The title of thesis suggests that the work is in context to surface coating based on rosinified phenolic resin and castor oil. Thus it is appropriate to represent surface coating, with rosinified phenolic resin and polyurethanes based on castor oil.

1.1 Surface coatings

Surface coatings or paints on a substrate give aesthetic desired appearance such as gloss and color, but also provide protection against environmental influences like mechanical or chemical damages, corrosion or radiation.

Paints have been used for decorative purpose for many centuries. The cavemen the first to use the paints to record their legacy. They used the paints as the means of communication and decoration. Paint making and paint application were meant to be an art rather than a science. But after industrial revolution the whole scenario has been changed which led scientists to emphasis more one better understanding of composition. Constituents, application and testing of paints to meet the new requirements arose due to revolution. This in turn slowly transferred the art of paint-making into science which led to discoveries of new materials and new ways of application of paints, to meat the stringent requirement of protection coupled with decoration in certain instance under diverse service conditions.

Major constituents of paint generally are pigments, binders and solvents with smaller quantities of additives. A dispersion of the pigments in the binder constituents the paint film, the properties of which depend on the nature of the binder to a large extent, but the nature and quantity of pigments also affect the properties of paint film.

Pigments generally give aesthetic appearance i.e. color and opacity to paint film and some pigments also protection to much or less extent, to curd
film from UV radiation and penetration of liquids and this can be attributed to their chemical composition and structure of the pigment.

Binders in form of thermoset resins or thermoplastic polymers are the polymeric materials which form a continuous and adherent film when applied over a substrate and so often termed as film formers. They also bind pigments in the film. The performance properties of a paint film thus largely depend on the nature of binder so more emphasis will be given on binders in this chapter.

Solvents are volatile compounds leave the film by evaporation and so do not affect the performance of dry paint film. They are incorporated in paints to provide ease of processing during paint manufacturing and ease of application.

Additives are included in a paint system for many different reasons. Though they are present in relatively small quantities, they can significantly influence properties of the liquid paint and/or the dried paint film. They are used either to overcome some defects or to provide certain properties and to improve overall performance of a coating system. To reach the high quality requirements of today, additives play a major role in formulation and functioning of paint system.

1.2 Resins for surface coating

A wide range of binders as well as polyols are commercially available for coating industries now days but earlier chemists had to depend on natural products like natural resins or oils until the attempts were made to modify the natural resins to produce synthetic natural products and led to availability of synthetic polymers used in recent age. Very first synthetic plastic suitable for coating material and which is still in use today was phenolic resin, developed by Leo Baekeland in early 1900s [1]. After this, there came the new resin
called alkyd in 1923 which is used till date. After the industrial revolution, extensive research in the field of polymer chemistry resulted in the availability of numbers of different resins suitable for surface coating industries.

Resin is the continuous phase in a paint film and is largely responsible for the protective and general mechanical properties of the films. A large number of resins with different chemical composition, solubility, nature of film formation, application characteristics and performance properties of their films are available for surface coating industries. It is generally found that the performance properties of a coating system are best at higher molecular weight resin but it will be difficult to process higher molecular weight polymer during paint manufacturing or even at the time of paint application whereas at low molecular weight polymer will facilitate ease of processing during manufacturing of a coating system but at the loss of performance properties. To achieve the optimum balance between ease of processing and performance properties two distinct methods are used to arrive at final films.

In the first approach film formation takes place slowly due to evaporation of solvents from the film and no chemical reaction of any short is involved in film formation. The resin used is of sufficiently high molecular weight to provide better performance properties but the dried paint film remains sensitive to parent solvent/solvents. Such types of resins are known as non-convertible resins.

In the second method initially a low molecular weight precursor or a pre-polymer is used to provide ease of a processing an ease of application which is then converted to a high molecular weight polymer to provide better performance properties through chemical reaction known as curing. Curing reaction involves use of either simple chemicals called curing agents or another resin with some special functional groups. Such resins are referred as convertible resins.
The most commonly used convertible resins are alkyds resin, epoxy resins, amino resins, polyester resins and phenolic resins in surface coating industries are briefly discussed below:

1.2.1 Alkyd resins

Alkyd resins [2-4] form the largest group of the synthetic resins available to the paint industries and consumption is greater than that of the any other resin for wide variety of application due to their low cost and versatility [5-7]. Alkyds are formed by poly condensation of a dibasic acid and a polyhydric alcohol in the presence of glyceride oil or oil derived fatty acid and in a strict manner alkyds can be defined as oil modified polyester resin [8]. Most commonly used dibasic acid in alkyd synthesis is phthalic anhydride while glycerol, pentaerythritol, trimethylol propane, glycols, etc. are used as polyhydric alcohols. The nature and amount of oil/oil derived fatty acid determines the drying characteristics of the alkyd resin. Saturated fatty acid yields non-drying or plasticizing resin while drying properties are conferred by unsaturated acids. Alkyds are compatible with most of the resins used in paint industries like rosin, epoxy, phenolic resin, amino resin, polyurethane resin etc. So it can be easily modified to achieve specific properties [9].

Alkyd is the ‘work horse’ of coating industries which find application in printing inks, decorative as well as industrial coating and water soluble and electrodeposition systems.
1.2.2 Epoxy resins

Epoxy resins [10] are the products of condensation of epichlorohydrin and bisphenol derivatives. They are formed by condensing the reactants in presence of alkali and resulting product is known as diglycidyl ether of bisphenol. The most commonly used diphenylol derivative is 2, 2’-bis (4-hydroxyphenyl) propane also known as its trivial name bisphenol-A. It is designated as diglycidyl ether of bisphenol-A and commercially available as DGEBA. The epoxy resins with wide structural variation were commercialized [10].

Epoxy resins contain hydroxyl and epoxy groups. They can be cured by cold curing or stoving with a wide range of materials which includes amino and phenolic resin, amines, anhydrides, polyamides and isocyanates etc.
1.2.3 Amino resins

These [11] are derived by reaction between formaldehyde and urea or melamine to produce urea-formaldehyde or melamine-formaldehyde resin respectively. They are not used on their own as a coating material as they give very brittle films but widely used in combination with alkyd resins mainly and also with other resins in co-cure systems.

Amino resins used in surface coating industries modified with butanol. The modification of amino resins with butanol provides solubility in normal coating solvents and better compability with other reins in co-cure systems. Melamine formaldehyde shows better properties than urea-formaldehyde in terms of color retention and exterior durability.

Amino-alkyd systems are widely used in stoving finishes of all types. Amino resins also used with many other resins like saturated polyester, epoxides, acrylic etc.
1.2.4 Polyester resins

The product obtained from the condensation polymerization of a polyhydric alcohol and polyfunctional acid is known as polyester resin [12] and widely used in surface coating industries. The most commonly used polyfunctional acids are maleic anhydride, phthalic anhydride, adipic acid, sebacic acid etc. whereas ethylene glycol, propylene glycol, diethylene glycols are used as polyhydric alcohol. Depending upon the raw material used, polyester can be either saturated polyester or unsaturated polyester. Both find extensive use in surface coating [13-17]. Unsaturated polyester are cured by many different ways but the basic reaction of curing is free radical initiated addition reaction. Free radical initiation can be achieved either at elevated temperature by use of an electron beam or UV beam or certain metal ions as a catalyst by decomposition of peroxides. Unsaturated polyesters are
generally dissolved in reactive solvent such as styrene to produce final resin and then curing is carried out. Saturated polyesters are such formulated so that produce high hydroxyl contents as they are mainly used in production of polyurethane. They also react with some amino resins.

![Diagram of polyester resin reaction](image)

Figure: 1.5 Polyester resin

1.2.5 Phenolic resins

In 1899 Arthur Smith took out British patent 16274, on phenol–aldehyde reaction. In due course Leo Hendrik Baekeland discovered techniques of controlling and modifying the reaction that useful products could be made. The first of his 119 patents on phenol–formaldehyde plastics was taken out in 1907 and in 1910; the general Bakelite Company was formed in United States. Within a very few years the material had been established in many fields, particular for electrical insulation. The initial phenol-formaldehyde products may be of two types, novolacs and resoles. Phenolic resin chemistry has been discussed in detail elsewhere [18-22].

Synthetic Phenolic resins were developed and commercialized in the early 1900s by Leo Baekeland [23]. The reaction of phenol and formaldehyde
produces a product that forms a highly cross-linked three-dimensional polymer when cured.

Phenolic resins have two basic classifications: (A) resoles and (B) novolacs. Resoles, or heat-reactive resins, are made using an excess of formaldehyde and a base catalyst. The polymer that is produced has reactive methylol groups that form a thermoset structure when heat is applied. Novolaks are made using an excess of phenol and an acid catalyst. Reaction occurs by the protonation of the formaldehyde, [24] and the intermediate is characterized by methylene linkages rather than methylol groups. These products are not heat reactive, and they require additional cross-linking agents such as hexamethylenetetramine to become thermosetting. These reactions can be thought of as nucleophilic attack of phenoxide ion on the formaldehyde, or electrophilic substitution by protonated formaldehyde on the aromatic ring.

(A) Novolacs

The novolacs are prepared by reacting phenol with formaldehyde in a molar ratio of approximately 1:0.8 under acidic conditions. Under these conditions there is a slow reaction of the two reactants to form the o- and p-hydroxymethyl phenols. These materials will then slowly react with further formaldehyde to form their own methylol derivatives, which in turn rapidly react with further phenol to produce higher polynuclear phenols. The novolacs are sometime referred as two stage resins as it is necessary to add some curing agents that will enable additional methylene bridge to be formed.
(B) Resoles

A resole is produced by reaction of phenol with an excess of formaldehyde under basic conditions. In this case, the formation of phenol-alcohols is rapid but their subsequent condensation is slow. Thus, there is a tendency for polyalcohols, as well as mono alcohols, to be formed. The resulting polynuclear polyalcohols are of low molecular weight, while a solid resole may have only three to four benzene rings per molecule. Heating of these resins will result in cross-linking via the uncondensed methylol groups or by some complex mechanism. It is also called as one stage resin.
Application of phenolic resins

Phenolic resin have been widely used as paint, adhesive, coatings, composites, laminates, foundry resin, friction materials, abrasive material, in rubbers, heat and sound insulation materials, moulding compounds and matrix materials due to their excellent flame, heat, water, chemical resistance, dimensional stability, electrical insulation [25-27].

Phenolic resins are useful in adhesive preparation. They are also used on a wide variety of substrate including applied wood, paper, ceramics and metal coil to give a rigid, heat and water resistance structure.

Phenolic resin polymers have been used in the surface coatings industry for many years because of their excellent performance properties and their relatively low cost. Some of the major applications are in rigid packaging [28], maintenance primers [29-33], printing ink [34, 35], as epoxy hardeners [35].
Phenolic resins have been widely used as paint, adhesion and matrix materials due to their excellent flame resistance, dimensional stability and chemical resistance. Phenolic resins are brittle in nature to improvement of the toughness of phenolic resin is an important task for further application by modification. In terms of our present goal, therefore, we focus on modification of phenolic resin with rosin more particularly rosin modified phenolic resin.

1.3 Rosin

Rosin, also called colophony or Greek pitch (Pix gracea), is a solid form of resin obtained from pines and some other plants, mostly conifers, produced by heating fresh liquid resin to vaporize the volatile liquid terpene components. It is semi-transparent and varies in color from yellow to black. At room temperature rosin is brittle, but it melts at stove-top temperatures. It chiefly consists of different resin acids, especially abietic acid [36]. The term "colophony" comes from colophonia resina or "resin from the pine trees of Colophon," an ancient Ionic city.

![Structure of abietic acid](image)

**Figure: 1.8 Structure of abietic acid, a component of rosin.**
The rosin is a natural resin obtained from pine tree. Gum rosin, wood rosin and turpen oil rosin are the types of rosin. It contains about 90% Abietic acid and its isomers - dextropimaric and levopimaric. Gum rosin is an ingredient in printing inks, photocopying and laser printing paper, varnishes, adhesives (glues), soap, paper sizing, soda, soldering fluxes, and sealing wax. Rosin can be used as a glazing agent in medicines and chewing gum.

Rosin is composed primarily of resin acids and modified resin acids such as dimers and decarboxylated acids. Rosin acids are the complex mixture of several compounds, particularly abietic acid types and the pimaric acid types which belong to the diterpene group of organic compounds. Abietic acid has conjugated double links and carboxyl groups. Pimaric acid is the dehydro form of abietic acid. Oxidation of abietic acid makes colophony more brittle and darker. The carboxyl group and double links in the acids can yield many kinds of salts and modified compounds for better purposes. Rosin and modified forms (salts and esters) are used in making papers, varnishes, paints, adhesives, and some soaps. Modified products with fumaric and maleic acids (or anhydrides) are used in manufacturing alkydes. Other uses include sizing for paper products, paint dryers, plasticizer in rubber, waterproofing, emulsified oils, dressings for machine belting, enamels used in ceramic manufacture, roofing cement, sealing wax, linoleum, oil cloth, lutes ointments, plasters, veterinary medicines, disinfecting compounds, dry batteries and electrical insulation, production of fungicides, antislip agents for floors and shoes, violin bows [36].

It possess good properties such as water, alkali and acid resistance and which are expected from a surface coating materials. Therefore, rosin acids are chemically modified to increases their coating application but a low amount in formulation. The most modified rosins are limed rosin, ester gum, maleic modified rosin and rosin modified phenolic resins, obtained by hydrogenation, and disproportionation of rosin acids [37-41].
1.4 Rosinified Phenolics

Rosin, a natural resin, contains abietic acid and its double bond isomers as main components. In 1910 oil-soluble modified Phenolic resins were produced by BEHRENDS polycondensation of phenols, formaldehyde and rosin. Resols reacts with the unsaturated centers of these resin acids to form polycarboxylic acids with methylene bridges [42-45].

These condensation products from rosin and phenol-formaldehyde resin are known as sorbitol acids. They can be converted by esterification with polyols, or by salt formation, into higher molecular mass products which are readily soluble in nonpolar solvents but can release the solvents rapidly. Although the term rosin modified phenolic resins has become established, phenol-modified rosins would be more appropriate because rosin predominates in quantity and character. These rosins were also known as synthesis copals because they were able to replace natural copals on account of their technological advantages [45].

The most common phenols used in the modification of rosin are 4-tert-butylphenol and 4,4’-diphenylpropane (bisphenol-A). Through this choice and the wide variation in the ratio of phenol to formaldehyde, a large number of rosin-modified phenolic rosins are accessible. The number is increased still further by the fact that polymerized-dimerized rosins can also undergo this reaction [36].

The melting point of this group of rosins is in the range of 100-180°C the acid value varies between 10 and 40. Special types with higher acid values (up to 140) also exhibit good solubility in alcohol. Rosin-modified phenolic rosins can be combined with many alkyd rosins and also show good oil compatibility. They accelerate the drying of coating, increase the resistance to water and chemical, and improve the gloss. Rosin-modified phenolic rosins are used in alkyd coatings, printing inks, specially for gravure and offset printing [43, 45].
Resoles also undergo analogues reaction with other natural or synthetic unsaturated compounds such as fatty oils, rubbers, and polymer oils. A limited increase in the molecular mass or cross-linking can thus be achieved. Whether a particular reaction can be carried out successfully depends on the ratio of the rate of auto-condensation of the starting materials to co-condensation with the other reaction partners, but particularly on their mutual compatibility. Phenolic resin are therefore often classified as water-soluble, alcohol-soluble, oil-soluble etc. Compatibility of resoles with other components can be produced in many ways, e.g.

(1) by using ring-alkyd phenols as the raw materials;

(2) by esterification of the hydroxymethyl groups with alcohols;

(3) by co-condensation of the resole with natural resins; or by a combination of these measures [44].

Properties

Rosin modified phenolic are soluble in coal tar, esters and terpantine. Insoluble in alcoholic solvents. Partially soluble in petroleum solvents and mixed well with vegetable oil of high softening point.

Usage and Application

Rosin modified Phenolic resin are used in printing inks, in oil lacquers and as additives to alkyd paints because good compatibility with natural oils in which they improve the drying and shine. It can be polymerized by cooking with vegetable oils to make Phenolic paints with fast drying, good hardness and high gloss. They can improve the adhesion and reduce the cost for pressure-sensitive adhesive, hot-melt adhesive and other bonding agents. They also can improve the gloss and bulkiness for printing inks.
These resins are soluble in oils and these resins are known as rosin modified phenolics which find extensive application in decorative undercoats, primers, marine paints and in certains types of printing inks [43].

\[
\begin{align*}
\text{Where, } R &= -C_2H_4
\end{align*}
\]

**Figure: 1.9 Rosinified Phenolic Resin**

### 1.5 Castor oil and its reaction product

Castor oil, obtained from the Castor nut (Ricinus communis) (oil content approx. 50%), is an unusual oil in that it contains a very high amount (900/) of ricinoleic acid: a hydroxy moiety-containing fatty acid (12-hydroxy-9c-octadecenoic acid) (Fig. 4). It is at present the only commercially available source of natural hydroxylated triglycerides. Although castor oil in itself has no drying properties, it is interesting oil for the coating industry. This is to some extent due to the fact that its hydroxyl functionality allows the oil to be used, for example, in polyurethane coatings. Also the hydroxyl functionality imparts a high viscosity, stability and polar solvent (alcohol) Miscibility to this oil, making it useful as viscosity modifiers, plasticizers and wetting agents in various applications [46-48].

The versatility of castor oil can be further enhanced by a catalytic, high-temperature conversion of this oil to dehydrated castor oil. In this process the ricinoleic acid in castor oil is converted to partially conjugated
fatty acids, rendering oil drying properties that are intermediate to linseed and tung oil. Dehydrated castor oil yields pale, non-yellowing films with outstanding color retention properties that are exploited in vehicles for gloss lithographic inks, metal decorating inks as well as in air-drying and stoving alkyd resins. It is seldomly used as an oil in air-drying varnishes or paints, since after drying it retains a characteristic ‘after-tack’ for some time [49-50].

Castor oil is used in various forms in the surface coating [51, 52] and other industries [53-56]. Several modification of castor oil are also attempted [57] and find many applications. The peer review about castor oil. Its modification is given in chapter-2.

Castor oil and its many derivatives have been successfully used for at least twenty years polyols for the preparation of polyurethane, particularly in the preparation of polyurethane coatings [58-64], adhesives and casting compounds [65-70]. Urethane are prepared by the reaction of polyhydroxy compounds such as castor oil with polyfunctional isocyanates. Urethane prepared from castor-based polyols are characterized by their excellent hydrolytic stability and shock absorbing and electrical insulating properties [71-80].

Transesterification (alcholysis) of castor oil [81-83] with polyols results in castor oil polyols with higher or lower hydroxyl value functionality. Polymerization of castor oil, chemical or oxidative, results in higher viscosity or bodied oil, which are more useful in urethane coatings then the unreacted castor oil [65]. Other derivatives used to prepare urethanes are amides prepared by reaction of castor oil with alkanolamines, amides of ricinoleic acid with long chain di and triamnes and butanediol dirinileate [84]. Other methods of preparing castor-based polyols are by acetylation, dehydration, epoxidation and hydrogenation.
Castor oil and its polyol derivatives have found to be very useful in the preparation of the rigid, semi-rigid and flexible urethane foams. These foams are resistant to moisture, shock absorbing and have good low temperature flexibility. Castor-based urethane foams have been used in the manufacture of foam packaging, in application requiring high shock absorbing properties, in clothing interliners and in filters. High density semi-rigid castor-based urethane foams have also been used for potting electrical components where their excellent electrical and shock absorbing properties as well as their excellent hydrolytic stability are utilized.

Castor oil’s resistance to hydrolysis, pigment dispersion ability and compatibility with polyether polyol has also made it useful as modifier for polyether-based foams. Foams based on castor oil are semi-rigid at low densities and become more rigid as the foam density increases. These foams generally possess an open cell structure [65]. Castor oil can be used to formulate commercially acceptable rigid polyurethane foams for such uses as thermal insulation and structural support [85]. Superior rigid polyurethane foams have been prepared from hydroxymethylated polyol esters of castor acids [86]. Recently considerable emphasis has been placed on developing fire-retardant urethane foams. Brominated castor oil has been investigated as a modifier for preparing fire-resistant urethane foams [87, 88].

![Figure: 1.10 Castor oil](image)

**Figure: 1.10 Castor oil**
The modified oils have higher hydroxyl values and lower number of unsaturated acids polyol than the unmodified oils. Castor oil can be modified to produce modified polyols that react with isocyanates to form polyurethane foams, elastomers and coating. For polyurethane coating system polyols are major components, which designed to suit the performance and requirements of the product [89].

1.6 Polyurethane chemistry

The polyurethane chemistry is centered on the reactivity of isocyanate groups with compounds carrying labile hydrogen atoms like hydroxyl or amine functions. There are many compounds that contain active hydrogen like water, alcohol, amines hydroxyl groups etc. Thus polyurethane film may contain ester, ether, amide, urea or other groups. The hydroxyl component may be polymeric polyols like polyesters, polyether, vegetable oils etc. Diisocynates generally used toluene diisocyanate (TDI), isophorone diisocyanate (IPDI), hexamethylene diisocyanate (HMDI) etc. Aromatic isocyanates are more reactive than aliphatic ones with decreasing reactivity from primary through secondary to tertiary isocyanate groups unless steric or catalytic influences result in reversal reactivity. Primary and secondary alcohols will react easily at 50-100 °C while tertiary alcohols and phenols will be slower. The reaction of primary and secondary aliphatic amines or primary aromatic amines with isocyanates at 0-25 °C will proceed rapidly. Isocyanates are also very sensitive to water to yield amine groups. Therefore, PU paint films possess a complex polymeric structure with urethane groups but also urea, biuret or allophanate coupling groups. Polyurethane can be either single pack or two pack system. The basic reaction scheme of diol and diisocyanate are as follow.
The polymer known as polyurethanes are widely used in the fields of daily life due to its excellent wear resistance, toughness, mechanical properties and chemical resistance. It is an important class of block polymer in which the properties of the end product can be designed according to the user need. Due to potential large volume of applications combined with high versatility in the properties, these materials require a thorough understanding of synthesis and properties as well as update of knowledge.

The ability of a synthetic chemist to maneuver numerous possibilities and combinations ideally suits the synthesis of polyurethanes and their development. Polyurethane comprises a class of materials ranging widely in their properties and this versatility is associated with a greater than normal complexity in manufacture. Indeed the manufacture of polyurethanes involves a greater degree of control of chemical reactions than most other polymers. Their properties range from liquid, soft and rubbery solid to rigid thermoplastics and thermoset materials [90-93].
Polyurethanes are long chain molecules in which different chemical fragments are linked by the \(-\text{NH} \leq \text{C} \leq \text{O} -\) linkage. The chemical term for the unit is an ester of carbonic acid but the whole of this polymer is called polyurethane, which is a misnomer that arose from the compound ethyl carbamate (H$_2$NCOOC$_2$H$_5$), which has been known for many years by the simple term “Urethane”.

There are wide ranges of raw materials; both active hydrogen containing compounds as well as isocyanate bearing monomers, available to design the polyurethane building blocks. The resulting oligomers / polymers can be obtained for tailor-made performance in surface coatings. In fact the polyurethane resins have proven high performance film forming binders for variety of industrial coating applications. This is due to their inherent characteristics in terms of

(a) Wide range of flexibility coupled with toughness

(b) High chemical and abrasion resistance and

(c) Low temperature cure [94].

Application of polyurethanes

Despite the outstanding gloss, weatherability and solvent resistance of PU coatings, the optimization of their scratch resistance and impact toughness would greatly broaden their spectrum of application. In recent years, nanotechnology has experienced significant growth in the field of materials. The area of coatings has not been spared and the combination of inorganic nanoparticles with organic building blocks, in particular, has led to innovative materials with novel properties and functions as outlined below.

Polyurethane possesses a unique combination of performance and application properties with excellent abrasion resistance, flexibility, hardness, chemical resistance, UV light resistance and anti-microbial characteristics [95]. A great number of factors, which affect or influence the properties of
polyurethane resins, are nature of polyol and diisocyanate, crosslinking density, NCO/OH ratio, curing conditions, etc [96, 97].

Over the last few decades polyurethanes are widely used as adhesive materials and have developed a reputation for reliability and high performance in many applications including footwear industry, packaging applications, plastic bonding, furniture assembly and the automotive industry.

Polyurethanes are rapidly developing products of coating and paint industry because of unique combinations of performance and application properties such as excellent elasticity, high hardness, high scratch and abrasion resistance, excellent impact resistance, high water, solvents, acids and alkali resistance and resistance to degradation from light and weathering. The polyurethane coated fabrics find applications in inflatable structures, conveyer belts, protective coatings, biomaterials, etc [98, 99].

Polyurethanes are very appealing class of polymers for use in the biomedical field. This is because of their relatively good biocompatibility, their physical properties and the ease with which their properties can be tailored to end use. They are widely used in the development of medical devices, for tissue and blood contact such as mammary prosthesis, vascular catheters, artificial skins, vascular grafts, artificial heart diaphrams and valves. They can be biodegradable depending upon their chemical structures [99].

1.7 Objectives

The objectives of the produced research work are,

(1) To study the polyurethane coats based rosinified phenols and castor oil/modified castor oil blends with diisocyanates.

(2) To develop modified castor oil and rosinified phenolics.
1.8 Present work

In the view of above objectives, the research work was carried out in which castor oil/modified castor oil blended with rosin ester modified phenolic resin by admixing to obtain polyols which were reacted with aliphatic and aromatic diisocyanates to form polyurethane. The coating behaviour of the resulting systems was studied and whole research work is bifurcated six chapters of the thesis.

The blends of rosin ester modified phenolic resin and castor oil/modified castor oil prepare and their synthesis as well as characterization is summarized in chapter-2.

Polyurethane coating performance properties on ms panels have been studied. All the details are furnished in chapter-3.

Thermal analysis of polyurethane films were studied the whole study of system is given in chapter-4.

The blends of rosin ester modified phenolic resin and brominated castor oil prepare and their synthesis as well as characterization is summarized in chapter-5.

Thermal and flame retardant properties of polyurethane films were studied the whole study of system is given in chapter-6.

The whole work is scanned in scheme-I, II and III.
Scheme-I

Modified castor oil + RPR

Blend

Toluene diisocyanate | Isophorone diisocyanate

MCO+RPR+TDI | MCO+RPR+IPDI

Casted into film

Characterization of Film

Scheme-II
Scheme-III
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