

CHAPTER I

INTRODUCTION

1.1 Natural rubber latex (NRL)

Natural rubber latex originates as the sap of the *Hevea brasiliensis* tree. The latex is a milky white or slightly yellowish opaque liquid, and its function is believed to be protection of leaves and tissue of the tree against external infection (Archer *et al.*, 1981). The fresh natural rubber latex is collected from the tree by a process call tapping. Tapping involves diagonal incision into the bark of the tree and allows seepage of some of the liquid latex into a collection cup placed at the base of the incision.

1.1.1 Composition of NRL

Fresh natural rubber latex is a cytoplasmic fraction which normally contains about 30-45% w/w rubber hydrocarbon (*cis*-1,4- polyisoprene) and about 3-5 % w/w non-rubber components, of which 1-1.5% w/w is made up of proteins. Some of these non-rubber compounds are either dissolved or suspended in the aqueous medium of the latex while others are adsorbed on the surface of the rubber particles (Blackley, 1966). The variation is due to factors such as type of tree, tapping method, soil condition, and season. In rainy season, the rubber yield and non rubber content in the latex are higher than in summer (medium) and winter (low), and the ratio between rubber and non rubber are different in each season. Therefore, the properties of rubber that is processed in different seasons show variation (Habibah and Lim, 1986). A typical composition of fresh latex is shown in Table 1.1

Fresh natural rubber latex contains rubber particles that are usually spherical droplets of hydrocarbon enclosed in a fine phospholipid envelope suspended in water

(Figure 1.1) (Jacob et al., 1993). The average particles size were reported between 0.1 μm and 1.0 μm with a diameter ranging from about 0.02 μm to 3 μm . The particles in fresh latex are protected and stabilized by negatively charged complex film containing proteins and lipids (Smith, 1953 and Fong, 1992). The colloid stability of fresh natural rubber latex therefore results from electrostatic, steric, and hydration effects. Proteins dissolved in the aqueous phase may also contribute to stability by the exclusion mechanism (Vongbupnimit, 1992).

1.2.2. Rubber Latex proteins

Among non-rubber constituents, proteins are major components. Proteins in fresh latex are distributed in three phases. In rubber particle phase, protein or polypeptides associated with the rubber particle phase are about 26% of the total protein in the latex. The rubber particle has been studied and the data shows that it associates with the 14.6 kD protein which are rubber elongation factor (REF). The 24 kD protein and the other proteins ranging in molecular weight from 14-70 kD are also found associated with the rubber phase. C-serum proteins have about 48% of the total protein. About fifty different enzymes are distributed in this phase. Data from two-dimensional immunoelectrophoresis shows the presence of about 30 components (Kekwick, 1993). Kekwick reported that the predominant protein has native molecular weight of 80 kD which is composed of two 40 kD sub-units.

The bottom fraction is composed of lutoid particles. There are about eight protein components, five cationic and three anionic, separable by electrophoresis, at pH 8.6 (Kekwick, 1993). Two of these proteins have been characterized. The most cationic, heveamine (Archer, 1976), is a lysozyme and the most anionic, hevein, has

Table 1.1 Composition of acid coagulated field latex (Fong, 1992 and Kevin, 1999)

Constituents	Percent (w/v)
Total Solids Content	25.00 - 45.00
Dry Rubber Content	23.00 - 42.00
Amino Acids and N-Bases	0.30 - 0.40
Neutral lipids	0.40- 1.00
Proteins	1.00 - 1.80
Phospholipids	0.50 - 0.60
Inositols-Carbohydrates	1.00 - 2.00
Salts (mainly K,P and Mg)	0.40 - 0.60
Water	48.50 - 71.80

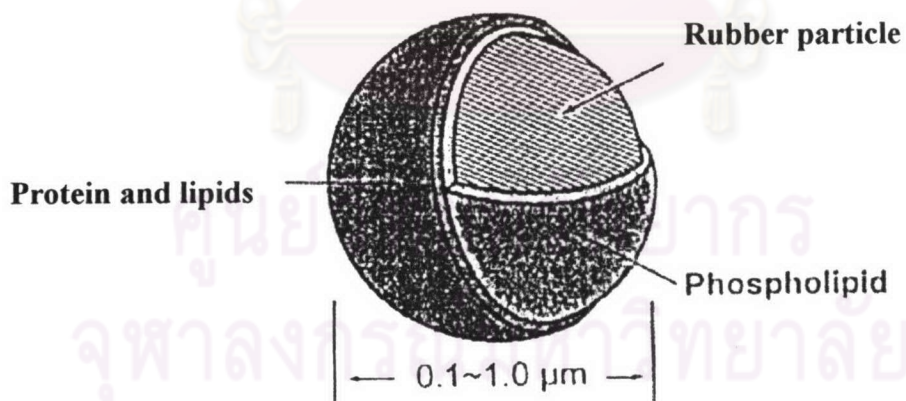


Figure 1.1 Presumed structure of rubber particle (Jacob *et al.*, 1993)

a molecular weight of 43 kD and contains chitin-binding domains similar to those found in a number of other plant species.

However, there are many kinds of protein distributed in c-serum of *Hevea* latex, by their polar and hydrophilic nature, are believed to affect the properties of rubber in many aspects from the raw rubber properties to the vulcanizate properties (Perera and Siriwardena, 1985). Tanaka (1984) had shown that newly formed network, containing a large proportion of nitrogen content, may occur by the formation of protein with other particles resulting in the hardening phenomenon.

During processing, protein has been suggested to act as filler, having variable stiffening effect resulting in modulus variation (Metherell, 1980), poor dispersion of vulcanized curatives and finally leading to local over cross-linking and properties variation (Bloomfield, 1973), and absorb water affecting the degree of cross-linking in the vulcanizing system (Eliott et al., 1970). Moreover, it has been recently reported in United States that medical instruments with the use of natural rubber such as surgical gloves can give rise to allergic symptoms.

1.1.3. Commercial production of concentrated Natural rubber latex

Fresh field latex contains only about 30-45% w/w of dry rubber. The low rubber content makes it unsuitable for manufacturing of rubber products, whether by dipping, foaming or extrusion processes. Furthermore, the high water level it contains also makes transportation of the latex uneconomical. There fore, for commercial purpose, natural rubber latex has to be concentrated to increase the solid content to at least 60% by weight.

Centrifugation, evaporation, creaming and electrodecantation may accomplish concentration of natural rubber latex but the most widely used method for the production of concentrated latex is the centrifugation method (Vongbunimit, 1992).

The fresh field latex is preserved and stabilized with ammonia, tetramethyl thiuram disulfide (TMTD) and zinc oxide. After determination of magnesium content, Mg, diammoniumhydrogenphosphate (DAP) is added to precipitate Mg for 12 hours to reduce Mg content to 50 ppm maximum. The DAP-ammoniated latex is centrifuged to remove some of the water and increase the rubber content of the latex. Latex concentrate is formed which contains about 60% of dry rubber content and 2 % maximum of non rubber contents. This concentrated natural rubber latex has been used widely for produced natural rubber product such as glove, condom, catheters tip, endotracheal tubing, latex balloon, baby bottle nipples, and dental cofferdams.

The ISO 2400 specifications of concentrated latex are shown in Table 1.2.

1.1.4. Dipping product from natural rubber latex

The dipping process is used for large number of rubber products. Examples of products made using the dipping process are rubber gloves (household and industrial), condoms, surgical gloves, examination gloves, various tubes and miscellaneous products for a variety of uses.

Molds of the desired shape and size are dipped into the latex compound, which is circulating in a stainless steel tank, and allow to dwell for a set amount of time (this determines the thickness), withdrawn and then dry at around 80° C. The dry film that has been formed can be stripped from the mold, giving the finish article.

Table 1.2 The ISO 2400 specifications of concentrated latex

Physical properties	ISO 2400 Specification
Total solid content (TSC), (%)	Min. 61.50%
Dry rubber content (DRC) , (%)	Min. 60.0%
Non rubber content (NRC), (%)	Max. 2.00%
Ammonia (HA-L), (%)	Min. 0.60%
KOH (%)	Max. 1.00%
Volatile fatty acid (VFA)	Max. 0.20%
Magnesium content (ppm)	Max. 50.00 ppm
Mechanical stability time (MST), (second)	Min. 650 sec.

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Vulcanization which is the process of cross linking rubber molecule, is the important process in the manufacture of rubber products. Conventional vulcanization system, i.e. sulfur vulcanization, is prepared by reacting latex with ingredients including sulfur and one or more accelerators of the dithiocarbamate type, usually zinc diethyldithiocarbamate. These chemicals are reported to be carcinogenic and nitrosamine producing and hence unsuitable for the manufacture of articles which may come into contact with human tissue (Jacob and Vijayakumar, 1997).

1.1.5. Problems associated with natural rubber latex products

With more widespread use of natural rubber products, there has been an increase in reported NRL allergies, among patients as well as among workers, notably health care workers (Dennis and Ownby, 2002). In addition to reports from the dermatology, allergy, and pulmonary literature of severe skin and respiratory symptoms, life threatening reactions to NRL products have been noted in pediatric patients with spina bifida who had undergone numerous surgical procedures, resulting in repeated NRL exposure (Cawley *et al.*, 1994). In addition, over 1000 allergic and anaphylactic reaction and over 15 anaphylactic deaths related to the use of latex derived medical devices have been reported (Varghese *et al.*, 2000).

The two major routes of exposure include dermal exposure and inhalational exposure. NRL protein absorption has been reported to be enhanced when perspiration collects under latex clothing articles (Turjanmaa *et al.*, 1988). Exposure may also occur by the respiratory route, particularly when glove powder acts as a carrier for NRL protein which becomes airborne when the gloves are removed (Tomazic *et al.*, 1994).

Furthermore, natural rubber products may contain chemical accelerators such as thiuram, carbamates, and benzothiazoles to which a worker may also develop sensitization, resulting in allergic contact dermatitis. Antioxidants, biocides, soaps, and other chemicals used in the processing of natural rubber products may contribute to sensitization as well.

1.1.6 Allergic reactions to natural rubber latex

There are 3 different types of reactions to natural rubber latex.

1.1.6.1. Irritation

This is a non-allergic condition, the effects of which are usually reversible.

When latex products or latex gloves are used, a rash may occur on the back of the hands which is characteristically dry and itchy. These symptoms usually resolve once contact with the latex product is discontinued. It is important to note however that skin irritation may be caused by a wide range of substances. For example skin cleansing and disinfecting agents may induce skin reactions which may be confused with latex sensitization. Where necessary, advice should be sought on a differential diagnosis, precautions or treatment from an occupational physician (Brehler and Kutting, 2001).

1.1.6.2. Delayed Hypersensitivity (Type IV)

This reaction is predominantly caused by an allergy to the residues of accelerating agents such as mercaptobenzothiazole, carbamate and thiuram used in the manufacturing process of rubber products (Brehler and Kutting, 2001). Also known as allergic contact dermatitis, the severity of this type of allergy varies greatly. It is often characterized by a red rash on the back of the hands and between the fingers. The skin may become leathery and express papules or blisters. The reaction is delayed,

occurring several hours after contact, reaching a maximum after 24-48 hours (Hamilton, 2002) and then subsides. Repeated exposure to rubber latex may cause the skin condition to extend beyond the area of contact with the gloves or other medical device.

1.5.3. Immediate Hypersensitivity (Type I)

This reaction is predominantly a response to the natural protein residue found in natural rubber latex. This type of reaction, sometimes referred to as an Immunoglobulin E (IgE) response, generally produces symptoms within 5-30 minutes of latex exposure. Such a reaction is almost immediate in effect but usually diminishes rapidly once contact with the rubber material has ceased. The symptoms are characterized by local or generalized urticaria and edema (McFadden, 2002). If mucous membranes are affected, rhinitis, conjunctivitis or asthma may result. Respiratory difficulties and anaphylaxis may occur in extreme cases. Anaphylactic shock, characterized by generalized hives, respiratory distress and low blood pressure can occur within minutes of exposure. It is most likely to occur when the skin barrier is broken or the rubber latex device comes into contact with mucous membranes. The potential allergens which produce type I or IV reactions exist in the finished product as protein or process residues. These are water soluble and readily leach out of the latex. The washing process used in glove manufacture often removes substantial amounts of proteins and process residues. Some will remain, to a greater or lesser extent, depending on the frequency of washes and the chemical processes used. Repetitive skin or mucous membrane contact with any rubber latex product containing high protein residues may cause sensitization. Once this has occurred

future allergic reactions may be caused through contact with rubber latex products containing lower residue levels (Sussman *et al.*, 2002)

1.6. Effect of gamma radiation on 60 % natural rubber latex

The main components of the natural rubber latex are natural rubber particle and water. These components are separated from each other in the natural rubber latex. The natural rubber molecules are dispersed in water as fine particles in the natural rubber latex. Natural rubber molecules and water molecules independently absorb radiation energy such as gamma radiation and electron beam accelerator. The natural rubber radicals are generated by radiolysis of the natural rubber molecules in the natural rubber particles. The natural rubber radicals recombine with each other to crosslink (Makuuchi, 2003). The process of crosslinking rubber molecules by gamma radiation is called radiation vulcanization.

Vulcanization of rubber increases the crosslinking density and thereby improves the physical properties of rubber making it suitable for manufacturing a large number of products. The conventional method of vulcanization is by use of sulfur. It is also possible to vulcanise rubber by exposing chemically processed latex to a high dose of ionizing radiation (Lanzad, 1996). Radiation vulcanization has a number of advantages over conventional sulfur vulcanization such as absence of N-nitrosamines, which is a carcinogenic substance, very low cytotoxicity, less protein allergy response, transparency and softness, degradability in the environment, space and energy saving in a latex factory, low emission of SO₂ and less formation of ashes when burned and no contamination of effluent with ZnO (Makuuchi, 2003).

Radiation vulcanized natural rubber latex has been investigated for a long time. The first report appeared in 1956 as a patent which claimed a successful

crosslinking of natural rubber latex by irradiating latex with dose more than 300 kGy and without sensitizing (Gehman and Auerbach, 1956). Later on, several kinds of sensitizers were used to reduce the radiation dose. Halogenated hydrocarbons such as carbon tetrachloride, chloroform had been used as sensitizers in the form of emulsion using stabilisers in the form of emulsion using stabiliser or emulsifier such as potassium laurate, or detergent to prevent coagulation of latex (Lamm and Lamm, 1964; Kartowardoyo and Sundardi, 1977). In 1961, Asao et. al, reported that in the presence of 5 phr of carbon tetra chloride, the dose for vulcanization of natural rubber latex can be reduced to 40 kGy. However, carbon tetrachloride is toxic to human and environment. Polyfunctional monomers (PFM) are commonly used to enhance the radiation crosslinking of polymer. However, only divinyl benzene was investigated as radiation vulcanization accelerator. The accelerating efficiency of a PFM is supposed to depend on its solubility in natural rubber and reactivity with natural rubber (Makuuchi and Hagiwara, 1984).

In 1985 Makuuchi and Tsushima studied sensitizing effect of a monofunctional monomer that is 2-ethylhexyl acrylate (2-EHA). The results showed that using only 2-EHA , the vulcanization dose required is 30 kGy but with the addition of 1 phr of carbontetrachloride to 5 phr of 2-EHA, the dose required to effect good crosslinking was reduced from 30 kGy to 15 kGy. But 2-EHA is not used as a radiation vulcanization accerelator due to the very bad smell of radiation vulcanized natural rubber latex film. This odor was caused by the remaining 2-EHA. It is difficult to remove trace amount of 2-EHA which remains in the rubber products prepared from radiation vulcanized natural rubber latex. N-Butyl acrylate (n-BA), which is a new accelerator, has higher vapour pressure than 2 EHA, but n-BA tends to reduce the stability of natural rubber latex. Usually some stabilizers are used to prevent the latex

from coagulation due to the addition of sensitizer. Zhonghai and Makkuchi (1989) obtained the optimum vulcanization dose of 15 kGy using 5 phr n-BA with potassium hydroxide as a stabiliser. Soebianto and Sundardi (1989) claimed to reduce the vulcanization dose to 10 kGy by using hydrogen peroxide together with the sensitizer system n-BA and carbon tetrachloride.

The effect of oxidizing agents such as hydroperoxides were investigated and it was found that the addition of 0.1 phr of t-butylhydroperoxide can reduce the vulcanization dose from 12 kGy to 8 kGy with 5 phr of n-BA (Aroonvisoot and Makuuchi, 1990).

Tsushima *et al.* (1990) produced protective gloves for radioactive contamination from radiation vulcanized natural rubber latex. The gloves are transparent and softness. The mechanical properties of the gloves meet Japanese Industrial Standard (JIS) specification for protective gloves. Combustion analysis of the gloves revealed that the amount of evolved sulfur oxide and remaining ashes are less than those from sulfur vulcanization gloves.

Hien *et al.* (1990) produced surgical and examination gloves from natural rubber latex 55% DRC containing 3 phr of carbon tetrachloride, which was irradiated at dose rate 7.5 kGy/h. Specifications of irradiated latex and mechanical properties of the radiation vulcanised latex were studied. The maximum tensile strength which was obtained at 25 kGy was 240 kg/cm² or 23 Mpa. The viscosity of the irradiated latex remained at constant value under 30 kGy. The G value for crosslinking calculated from swelling is 17.0. Chlorine contents measured with activation analysis increased with increasing irradiation dose. When 400 kg of latex was vulcanized at 25 kGy and used for production of rubber gloves in an existing factory with coagulant dipping process. The physical properties of the rubber gloves were as follows: tensile strength

220-250 kg/cm² (21-24 Mpa); elongation at break 950 %; permanent set 5-10 %; residual tensile strength after aging at 70 °C for 72 hours 70-80 %. The gloves were accepted for domestic use as surgical and examination gloves.

After the previous studies about improvement of radiation vulcanization methods, various factors affecting properties of radiation vulcanized natural rubber latex films have been studied.

Shukri *et al.* (1990), studied the effect of heating and leaching on the mechanical properties of radiation vulcanized natural rubber latex films. It was found that heating and leaching improved tensile strength of film considerably. The tensile strength could increase as high as 25% upon heating alone and as high as 75% upon leaching and drying. The increase in the tensile strength was attributed to reduced moisture content, better particle cohesion and improved entanglement of molecular chains. Complete leaching and drying of radiation vulcanized natural rubber latex was found to be important to obtain better and consistent results on the mechanical properties of films from radiation vulcanized natural rubber latex.

Sumbogo (1990) studied the effect of antioxidants on the aging property of film prepared from radiation vulcanized natural rubber latex. Commercial antioxidants studied were Vulcanox, Ionol and Nonox. Two kinds of radiation vulcanized natural rubber latex were studied, those which prepared by using carbon tetrachloride and n-BA sensitizers. The antioxidants were in the form of emulsion and dispersion before blending with the latex. The antioxidants were blended with natural rubber latex just after irradiation. It was found that the addition of Vulcanox, Ionol or Nonox, in the form of emulsion or dispersion into radiation vulcanized natural rubber latex, would much improve the aging property of the film. Emulsion of Vulcanox (0.5 phr) appeared to be the best antioxidant for radiation vulcanized natural rubber latex

prepared using carbon tetrachloride sensitizer. Decreasing in tensile strength after 14 days of aging at 70 ° C was 17.9% compared to 26.5 % for film without that antioxidant. Emulsion of Vulcanox also showed the best sensitizer for radiation vulcanized natural rubber latex prepared using n-BA sensitizer.

Wahab *et al* (1990) found that adding antioxidant can improved aging property of radiation vulcanized natural rubber latex film after leaching. Radiation vulcanized natural rubber latex obtained using carbon tetrachloride and n-BA as sensitizers respectively were evaluated. Antioxidant 2' 2'-methylene-bis-(4-methyl-6-tert-butylphenol) containing 0.8 phr was found to be the most effective for radiation vulcanized natural rubber latex produced by using carbon tetrachloride as sensitizer, whereas and antioxidant 2,4-Bis [(octylthio) methyl]-o-cresol at 1.0 phr was best for radiation vulcanized natural rubber latex produced by using n-BA as sensitizer. Antioxidant 2- mercaptobenzimidazole showed slightly less effective but gave less tendency for discoloration compared to 2,4-Bis [(octylthio) methyl]-o-cresol when used in the n-BA system.

Vongbupnimit (1992) developed the technology of radiation vulcanization natural rubber latex in Thailand and studied various factors affecting the properties of gamma radiation vulcanized natural rubber latex. The results showed that good radiation vulcanized natural rubber latex properties could be obtained from 50% DRC concentrated latex, irradiated at room temperature without having to stir. Radiation vulcanized natural rubber latex samples had to be leached in water at 60°C for 1 hour and dried at 60°C for 30 minutes. Humidity has a significant effect in lowering properties of radiation vulcanized natural rubber latex film and, therefore, must be carefully controlled. Application of pressure to radiation vulcanized natural rubber

latex film sample dose not help improve their properties. No anisotropic effect was observed in radiation vulcanized natural rubber latex sample casted from the latex.

Haque *et al.* (1996) optimized the radiation dose required for the vulcanization of natural rubber latex. To enhance the cross linking, several sensitizers were used. Among the sensitizers, n-BA alone was found to be the best one. The effects of concentration of n-BA, mixing and standing time of latex with n-BA on the tensile properties of latex film were investigated. At 12 kGy radiation dose 5 phr n-BA and 30-40 min of mixing time were found to be the optimum conditions for irradiation.

In the middle of the 1980s, the consumption of rubber gloves and condoms increased to prevent the risk of being infected by AIDS. After several years, an increasing number of people began to develop adverse reactions to latex products. These reactions ranged from a simple rash or itchy feeling to more severe asthmatic and allergic reactions. The problems were associated with the use of the natural rubber latex are mainly caused by two factors, which are Type I immediate-type hypersensitivity and Type IV delayed-type chemical hypersensitivity. Currently regarded as the most important one is the reaction caused by the proteins classified as a Type I, and second problem is mainly caused by the chemicals that are added to the latex in order to start the vulcanization process. (Makuuchi, 2003) Radiation vulcanized natural rubber latex is expected to solve these two problems because the process needs only one chemical for vulcanization and sensitizer radiation can cause protein disintegration.

Ratnayake *et al.* (1999) has reported that water soluble polymers can be used to reduce the concentration of water extractable proteins in radiation vulcanized natural rubber latex. The soluble protein content in radiation vulcanized natural rubber latex is reduced more effectively, by combined treatment with polyvinyl alcohol and

centrifugation, compared to individual (i.e. polyvinyl addition or centrifugation) treatment.

Varghese *et al.* (2000) developed a new process for the preparation of protein free latex. In this new process the radiation vulcanized, centrifuged latex is diluted to 30% DRC and then recentrifuged. In the case of field latex, it is irradiated first and then centrifuged after diluted to 20% DRC. The new process results in prevulcanised latex almost free from soluble proteins.

Ratnayake *et al.* (2001) investigated the effect of water soluble polymers, such as polyvinyl alcohol and polyvinyl pyrrolidone, on radiation vulcanised natural rubber latex. Extractable protein measurements showed that addition of 3 phr water soluble polymers into 30% DRC radiation vulcanized natural rubber latex, followed by centrifugation, effectively reduced the extractable protein from radiation vulcanized natural rubber film to 0.06 mg/g rubber after 20 minutes leaching in 1% ammonia solution. It was concluded that addition of water soluble polymer before centrifugation is more effective than additive WSP after centrifugation.

Regero *et al.* (2003) irradiated field natural rubber latex with different dose to reduce the water soluble protein content in the final product. The protein content of the films obtained by casting method was extracted with phosphate buffer solution, pH 7 and measured using Micro BCA Protein Assay kit. Protein was also measured in the serum samples of field natural rubber latex. The concentration of extractable proteins increased with increasing radiation dose.

1.7. The rationale and aim of this study

Vulcanization is the process of crosslinking rubber molecules. It is a chemical reaction, which imparts elastic properties to rubber. The rubber products will fail to

retain its shape unless they are vulcanized. Conventional vulcanization system consists of a variety of chemicals such as sulfur, zinc oxide, dithiocarbamates etc. These chemicals are reported to be carcinogenic and nitrosamine producing and hence unsuitable for the manufacture of articles which may come into contact with human tissue (Jacob and Vijayakumar, 1997).

Since 10 years ago, many reports of wide spread life-threatening latex associated Type I allergy have focused attention on latex proteins as serious allergens. About 1% of the general population is believed to be allergic to latex. Over 1000 allergic and anaphylactic reactions and 15 anaphylactic deaths related to the use of latex derived medical devices have been reported. The most common manifestation of latex allergy is non-immunologic irritant dermatitis of the hand. An estimated 7-10 % of health care workers regularly exposed to latex and 25-67 % of children with spina-bifida have positive skin tests for latex proteins. It has been well established that residual protein from natural rubber latex in a finished product may cause allergic reaction of immediate Type I hypersensitivity in some sensitized individuals (Brehler and Kutting, 2001).

The radiation vulcanized natural rubber (RVNRL) latex has definite technical advantages over conventional sulfur cured latex in some specialized areas, namely less nitrosamine, low cytotoxicity, and RVNRL films are very transparent. Hence it can be used in areas of body contact and food contact applications. Radiation vulcanization has been developed as a viable alternative process to conventional sulfur vulcanization (Ratanayake et al., 2001). Proteins in natural rubber latex are degraded to a great extent during irradiation and become water soluble and can be leached out, so that protein allergic problems should be decreased.

The aim of this research is study the effect of gamma radiation on water extractable proteins natural rubber latex to develop low WEP radiation vulcanized natural rubber latex. This radiation prevulcanized concentrated latex material should be the first milestone to produce allergen free rubber products such as medical and pharmaceutical devices. The other objective is to characterize the physical properties of this low WEP natural rubber latex concentrate, and radiation vulcanized rubber film.

The objectives of this research are:

1. To study the effect of seasonal variation and increasing dose of gamma radiation on WEP of fresh field and concentrated latices.
2. To select effective dose of gamma radiation that disintegrate WEP with beneficial effect on the physical properties of deproteinized concentrated latex and low protein natural polysaccharide added concentrated latex.
3. Intercomparison of WEP from fresh field latex, control concentrated latex, deproteinized concentrated latex and alginate added concentrated latex before and after irradiation and to study allergenic response of WEP from radiation vulcanized rubber film after leaching in the absence and presence of alginate added before preparing concentrated latex.
4. To study physical properties of radiation vulcanized rubber film prepared from control, deproteinized and alginate added concentrated latices.