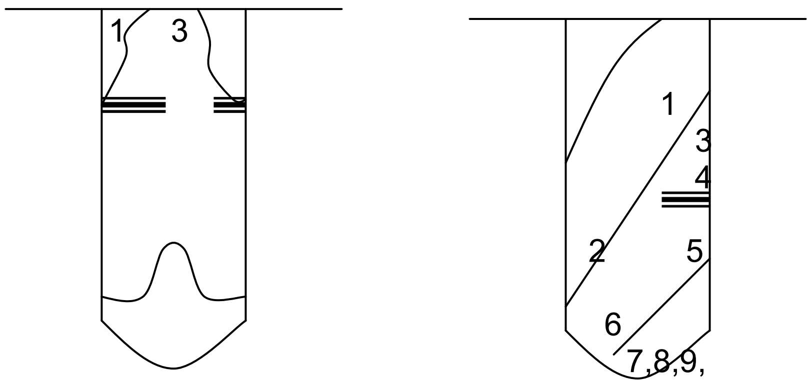
- These are 10 – 20 % of the volume of latex.
- 2-5 micrometer dia
- Enclosed by a unit membrane which is rich in phosphatidic acid and
- Contains helical spring like protein molecules.

Laticifer cells composition:

Cell wall
Nucleus
Plastids &Frey-Wyssling particles
Nitochondia
Vacuome (lutoids and classic vacuoles)
Endoplasmic reticulum
Dictyosomes
Rubosomes
Rubber particles (25 – 45 % volume of latex)

- Rubber particles are usually spherical
- Size : 50 angstrom to 5-6 micrometers
- Small particles have higher molecular weight
- It is covered by phopholipproteinic .
- Surface negative charge maintains stability;

Centrifuging to separate rubber



1 -largest particles
2 0.005 to 0.25 microns
3 0.035 to 0.2 microns dia

1, 2 3 – rubber
4 Frey Wyssling particles
5 clear serum , 6 serum
7-9 bottom fraction

0.1 micron dia particles contains several hundred cis polyisoprene molecules.

<u>Size distribution:</u>

- Average: 0.1 microns,
- Less than 0.045 microns ~ 30 %
- Less than 0.36 microns ~ 95 %

<u>Membrane covering the rubber (Phospholipoproteinic)</u>

- Neutral lipids (pigments, sterol esters, fattyacid esters, etc)
- Phospholipids (phosphatidyl choline, phosphatidyl ethanol amine etc)
- Proteins (alpha globulin mainly)
- Enzymes (rubber transferase)

Surface negative charge, moves to positive side:
0 – 120 micrometer/s and proportional to electric field for potential gradient 0 – 20 V/ cm.
Surface potential is 35 to 45 mV.

Protein

1% on latex **of which** 20 % is on rubber , 20 % is in bottom fraction and the rest in serum (60%)

There are **15 proteins** in rubber serum and **8 in bottom fraction**. (alpha globulin in rubber and serum and Hevein in bottom fraction.

Latex contains : Fubber, Frey Weysling particles, Lutoids, Ribosomes, cytosol etc.

Mineral content:

Nitrogen	0.26 %
Phosphorus	0.05 %
Potassium	0.17 %
Calcium	0.003%
Magnesium	0.05 %

Rb (7), Mn (0.1), Fe (1.0), Cu (2.0), Zn (0.3) mg / 100 g of fresh latex

Low Molecular weight organic solutes

- Polyols and glucids
- Organic acid
- Aminoacid
- Nitrogenous bases
- Reducing agents
- Nucleotides

High molecular weight compounds

- Protein
- Lipids
- Nuclic acid

Polyols and glucids (Monomethyl 1-inositol)
Organic acid (malic acid, citric acid - 90% of acid in latex).

Also contains: succinic, fumaric, aconitic, alonic, glycolic, lactic etc

<u>Amino acid</u>
Glutamic, alanine, aspartic acid (constitute 81.% of total amino acid in cytosol)

<u>Nitrogenous bases</u>
Methyl amin, tetramethylene diamine, pentamethylene diamine

<u>Reducing agents</u>
Cysteine, ascorbic acid

<u>Nuecleotides</u>
Adenosine, guanosine, uridine etc,

Yield – 70 to 85 % as latex, the rest being field coagulum (treelace, cup lump, earth scrap, black shell)

<u>Contamination During Collection:</u>

20% from cut
20% from spout
60% from cup
bacteria population is 10^4 to 10^6 per ml of latex
bacteria thrive on the non-rubber constituents of latex producing acids

<u>Short Term Preservation</u>

<u>Precoagulation</u>

- Happens in 4-6 hours. Depends on the mocroorganism and the nature of latex
- Prior to winter the Mg content in latex increase(faster coagulation)
- During winter, due to loss of leaves, exposed to direct sun light (faster coagulation)
- Clonal susceptibility- some clones have high Mg content eg. GI 1, Tjir 16, LCB 1320. Young trees show high Mg content.
- Rain water contamination also causes faster coagulation

<u>Anticoagulants</u>

- Sodium sulphite,
- ammonia
- formalin

Choice of anticoagulants

- Sodium sulphite – a mild preservative, not good for latex with high precoagulation tendency.
- Ammonia – general purpose, particularly used in concentrated latex preservation. For PLC it gives discolouration. For sheet it gives coagulation problems. For TSR coagulation problems (because of high ammonia content). *(Low ammonia systems, in combination with hydroxylamine or boric acid*
- Formalin- can be used with sheets; not used with PLC production (discolouration). With conc. Latex it reacts with ammonia)

Loading

Sodium sulphite

- White powder, stored in airtight containers
- 5% stock solution (50 g in 1 L water)
- 0.05% on the volume of latex is used (100 ml in 10 L latex)
- excess – retards drying. Tackiness (absorption of moisture by residual salts which remain on the surface of rubber sheets)

ammonia

- 1% stock solution (1 kg of gas in 100 L of water) (or 50 ml of 20% solution. Can be diluted to 1 L)
- 0.01% on the volume of the latex is used (100 ml in 10 L of latex)
- stored in the coolest place, immersed in water, stopper may be loosened slowly, left hand in an inclined position, wear goggles.

Formalin

- 1 % stock solution (25 ml in 1 L)
- 0.02 % on the latex volume (200 ml of the stock solution to 10 L of the latrex)
- for latex with high tendency of coagulation combination of sodium sulphite and formalin can be used (0.02 and 0.02 vol %)

Hydroxylamine – ammonia system

- It is bactericide but does not preserve latex
- Hydroxylamine neutal sulphate (HNS) is used along with ammonia
- 0.15% of HNS on the dry rubber content. Ammonia varies from 0.03 to 0.07 % on the volume of latex. For different lengths of preservation (11, 19,30 estate and 5,11 and 20 hours of small holding)
- The combination is prepared as one stock solution.

Boric acid

- Used as short term preservative for field latex. Not as effective as ammonia
- Does not discolour rubber even when used at higher levels
- Combination with ammonia is used in the production of light coloured rubber
- 0.4 to 0.5% boric acid 0.07 % ammonia (on the volume of latex) is good (as good as 0.17 % ammonia alone)

Collection

- Latex usually ceases 1.5 to 3.0 hours after tapping. Collected in coconut shell cups or plastic cups and transferred to buckets which are not to be exposed to sunlight.
- Field coagulum collected and cleaned, sorted and stored after smoke drying in smoke house (Long time exposure to sunlight or soaking them in water for long periods may accelerate degradation)

Pre processing operation

1. Weighing
2. Estimation of DRC:
    - standard laboratory method (10 – 15 g of latex, acetic acid 2 %, steam bath, 2 mm sheet, 70 deg. C 16 hours)

      Longer drying time is one drawback. Overcome by using methylated spirit. Ie. A mixture of 90 – 95 part by weight of methylated spirit and 5-10 part by weight of acetic acid is used for coagulation and the quantity of latex used is 3-4 g)

    - Dipper method (definite volume with a dipper, acetic acid 2 % steam bath, 2 mm sheet, 70 deg C, 16 hours)

    - Metrolac method (easy and widely used method, not very accurate)
      Latex + 2 parts by weight of water, filled in a cylindrical jar of slightly more dia than the Metrolac. Froth removed, Metrolac dipped, reading multiplied by 3
      Very convenient and fast But not very accurate

3. Sieving and bulking

   Sieved first through a 40 mesh and then 60 mesh sieve(Monel metal, Al or stainless steel)

4. Bulking is required for:
    - Uniformity
    - to remove sedimentable impurities

(latex differ in colour, viscosity, DRC, mol. weight, susceptibility to enzymatic action)

Done in brick work or concrete tank lined inside with glazed tiles.

Marketable forms

1. RSS,
2. PLC & sole Crepe,
3. Solid block rubber
4. Speciality rubber
5. Preserved filed latex
6. Latex concentrate
7. Estate brown crepe and solid block rubber;

Choice of processing method depends on:

- Present and potential demand
- and prices for the various marketable forms and their relative cost of production,
- size of plantations and their production.
- Types of planting materials,
- machinery, utilities and know-how.

Effluent

The specification parameters and their limits:

PH	5.5 – 9.0
BOD	30
COD	250
Suspended solids	100
Phosphate	5
Ammoniacal nitrogen	50 mg /L

Typical effluent from different latex processing units (Table 20.2)

Treatment

- Physical (Filtration, sedimentation and reverse osmosis)

- Chemical Treatments (precipitation, flocculation, ion-exchange, oxidation and reduction.

- Biological (Anaerobic/ aerobic ponding system(economic but more space required) and oxidation ditch system (less space)

Complex organic molecules

↓ Hydrolysis

Hydrolysed molecules

↓ Acidification

Fatty acid/ alcohol

Complex organic molecules + oxygen

↓ Aerobic bacteria

CO_2 + water

Favourable conditions (aneaerobic)

- PH 6.5 to 7.5
- absence of dissolved oxygen and
- tolerable level of volatile acids and free ammonia (*these are known to be toxic to methano-bacteria*)

*for a*erobic :

- sufficient supply of oxygen from the photosynthesis of algae and bacteria. Tolerable pH
- sunlight
- adequate availability of carbon, nitrogen and phosphorus.

In oxidation ditch- supply of oxygen is achieved by mechanical aeration.

PRESERVED FIED LATEX AND LATEXS CONCENTRATE

Spontaneous coagulation in 6 – 12 hours
Preservation required

Attributes of a good preservative

- Destroy or inactivate microorganisms
- Contribute positively to stability
- Deactivate or remove traces of metal ions
- Not harmful, no adverse effect, cheap, ready availability, ease of handling

<u>Ammonia</u>

- 0.7 – 1 % by weight of latex
- fatty acids are hydrolysed (stability improved)
- bactericide at 0.35% level and above
- magnesium removed as sludge (Magnesium ammonium phosphate)
- copper is deactivated as complexes

Drawbacks of Ammonia

- Handling difficulties
- Manufacturing problems
- Hydrolysis of serum constituents (salts)
- Loss of ZnO stability
- Low Ammonia Preservative systems

<u>Pentachlorophenol</u>

Ammonia 0.2 %
Sodium pentachlorophenate 0.2 % (on the weight of whole latex)

Or : 0.1 : 0.1 = SPP : ammonia : EDTA

(Gelling problems, poisonous, dermatitis and discolouration)

<u>ZDC</u>

0.2 % ZDC : 0.2 % Ammonia and 0.2% Lauric acid (optional)
(Lauric acid is to improve mechanical stability(Discolouration on ageing)

<u>BORIC ACID</u>

% Boric acid, 0.2 % Ammonia and 0.05 Lauric acid

It is harmless, cheap, easily available and convenient to handle and has not effect in vulcanisation.

Formaldehyde

Bactericide – better than Ammonia

0.15 % - 0.2 % HCHO soon after collection.
Allow to stand for 15 to 30 hours (interacts with protein)
Finally ammonia up to 2% on aqueous phase (enhanced stability and resistance to freezing)

CONCENTRARED LATEX

Sieving, bulking, ammonia bubbling (0.7 % to 1 % on volume of latex).
Store for 15 to 20 minutes (sedimentation), transfer to drums, seal and market

Dosage

Filed latex (0.4 – 0. 5 % on latex) for 1- 2 days
Minimum concentration is 1 % (for longer period)

Sludge Removal

Magnesium to be removed as sludge along with sand and other impurities

Phosphate comes from phospholips or from diammonium hydrogen orthophosphate solution added to latex
Leave overnight

Preserved Latex Concentrate

- Economy in transportation
- High DRC
- Better uniformity
- Purity

Concentration

Evaporation, creaming, centrifuging and electrodecantation

Evaporation

Double walled cylindrical vessel and a hollow iron roller floating in the latex (homogenises, prevents scum formation, minimises frothing and provides stirring)

Spray hot latex into partially evacuated chamber

LUWA type evaporators

CREAMING

$$V = 2 g (Ds- Dr)^2 / (9 \square)$$

Formation of a loose network between the molecules of the creaming agent adsorbed upon the surface of the particfles and those dissolved in the serum. Buoyancy of the clusters break them free from the network

Agent: sodium alginate, tamarind seed powder and methyl cellulose (0.2 – 0.3 % of dry material, calculated on the water phase of latex)

Factors affecting creaming
Concentration of creaming agent, age of latex, temperature, alkalinity of latex, striring, soap (0.3 to 0.5% on latex)
Viscosity (Opt. PH 10.8 to 11.8)

Process
Collection, ammoniation to 1%, ageing for a few days, desludging, (creaming agent 3% solution prepared by boiling and sieved)
Calculated quantity to be added
10 % soap solution (0.3 % on latex). Leave till desired level of creaming (48 hours minimum)

Advantages
Simple equipment, lower labour cost, lower power consumption

Disadvantages
Slowness, efficiency depends on quality of latex
After creaming

Centrifuging
De Laval Machine that run at 6000 rpm

Ammonia content to be adjusted to 0.25% for immediate and 0.8% for more than 2 days old latex
Final ammonia conte4nt in concentrated latex is 0.7% of latex. Packed in drums

Efficiency of centrifuging

$E = (C \times c) / (F \times f)$
C = drc of cream
C = weight of cream
F = drc of field latex
F = weight of field latex

(usual value of efficiency is 0.85 to 0.90)

SKIM RUBBER

Skim rubber – 10 to 15 % of the incoming rubber
DRC of skim latex is 2.5 to 10 % and 2/3 serum. Protein content per unit weight of rubber is more.

RECOVERY

Either natural coagulation or by addition of sulphuric acid. Coagulum obtained is processed into crepe or sheet by conventional means with thorough washing.

Improved Skim Rubber

Enzymatic de-proteinisation (Trypsin 1 kg / 1000 kg skim with 6 % rubber), 25 hours in wax lined tanks. Trypsin is added as 8% slurry in water. Deammoniation by agitation, sodium thiosulphate or sodium metabisulphate addition, coagulation by dil. Formaic acid and then to crepe

Characteristics of Skim Rubber

Colour	Light
Dirt	Very low
Non rubber content	Up to 30 %
Cu	4- 20 ppm
Acetone extractables	3 – 5%
Mill breakdown	Normal
Power consumption	Slightly higther
Mill shrinkage	Less than for normal rubber
Cure rate	Fast, giving scorcy compounds
Hardness	Higher
Modulus	Higher
Resilience	Lower
Ageing behaviour	Variable

<u>ELECTRODECANTATION</u>