



## CHAPTER 2

### REVIEW LITERATURE

#### 2.1 Definition of soft lining denture base material

Soft lining materials have been defined as soft elastic and resilient materials forming all or part of the fit surface of denture. The purpose of using the soft lining material is to absorb some of stresses produced by masticatory force<sup>(1-4)</sup>. Therefore, it serves as a cushion between the inner surface of denture base and the oral tissue when patients cannot tolerate the hard denture base. Soft lining materials are also used to improve retention for an ill-fitting denture or obturator. Elasticity ensures that the material will regain its original shape following deformation, while resilience is also important because of its determinations the rate of recovery. This has led some to label these materials as “Resilient”, but soft lining material is more correct because of the softness or ease of deformation that particularly separates them from other denture base materials<sup>(4)</sup>.

#### 2.2 A brief history of soft lining denture base material

The earliest soft lining material recorded was the soft rubber and used by Twitchell in 1869. No others were mentioned until just before 1940, when a soft natural rubber known as “Velum” was vulcanized in conjunction with obturators and used as a soft lining for mandibular complete denture. However, this material had high water absorption, and it becomes foul and ill fitting after a period of time (reviewed by Braden<sup>(4)</sup>).

One of the first synthetic resins used as a soft lining material was polyvinyl chloride (PVC), in which a plasticizer was necessary. The purpose of plasticizer was to reduce the transition of polymer from liquid to solid below mouth temperature. Thus at mouth temperature, the material was still soft. In 1945, Matthews<sup>(5)</sup> used PVC powder with a liquid di-n-butylphthalate plasticizer for facial prostheses and also soft lining materials for patients with chronic mucosal tenderness. He found that it eliminated the soreness under complete dentures in some selected patients. Lammie and Storer<sup>(6)</sup> described the use of PVC with di-n-butyl phthalate plasticizer and found it to be very unsatisfactory material. It hardened in a short period of time (6-12 months) because of the plasticizer leaching out. Dioctyl phthalate was considered a better plasticizer for PVC because the lining remained soft longer<sup>(7)</sup>.

In late 1940s<sup>(8)</sup>, there was a report using vinyl chloroacetate with butyl phthalate butyl glycolate plasticizer. This plasticizer improved the adhesion between the lining and the polymethyl methacrylate denture base. It was claimed that there was less leaching out of plasticizer, and therefore the soft lining remained soft for a longer period of time. However, Lammie and Storer<sup>(6)</sup> reported the unsatisfactory effect of its high water absorption, hardening, and cracking.

In 1961, "Softdent" was developed as a soft lining material, a hydrophilic gel based on glycol methacrylate ester chemistry. When immersed in water, the material gradually swelled and became soft, with final water content of approximately 37 %. Laboratory and clinical studies showed that it was not suitable for using as soft lining material because of continuing changes in its volume. It was finally withdrawn from the market<sup>(8)</sup>.

Silicone rubber materials based on poly(dimethyl siloxane) have been used as soft liners since 1958<sup>(6)</sup>. Many of the early silicone rubber soft lining materials

were processed separately from the denture base and then cemented to it <sup>(9,10)</sup>. Materials that could be processed with polymethyl methacrylate at room temperature soon became available <sup>(7, 10)</sup>, however, the poor adhesion to the denture base resulting from higher water diffusion limited their uses.

### 2.3 Currently available soft lining denture base materials

The commonly used soft lining materials on the market are heat polymerized acrylic and autopolymerized acrylic resin, heat polymerized and autopolymerized silicone, and tissue conditioner or treatment liner. In addition, the newly developed soft lining materials, the fluorinated resin and the olefinic material have been mentioned with less report <sup>(3)</sup>. Some examples of those current available soft lining materials with their composition are presented in Table 2.1-2.3

Both the heat-processed and autopolymerized acrylic resin soft lining materials consist of powder and liquid components. The powder is believed to contain the acrylic polymer or copolymer, and the liquid is the mixture of methyl methacrylate monomer and a plasticizer such as di-n-butylphthalate, which can reduce the modulus of elasticity of the soft material to a satisfactory level <sup>(11)</sup>. The chemical composition of the acrylic resin soft lining shown in table 2.1 is similar to that the acrylic resin denture base material; thus no adhesive is required to form a bond.

Table 2.1. Composition of two acrylic resin soft lining materials

Material	Polymer	Monomer
Vertex Soft	Poly(ethyl methacrylate)	Acetyl tributyl citrate + methyl methacrylate
Coe Soft	Poly(ethyl methacrylate)	Di-n-butyl phthalate + benzoyl salicylate + ethyl alcohol

Table 2.2. Composition of two silicone soft lining materials

Material	Polymer	Cross-linking agent	Catalyst	Adhesive
Molloplast-B	Poly(dimethyl siloxane)	Acryloxy alkylsilane	Heat + benzoyl peroxide	Methacryloxy propyl-trimethoxysilane
Flexibase	Poly(dimethyl siloxane)	Triethoxysilanol	Dibutyl tin dilaurate	Silicone polymer in solvent

Table 2.3. Composition of two treatment liners

Material	Polymer	Cross-linking agent	Catalyst
Viscogel	Poly(ethyl methacrylate)	Ethyl alcohol	Dibutyl phthalate
Coe Comfort	Poly(methyl methacrylate)	Ethyl alcohol	Dibutyl phthalate

The silicone rubber materials (listed in table 2.2) are basically composed of polymers of dimethyl siloxane a viscous liquid that can be cross-linked to provide good elastic properties. The cross linking agent is normally an alkylsilane, and the reaction is usually catalyzed by an organic metal salt or benzoyl peroxide <sup>(11)</sup>. Molloplast b, a heat polymerized silicone rubber is supplied as one paste system activated by heat; boiling water for 2 hours. An adhesive ( $\gamma$ -methacryloxy propyl trimethoxysilane <sup>(12)</sup>, a silicone polymer in solvent) is supplied to aid bonding to the denture base. The silicone autopolymerized, Flexibase, is supplied as a paste and a liquid system. The liquid or the catalyst is a mixture of dibutyl tin dilaurate. Wright <sup>(12)</sup> stated that because silicone rubbers have no natural adhesion to PMMA, an adhesive composed of a silicone polymer in a volatile solvent must be used.

Treatment liners (temporary soft linings/ tissue conditioners, examples of which are included in Table 2.3) remain soft for a limited period of days to weeks and can be used when it is necessary to give the oral soft tissue an opportunity to recover before fabricating a new denture or rebasing or relining an existing one. They may also be used as functional impression materials, for immediate denture maintenance, cleft palate, speech aids, and immediate surgical splints <sup>(13)</sup>. McCarthy and Moser <sup>(14)</sup> summarized other clinical uses of the treatment liners, and their properties were evaluated. The treatment liners usually consist of two components, powder and liquid. The powder is a higher methacrylate, e.g. polyethyl methacrylate (PEMA) or copolymers, while the liquid is usually a mixture of ethyl alcohol as a solvent and dibutylphthalate as a plasticizer. The alcohol and ester are solvents for the polymer beads. They swell the beads and allow the plasticizer to diffuse in. Usually, the gel forms more rapidly and is initially softer with a higher concentration of volatile

solvent. However, leaching and evaporation of these components lead to rapid hardening of the material in the mouth.

The plasticizers contained in these materials can be absorbed by acrylic resin denture base, which in turn itself to be soft. The effect is mostly marked when the base material is an auto-polymerized acrylic resin resulting in a decrease in the yield strength of approximate 20% <sup>(15)</sup>. Effects on heat-polymerized acrylic resin are likely to be clinically insignificant.

#### **2.4 Ideal Properties of the soft lining materials**

For maximum efficacy, soft lining material should display the following properties:

1. They should be easily processed using conventional laboratory equipments.
2. They should exhibit minimal dimensional change during processing and such change should be the same as the denture base materials <sup>(4)</sup>.
3. Water absorption should be minimal. Bate and Smith <sup>(16)</sup> commented that high water absorption might lead to swell and stress at the denture base interface and tend to increase distortion and reduce bonding. Ideally, the total water absorption should be close to that of the acrylic resin denture base polymers, reported as 2.2% <sup>(17)</sup>. Braden and Causton <sup>(18)</sup> had discussed the effects of prolonged immersion of the soft lining material in water. If swelling occurs, the bacteria and nutrient material in the mouth would find their way between the lining and the denture base, and the area becomes unhygienic.
4. The materials should have minimal solubility in saliva. Ideally, the plasticizer should not leach out with time, however, if leaching does occur, it should be minimal.

5. The materials should have the softness property by themselves without using plasticizer such as phthalate ester because of the estrogenic effect<sup>(19)</sup>.
6. They should retain their resilience. The degree of resilience will depend the chemical composition of the material and the thickness of the soft lining. Several authors<sup>(20-23)</sup> suggested that a thickness of 2-3 mm is the most appropriate for soft lining materials.
7. They should bond sufficiently well to PMMA to avoid separation during use. If the bond between the two materials is weak, separation takes place during use and such localized areas of separation rapidly become unhygienic because of the difficulty in cleansing.<sup>(1-3)</sup>
8. Adequate tear resistance is practical importance to resist rupture during normal use. The propagation of crack or small tear at the periphery of the soft lining could lead to failure and detachment of the material<sup>(1-4)</sup>.
9. They should be easily cleaned and not affected by food, drink, or tobacco. It is also important that the resilience and surface texture of the lining are not affected by freely available denture cleanser of all types<sup>(1-4)</sup>.
10. They should be nontoxic, odorless, and tasteless to encourage long-term wear of the denture by the patients<sup>(1-4)</sup>.
11. They should be aesthetically acceptable and their color should match of the denture base material<sup>(1-4)</sup>.

## 2.5 Permanent soft lining materials

It is not possible to estimate accurately the useful functional life of any denture because of the large variation in clinical factors that may necessitate its replacement. It is normally considered, however, that the average conventional

complete denture will need replacement approximately once every five years<sup>(23)</sup>. The physical properties of PMMA, the denture base materials, are more than adequate for this life span. It would seem reasonable to expect the soft lining materials to last about this period of time. Gonzalez and Laney<sup>(23)</sup> proposed that the soft liner material that serves for more than two years can be considered as essentially adequate lining material presumably on the basis that replacement every two years is not an excessive liability to the patient and the dentist. Many of the disadvantages of soft lining materials that have identified including the loss of compliance, the poor dimension stability, the failure of bond between the soft lining and denture base materials, the tendency to tear and abrade, the changes in the surface detail and the consequences of poor dental hygiene, especially the colonization by *Candida albicans*<sup>(24)</sup>, might prevent the soft lined denture from fulfilling this requirement.

## 2.6 Clinical failure of soft lining materials

Assuming the provision of a soft lining material meets the patient's expectations, the lined denture will continue to be worn until either the lining or denture fails. Only the former will be considered here and such failure may be attributed to changes in the physical properties of the material i.e. hardening, roughening, cracking or tearing, loss of adhesion to the PMMA denture base, staining, deposition of calculus or oral yeasts. Soft linings have also been shown to be less flexible during and after simulated chewing and clenching test sequences<sup>(25)</sup> and after thermocycling<sup>(7)</sup>.

Loss of compliance in the oral aqueous environment has most often been reported with elasticized acrylic materials<sup>(26-28)</sup> because of the susceptibility of the plasticizer to leaching out of the material. Silicone rubber materials have most often



been reported to maintain their softness over a long period of time <sup>(29-32)</sup> although these reports are generally based on subjective opinions. The effect of plasticizer loss may be confused by the absorption of water into the soft lining material which will act as plasticizer itself, thus maintaining or increasing compliance of the material <sup>(33)</sup>.

The repeated absorption and desorption of water from the surface of the soft lining may be one factor in producing the roughening of the surface <sup>(32,34)</sup>. Other factors may be the constituents of food and drinks such as essential oil, denture cleanser, brushing. The initial surface roughness may also differ depending upon the effects of finishing and polishing the surface.

Surface failure can also occur because of poor rupture properties of soft lining materials either because of tearing of small pieces of lining from the periphery of the denture which can occur with silicone rubber materials or cracking of that portion of the soft lining related to the crest of the residual ridge which has been reported for soft acrylic resin materials <sup>(7)</sup>.

Loss of adhesion of the soft lining material to the PMMA denture base has often been reported as the cause of failure for silicone rubber materials in clinical use <sup>(7, 30)</sup>. Complete separation does not always occur but local area of separation between the liner and the base may become unhygienic because of difficulty in cleansing between these two surfaces.

Patients rarely complained of staining, color changes or odor from the soft lining when used in the lower complete denture although such changes have often been reported in clinical studies and may lead to a clinical decision to replace the soft lining. There are numerous reports of soft lining materials being colonized by *Candida albicans* in the clinical situation <sup>(29,30,35)</sup> but there is no evidence that the presence of yeast has any adverse effects on the mandibular oral mucosa. However,

the presence of *Candida albicans* in the mouth is associated with the inflammatory changes was observed in denture related stomatitis. It is best avoided by the use of appropriate cleansing regimens<sup>(36)</sup>.

Since there were many problems on physical and chemical properties of lining materials, different modifications of these materials have been reported as described below:

### **2.6.1 Natural rubber/PMMA graft copolymer system**

In 1958 Lammine and Storer at the London Hospital Medical College, started using rubber as a soft lining material. Later on the Malaysia Rubber Producer Research Association developed a new rubber type lining material comprising a natural rubber/PMMA graft copolymer, cured at 100 °C sulfur/zinc dimethyl dithiocarbamate systems. Adhesion of the new material was achieved with a toluene solution of the graft polymer, applied to the PMMA denture. This preparation gave excellent mechanical results and showed great promising clinical results. Unfortunately, it had to be abandoned because of the potential dangers of the mucosal reaction to the dithiocarbamate<sup>(6)</sup>.

### **2.6.2 Powdered elastomer soft acrylic systems**

The concept that initiated this work was to retain the advantage of soft acrylic systems, and avoid the need for plasticizers. Elastomer in powder form were manufactured by cryogenic grinding, or from latex; many use talc or other silicates as a separating agent, and were to be avoided because they result in very high water uptake. Powdered elastomers react easily with the right choice of monomer and the cured products have acceptable strength and adhesion to PMMA<sup>(4)</sup>.

### 2.6.3 Fluoropolymers

Recent work reported from Japan suggested the use of visible light cured soft resins prepared by combining fluoroalkyl methacrylate monomers with a vinylidene fluoride/ hexafluoropropylene copolymer, or a vinylidene fluoride/tetrafluoroethylene/ hexafluoro propylene copolymer <sup>(4)</sup>. They are reported to be more wettable than silicones and have low solubility and low residual monomer. Softer resins could be prepared by using lower molecular weight fluoropolymers. Such materials have been reported before <sup>(37)</sup> but they have not become widely commercially available. There is one heat-cured material of similar chemistry, Kurepeet<sup>®</sup> currently on the market.

The successful of clinical use of soft lining material is very importance. Hence, there are many previous testing on physical and mechanical properties of these materials as be described below.

### 2.7 Bonding to PMMA

The bonding ability between soft lining materials to PMMA material is one the most important factors for clinical use. The silicone type of soft lining materials cannot efficiently bond to PMMA by itself. The bonding between silicone and PMMA is easily deteriorated after immersion in water for a short period of time. Therefore, the adhesive or primer was used to enhance the bonding with the report of a little success <sup>(38)</sup>. To determine the bonding property of the materials, it can be performed by the peel test and the test should be conducted using the manufacturer instructions. The bond energy of different soft lining materials to PMMA by the peel test in one study was shown in Table 2.4 <sup>(39)</sup>.

Table 2.4. The peel energy (KJ/m<sup>2</sup>) of some soft lining materials

Material	Dry	7 days in water	90 days in water
Coe Suppersoft <sup>®</sup>	13.39	13.69	14.97
Molloplast B	1.80	2.23	1.98
Flexibase	0.63	1.19	0.3

From the table, Coe Supersoft<sup>®</sup> showed the best bonding which was unaffected by water immersion. The two silicone type materials, Molloplast B and Flexibase, have far lower peel strength and both were reduced after long-term water immersion. Of the two, Molloplast B was better.

Another method for investigation of the bonding ability is the tensile bond strength testing<sup>(40, 41)</sup>. This method is more effective than the peel test because it can determine both of bond strength and mode of failure.

## 2.8 Tensile properties

Both natural rubber and silicone material are elastomeric materials that are non-linear in tension, except at very near the origin. The ultimate tensile strength and the elongation at break values are important because they refer to the resilience and elasticity of the tested materials. The tensile properties of some soft lining materials were shown in the table 2.5<sup>(42)</sup>.

Table 2.5 The tensile properties of some soft lining materials

Material	Tensile strength (MPa)	Elongation at break (%)
Coe Supersoft	2.66	230
Molloplast B	4.28	325
Novus (Polyphosphazine)	3.60	240

## 2.8 Tearing properties

The tear resistance is another important property of the soft lining materials<sup>(43, 44)</sup>. It represents the maximum energy or strength that caused tear in the material. If the soft lining materials have low tear resistance, it will be easily torn and cause the soft tissue irritation or food deposition that leading to the bad smell later. The tear energy of several soft lining materials from one study was shown in Table 2.6<sup>(42)</sup>.

Table 2.6. The tear energy of some soft lining materials

Material	Tear energy (KJ/m <sup>2</sup> )
Coe Supersoft <sup>®</sup>	11.5
Molloplast B	1.43
Novus	21

From the table, Molloplast B showed the least tear strength that demonstrated the disadvantage of silicone type materials.

## 2.9 Hardness

Unlike the hardness testing of metals, the hardness testing of soft lining materials requires different equipment since the deformation of soft materials by the indenter can recover. For this phenomena, the shore A hardness tester is used for soft materials. There was a study demonstrated that the hardness of soft acrylic resin type increased with age in the mouth as a result of leaching of plasticizer <sup>(45)</sup> leading to irritation of the oral soft tissue and ill fitting denture..

## 2.10 Water absorption

This test, in the soft lining materials, needs great circumspection because the soft materials always consist of plasticizer materials to produce softness. These plasticizers were physically blended with the polymer therefore they were easily leached out when stimulated by mastication or immersion in aqueous environment. In addition, soft lining material can absorb liquids . This is the major pitfall of any elastomer in an aqueous environment. The water uptake phenomenon of the soft lining materials was usually lasted for many years, and irrespective of the chemical structure of the elastomers<sup>(46)</sup>. The water uptake is governed not only by diffusion, but also by water-soluble impurity within polymer. The explanation of water absorption was shown in Figure 2.1.

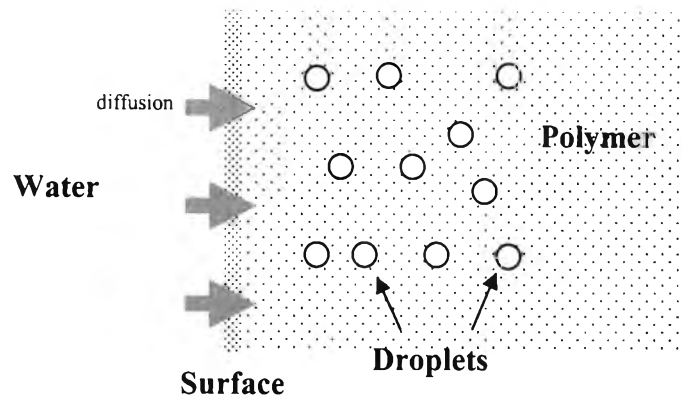


Figure 2.1. The water uptakes by water-soluble impurities

When the diffusing water reaches the water-soluble impurity site, the solution droplets are formed. The amount of droplets increase as the water absorption increases and the process can continue for a long time. The water diffusion and the droplet formation occur until osmotic pressure and elastic forces balanced. The water uptake of the acrylic soft lining material demonstrated by increasing of the material weight when it was submerged in the water at different time periods in one study <sup>(46)</sup> was shown in the Figure 2.2.

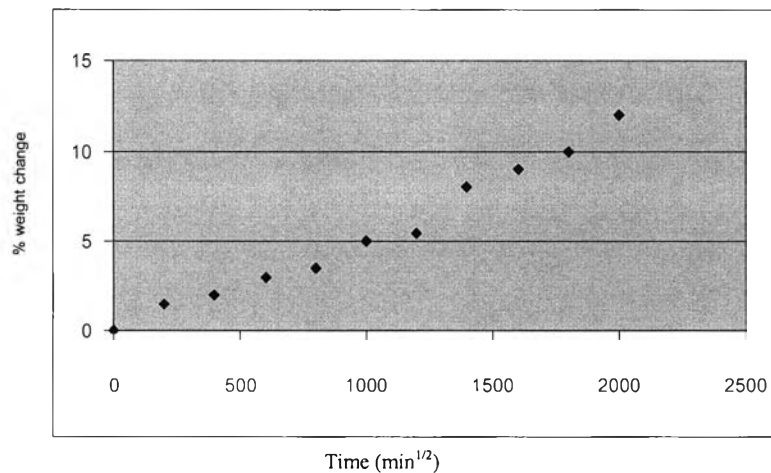


Figure 2.2. The water uptake of the acrylic soft lining material <sup>(46)</sup>.

The water uptake is the unwanted property of the soft linging material since it affects the dimensional stability of the material. This problem seems to be serious in producing a satisfactory material and is potentially not easy to solve.

Clinically, the soft lined denture is rarely placed in pure water but it is bathed in saliva in the mouth and is often soaked in solutions of denture cleanser overnight. The effects of immersion some soft lining materials in the artificial saliva have been shown to be different to those found in the distilled water<sup>(47)</sup> and the compatibility of soft lining materials and the main types of denture cleansers has also been studied<sup>(48)</sup>. There was no adverse effects identified in both studies. Recently the new oxidizing denture cleanser without any adverse effect on some soft lining materials has been reported<sup>(49)</sup>.

### 2.11 Natural Rubber

Natural rubber is the polyisoprene formed through a natural polymerization in the tree. It is obtained from more than 2,000-plant species all over the world. Natural rubber from *Hevea brasiliensis* holds shares more over than 99% of the market of natural polyisoprenes. Other plants that contain rubber are guayule, balata and gutta percha tree<sup>(50,51)</sup>. Generally, the term “natural rubber” is used for *Hevea* rubber coming from the rubber tree *Hevea brasiliensis*. The natural rubber from plants is a high-molecular weight hydrocarbon polymer consisting almost entirely of five-carbon isoprene units, C<sub>5</sub>H<sub>8</sub>. The rubber from *Hevea brasiliensis* and guayule are *cis*-1,4-polyisoprene, while that from balata and gutta percha are *trans*-1,4-polyisoprene. The molecular structures of *cis* and *trans* polyisoprene are shown in figure 2.3 and 2.4<sup>(52)</sup>.



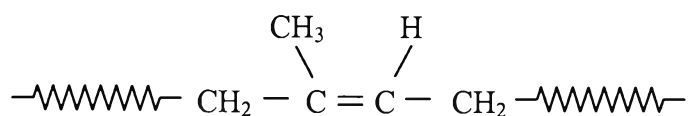


Figure 2.3. The molecular structure of *cis*-1,4-polyisoprene

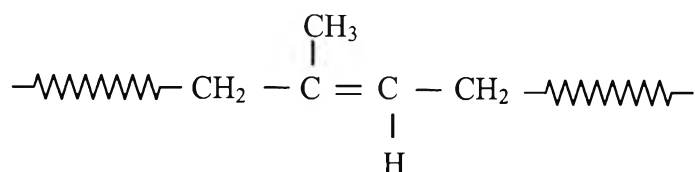


Figure 2.4. The molecular structure of *trans*-1,4-polyisoprene

### 2.11.1 Natural rubber latex

Latex is the form of liquid resin secreted from the inner bark of some trees. Latex is not tree sap. Natural rubber latex is the form in which rubber extruded from the *Hevea* trees as aqueous emulsion. The rubber and non rubber particles dispersed in an aqueous serum phase, as a milk-like liquid. Latex is harvested from the tree by a process call "tapping" and it is collected in a small cup as shown in figure 2.5. The freshly collected latex (fresh field latex) has a pH of 6.5-7.0, a density of 0.98 g/cm<sup>3</sup>, and a surface energy of 4.0-4.5 μJ/ cm<sup>2</sup>. The total composition of fresh latex, apart from water, can be summarized as shown in Table 2.7 <sup>(53)</sup>. The % content of the components varies according to clonal variations of the rubber clones.

Figure 2.5. The fresh latex was collected from *Hevea* tree by tapping.



Table 2.7. The composition of fresh natural rubber latex

Component	Content (% wt/vol)
Rubber hydrocarbon	25-45
Proteins	1-2
Carbohydrate	1-2
Lipids	0.9-1.7
Organic solutes	0.4-0.5
Inorganic substances	0.4-0.6

Separation of the latex into three principal phases is by ultracentrifugation. Both rubber and non rubber parts in freshly tapped latex are separated into three principal phases as shown in Figure 2.6. The top layer which contains the cream of rubber particles is called the rubber phase. It accounts for 25-45% of the latex by weight. The middle or serum phases occupies approximately 45-65 % and the bottom layer, the bottom phase, contains predominantly the lutoids occupying about 10% by weight .

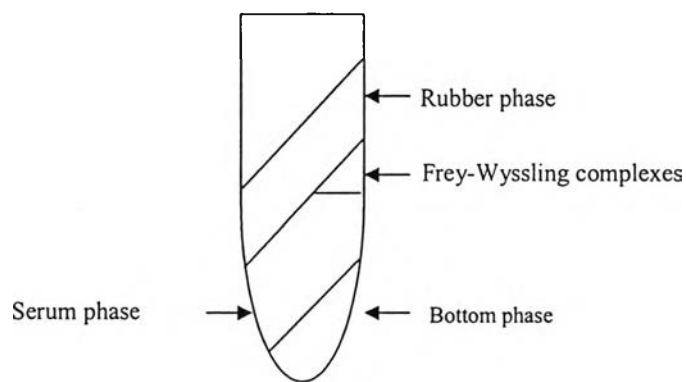


Figure 2.6. The ultracentrifugation of natural rubber latex <sup>(54)</sup>

### 2.11.1.1 The rubber phase

This phase contains the rubber particles (Figure 2.7). These rubber particles are usually spherical in shape with a diameter ranging from 0.01  $\mu\text{m}$  to 5  $\mu\text{m}$ . The hydrophobic rubber molecules, the hydrocarbon, are protected from the hydrophilic medium by a complex film of protein and phospholipid <sup>(55)</sup>.

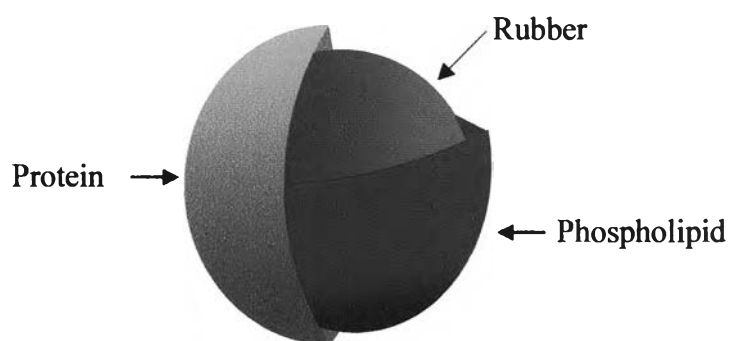


Figure 2.7. Presumed structure of a rubber particle

#### 2.11.1.2 The serum phase

The serum phase, sometimes referred to as the clear serum or C-serum or aqueous phase, contains many different chemical species, including carbohydrates, proteins, enzymes, and nitrogenous bases. The yellow color of this phase is caused by "Frey Wyssling particles" which are spherical, non-rubber particles. This color is due to the presence of carotenoid pigments<sup>(53)</sup>.

#### 2.11.1.3 The bottom phase

The bottom phase or lutoid phase consists mainly of lutoid particles. These are vacuoles with spherical membrane-bounded bodies. Within the lutoids there is an aqueous environment containing dissolved substances such as acids, minerals, proteins and sugar<sup>(53)</sup>.

### 2.7.2 The preservation of natural rubber latex

Fresh latex coagulates within a few hours after tapping from the tree. It has to be stabilized with  $\text{NH}_3$  and transported from the plantation to a factory where it

undergoes continuous centrifugation to produce concentrated natural rubber latex containing approximately 60% dry rubber content (DRC). For a long time preservation of concentrated latex, the ammonia ( $\text{NH}_3$ ) content is usually raised to 0.6-0.7%. This is referred to as high- ammonia preserved concentrated latex, low-ammonia preserved concentrated latex contains only 0.2-0.3%  $\text{NH}_3$  plus tetramethyl thiuram disulfide (TMTD), as a bactericide<sup>(56)</sup>.

Natural rubber has been widely used as a raw material of several industrial products such as tires, gloves, condoms, cushions, outsole of footwear, etc. Modification of natural rubber is necessary for the improvement of the properties and quality of rubber to match the purpose of usage. One of the most common modification methods is the grafting.

## **2.8 Graft copolymers of natural rubber**

By the term “graft copolymer” is meant a special type of block copolymer in which one or more blocks of homopolymer are grafted as a branches onto a main chain or backbone homopolymer that consists exclusively of units derived from the other monomer<sup>(57)</sup>. The polymerization is largely initiated by chemical or irradiation methods .

The graft copolymer of natural rubber is produced by polymerization of a monomer onto an existing polyisoprene chain, which acts as the backbone polymer. The physical properties of graft copolymer are greatly depended on the grafted component and frequency and extent of grafting. The general structure of graft copolymer can be indicated in Figure 2.8.

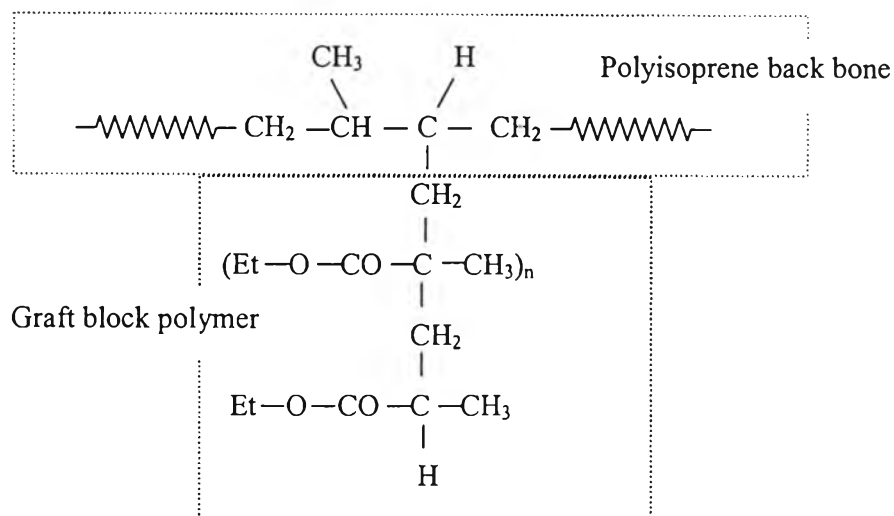


Figure 2.8 Polyisoprene is a back bone while as polyethyl methacrylate is a graft block polymer.

Nowadays, there are still no completely satisfactory soft lining materials. All of these soft lining materials available in the market are synthetic materials and quite expensive. There were many researchers tried to develop the synthetic polymers for using as the soft lining materials but they were not successful in clinical use. There was only one report on using conventional method for grafting natural rubber with polymethyl methacrylate (PMMA) as a soft lining denture base material but this material was abandoned because the reagents used for processing were toxic to the oral mucosa.

Considering the good physical and mechanical properties of the rubber, it is of interest to modify natural rubber for using as soft lining denture base materials.

Presently, the gamma irradiation has been introduced to a lot of medical and industrial productions with many advantages. One of the major advantages is the gamma ray can reduce the usage of toxic reagents usually used in several conventional methods of polymer vulcanization and grafting. In this study, the natural rubber was modified to improve its physical and mechanical properties as well as its cellular biocompatibility by using gamma irradiation in the vulcanization and grafting with ethyl methacrylate processes.

**The objectives of this research are:**

1. To prepare the high ammonia concentrated latex without TMTD.
2. To determine the proper doses of gamma ray for both of prevulcanization of concentrated latex and grafting process.
3. To prepare the graft copolymer of natural rubber with ethyl methacrylate by gamma irradiation.
4. To evaluate the ultrastructure of graft copolymer latex.
5. To examine the grafting efficiency of graft copolymer.
6. To determine the transitional glass temperature of graft copolymer.
7. To examine the physical and mechanical properties of graft copolymer.
8. To study the cellular biocompatible between the graft copolymer and human gingival fibroblasts.
9. To modified the graft copolymer for using as denture base material.