SUBSTITUTES

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A Handbook of Substitutes and Alternatives for Chemicals, Metals, Fibers and Other Commercial Products Including a Plan for Making a Proper Choice

by
H. BENNETT
Technical Director, Glyco Products Co., Inc.
Editor-in-Chief — The Chemical Formulary

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Preface

HISTORICALLY, this book was started about sixteen years ago. At that time, the cosmetic, drug and flavor industries were seeking substitutes for glycerin and ethyl alcohol—for economic reasons and to avoid the "red-tape" connected with the buying, storage, use and selling of alcohol and alcoholic products. Fair substitutes were developed for both of these products, but when the price of glycerin was stabilized at a reasonable figure, these substitutes were almost completely forgotten.

Over a period of years, the writer has developed substitutes or alternatives for numerous products in diverse industrial fields. Thus, a file of such materials has been built up. To this has been added the suggestions of others and references from scientific and technical journals and texts.

This book cannot be regarded as complete or encyclopediac. The subject matter is in a state of flux and is growing and changing continuously and continually. It should be useful to many as a starting point. It should not be expected to give the final answer to a highly specialized need. It is the task of the specialist or expert to glean from it what may

be applicable and to interpret, interpolate or "imagineer" a solution to his specific problem.

Condensation, rather than elaboration, has been the precept in assembling this information, in order to expedite the publication of this book. It is the concentrated essence of many years of experience of many chemists, engineers and other technical workers.

The writer will greatly appreciate learning of any errors or omissions or additions that might be made, from those who use this book. Grateful acknowledgement is made to Kenneth Tator, Chemical Consultant of the War Production Board, Division of Industrial Conservation, Conservation and Substitution Branch, for his kind assistance as well as to others, who prefer to remain anonymous, who also were most helpful.

H. BENNETT

Introduction

WHETHER they be called substitutes, replacements or alternatives, such materials have been used from time immemorial. Sometimes they have been used to reduce costs; sometimes to replace unobtainable materials; and sometimes to produce better or different properties.

Selecting the proper substitute is no easy task. Since no material has all the same properties as the material which it will replace, it cannot be expected that the replacement will yield a finished product possessing exactly the same characteristics as the original. A replacement, therefore, that will produce a finished product which will perform almost the same function as the original, without too great difference, is ordinarily considered satisfactory. For example glycerin, in an anti-freeze, has been satisfactorily replaced by ethylene glycol even though the two products differ in certain chemical and physical properties.

A substitute material, excluding price and availability, must be considered from many angles before it can qualify as a good substitute. Since it cannot have *all* the same physical and chemical properties

as the original material, a compromise must be made. Thus, corn syrup may be suitable as a glycerin replacement in a suspending medium, where its viscosity is primarily desired, as in certain tooth-pastes. It is not of importance that corn syrup does not lower the freezing point of water or that it is not as hygroscopic as glycerin. Where, however, the last two factors or others are important, the use of corn syrup in place of glycerin, is not advisable.

Even when a suitable substitute is found, it may be necessary to modify the original formula by using a smaller or larger amount of the substitute and often, to add one or more other ingredients to balance it. Thus, because corn syrup is more viscous and less hygroscopic than glycerin, it may be necessary to reduce its viscosity by the addition of water and increase its hygroscopicity by means of a compatible hygroscopic salt. Introduction of these two additional ingredients may require considerable testing and aging to avoid subsequent undesirable effects.

Because of the uncertainty of the continued availability of any substitute material, it is advisable to try out a number of materials on each problem, so as to have a substitute ready for the substitute used. It means additional work, but is a worth while insurance for continuance in business.

Sometimes it may be desirable to change the composition of a formulation radically or entirely because a suitable substitution cannot be made. For example, flavoring extracts depend on the use of

pure alcohol as the solvent for the flavoring ingredients. Since there is no good substitute for alcohol (in food products) available, a formulation without alcohol is indicated, e.g., an emulsion of the flavoring ingredient (e.g. lemon oil) made with an edible gum (gum tragacanth) and water. Of course, the finished product does not look like the original lemon extract, but it can replace it in most of its uses.

Price should not be too great a deterrent in selecting a substitute. Sometimes a substitute will alter a product so as to make it more useful, desirable and salable. An example of this is the use of monoglycollin in place of glycerin. Although the former is more than twice as expensive as the latter, its much greater solvency for certain dyes makes it far more economical to use than the cheaper material which it will replace. In electrolytic condenser manufacture, mannitol, at about three times the cost of glycerin, is replacing the latter because it gives a much more desirable product.

In getting outside assistance in finding a substitute, it is important to disclose a problem in its entirety. Reputable manufacturers and consultants hold all communications in strict confidence. Therefore, give them the complete formulation, method of manufacture, packaging and a sample of the finished product. Also inform them how and where the finished product is to be used. Only with such complete information can an intelligent recommendation be made.

Substitute Requirements

EVERY CHEMICAL IS UNIQUE in its chemical and physical properties. Therefore no chemical can replace another equally in all its characteristics. The following list which should be scrutinized gives most of the factors which must be considered in searching for a suitable substitute or alternative. Only those properties which are absolutely essential should be demanded, otherwise the search for a substitute will be greatly hampered, if not made futile.

Availability
Homogeneity
Uniform Replacement
Grade or Purity
Form
Optical Properties
Odor
Taste
p H
Density and Specific Gravity
Viscosity
Gelling or Thixotropic Tendencies
Freezing Point (Melting Point)
Vapor Pressure
Sublimation
Boiling-Point
Solubility
Hardness
Tenacity or Cohesion
Plasticity and Ductility
Flexibility
Elasticity
Length
Stickiness
Adhesion

Slipperiness
Drying Qualities
Feel or "Hand"
Cryoscopic Properties
Hygroscopicity or Efflorescence
Inflammability
Explosiveness
Toxicity
Effect on Skin, Hair or Finger-Nails
Edibility
Thermal Changes
Effects of Pressure
Solvency
Plasticizing or Flexiblizing Properties
Interaction With Other Materials
Stability
Bacterial Content
Emulsifiability
Surface Tension
Dispersing Properties
Adsorption and Absorption
Heating Power
Lighting Power (Candle Power)
Electrical Properties
Thermal Conductivity
Radio Activity
Handling
Legal Restrictions

Availability

Unavailability, now due primarily to a world wide war, is not a new phenomenon. Shortages or unavailability of certain materials have existed at certain times in various parts of the world—grain in Egypt, during Biblical times; rice in China in modern times; oils and fats in Germany, during the first World War; quinine, rubber and other monopolistically controlled commodities because of restrictions in production and sale, prior to the second World War; silk, quinine, rubber, coconut oil and many other raw materials in the United Nations,

today, because the sources are controlled by the enemy.

Availability—the ability to get a material when and where it is wanted is of paramount importance. No matter how good a substitute may be, it is useless if not available. Therefore, the first step is to make sure that the substitutes, to be examined, are in plentiful supply; that they be preferably of domestic and not foreign origin; that the known suppliers will be able to take care of quantity requirements as needed.

With conditions being as they are today, it is seldom possible to plan ahead, as far as raw materials are concerned, for more than about three months. What is available today may soon become unavailable. However, since all consumers are subject to this same uncertainty, everyone is on an equal footing. That is why secondary substitutes must be decided on, in the event that the best substitute cannot be obtained.

Homogeneity

Homogeneity implies uniform composition so that every part of a substance or mixture is of identical composition and appearance. Some products change in homogeneity because of differences in specific gravity, solubility or for other reasons and produce a nonuniform condition. They must either be stabilized against such change or must be mixed or warmed to produce homogeneity before use. If the

material is such that it cannot be brought back to its original state of uniformity (e.g., a decomposed glue) then it should not be used.

Uniform Replacement

Uniform replacement refers to the ability to obtain the same grade of product each time that it is ordered. Slight variations when unavoidable, may be compensated for, by technical control. Large or certain types of variations may make a product unusable. Thus, traces of copper are undesirable in materials used in rubber compounding. Consequently a material, which is the same in all respects, as previous deliveries, would be ruled out if contaminated with copper or its compounds. A material containing 0.1% of iron might be suitable, for another purpose, but if the iron content increased to 0.5%, it may no longer be usable.

Grade or Purity

The following grades of chemicals may be available:

C. P.
Commercial
Technical
Special
Natural
Synthetic
U. S. P.

B. P.
Unofficial
N. F.
N. N. R.

C. P. stands for chemically pure. Each container usually bears a label of analysis, indicating the amounts of impurities present. This grade is usually the purest grade of chemical available. It is generally more expensive than the other grades but it is not specified except when high purity is required.

Commercial is the most common grade of chemical sold. Any chemical which does not bear a grade designation can be considered of commercial grade.

Technical is the ordinary commercial grade or some slight variation from it. This grade should not be used for food, drug or cosmetic purposes without investigation.

Special refers to a particular grade made for a particular consumer or industry. It is different, in degree, from all other grades—either more or less pure. Its form and packaging may also be different.

Natural refers to a crude or refined product of vegetable, mineral or animal origin, e.g. crude or resublimed iodine or camphor.

Synthetic refers to a chemical which is built up from a number of different chemicals by a chemical reaction, process, e.g. synthetic menthol. A synthetic chemical usually contains fewer impurities than the corresponding natural product.

U. S. P. refers to the United States Pharmacopoeia, an official compendium giving the requirements for purity for many drugs and chemicals. A drug or chemical marked U. S. P. indicates that it meets all the specifications of the United States Pharmacopoeia

B. P. refers to the British Pharmacopoeia, an official British compendium giving the requirements for purity for many drugs and chemicals. A drug or chemical marked B. P. indicates that it meets all the specifications of the British Pharmacopoeia.

Unofficial indicates that the drug and chemical has not been tested by the proper authorities and that it is not yet officially recognized in the pharmacopoeia.

N. F. shows that the product is listed in the National Formulary and is recognized by the American Pharmaceutical Association.

N. N. R. shows that the product is listed in New and Non-Official Remedies and is recognized by the American Medical Association.

Form

Materials occur or are produced as gases, liquids or solids. These are always the same under the same conditions of temperature and pressure. Gases and liquids usually do not exhibit any variation in appearance, handling or use under similar conditions. Solids, however, do differ and may cause trouble. If they are crystals, the crystals may be large or small.

A substitute may have a different crystalline form or shape (needle-like, cubical, etc.) which if used dry, may be undesirable because of appearance or bulking properties. Powders, likewise consist of particles which may vary in size. Such variations not only affect appearance but also density, flow, agglomerating or "caking" tendencies, suspension, deposition, friction and other properties.

Optical Properties

A. Color
B. Clarity
C. Fluorescence
D. Phosphorescence
E. Iridescence
F. Refractive Index
G. Reflectance
   a. Dull
   b. Shiny

Color is of importance not only for appearance, but also where staining, dyeing or pigmentation will occur. The color of a material may vary with the size of the particles, larger particles being darker. Thus crystalline copper sulfate is blue while the finely powdered material is a very light blue. Certain materials lose or change their color on being dissolved, dehydrated or on interaction with another ingredient.

Clarity refers to clearness and freedom from haze

or turbidity. Most commercial products are clear. Sometimes they develop a haze, turbidity, deposit or a sediment, especially in metal containers. Others lose clarity even in glass containers, because of polymerization (e.g. formaldehyde).

Fluorescence is the instantaneous re-emission of light from a substance, of a greater wavelength than that light originally absorbed. Common examples are seen in a solution of fluorescein in water and in certain types of mineral oils.

Phosphorescence is the re-emission of light, after a time-lag, of a longer wave length than that absorbed. This phenomenon is typified by the glowing of yellow phosphorus, in the dark.

Iridescence is the rainbow like play of colors as of pearls and soap-bubbles.

Refractive index is the relationship between the speed of light in a vacuum and its speed in a substance. The refractive index of a substance determines the degree of bending or distortion of an object viewed thru the substance. Thus it is of importance in adhesives for cementing optical glass, transparent plastics, etc.

Reflectance refers to the fraction of light which is reflected when light falls on any surface. Thus a rough surface reflects very little whereas a smooth surface reflects more light. The former appears dull and the latter shiny.

Odor

A. Pleasant
B. Unpleasant
C. Strong
D. Faint
E. Temporary
F. Permanent

Odor is the effect on the sense of smell produced by particles emanating from a substance. In many products such as food, cosmetics and household articles, odor is an important factor. Where an undesirable odor cannot be eliminated, it may often be "covered-up" by a stronger more desirable odor.

No odor is equally pleasing to all. Certain types of pleasant odors are bland, refreshing or stimulating and are not objectionable in certain products. Unpleasant odors may be sickening, irritating or depressing. An odor may be strong or faint. Faint unpleasant odors are more tolerable than strong unpleasant odors and may be masked more easily.

Very volatile odors may only be temporary and may disappear quickly on ageing, storage or use. Permanent odors must be recognized as an ever present factor.

In blending various materials there may be a diminution of odor, caused by the dilution or change in character or strength of the substance. These changes may result from decomposition or interaction with another ingredient.

Taste

Sweet
Sour
Bitter
Salty
Spicy
Oily
Fruity
Neutral or Tasteless
Pleasant
Unpleasant
Strong
Permanent

Taste is a factor in those products that enter the mouth. Such products are foods, beverages, medicines, dentifrices and certain cosmetics for the lips.

Pleasant tastes may be sweet (as in sweet chocolate) sour (as in lemon drops); bitter as in hops, used in beer making); spicy (as in ginger); salty (as in brine); oily (as in olive oil); neutral or tasteless (as in water); fruity (as in berries).

Just as with odors, strength and permanence are of importance, and must be given due regard. An undesirable taste may often be "covered-up" by a stronger or more desirable taste. Certain tastes which are unpleasant, when too strong, are more pleasant when diluted, e.g. saccharine.

p H

p H is the logarithm of the reciprocal of the hydrogen ion concentration in gram molecules per liter or, more simply, a measure of acidity or alkalinity of a water solution of a substance. Pure water, which is neutral has a p H of 7. Any p H value above 7 is considered alkaline and below 7 is considered acid.

Thus the p H of a solution of a material is indicative as to whether it is alkaline or acid and sometimes is a measure of its strength. This is a clue to how it will affect materials with which it is mixed or with which it is or may come into contact. Further details of the influence of acidity and alkalinity are given in the section on Interaction With Other Materials.

Density and Specific Gravity

Density is the weight per unit volume, e.g., pounds per cubic foot. Specific gravity is the relation between the weight of given substance compared with the weight of an equal volume of water, at the same temperature.

The density or specific gravity of a product will vary with its purity, porosity, size of its particles and the process by which it was made.

Density or specific gravity are critical factors where bulking value, suspension, low cost, etc. are important.

Thus calcium carbonate will vary in density or

specific gravity, depending on whether it is in the form of natural limestone, marble or chalk or a chemically precipitated product.

Viscosity

Viscosity is the resistance of a fluid to shear, agitation or flow.

More commonly it refers to rate of flow of a specific liquid as compared to water or any other commonly used liquid.

In some cases, viscosity is of importance because the greater the viscosity of a liquid the lower the rate of flow, spreading, penetration, wetting, etc., and the better its suspending power. A lower viscosity, of course, reverses these properties. A viscous liquid is harder to mix, fill, pour and apply than a less viscous liquid.

Viscosity may be increased or lowered by suitable additions and treatments. Thus the viscosity of mineral oil can be increased by heating it with some aluminum stearate; the viscosity of an alkaline casein dispersion can be reduced by means of urea. Other specific methods for altering viscosity are known and these should be used when a substitute is suitable in all other respects.

Gelling or Thixotropic Tendencies

Gelling is the formation of a gel or jelly like substance, e.g., glue or agar with water.

The thixotropic state refers to a gel which liquifies on shaking or stirring, and which regels on standing, e.g., iron hydroxide or certain clay suspensions in water.

Gelling may be desired in certain cases as in hectograph (duplicating) compositions, whereas in the case of a paint, gelling, which would prevent brushing or spraying, is undesirable.

Gelling may be due to the colloidal properties of a single substance in a liquid (as with gelatin and water) or may result from the interaction of one or more substances (as with sodium silicate and dilute hydrochloric acid.

Gelling may be temporary, as in the case of a cold gelatin and water jelly, which becomes liquid on warming; or it may be more or less permanent as in the case of rubber cement (rubber swollen in a hydrocarbon solvent).

Gels may be thinned or prevented from forming by the addition of suitable agents. Thus fish glue in water is prevented from jelling by the addition of acetic acid.

Freezing Point
(Melting Point)

The freezing point is the temperature at which a liquid solidifies or begins to form crystals, under normal conditions. Liquids containing impurities or added substances have different freezing points than the pure liquids. Therefore, the freezing point of a liquid is a measure of its purity. Similarly, if the

freezing point of a substance is too high or too low, it may be altered by suitable additions.

The melting point is that temperature at which a solid changes to a liquid, under normal conditions. The melting and freezing point of any substance is the same.

Some substances (mixtures), e.g. hydrogenated coconut oil, do not have a definite melting point but melt over a specific temperature range. Other substances soften or become plastic at certain temperatures, e.g. pitch, cellulose acetate, etc. Still others do not melt but sublime when heated sufficiently.

Vapor Pressure

Vapor pressure is the pressure of any vapor above its liquid or solid form, at the temperature at which equilibrium is established.

The greater the vapor pressure of a substance, the greater is its tendency to evaporate and disappear when exposed. High vapor pressure is desired in products which are expected to evaporate or dry quickly, as in cleaning fluids and lacquer thinners. Low vapor pressures are desired in products which should not change in bulk or dry out as in flexibilizers for glue, casein, etc., or plasticizers for lacquers or plastics.

Sublimation

Sublimation is the direct vaporization of a solid that does not first liquify, e.g., camphor or naphthalene.

Substances that sublime are useful when volatilization at certain temperatures is desired. Certain substances (camphor and naphthalene) sublime at ordinary temperatures. Of course, this means that the latter will gradually disappear when exposed. Where such volatilization is undesirable, subliming substances should not be used.

Boiling Point

The boiling-point is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure. Pure liquids have a definite boiling point. Commercial products, which contain impurities, boil over a range of temperatures, which is known as the boiling range. Thus pure water boils at 100° C. at 760 mm. pressure. Commercial methyl oleate boils at 200–215° C. at 15 mm. pressure.

Low boiling liquids volatilize readily and disappear. This, of course, is advantageous where quick drying is necessary, as in the case of rubber cement or hair lacquers. High boiling liquids are specified where volatility is to be kept at a minimum to prevent drying out, brittleness, shrinkage, etc., as in the use of glycerin in "Cellophane" or castor oil in ethyl cellulose.

Boiling points can be varied by dissolving soluble materials in a liquid or by mixing it with another liquid of a different boiling point. In the former instance, the boiling point is raised whereas in the latter it is either lowered or raised, depending on

the boiling point and solubility of the added liquid.

Certain mixtures (azeotropic) form a constant boiling mixture, at a temperature different than that of any of their components. Here the distillate has the same composition as the substance being distilled.

Solubility

Solubility is the weight of a substance that can be dissolved in a definite weight of solvent at a given temperature. Thus 100 g. water will dissolve 35.8 g. salt at 10° C.

Most substances are more soluble in hot water or other solvent than in the cold. Therefore it is important to determine the solubility of a substance in the solvent in which it will be used, in the temperature ranges to which it will be exposed. Otherwise precipitation may result on later cooling or heating due to temperature changes.

Many substances form a true solution when added to a solvent, e.g. salt in water or menthol in alcohol. Other substances disperse colloidally, as does soap in water or nitrocellulose in acetone. Colloidal substances usually swell slowly and a new material, if it is colloidal, should not be hastily discarded on account of poor solubility. Let it stand over-night, with the solvent, before stirring.

Certain substances may not dissolve in either of two solvents, but will dissolve in a suitable mixture of the two, e.g. nitro cellulose in ether and alcohol.

Hardness

Hardness can be measured by the ability of a substance to abrade or scratch other materials or conversely the ability to be abraded or scratched by other materials; or by the depth of penetration of a sharp edge or point under a definite weight or pressure.

Thus if a coating is to be applied to a floor, it should be sufficiently hard to withstand a certain amount of wear. For this reason, in a wax polish, carnauba wax, which is harder than paraffin wax, is preferable.

An abrasive for rough polishing of quartz must be harder than quartz e.g., corundum would be satisfactory.

A typical scale of abrasion hardness is that of Moh given below, with 1 as the softest and 10 as the hardest.

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

Penetration tests of hardness made with a penetrometer or durometer are expressed, in the case of the former, in units referring to a standard material under certain conditions and, in the latter in units on a calibrated dial. Rockwell and Brinell hardness values are used for referring to the hardness of metals, alloys and similarly hard materials.

Tenacity or Cohesion

Tenacity or cohesion is the property preventing a substance from breaking into pieces when struck, pressed or pulled strongly.

Certain materials possess tenacity or cohesion inherently, as rubber or sisal fiber (fresh). Others require the addition of a plasticizer e.g. as in "Pliofilm", "Cellophane", etc. This property varies in degree in all materials and also varies in accordance with the ingredients with which it is mixed and the process of manufacture. Thus, unvulcanized or soft vulcanized rubber is tenacious and coherent, whereas highly vulcanized hard rubber is brittle.

Plasticity and Ductility

Plasticity is that property of a material that permits the altering of its shape or size by the use of pressure, tension, heat or a combination of these forces, and does not permit a return to the original shape with the removal of these forces. Examples of plasticity are seen in butter and gelled glue solutions. When heat is one of the elements producing

plasticity in a substance, the substance is said to be thermoplastic. When the shape or size becomes fixed and cannot again be altered by the original or any other forces, the substance is said to be thermosetting. e.g. Bakelite. When maintenance of shape and size is important, the use of plastic deformable materials should be avoided, whereas, if rigidity is not desired and alterations in shape or size are immaterial or quite desirable, a plastic deformable body should be used.

Ductility is that property which permits the drawing out of a body in the direction of its length; i.e. into a continuous thread, wire, tube or rod, e.g. Rayon thread, steel wire, lead tubing or brass rod. Thus, when continuous threads, wires, rods or tubes are to be made by the drawing out of a material, it is important to use only those materials which exhibit a high degree of ductility.

Flexibility

Flexibility refers to the ability to bend repeatedly within limits under certain conditions, without cracking or breaking. Thus, soft rubber qualifies as a flexible material but hard rubber is inflexible and brittle. Most materials are more flexible at higher than at lower temperatures. The addition of suitable plasticizers or flexibilizers increases flexibility in many commercial products, e.g., dibutyl phthalate or "Glaurin" in lacquers and certain plastics.

Elasticity

Elasticity is the property of recovering original shape and dimensions after stretching, squeezing or twisting.

Soft rubber is the classic example of an elastic material. Elasticity of many substances will vary with age, use and admixture with other ingredients.

Length

Length refers to the stringiness of a fluid when it is poured or when a rod is dipped into it and then pulled out. For example, mineral oil possesses length, after it has been heated with a certain amount of aluminum stearate; also a strong "solution" of gum karaya in water.

Length is required in certain products to decrease their rate of flow and penetration so that they will remain in place, for a longer time.

Stickiness

Stickiness is the property of a substance to adhere to anything that it touches. It is advantageous in adhesives, glues, cements, etc. but is detrimental to many other uses. Certain products require adhesiveness on one side and non-adhesiveness on the other. Thus a paint should stick to surface to which it is applied and dry, free from adhesiveness, on its exposed surface.

In some cases stickiness must be permanent, as in fly paper. In other cases it must be temporary as in rubber cement for paper. In the latter case, it eventually dries (without losing its adhesiveness) and can be peeled off, without damaging the paper.

Adhesiveness may be increased by suitable additions or processing. For example the addition of an alkaline casein solution to rubber latex. Conversely, stickiness may be decreased, as in the case of the addition of "Acrawax C" to the polyvinylbutyral resin that is used to replace rubber for coating raincoats.

Adhesion

Adhesion is the attraction that causes two surfaces to stick to each other, so that they cannot be separated easily. This is usually brought about by means of an agent which solidifies by drying, cooling, chemical or physical change. Adhesion differs from stickiness (previously mentioned) which produces a bond between two surfaces, which can be easily separated by pulling.

Adhesion varies with the composition of the surfaces to be united, their smoothness or roughness and other factors. The choice of an adhesive material is dependent on whether it is to be applied hot or cold, wet or dry, in aqueous or other solution; whether it is to "set" slowly or quickly; whether it is to be temporary or permanent. The choice is also dependent on conditions of temperature, stress

and contact with water, solvents or chemical, and effect on the materials with which it is used, etc.

Slipperiness

Slipperiness is the property of a substance to slide or move with very little friction.

Certain materials such as oils, greases, waxes, talc and graphite are inherently slippery. Of course they vary in degree and with the nature of the surfaces on which thev are used. Other pertinent factors are temperature and load.

Slipperiness can be increased by the addition of ingredients mentioned above. Conversely slipperiness can be decreased by the addition of adhesives or abrasives, e.g. rubber or sand respectively. Slipperiness may be temporary as in the case of linseed oil, which dries to a non-slippery solid, or permanent as in the case of talc which is not readily affected by age or oxidation. Suitable additives are available for increasing the useful life of a slippery material.

Drying Qualities

Most coating materials such as paints, lacquers, varnishes, etc. must dry fairly rapidly so as not to mar, stick or hold dust, insects, etc. Rapid air-drying (at normal temperatures) is a pre-requisite for them.

Other products such as lubricants or fly-paper must be non-drying.

Drying may be due to evaporation, absorption, oxidation, polymerization or other factors. Time of

drying may be modified by admixture with other substances, change of temperature or pressure, chemical treatment, contact with catalysts or inhibitors, etc.

Feel or "Hand"

Feel or "hand" refers to the sensation felt by the fingers or other part of the body in contact with a material. Thus jute is rough and "Rayon" is smooth. Wood, being a poor conductor of heat, is warm to the touch, whereas aluminum, a good conductor of heat, is cool to the touch.

Rough materials can be made smooth by mechanical processes such as grinding, polishing, weaving, compressing or coating with wax, resins or starch. Smooth materials may be made rough by grinding, sand-blasting, garnetting and other mechanical processes as well as by treatment with certain chemicals. Materials that feel warm can be modified by combining with good conductors of heat, as by weaving a fabric from textile and metal threads. Conversely a metal can be made to feel warmer by mixing the powdered metal with a plastic or fiber powder and compressing them until they form a homogeneous body.

Cryoscopic Properties

Cryoscopic properties refers to the ability of a substance to lower the freezing point of a liquid.

Thus water which ordinarily freezes at 32°F. is

protected against freezing to about 20°F. by the addition of 9 pints of 60% glycerin per gallon of water. Most chemicals that dissolve in water or other solvent, affect its freezing point. Caution should be observed, therefore in making substitutions, in preparations that may be exposed to low temperatures, as freezing will not only cause congealing or crystallization but may cause expansion that might rupture the container.

In many cases a frozen product will revert to its original state of uniformity, when it thaws out. In other cases as in certain emulsions, particularly those made with vegetable gums, freezing breaks the emulsion and the latter does not re-emulsify on thawing out.

Hygroscopicity or Efflorescence

A material is said to be hygroscopic when it can absorb moisture from its surrounding medium (usually air); efflorescent when it loses moisture when exposed to dry air.

While hygroscopicity is often useful in preventing drying out or embrittlement, it may be undesirable where caking or lumping of dry materials or liquifaction results, because of it.

Efflorescent materials tend to give up moisture and dry out and lose their original bulk or crystal form.

Both of these properties can often be neutralized by coating dry materials with waxes, fats, oils or other

filming materials which prevent the ingress or egress of moisture.

Typical of hygroscopic products is calcium chloride. A typical efflorescent product is sal soda (sodium carbonate crystals.)

Inflammability

The flash point of a substance is a measure of its inflammability.

Specifically, it is the lowest temperature at which a substance, in an open vessel, gives off enough combustible vapors to produce a momentary flash of fire, when a small flame is passed near its surface.

Flash point must be considered not only from the standpoint of a fire-hazard, but because of local, state and national regulations for storing, shipping and using products that are inflammable. Thus a "hi-flash" naphtha is less hazardous than a lower boiling naphtha or gasoline.

Burning point is the lowest temperature at which a substance will burn when a source of heat is applied under specific conditions. Thus different woods will burn at different temperatures, depending on their nature, dryness, etc.

Explosiveness

Explosiveness refers to the tendency of a material or its combustion or decomposition products to burst or expand violently. An explosion is usually initiated by impact, heat, pressure, an electric spark,

contact with another substance or a catalyst. Certain explosive materials are quite safe if carefully handled, whereas others are very sensitive and extremely dangerous. An example of the former is dynamite and of the latter is mercury fulminate.

The choice of a substitute explosive material should involve consideration of its conditions of handling, storage, use and transportation.

Toxicity

Toxicity refers to harmful physiological effects of a substance on living beings and things. The toxicity of many materials must not only be considered because of their effect on human beings but also on animals, fish and plants, with which they may come in contact. Nearly every substance is toxic, if taken in or applied beyond a certain limit. For example salt is not harmful in small quantities. Larger amounts will produce vomiting and other harmful effects. Similarly lemon oil, which is used in baking, candy and other internal preparations becomes very toxic and corrosive when used in larger doses.

Some substances exert a toxic effect thru their vapors (particularly in confined spaces) as e.g. mercury; others when taken thru the mouth as e.g. sodium fluoride; and others by absorption thru the skin as e.g. p-toluidine.

By providing proper conditions and utilizing all safety measures, many toxic substances may and are being used with a minimum of hazard.

Effect on Skin, Hair or Finger-Nails

Some materials produce undesirable effects on the skin, hair or finger-nails. These effects, especially in small amounts, may not be dangerous but they are nevertheless undesirable.

As typical examples, cresols irritate and cause the skin to crack; sulfuric acid corrodes the skin; picric acid stains the skin; acetone and other solvents cause brittleness of finger-nails; alkali (e.g. lye) causes roughening and reddening of the skin and hair; alum or formaldehyde causes toughening of the skin; vegetable oils cause softening of skin, nails and hair.

All these effects are dependent on concentration of the substance and time of contact. Therefore, if a substance is present in only certain small amounts and in contact but momentarily, it is not necessarily objectionable. But substances of this nature should be carefully evaluated, before use.

Edibility

A substance is considered edible if it possesses food value and is not harmful when eaten in certain amounts.

Thus, the use of glycerin in cakes is permitted, because it has food value and is not harmful in the amounts used. Mineral oil, while not harmful, is not permitted in mayonnaise, because it has no food value.

Physiological data should be obtained from the supplier, or from authoritative tests, before using a new material for edible purposes.

Thermal Changes

Temperature can produce many effects on different materials. Heat may change a liquid to a gas (e.g. ether); a solid to a vapor (e.g. naphthalene); a solid to a liquid (e.g. paraffin wax). Cold will, of course, reverse the above changes. Crystalline materials may melt and fuse to a solid mass and not revert to crystals when cooled (e.g. abietic acid crystals). Solid objects may flow out of shape on heating, with a resultant change in appearance. (e.g. thermoplastics, like cellulose acetate).

Most materials shrink on cooling, but water expands on being frozen. Most materials expand on heating but ice shrinks on being melted. Each material shows a definite amount of expansion or shrinkage on heating or cooling. This information may be of importance in storage and use of certain products.

Heat will decompose or alter some substances (e.g. egg white). The effect of heat on color, odor, taste, viscosity and all other properties mentioned in this chapter should be noted.

Cooling will often cause precipitation or thickening. Freezing will "break" emulsions, which in many cases, will not revert to their original form on thawing.

Heating may also produce changes in stickiness,

adhesion, drying, optical properties, p.H., odor, taste, density, viscosity, "length", vapor pressure, solubility, hardness, flexibility, tenacity or cohesion, feel, slipperiness, elasticity, hygroscopicity, inflammability, explosiveness, drying qualities, plasticizing properties, chemical re-activity, stability, toxicity, effect on skin, hair or finger-nails, edibility, pressure, solvency, bacterial content, emulsifiability, surface tension, wetting-out properties, dispersing properties, adsorption and absorption, electrical properties, radio activity, etc. It would be prudent, therefore, to refer to each of the above named headings, and try to judge how temperature changes in any substitute may affect its final use.

Cooling will usually produce an opposite effect to that of heating.

Effects of Pressure

Increased pressure usually increases the solubility of gases in liquids (e.g. carbon dioxide in beverages). It may also increase the speed of chemical reaction. It usually increases density, viscosity, hardness and rigidity. Conversely it decreases vapor-pressure, flexibility, elasticity, absorption and size.

Solvency

Solvency refers to the ability of one material to dissolve another at a given temperature. For example the solvency of water for borax is 14.2 grams per 100 c.c. at 55°C.

One ingredient may be used primarily as a thickener or to prevent drying out. If its solvent properties are ignored, precipitation or crystallization may result. Thus corn syrup may replace glycerin as a thickener but its solvent powers for vanillin, borax and many other ingredients are much lower thereby causing possible difficulties.

Plasticizing or Flexibilizing Properties

A plasticizer or flexibilizer is used because of its ability to prevent brittleness or cracking of a solid material, e.g. glycerine with glue or dibutyl phthalate with pyroxylin.

A good plasticizer should be compatible with the material in which it is used and be sufficiently nonvolatile to remain in it for its useful life. It should not change appreciably the properties desired in the finished product. The amount of plasticizer used is often critical—too much will give a soft or sticky product, too little will not be sufficient to plasticize properly.

Interaction with Other Materials

Chemical reaction between two ingredients may produce changes which rule out the finished product. Therefore it is best to avoid the substitution of a substance, which may react with any of the substances already present.

Acids may produce esters or salts or induce hydrolysis. Thus, adding acetic acid to alcohol will pro-

duce some ethyl acetate on standing. The addition of phosphoric acid to a caustic soda solution will form sodium phosphate. Ethyl lactate will be hydrolyzed by the addition of an aqueous acid, such as hydrochloric acid.

Alkalies may form soaps, induce hydrolysis or form hydroxide gels or precipitates. Thus, the addition of caustic potash to a solution of castor oil in alcohol will produce a castor oil soap. An ester such as methyl oleate will be hydrolyzed by an alkali such as sodium carbonate. The addition of ammonium hydroxide to a solution of ferric chloride will produce a colloidal precipitate or gel of iron hydroxide.

Salts may produce electrolytic effects, such as increased conductivity of an electric current or generation of an e.m.f. which may induce corrosion. Distilled water is a poor conductor of electricity but the introduction of an electrolytic salt, such as sodium chloride, increases its conductivity greatly.

Oxidation or reduction of other ingredients or of the newly added material by the other ingredients may produce many changes in properties.

Hydrogen peroxide will oxidize many organic materials with a lightening or darkening effect. Reduction with hydrogen (produced from metal and acid) will also often bring about undesirable changes.

Double decomposition of two substances with resultant precipitation or formation of new gaseous or liquid substances may result in certain cases.

Thus if barium chloride is added to a solution

containing a sulfate, such as sodium sulfate, a heavy, white precipitate of barium sulfate forms. If sodium acid sulfate is added to sodium bicarbonate—a gas, carbon dioxide, is formed.

Bacterial or enzymatic reactions may be induced by the new material, or it may itself, be thus affected.

Many organic substances such as starch, sugar, etc. are decomposed by bacteria or enzymes. Such decomposition can be avoided by sterilization or by the use of suitable preservatives.

The addition of a substance having an absorptive or adsorptive effect may abstract an amount of material so as to change many characteristics of the composition. Thus adding bentonite to a gum tragacanth oil and water emulsion, will abstract water and break or thicken the emulsion considerably.

Stability

Stability refers to the property of a substance to remain substantially unaltered over a certain period of time. A substance or composition is subjected to so many detrimental conditions, that it is really surprising that commercial products, which remain in a dealer's stock for extended periods, are still suitable for use when purchased. This is not due to luck, but to judicious testing and aging.

Water, when present, is useful in many products but detrimental to others. Thus, a dry starch preparation will keep indefinitely. The introduction of

even a small amount of water may cause bacterial decomposition which will ruin the product.

Air which is so necessary to living things, is detrimental to many substances. Thus, cotton-seed oil tends to absorb and react with the oxygen in the air and becomes rancid.

The effects of heat and cold have been indicated under Thermal Changes (see).

Sunlight may improve some products (e.g. irradiated foods) and injure others. An example of injury by sunlight is the effect of the latter on rubber, which becomes brittle and cracks.

Motion often produces detrimental effects. A powdered mixture consisting of materials of different densities (e.g. bentonite, soda ash and soap) may separate into different layers, thus destroying uniformity, because of the motion produced during transportation.

Age may also produce various changes. Certain crystalline rearrangements take place in metallic alloys on aging. Unless these are properly controlled, the alloy may be unserviceable.

The electric discharge or "corona" effect, producing ozone is detrimental to many organic products. Thus, rubber insulated electrical ignition wires deteriorate rapidly when exposed to electrical discharges.

Abrasion is a factor that must be considered when selecting a material that is subject to friction or pounding. Thus, while marble makes beautiful

steps, it wears down much more rapidly than a harder material like granite.

The material in which a composition is to be packaged is of utmost importance. Thus, it would be foolish to package a caustic paste in aluminum tubes as the latter would be readily attacked and soon destroyed. Even ordinary water solutions corrode beneath the tin-plate in cans. To avoid these corrosion effects, either other suitable packaging materials are selected or, when possible, suitable inhibitors are added to stop or delay such action.

Bacterial Content

While a material may not be susceptible to bacterial decomposition, it may act as a carrier for bacteria, which may affect other ingredients. Thus, with compositions containing organic matter on which bacteria may thrive, it is necessary to avoid the introduction of bacteria or to destroy them by sterilization or antiseptic action.

Emulsifiability

Emulsifiability is the ability to form an emulsion with one or more immiscible fluids.

Thus cottonseed oil is emulsifiable with water and gum tragacanth. The latter is the emulsifier. Different substances have different degrees of emulsifiability and therefore different types and amounts of emulsifiers as well as different processing methods.

Vegetable oils, for example, can usually be emulsified with ammonium linoleate. Paraffin wax, in the presence of salts, is usually emulsified with gelatin or gum arabic. Toluol with acetic or other acids requires a special emulsifier that will act in the presence of acid, such as "Emulgor A".

For certain purposes, a water in oil or an oil in water type of emulsion is desired. The introduction of a substitute ingredient may produce a type of emulsion, opposite to the one desired. Sometimes a change in type can be made by changing the emulsifier, or the proportions of one or more ingredients, or by reversing their order of introduction and mixing, or by altering the p.H.

Variations in quantity and identity of ingredients and methods of emulsification will also produce variations in particle size, color, viscosity and other properties.

Surface Tension

Surface tension refers to the tendency of the surface of a liquid to contract to the smallest area possible. The lower the surface tension, the greater the contraction. A high surface tension produces the opposite effect.

Low surface tension permits rapid and thorough wetting of an insoluble material. Thus, the addition of a small percentage of a wetting agent like "Sulfatate" (a sodium salt of a sulfonated hydrocarbon) to a water solution of a flame proofing agent like

sodium borophosphate, permits a fabric to be impregnated quickly and thoroughly.

The addition of a wetting agent to various solutions makes them spread more quickly and evenly on smooth surfaces such as glass, steel, etc.

Certain oils are caused to penetrate more quickly and deeply into crevices when a suitable surface tension reducing agent is added to them.

Dispersing Properties

Dispersing properties refers to the ability of a substance to suspend insoluble particles in a fluid. For example, colloidal carbon is suspended in water with gum arabic to form India Ink. Pigments are suspended in drying oils by suitable grinding with "Glaurin".

Proper dispersion of insoluble particles in a liquid is important to avoid deflocculation or settling, and in forming uniform films and coatings as in paints and pigmented lacquers.

Adsorption and Absorption

Adsorption is the taking up (concentration) of a substance on the surface of another substance. This is illustrated by charcoal taking up odors in a refrigerator. Absorption is the taking up, of a gas or vapor, by a fluid in which it dissolves, e.g. the dissolving of acetylene in acetone.

Adsorptive materials may take up certain materials and thus throw a formulation out of balance. They

may also remove or lighten the color or odor of a product and thus produce an unwanted change.

Heating Power

Heating power refers to the property of a substance to increase the temperature of another substance. Thus, the substitution of butane, which has a different calorific value, for gasoline fuel, will produce a different amount of heat. The addition of caustic soda solution to aluminum produces an exothermic reaction generating much heat. Simple solutions of many materials in water produce a heating or cooling effect. (See Thermal Changes for changes in properties produced by heating and cooling.)

Lighting Power (Candle Power)

Lighting power is the ability of a substance to produce illumination.

Materials such as illuminating gas, kerosene, etc. are used for producing illumination. Every pure hydrocarbon produces a definite candle-power when it burns under certain conditions.

Metals such as tungsten or zirconium alloys produce light when heated sufficiently, e.g. an electric current. Carbon and other conductive refractories produce light when an electric arc is formed between two electrodes, in an electrical circuit.

Gases, subjected to an electric discharge are also used to produce light, e.g. as in neon tubes.

Electrical Properties

Conductivity

Conductivity, the reciprocal of resistance, is the rate or degree of transmission of electricity through a substance. Thus silver and copper are excellent conductors of electricity and rubber and slate are poor conductors (insulators).

If any other electric properties or effects are of importance, the necessary data should be gotten or specific tests made as outlined in electrical texts or handbooks.

Thermal Conductivity

Thermal conductivity refers to the degree or rate of heat transmission through a substance.

Good conductors of heat are exemplified by silver and aluminum. Poor conductors of heat (insulators) are typified by asbestos and "Fiberglas".

Radio Activity

Radioactivity is the property of a substance to emit rays that can penetrate many solids, ionize air and excite phosphorescence in certain substances.

Radium is typical of radio-active materials and use is made of it in taking photographs of ordinary opaque objects, e.g. the human body. Uranium compounds are used in luminous paints for watch and instrument dials.

Radio-active materials differ in intensity and in span of life. They are also subject to change in activity by admixture with other substances.

Miscellaneous

Handling

The selection of a substitute may introduce new problems in handling. Often this is of minor importance. Sometimes it may require new or changed equipment and special precautions.

Thus when a solid material is to be replaced by a liquid, it may have to be stored in tanks, instead of bins and pumped instead of dumped or shoveled.

In changing from the use of a solid to a liquid (or a gas) or vice versa, all the headings in this chapter should be scrutinized for possible sources of difference in receiving, storing, using, grinding, mixing, melting, dissolving, etc.

Legal Restrictions

The purchase, ownership, storage, use or sale of many materials and products is covered and bound by national, state, city or local regulations.

Foods, drugs and cosmetics must conform to the regulations of the U. S. Food and Drug Administration and State and City Departments of Health.

Habit forming drugs such as cocaine and mor-

phine are strictly regulated by the federal government under the Narcotics Act.

Certain states and cities require licenses for the manufacture and sale of drugs, cosmetics and other products.

New explosive regulations of the U. S. Bureau of Mines require a license for owning any type of explosive material, even though it is to be used in a non-explosive product.

The use of new materials is not only subject to the above regulation (which is far from complete in scope) but to State and local laws on production of disagreeable odors, toxic materials and other hazardous products, that may increase the fire or explosion hazard, or injure anyone in or near the factory in question.

Since many substances and their uses are patented it is also well to ascertain whether the use of a substitute (for commercial purposes) will mean infringement on a patent covering the same.

Formulation

The use of a substitute material may involve only a slight or a radical change in formulation. If only a change in proportions (see Proportions) is necessary, then reformulation is relatively simple, as e.g., the replacement of glycerin by ethylene glycol in an anti-freeze mixture for automobile cooling systems.

A more complicated case is the use of polyvinyl alcohol as an emulsifying agent for a carnauba wax

water emulsion. There are many emulsifying agents such as ammonium linoleate or other fatty acid derivatives, which can function equally as well as polyvinyl alcohol as an emulsifying agent, but, they are not suitable because they are not film-forming adhesives. The latter quality is necessary in a particular coating problem. The nearest logical substitute would be a film-forming adhesive type of emulsifier such as methyl cellulose. In doing this, different proportions of emulsifier wax and water, mixed under different conditions would have to be tried to get optimum results. It might be necessary to add a secondary emulsifier or stabilizer and perhaps even a plasticizer or solvent coupling agent, such as "Carbitol".

The replacement of dibutyl phthalate as a plasticizer in lacquers is also an example of a more complicated case. When "Glaurin" (diethylene glycol monolaurate) is substituted for the former, it is necessary to use a smaller amount of the latter and also vary the resin and solvent proportions in order to get a good lacquer.

Sometimes, the use of a substitute may entirely change the character and use of a product. For example, trichlorethylene, a low boiling liquid (non-aqueous) used in degreasing of metals, may be replaced by sodium abietate, a dry crystalline material which is used with water. Here is an example of a substitute being totally different in its properties and method of use but serving the same function.

Proportions

It is very seldom that one is fortunate enough to get a substitute for use in a composition, that will replace the original material pound for pound. It may be necessary to use a greater or a smaller amount of a new material to produce the desired result.

Thus, where a soap was formerly made from coconut oil and alkali and the former is to be replaced by castor oil, a larger amount of castor oil would be needed for complete saponification. This is due to the difference in combining weights of these two oils. Combining weights are only of importance in determining amounts to be used, when a chemical reaction takes place.

Where a substitute material is to be used in the same volume as the material which it is to replace, then the finished product will usually have a different unit weight. Thus in a composition containing 2 quarts of glycerin per gallon of solution, wherein the glycerin is to be replaced by 2 quarts of propylene glycol, the difference in weight per gallon of solution produced by this substitution will be appreciable.

Certain materials that have great strength or activity are used in smaller amounts when substituting for weaker materials. For example, if hydrochloric acid is used in place of acetic acid, a much smaller amount may be needed. Similarly caustic soda, which is a much stronger base than triethanolamine, would be used in a smaller amount. Conversely, when a

weak material replaces a strong material a larger amount may be needed, e.g. replacing phosphoric by lactic acid.

Methods of Manufacture

The different properties (as indicated in this chapter) of a substitute or alternative may present many problems in the manufacture of a finished product. In some cases this problem may be minor and in others more serious.

For example if sugar is to be replaced by molasses, the latter may require a tank for storage; pumps and valves for delivering it to the mixing tank; exhaust fans for drawing off the odor; special materials of construction to prevent corrosion; cleaning and sterilization of all tanks, pipe-lines, valves, pumps, etc. to prevent fermentation. A sludge (due to impurities present in molasses, not present in sugar) may also require special filtering apparatus or settling tanks. If color is a factor, it may be necessary to heat the molasses with a decolorizing carbon or other materials and then filter it.

In cold weather the storage tank may have to be heated to reduce viscosity and permit ready flow of the molasses. None of these factors is present when sugar is used, because it is a dry powder or crystal material, that can be dumped into the kettle from sacks or barrels and presents none of the problems, mentioned above.

When a corrosive material replaces a non-corrosive

material as in the case of calcium chloride in place of activated alumina for moisture absorption, the calcium chloride may corrode the metals formerly used and require the installation of materials at points of contact, which are resistant to it.

Costs

The relative price per pound of a substitute to that of the material which it replaces is not the sole economic criterion in making a choice. Thus while propylene glycol is more expensive than glycerin, it may be more economical to use it in making an imitation vanilla flavor, because of its far greater solvent power for vanillin and coumarin. Accordingly a much smaller amount of it is needed.

Sometimes a higher cost for a substitute may be justified if the finished product is superior in use or salability. For example a stamp pad ink made with glycerin varied too much in consistency during dry and damp weather. Furthermore, the rubber stamps had a limited life period. Replacing the glycerin with glyceryl monoricinoleate produced an ink which varied very little with atmospheric moisture changes and prolonged the life of the rubber stamps considerably.

Substitutes which are usually introduced by necessity are sometimes continued in use after the necessity has ceased to exist. The reasons for this may be one or more of the following: ease in handling, uniformity, more than one source of supply, shorter

manufacturing time, lower maintenance and labor costs, reduction in insurance, avoidance of license fees or patent suits, governmental regulations and record-keeping and other possible advantages.

Use of the Finished Product

The introduction of substitute or alternate materials may produce such changes in a product as to necessitate changes in the method of use by the consumer. This, while highly undesirable, is sometimes unavoidable.

For example lemon extract as used by bakers consists of a solution of lemon oil in alcohol. When the alcohol is replaced by emulsifying the lemon oil in water with a vegetable gum, a thick messy emulsion results which is less easy to handle than the limpid alcoholic lemon extract. Once the user learns how to handle and mix the lemon emulsion into his baking batter, he gets equally good results. Educating the user, however, is a slow expensive process.

A classical example of consumer education in a new way of using a new product is that of the non-rubbing (self-polishing) floor waxes. Before these were introduced, the best floor wax polishes were pastes, consisting of carnauba and other waxes in turpentine, naphtha or different solvent mixtures. The standard method of application was to apply the paste to a soft cloth or dauber and spread it over a section of the floor. This then was rubbed and

rubbed (using much "elbow grease") until a high polish resulted.

When the non-rubbing (water) waxes were first introduced, the instructions were to wash the floor, mop and dry it and then apply a thin even coating of the new wax with a clean soft cloth or mop. This sounds perfectly simple, but those who are interested in this field know how many wrong ways were discovered by housewives and maintenance men for applying this wax. Each of these incorrect methods produced a bad result, consequently, this type of product was slow in gaining favor. Now, that the public has learned how to use it, the results are excellent.

Testing

This book is not intended to give explicit methods of chemical and physical testing. Such methods are known to most chemists and can be found in the standard books on testing.

The following general information may prove useful, as a starting point in eliminating unsuitable substitute or alternate materials.

Data from manufacturers' literature, technical handbooks or dictionaries, will usually give some information and should be consulted.

Sensual Inspection

Color, clarity, odor, form, homogeneity, grade, etc., can often be checked, quickly, with a small sample.

Heating a sample in a test tube will give some indication of changes that may be expected in color, odor, form, taste, density, melting-point, boiling-point, viscosity, vapor pressure, flexibility, cohesion, stickiness, adhesion, drying, slipperiness, elasticity, composition, solvency, stability, bacterial activity, surface tension, explosiveness, fire-hazard, etc.

Strong cooling with "dry-ice" or other freezing mixtures will show changes in many other properties. Manipulation with the fingers will give a quick rough estimate of hardness, flexibility, tenacity or coherence, stickiness, adhesion, feel, slipperiness, elasticity, etc.

A rough estimate of solubility is made by dropping a little of the substitute material and the other ingredients in a test tube with water or with one of the solvents to be used, shaking to see if it dissolves. Solvency is determined in the same way, only, in this instance, the solvent is the substitute.

Interaction with other ingredients is tested by using the substitute in the finished product, letting it stand (or even warming it) and determining any apparent change in the properties mentioned in this chapter.

Acidity or alkalinity (pH) is tested with pH papers or a pH meter.

Accelerated Aging Tests

Whirling a sample in a centrifuge will cause the separation of finely divided particles. This separation might not otherwise appear for some time.

The effect of heat is determined by placing a sample in an open or closed tube on a steam or electric plate for a working day or overnight. Heat speeds up most reactions and a test of this nature is often indicative as to how a material will change on aging.

The effect of sunlight can be checked fairly rapidly by exposure to the actinic rays in such devices as the "Fade-o-Meter" or the "Launderometer".

The effect of moisture or dryness is seen by exposure in a closed vessel, containing either a dish of water or a desiccant ("Drierite" or sulfuric acid).

The effect of oxygen is rapidly determined by the oxygen bomb test or treatment with an active oxidizing agent such as hydrogen peroxide.

List of Substitutes and Alternatives

THE following list must be used with discretion. As previously explained, a substitute for any material may be excellent in one instance and absolutely worthless in another. For example, salt which has no chemical relationship to acetic acid, is being used instead of the latter, in creaming and separating rubber from latex, but it would be useless in a textile "sour" where acidity is a pre-requisite. Therefore, any substitute must be tried and tested before commercial use is attempted. Such tests should be made by a competent worker or consultant to avoid subsequent difficulties.

A substitute or alternative need not necessarily be a substance or composition. It can be a process. An example of this is the removal of a metal plating by an electrolytic de-plating process, or by grinding it off with an abrasive instead of with an acid or other corrosive material.

Some of the listings given are *not* substitutes, but different members of a certain class of products, which can be used as alternatives. This serves a dual purpose. First, it shows the representative commercial materials of one group, so that available mate-

rials which may have been overlooked, can be seen. Secondly, if each of the products is looked up individually, its substitutes will be found.

This list has been compiled, not only for the needs of today, but for the future. A material that is freely available today may be scarce or unavailable tomorrow. On the other hand, a material that is scarce or unobtainable today may be available tomorrow. Furthermore what may be scarce in the United States may be easily obtained in another country—carnauba wax in Brazil, for example.

How To Use This List

After looking up the substitutes for a given material, look up, in turn, each substitute mentioned. For example, in looking up glycerin, some of the substitutes listed for it are ammonium lactate, dextrin, glucose, methyl cellulose and many others. By looking up ammonium lactate, dextrin and all the other substitutes listed under glycerin, the total number of possible substitutes will be covered.

Sources of supply of chemicals and allied products can be obtained from the following publishers:

Chemical Industries	New York, N. Y.
Oil, Paint and Drug Reporter	New York, N. Y.
American Perfumer	New York, N. Y.
Drug and Cosmetic Industry	New York, N. Y.
Metals and Alloys	New York, N. Y.
Chemical Catalog Company	New York, N. Y.
Modern Plastics	New York, N. Y.

Product	*Substitute or Alternative*
Abietic Acid	"Liqro"
	Rosin
	Acid etching
	Application of centrifugal force
	Electrolytic corrosion
	Heating to form scale or melt
	Pressures, high
	Vibration, high speed
*Abrasives	Aluminum oxide, fused
	Bentonite
	Boron carbide
	"Borop"
	Carborundum
	Chalk
	Corundum
	Crocus
	Cuttlefish bone
	Diamond, industrial
	Diatomaceous earth
	Emery
	Flint
	Fuller's earth
	Garnet
	Iron oxide, red
	Pumice
	Rottenstone
	Rouge
	Sand
	Silica

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Silicon carbide
	Tripoli
Absorption Bases	Cholesterol with lanolin
	Emulsifiers
	"Sublan"
Accroides, Gum	"Glycolac"
	Rosin
	Seed-Lac
	"Vinsol"
Acetaldehyde	Aldol
	Formaldehyde
	Furfuraldehyde
	Glyoxal
Acetamide	Ammonium acetate
	Ethanolamine acetate
	Formamide
	Urea
Acetanilide	Alum
	Pyramidon
	Zinc sulfocarbolate
Acetic Acid	Ammonium sulfate with dilute sulfuric acid
	Boric acid
	Citric acid
	Formic acid

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Glycollic acid
	Lactic acid
	Levulinic acid
	Phosphoric acid
	Propionic acid
	Pyroligneous acid
	Saccharic acid
	Salt
	Sodium diacetate
	Sodium bisulfite
	Sulfuric acid, dilute
	Tartaric acid
	Vinegar
Acetone	Butyl alcohol, tertiary
	"Cellosolve" with alcohol
	Diacetone
	Ethyl acetate with isopropyl acetate
	Isopropyl ether
	Methyl acetone
	Methyl ethyl ketone
	Solvents
Acetylene	Butane
	"Calorene"
	Gas, natural
	Gas, producer
	Gasoline
	Hydrogen
	Propane

Product	*Substitute or Alternative*
Acetylene Black	Carbon black
	"Spheron C"
Acetylene Tetrachloride	See Tetrachlorethane
	Soap
	Solvents
Aconite	Isobutyl p-aminobenzoate
Acrylonitrile	Styrene
Adeps Lanae	Absorption bases
	Lanolin alcohols
	"Sublan"
*Adhesives	"Abopon"
	Albumen
	Casein
	"Catalin" liquid resins
	Cellulose esters
	Dextrin
	Flaxseed mucilage
	"Glycolac"
	Glue
	Gums, water dispersible
	Latex
	Pitch
	Resins, natural
	Resins, synthetic
	Sodium silicate
	Starch

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Adipic Acid	Fumaric acid
	Maleic acid
	Malonic acid
	Mucic acid
	Tartaric acid
Agar	Albumen
	Chondrus
	Egg white
	Gelatin
	"Gomagel S 543"
	Gums, water dispersible
	Isinglass
	Methyl cellulose
	Mucin
	Pectin
	Silica gel
	Sodium alginate
	Sodium caseinate
	Sodium cellulose glycollate
Agate	Steel, polished cyanided
Agave Fiber	Cotton
	Fibers
	Istle fiber
	Jute
Albumen	Adhesives
	Agar
	Alum, potash
	Casein
	Emulsifiers
	Protein, fish

Product	*Substitute or Alternative*
	Protein, soybean
	Resins, natural
	Resins, synthetic
	Thickeners
Alcohol	See Ethyl alcohol
*Alkalies	Amines, primary, secondary, tertiary, quaternary
	Aminoalcohols
	Ammonium hydroxide
	Barium hydroxide
	Borax
	Calcium hydroxide
	Calcium oxide
	Lithium hydroxide
	Magnesium hydroxide
	Magnesium oxide
	Nephelin
	Potassium carbonate
	Potassium hydroxide
	Potassium silicate
	Sodium carbonate
	Sodium hydroxide
	Sodium metasilicate
	Sodium orthosilicate
	Sodium pyrophosphate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Sodium silicate
	Trisodium phosphate
Alkyd Resins	"Flexoresins"
	"Piccolyte" resins
	Resins, synthetic
Alloys	See Metals
Almond Oil	Apricot kernel oil
	Benzaldehyde
	Cherry kernel oil
	Mineral oil, refined
	Peach kernel oil
	"Persic" oil
	Vegetable oils
Aloes	Sucrose octa-acetate
"Alperox"	Hydrogen peroxide
"Alpha" Protein	Casein
Alum	Acetanilide
	Alum, potash
	Aluminum chloride
	Aluminum hydrate
	Ferric chloride
	"Ferri-Floc"
	Tannic acid
	Zinc chloride
	Zinc sulphocarbolate
Alum, Potash	Albumen
	Aluminum hydrate
	Aluminum sulfate

Product	*Substitute or Alternative*
	Ammonia alum
	Bentonite
	Boneblack
	Calcium phosphate
	Carbon activated
	Casein
	Clay
	Copperas
	Diatomaceous earth
	Gums, water dispersible
	Ferric sulfate
	Irish moss
	Isinglass
	Lime
	Magnesium carbonate
	Magnesium oxide
	Montmorillonite (aluminum silicate)
	Paper pulp
	Silica
	Sodium aluminate
	Sodium alginate
	Talc
Alumina, Fused	Abrasives
Alumina, Activated	Carbon, activated
Aluminum	Alloys
	Asbestos

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Cadmium
	"Cellophane", silver coated
	Cement, light weight
	Fiberglass board
	Glass, silvered
	Indium
	Iron castings, gray
	Lead, varnish coated
	Linen, impregnated with plastics
	Magnesia
	Magnesium
	Metal
	"Metalglas"
	Paint
	Paper, oiled
	Plastics
	Plastics, laminated (paper, wood, fiber, glass or metal coated with pearl lacquer.)
	Parchment paper
	Porcelain
	Plywood
	Rubber, hard
	Silicon bronze
	Steel, austenitic stainless
	Steel, enamelled
	Steel, low carbon alloy
	Steel, stainless

Product	*Substitute or Alternative*
	Vulcanized fiber
	Wood
Aluminum Acetate	Aluminum chloride
	Aluminum formate
	Aluminum sulfate
Aluminum Boro-Tartrate	Aluminum citrate
	Zinc sulphocarbolate
Aluminum Bronze	Mica
	Pearl essence
	Sericite
	Slate powder
Aluminum Chloride	Aluminum acetate
	Aluminum formate
	Aluminum sulfate
	Aluminum sulfocarbolate
	Catalysts
	Ferric chloride
	Formaldehyde
	Hydrofluoric acid (anhydrous)
	Lignin sulfonates
Aluminum Citrate	Alum
	Aluminum acetate
	Aluminum boro-tartrate
Aluminum Ethylate	Magnesium ethylate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Potassium ethylate Sodium ethylate
Aluminum Formate	Aluminum acetate Aluminum chloride Aluminum sulfate
Aluminum Hydrate	Alum Ammonia alum Copperas Ferric sulfate Lime Potassium alum Sodium aluminate
Aluminum Hydroxide	See Aluminum hydrate
Aluminum Oleate	Calcium oleate, palmitate, resinate or stearate Lead oleate, palmitate, resinate, or stearate Magnesium oleate, palmitate, resinate, or stearate Zinc oleate, palmitate, resinate, or stearate
Aluminum Oxide	Abrasives
Aluminum Phosphate	Calcium phosphate
Aluminum Powder	Graphite Mica Pearl essence Sericite Slate powder

Product	*Substitute or Alternative*
Aluminum Resinate	Aluminum oleate
	Barium stearate
	Calcium resinate
	Lead resinate
	Magnesium resinate
	Zinc palmitate
Aluminum Silicate	Alum, potash
	Fillers
Aluminum Stearate	"Acrawax B"
	Aluminum oleate
	Barium stearate
	Calcium resinate
	Calcium stearate
	"Dicalite"
	Magnesium stearate
	Manganese stearate
	Paraffin wax
	Soap
	"Stroba wax"
	Talc
	Zinc palmitate
	Zinc stearate
Aluminum Sulfate	Alum, potash
	Aluminum acetate
	Aluminum chloride
	Aluminum formate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Chromium acetate
	Copper sulfate
	Ferrous sulfate
	Formaldehyde
	Lignin sulfonates
	Sludge, activated
	Sodium bichromate
Aluminum Sulfocarbolate	Aluminum chloride
Alunite	Bauxite
Amaranth	Cudbear
Amber	Copal, gum
	Plastics
	Resins, synthetic
* Amides	Acetamide
	"Acrawax"
	Cyanamid
	Dicyandiamid
	Stearamide
	Urea
Amine Soaps	Emulsifiers
*Amines	Alkali
	Amines quaternary e.g. "Triton"
Aminoacetic Acid	See Glycine
Aminoalcohols	Alkali
	"Carbitol"
	Glycerin

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Ammonia Alum	Alum, potash Aluminum hydrate
Ammonia, Anhydrous	Methyl chloride Nitrogen
Ammonia, Aqua	See Ammonium hydroxide
Ammonium Acetate	Acetamide
Ammonium Bicarbonate	Carbon dioxide Sodium bicarbonate
Ammonium Bichromate	Tannic acid
Ammonium Bifluoride	Fluorspar
Ammonium Carbonate	Urea
Ammonium Compounds	Alkalies Amides Amines Ammonium thiocyanate Cyanamide Dicyandiamid Urea
Ammonium Chloride	Manganese chloride Zinc chloride
Ammonium Hydroxide	Alkalies
Ammonium Lactate	Ammonium glycollate Glycerin

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Ammonium Phosphate	Calcium cyanamid Guano Potassium phosphate Sodium nitrate Sodium phosphate
Ammonium Sulfamate	"Abopon" Borax with boric acid Sodium chlorate
Ammonium Sulfate	Ammonium phosphate
Ammonium Sulfite	Potassium bisulfite with ammonia Sodium bisulfite with ammonia
Ammonium Sulfocyanate	See Ammonium thiocyanate
Ammonium Thiocyanate	Ammonium compounds Sodium chlorate
Amyl Acetate	Solvents
Amyl Alcohol	Capryl alcohol Fusel oil Hexyl alcohol Octyl alcohol Solvents Tetrahydrofurfuryl alcohol
Aniline	o-Aminodiphenyl Furfural Pyridin

Product	*Substitute or Alternative*
Anise Oil	"Annol"
Annatto	Dyes, aniline
Anodizing Process	Paints
Antimony	Cadmium Calcium Selenium Silver Tellurium
Antimony Lactate	Tartar emetic
Antimony Oxide	Tin oxide Titanium oxide Zirconium oxide
Antiseptics	See Preservatives
Apricot Kernel Oil	Almond oil
Argon	Helium
Arrowroot	See Starch Thickeners
Asbestos	"Balsam Wool" Cork "Densite" Ebonite "Electrite" "Fiberfoam"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	"Fiberglas"
	Fillers
	Magnesia
	Magnesium silicate, fibrous
	Mica
	Mineral wool
	Peat moss
	Refractories
	"Rock Wool"
	Silica aerogel
	Slagwool
	Slate
	Talc
	Vermiculite, expanded
	Vulcanized fiber
	Wood wool
Asbestos Board	Fiber glass board
Asphalt	Coal tar
	Pitch
Atropine	Beta perimonoethylp-phenylacetamide
	"Evmydrine"
	Hyoscyamine sulfate
	Methyl bromide
	"Novatropine"
	"Syntropan"
	"Trasentin"
Babassu Oil	Coconut oil
Babbitt	Camwood
	"Defender Metal"

Product	*Substitute or Alternative*
	Indium plated iron
	Iron, powdered pressed
	Lead arsenic alloy with ¾% tin
	Lignum vitae
	"Magnetco"
	Paper, reinforced Kraft
	"Rex" bearing metal
	Silver lead
Balata	Chlororubber
	Gutta percha
	Rubbers, synthetic
Balsa Wood	"Foamglas"
	Sponge rubber, hard
Barium	Calcium
	Magnesium
Barium Chloride	Cadmium chloride
	Cobalt chloride
	Ferrous chloride
	Lead chloride
	Nickel chloride
Barium Carbonate	Barium sulfate
	Witherite
Barium Hydroxide	Alkalies
	Calcium hydroxide

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Barium Silicofluoride	Insecticides
Barium Stearate	Aluminum stearate Calcium resinate Paraffin wax
Barium Sulfate	Barium carbonate Blanc Fixe
Barium Sulfide	Calcium sulfide
Barytes	See Barium sulfate
Bauxite	Alunite Clay, calcined Kaolin, high alumina
Batching Oil	Paraffin wax, low melting
Bayberry Wax	Diethylene glycol distearate Japan wax
Beeswax	"B-Z Wax" Ceresin with soap Coffee wax Flax wax "Flexo Wax" "Glaurin" "Isco 662, 663." "Norco Wax 36" "Prostearin" Sugar cane wax Wax, synthetic
Belladonna	Atropine Stramonium

Product	*Substitute or Alternative*
Bentonite	Abrasives Alum, potash Clay, colloidal Emulsifiers Fillers Gums, water dispersible Thickeners
Benzaldehyde	Bitter almond oil Nitrobenzol
Benzene	See Benzol
Benzine	Petroleum ether
Benzene Sulfonic Acid	Phenolsulfonic acid
Benzoic Acid	Cumic acid p-Hydroxybenzoic acid "Moldex" Preservatives
Benzoin	Balsams Peru and tolu with trace of vanillin Southern sweet gum
Benzol	Ether, petroleum Gasoline Solvents
Benzoyl Peroxide	Hydrogen peroxide Oxygen

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Benzyl Alcohol	"Benzocaine" "Chloratone" Plasticizers
Benzyl Benzoate	Propylene glycol
Bergamot Oil	"Iso Bergamone"
Beryllium	Lithium
Beta Naphthol	Pyrogallol Resorcinol "SA 326"
Biacetyl	See Diacetyl
Birch Tar Oil	Cade oil
Bismuth	Mercury
Bismuth Subnitrate	Bismuth oxychloride
Bitter Almond Oil	Benzaldehyde
Bitumen	See Asphalt
Blanc Fixe	Fillers Pigments "Witco Blancal"
Bleaching Powder	Bromine Hydrogen peroxide Potassium binoxalate Sodium chlorite Sodium perborate Sulfur dioxide Zinc hydrosulfite

Product	*Substitute or Alternative*
Blood Albumen	Adhesives Casein
Blood, Human	Bovine serum albumen
Blood Plasma	Pectin
Bone	Plastics
Boneblack	Alum, potash Carbon, activated Fuller's earth
Boracic Acid	See Boric acid
Borax	Alkalies Boric acid Boron oxide Lead borate Lead silicate Lead sulfate, basic Litharge Potassium fluoride Rasorite Red lead Sodium fluoride White lead
Bordeaux Mixture	Insecticides
Boric Acid	Acetic acid Benzoic acid

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Product	*Substitute or Alternative*
	Borax
	Phosphoric acid, dilute
	Preservatives
Boroglyceride	"Abopon"
	"Aquaresin"
	Mannitol borate
	"Stacol"
Boron Carbide	Abrasives
Boron Fluoride	Catalysts
Boron Oxide	Borax
Bort	See Diamond, industrial
Brass	Glass
	Iron, cast
	"Masonite"
	"Maulron"
	Metal, silver plated
	Millboard, impregnated
	Plastics
	Porcelain
	Steel, enameled
	Steel, plated
	Tile, glazed
	Vulcanized fiber
Brazilwood	See Hypernic
Brea Gum	Gum acacia
Bristles	Bamboo
	Broomcorn
	"Fiberglas"

Product	*Substitute or Alternative*
	Fibers
	Grass roots
	Hair, treated animal
	Kittool
	"Nylon"
	Palm fiber, fine
	Piassava
	"Rayon", resin treated
	Rice roots
	Rubber
	Wire, metal
British Gum	See Dextrin
Bromeline	Keralin
Bromine	Catalysts
	Chlorine
	Iodine
Bronze	Babbitt
	Brass
	Ceramics, glazed
	Iron, compressed powdered
	Textiles laminated with synthetic resins
	Wood, impregnated
Bronze Powder	See Aluminum powder

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Burlap	"Aqualized" paper
	Fibers
	Kraft paper laminated with asphalt
Butane	Acetylene
	Ethylene
	Gas, natural
	Gas, manufactured city
	Gasoline
	Propane
Butanol	See Butyl alcohol, normal
Butter	Glyceryl oleo myristate
	Hydrogenated citrus oils
	Hydrogenated fish oils
	Hydrogenated vegetable oils
	Lard
	Mineral oil
	Petrolatum
Butyl Acetate	Solvents
Butyl Acetyl Ricinoleate	Diglycol ricinoleate with "carbitol"
Butyl Alcohol, Normal	Butyl alcohol, tertiary with isopropanol
	Solvents
Butyl Alcohol, Tertiary	Acetone
	Isopropyl alcohol
	Solvents

Product	*Substitute or Alternative*
Butyl "Carbitol"	Solvents Triacetin
Butyl "Cellosolve"	Solvents
Butyl Glycollate	Solvents
Butyl Lactate	Glycol glycollate Solvents
Butyl Oleate	Benzyl alcohol Glycol oleate
Butyl Propionate	Solvents
Butyl Stearate	Benzyl alcohol Diglycol laurate Glyceryl monoricinoleate with a little stearic acid
Butylene Glycol	Glycerin Glycol
Butyric Acid	Acetic acid Propionic acid
Cacao Butter	Borneo tallow Cetyl alcohol with mineral or vegetable oil Hydrogenated vegetable oils, partially

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Hydrogenated oil with beeswax
	Propylene glycol stearate
Cade Oil	Birch tar oil
Cadmium	Aluminum
	Chromium
	Metals
	Silver
	Zinc
Cadmium Base Babbitt	Copper, lead base babbitt
Cadmium Chloride	Barium chloride
Calcium	Antimony
	Barium
	Lithium
Calcium Arsenate	Insecticides
Calcium Carbonate	Calcium phosphate
	Chalk
	Dolomite
	Fillers
	Limestone
	Marble dust
Calcium Chloride	Alumina, activated
	Barium chlorate
	Barium monoxide, porous
	Calcium sulfate, anhydrous
	Coal tar
	Copper sulfate, anhydrous
	"Curbay" binder

Product	*Substitute or Alternative*
	"Doucil"
	"Drierite"
	Ethyl potassium phosphate
	"Florite"
	Fuel oil
	Glycerin
	Lithium chloride
	Magnesium chlorate
	Magnesium chloride
	Molasses
	Potassium acetate
	Silica gel
	Sodium hydroxide, anhydrous
	Sugar
	Sulfite liquor
	Sulfuric acid
	Zinc chloride, anhydrous
Calcium Cyanamid	Ammonium phosphate with lime
	Sodium nitrate with lime
Calcium Fluoride	See Fluorspar
Calcium Gluconate	Calcium levulinate
Calcium Hypochlorite	See Bleaching powder
Calcium Levulinate	Calcium gluconate

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Product	*Substitute or Alternative*
Calcium Oleate	Aluminum oleate Calcium palmitate Magnesium resinate
Calcium Oxide	See Lime Alkalies
Calcium Peroxide	Hydrogen peroxide
Calcium Phosphate	Alum, potash Aluminum phosphate
Calcium Propionate	Preservatives
Calcium Resinate	Aluminum resinate
Calcium Stearate	Aluminum Stearate
Calcium Sulfate	See Gypsum Barium sulfide
Calcium Sulfide	Methylamine Strontium sulfide
"Calgon"	Sodium tetraphosphate
Camels' Hair	Fibers "Nylon" fleece
Camphor	Benzyl benzoate Camphene Dibenzyl Dibutyl tartrate "Dehydranone" Diethyl phthalate Esparto wax Hexachloroethane Insecticides

Product	*Substitute or Alternative*
	Menthol
	Naphthalene
	Paradichlorbenzene
	Phenol
	Plasticizers
	Resorcinol
	"Tetralin"
	Triphenyl phosphate
Camphor Oil	"Japp-O"
	"Terpesol"
	Turpentine
Camphor Sulfonic Acid	p-Cymene sulfonic acid
Candelilla Wax	"Norcowax 72"
Cane	See Rattan
Cane Sugar	See Sugar
Capric Acid	"Alox" acids
	Coconut oil fatty acids
Capryl Alcohol	See Octyl alcohol, normal
Caramel Coloring	"Curbay" binder
	Dyes
	"Glutrin"
	Malt extract
	Molasses
"Carbitol"	Aminoalcohols
	Ethyl lactate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Monoglycollin
	Solvents
	Triacetin
"Carbitol" Acetate	Ethyl lactate
	Propyl glycollate
Carbolic Acid	See Phenol
Carbon, Activated	Alumina, activated
	Alum, potash
	Asbestos
	Bauxite
	Bentonite
	Bone char
	Carbon, cherry-pit
	Carbon, coconut shell
	Carbon, peach-pit
	Carbon, walnut shell
	Carbon, wood sawdust
	Catalysts
	Cellulose
	Clay
	Coal, treated
	"Filtrol"
	Infusorial earth
	Magnesium carbonate
	Magnesium silicate
	Peat, treated
	Silica gel
	Sodium alumino-silicate
	Talc
	Wood char

Product	*Substitute or Alternative*
Carbon Black	Asphalt
	Boneblack
	Bone char
	Carbon, activated
	Charcoal
	Fillers
	Iron oxide black
	Lampblack
	Litharge
	Mineral black
	Mineral rubber
	Silica black
	Tar
Carbon Brushes	Silver-graphite brushes
Carbon Dioxide	Ammonium bicarbonate
	Carbon tetrachloride
	Methyl chloride
	Nitrogen
	Sodium bicarbonate
Carbon Disulfide	Solvents
Carbon Tetrachloride	Carbon dioxide
	Chloroform
	Ether, petroleum
	Ethylene dichloride with sulfur dioxide
	Methyl bromide

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Methyl chloride
	Solvents
	Trichlorethylene
Carborundum	Abrasives
"Carbowax"	Glycerin
	Polymerized glycol stearate
Cardamom Oil	"Card-O-Mar"
Carnauba Wax	"Acrawax"
	Candelilla wax
	Cotton wax, green
	Esparto wax
	Hydrogenated castor oil
	"Norcowax 350"
	Ouricuri wax
	"Rezowax"
	"Santowax M"
	Stearamides, substituted
	"Stroba Wax"
	Sugar cane wax
Carob Gum	Gums, water dispersible
Carragheen	Gums, water dispersible
Casein	Adhesives
	Albumen
	Alum, potash
	Alkyd resins
	"Alpha" protein
	"Cellofas WLD"

Product	*Substitute or Alternative*
	Cellulose esters
	Emulsifiers
	"G"-protein
	Gluten
	Gums, water dispersible
	"Proflex"
	"Prosein" (Soya protein)
	Resins, natural
	Resins, synthetic
	Shellac
	Sizes
	Thickeners
	Zein
Castor Oil	Diglycol laurate
	"Dipolymer"
	"Flexoresin L 1"
	Glyceryl monoricinoleate
	Glycol hexaricinoleate
	Grapeseed oil
	Vegetable oils
Castor Oil, Dehydrated	Linseed oil, activated (*710)
Catalysts	Alkyl phosphoric acids e.g. methyl phosphoric acid
	Aluminum chloride

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Aluminum ethylate
	Boron fluoride
	Carbon, activated
	Caustic soda
	Chlorine
	p-Cymene sulfonic acid
	Ferric chloride
	Hydrochloric acid
	Hydrofluoric acid
	Iodine
	Platinum gauze
	Sodium
	Sodium bisulfite
	Sulfuric acid
	p-Toluene sulfonic acid
	Vanadium pentoxide
	Zinc chloride
Catechin	Mahogany sawdust
Catechu	Mahogany sawdust
Catgut	Gut
Caustic Potash	Alkalies
Caustic Soda	Alkalies
Cedar, Spanish	Toon (Moulmein cedar)
Cedarwood Oil	Naphthalene
"Celite"	See Diatomaceous earth
"Cellophane"	Cellulose acetate
	Cellulose esters

Product	*Substitute or Alternative*
	Films, synthetic resin
	Films, plastic
	Parchment paper
	"Pliofilm"
	Varnished paper
	"Vuepak"
	Waxed paper
"Cellosolve"	Solvents
"Cellosolve" Acetate	Solvents
*Cellulose	Bagasse
	Cotton linters
	Fillers
	Paper pulp
	Rice hulls
	Sawdust
	Straw
	Tanbark, spent
	Wood flour
Cellulose Esters	Adhesives
	Casein
	"Cellophane"
	Plastics
	Resins, natural
	Resins, synthetic
	Starch acetate

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Sucrose acetate
	Viscose
Cellulose Acetopropionate	Cellulose acetobutyrate
	Cellulose esters
	Cellulose nitrate with cellulose acetate
	Plastics
	Polystyrene
	Resins, synthetic
Ceramic Insulators	Glass
	Plastics
	Stone
	"Styramic"
Ceramics	Glass
	"Karbate"
	Metals
	Paper, impregnated
	Plastics
	Rubber, hard
	Vulcanized fiber
	Wood
Ceresin Wax	Wax, amorphous
Cetyl Alcohol	Lanolin alcohols
	Monostearin
	Oleyl alcohol
	Stearyl alcohol
Chalk	Abrasives
	See Calcium carbonate

Product	*Substitute or Alternative*
Charcoal	Carbon, activated Coal Coke Gas, natural Propane
Cherry Gum	Gums, water dispersible
Cherry Kernel Oil	Almond oil
China Clay	Fillers Talc
China Wood Oil	See Tung oil
Chinese Wax	See Insect wax
Chinese Blue	See Iron blue
Chloramin	Hydrogen peroxide Preservatives
Chlorine	Bleaching powder Bromine Catalysts Hydrogen peroxide Iodine Nitric acid Ozone Sodium chlorite Sulfur dioxide
Chlorobenzene	Solvents

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Chloroform	Carbon tetrachloride Solvents
Chlorophyll	Dyes, aniline
Chloropicrin	"Dry-Ice" with 10% ethylene oxide "Ethide" Furoylchloride Insecticides Methyl bromide
Chlororubbers	"Halowax" Rubbers, synthetic
Chlorthymol	Preservatives
Chlorxylenol	Preservatives
Cholesterol	Lanolin alcohols
Chondrus	Agar
Chrome Alum	Alum, potash
Chrome/Alumel	Platinum/platinum rhodium
Chrome Orange	Ochre Orange mineral Pigments Sienna
Chromite	Zirconium silicate
Chromium Acetate	Aluminum sulfate
Chromic Acid	Nitric acid
Chromic Anhydride	See Chromic acid

Product	*Substitute or Alternative*
Chromium	Cast iron with small amounts of phosphorus and titanium Molybdenum Phosphorus with titanium
Chromium Plating	Cadmium plating Nickel & silver plating Paints Pearl lacquer
Chromium Potassium Sulfate	See Chrome alum
Chromium Sulfate	Ferric sulfate
Chromium Trioxide	See Chromic acid
Cinnamon	Cinnamaldehyde and eugenol with powdered nut shells
Citral	Lemongrass oil, Florida
Citric Acid	Acetic acid Gluconic acid Glycollic acid Lactic acid Lemon juice Levulinic acid Malic acid

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Product	*Substitute or Alternative*
	Phosphoric acid
	Propionic acid
	Saccharic acid
	Sodium acid sulfate
	Sodium bisulfite
	Sodium diacetate
	Tartaric acid
	Sulfuric acid, dilute
	"Tartex"
	Vinegar
Citronella Oil	"Andro"
	Eucalyptus oil
	"Javonella"
	Pennyroyal oil
	Tetra hydrofurfuryl lactate
Clay	Alum, potash
	Fillers
	Plastics
Clay, Colloidal	See Bentonite
	Kaolin
Clove Oil	"Clovel"
	Eugenol
Coal	Natural Gas
	Charcoal
	Oil
	Peat
	Shale
	Wood

Product	*Substitute or Alternative*
Cobalt	Lead Manganese Molybdenum Nickel Tantalum Tungsten
Cobalt Chloride	Barium chloride
Cobalt Oxide	Sodium antimonate, manganate, uranate or vanadate with copper carbonate
Cobalt Naphthenate	Driers "Nuolate Cobalt"
Cobalt Magnet Steel	Carbides, metal Mishima alloys Molybdenum manganese chromium steel Molybdenum steel Nickel steel Nickel aluminum steel Nickel copper steel Tungsten boron silicon steel Tungsten chromium molybdenum steel

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Product	*Substitute or Alternative*
	Tungsten, titanium cerium steel
Cocoa Butter	See Cacao butter
Cochineal	Dyes, aniline
Coconut Oil	Babassu oil Castor oil Castor with cottonseed oils Coconut oil fatty acids Cohune oil fatty acids Confectioners' oil, "Crystal" Corozo oil Coyol oil Glyceryl myristate with castor oil Hydrogenated vegetable oils, partially Lard oil Macanilla oil Mineral oil with lard oil Murumuru oil Myristic with ricinoleic acids Neatsfoot oil "Neo-Fat 13" Oleic with ricinoleic acids Olive oil with mineral oil Oxidized paraffin wax with red oil Palm kernel oil

Product	*Substitute or Alternative*
	Peanut oil, blown
	Polyhydric alcohol, fatty acid esters, e.g. Diglycol ricinoleate
	Rosin with linseed oil
	Tucum oil
	Vegetable oils
	Vegetable oils, blown
Cod Oil	Degras
	Herring oil, blown
	Menhaden oil, blown
	Pilchard oil
	Sardine oil, blown
	Whale oil
	Hake Liver Oil
Cod Liver Oil	Rice bran oil, purified
	Sardine oil
	Shark liver oil
	Sterols, irradiated animal
	Tuna liver oil
Coffee	Bicho seeds
	Chickory
	Grains, mixed roasted
Coffee Wax	Beeswax
	Wax, synthetic
Colchicine	Sanguinarin

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Collodion	Adhesives Cellulose esters solutions Plastics solutions Resins, solution of synthetic
Colophony	See Rosin
Congo, Gum	See Copal
Copal, Gum	Adhesives Resins, natural Resins, synthetic
Copper	Iron, wrought Metals Plastics Silver Steel, asphalt coated Steel, copper plated Steel, enameled Steel, galvanized Steel, lead coated
Copperas	Alum, potash Aluminum hydrate
Copper Chromate	Creosote Preservatives
Copper Naphthenate	Copper "Alanate" Copper carbonate, basic Copper "mahogany" sulfonates Copper oleate

Product	*Substitute or Alternative*
	Creosote
	Driers
	Preservatives
	Tar oil
Copper Oxide	Manganese dioxide
	Mercuric chloride
Copper Plating	Anodizing
	Metal plating
	Paint
	Pearl lacquer
Copper Sulfate	Aluminum sulfate
	Preservatives
Copper Tungsten	Silver molybdenum carbide
Cork	Asbestos fiber with asphalt or resin binder
	Bark fiber with asphalt or resin binder
	Bran fiber with asphalt or resin binder
	"Cushiontone"
	Felt, impregnated hair or wool
	Fiberboard
	"Fiberglas"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	"Foamglas"
	Frothed and set synthetic resins e.g. "Iporka"
	"Joinrite"
	Linseed meal
	Millboard, soft
	Mineral wool
	"Naturazone"
	Oatmeal
	Palmetto wood
	Pao Santo bark
	Paper pulp
	Peat moss
	Redwood bark
	"Rock Cork"
	Rock "wool"
	Rubber
	Rubbers, synthetic
	Rubber with lignin, synthetic
	Sawdust
	Silica aerogel
	Sphagnum moss with asphalt or resin binder
	Wood
	Wood wool
Corn Sugar	See Sugar
Corn Syrup	See Sugar
	Glycerin
Corundum	Abrasives

Cotton	Cellulose Fibers
Cotton Linters	Alpha cellulose
Cotton, Soluble	See Nitrocellulose
Coumarin	Melilotin "Toncarome" "Tonka-Mel"
Cream of Tartar	Adipic acid Ammonium sulfate Mucic acid Saccharolactic acid
Creosote	Coal tar Copper "Alonate" Copper chromate Copper naphthenate Copper oleate Copper phosphate Copper sulphate Cresylic acid Pentachlorphenol Preservatives Tar oils Zinc chloride
Cresol	Coal tar acids Creosote Furfural

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Product	*Substitute or Alternative*
	Phenol Preservatives
Cresylic Acid	Creosote See Cresol
Crocus	Abrasives See Iron oxide
Cryolite	Cryolite, synthetic Sodium silicofluoride
Cube Root	Insecticides "Thanite"
Cudbear	Amaranth Dyes, aniline
Cumic Acid	Benzoic acid
Cutch	Dyes, aniline Mahogany sawdust
Cuttlefish Bone	Abrasives
Cyanamid	Ammonium compounds Nitrogenous wastes, e.g. cattle blood
Cyclohexanol	Solvents
Cyclohexanone	Solvents
Cymene	Solvents
"Decalin"	Solvents Turpentine
Decolorizing Carbon	See Carbon, activated

Product	*Substitute or Alternative*
Degras	Cod oil
	"Sublan"
	See Wool grease
Derris	Devil's Shoestring root
	Insecticides
	"Thanite"
Dextrin	"Abopon"
	Adhesives
	Glycerin
	Gums, water dispersible
	Malt extract
	Sodium silicate
	Sodium sulfate
	Thickeners
	Sugar
	Urea
Dextrose	See Sugar
Diacetone	Acetone
	Solvents
Diacetone Alcohol	Solvents
Diacetyl	Acetyl methyl carbinol
Diamond, Industrial	Abrasives
	Boron
	Boron carbide

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Product	*Substitute or Alternative*
	"Corundum"
	Sapphire, synthetic
	Silicon carbide
Diamyl Phthalate	Plasticizers
Diatomaceous Earth	Alum, potash
	Abrasives
	Carbon, activated
	"Dicalite"
	Fillers
	Fuller's earth
Dibenzyl	Camphor
Dibutyl Phthalate	Butyl oleate
	Castor oil
	Castor oil, blown
	"Dipolymer"
	"Glaurin"
	Glycol hexaricinoleate
	2, 5 Hexanediol
	Monoglycollin
	Plasticizers
	"Theop"
Dichloramine	Hydrogen peroxide
Dichlorodiethyl Ether	Solvents
Dichlorethylene	Methyl chloride
Dicresyl Carbonate	Butyl oleate
	Dibutyl phthalate
	Glycerin
Dicyandiamid	Ammonium compounds

Product	*Substitute or Alternative*
Die Castings	Porcelain, molded
Diethyl "Carbitol"	Solvents
Diethyl Carbonate	Solvents
Diethylene Glycol	Glycols
Diglycol Glycollate	Solvents
Diglycol Laurate	Diethyleneglycol oleoric-inoleate "Glyco S658"
Diglycol Phthalate	Plasticizers
"Diglycol" Stearate	Emulsifiers Gums, water dispersible Wax, emulsified e.g. "Japsol"
Dioxan	Solvents
Diphenyl Oxide	Plasticizers
Divi-Divi	Cascolate pods Tara
Dolomite	Calcium carbonate Limestone Magnesite Magnesium chloride
"Doucil"	Calcium chloride

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Product	*Substitute or Alternative*
"Dowicides"	Preservatives
Dragon's Blood	Dyes, aniline
"Drierite"	Calcium chloride
Driers	Cobalt linoleate Cobalt naphthenate Cobalt resinate Lead linoleate Lead naphthenate Lead resinate Magnesium oleate Manganese linoleate Manganese naphthenate Manganese resinate "Nuodex" Zinc palmitate
Dulcitol	Sorbitol
"Duponol"	Wetting agents
"Duriron"	Ceramics "Karbate" Plastics Porcelain "Pyrex" Resins, synthetic "Saran" "Tygon"
*Dyes, Aniline	Amaranth Annatto

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Caramel coloring
	Chlorophyll
	Cochineal
	Coffee grounds
	Cudbear
	Cutch
	Dragon's blood
	Fustic
	Hypernic
	Indigo
	Logwood
	Madder
	Orchil extract
	Osage orange extract
	Pigments, mineral, e.g. sienna
	Precipitates, chemical e.g. antimony sulfide
	Quercitron bark
	Saffron
	Tannin
	Turmeric
*Dyes, Vat	"A.A.P. Naphthols"
	Dyes, aniline
	Precipitate, chemical e.g. lead chromate

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Ebony	Asphalt compositions Plastics
Egg	Agar "Galagum C" Pectin
Egg White	Agar Soyabean protein
Egg Yolk	Emulsifiers Fish milt Polyhydrical alcohol fatty acid esters, e.g. glyceryl monostearate Lecithin
Elaterite	See Mineral rubber
Emery	Abrasives Aluminum oxide, artificial
*Emulsifiers	Albumen Amine soaps, e.g. trihydroxyethylamine oleate Bentonite Casein G-protein Gelatin Gum, water dispersible Lanolin Lecithin Lignin sulfonates Methyl cellulose

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Petroleum sulfonates
	Polyhydroxyalcohol fatty acid esters e.g. glyceryl monoricinoleate
	Saponin
	Soap
	Sulfonated vegetable oils
	Thickeners
	Wetting agents
Enameled Ware	Ceramics
	Plastics
	"Pyrex"
	Wood
Ergot	Huitlacoche (Mexican corn fungus)
Esparto Wax	Carnauba wax
Essential Oils	Synthetic aromatics
	Synthetic oils
Ester Gum	Casein
	Plastics
	Resins, natural
	Resins, synthetic
	Rosin
	Shellac

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Product	*Substitute or Alternative*
	Soya protein
	Zein
Ethanol	See Ethyl alcohol
Ethanolamines	Acetamide
	Alkalies
	Amines
Ethanolamine Acetate	Acetamide
Ether, Ethyl	Ether, petroleum
	Ethyl chloride
	Isopropyl ether
	Methylal
	Solvents
Ether, Petroleum	Benzol
	Carbon tetrachloride
	Ether, ethyl
	Ethyl chloride
	Isopropyl ether
	Pentane
	Solvents
Ethyl Acetate	Acetone
	Isopropyl acetate
	Methyl acetate
	Solvents
Ethyl Alcohol	Ethylene
	Kerosene
	Methyl alcohol
	Pentane
	Propylene glycol

Product	*Substitute or Alternative*
	Rum
	Solubilizers or emulsifiers
	"Glyco S533"
	"Stago CS"
	Sulfonated oils
	Solvents
	Tetrahydrofurfuryl alcohol
	Wine
Ethyl Ammonium Phosphate	Glycerin
Ethyl Butyrate	Solvents
Ethyl Chloride	Ether, ethyl
	Ether, petroleum
Ethyl Ether	Solvents
Ethyl Lactate	"Carbitol"
	"Carbitol" acetate
	Solvents
Ethyl Propionate	Solvents
Ethylene	Butane
	"Calorene"
Ethylene Chlorhydrin	Glycerylchlorhydrin
Ethylenediamine	Alkalies

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Product	*Substitute or Alternative*
	Ammonia
	Morpholine
Ethylene Dichloride	Methyl chloride
	Propylene dichloride
	Solvents
Ethylene Glycol	Glycols
Ethylene Glycol Momo-ethyl Ether	See "Cellosolve"
Excelsior	Grass, dried
	"Kimpak"
	Paper, shredded
	Peat moss
	Sawdust
	Spanish moss
	Tanbark, spent
*Fatty Acids	Fatty Acid Blends "C.CH.CW"
	"Indusoil"
	"Liqro"
	Oxidized paraffin wax
	"Paralube+SL20"
	Ricinoleic acid
	Rosin
	"Staybellite"
	Talloil
Felt	Asbestos
	Cellulose
	Cork

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Fibers
	"Fiberglas"
	Nylon fleece
	Rubbers, synthetic
	Spanish moss
	Straw
Ferric Chloride	Alum
	Aluminum chloride
	Catalysts
	Ferric sulfate
	Magnesium chloride
Ferric Sulfate	Alum, potash
	Aluminum hydrate
	Chromium sulfate
	Dolomitic lime with ordinary lime
	Ferric chloride
"Ferri-Floc"	Alum
Ferromanganese	Spiegeleisen
Ferrous Chloride	Aluminum chloride
	Barium chloride
Ferrous Sulfate	See Copperas
* Fibers	Agave
	"Aralac"
	Asbestos

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Product	*Substitute or Alternative*
	"Balsam wool"
	Bristles
	Cellulose esters
	Coir
	Cotton
	Esparto grass
	"Fiberglas"
	Fique
	Flax
	"Glolene"
	Hair, animal
	Hair, human
	Hemp
	Ixtly fiber
	Mohair
	Nylon
	Paper, braided
	Piassava
	Protein, hardened
	Ramie
	Rayon
	Resins, synthetic
	Sansevieria
	Silk
	Sisal
	Straw
	"Vinyon"
	Viscose
	Wool
	Yucca

Product	*Substitute or Alternative*
*Fillers	Asbestos
	Barytes
	Calcium carbonate
	Calcium sulfate
	Clay
	Cotton flock
	Diatomaceous earth
	Kaolin
	Magnesia
	Magnesite
	Paper pulp
	Pyrophyllite
	Rayon flock
	Silica
	Slate flour
	Talc
	Whiting
	Wood flour
Filter Cloth	"Saran"
	Fibers
Fire Clay	Agalmatolite
	Chalcedony
	Pinite
Fish Oils	Animal oils
	Cod liver oil fatty acids

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Herring oil
	Menhaden oil
	Pilchard oil
	Sardine oil
	Vegetable oils
	Whale oil
Flavoring Extracts	Imitation flavors
Flax	Cotton with jute
	Fibers
	Flax tow
Flax Wax	Beeswax
Fleaseed	See Psyllium seed
"Flexol" Plasticizers	Plasticizers
	Polymerized glycol stearate
	Triethanolamine
Flint	Abrasives
Fluorine	Iodine
Fluorspar	Ammonium bifluoride
	Cryolite
	Sodium silicofluoride
Formaldehyde	Acetaldehyde
	Acetic acid
	Aluminum chloride
	Aluminum sulfate
	Ammonia
	Ethyleneglycol diformate
	Formic acid
	Furfural

Product	*Substitute or Alternative*
	Glyoxal
	Potassium bichromate
	Preservatives
	Sodium bichromate
	Tannin
Formalin	See Formaldehyde
Formamide	Acetamide
	Urea
Formic Acid	Acetic acid
	Formaldehyde
	Lactic acid
	Sulfuric acid
	Tannin
"Freon"	Ammonia (anhydrous)
	Methyl chloride
	Methylene dichloride
	Sulfur dioxide
Fuller's Earth	Abrasives
	Carbon, activated
	Diatomaceous earth
Fumaric Acid	Adipic acid
Furfural	Aniline
	Cresol
	Formaldehyde

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Product	*Substitute or Alternative*
	Preservatives
	Solvents
Furfuryl Alcohol	Solvents
Furoyl Chloride	Chloropicrin
Fusel Oil	Amyl alcohol
	Butyl and amyl alcohols
	Solvents
	Tetrahydrofurfuryl alcohol
Fustic	Dyes, aniline
Gallium	Mercury
"Gardinol"	Wetting agents
Garnet	Abrasives
	Quartz
Gas, Natural	Acetylene
	Butane
	Ethylene
	Propane
Gas Oil	Butane
	Gasoline, crude
Gasoline	Acetylene with anhydrous ammonia
	Alcohol
	Benzol
	Butane
	Hydrogen
	Methane

Product	*Substitute or Alternative*
	Petroleum ether
	Producer gas
	Propane
Gas, Producer	Acetylene
Gelatin	Adhesives
	Agar
	Alum, potash
	Casein
	Dextrin
	"Elastolac"
	Emulsifiers
	Gums, water dispersible
	Lacquer
	Polyvinyl alcohol
	"Proflex"
	"Protoflex"
	Resins, synthetic
	Shellac, alkali
	Sodium alginate
	Soaps
	Thickeners
Gilsonite	See Mineral rubber
	Manjak
	Pitch
Glass	Ceramics
	Isinglass

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Product	*Substitute or Alternative*
	"Lucite"
	Marble, transparentized
	Mica
	Paper, oiled or waxed
	Plastics
	"Resinex"
	Resins, synthetic
	"Vuelite"
Gluconic Acid	Citric acid
	Lactic acid
	Mucic acid
Glucose	See Sugar
Glue	Adhesives
	Casein
	Emulsifiers
	Gelatin
	Gums, water dispersible
	Latex
	Resins, synthetic
	Rosin soaps
	Thickeners
Gluten	Casein
Glycerin	Aminoalcohols
	Ammonium lactate
	Apple syrup
	"Aquaresin"
	Butylene glycol
	Calcium chloride
	"Carbowax"

Product	*Substitute or Alternative*
	Corn syrup
	Dextrin
	Dibutyl p'.thalate
	Dicresyl carbonate
	Diglycol oleate
	Ethylammonium phosphate
	Glycols
	"Glycopon"
	"Glucarine B"
	Glucose
	Invert sugar
	Kerosene
	Lactic acid
	Magnesium chloride
	Methyl cellulose
	Methyl sodium potassium phosphate
	Mineral oil
	Nonaethylene glycol ricinoleate
	Polymerized glycol oleate
	Sorbitol syrup
	Sugar
	Sulfonated castor oil
	Sulfuric acid
	"Yumidol"

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Product	*Substitute or Alternative*
Glyceryl Chlorhydrin	Ethylene chlorhydrin
Glyceryl Phthalate	Glyceryl maleate
Glycine	Sugar
Glycol Diacetate	Monoglycollin Solvents
Glycol Glycollate	Butyl lactate
Glycollic Acid	Acetic acid Citric acid Lactic acid
Glycol Monoacetate	Monoglycollin
Glycols	Ethyl potassium phosphate Glycerin Sorbitol
Glyoxal	Formaldehyde
"Glyptal" Resins	See Alkyd resins
Grapeseed Oil	Castor oil
Graphite	"Acrawax" Bone black with talc Diglycol stearate Iron oxide Metals, powdered Mica, powdered Paraffin wax Red lead Silica black Talc

Product	*Substitute or Alternative*
Gums	"Abopon" Adhesives Emulsifiers Gums, water dispersible Resins, natural Resins, synthetic Thickeners
Gum Arabic	See Gum acacia
Gum Benzoin	See Benzoin
Gum Karaya	Gums, water dispersible
Gum, Locust Bean	Gums, water dispersible
Gum Tragacanth	Gums, water dispersible Thickeners
*Gums, Water Dispersible	Adhesives Agar Algin "Algaloid" Ammonium alginate Carragheen Casein Cherry gum Dextrin "Diglycol" stearate Emulsifiers

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Gum acacia
	Gum karaya
	Gum tragacanth
	Locust bean gum
	Methyl cellulose
	Pectin
	Quince seed
	Sodium alginate
	Sodium borophosphate
	Soap
Gut	"Cellophane"
	Fibers
	Metal wire
	"Nylon"
	Plastics
	Protein
	Resins, synthetic
	Rubber, synthetic
Gutta Percha	Balata
	Resins, synthetic
	Rubber, synthetic
Gypsum	Fillers
Hair	Bristles
	Fibers
	Rubber sponge
	Wire, steel
"Halowax"	"Arochlor"
	Chlorinated mineral oil
	Chlorinated paraffin wax

Product	*Substitute or Alternative*
	Chlororubbers
	"Parlon"
	Resins, synthetic
Heliotropin	"Heliocrete"
Helium	Argon
	Hydrogen
Hematine Extract	See Logwood
Hemp	Fibers
Hempseed Oil	Sunflower oil
Heparin	3, 3′ Methylene-bis (4-hydroxycoumarin)
Herring Oil	Cod oil
Hexamethylenetetramine	Hydrofuramide
	Phenyl salicylate
	Urea
Hexamine	See Hexamethylenetetramine
Hexyl Acetate	Solvents
Hexyl Alcohol	Octyl alcohol, normal
Hormones, Sex	Cafesterol
Horn	Plastics
	Wood

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Horse Hair	Bristles Fibers Ixtle de Lechuguilla fiber Kittool
Hydrobromic Acid	Bromine Hydrochloric acid
Hydrochloric Acid	Catalysts Chlorine Hydrobromic acid Nitre cake Sulfuric acid
Hydrocyanic Acid	Insecticides
Hydrofluoric Acid	Aluminum chloride, anhydrous Ammonium bifluoride Catalysts Phosphoric with chromic acids Sodium silico fluoride
Hydrofuramide	Hexamethylenetetramine
Hydrogen	Acetylene Helium
Hydrogen Peroxide	"Alperox" Benzoyl peroxide Bleaching powder Calcium peroxide Chloramine Chlorine

Product	*Substitute or Alternative*
	Dichloramine
	Magnesium peroxide
	Oxalic acid
	Oxygen
	Ozone
	Potassium bichromate
	Potassium chlorate
	Potassium chromate
	Potassium perchlorate
	Potassium permanganate
	Preservatives
	Selenium dioxide
	Sodium chlorate
	Sodium chlorite
	Sodium hypochlorite
	Sodium hydrosulfite
	Sodium perborate
	Sodium perchlorate
	Sodium peroxide
	Sulfur dioxide
	Zinc hydrosulfite
	Zinc peroxide
Hydroquinone	Maleic acid
	Naphthol, beta
	Pyrogallol
	Resorcinol
	Selenium

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Hydroxyacetic Acid	See Glycollic acid
Hydroxycitronellal	Cyclamen aldehyde
Hypernic	Dyes, aniline
Ice	Carbon dioxide, solidified Freezing mixtures e.g. ammonium nitrate with water Refrigeration, electrical, mechanical or thermal
Iceland Moss	Emulsifiers Gums, water dispersible Thickeners
India Gum	Gums, water dispersible
Indigo	Dyes, aniline
Indol	"Indolene"
Infusorial Earth	See Diatomaceous earth
*Insecticides	Amides, higher fatty, e.g. lauryl amide Barium silicofluoride Bordeaux mixture Calcium arsenate Castor leaf extract Chloropicrin Cryolite "Derex" "Ethide" Hydrocyanic acid

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Ketones, higher fatty
	Lead arsenate
	"Lethane"
	Methyl bromide
	Naphthalene
	Nicotine
	Paradichlorobenzene
	Paris green
	Phenothiazine
	Phthalonitrile
	Pyrethrum
	Rotenone
	Sodium fluoride
	Sodium silicofluoride
	Sulfur
	Tetrahydrofurfuryl lactate
	"Thanite"
	Tobacco dust
Insect Wax	See Chinese wax
Invert Sugar	Glycerin
	Honey
Iodine	Bromine
	Catalysts
	Chlorine
	Fluorine
	Preservatives

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Product	*Substitute or Alternative*
Iridium	Ruthenium Ruthenium with platinum
Irish Moss	Gums, water dispersible Thickeners
Iron	See Metals
Iron Blue	See Pigments, inorganic
Iron, Cast	China, vitrified Earthenware Glass Gypsum Plastics
Iron Oxide	Abrasives Alumina Graphite Spanish oxide
Isinglass	Agar Alum, potash Emulsifiers Gums, water dispersible Thickeners
Isobutyl p-Aminobenzoate	Aconite
Isophorone	Solvents
Isopropyl Acetate	Ethyl acetate Solvents
Isopropyl Alcohol	Butyl alcohol, tertiary Emulsifiers Solvents

Product	*Substitute or Alternative*
Isopropyl Ether	Acetone
	Ether, ethyl
	Ether, petroleum
	Solvents
Ivory	Aminoplasts
	Ivory nut
	Plastics
	Resins, synthetic
Ivory, Vegetable	Melamine resins
Japan Wax	Bayberry wax
	"Hydrofol Wax #1"
	"Hydrofol Glycerides #50"
	"Isco" Japan wax substitute
	"Nipocer N"
	"Norcowax 110"
Jet	Plastics
Jute	Fibers
	Kraft paper, twisted with cotton braid
	Malva fiber
	Yucca fiber
Kaolin	See China clay
	Bentonite
	Fillers

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Kapok	"Bubblfil"
	"Foamglas"
	Milkweed floss
"Karbate"	Ceramics
	Glass
	Plastics
	Resins, synthetic
	Silver
Kieselguhr	See Diatomaceous earth
Kyanite	Alumina, fused
	Chrome magnesia
	Kaolin
	Magnesia alumina (Spinel)
	Mullite
	Silica brick
	Stillimanite
Lacquer	Paint
Lactic Acid	Acetic acid
	Ammonium sulfate with dilute sulfuric acid
	Citric acid
	Formic acid
	Gluconic acid
	Glycollic acid
	Maleic acid
	Malic acid
	Phosphoric acid
	Saccharic acid
	Sulfuric acid, dilute
	Tartaric acid

Product	*Substitute or Alternative*
Lactose	Dextrose Milk powder, skimmed Sugar
Lampblack	Carbon black
Lanolin	Petrolatum with rosin "Sublan"
Lanolin Alcohols	Cetyl alcohol Cholesterol "Emulgor A" Emulsifiers Monostearin Phytosterols
Lard	Hydrogenated vegetable or fish oils Tallow, refined
Lard Oil	Fish oil Mineral oil Mustard seed oil Polyhydric alcohol fatty acid esters, e.g. diglycol-oleate Rosin oil Vegetable oils
Latex	Adhesives Blood Albumen

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	"Dispersite"
	"Emulsion 58-8"
	Gelatin
	Glue
	Methyl cellulose
	Reclaimed rubber emulsions
	Resin emulsions
	Rubber emulsions, synthetic
	"Seatex"
	Vinyl copolymer emulsions
Lauric Acid	Fatty acids
	Myristic acid
	Stearic acid with castor oil
Lavender Oil	Cedar leaf oil
	Terpenyl acetate
Lead	Earthenware
	Metals
	Plastics
	Polyisobutylene with carbon black
	Sulfur cements
	"Tegul Mineral Lead"
Lead Arsenate	Insecticides
	Nicotine sulfate with bentonite
	Phthalonitrile
Lead Azide	Lead fulminate

Product	*Substitute or Alternative*
	Mannitol hexanitrite
	Mercury fulminate
Lead Chloride	Barium chloride
Lead Chromate	Yellow iron oxide with a little zinc chromate
	Zinc tetroxy chromate
Lead Fulminate	Lead azide
Lead Linoleate	Driers
Lead Naphthenate	Driers
	"Nuolate" lead
Lead Oleate	Aluminum oleate
	Tin oleate
	Calcium oleate
	Chlorine
	Lead naphthenate
Lead, Red	Graphite
	Iron oxide
	Iron phosphate
	Pigments
	White lead
Lead Wool	Asbestos wool
	Fibers, resin impregnated
Lead Resinate	Aluminum resinate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Leather	Barks, tree
	"Fabrikoid"
	Felt
	Fiberboard
	Fibers woven, impregnated, coated or compressed
	Linoleum
	"Onco V"
	Paper, impregnated
	Plastics
	Plywood
	Rubber
	Rubbers, synthetic
	Vulcanized fiber
	Wood
Lecithin	Egg yolk
	Betaine di-oleylglycerophosphate
	Emulsifiers
	Phosphatides, vegetable oil
Lemon Oil	Citral with limonene or lemon oil terpenes
Lemongrass Oil	Dipentine
	Lemon oil terpenes
	"Lemenone"
"Lethane"	Insecticides
Levulinic Acid	Acetic acid
	Citric acid

Product	*Substitute or Alternative*
Levulose	Sugar
Licorice Root	"Durafoam" "Foamapin" Protein, hydrolyzed "Sicapon" Wetting agents
Lignin Sulfonates	Aluminum sulfate Emulsifiers Thickeners
Lime	Alkalies Alum, potash Barium oxide Calcium carbide residue
Limonene	Dipentene Lemon oil terpenes
"Lindol"	See Tricresyl phosphate
Linoleum	Asphalt tile Cork Glass, tempered Leather Plastics Plywood Porcelain Resins, synthetic Rubber, synthetic

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Textiles, treated
Linseed Oil	Alkyd resin solutions Fish oils "Petropol 2138" with vegetable oils Vegetable oils
Litharge	Red lead
Lithium	Beryllium Calcium
Lithium Hydride	Calcium hydride Potassium hydride Sodium hydride
Lithium	Calcium
Lithium Chloride	Calcium chloride
Lithium Hydroxide	Alkalies
Logwood	Dyes, aniline
Lubricating Oil	Castor oil Diglycol ricinoleate Glycerin Graphite Rape seed oil, blown
"Lucite"	See Polystyrene
Lycopodium	Buck-grass, Clubfoot moss, milkweed spores, dried and powdered, Pine grass, Snake moss or walnut shell partings, powdered

Product	*Substitute or Alternative*
Madder	Dyes, aniline
Magnesia	Alkalies Aluminum foil Asbestos Fibers Fillers Manganese hydroxide Peat Refractories Zinc oxide
Magnesia, Milk of	Magnesium trisilicate
Magnesite	Dolomite Fillers Magnesium carbonate
Magnesium	Aluminum Barium Plywood
Magnesium Carbonate	Talc
Magnesium Chloride	Dolomite Ferric sulfate Glycerin
Magnesium Ethylate	Aluminum ethylate
Magnesium Hydroxide	Alkalies
Magnesium Peroxide	Hydrogen peroxide

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Product	*Substitute or Alternative*
Magnesium Oleate	Aluminum oleate
Magnesium Oxide	See Magnesia
Magnesium Resinate	Aluminum resinate Driers
Magnesium Silicate, Fibrous	Asbestos "Celite #110"
Magnesium Stearate	Aluminum stearate
Mahogany	Crabwood
Maize Oil	See Corn oil
Maleic Acid	Adipic acid Hydroquinone Lactic acid Malic acid Phthalic anhydride Sebacic acid Succinic acid
Malic Acid	Citric acid Lactic acid Tartaric acid
Malonic Acid	Tartaric acid
Manganese	Ferro carbon titanium Soda ash Titanium Zirconium
Manganese Chloride	Ammonium chloride

Product	*Substitute or Alternative*
Manganese Dioxide	Aluminum oleate Hydrogen peroxide Selenium
Manganese Hydroxide	Lime, slaked Magnesia
Manganese Naphthenate	Driers "Nuolate" manganese
Manganese Stearate	Aluminum stearate
Manila Fiber	Cotton Fibers Jute
Manila Gum	Cumarone resins "Flexoresin"
Manjak	Mineral rubber Pine tar
Mannitol	Sorbitol
Mannitol Borate	"Aquaresin" Boroglyceride
Mannitol Hexanitrate	Lead azide
Meat	Cheese Fish Soyabean flour
Menhaden Oil	Cod oil

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Product	*Substitute or Alternative*
	Tallow oil
Menthol	Camphor with peppermint oil
Mercuric Chloride	Catalysts Copper oxide Preservatives Silver proteinate
Mercury	Alcohol Alloys, low melting Bismuth Gallium
Mercury Fulminate	Diazodinitrophenol Lead azide Lead styphnate-hypophosphite Nitro mannite
Mesityl Oxide	Solvents
Metals	Cement Ceramics Concrete, reinforced Decalcomania Glass Horn Iron, enameled or coated Ivory Laminated "Bakelite" or other plastics Leather "Lignolite"

Product	*Substitute or Alternative*
	Paper, impregnated
	Plastics
	Plywood
	Porcelain, molded
	Porcelain, conductive
	Stone
	Sulfur cements
	Textiles, impregnated
	Vulcanized fiber
	Wood, impregnated
Metaldehyde	Paraformaldehyde
Metal Wire	Fibers
	Gut
	"Saran"
	Spider webs
Metallic Coatings, Shiny	Graphite
	Paint
	Pearl lacquer
	Plastics
	Resins, synthetic
	Wax
Methanol	See Methyl alcohol
Methyl Acetanilide	Camphor
	Plasticizers

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Product	*Substitute or Alternative*
Methyl Acetate	Ethyl acetate Solvents
Methyl Acetone	Acetone
Methylal	Ether, isopropyl Formaldehyde Solvents
Methyl Alcohol	Alcohol, denatured Ethyl alcohol Solvents
Methylamine	Ammonia Morpholine
Methyl Bromide	Solvents
Methyl "Cellosolve"	Carbon tetrachloride Chloropicrin Insecticides
Methyl "Cellosolve' Acetate	Solvents
Methyl Cellulose	Agar Casein Emulsifiers Glycerin Gums, water dispersible Latex Polyvinyl alcohol Thickeners
Methyl Chloride	Ammonia, anhydrous Carbon dioxide

Product	*Substitute or Alternative*
	Dichlorethylene
	Ethylene dichloride
	"Freon"
	Methylene chloride
	Propane
	Sulfur dioxide
Methyl Ethyl Ketone	Acetone
	Solvents
Methylene Chloride	Solvents
Methylheptine Carbonate	Phenylethylphenyl acetate
Mica	"Alsifilm"
	Asbestos
	Ceramics
	"Fiberglas"
	Graphite
	"Lustron"
	Magnesium silicate, artificial
	"Mycalex"
	Plastics
	Porcelain, electrical
	Pressboard, thoroughly dried and impregnated with oil
Milk	Soyabean milk

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Product	*Substitute or Alternative*
Milk Sugar	See Lactose
Milori Blue	See Iron blue
Mineral Rubber	Asphalt Manjak Pitch
Moellen Degras	See Wool grease
Mohair	Fibers
Molasses	Dextrin Distillery slop "Hydrol" Milk whey, concentrated "Sicaseal" Sorghum syrup Sulfite liquor
Molybdenum	Aluminum Boron Silicon Titanium Tungsten
"Monel"	Ceramics Glass Metals "Nocorodal" carbon Plastics
Monoacetin	Monoglycollin
Monoglycollin	"Carbitol" Glycol diacetate

Product	*Substitute or Alternative*
Montan Wax	Lignite wax "Monten" wax "Norcowax 12A" Peat wax "Rezo Wax" "Santowax"
Montmorillonite	See Aluminum silicate
Morpholine	Ammonia Ethylenediamine Methylamine Triethanolamine
Mother-of-pearl	Melamine resins Pearl essence (Fish scale lacquer)
Mucic Acid	Adipic acid Cream of tartar Gluconic acid Saccharic acid Tartaric acid
Mucin	Agar
Mullite	Topaz, calcined
Muscovite	See Mica
Musk	Abelmoschus
Mustard Gas	Benzyl dichloride

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Product	*Substitute or Alternative*
Mustard Seed Oil	Lard oil Mustard oil, artificial
Myristic Acid	Coconut oil fatty acids with stearic acid Palmitic acid Stearic acid
Naphtha	Solvents
Naphthalene	Camphor Cedarwood oil Insecticides Paradichlorobenzol "Santochlor" Sulfur
Naphthenates, Metallic	Driers "Dryall Tallate" driers "Nuolates"
Naphthenic Acid	Fatty acids
Neatsfoot Oil	"Glyco S 475" "Nopco 2114-P" Polyhydric alcohol fatty acid esters, mixed
"Neoprene"	Chlororubbers Parchment paper Plastics Resins, synthetic Rubbers, synthetic
Nephelin	Alkalies

Product	*Substitute or Alternative*
"Nichrome"	Carbon
	Cast iron grids
	Silicon carbide
Nickel	Catalysts
	Copper indium alloys
	Indium alloys
	Iron chromium alloys
	Iron, enameled or coated
	"Monel"
	Nitrogen
	"Nocorodal" carbon
	Platinum (96%) with tungsten (4%)
	Silver
	Steel, stainless
	Tin
	White copper alloys
Nickel Alloy, Coin	Silver, copper, manganese alloy
Nickel Alloy, Magnetic	"Hypersil"
Nickel Chloride	Barium chloride
Nickel Oxide	Chromium oxide
	Cobalt oxide
	Copper oxide
Nickel Plating	Cadmium plating
	Chromium plating

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Product	*Substitute or Alternative*
	Paints
	Pearl lacquer
	Silver plating
Nicotine	Insecticides
"Nipagen"	"Moldex"
	"Parasept"
	Preservatives
Nitre Cake	Hydrochloric acid
Nitric Acid	Chlorine
	Chromic acid
	Hydrochloric acid
	Hydrogen peroxide
Nitrobenzene, Substituted	o-Nitrodiphenyl
Nitrocellulose	Adhesives
	Cellulose esters
	Plastics
	Resins, synthetic
	Vinyl copolymers
Nitrogen	Ammonia, anhydrous
	Carbon dioxide
Nitromannite	Mercury fulminate
Nutgalls	Gall apples
	Oak galls (oak apples)
	Tannin
Nux Vomica	Strychnine hydrochloride
"Nylon"	Fibers
	Plastics

Product	*Substitute or Alternative*
	Resins, synthetic
Ochre, French	"Witco Yellow"
Octyl Alcohol, Normal	Hexyl alcohol Tributyl phosphate
Oleic Acid	Fatty acids "Indusoil" Talloil
Oleyl Alcohol	Cetyl alcohol
Olive Oil	Apricot kernel oil "Lenolene" Corn oil with crushed green olives Diglycol laurate "Glaurin" Grapeseed oil Lard oil with mineral oil Mineral oil with coconut oil "Nopco C.P." "Olev-ol" Peach kernel oil Peanut oil, destearinated Rice oil Vegetable oils

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Product	*Substitute or Alternative*
Onyx	Petrified wood Stone, artificial
Orchil Extract	Dyes, aniline
Orris Root	Methyl ionone "Resone Orris"
Orthodichlorbenzol	"Emulgor A" with oxalic acid Oxalic acid
Osage Orange Extract	Dyes, aniline
Ouricuri Wax	Carnauba wax
Oxalic Acid	Citric acid Hydrogen peroxide Lactic acid Malic acid Orthodichlorobenzol Sodium oxalate Sulfur dioxide Tartaric acid
Ox-Gall	Emulsifiers Soaps Wetting agents
Oxyquinoline Sulfate	Preservatives
Ozokerite	Carnauba with amorphous paraffin wax "Deetee" wax "Ozowax"

Product	*Substitute or Alternative*
Ozone	Chlorine
	Hydrogen peroxide
	Oxygen
*Paints	Anodizing process
	Asphalt solutions or emulsions
	Embossing
	Enamel, vitreous
	Etching, chemical or friction
	Finishes, chemical
	Gelatin
	Lacquer
	Oxidized finishes (metal)
	Plastic coating
	Plating, metal
	Rust-proofing
	Stain (wood)
	Varnish
	Wax solutions or emulsions
Palm oil	Glyceryl myristate
	Glyceryl oleo-stearate
	Hydrogenated vegetable oils, partially

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* See paragraph 5, p. 52.

Product	*Substitute or Alternative*
	Mineral oil, compounded hi-flash
	Tallow
	Vegetable oils
Palmitic Acid	Fatty acids
	Stearic acid with oleic acid
Papain	"Keralin"
	Papaya juice
	Pineapple juice
Papaverine	Beta-phenylethyl-beta-methoxy-beta-phenyl-ethyl methylamine
Papaya Juice	Papain
Paper Pulp	Alum, potash
	Fibers
	Fillers
Parachlormetacresol	Preservatives
Parachlormetaxylenol	Preservatives
Paradichlorobenzene	Insecticides
	Naphthalene
Paraffin Oil	See Mineral oil
Paraffin Wax	Aluminum stearate
	"Diglycol" stearate
	Glyceryl tristearate
	Graphite
	Naphthalene
	Stearic acid

Product	*Substitute or Alternative*
	Stearin
	Wax, synthetic
Paratoluenesulfonic Acid	Catalysts
	Cymene sulfonic acid
	Phenolsulfonic acid
Parchment Paper	"Cellophane"
	Paper, impregnated with melamine resins
	Resins, synthetic
	Waxed paper
Paris Green	Insecticides
Paris White	See Whiting
Peach Kernel Oil	Almond oil
Pearl, Button	Melamine resins
Pearl Essence	Bismuth oxychloride
	"H Scale"
Pebbles, French	Flint pebbles
Pectin	Agar
	Apple pomace
	Cranberries
	Egg
	Emulsifiers
	Gelatin
	"Gomagel" with sugar

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Gums, water dispersible Protein, soyabean Thickeners
Pentachlorethane	Solvents
Pentachlorphenol	Creosote
Pentaerythritol	Sorbitol
Pentane	Butane Ethyl alcohol
Pepsin	Keralin
Peppermint Oil	"Norimint" Spearmint oil
Perilla Oil	Linseed oil, boiled Tung oil
"Perminvar"	See Cobalt Magnet Steel
Peroxide of Hydrogen	See Hydrogen peroxide
Persic Oil	Almond oil
Petrol	See Gasoline
Petrolatum	Micro-crystalline paraffin wax with light refined mineral oil
Petroleum	Shale oil
Petroleum Sulfonates	Emulsifiers Soaps
Phenol	Cresol Furfural

Product	*Substitute or Alternative*
	Oxyquinoline derivatives
	Preservatives
	Resorcinol
Phenol Formaldehyde Resins	Adhesives
	Asphalt
	Ester Gum
	Plastics
	Resins, natural
	Resins, synthetic
	Rosin, limed
	Zinc resinate
Phenolsulfonic acid	Benzenesulfonic acid
	Paratoluene sulfonic acid
Phenothiazine	Insecticides
Phenyl "Cellosolve"	Solvents
Phenyl Mercuric Nitrate	Preservatives
Phenyl Salicylate	Hexamethylenetetramine
Phosphoric acid	Acetic acid
	Citric acid
	Glycollic acid
	Lactic acid
	Sodium bisulfate
	Sulfuric acid
Phthalic Anhydride	Maleic acid

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Substitute or Alternative	*Substitute or Alternative*
	Phthalic acid
	Succinic acid
Phthalonitrile	Insecticides
Phytosterols	Lanolin alcohols
*Pigments, Inorganic	Antimony orange
	Antimony oxide
	Antimony red
	Cadmium yellow
	Cadmium red
	Carbon black
	Chrome green
	Chrome orange
	Cobalt blue
	English vermilion
	Iron blue
	Iron oxide, red
	Iron oxide, yellow
	Lead chromate
	Litharge
	Lithopone
	Mercuric sulfide
	Molydate orange
	Ocher
	Orange mineral
	Orpiment
	Red lead
	Sienna
	Titanium oxide
	Ultramarine blue

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Umber
	Vermilion
	White lead
	Zinc oxide
	Zinc yellow
*Pigments, "Organic"	Chlorinated para red
	Hansa yellow
	Lamp black
	Lithol red
	Madder lake
	Molybdic lake
	Orange lake
	Orthonitraniline orange
	Para red
	Phospho-tungstic lake
	Phthalocyanine blue
	Phthalocyanine green
	Toluidine red
	Yellow lake
Pilchard Oil	Cod oil
Pinene	Pine oil
Pine Needle Oil	Canadian fir oil
Pine Oil	Insecticides
	Pinene
	Solvents

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Sulfonated tall oil
	Synthetic pine oil
	Wetting agents
Pine Tar	Coal tar
	Manjak
	"Pic tar"
	Pitch, hardwood
	Pitch, mineral
	Pitch, petroleum
	Pitch, pine
	Pitch, stearin
Pipe Clay	See China clay
Pitch	Adhesives
	Asphalt
	"Belro"
	Coal-tar
	Mineral rubber
	Pine tar
	Rosin
	"Vinsol"
Plaster of Paris	See Calcium sulfate
*Plastics	Acrylic resins
	Alkyd resins
	Aminoplasts
	Aniline formaldehyde resins
	Asphalt with soft cumarone resins and wood flour

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	"Bakelite"
	"Beetle"
	Bone
	"Butacite"
	"Butvar"
	Casein
	"Catalin"
	"Celluloid"
	Cellulose acetate
	Cellulose acetobutyrate
	Ceramics, pressed, e.g. "Isolantite"
	"Crystalite"
	Cumarone-Indene resins
	"Dilectene"
	"Durez"
	"Durite"
	Ethyl cellulose
	Felt with asphalt or synthetic resin binder
	"Formica"
	"Gelva"
	Glass
	Glass, tempered
	Glass wool
	"Hyflex"
	"Indur"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Plastics (*Continued*)	Iron, cast
	Lignin resins
	"Lignolite"
	Lignum vitae
	"Lucite"
	"Lumarith"
	"Makelot"
	"Marblette"
	Melamine aldehydes
	Metal, sintered pressed, powdered
	Methyl methacrylate
	"Micarta"
	"Nixonite"
	Phenol formaldehyde resins
	Phenol furfural resins
	Pitch with fillers
	"Plaskon"
	"Plastacele"
	Plexiglas
	"Polystyrene"
	Porcelain, molded
	"Protectoid"
	"Pyralin"
	"Resinox"
	"Saran"
	Shellac
	Styron
	Sulfur with soft cumarone resin

Product	*Substitute or Alternative*
	Tar with fillers
	"Tenite"
	"Texolite"
	Urea formaldehyde resins
	Vinylacetal resins
	Vinylbutyral resins
	Vinylidene chloride resins
	"Vinylite"
	Vulcanized fiber
	Wood
*Plasticizers	Benzyl benzoate
	Butyl lactate
	"Carbowax"
	Camphor
	Castor oil
	Castor oil, blown
	Diamyl phthalate
	Dibutyl phthalate
	Diglycol phthalate
	Diphenyl
	Diphenyl oxide
	"Glaurin"
	Pitch
	Tar
	"Theop"
	Triacetin

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Tricresyl phosphate
	Triphenyl phosphate
Plating, Metal	Paints
Platinum	Catalysts
	Iridium
	Iron containing 42–50% nickel
	"Palau"
	"Proplatinum"
	Quartz
"Pliofilm"	"Cellophane"
	"Ethocel"
	Plastic films
	Parchment paper
Plumbago	See Graphite
	Emulsifiers
Polymerized Glycol Stearate	Plasticizers
Polystyrene	Cellulose acetopropionate
	Glass, tempered
	Plastics
Polyvinyl Alcohol	"Abopon"
	Gums, water dispersible
	"Hevealac"
	Methyl cellulose
	Synthetic resin emulsions
	Urea-formaldehyde resins
Porcelain	"Catalin", cast

Product	*Substitute or Alternative*
	"Formica"
	Glass
	Plastics
	Steatite
Potash	Coconut husk ashes
	Fermentation residue, molasses
	Wood ashes
Potassium	Sodium
Potassium Alum	Aluminum hydrate
	Catalysts
Potassium Bichromate	Formaldehyde
	Hydrogen peroxide
	Tannic acid
Potassium Bitartrate	See Cream of tartar
Potassium Bromide	Calcium bromide
Potassium Carbonate	Alkalies
Potassium Chlorate	Hydrogen peroxide
Potassium Chromate	Hydrogen peroxide
	Sodium chromate
Potassium Cyanide	Sodium cyanide
Potassium Ethylate	Aluminum ethylate
Potassium Ferricyanide	"Redsol"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Potassium Hydroxide	Alkalies
Potassium Metabisulfite	Sodium bisulfite
Potassium Perchlorate	Hydrogen peroxide Sodium chlorite
Potassium Permanganate	Hydrogen peroxide
Potassium Silicate	"Abopon" Adhesives Alkalies
Potassium Sulfate	Potassium chloride Sodium sulfate
*Preservatives	Alcohol Ammonia "Aseptex" Benzoic acid Borax Boric acid "Butaben" Calcium propionate Chloramine T Chlorothymol Chloroxylenol "Cresophane" Creosote Cresol "Dowicides" Essential oils Formaldehyde Hydrogen peroxide

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	"Moldex"
	Oxyquinoline sulfate
	Parachlorometacresol
	"Pentaphen"
	Phenol
	Phenylmercuric nitrate
	Salicylic acid
	"Santophen"
	Sodium benzoate
	Sodium fluoride
	Sodium propionate
	Sodium tribenzoate
	Spices
	Thymol
	Wetting agents
	"Zephiran"
Propane	Acetylene
	Butane
	Gasoline
	Methyl chloride
Propionic Acid	Acetic acid
	Butyric acid
	Citric acid
Propylene Dichloride	Ethylene dichloride
Protein, Fish	Albumen

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Propylene Dichloride	Solvents
Propylene Glycol	Solvents
Propyl Glycollate	"Carbitol" acetate
Protein, Soybean	Albumen
Prussian Blue	See Iron blue
Psyllium Seed	"Fijioline" "Gomagel S 453" Gums, water dispersible
Pumice, Italian	Abrasives Pumice "Valencia" Pumicite
Pyramidon	Acetanilide Aspirin
Pyrethrum	Acetylated pine oil Aliphatic thiocyanates Cucaracha Insecticides "Lethane 145" "Thanite"
Pyridin	Amines Aniline Bone oil Solvents
Pyrogallic Acid	Hydroquinone
Pyrogallol	Hydroquinone Naphthol, Beta Pyrogallic acid

Product	*Substitute or Alternative*
	Resorcinol
	"S A 326"
Pyroligneous Acid	Acetic acid
Pyrophyllite	Fillers
	Steatite
Pyroxylin	See Nitrocellulose
Quartz	Abrasives
	Garnet
	Platinum
	Silica, fused
	"Vycor"
Quercitron Bark	Dyes, aniline
Quicksilver	See Mercury
Quince Seed	Gums, water dispersible
	Pysillium seed
Quinine	"Atabrin"
	Pamaquine naphthoate
	"Promin"
	Quinarine hydrochloride
	Salicin
	Sulfadiazin
Quinine Hydrochloride	Hydroxyethyl apocupriene
	Sinine

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Rapeseed Oil	"Glyco S 558" Vegetables oils
Rattan	Fibers, impregnated Plastics "Saran"
Rayon	Fibers
Rayon Flock	Fillers
Red Gum	See Yacca gum
Red Lead	Graphite Litharge Paint Pigments Zinc tetroxy chromate
Red Oil	Fatty acids Fish oils "Indusoil" Rosin oil Talloil Vegetables oils
*Resins, Aldehyde	Resins, synthetic "Velsicol" resin
*Resins, Natural	Adhesives Cellulose esters "Cumar" "Durez 11036A" Ester gum "Flexoresin"

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	"Glycolac"
	"Nevindene"
	"Nuba"
	"Paradene"
	Resins, synthetic
*Resins, Phenol-Formaldehyde	See Phenol Formaldehyde Resins
*Resins, Synthetic	Adhesives
	Albumen
	Cellulose esters
	Furfuryl lignin resin
	"Glycolac"
	Melamine aldehyde resins
	"Piccolyte"
	Plastics
	Resins, natural
	"Vandiset"
Resorcinol	Camphor
	Hydroquinone
	Phenol
Rope	Beads, strings of
	Fibers
	Leather
	Paper
	"Saran"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Rose Oil	Butyl phenyl acetate Rhodinol
Rosemary Oil	Isobornyl acetate with terpinyl propionate and isoborneol
Rosin	Abietic acid Adhesives "Belro" Fatty acids "Liqrol" Naphthenic acid Pitch Resins, natural Resins, synthetic Tallow "Vinsol"
Rosin Oil	"Flexoresin L 1" Lard oil Mineral oil with rosin Vegetable oils Talloil
Rosin Soap	"Liqrol" with alkali Talloil with alkali
Rotenone	Anabasin Insecticides "Thanite" Xanthone
Rottenstone	Abrasives Tripoli

Product	*Substitute or Alternative*
Rouge, Jeweler's	Abrasives
Rubber	Adhesives
	Asbestos
	Asphalt with graphite
	Canvas, impregnated
	"Dilectene"
	Ethyl cellulose with castor oil
	Factice with resin and filler
	Felt with synthetic resin
	"Fiberglas"
	Fibers
	"Foamglas"
	"Haydenite"
	"Hyflex"
	"Jointite"
	Lead
	Lead oleate with carbon black
	Leather
	Linoleum
	Polyvinyl butyral resin with 1% Acrawax C
	Resins, synthetic
	"Resistoflex PVA"
	Rubbers, synthetic
	"Saflex"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Shellac
	"Tygon"
	Varnished cambric
	Vinyl acetate and chloride copolymers
	"Vinylite"
	"Vistanex"
Rubber Cement	Adhesives
	Blood albumen
	"Cement E C-226"
	Polyvinyl acetate and copolymer emulsions
	Resins, synthetic, solutions of
	Rubber, synthetic solutions
	"Vinylite" solutions
Rubber, Chlorinated	Cumarone resin
	Rubbers, synthetic
	Bricks, impregnated with sulfur and resins
Rubber, Hard	Ceramics, pressed
	"Densite"
	"Electrite"
	Glass, tempered
	Plastics
	Resins, synthetic
	Rubber, synthetic vulcanized
	Tellurium lead alloy

Product	*Substitute or Alternative*
	Tile, glazed
	Vinyl acrylic polymers
	Vulcanized fiber
Rubber, Sponge	Balsa wood
	"Bubblfil"
	Cellulose sponge
	Felt
	"Foamglas"
	Mineral rubber
	Plastics
	Sponge, natural
	Vulcanized vegetable oils
*Rubber, Synthetic	"Ameripol"
	"Buna"
	Butyl rubber
	"Chemigum"
	"Hy-car"
	"Koroseal"
	"Neobon"
	"Neoprene"
	"Perbunan"
	"Resistoflex PVA"
	Rubber
	"Thiokol"
	"Vistanex"
	"Zerok"

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Saccharic Acid	Acetic acid Citric acid Lactic acid Mucic acid Tartaric acid
Saccharin	Glysin
Saffron	Dyes, aniline
Sage	Mexican oregano
Sago	Adhesives Gums, water dispersible Starch, sweet potato Starch, waxy sorghum Thickeners
Salicylic Acid	Preservatives Trichloracetic acid
Sand	Abrasives
"Santochlor"	Naphthalene
Santonin	Phenothiazin
"Santophen"	Preservatives
Saponin	Ammonia "Emulgor A" Emulsifying Agents "Foamapin" Soap bark "Virifoam" Wetting agents

Product	*Substitute or Alternative*
Sapphire	Glass, fused hard Steel, hardened
Sardine Oil	Cod oil Rice bran oil Vegetable oils
Sassafras oil	"Cam-O-Sass" "S-O-Frass"
Sebacic acid	Maleic acid Phthalic anhydride
Seed-Lac	Accroides, gum Ester gum, alcohol soluble Resins, synthetic
Selenium	Antimony Hydroquinone Manganese dioxide Sulfur Tellurium
Selenium Dioxide	Hydrogen peroxide
Sesame Oil	Diglycol dilaurate Peanut oil Sunflower seed oil Vegetable oil
Sheep-Gut	See Gut

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Product	*Substitute or Alternative*
Shellac	Alkyd resins
	"Bullzite"
	Batavia gum
	Casein
	Copal, alcohol soluble
	"Elastolac"
	Ester gum with plasticizer
	Gelatin
	Glass with "Vinylite" coating
	Glyceryl monostearate (water insoluble)
	Glyceryl phthalate
	"Glycolac"
	Gum accroides
	Gum kauri
	Polyvinyl chloride
	"Protoflex"
	Resins, synthetic
Silica	Abrasives
	Fillers
Silica Bronze	Textiles laminated with synthetic resins
Silica Gel	Agar
	Calcium chloride
	Carbon, activated
	Sodium alumino-silicate
Silicate of Soda	See Sodium silicate
Silicon Carbide	Abrasives

Product	*Substitute or Alternative*
Silicon Tetrachloride	Ammonia with hydrochloric acid
	Titanium tetrachloride
Silk	Asbestos
	Cotton, mercerized
	Fibers
	"Fortisan"
	Gut
	"Nylon"
	Rayon
Silk, Oiled	"Koroseal"
	Parchment Paper
	"Pliofilm"
	Resins, synthetic
	Rubbers, synthetic
	Vegetable parchment
Silk, Varnished	"Celanese", resin impregnated
Silver	Indium
	Mercury
	Pearl lacquer
Silver Nitrate	Silver phosphate
Silver Proteinate	Mercuric chloride
	Preservatives
Sisal	Fibers

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Product	*Substitute or Alternative*
*Soaps	Alkalies Amine soaps e.g. butylamine stearate Amino alcohol soaps e.g. triethanolamine oleate Emulsifiers Fatty acids with alkali "Foamapin" Gums, water dispersible Lignin sulfonates Muscovite, white Polyhydric alcohol fatty acid esters e.g. "Diglycol" stearate Saponin Soap bark Thickeners Vegetable oil with alkali Wetting agents Yucca sap
Soap Bark	"Foampin"
Soap, Coconut Oil	Sodium ricinoleate with water soluble soap solvent, e.g. "Carbitol"
Soapstone	See Talc
Soda Ash	Alkalies Sodium metasilicate

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Sodium	Calcium Catalysts Lithium Potassium
Sodium Abietate	Soaps
Sodium Acetate	Catalysts Sodium formate
Sodium Acid Sulfate	Citric acid
Sodium Alginate	Agar Emulsifiers Gelatin Gums, water dispersible Thickeners
Sodium Alkyl Sulfate	Wetting agents
Sodium Aluminate	Alum, potash Aluminum hydrate Copperas with slacked lime
Sodium Acid Sulfite	See Sodium bisulfite
Sodium Antimonate	Cobalt oxide Tin
Sodium Antimony Fluoride	Tartar emetic
Sodium Arsenite	Sodium fluosilicate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Sodium Benzoate	Preservatives
Sodium Bichromate	Aluminum sulfate Formaldehyde Hydrogen peroxide Tannin
Sodium Bisulfite	Acetic acid Calcium sulfide Catalysts Potassium metabisulfite Preservatives Sodium hyposulfite
Sodium Borate	See Borax
Sodium Carbonate	See Soda ash Alkalies
Sodium Caseinate	Emulsifiers
Sodium Cellulose Glycolate	"Foamex" Methyl cellulose
Sodium Chlorate	Ammonium sulfamate Ammonium thiocyanate Hydrogen peroxide Potassium chlorate
Sodium Chlorite	Hydrogen peroxide
Sodium Diacetate	Acetic acid Citric acid
Sodium Ethylate	Aluminum ethylate
Sodium Fluoride	Borax Insecticides

Product	*Substitute or Alternative*
	Preservatives Sodium silicofluoride
Sodium Formate	Sodium acetate Sodium glycollate
Sodium Glycollate	Sodium formate
Sodium Hexametaphosphate	Sodium tetraphosphate
Sodium Hydrosulfite	Hydrogen peroxide
Sodium Hydroxide	Alkalies
Sodium Hypochlorite	Hydrogen peroxide
Sodium Hyposulfite	Sodium bisulfite Sodium chlorite
Sodium Lactate	See Glycerin Mineral oil
Sodium Lauryl Sulfate	Wetting agents
Sodium Lignosulfonate	See Lignin sulfonates
Sodium Manganate	Cobalt oxide
Sodium Metasilicate	Alkalies
Sodium Orthosilicate	Alkalies
Sodium Perborate	Hydrogen peroxide Sodium chlorite

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Product	*Substitute or Alternative*
Sodium Perchlorate	Hydrogen peroxide
Sodium Peroxide	Hydrogen peroxide Sodium chlorite
Sodium Propionate	Preservatives
Sodium Pyrophosphate	Alkalies Trisodium phosphate
Sodium Resinate	See Sodium abietate Soap
Sodium Silicate	Adhesives Alkalies Gums, water dispersible Sodium borophosphate Titanium sulfate
Sodium Silicofluoride	Fluorspar Kryolite Insecticides Sodium fluoride
Sodium Stearate	Ammonium stearate Potassium stearate Soaps Thickeners
Sodium Sulfate	Salt Salt cake
Sodium Tetraborate	See Borax
Sodium Uranate	Cobalt oxide

Product	*Substitute or Alternative*
Sodium Vanadate	Cobalt oxide
Solder (Lead-Tin)	Lead silver alloy
	Lead, antimony, silver alloy
*Solvents	Acetone
	Amyl acetate
	Alcohol
	Benzol
	Butyl acetate
	Butyl "Carbitol"
	Butyl "Cellosolve"
	Butyl glycollate
	Butyl lactate
	Butyl propionate
	"Carbitol"
	Carbon disulfide
	Carbon tetrachloride
	"Cellosolve"
	"Cellosolve" acetate
	Chlorobenzene
	Chloroform
	Cyclohexanol
	Cyclyhexanone
	p-Cymene
	"Decalin"
	Diacetone

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Solvents (*Continued*)	Dioxan
	Diacetone alcohol
	Dichlorodiethyl ether
	Diethyl "Carbitol"
	Diethyl carbonate
	Diethylene glycol
	Ethyl acetate
	Emulsions, aqueous, e.g. gum tragacanth emulsion of lemon oil and water
	Ethyl ether
	Ethyl butyrate
	Ethyl lactate
	Ethyl propionate
	Ethylene dichloride
	Ethylene glycol
	Furfural
	Furfurylalcohol
	Glycol diacetate
	Diglycol glycollate
	Hexyl acetate
	Hydrotropic solutions e.g. saturated water solution of sodium p-cymene sulfonate
	Isophorone
	Isopropyl acetate
	Isopropyl alcohol
	Isopropyl ether
	Mesityl oxide
	Methyl acetate

Product	*Substitute or Alternative*
	Methyl acetone
	Methyl alcohol
	Methyl "Cellosolve"
	Methyl cyclohexanol
	Methyl "Cellosolve" acetate
	Methyl ethyl ketone
	Methylene chloride
	Mineral spirits (different boiling ranges)
	Nitroparaffins e.g. nitro propane
	Octyl alcohol
	Pentachlorethane
	Pine oil
	Propylene dichloride
	Propylene glycol
	Tetrachlorethane
	Tetrahydrofurfuryl alcohol
	"Tetralin"
	Toluol
	Trichlorethylene
	Turpentine
	Water
	Xylol **

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** For a more complete list of solvents and their properties see Jordan Technology of Solvents. Chemical Publishing Co., Inc., Brooklyn, N. Y.

Product	*Substitute or Alternative*
Sorbitol	Dulcitol Glycerin Mannitol Pentaerythritol Plasticizers
Spanish Oxide	"Brilliant-Tone Red Oxide"
Spermaceti	Cetyl palmitate Wax, synthetic
Sperm oil	Glyceryl monoricinoleate with thin refined mineral oil Lard oil, highly refined Neatsfoot oil "Nopco 2091X" Peanut oil, blown Tricresyl phosphate
Sponges	Cellulose (viscose) sponge Rubbers, sponge
Spruce (Wood)	Hemlock, west coast Noble fir, west coast
Stainless Steel	See Steel, stainless
Starch	Adhesives Emulsifiers Gums, water dispersible Soaps Thickeners Urea-formaldehyde resins

Product	*Substitute or Alternative*
Starch Acetate	Cellulose esters
	Resins, synthetic
Stearic Acid	Abietic acid
	Fatty acids
	Lauric acid
	Myristic acid
	Naphthenic acid
	Oxidized paraffin wax
	Palmitic acid
	Paraffin wax
	Rosin
	Tallow
Stearin	Glyceryl tristearate
	Paraffin wax
	Zinc stearate
Stearyl Alcohol	Cetyl alcohol
Steel	Alloys
	"Armasteel"
	Asbestos board
	Brick masonry, reinforced
	Clay tile, structural
	Concrete, reinforced
	Glass, tempered
	Iron, wrought
	"Lignolite"
	"Masonite"
	N E Steels

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Plastics
	Plywood
	Porcelain, molded
	Steel, stainless
	Vulcanized fiber with concrete
	Wall board
	Wood
Steel, Chrome	Carburized carbon steel or silicon, molybdenum steel
	Iron, nitrided cast
	Molybdenum steel
	Molybdenum, manganese, silicon steel
Steel, Chrome Vanadium	"Amola" steels M.S. 241-291
Steel Pivots	"Permopivots"
Steel, Stainless	Carbon, pressed
	"Hastelloy"
	"Haveg"
	"Karbate"
	"Lignolite"
	"Nocorodal" carbon
	Plastics
	Porcelain
	"Pyrex" glass
	Silica stone
	Silicon bronze
	Steel, enamelled

Product	*Substitute or Alternative*
	"Stellite"
	Textiles laminated with synthetic resins
	"Transite"
Storax	See Balsam
Styrene	Acrylonitrile
Succinic Acid	Maleic acid
	Sebacic acid
Sucrose	See Sugar
Sucrose Acetate	Cellulose esters
	Resins, synthetic
Suet	Tallow, edible
*Sugar	Apple juice, concentrated
	Calcium chloride
	Dextrin
	"Diglycol" stearate with water and saccharin
	Fruits, fresh, dehydrated or juice
	Glycerin
	Glycols
	Glucose
	Gums, water dispersible
	Honey

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	Invert sugar
	Lactose
	Magnesium chloride
	Malted barley
	Malt syrup
	Molasses
	"Nulomoline"
	Potassium metabisulfite
	Preservatives
	Saccharin
	Sorghum
	"Sweetose"
	Urea
Sugar Cane Wax	Beeswax
Sugar Coloring, Burnt	See Caramel coloring
Sulfated Fatty Alcohol	Emulsifiers
	Wetting agents
Sulfonated Castor Oil	Emulsifiers
	Glycerin
	Naphthenic soaps
	Polyglycol fatty acid esters with or without wetting agents, e.g. nonaethylene glycol oleate
	Sulfonaphthenic soaps
	Sulfonated olive oil
	Sulfonated tall oil
	Sulfonated vegetable oil
Sulfonated Coconut Oil	Sulfonated castor oil

Product	*Substitute or Alternative*
Sulfonated Olive Oil	Diglycol monoricinoleate Diglycol oleate Emulsifiers Glyceryl mono-oleate Sulfonated castor oil
Sulfonated Pine Oil	Sulfonated tall oil
Sulfonated Red Oil	Sulfonated castor oil
Sulfonated Tallow	Sulfonated castor oil
Sulfur	Calcium sulfide Fillers Insecticides Selenium Sulfur chloride
Sulfur Dioxide	Chlorine Hydrogen peroxide Methyl chloride Preservatives
Sulfuric Acid	Acetic acid Alumina, activated Carbon, activated Calcium chloride Catalysts Glycollic acid Hydrochloric acid

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	Lactic acid
	Nitre cake
	Sodium alumino silicate
	Sodium bisulfate
	Sodium sulfate, anhydrous
Sumac, Silician	Acacia, shrub, domestic
	Sumac, domestic dwarf
	Tara
Sunflower Oil	Fish oil
	Hempseed oil
	Vegetable oils
"Syntans"	"Permanol"
Syrup	See sugar
Talc	Abrasives
	Alum, potash
	Aluminum stearate
	Fillers
	Flour, wheat
	Fuller's earth
	Graphite
	Magnesium carbonate
	Serpentine
	Soapstone
	"Stroba" wax
	Wax, synthetic
	Zinc, stearate
Talc, Italian	Pyrophyllite
	Trinity (California) talc

Product	*Substitute or Alternative*
Tallow	Fatty acids
	Garbage grease
	Glyceryl oleo-stearate
	Hydrogenated vegetable oils
	Lard
	Lubricating grease
	Petrolatum
	Soaps
	Stearin
	Vegetable oils
	Whale oil with stearin
Tallow Oil	Menhaden oil
Tannic Acid	See Tannin
	Alum
	Ammonium bichromate
	Formaldehyde
	Potassium bichromate
	Sodium bichromate
Tannin	Dye, aniline
	Formaldehyde
	Lignin sulfonates
	"Maratan"
	"Mertanol"
	Nutgalls

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Product	*Substitute or Alternative*
	Tannic acid
	Tara pods
Tantalum	Cobalt
	Molybdenum
	Platinum plated brass
	Tungsten
Tapioca	Adhesives
	Gums, water dispersible
	Starch, waxy corn
	Starch, waxy sorghum
	Thickeners
Tartar Emetic	Antimony lactate
	Antimony lactophenolate
	Sodium antimony trifluoride
	Tin ammonium chloride
Tartaric Acid	Acetic acid
	Adipic acid
	Ammonium sulfate with dilute sulfuric acid
	Citric acid
	Cream of tartar
	Gluconic acid
	Glycollic acid
	Lactic acid
	Levulinic acid
	Malic acid
	Oxalic acid
	Phosphoric acid

Product	*Substitute or Alternative*
	Propionic acid
	Saccharic acid
	Saccharolactic acid
	Sodium acid sulfate
	Sulfuric acid
Tea	Yerba maté
Tea Seed Oil	Orange seed oil
"Tegosept"	See "Nipagin"
Tellurium	Antimony
	Sulfur
Tetrachlorethane	Solvents
Tetrachlorethylene	Trichlorethylene
Tetrahydrofurfuryl Alcohol	Ethyl alcohol
	Solvents
	Trichlorethylene
"Tetralin"	Solvents
	Turpentine
*Thickeners	Agar
	Albumen
	Ammonium caseinate
	Ammonium stearate
	Arrowroot

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
Thickeners (*Continued*)	Bentonite
	Blood, dried
	Casein
	Clay
	Dextrin
	Egg white
	Emulsifiers
	Flaxseed, crushed
	"G"-protein
	Gelatin
	Glucose
	Glue
	Gums, water dispersible
	Isinglass
	Lanolin
	Lecithin
	Magnesium hydroxide (colloidal)
	Magnesium trisilicate
	Nitrocellulose
	Plastics
	Polyisobutylene
	Poly vinyl alcohol
	Protein, fish
	Protein, vegetable
	Resins, synthetic
	Rubbers, synthetic
	Soaps
	Sodium alginate
	Sodium silicate
	Sugar

Product	*Substitute or Alternative*
	"Vistanex"
	Zein
Thinners	See Solvents
Thyme Oil	Rosemary oil
Thymol	Di-isopropylmetacresol
	Isopropylorthocresol
	Preservatives
Tin	Aluminum
	Calcium alginate film
	Gelatin
	Glass
	Iron, enameled
	Iron, paint on
	Lead
	Lead-antimony alloy
	Lead silver alloy
	Parchment
	Plastics
	"Sheffaloy"
	Silver
	Steel "Bonderized"
	Synthetic resin coated steel, wood, paper, etc.
	Titanium copper alloy
	Vitreous enamel ware

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
Tin Ammonium Chloride	Tartar emetic
Tin Base Babbitt	Cadmium, silver, copper base babbitt Cadmium, nickel base babbitt
Tin Bronze	Beryllium copper Copper silicon
Tin Oleate	Lead oleate
Tin Oxide	Antimony oxide Sodium antimonate Titanium oxide White lead Zinc oxide Zirconium oxide Zirconium silicate
Titanium	Vanadium Zirconium
Titanium Dioxide	Antimony oxide "Gelite #340" Tin oxide White lead Zinc oxide
Titanium Sulfate	Sodium borophosphate
Titanium Tetrachloride	Silicon tetrachloride
Toluol	p-Cymene "Enn Jay" solvents Hydrogenated petroleum

Product	*Substitute or Alternative*
	fractions
	"Nevsol"
	"Notol 1"
	Solvents
	"Solvesso 1"
	Tollac solvent
Tonka Beans	Coumarin
	"Tonka-Mel"
Triacetin	Butyl "Carbitol"
	"Carbitol"
	Plasticizers
	Triglycollin
Tributyl Phosphate	Octyl alcohol
	Plasticizers
Trichloracetic Acid	Salicylic acid
Trichlorethylene	"Dresinate"
	Insecticides
	Mineral spirits
	Naphtha, petroleum (340–410°F)
	Soap with solvent
	Solvents
	Tetrahydrofurfuryl alcohol
Tricresyl Phosphate	Diglycol oleate

NOTE: Always be sure to look up each of the items in the right hand column, e.g., for abietic acid the following substitutes are given: "Liqro" and rosin. By looking up each of these, in turn, a fuller choice of substitutes is found. Each of the substitutes for *these* substitutes should also be looked up, thus locating additional possible substitutes.

Product	*Substitute or Alternative*
	"Glaurin"
	Plasticizers
	Sperm oil
Triethanolamine	Alkalies
	Alkyl amines e.g. amyl-amine
	Amino alcohols e.g. amino-methyl propanol
	Emulsifiers
	Glycerin
	"Glyco S489"
	"Trigamine"
Trioxymethylene	See Paraformaldehyde
Tripoli	Abrasives
	Diatomaceous earth
Trisodium Phosphate	Alkalies
Tritolyl Phosphate	See Tricresyl phosphate
Tung Oil	Castor oil, dehydrated
	"Conjulin"
	"Kellsoy"
	"Kellin"
	Linseed oil, activated (710)
	Linseed oil, polymerized
	Resin solutions, synthetic
	Vegetable oils
Tungsten	Cobalt
	Molybdenum chromium vanadium alloys

Product	*Substitute or Alternative*
	Platinum silver palladium alloys
	Silvermolybdenum
	Tantalum
	Zirconium iron aluminum titanium alloys
Turmeric	Dyes, aniline
Turpentine	p-Cymene
	"Decalin"
	Solvents
	Terpinolene
	"Tetralin"
Urea	Acetamide
	Ammonium carbonate
	Ammonium compounds
	Ammonium thiocyanate
	Dextrin
	Dicyanamid
	Formamide
	Hexamethylenetetramine
	Sugar
Vanadium	Aluminum
	Aluminum with titanium or zirconium
	Boron

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Product	*Substitute or Alternative*
	Titanium
	Zirconium
Vanadium Pentoxide	Catalysts
	Platinum gauze
Varnish	Paints
Vegetable Oils	"Abalyn"
	Animal oils
	Diploymer
	"Flexoresin L 1"
	Glyceryl higher fatty acid esters e.g. glyceryl oleate
	"Hercolyn"
	Mineral oil with rosin
	Rosin oil
Venice Turpentine	Balsam
	"Flexoresin L 1 or DA 4"
Vermilion Red	Antimony red
Vinegar	Acetic acid
	Lemon juice
"Vinyon"	Fibers
"Viscose"	Cellulose esters
	Fibers
"Vuepak"	"Cellophane"
Vulcanized Fiber	Asbestos
	Cork
	Glass
	"Lignolite'
	Plastics

Product	*Substitute or Alternative*
	Porcelain, molded
	Slate
	Wood, impregnated
Walnut Wood	Mahoe wood
Wax, Amorphous	"Flexo Wax C Light"
	Wax, synthetic
Wax, Microcrystalline	See Wax, amorphous
Wax, Natural	Paraffin wax
	Wax, synthetic
Wax, Synthetic	"Acrawax"
	"B-Z Wax"
	Glyceryl tristearate
	Hydrogenated vegetable oils
	"Opal Wax"
	"Rezowax"
	"Santowax"
*Wetting Agents	"Aerosol"
	"Alkanol"
	"Areskap"
	Cresylic acid
	p-Cymene sulfonic acid, sodium salt
	"Deceresol"

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* See paragraph 3, p. 52.

Product	*Substitute or Alternative*
	"Gardinol"
	"Duponol"
	"Naccanol"
	"Neomerpin"
	Pine oil
	Polymerized glycol esters
	Quaternary ammonium compounds
	"Sapamine"
	Soap
	"Sulfatate"
	Sulfated fatty alcohols
	Sulfoned oils
	"Tergitol"
	Triethanolamine
	"Triton"
	"Wetanol"
Whale Oil	Cod oil
	Mineral oils
	Vegetable oils
White Wax	See Beeswax
Whiting	See Calcium carbonate
	Bentonite
	Fillers
Wood Alcohol	See Methyl alcohol
Wood Pulp	Cotton linters
	Straw
	Tanbark, spent
Wool	Fibers

Product	*Substitute or Alternative*
	Redwood bark "Wool"
Wool Grease	See Lanolin
	Mineral oil with limed rosin
	Petrolatum
	Petroleum grease
Xylene	See Xylol
Xylol	"Neville High Flash Solvent"
	Petroleum xylol
	Solvents
Yacca Gum	See Accroides, gum
	"Glycolac"
	Resins, synthetic
	Shellac
Yellow Wax	See Beeswax
	"Flexowax C"
	Soap with rosin
Zein	Casein
	Protein, vegetable
Zinc	Bonderizing process
	Catalysts
	Ceramics, glazed
	Iron, cast

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Product	*Substitute or Alternative*
Zinc (*Continued*)	Iron filings
	Lacquer coating
	Magnesium
	Metals
	Paints
	Parkerizing process
	Pigments
	Plastics
	Porcelain
	Ternplate
	Varnish coating
	Vulcanized fiber
	Wood
Zinc Chloride	Alum
	Ammonium chloride
	Calcium chloride
	Catalysts
	Creosote
Zinc Hydrosulfite	Hydrogen peroxide
Zinc Oleate	Calcium oleate
	Lead oleate
	Magnesium oleate
Zinc Oxide	Barium sulfate
	"Bolted King White"
	"Pigment 725"
	Titanium dioxide with talc or kaolin
	Whiting
Zinc Perborate	Hydrogen peroxide
	Sodium chlorite

Product	*Substitute or Alternative*
	Sodium perborate
Zinc Peroxide	Hydrogen peroxide
Zinc Phenolsulfonate	See Zinc sulfocarbolate
Zinc Stearate	Aluminum stearate
Zinc Sulfate	Barium sulfate, purified Graphite Magnesium stearate Stearic acid Stearin Talc Talc with stearic acid Alum, potash
Zinc Sulfocarbolate	Alum Aluminum borotartrate
Zinc Yellow	Zinc tetroxy chromate
Zirconium	Manganese Titanium Vanadium
Zirconium Oxide	Alumina Aluminum silicate Antimony oxide Bismuth salts Lime Magnesia

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Product	*Substitute or Alternative*
Zirconium Oxide (*Continued*)	Pigments
	Sodium antimonate
	Tin oxide
	Titanium dioxide
	Topaz with Calcium fluoride
	Zirconium silicate
Zirconium Silicate	Chromite
	Dolomite, calcined
	Magnesite, calcined
	Tin oxide

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