

Chapter 2 – Literature review

2.1 History and the Introduction of NRL into Sri Lanka.

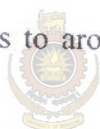
NR latex as a raw material for industry is relatively young. Although solid rubber has been known ever since the days Christopher Columbus and his men marveled at the native of Haiti playing with ball made from the gum of a tree- which was in 1496- latex received little attention until the third decade of the twentieth century. By the time the rubber plantation industry had developed to such an extent it appeared feasible to collect, preserve and transport latex on large scale.

Hevea Brasiliensis of Euphorbiaceae family is a most important commercial source of NR. It is a native of Brasil and was introduced into tropical Asia in 1876 by Sir Henry Wickham. Through rubber had been known for many years it was not until 1875 that the now famous para rubber was seriously talked about in Ceylon. In the following year two thousand seedling of *Hevea Brasiliensis* were dispatched to Peradeniya, Ceylon from Kew garden in London. It was principally from Sri Lanka that the *Hevea Brasiliensis* was introduced in other parts of the far East.

Natural Rubber produced in Sri Lanka is a valuable resource for the rubber industry, as well as for foreign exchange earning through exports. Presently, the rubber industry contribution to export earning of the country is about 8%. The rubber exports accounted for US\$ 542 mn for the year 2006 out of which 17% were from natural rubber exports whereas the balance is from rubber products exports. The value added rubber products manufacturing sector has recently emerged as the key driving force in the industrial based development of the economy. The

European union is the major exporter of natural rubber with the export quantity of 11.2 MT in the year 2006. This is followed by Pakistan with the export quantity of 11.1 MT. The major rubber products exporting countries are EU, USA, Japan, Canada and India(http://www.boi.lk/2009/rubber_industry.asp).

The rubber industry in Sri Lanka has the potential to be one of the world leading rubber product manufacturing countries due to its production of top quality grade of NR with a very low level of proteins and production of high quality RSS as raw materials at relatively low processing cost. Wide variety of rubber products are manufactured by the rubber manufacturing sector in Sri Lanka. Surgical gloves, house hold, agriculture and examination gloves, balloons, Halloween masks and rubber toys are among the major products manufactured by the latex products industry has expanded significantly over the last decade and presently it attributes to around 35 % of the local consumption of NR (Hand Book of Rubber, RRISL, Vol 2).



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2.2 Natural Rubber Latex

Hevea Brasiliensis is only one albeit the most important commercially, of some 2000 plants known to bear latex containing terpene material. In addition to all the natural features of trees, the *Hevea* tree has several concentric layers of latex vessels between the cambium and the bark. NRL are found in these cells of *Hevea Brasiliensis* tree. Field latex is secreted by latex vessel of the *Hevea Brasiliensis* tree on every second day in a left hand, down ward, semi-spiral at 30° . Freshly taped latex is a whitish fluid of density between 0.975 gml^{-1} and 0.98 gml^{-1} , pH from 6.5 to 7.0 and surface energy from 40- 45 ergscm^{-2} .

2.2.1 Importance of NR to the modern world

Rubber has become an almost inevitable material for modern man. Over thirty thousand different products are made using this material. In a modern automobile there are over 300 rubber components. The most important use of natural rubber is production of automobile tyres and tubes. The role of rubber in foot wear, medical products, garments and furniture industry, sports wears, toys etc. need no elaboration.

The economical importance of natural rubber was elaborated in a recent report published from Malaysia. Nearly 22 million people of South –East Asian countries are solely dependant on natural rubber for their livelihood. In India nearly 1.5 million people are directly dependant on this crop for their survival (Thomas, EV, 1984)



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All the predictions for cars of the future, envisage the use of rubber in tyres, albeit their profile may change and their weight decrease. This together with tomorrow's world space shuttles and other aircraft landing on NR tyres, should see a bright future for the NR industry. (Hand Book of Rubber, RRISL, Vol 2)

2.2.2 NRL in the field of Medicine

Any polymer material used in medical or surgical applications must meet the stringent requirements; it must be non toxic, non biodegradable and, in the case of important surgery, causing no acute tissue reactions; it should ideally also be easy and cheap to manufacture and posses all the properties required for efficient performance. NRL with suitable compounding, purification and sterilization can meet all these demands, and is now well established as a

'medical' rubber. Many examples ranging from one of the earliest product used in this field such as surgeons' gloves, to more recent development including radio- opaque washer used in tumour therapy, post operative ear grommets, small diameter artificial blood vessels, and the injection of latex into transplanted pancreases. Another 'early' use of the natural rubber in medicine, which survives today, is in the area of artificial ducts, surgical tubing and catheters (Rubber Development, 1981).

NR saves lives in the medical field as well. Surgeons' gloves and examination gloves are now universally used to protect hospitals workers, Dentist others in the medical field against AIDS. The market has risen dramatically since 1988, and for the most part consumers cannot imagine a better material for feel and grip (Hand Book of Rubber, RRISL , Vol 2).

Miraculous discovery of the rubber tree be its effort to convert plant into medicine factory . In fact Hevea tree are creating pharmaceutical factories powered by solar energy. By inserting pharmaceutical proteions into rubber tree then tapping the latex, antibiotics, vaccines and hormones can be obtained along with latex (Rubber Asia, 1995). These protein- based pharmaceuticals are blood clotting factors for haemohiliacs, clot dissolving plasminogen activities for cardiac treatment, insulin for diabetics, tumour necrotic factors to combat cancers, erythroprotein to anemia, viral coat protein for vaccines etc (Int'l Rubber Digest, 1992; Rubber Asia, 1995).



2.3 Definition of Latex

Latex may be simply defined as a stable dispersion of a polymer substance in an aqueous medium. From the definition it is evident that latex is a two phase system consisting of a dispersion phase and dispersion medium. The dispersion phase consist of small particles, normally less than 5 μm in diameter, particles made out of *cis* poly isoprene molecules of which are polymeric in nature, that is they are large in size and repeated many times over . the dispersion medium is predominantly water.

2.3.1 Constitution of NRL

Major constitution in latex is hydrocarbon. In addition to rubber hydrocarbon NRL contain non- rubber substances. This may be < 5 % of the weight of latex. Most of the non-rubber particles are dissolved in the aqueous phase and some are adsorbed at the surface of the rubber particles. These are mainly proteins, soap and lipids.

Principal phase of fresh NRL: University of Moratuwa, Sri Lanka.

Rubber phase	35%
Aqueous phase	55%
Lutoid phase	10%

Being natural product composition of fresh latex varies between wide limits

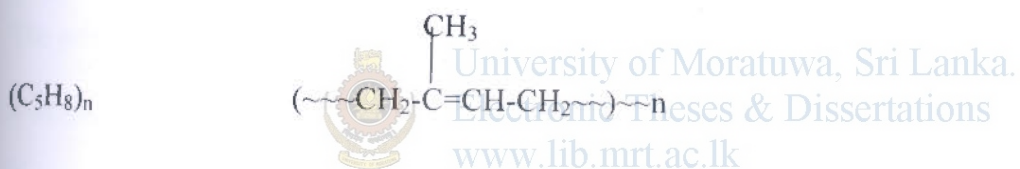
Table 1:- Typical Composition of Field Latex

Property	Composition
TSC	36 %
DRC	33 %
Lipids(resinous substance)	1-2.5 %
Protenious substance	1-1.5 %
Sugar	1 %
Ash	Up to 1 %
Water	ad.100 %

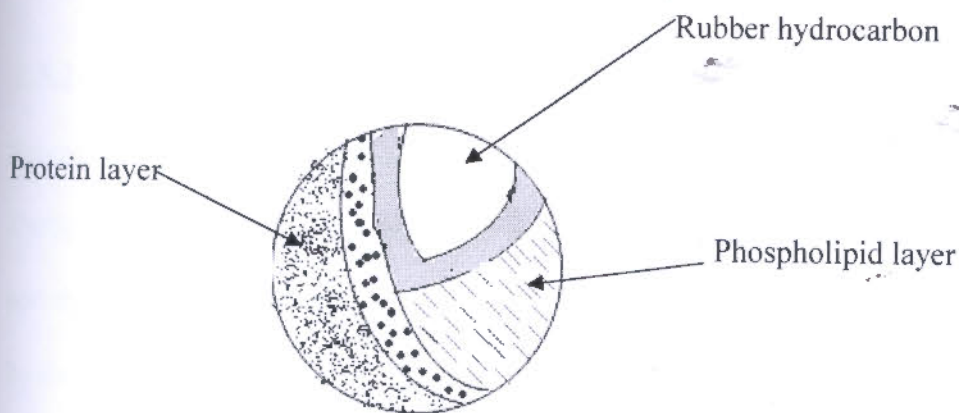
Table 2:- Typical Composition of Rubber phase of NRL

Property	Composition
Rubber hydrocarbon	86 %
Water (dispersed in rubber phase)	10 %
Protein	1 %
Lipids	3 %

In addition to this trace metals mainly Mg, K, and Cu are also associated with the rubber phase to an extent of above 0.05 %. Rubber particles are mostly spherical in shape. The density of rubber particles is 0.92 g/cm^3 . The rubber Hydrocarbon in NRL is called *cis*-1,4 poly isoprene.



It is observed that *cis*- 1,4 poly isoprene is of high molecular weight around 3000,000. The two protective envelops of lipid and proteins are constituted in the following manner



Representation of rubber particle in fresh natural rubber latex

The protein component of the rubber particle occurs exclusive as an adsorbed layer, which surrounds component of the adsorbed protein is α -globulin. The latex is thermodynamically unstable because of this adsorbed protein anion.

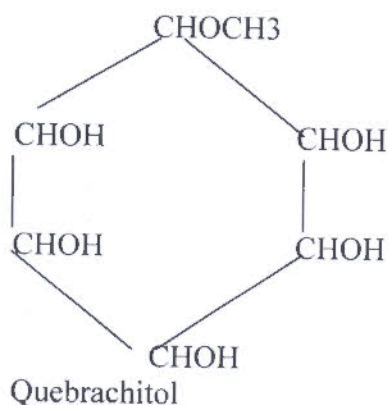
The lipids, which are associated with rubber particle, comprise sterols esters, phospholipids, fats and waxes. Phospholipids are strongly adsorbed on to the rubber particles while other occur predominantly with in the bulk of the latex particle, probably dissolved with in the hydrocarbon. The presence of hydrocarbon radicals in a molecule, which also contain a remote permanent ionized site, is responsible for strong adsorption of this substance at the rubber-serum interface.

The principal phospholipids which are surrounds the rubber particles are of lecithin type carries a slight overall positive charge, where as the protein, being on the alkaline side of their isoelectric points, are negatively charged, so that ionic attraction between two species are possible and probably accounts for the adhesion between proteins and lipids.

2.3.2 Substances dissolved in aqueous phase

Serum (c-serum) is essentially aqueous and contains the dissolved materials such as Carbohydrates, Proteins and inorganic ions . The inorganic anions are mainly CO_3^{2-} and PO_4^{2-} and the cations Mg^{2+} , Ca^{2+} , K^+ , Cu^{2+} , Na^+ and Rb^+ together with Mn^{2+} absorbed from the bark by the latex during flow down the tree.

The principal carbohydrate in NRL is called L-methyl inositol. This is also known as quebrachitol.



The concentration of this carbohydrate is about 1% of latex. The growth of microorganisms on these substances causes them to oxidize to given volatile fatty acids such as formic, acetic and propionic.



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2.3.3 Lutoid Phase

When undiluted fresh latex is centrifuged at a high speed, separation of latex into two principal phases can be observed. Top layer is white and contains most of the rubber particles. The bottom layer is called the bottom fraction and in this fraction there are some ill defined aggregates which are quite different in character to rubber. These aggregates in the bottom fraction are called lutoids. This Lutoid phase disappears during the ammoniation. They are not found in ammonia preserved NRL.

2.4 Preservation.

Once the field latex exudes from the tree, it is liable to contaminate by bacteria from the bark of the tree or from the air. The relatively high protein and carbohydrate content of field latex provided nutritious base for these bacteria, which would therefore grow rapidly if unchecked. The addition of preservatives in the field is intended to stop bacterial growth which would otherwise cause coagulation of the latex within a few hours of leaving the tree and at a later stage putrefaction sets in, with the development of bad odors. Therefore it is virtually important that any field latex that is to be processed into concentrate should have been subjected to a minimal level of bacterial attack prior to concentration and hence preservation is necessary.

Ammonia functions as a bactericide, as an alkali, metallic ions sequester and successfully satisfy the primary and ancillary requirement of a preservative (Blackly, 1997). Lattices were preserved as HA and LA.



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Because of the certain limitations such as ammonia odour, economic disadvantages such as need for deammoniation in processing and thus inevitable materials loss, increasing of VFA on storage, surface skin formation, and environmental problems associated in HA lattices it was thought advisable to have preservation system, with lesser amount of ammonia. Several low ammonia system were introduced and LATZ latex has superiority due to the drawbacks of other systems such as toxicity, poor film colour, poor storage stability, poor chemical stability etc.

2.5 LATZ System as a preservative

To overcome the drawbacks of LA lattices and HA lattices, a composite preservation system containing ammonia, TMTD, ZnO was introduced. It is popularly known as LATZ latex. Following strength of chemicals was used for preservation (Sebastian, 1998).

Ammonia	0.2-0.3 %
TMTD	0.0125 %
ZnO	0.0125 %

Ammonia at the level of 0.2 – 0.3 % has only weak bactericidal activity (Sebastian, 1998). Therefore TMTD and ZnO have to be added. In the composition of fresh latex, 1% of sugar mainly sucrose, play an important role in latex destabilization. This sugar is converted to glucose and fructose by enzyme invertase. Eventually acetic acid is produced on the formation of VFA by the bacterial activity on these lower sugars. The TMTD being a disulphide, interacts with the thiol group of the enzymes invertases, by thiol disulphide, and inactivates the enzyme. The protein are important stabilizers of the NR latex particles. TMTD enhance the stability of latex protein by reacting with any reactive thiol containing groups by thiol disulphide interchange.

The product resulting from the TMTD and the thiol disulphide interchange is dithiocarbamic acid which reacts with excess Zinc Oxide to give Zinc diethylmonothiocarbamate which is a powerful bactericide. The amount of ZnO added is in excess to the dithiocarbamate ions so that the Zinc diethyl monothiocarbamate can be formed. Zinc diethyl dithiocarbamate (ZDC) is also

used as a bactericide, but is much weaker than the monothiocarbamate. There also present in natural rubber, free thiols such as cysteine and glutathione and these could interact with the TMTD to produce dithiocarbamic acid.

The bacteria which multiply in ammonia, i.e, and the ammonia- resistant bacteria are mainly proteolytic bacteria and produce enzymes, which degrade proteins. These enzymes are also thiol-containing enzymes and TMTD is known to deactivate these enzymes.

Thus it is seen that the ZnO/TMTD system function as

- An enzyme poison to invertase
- A bactericides, and also
- Protect the proteins which are natural stabilizers of NR latex (M.Nadrajah, 1979)



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2.6 Concentration of NRL

The average rubber content of field latex is about 30 % by weight. This material is not utilized in it's original form due to it's high water content and susceptibility to bacterial attack. There for it is necessary to preserve and concentrate latex. So that the end product is stable and contain 60 % or more rubber.

The number of methods has been proposed for the concentration of latex. High- attention has obtained by evaporation, creaming, centrifuging and electrodecontation. Among these four method centrifugation is the most widely used method in the industrial sector.

2.7 Stability of the Colloidal System

The term stability of polymer latex means, tendency for the system to remain unchanged as a colloidal dispersion as time elapses. But here is a thermodynamic tendency and also mechanistic pathway by which it can prevent the occurrence of this stability. Colloidal stability is govern by a barrier arise by the balance between various attractive and repulsive force operating between two particles as they approach each other. Electro static, Born and Steric repulsions, Vander-waals attraction and Solvation forces have been accounted for the stability of latex.

The system may be stabilized by two general mechanisms, electrostatic stabilization and steric stabilization. In the first process, electrical double layer involves which is describes the charges distribution generally found at interfaces and surface and particle acquire a charged. Stability is due to electrostatic repulsion between counter ion clouds, which are associated with the particles. In the latter case lyophilic polymer, non-ionic surfactant firmly adsorbed at the particle surface and extend an appreciable distance into dispersion medium that provide a steric barrier is responsible for stability.

2.7.1 Mechanism of Spontaneous Coagulation of NRL

Two general theories have been proposed to explain the spontaneous coagulation of NR latex (Blackly,D.C,1966)

First Theory

The theory suggests this is due to the development of acid through microorganisms interacting with various non rubber substances in NR latex. In other words fresh NRL gets contaminated by microorganisms during tapping as well as during collection. These microorganisms can

multiply rapidly by utilizing some of the non rubber specially carbohydrates with the production of acids such as formic acetic and proponic. These acids neutralized the charge of the particles in the latex causing destabilization of latex.

Second Theory

In this theory spontaneous coagulation has been connected to the liberating of fatty acids anions to the hydrolysis of various lipid substances present in the latex. These ions are then though to be adsorbed on the surface of the rubber particles possibly by partially displacement adsorb proteins. Then they interact with metallic ions such as Ca^{2+} and Mg^{2+} forming insoluble salts causing destabilization of latex.

2.7.2 Destabilization

Rubber particles are constantly moving (Brownian motion) and they are small in size. Therefore surface area is larger thus surface free energy is high which, is not a stable system. It may be said that all lattices are thermodynamically unstable but aggregation and coalescence occur very slowly and it is regarded as stable for practical purposes.

The destabilization may occur as gelation, coagulation and flocculation. Liquid system gradually changes to semi rigid gel of same size and shape as original in the process of gelation while few lumps of polymer rapidly separate from latex and remain suspended in the medium during coagulation. Large number of tiny agglomerates of polymer particles forms in the process of flocculation.

Delaying the attainment of the flocculated and coalesced states are due to reduction in interface associated free energy, electrical charge on the surface leading to mutual coulombic repulsion between particles and tightly bound water molecules layer around the particle, which acts as a mechanical barrier against coalescence. These factors principally arise due to the adsorption of surface-active substance from aqueous phase.

2.7.3 Mechanism of Destabilization

2.7.3.1 Chemical Destabilization

The destabilization occurs with the reduction of zeta potential, which is associated with the electric double layer surrounding the latex particle. Destabilizer in other words coasevant is responsible for this process. There are three types of destabilization called direct chemical, heat sensitizing and delayed action.



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Strong acids, metallic ions miscible liquids, polymer miscible organic liquids and cationic surface-active substances function as direct coaservants. Heat sensitizing agents are less effective at room temperature but when heated destability occurs as gelation. Major heat sensitizers are Zinc ammine systems, polyvinyl methyl ether and poly propylene glycols. Delayed action destabilizes too have little effect upon stability when first added but effective as time elapses. Alkali salt of Na, K of hydrofluorosilicic acid, H_2SiF_6 is effective destabilization.

2.7.3.2 Physical Destabilization

The destabilization occurs if either frequency or the violence of the collision between particles increases. Raising temperature increases the violence while lowering the temperature reducing

the mobility and enhance stability. However freezing of the aqueous phase leads to crystal formation thus become closer. Therefore stability is greatly reduced.

2.8 Characteristic Properties of NRL

The properties of polymer lattices are of interest for three quite separate kinds of reasons. First they may be investigated in a spirit of enquiry, the motive being to gain there by a better understanding of the physical and chemical nature of the latex. Secondly certain properties may be evaluated because it is through that they can be used to assess the fitness of latex for a particular application. Thirdly certain properties may be used for the purpose of quality control.

The properties of latex concentrate may be separate into two classes as follows: -

1. Relatively fixed properties, such as latex total solid, dry rubber content, ammonia content etc. while latex creams on storage and so improper sampling may reveal an increased total solids and rubber content. If these properties properly measured do not change sensibly during life of the latex. Hence these may be termed as basic properties.
2. Variability properties such as Potassium Hydroxide Number (KOH No), Volatile Fatty Acid number (VFA No) and Mechanical Stability Time(MST) change during the life of the latex concentrate because of hydrolytic and bacterial action on the non- rubbers responsible for its colloidal stability.

2.8.1 Mechanical Stability of NRL.

Mechanical stability of latex as its resistance to destabilization by mechanical forces (mechanical agitation or shear forces) is of the greatest practical importance whenever latex is handling. Possibility of destabilization exists as mechanical forces are applied during

concentration, in pumping and transportation and in compounding and processing. The measurement and control of mechanical stability is therefore of considerable importance to both producer and consumers of latex and currently determined by international test method call MST test. Destabilization is usually assessed as the time to see the first visible sign of flocculants and expressed in either second or minutes.

The MST of freshly prepared latex concentrate is always low ~100 Sec or less and increases with the time of storage. The proactive layer of proteins, lipids and HFA soaps on latex particles, the composition and nature of the dissolved substance in the aqueous phase of latex play important role in governing the MST of latex. The ionic materials present like non-volatile fatty acids, carbonate and bicarbonate and divalent metallic ions mainly Mg, Ca have all shown to decrease MST of latex. Compression of electrical double layer around latex particle or specific interaction has been accounted for the decrease.



Various factors have been reported to affect MST of ammonia preserved latex concentrated, which has been stored for a considerable period. Some are deleterious while some are beneficial. Most important factors are to be

1. Activity of microorganisms on non- rubber substance resulting in the formation of VFA anions, which tend to reduce colloidal stability because of the presence of the associated cations
2. Formation of the anions of the long chain carboxylic acids (HFA) by hydrolysis of lipids these anions tend to increase colloidal stability.



Balance between these two factors, mainly determines the final colloidal stability. Literature shows that higher fatty acid soap tend to increase mechanical stability of the latex by adsorbing at the particle interface thereby increasing the higher surface charge to obtain higher repulsive energy between particles.

2.8.2 KOH number of NRL

A term KOH No is used to denote the amount of ammonium salt in concentrated natural rubber latex. Expressed as the number of potassium hydroxide grams necessary to decompose the ammonium salt contain in 100g of dry solid in the latex. It is thus, a measure of the ionic strength of the serum, in the presence of ammonia. If latex bacterially degrades, the ionic strength of the serum increases and the KOH No increases. Presence of ions such as phosphates and amino acids also increases KOH number

KOH number of natural rubber latex is low as 0.3 and increase with time indicating a growth in the aqueous phase. Exposure of latex to air tend too enhance the natural increase in KOH number, presumably via absorption of CO_2 and the formation of $\text{CO}_3^{2-}/\text{HCO}_3^-$ ions(Chain H.C *etal*, 1979)

2.8.3 VFA number of NRL

The VFA content of a natural latex concentrate is known to be the primary index of its state of preservation. The VFA which occurs in ammonia preserved natural rubber latex are present as their ammonium salts. It is to be expected that the principal effects of these salts will be to reduced the colloid stability of the latex, and that this will be manifest as reduction of the mechanical and chemical stability of latex.

These volatile acids consist predominantly of acetic acid, but trace of formic acid and propionic acids are also present. The anions are formed by the action of microorganism, especially bacteria upon certain of carbohydrate which are present in the aqueous phase of the latex

Well preserved concentrate will have VFA of 0.01 - 0.02 at producer end. This will increase to 0.08 - 0.1 at consumer end after shipment. At VFA levels of 0.25 - 0.35 putrefactive smells is evident and the latex concentrate can be very difficult or impossible to process.

2.8.4 Conductivity of NRL

The specific resistance of latex is defined as resistance per unit volume of latex. Conductivity is the reciprocal of specific resistance. Electrical conductivity can be used as an index of the quality of latex. It is well known that latex deteriorates; its electrical conductivity tends to increase. It can be shown that at a DRC of 30% i.e a dispersed phase volume fraction of 0.3226 ratio of the serum conductivity to that of the latex would be 1.71 if the particle surface conductivity were negligible (Planters Bulletin, 1971).

2.8.5 Viscosity of NRL

The viscosity of latex is determined by means of a viscometer which measure the torque produced on a specified spindle rotating at constant rotational frequency and at a low rate of shear while immersed to a specific depth in the latex. In polymer lattices, polymer molecules are normally tightly aggregated together as particles, which have little tendency to absorb molecules of the dispersion medium or to release polymer molecules into the dispersion



medium. The dispersion medium is therefore essentially free of the polymer molecules, which comprise the particles. Of course, other types of macromolecules, which are soluble in the dispersion medium, may also be present in latex, either indigenously or added deliberately, such dissolved macromolecules will modify the flow behaviour of both the dispersion medium and the latex.

The polymer particles themselves have relatively little influence upon the flow behavior (Provided that the volume fraction of the dispersed particles is such that flow of the dispersion medium between the particles is not seriously restricted). As the volume fraction of dispersed particles increases, there comes a stage at which the particles are now so close to each other that flow of the dispersion medium between the particles is seriously restricted. Thus is the stage at which the viscosity of the latex relative to that of the dispersion medium begins to rise sharply with further increase in the volume fraction of the dispersion polymer.



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2.9 Examination of Properties of Natural Rubber Lattices in various conditions

Some of the previous studies carried out by various methods and exposure are summarized below

Stemberger (1940) has suggested that the rate of degradation in latex can be traced by conductivity determination and Murphy (1952) and Paton (1947) have shown that specific conductivity has a relationship with KOH No.

Madge (1952) suggest that long chain ammonium soap contributes more to the KOH No. than to conductivity and it seems likely therefore that there may be a direct relationship between

VFA No. and conductivity in freshly ammoniated field latex, where long chain soaps have not usually been formed to any greater extent.

Conductivity measurement made by Van Gils (1941) on-ammoniated and dialyzed latex throws some more light on the structure of the electrical double layer. On storage of latex conductivity continually increase with the greatest change occurring during the first two days. The largest change may be attributed to the action of microorganisms and the slow constant rise is possibly due to chemical effect i.e. hydrolysis.

As per studies of Vehar (1959) it was observed that there is no use full correlation between mobility and MST. For this purpose they have used two different clones of latex. Mobility and MST of these clones were tested immediately after concentration, after ageing period of 30 and 90 days. It was observed by them there is no significance difference in mobility between two clones and for both clones concentrates the mobility increases in the high pH region with the age of latex, probably as a result of ester of high molecular weight fatty acid with the consequent formation of ammonium soap.

Chin, Singh and Loke (1979) have reported that the electrical conductivity of ammonia preserved natural rubber latex increase significantly during storage. This indicates a progressive increase in the ionic strength of the aqueous phase as additional anions are formed together with equivalent numbers of ammonium ions. The enhancement of electrical conductivity increases with increase temperature, but is little affected by the degree of aeration of the latex. These workers also reported that the KOH numbers increase during storage, again indicating enhancement of the concentration of anions in the latex aqueous phase. The

concentration of carbon dioxide in the latex increases during storage. Storage temperature has little effect but aeration gives slightly higher concentration than that do in anaerobic condition.

At study carried out in RRIM by Seong Fong Chen *et al*(1984) has noted that the close similarity in behavior between the rates of increase in MST and these natural HFA. It has been shown that the natural HFA soaps in NRL increase with time and eventually reach a constant value. MST were also measured with time and observed that it also increase and attain a constant value at about the same time. This relationship clearly shows the effect of HFA in raising MST of NRL.

According to the practical electrophoresis rubber particles are negatively charged. Due to the carboxyl groups of the surface protein on storage, saponifiable lipids hydrolyzed gradually to produce HFA soaps, which are negatively charged. Stability power of this HFA soap are apparently due to their adsorption at latex-particle interface. The resulting increase in particles charge density and repulsive between particles contribute to higher mechanical stability of latex.

According to the study of MRPRA in UK by Pendle *et al* (1978) announced the co-relation between VFA of the latex and response to soap addition. They have worked on saturated C chain length in range from C₆ to C₁₆ at three different VFA level (0.02, 0.11, 0.34) to HA lattices with 0.03% of potassium soap. Their results reveal that as the VFA No increase the response to soap addition diminishes. However maximum MST increases was obtained with potassium laurate (C₁₂) soap.

Carbohydrates in latex become microbiologically oxidized to volatile fatty acids. They consist of trace of formic and propionic acids and predominantly being acetic acids. Consequent increase in ionic strength of the aqueous phase and been accounted for the deleterious effect of increase VFA number on MST. Resultant compression of the electric double layer around the particles permitting the closer approach of adjacent particles corresponds to decrease in mechanical stability.

Cook, A.S. and Sekar, K. C.(1955) shown that formation of volatile acids is delayed for a certain time depending on the amount of ammonia present, thereafter they increase rapidly and this rapid increase usually take place after a value of 0.1 is reaches. They have found a significant linear relationship between specific conductivity and VFA No and have adopted a regression equation for the data is $y = 4.50 + 4.7 x$, but an insufficient number of lattices have been examined to justify adoption of this equation as a general rule. For his work, three lattices from different sources were ammoniated to about 0.35% NH_3 and stored in stoppered demijohn bottle and loosely covered buckets.

Further, they revealed that in practice a latex conductivity exceeding 5×10^{-3} mhos indicates a VFA No above 0.1. Volatile fatty acids in centrifuged latex concentrate have been shown to affect considerably the mechanical stability. Volatile acids develop rapidly in the field latex before centrifuging and since their formation is attributed to contaminating micro-organisms, the first essential for the high quality concentrate is cleanliness at all stages of preparation. The acids are produced in fresh latex and ammoniated at an adequate level should take place as soon as possible after tapping. A small quantity of formaldehyde followed by less than the normal amount of ammonia appeared to give good preservation to field latex. After a few days,

volatile acids develop rapidly in field latex ammoniated to between 0.2% - 0.5% NH_3 and between 1/3 - 1/2 of the VFA No of the field latex is transmitted to the concentrated latex during centrifuging, since it is advisable to centrifuge field latex soon after collection, preferably within twenty four hours. Newly collected latex should not be mixed with old ammoniated field latex before centrifuging. Poor quality concentrated having a high amount of VFA can be purified by diluting with water and recentrifuging.

Pholpott and Sekar (1953) have shown that volatile acids develop rapidly in fresh latex. The time of ammoniation, therefore, should have an important bearing on the quality of the latex concentrate produced.

Blackly *et al* have studied on behaviour of various counter ions of laurate soap in NRL. Effect of laurate soap was studied with different molal levels of particular soap and the laurate soap of various counter ions. They have worked on Lithium, Sodium, Potassium, Ammonium, and Morpholinium laureates. Further results shown that, the counter ions of the soap can influence to some extent upon increasing mechanical stability of NRL and its significant effect has been confirmed by ANOVA test. Highest influence was obtained by potassium while morpholinium has least effect. Effectiveness of the ions increase in the order of : Ammonium < Lithium < Sodium. Furthermore their results showed that the increasing molal level of externally added soap progressively increase the MST of NRL.

Blackly *et al* (1979) of NCRT England have shown that the effect of level and alkyl chain length of potassium fatty acid soap has direct influence on the mechanical stability of natural rubber latex. Work on MST with different straight chain potassium fatty acid soap levels found

that large enhancement in MST can be brought about by the addition of small amounts of certain fatty acid soaps.

Further they have worked on number of carbon atoms in alkyl chain of soap and MST. As the alkyl chain length of added soap increases, the effectiveness of the soap on a molecular basis passes through a maximum. Existence of an optimum arises from balance of the effect of two opposing tendencies as the alkyl chain length of soap is increased, i.e. Balance of the effect of decreasing critical micelle concentration on one hand and increasing tendency to be adsorbed at oil-water interface on the other.

Soap anions already present having long alkyl chains cohere in clusters or islands and therefore the effect of enhancing MST is less. Added soap of intermediate alkyl chain length are strongly adsorbed at the rubber-water interface and mix with the adsorbed fatty acid anions which are already present in ammonia-preserved NRL and cause the island to disperse. This strongly adsorbed anions show a marked tendency to reduce lateral cohesion and have a large effect upon mechanical stability. Explanation of the phenomenon that added FA soaps are so effective in increasing MST because their alkyl chains are sufficiently long for soap anions to be strongly adsorbed at the rubber-water interface but sufficiently short to disrupt the coherence of the island of indigenous adsorbed soap anions.

K M D Silva's Thesis, University of Moratuwa, 2003 has revealed on joint of both soap concentration and storage upon low quality NRL. Results showed that mechanical stability of low quality latex cannot be enhanced upon maturation, up to the technology requirements, without the cooperation of added FA soaps.

Optimum ammonium laurate soap concentration that can be employed to low quality latex is 5×10^{-4} moles of soap per 100g of latex. Minimum soap level that is necessary to create observable change in MST and foaming height lies between 0.5×10^{-4} and 0.84×10^{-4} moles per 100 g latex. Between 4.2×10^{-4} and 5×10^{-4} levels of soap system attain to critical micelle concentration of soap molecules in the latex medium. Soap adsorption to the rubber particle cannot be brought about in NRL after complete destabilization of latex has taken place

Fatty acid soap ions that are adsorbed at the particle surface primarily cause the variation in MST and viscosity. Variation in KOH numbers, conductivity and foaming has brought about by consequent changes taking place in the medium.

Although the soap addition is a beneficial feature for latex to upgrade mechanical stability, its deleterious effect upon excessive addition causes remarkable failure in the industry. The excessive FA soap enhances the rate of adsorption of the soap molecules and increase the mechanical stability of the latex. But in contrast large number of FA tend to remain in the medium as free FA. Although the expected MST is obtained at the producer's factory at a premature length of time, it tends to produce unfavorable complications on storage at the consumer end. Principal problem to the industry being effervescence may possible by the effect of free FA present in the medium. Apart from that, the latex that has stabilized with excessive soap may not have attained to the equilibrium. Therefore soap addition may be desirable it is a control addition with a perfect understanding on it. Further more, all lattices do no perform in similar manner after addition of a particular soap. Other properties also affected by addition of soap.

Also measurements of specific conductivity is quicker than the convenient method for determining volatile fatty acids and KOH No. and prove to be a usual method for factory control when many bulks of latex have to be rapidly tested for quality.

Study made by Ganga Illangachellen, University of Moratuwa, 2006 has given some information concerning effects of soap concentration and storage addition upon low quality NRL. Amazing study on establish correlation between (1) aeration level and mechanical stability time (2) aeration level and volatile fatty acid number (3) aeration and alkalinity has never been carried out in Sri Lanka. And also this study check whether there is any relationship between conductivity and maturation of latex. And also study whether conductivity can be used as a quicker method of investigation of latex quality



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