EFFECT OF ADDITION OF POTASSIUMSULPHATE ON VISCOSITY AND MECHANICAL STABILITY OF RVNRL

PROJECT REPORT

Submitted to the Mahatma Gandhi University, Kottayam in partial fulfilment of the requirements for the M.Sc. Degree in Analytical Chemistry

Submitted by

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CERTIFICATE

This is to certify that the project work entitled **"Effect of Addition of potassiumsulphate on the viscosity and mechanical stability of RVNRL"** *is a bonafide record of project work carried out by* **Babitha Jacob** *in partial fulfilment of the Degree of Master of Science in Analytical Chemistry under the faculty of science of the M.G. University during the year 2001 – 2003.*

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CERTIFICATE

Certified that the project report entitled " **Effect of addition of Potassium Sulphate on Viscosity and Mechanical Stability of Radiation Vulcanized Natural Rubber Latex"**,being submitted by **Miss Babitha Jacob,** S.B.College , Changanacherry, for the Degree of Master of Science (Analytical Chemistry) is a bonafide record of the research work carried out by her under my supervision. The results included in this report have not been submitted for the award of any other degree or diploma.

M.Sunny Sebastian

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DECLARATION

I, the undersigned, hereby declare that this project report on **"Effect of Addition of Potassiumsulphate on the Viscosity and Mechanical Stability of RVNRL"** is written and submitted as a part of the academic programme requirement for the Degree of Master of Science in **Analytical Chemistry**. While preparing this report, I have not copied any other report and I declare that this report has not been submitted to any other university or institution for the award of any fellowship or degree.

Babitha

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My sincere thanks to all my friends, who helped me to make this project a success.

Babitha Jacob

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ABSTRACT

Radiation Vulcanised Natural Rubber Latex (RVNRL) is a new development in latex industry. Generally in natural rubber, as latex or dry film, cross-linking of rubber molecules is attained by accelerated Sulphur Vulcanisation. In RVNRL processing, molecular cross-linking is brought about by irradiation with high-energy gamma radiation, in presence of sensitizer. Latex is exposed to a predetermined dose of gamma radiation. RVNRL, thus produced can be used for producing dipped articles, especially those used in the medical and pharmaceutical field.

The present work was to study the effect of addition of ***Potassiumsulphate*** on Viscosity and Mechanical Stability of ***RVNRL***.

INTRODUCTION AND REVIEW

Blackley has defined latex as a stable colloidal dispersion of polymeric substances in an essentially aqueous medium. Latex of different nature is obtained from several plants, in addition to those produced synthetically. Among the natural latex, that is obtained from the botanical source "Heveabrasiliensis' alone is of commercial importance even though the rubber obtained from guayule plants, also has gained some importance. The polymeric substance dispersed in natural rubber latex is cis-1, 4 polyisoprene, of high molecular mass. In rubber plants the rubber hydrocarbon cis-1, 4 polyisoprene is synthesised by a complex process involving some protein. The rubber produced in the latex is obtained by a process called "tapping". The latex obtained can be processed to recover the solid rubber or it can be processed to utilise the rubber in latex form.

1. Composition of Natural Rubber Latex

In addition to rubber hydrocarbon and water, natural rubber latex contains several non-rubber substances, both organic and inorganic in origin.

Typical composition of NR latex is given in the table below:

Constituent	Proportion % m/m of whole latex
Total Solids Content (TSC)	36
Dry Rubber Content (DRC)	33
Proteins	1 – 1.5
Resin Matter	1 – 2.5
Ash	Upto 1
Sugar	1
Water	Ad. 100

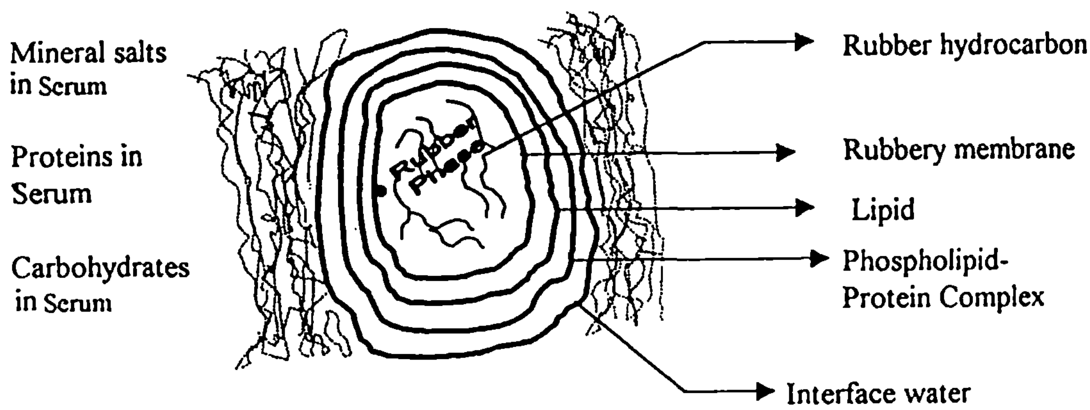
The presence of some of the non-rubber substances is essential either for synthesizing the rubber hydrocarbon (e.g. Proteins like Rubber Elongation Factor, REF and phenyl transferase) or for imparting colloidal stability to latex (e.g. Phospholipids like lecithin). Other constituents also have some physiological function in the biosynthesis of rubber hydrocarbon.

2. Natural Latex as a colloid

The size of rubber particles in the latex is not uniform, but falls in a range of 20-5000 nm. The rubber particles are predominantly pear shaped. The distribution of particle size in fresh natural latex is present in the form of a minority of large particles. Thus less than 4% of the particles have diameter above 400 nm, however they account for the 85% v/v of the total dispersed rubber. It is possible that these large particles are formed by agglomeration and coalescence of smaller particles.

A major portion of the resin matter in the latex consists of phospholipids, which are strongly adsorbed on the surface of rubber particles. The rubber particles are further covered by absorbed protein layer. These absorbed phospholipids and proteins so overlap in molecular level that it is difficult to say which one forms the outer layer. The proteins in latex generally have iso-electric point below 5.0, so that proteins carry negative charge at the normal p^H of latex (6.5). The negative charges on the particle contribute to the coulombic repulsive forces. Also a layer of water molecules due to Vander Waal's forces surrounds the rubber particles. These factors contribute to the colloidal stability of latex.

3. <u>Schematic diagram showing studies of field latex</u>



4. <u>Properties of Natural Rubber</u>

The rubber hydrocarbon is almost completely soluble in solvents like toluene, tetrahydrofuran etc. Freshly prepared natural rubber has low gel content (about 5 – 10%), but increases on storage to about 50%. So natural rubber latex hardens on storage since the polyisoprene chains are highly stereo regular, they crystallise when they are stretched or cooled.

Natural Rubber has excellent abrasion resistance, high resilience and good resistance to flexing and fatigue. Due to the presence of doubled bonds on the polymer backbone, they are less resistant towards ozone. Raw natural rubber has high plasticity but lacks tensile properties, which is very important to meet the requirements. So we have to increase the tensile properties of Natural Rubber.

Preservation of Latex

Natural latex, if left unattended, gradually thickness within a few hours after tapping and then undergoes coagulation. This is followed by putrefaction at a later stage with the development of malodour. Mainly bacteria bring about putrefaction. For preventing spontaneous coagulation and putrefaction, latex has to be preserved by the addition of a suitable chemical.

The essential requirements for a chemical to function as a preservative are given below.

1. Enhance the colloidal stability of latex.
2. Destroy microorganisms that lead to putrefaction.
3. Deactivate metallic ions that can cause spontaneous coagulation.

Ammonia as a Preservative – HA Latex

In presence of ammonia, the density of the bound electric charge on the rubber particles and the electro kinetic potential of the interface between rubber particles and its aqueous phase is increased, there by increasing the colloidal stability of latex. In presence of ammonia, these phospholipids in latex undergo slow hydrolysis, liberating higher fatty acids (HFA). The HFA anions are strongly surface active and add to the colloidal stability of latex.

5. Need for Vulcanisation

To increase the tensile properties of natural rubber we have to cross-link different chains together. This interlinking of polymer chains with or without external bridging constituents is termed as vulcanisation.

6. Methods for Vulcanisation

Vulcanisation is mainly done by using sulphur as the bridging agent. To get good results we have to add several chemicals like accelerators, activators etc. with sulphur or sulphur donors. In conventional system, vulcanisation is done by adding excess sulphur and lesser amount of accelerators. Also it can be done by adding less of sulphur and higher amount of accelerator. This is the Efficient Vulcanisation (EV) system.

7. Drawbacks of Sulphur Vulcanisation

It is reported that the Sulphur Vulcanised Natural Rubber Latex (SVNRL) products like examination gloves, surgical gloves, and catheters etc. cause serious health problem to some of the users. This is due to the residual traces of accelerators, which cause type IV allergy. The residual proteins also cause type I allergy.

Moreover nitrosamines are produced in the latex products from nitrosatable amines present in the antioxidants or accelerators, which are carcinogenic.

Vulcanisation with accelerator like Xanthates overcomes type IV allergic and nitrosamine problems. Xanthates, although potentially fast curing fail to hydrolyse rapidly in alkaline latex and thereby lose their effectiveness and can cause destabilization of latex compound.

So it becomes necessary to develop a new technology to vulcanise Natural Rubber Latex without toxic chemical to avoid the above mentioned health hazards.

8. Development of Radiation Vulcanisation

To overcome the problem associated with Sulphur Vulcanisation, a new technique was developed viz. Radiation Vulcanisation. Here vulcanisation is done by using high energy γ – radiations.

Radiation Vulcanised Natural Rubber Latex (RVNRL)

RVNRL is an attractive alternative to the conventional Sulphur Vulcanised Natural Rubber Latex (SVNRL).

In RVNRL, vulcanisation is achieved through the exposure of natural rubber latex to gamma rays from a Cobalt-60 source. The product, RVNRL is non-radioactive and safe to handle. The attraction is the simplicity of the process. It requires no curatives like sulphur, zinc oxide and accelerators. Thus contributing to the environment-friendly products. Industrial tests carried out both at home and abroad showed a tremendous potential of RVNRL for use in latex dipped products manufacturing. RVNRL can be processed into dipped products according to the existing standard techniques already available. Some of the advantages of RVNRL are as follows: -

- Better latex stability – longer shelf life possible.
- Lower modulus – suit the requirement for specific application.
- Less or absence of toxicity –free from nitrosamines and accelerator induced allergies.
- Better products clarity – better colouration.
- Environment friendly process–less polluting industrial effluent.
- Lower ash remains – reduced environment pollution.
- Absence or lower acid combustion gases–safer disposal of used products.

But this technique had not been industrially used due to high cost of irradiation, inferior quality of products and ambiguous advantages of products. But recently significant progress has been made in the cost reduction and quality improvement in support of International Atomic Energy Agency (IAEA) and United Nation Development Programme known as Regional Co-Operative Agreement (RCA).

9. Source of irradiation

The source of gamma radiation used in Radiation Vulcanisation is a radioactive Co-60 nucleus. Since it is unstable it emits excess energy in the form of gamma radiation. The Co-60 does not exist in nature. It is produced by bombarding a suitable nucleus of Co- 59 with a neutron in a nuclear reactor. The reaction is as follows:

$$^{59}_{27}Co + ^{1}_{0}n \longrightarrow ^{60}_{27}Co \text{ (Radioactive)}$$

$$^{60}_{27}Co \longrightarrow \text{Gamma radiation } + \beta \text{ - ray} \longrightarrow ^{60}_{28}Ni$$

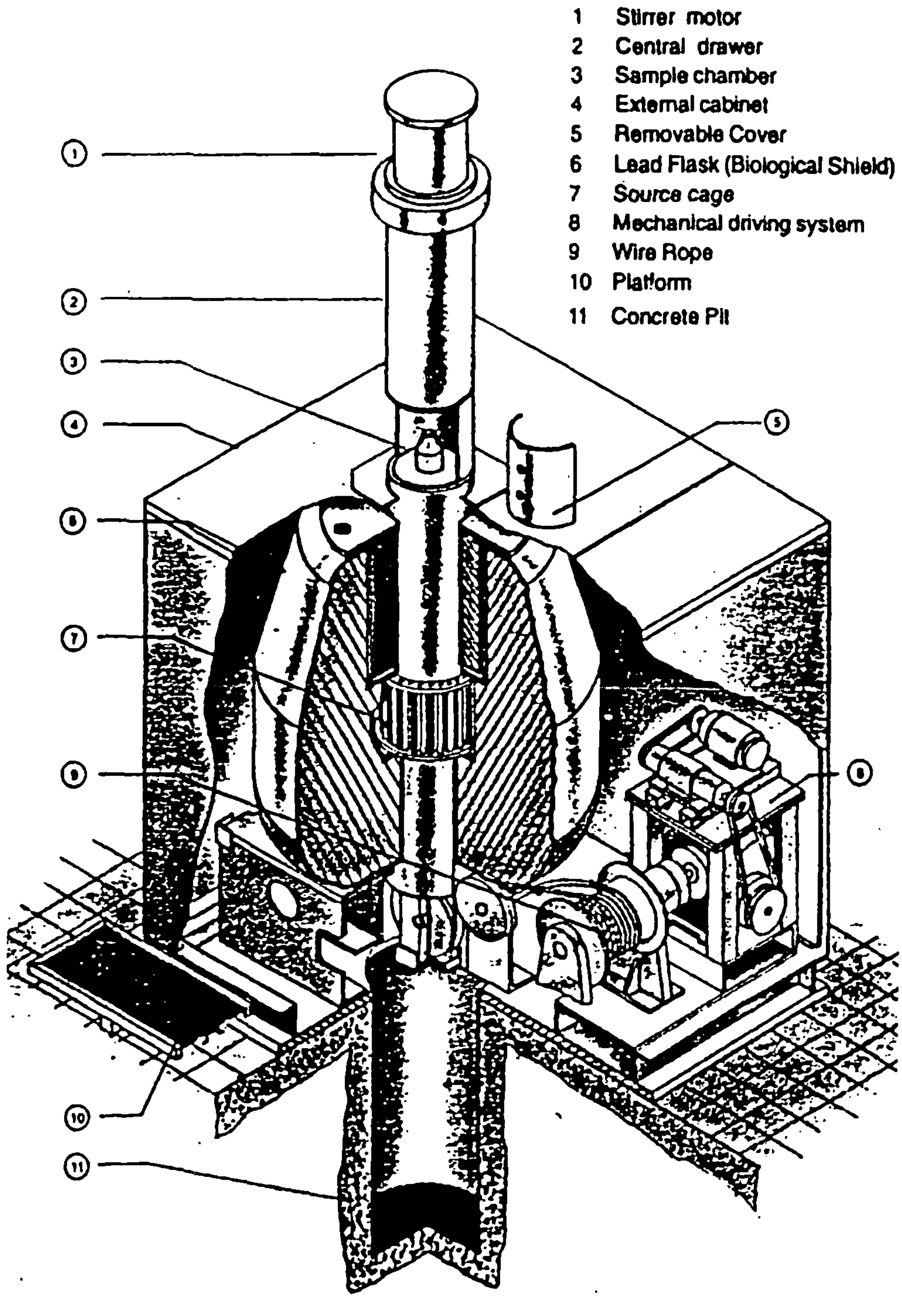
But the β-rays emitted is recaptured by the source itself.

The gamma source is shielded inside a lead flask of specific thickness.

The following table gives data about Co-60 source.

COBALT DATA

Name	:	Cobalt
Symbol	:	Co
Atomic Number	:	27
Atomic Weight	:	58.933
Mass Number	:	59
Melting Point	:	1495^0 C
Boiling Point	:	2900^0 C
Crystal Structure	:	Hexagonal
Density (g/ml)	:	8.9
Wavelength of γ – ray of (1.25 Me V) Co – 60	:	$10^{-2} - 10^{-5}$ nm = 10^{-4} A.U. (1 A.U. = 0.1 nm)
Frequency of γ-ray	:	3×10^{22} Hz



Gamma Chamber 5000 Unit

10. Installation of Radiation Source – 'Gamma Chamber'

Gamma Chamber – 5000 unit, is a compact self-shielded Co-60 gamma irradiator providing irradiation volume of approximately 5000 cc. The material for irradiation is placed in an irradiation chamber located in the vertical drawer inside the lead flask. This can be the moved up and down with the help of a system of motioned drive, which enables precise positioning of the irradiation chamber at the centre of the radiation field. Radiation field is provided by a set of stationary Co-60 sources placed in a cylindrical cage. The sources are doubly encapsulated in corrosion resistant stainless steel pencil and are tested in accordance with international standards. Two access holes of 8-mm diameter are provided in the vertical drawer for the introduction of service sleeves for gases, thermocouple etc. A mechanism for rotating or stirring samples during irradiation is also incorporated. The lead shield is provided around the source to keep the external radiation field well within permissible limits, because lead has the ability to absorb radiation, it prevents the harmful radiation to reach the living things. The Gamma Chamber 5000 unit can be installed in a room measuring 4 m × 4m × 4m.

The main features of Gamma Chamber 5000

1. Safe and self shielded.
2. Automatic and manual control of radiation time.
3. Manual control of radiation temperature.
4. Remote operation.

5. Dose uniformity.
6. Easy loading and unloading.
7. Safety assurance.

11. Details of Radiation Vulcanisation

Radiation Vulcanised Natural Rubber Latex can be obtained by irradiating Natural Rubber Latex without using sensitizer. But the vulcanisation dose (Dv – the dose at which the maximum tensile property of dried film of irradiated latex is found) needed will be about 200–300 KGy. This is too high to be used for industrial applications. So it becomes necessary to decrease the dose to a considerable extent, which is achieved by adding a suitable sensitizer.

12. Sensitizers used in Radiation Vulcanisation

a. Halogenated Hydrocarbon

Halogenated hydrocarbons such as CCl_4, $CHCl_3$ etc. were found to be good sensitizers. Five parts of CCl_4 was necessary for 100 parts of dry rubber in latex for getting proper sensitisation, CCl_4 gave good Tb value for RVNRL films and Dv was also reduced to 20 KGy. But the toxic effect of CCl_4 made it unacceptable material for the industry. Also there are environmental problems like the destruction of stratospheric ozone layers in using halogenated hydrocarbons in large scale.

b. Poly Functional Monomers (PFM)

Many PFM's (containing more than two polymerisable C=C) can be used to enhance cross-linking of polymers. It was postulated that the sensitising efficiency of PFM depends on its solubility in NR as well as on its reactivity with NR to be cross-linked.

Among PFM's, at first only divinyl benzene was investigated as sensitizer for RVNRL. But its sensitising efficiency is not satisfactory. After that neopentyl glycol dimethacrylate (NPG) and neopentyl glycol diacrylate (ANPG) were suggested as sensitizers. But these diacrylate reduce the colloidal stability of latex. Moreover it produces skin irritation and causes damage the to human body. So PFM's also turned out to be unacceptable for RVNRL processing.

c. ***Mono Functional Acrylates***

MFA such as 2 – Ethyl Hexyl Acrylate (2EHA) and n–butyl Acrylate (n-BA) also accelerate RVNRL. The sensitising efficiency increases with increasing molecular weight of MFA. Thus 2EHA was selected as sensitizer. But the smell of the gloves was very bad due to residual 2EHA, which also causes skin irritation and other health problems. The attempts to remove residual 2EHA by drying failed due to its low vapour pressure. The complete polymerisation of 2EHA by irradiation was not practical because further irradiation results in lowering of tensile strength.

Sensitising Action of n-BA

n-BA is selected as the suitable sensitizer for RVNRL because it can be easily removed by drying owing to its high vapour pressure. But the addition of n-BA increases the viscosity of NRL, sometimes causing coagulation. To stabilize NRL against n-BA, KOH is added as stabilizer. In practice 0.2phr KOH is enough to stabilize the latex containing 5phr of n-BA.

13. Mechanism of Sensitizers.

It is usually believed that polyfunctionality of the sensitizer is essential to enhance the radiation induced cross-linking. In PFM's, sensitising mechanism consists of two steps. The first step is the graft polymerisation of PFM onto NR latex forming a pendant chain containing many polymerizable C = C bonds. The second step is the polymerisation of the C = C bond. But in the case of MFA containing only one polymerizable C = C bond, sensitising occurs through other mechanism. This mechanism was investigated using a system of liquid poly isoprene (LIP) and 2EHA. 2EHA is added to LIP to increase the ratio of gel formation and also to enhance the cross-linking of LIP through the polymerisation of 2EHA.

The sensitising mechanism of MFA including its chain transfer is illustrated in the following equations.

- Radiolysis of NR

$$RH \rightarrow R^{\bullet} + H \qquad (1)$$

- Radiolysis of water

$$H_2O \rightarrow H^{\bullet}, OH^{\bullet}, e_{aq} \qquad (2)$$

- Hydrogen abstraction

$$RH + OH^{\bullet} \rightarrow R^{\bullet} + H_2O \qquad (3)$$

- Homo polymerisation

$$nM \rightarrow P^{\bullet} \qquad (4)$$

- Graft polymerisation

$$R + nM \rightarrow RP^{\bullet} \qquad (5)$$

- Chain transfer

$$P^{\bullet} + RH \rightarrow P + R^{\bullet} \qquad (6)$$

$$RP^{\bullet} + RH \rightarrow RP + R^{\bullet} \qquad (7)$$

$$R^{\bullet} + P \rightarrow RP^{\bullet} \qquad (8)$$

$$M^{\bullet} + RP \rightarrow RP^{\bullet} \qquad (9)$$

- Termination

$$R^{\bullet} + R^{\bullet} \rightarrow R - R$$

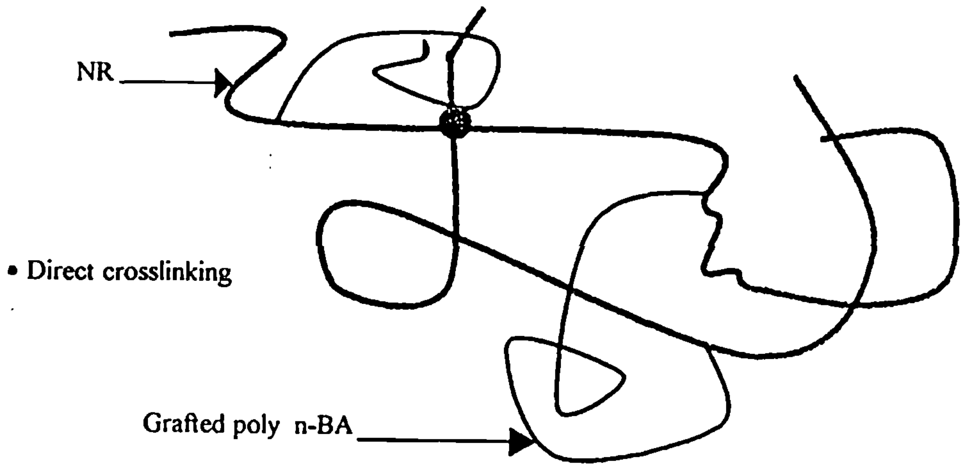
$$RP^{\bullet} + R^{\bullet} \rightarrow RP - R \qquad (10)$$

Here RH, M and P are NR, MFA and polymer of MFA respectively. $P^{\bullet}$ and $RP^{\bullet}$ are growing chain radical of monomer and rubber, respectively.

Chain transfer to monomer may be illustrated as follows: -

$$\begin{array}{llll} R^{\bullet} + CH_2 = \underset{\displaystyle O = C - O - R}{\underset{|}{CH}} & \longrightarrow & RH + CH_2 = \underset{\displaystyle O = C - O - R}{\underset{|}{C^{\bullet}}} & (11) \end{array}$$

<u>Structure of cross-linking of NR with n-BA</u>

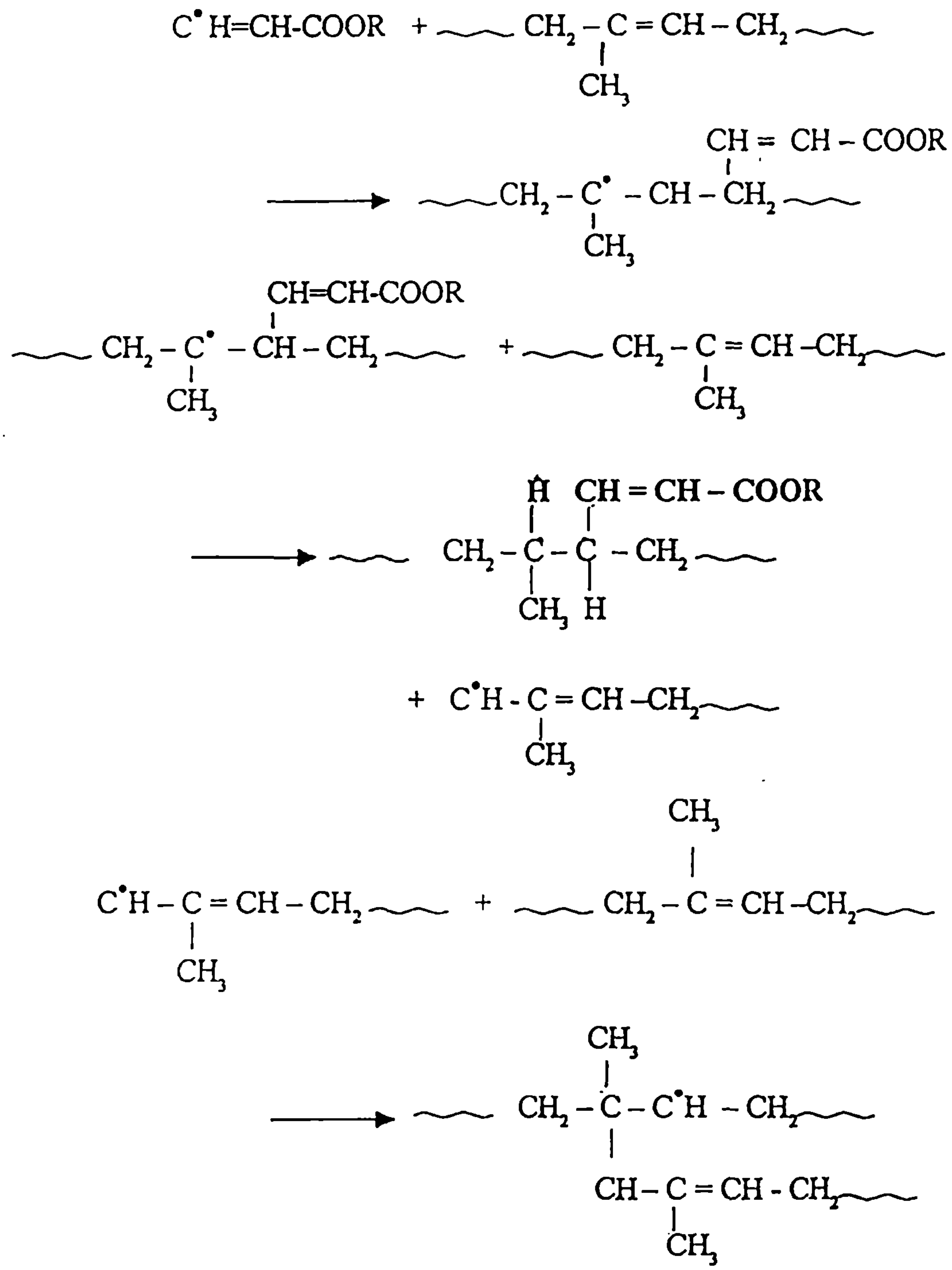


<u>Sensitising Mechanism of MFA (n-BA)</u>

The mechanism of sensitising action of MFA can be represented in the following manner.

$$CH_2 = CH - COOR \xrightarrow{\gamma} \underset{\text{acrylate radical}}{C^{\bullet}H = CH - COOR} + H^{\bullet}$$

As acrylate radical formed is more mobile than the rubber chain. It attacks a double bond in the adjacent chain.



Crosslinked structure

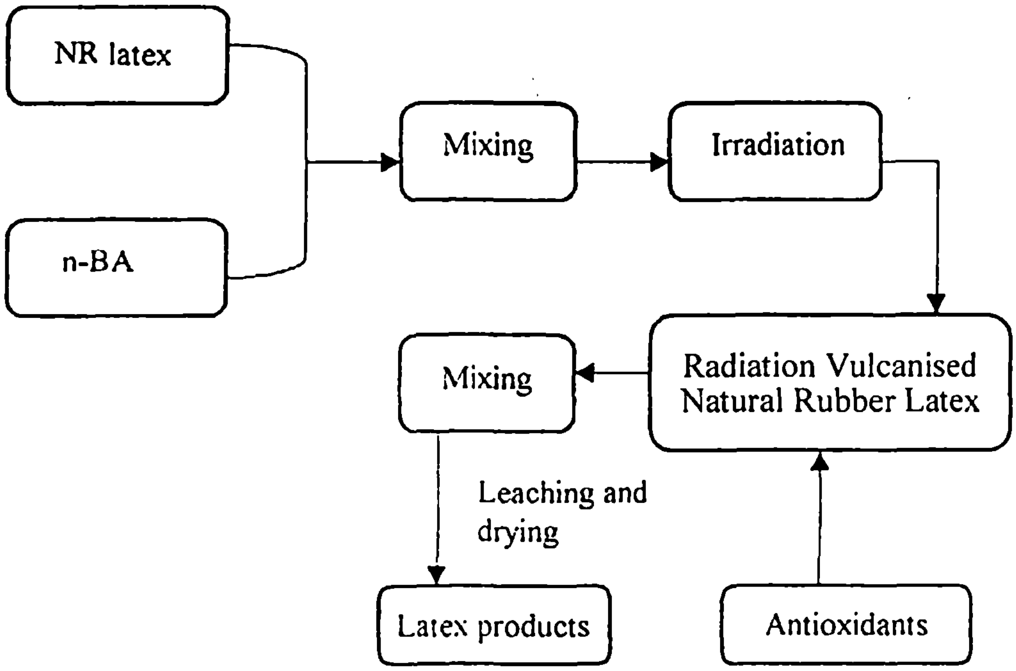
14. Advantages of Radiation Vulcanisation

Latex producers and product manufacturers were compelled to develop a new vulcanisation method for overcoming problems of allergy and nitrosamine based toxicity. RVNRL is completely free from toxic chemicals and its non-allergic. The chemicals used are KOH and n-BA. KOH is removed completely by leaching. n–BA itself polymerises and the residue will be removed on drying due to high vapour pressure. The anti–oxidant added is tris nonylated phenyl phosphite (TNPP), which gives a transparent appearance to the RVNRL film. The other advantages are the following: -

1. Longer shelf life period.
2. Lower modulus.
3. Biodegradability.
4. Less extractable protein content.
5. Low emission of SO_2.
6. Lower ash content.
7. No problem associated with zinc contamination in the effluent generated.
8. No problem associated with chemical stability or zinc oxide thickening.

15. Radiation Processing of NR Latex

The following chart gives a brief picture of Radiation Vulcanisation of Natural Rubber Latex.



Irradiation of latex is generally carried out at about 50% dry rubber content (DRC). But the cenex has a dry rubber content of 60% on adding sufficient ammonia water to cenex. We have to decrease the DRC to 50%. The typical properties of RVNRL are given in the following table.

DRC	36.5%
NH3	1.33%
VFA number	0.03
Mg	53 ppm

16. Dose of Irradiation

Dose can be defined as the energy absorbed per unit mass of the irradiated material at the place of intercept. Its unit is 'rad' (radiation absorbed dose).

1 rad = 100 erg/gm

SI Unit of dose in 'J/Kg' and is called Gray.

The symbol is Gy.

100 rads = 1 Gy.

When 1 Kg of matter absorbs 1J of energy, then this matter is said to have received a dose of 1 Gray.

When 1 Kg of material absorbs 1000 J of energy, it is said to have received a dose of 1 KGy (Kilo Gray).

Irradiation time

Irradiation time is calculated using the formula

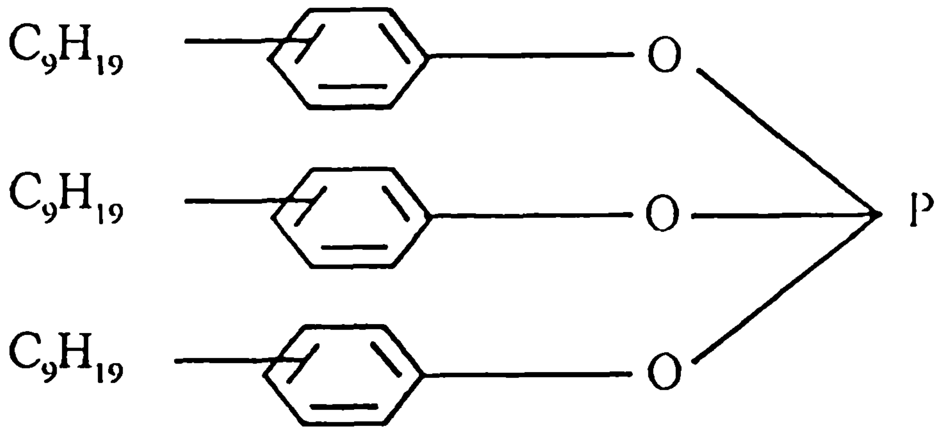
Irradiation time = Dose /Dose Rate

The value of dose rate changes from day to day, which is obtained from the table. The dose rate decreases day to day due to the disintegration of Co-60.

17. Anti oxidants

The most effective way of improving thermal and oxidative degradation of Radiation Vulcanised Natural Rubber Latex is by adding suitable antioxidant. Several antioxidants are available for protecting elastomeric materials from thermal and oxidative degradation. The antioxidant selected should not cause any allergic reaction and generate nitrosamines, which are carcinogenic.

Hence TNPP (Tris Nonylated Phenyl Phosphite) may be used as an antioxidant. The structure of TNPP is given below.



TNPP

(Tris Nonylated Phenyl Phosphite)

Actual effects of TNPP and other antioxidants on ageing property of RVNRL films were examined, as measured by the retention of Tb and Eb of the film aged at 100^0C for 20 hours. The Tb and Eb of the film before ageing were 30 MPa and 1020% respectively with 2 phr TNPP. 99% of Tb retention was achieved. Also the aged film containing TNPP possessed better transparency and low discolouration than those films containing any other antioxidants. Consequently, TNPP was selected as the suitable antioxidant for Radiation Vulcanised Natural Rubber Latex.

18. Properties of Radiation Vulcanised Natural Rubber Latex

The properties of Radiation Vulcanised Natural Rubber Latex, which is different from that of cenex used for irradiation properties of RVNRL, is given below.

DRC	51.77%
TSC	53.75%
NRS	1.98%
NH_3	0.68%
VFA number	0.04
KOH number	1.48
MST AT 52% TSC	1240 SEC
Coagulum content	0.005%
Viscosity at 52% TSC	30 cps
p^H	10.10

19. RVNRL Films

RVNRL films can be prepared either by casting or dipping. After casting the film, it has to be leached for sufficient time to extract proteins, which are degraded and changed into soluble proteins by the effect of radiation. Otherwise these proteins will cause cytotoxic problems. Generally films are leached in cold water for 4 hours. After leaching, the films show excellent physical properties. RVNRL films containing 2phr TNPP as anti oxidant show very good ageing behaviour. The tensile properties of RVNRL films are given in the following table.

Property	Before ageing	After ageing
Modulus at 100% (MPa)	1.10	0.95
300% (MPa)	1.64	1.30
500% (MPa)	2.50	2.25
Tensile strength, Tb (MPa)	31.47	28.45
Elongation at break, Eb (%)	842	752

20. Applications of RVNRL

a. *Examination Gloves*

Application of RVNRL for the manufacture of examination gloves was started in 1989. The physical properties of gloves manufactured from RVNRL and the ASTM specifications to examination gloves are given below.

Property	RVNRL glove	Requirements as for ASTM D 3578 – 95
Tensile strength MPa (min)		
Before ageing	28.5	14
After ageing	26.9	14
Elongation at break % (min)		
Before ageing	930	700
After ageing	800	500

The table above shows that RVNRL conforms to the specifications laid down for examination gloves. Also the colour of the glove is white and appearance is good. The wide spread use of examination gloves is likely to pose an environmental problem regarding the disposal of used gloves. The release of SO_2 and CO on burning RVNRL gloves are much less compared to conventional SVNRL gloves. Further RVNRL gloves are biodegradable. RVNRL gloves have low modulus and will not cause uncomfortness to the user, during prolonged use. Also due to the low level of extractable proteins type IV allergic problems are absent.

b. *Condoms*

Both laboratory scale and factory level production of condoms using RVNRL also have been investigated. The physical properties of the condoms produced from RVNRL and the Indian–Standard Specification for this product is given below:

Property	**Condom from RVNRL**	**IS – 3701 – 1985**
Thickness (mm)	0.066	0.07 (max)
Tensile strength (Mpa)	22.06	20 (min)
Elongation at break %	970	650 (min)
Burst volume (Litre)	42	Not specified

From the above table it is clear that RVNRL can be used effectively for manufacturing condoms. The condoms are white in colour and have good appearance. More over the condoms prepared from RVNRL have low modulus, high elongation at break and high burst volume.

c. *Other Medical and Pharmaceutical Products*

Products made from RVNRL can be used in medical field because of its very low cytotoxicity and absence of nitrosamines. The manufacture of optical endoscopic balloon using RVNRL was investigated. RVNRL balloon transmits 98% laser while SVNRL one, only 65%. The high transparency and low thickness facilitate accurate endoscopic examination. Thus RVNRL proved to be an effective substance for the manufacture of 'optic endscopic balloon'.

The drainage bag used to collect discharged fluids as post-operative measure restricts the mobility of the patient due to its bulkiness. This bag made of RVNRL is compact and causes less irritation to the attached skin because of its low toxicity. The high transparency of the bag facilitates easy observation of discharged fluids. Catheters and feeding bottles nipples can also be prepared using RVNRL due to its low cytotoxicity.

d. *Toy Balloons*

Low modulus, high transparency, low cyto toxicity, absence of carcinogenic nitrosamines and biodegradability make RVNRL a suitable material for toy balloon manufacture. Also the appearances of balloons are excellent.

EXPERIMENTAL DETAILS

TEST METHOD

A work was undertaken to find the effect of addition of ***Potassiumsulphate*** on Viscosity and Mechanical Stability of ***RVNRL*** .

The procedure followed is described below.
600g centrifuged latex (CENEX) is weighed out into a 1 litre beaker. Mixed with 0.2phr 10% aqueous KOH as stabilizer. 50% emulsion of n-Butyl Acrylate (n-BA) which is prepared by mixing n-BA with ammonia, oleic acid and distilled water, is stirred well for complete emulsification and is added as stabiliser. It is then stirred well for half and hour after adding 4 ml of potassiumsulphate to ensure homogenisation.

Then its Viscosity is found out using a Brook Field Viscometer.

We also find out the Mechanical Stability Time using an MST apparatus.

This latex is then sieved and transferred to a 650ml beaker. It is placed inside the Gamma Chamber 5000 unit for irradiation at an optimum dose of 15KGy. Then the sample is irradiated using gamma radiation for a specific time called irradiation time calculated by the formula,
Irradiation time = Dose / Dose rate

After irradiation the radiation vulcanised natural rubber latex is taken out of the gamma chamber and cooled.

The Viscosity and Mechanical Stabilty Time of RVNRL thus obtained are found out using the same instruments.

TEST METHODS AND EQUIPMENTS

BROOK FIELD DIAL VISCOMETER

The Brook Field Dial Viscometer measures fluid viscosity at given shear ratios. Viscosity is a measure of fluid's resistance to flow. The dial viscometer rotates a sensing element in a fluid and measures torque necessary to overcome the viscous resistance to the induced movement. This is accomplished by driving the immersed element, which is called a spindle, through a Be Cu spring. The degree to which the spring is wound, indicated by the red pointer, is proportional to the viscosity of the fluid.

There are four basic spring torque series offered by Brook Field,

Model	Spring Torque (Dyne-cm)
LV	673.7
RV	3187.0
HA	14,374.0
HB	57,456.0

The higher the calibration , the higher the measured range. The viscosity measurement range for each torque calibration may be found in

	SI	CGS
Viscosity	1 mpa	1 cps
Torque	1 Newton-m	107 dynecm

OPERATIONS

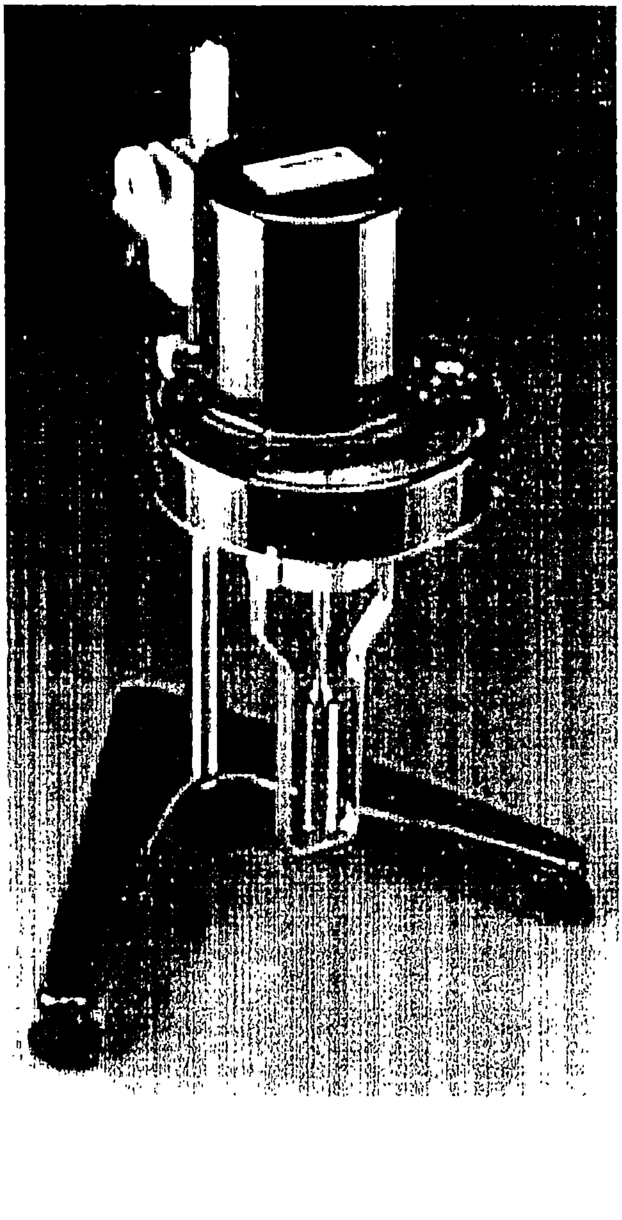
1. Mount the guard leg (spindle protector) on the viscometer . Attach the spindle to the lower shaft . Lift the shaft slightly, holding it firmly with one hand while screwing the spindle on with the other. Aviod putting side thrust on the shaft.

2. Insert the center spindle in the test material (600ml beaker) until the fluid's level is at the immersion groove on the spindle's shaft. With a disc type spindle , it is sometimes necessary to lift the instrument slightly while immersing to avoid trapping air bubbles on its surface.

3. To make a viscosity measurement , turn the motor switch 'on', which energized the viscometer drive motor . Allow time for the indicator reading to stabilize . The time required for stabilization will depend on the speed at which the viscometer is running and the characteristics of the sample fluid . When making a measurement at high speeds it will be necessary to depress the clutch and turn 'off' the motor, with the red pointer in view.

4. Turn the viscometer switch 'off' when changing spindle etc. Remove spindle before cleaning.

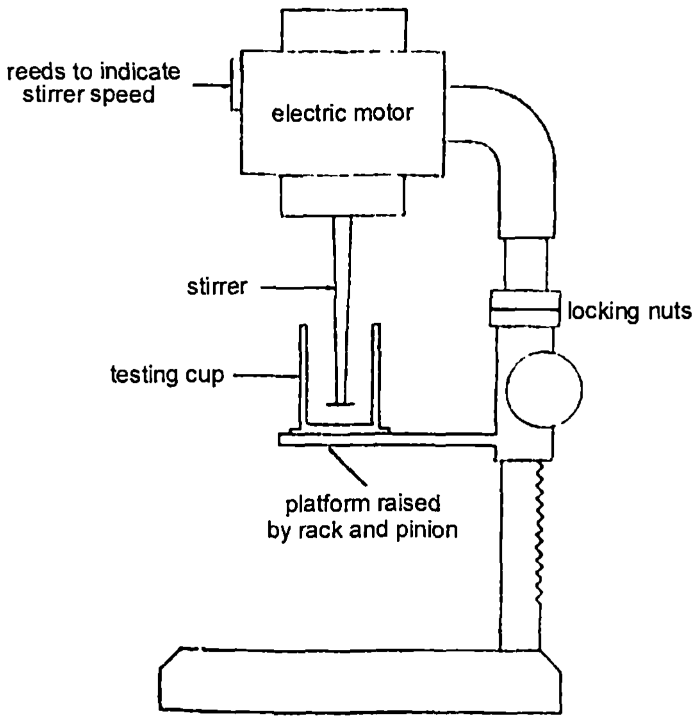
<u>BROOKFIELD VISCOMETER</u>



<u>**MECHANICAL STABILITY TESTING (MST)**</u>

The general procedure for mechanical stability determination is to stir a definite amount of latex under given conditions of dilution, temperature and speed of stirring , and to measure the time which elapses before signs of incipient coacervation appear.
The mechanical stability is expressed in seconds.

The apparatus used is shown in the diagram below:



- The stirrer rotates at 14000±200 rpm throughout the duration of the test .
- The speed is generally adjusted by means of a rheostatic control which is wired in series with the motor which drives the stirrer.
- The speed is estimated by means of the reeds shown in the diagram.

END POINT OBSERVATIONS

The main changes that occur as coarcervation commences are :

1.There is a change in the sound of the stirrer .

2.The surface of the latex may take on a curdy appearance.

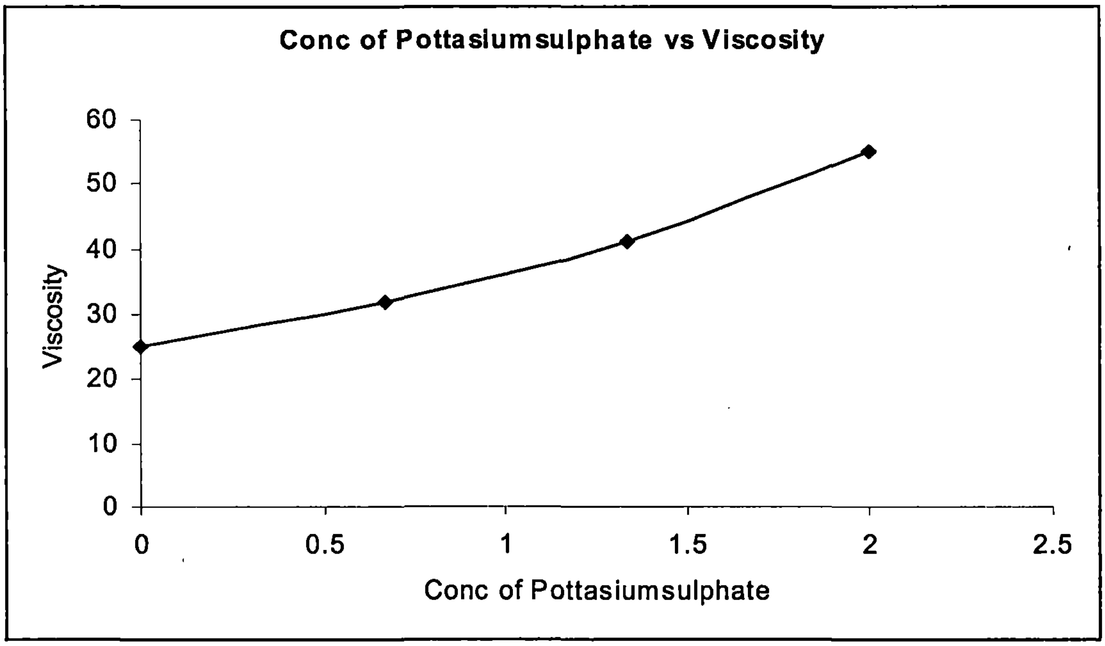
3.Droplets of latex removed and placed on the surface of a small quantity of distilled water, in a watch glass, showing small pieces of coagulam as latex spreads on the surface of water.

OBSERVATIONS:

The effect of addition of Potassiumsulphate on the viscosity of RVNRL is observed as:

Concentration of potassiumsulphate (g/kg latex)	Viscosity (cps)
0.000	25
0.666	32
1.333	41
2.000	55

Table no:1

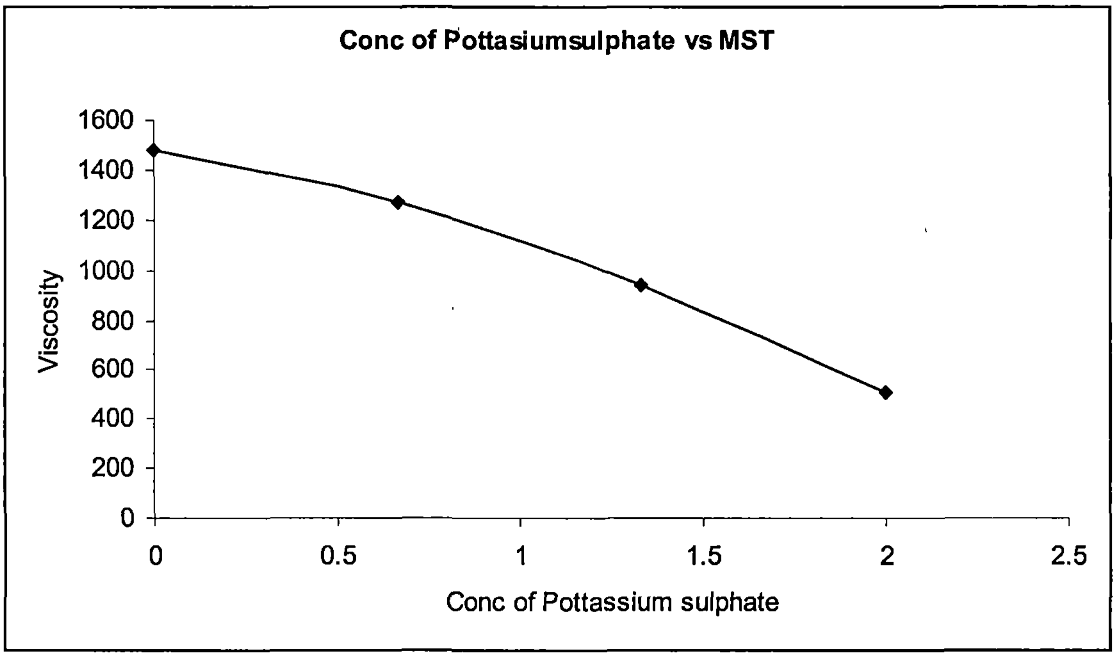


Graph no:1

Effect of addition of Potassiumsulphate on Mechanical Stability Time (MST) of RVNRL:

Concentration of potassiumsulphate (g/kg latex)	Mechanical Stability Time (Secs)
0.000	1480
0.666	1270
1.333	940
2.000	505

Table no:2



Graph no:2

RESULTS AND DISCUSSION:

- In Table no 1 we see that as we increase the quantity of addition of potassiumsulphate per kg of latex a consistent increase in the ***Viscosity*** values is seen.

  This trend is depicted in graph no 1.

- In table no 2 we see that as we increase the quantity of addition of potassiumsulphate per kg of latex a consistent decrease in the ***Mechanical Stability Values*** is seen.

  This trend is depicted in graph no 2.

CONCLUSION

From the observed results we conclude that :

1. The Viscosity of Radiation Vulcunised Natural Rubber Latex '***increases***' with the increase in the concentration of Potassiumsulphate added .

2. The Mechanical Stability Time of Radiation Vulcunised Natural Rubber Latex '***decreases***' with the increase in the concentration of Potassiumsulphate added.

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