

PRACTICAL EMULSIONS

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Volume 1

Materials and Equipment

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PREFACE TO THE THIRD EDITION

The third edition has maintained the tone and some of the practical hints established by Mr. Bennett in the first two editions. The current theories concerning emulsions have been added to enable the up-to-date technologist to follow the literature in the field. The section on equipment has been expanded to cover auxiliary equipment as well as the standard emulsification equipment. As many disciplines are involved in the study of the theory and practice of emulsions, many types of sources were consulted to produce information of a scope to be of help to readers with diverse backgrounds. Some reference tables have been incorporated for the convenience of the reader. In addition, the bibliography has been brought up to date. Much assistance was given by companies whose products are mentioned in the book.

The authors wish to thank especially Mr. J. Cekada, Mr. D. E. Findlay, Mr. M. E. Nelson, and Dr. L. J. Tyler—all of Dow Corning Corporation—and Dr. E. Hodnett—formerly of Dow Corning, now in London—for their comments and aid. They also wish to thank Dow Corning Corporation for providing the time and secretarial assistance for Mr. Bishop to prepare his portion of this book.

February 1967

J. L. Bishop, Jr.

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Introduction

Emulsions, though not new, are finding new and wider applications daily. One of the first references to emulsions was recorded by Galen (131-c.201), the Greek physician.¹ Beginning with that early reference to the emulsifying power of beeswax, the art and science of emulsification has flourished.

Emulsions are prepared and used for a variety of reasons. As oil paint cannot be applied to a damp surface, it is emulsified in water. The oil paint, then, in the form of an emulsion, can be applied to a damp surface. Therefore, the emulsion can change the application characteristics of a material.

Water is a desirable, cheap diluent, and an emulsion is an easy method of using water to dilute materials that are not soluble in water. In addition, the fire hazard of flammable water-insoluble materials can be decreased through emulsification.

The odor and taste of water-insoluble materials can be reduced by the use of an emulsion. Cod-liver oil, for example, loses much of its fishy, oily taste when it is emulsified.

The kinetics of many reactions are enhanced through the use of emulsion polymerization techniques.

On the other hand, emulsions are difficult to manufacture. A small deviation in temperature or mixing speed or small amounts of impurities can prevent the formation of a stable emulsion. Emulsions are sensitive in varying degrees to heat, cold, and age. The production of good, stable emulsions, therefore, is the combination of science and art. It is the purpose of this book to describe the art and technique of emulsification.

Reference

1. BECHER, P., *Emulsions, Theory and Practice*, p. 95; Reinhold Publishing Corp., New York, 1965.

chapter 1

BASIC CONSIDERATIONS

SOLUTIONS, DISPERSIONS, SUSPENSIONS

Before discussing emulsions, the differences among emulsions, solution, dispersions, and suspensions should be explained. All of these categories may be considered somewhat overlapping subdivisions of fluid mixtures.

A *solution* is the most intimate type of mixture because it is a single-phase, homogeneous mixture. A solution is generally the mixture of two or more substances on the molecular or ionic level. The material present in lesser quantity in the solution is called the *solute*, and the material in greater concentration is usually called the *solvent*, or carrier.

Dispersions, suspensions, and emulsions are two-phase mixtures.

A *dispersion* is a physical, usually temporary, mixture of two mutually insoluble phases. A solid—the dispersed phase—is usually finely divided and mixed into a liquid—the dispersing medium phase. If the dispersion is of a more lasting nature, it is said to be a *suspension*. The difference between a dispersion and a suspension is not distinct. Generally, however, the smaller the particle size of the dispersed substance phase and the more nearly equal the specific gravities of the two phases, the more lasting will be the dispersion. A suspension of very small particle size (colloidal) may begin to approach the appearance, and have many of the attributes, of a solution.

A colloidal system can be further subdivided depending on the relationship between the internal (dispersed) and external (continuous) phases. If there is little attraction between the dispersed particles and the dispersing medium, the system may be called a *suspensoid* or a *lyophobic* (lack of strong affinity) colloid. If, however, there is a strong attraction between the particles and the dispersing medium, the system is called an *emulsoid* or a lyophilic (showing affinity) colloid. If a sta-

bilizing agent (emulsifying agent) is required to provide a greater or lesser amount of stability to a lyophilic colloid, the colloid is called an *emulsion*.

Therefore, going from larger particle size and lowest stability to smaller particle size (molecular or ionic) and greatest stability, one can classify the mixtures as follows:

DISPERSION
SUSPENSION
General Suspension
Colloidal Suspension
Lyophobic Colloid
(Suspensoid)
Lyophilic Colloid
(Emulsoid)
EMULSION
SOLUTION

SUSPENSIDS (LYOPHOBIC COLLOIDS)

A number of statements can be made about lyophobic colloids in general. Typically, the concentration of the internal phase and the molecular weights of the components of the suspensoid are low. Because the concentration of the internal phase is low, the viscosity of the suspensoid is similar to that of the dispersing medium.

As a result of molecular collisions between the dispersed particles and the dispersing medium, the suspensoid will exhibit the familiar Brownian Movement. As the forces involved in these collisions are greater than the force effect of the difference in specific gravity between the phases, the dispersed particles will remain suspended. In addition, as all of the dispersed particles have a similar electrical charge (either positive or negative), the particles repel one another. This repulsion in the dispersed phase reduces the likelihood of coalescence or settling and increases the stability of the suspensoid. If the amount of charge on a dispersed particle is high, however, coalescence can occur; particles with a +5 charge will tend to coalesce sooner than particles with a +2 charge.

Finally, suspensoids do not generally exhibit reversible dilution or concentration. Evaporation of the dispersing medium will tend to cause coalescence of the dispersed particles. Subsequent dilution will not return the suspensoid to the original state.

EMULSOIDS (LYOPHILIC COLLOIDS)

The concentration of the internal phase and its molecular weight may be higher in a lyophilic colloid than in a lyophobic colloid. Generally, an emulsoid will exhibit a somewhat higher viscosity than its continuous phase alone.

Brownian Movement is less noticeable in an emulsoid than in a suspensoid. As a result, the stability of an emulsoid is a function of the interaction between dispersed particle and dispersing medium. If the dispersed particles have a high degree of affinity for the dispersing medium, the latter will be attracted to dispersed particles. This attraction, in turn, results in the formation of a type of protective layer around each discrete dispersed particle. The protective layer tends to prevent coalescence of the dispersed particles.

The particulate electrical charge in an emulsoid is a function of the acidic or basic nature of the dispersant. If the dispersant is acidic, the emulsoid itself will be acidic, and vice-versa. Because the electrical attraction between particles is responsible for much of the stability of an emulsoid, the addition of a copious amount of an electrolyte will cause the dispersed phase to coagulate ("salt out").

An emulsoid, unlike a suspensoid, is reversible. Within practical limits, evaporation of the dispersant and dilution with the dispersant will have no effect on the stability of an emulsoid.

Because a protected (or stabilized) colloid acquires the properties of the stabilizing colloid, suspensoids (lyophobic colloids) can be stabilized by the addition of emulsoids (lyophilic colloids).

SURFACE ACTIVITY

The physical and chemical properties of a colloidal system are influenced by the small particle size of the disperse phase. The smaller the particle size in the dispersed phase, the larger the effective surface (surface area of unit volume) becomes. The physical properties of solubility, melting point, heat of solution, and color are affected by high effective surface area. In addition, chemical reactions, catalysis, adsorption, and heat-transfer are affected by the number of surface molecules (ions, atoms) to the volume of dispersed phase. Emulsions have a high relationship of surface area to volume, and the importance of emulsion polymerization, (to be discussed later) is a direct result of this high *surface area to volume* relationship.

EMULSIONS

An *emulsion* is usually a dispersion of two mutually insoluble liquids, e.g., oil and water. The term *emulsion* is broad enough to include lyophobic colloids and macro-colloidal dispersions. They range in range in stability from the “shake-well-before-using” pharmaceutical products of a few years ago to the present homogenized milk.

Emulsions usually contain emulsifying agents (surfactants, surface-active agents) to stabilize the dispersion of the two insoluble liquids. The dispersed fluid is often called the *internal* or *discontinuous phase*, and the dispersing medium is called the *external* or *continuous phase*. Although the term *fluid* is used, particularly the internal phase may consist of waxes, asphalts, or other solids.

Emulsions have been historically considered as dispersions of oil and

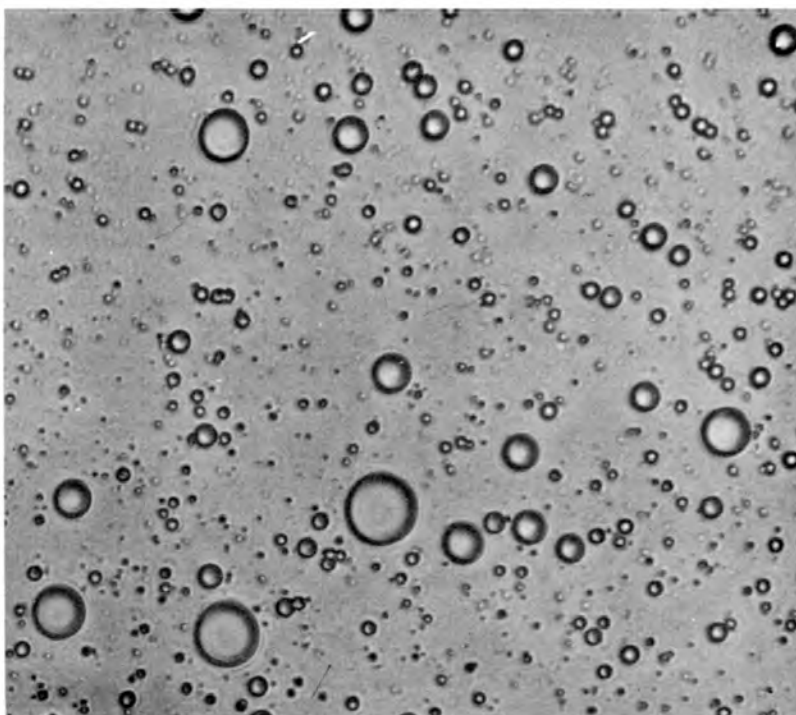


Fig. 1:1. PHOTOMICROGRAPH OF AN OIL-IN-WATER EMULSION
This is a polish, magnified 1100 times, using bright field. Range of sizes of particles and agglomeration are evident. (From *Dow Corning Corporation, Midland, Michigan*)

water. Even though one phase may be a solidified wax and the other a non-aqueous solvent, this simplified concept of an emulsion is encountered frequently. Within this simplified classification, emulsions are considered as *oil-in-water* emulsions, *water-in-oil* emulsions, or *dual* emulsions. The type of emulsion formed is a function of the viscosity, dielectric constant, relative concentration, and specific gravity of the two phases. The type of emulsifying agent and the pH of the aqueous phase will also influence the type of emulsion.

Oil-in-Water Emulsion

An oil-in-water (O/W) emulsion consists of a dispersion with oil as the internal phase and water as the external or continuous phase. Systems containing more than 31% of water will generally form an oil-in-water dispersion. In some systems nearly 45% of water is necessary to form an oil-in-water emulsion. The oil-in-water type of emulsion is the most common and can be recognized by two simple tests. As water is the external (continuous) phase, a drop of an oil-in-water emulsion will spread when placed on the surface of water. This type of emulsion will be readily diluted by the addition of more water, but will not necessarily retain its stability. The addition of a water-soluble dye, such as food color, will immediately tint the emulsion.

If an oil-in-water emulsion is desired, the oil is generally added to the water. If the water is added to the oil, the emulsion will begin as a water-in-oil emulsion and gradually thicken as the water is added. A "thick phase" will result, which will quickly disappear with the addition of more water or mechanical agitation as the emulsion "inverts". This inversion marks the change of the water's from the internal to the external phase.

The use of *hydrophilic* (water-loving) emulsifying agents will also tend to form oil-in-water emulsions. The so-called *Hydrophile-Lipophile Balance* (HLB: see Chapter 8) of hydrophilic emulsifying agents will be greater than 11. Such emulsifying agents as gum arabic, gelatin, and soap tend to form oil-in-water emulsions.

Water-in-Oil Emulsion

A water-in-oil (W/O) emulsion consists of a dispersion that has oil as the external phase and water as the internal phase. Systems that contain less than 25% of water will generally form a water-in-oil emulsion. Sometimes less than 10% of water will be necessary to ensure a water-in-oil emulsion.

A water-in-oil emulsion can be recognized if it coalesces when

51. Croda, Inc.
52. Crown Chemical Corp.
53. Crown Zellerbach Corp.
54. Culver Chemical Co.
55. DePaul Chemical Co.
56. Dexter Chemical Corp.
57. Diamond Alkali Co.
58. Distillation Products Industries
59. Dixo Company, Inc.
60. C. B. Dolge Co.
61. Dominion Products, Inc.
62. The Dow Chemical Co.
63. Drew Chemical Corp.
64. DuBois Chemicals, Inc.
65. E. I. du Pont de Nemours and Co.
66. Eastern Color and Chemical Co.
67. Emery Industries, Inc.
68. Emkay Chemical Co.
69. Essential Chemicals Corp.
70. W. F. Fancourt Co.
71. Far-Best Corp.
72. Fine Laboratories, Inc.
73. Fine Organics, Inc.
74. Finetex, Inc.
75. R. E. Flatow and Co., Inc.
76. Foremost Chemical Products Co.
77. Geigy Industrial Chemicals
78. General Aniline and Film Corp.
79. General Mills
80. Georgia-Pacific Corp.
81. Goldschmidt Chemical Corp.
82. Glidden Co.
83. Glyco Chemicals, Inc.
84. B. F. Goodrich Chemical Co.
85. Greenwood Textile Supply Co.
86. Guardian Chemical Corp.
87. C. P. Hall Co.
88. Hart Products Corp.
89. H e n k e l International Gmbh, A. H. Carnes Co., agent
90. Hercules Powder Co.
91. Hexagon Laboratories Inc.
92. Hodag Chemical Corp.
93. Hooker Chemical Corp.
94. Hope Chemical
95. E. F. Houghton and Co.
96. Humble Oil and Refining Co.
97. I. C. I. Organics, Inc.
98. International Selling
99. Intex Chemical Corp.
100. Ionac Chemical Co.
101. Isochem Corp.
102. Jefferson Chemical Co.
103. Andrew Jergens
104. Jersey State Chemicals
105. W. H. and F. Jordan, Jr., Mfg. Co.
106. Kali Mfg. Co.
107. Kalide Corp.
108. Kehew-Gradley and Co.
109. Kessler Chemical Co., Inc.
110. Knapp Products, Inc.
111. H. Kohnstamm and Co.
112. Laurel Soap Mfg.
113. Leatex Chemical Co.
114. Lever Brothers Co.
115. Leyda Oil and Chemical Co.
116. Maher Color and Chemical Co.
117. Malmstrom Color and

- Chemical Corp.
118. Marden-Wild Corp.
119. Mathe Chemical Co.
120. Merix Chemical Co.
121. Metro-Atlantic, Inc.
122. M. Michel and Co.
123. Harry Miller Corp.
124. 3M Company
125. Miranol Chemical Co., Inc.
126. Mona Industries, Inc.
127. Monsanto Chemical Co.
128. Moretex Chemical Products
129. Murphy-Phoenix Oil Co.
130. National Lead Co.
131. Nopco Chemical Co.
132. Northwestern Chemical Co.
133. Nostrup Chemical Works, Inc.
134. Onyx Chemical Corp.
135. Ottol Oil Co.
136. Patent Chemicals
137. Pecks Products, Co.
138. Pennsalt Chemicals Corp.
139. Pennsylvania Refining Co.
140. Perry Brothers, Inc.
141. Pilot Chemical Co.
142. Charles Pfizer and Co.
143. Pro-Chem, Inc.
144. Proctor and Gamble, Co.
145. Proctor Chemical Co.
146. Proven Products
147. Rohm and Haas Co.
148. Relly-Whiteman-Walton Co.
149. Retzloff Chemical Co.
150. Richardson Co.
151. Robeco Chemicals, Inc.
152. Robinson Wagner Co., Inc.
153. Rozilda Laboratories
154. Ryco, Inc.
155. Sher Brothers
156. Scholler Brothers, Inc.
157. Seaboard Chemicals, Inc.
158. Shawinigan Resins Corp.
159. Shell Oil Co.
160. George F. Siddall, Co.
161. Werner G. Smith, Inc.
162. Sole Chemical Corp.
163. Solvol Chemical Co., Inc.
164. Sonneborn Chemical and Refining
165. Southern Sizing Co.
166. Fredrick A. Stresen-Reuter, Inc.
167. A. E. Staley Manufacturing Co.
168. Standard Chemical Co.
169. Standard Chemical Products
170. Stauffer Chemical Co.
171. Stepan Chemical Co.
172. Sun Chemical Corp.
173. Suffact Co., Inc.
174. Swift and Co.
175. Synthetic Chemicals, Inc.
176. Synthron, Inc.
177. Tanatex Chemical Corp.
178. Textilana Corp.
179. Textron, Inc.
180. Thompson Chemical Corp.
181. Thompson-Hayward Chemical Co.
182. Titan Chemical Products, Inc.
183. Arthur C. Trask Co.
184. Treplow Chemicals, Inc.
185. Trylon Chemicals, Inc.
186. Union Carbide Corporation (Chemicals and Silicones Divisions)
187. United Merchants and

- Manufactures, Inc.
188. Universal Chemicals Corp.
189. Van Dyk and Co.
190. Varney Chemical Corp.
191. Verona-Pharma Chemical Corp.
192. Wasco Laboratories
193. Washine Chemical Corp.
194. Wayland Chemical Corp.
195. Wilson and Co., Inc.
196. Witco Chemical Co., Inc.
197. W. A. Wood, Co.
198. Woonsocket Color and Chemical Co.
199. Wyandotte Chemicals Corp.
200. General Electric Silicones Division
201. Dow Corning Corp.
202. Allied Chemical Corp, National Aniline Division
203. Chevron Chemical Co., Oronite Division
204. Tennessee Corp.

GLOSSARY

- ABS*—Alkyl benzene sulfonate.
- Absolute (Dynamic) Viscosity*—Ratio of stress to rate of shear strain.
- Acid Number*—Number of mg of KOH required to neutralize the free fatty acids in 1 g of fat, wax, or resin.
- Adhesion*—Condition in which unlike substances stick to each other.
- Adhesional Wetting*—Formation of a solid/liquid interface at the expense of the solid/air and the liquid/air interface.
- Adhesive*—Material that can hold other materials together by physical or chemical attachment at the surfaces.
- Adsorbate*—Material that adheres to the surface of another.
- Adsorbent*—Material on whose surface adsorption takes place.
- Adsorption*—Adhesion of a substance to the surface of a solid or liquid.
- Adsorption Curve*—Amount adsorbed from a solution plotted as a function of the concentration of the solute.
- Aerosol*—Colloidal suspension in which gas is the dispersant. Dispersion or suspension of extremely fine particles of liquid or solid in a gaseous medium.
- Agglomerate*—Cluster of particles adhering to one another.
- Aging*—Process of growing old shown by continued influence of light, temperature, external atmosphere, time, etc.
- Alginates*—Vegetable products made from kelp and seaweed.
- Aliphatic Hydrocarbons*—Straight-chain organic compounds such as the paraffins and their derivatives; e.g. propane, ethylene, acetylene.
- Alkyd*—Group of thermoplastic synthetic resins made from dibasic organic acids, anhydrides, alcohols, and drying oils.
- Amphipathy*—Simultaneous attraction and repulsion, specifically in a single molecule or ion, of one or more groups having an affinity for the phase in which the molecule or ion is dissolved together with groups that tend to be expelled by the medium.
- Amphiphilic Compounds*—Substances that exhibit amphipathy.
- Ampholytic*—Capable of acting either as a base or as an acid, depending on the nature of the surrounding medium.
- Amphoteric*—Reacting chemically as an acid to strong bases and as a base to strong acids.

- Angstrom*—Unit of wavelength equal to 10^{-10} m.
- Anhydrous*—Not containing water of hydration, or completely dry.
- Anion*—Negatively charged ion such as hydroxide (OH^-), carbonate ($\text{CO}_3^{=}$), phosphate (PO_4^{\equiv}).
- Anionic Surfactants*—Ionic surface-active agents in which the portion that associates with the internal phase is the anion; they include carboxylic acids, sulfuric acid esters, and sulfonic acids.
- Antifoamer*—Liquid of low intrinsic surface tension that prevents formation of a foam.
- API*—American Petroleum Institute.
- Apparent Viscosity*—Viscosity of a complex (non-Newtonian) fluid under given conditions.
- Aromatic Hydrocarbons*—Organic compounds that contain a benzenoid structure or ring. The simplest such compound is benzene, C_6H_6 .
- ASA*—American Standards Association.
- Asphalt Base Oil*—Type of petroleum that yields a pitch-like residue on distillation.
- Association*—Combination of molecules of the same substance, resulting in multiple molecules.
- ASTM*—American Society for Testing and Materials.
- ASTM Time Tube*—Viscometer of the rising-bubble type.
- Atlantic Viscometer*—Apparatus used to determine the kinematic viscosities of transparent Newtonian liquids of 0.6-5000 cS.
- Attrition*—Pulverization through abrasion.
- Baffle*—Partition or plate that changes the direction or restricts the cross section of a fluid, thus increasing velocity or turbulence.
- Base Stock*—Blend of materials that makes up the bulk of a product.
- Batch*—Fixed unit charge in the processing of materials.
- Bentonite*—A colloidal clay used as an adsorbent.
- Benzin (Petroleum Benzin)*—A refined light naphtha meeting USP specifications.
- Binder*—Nonvolatile portion of coating vehicle in the film-forming ingredient that is used to bind the pigment particles together.
- Biodegradability*—Susceptibility of a chemical compound to depolymerization by the action of biological agents.
- Bingham Plastic*—A substance that will not flow until its yield value is reached; thereafter, it flows like a normal liquid.
- Binodal Curve*—Curve in a triangular isothermal equilibrium plot that connects miscibility points.
- Biocolloid*—Lyophilic colloidal system found in living organisms.
- Bitumen*—Mixture of natural and pyrogenous hydrocarbons that is soluble in carbon disulfide.

- Bleeding*—Separation of the oil constituent of a grease from the base.
- Blending*—Mixing of several components to obtain a homogeneous material.
- Bloom*—Appearance of an emulsion as it is poured into a large amount of its continuous phase.
- Blowing*—Injection of compressed air into tanks to agitate and mix the contents; the act of foaming a system.
- Blowing Agent*—Material used to provide the gas needed for foaming operations.
- Bond*—Linkage between atoms in a molecule.
- Branched*—Condition in the molecular structure of polymers where the polymer has side chains attached to the main chain.
- Breakdown Time (gasoline)*—Time elapsed before gasoline forms gums in storage.
- Brookfield Viscometer*—Instrument that measures the viscosity of a liquid as a function of the torque produced by rotating a spindle at fixed rpm in a liquid.
- Brownian Movement*—Random movement of colloidal-size particles that arises from collisions between the particles and molecules of the fluid medium in which they are suspended.
- B Stage of Resin*—Partial cure of a resinous polymer in which it is more viscous with higher molecular weight, being insoluble but plastic and fusible.
- Buffer Action*—Property of certain solutions of resisting changes in pH upon the addition of acid or alkali.
- Buffer*—Substance that causes a resistance to change in pH when added to a solution.
- Bulk Density*—Weight per unit volume of a quantity of solid particles; depends on packing density.
- Bunker Fuel*—Fuel for marine boilers.
- Calendering*—Subjecting a material to pressure between two or more counter-rotating rollers.
- Cannon-Fenske Viscometer*—Modified Ostwald-type viscometer used to determine the kinematic viscosity of transparent Newtonian liquids (0.4-16,000 cS).
- Capillary Action*—Phenomenon observed on the surface of liquids due to unbalanced molecular attraction at the liquid boundary.
- Capillary Tube Viscometer*—Instrument for the measurement of viscosity as a function of the time required for a certain amount of fluid to flow through a small-bore tube of known diameter and length under a known constant pressure difference. Assuming laminar flow, the viscosity is calculated from the Hagen-Poiseuille law.

- Capillary Value of Adsorbent*—Difference between saturation and retentivity value. Amount of solvent held loosely in pores.
- Catalyst*—Substance that alters the rate of chemical change and remains unchanged at the end of a reaction.
- Catalyst Activity*—Measure of the relative performance of a catalyst in promoting the reaction of a material to give a desired performance.
- Cataphoresis*—Particle migration in a colloidal solution between electrodes exhibiting a potential difference.
- Cation*—Positively charged ion such as Na^+ , K^+ , NH_4^+ .
- Cationic Surfactants*—Ionic surface-active agents in which the portion that associates with the internal phase is the cation. They include simple amine salts, quaternary ammonium salts, amino imides and imidazolines. Cationic surfactants often have germicidal, anticorrosive, and antistatic properties.
- Centipoise (cP)*—Unit of viscosity equal to 1/100 dyne/sec²/cm².
- Channeling*—Physical parting or separating of the body of a lubricant.
- Chemical Change*—Change in which new substances with new properties are obtained from a chemical composition or decomposition of a substance.
- Chemisorption*—Adsorption process in which a polar group is bound to certain groups in a surface by chemical linkages.
- Chiller*—Cooler for separating wax from petroleum fractions.
- Clay Treatment*—Adsorption process used in oil refining.
- Cloud Point*—Temperature at which solutions become cloudy on cooling or heating.
- Coagulation*—Process in which the small particles in an emulsion are combined in agglomerates but still retain their character as individual particles.
- Coalescence*—Process by which small particles (droplets) in an emulsion combine to form larger particles (drops).
- Coarse Emulsion*—Emulsion that contains large globules.
- Cohesion*—Force of attraction of like molecules for one another within a substance.
- Cold Pressing*—Separation of a solid petroleum product from a liquid petroleum medium by means of a filter press.
- Collector*—Chemical additive controlling the wettability of ores in a flotation process.
- Colloid*—Finely divided substance 0.001-1 μ in diameter. The physical properties of a colloid are controlled by the surface forces.
- Colloidal Metals*—Colloidal suspension of metals.
- Colloid Mill*—Machine used for the preparation of emulsions of fine particle size. The emulsion is forced through the adjustable small

- annular space between a stator and a rapidly revolving rotor.
- Colloidal Suspension*—Two-phase system having small dispersed particles suspended in a dispersant.
- Complex Liquid*—Liquid in which the rate of shear is not proportional to the shearing stress; a non-Newtonian liquid.
- Complex Mixture*—Mixture of more than three components.
- Compound*—Two or more elements chemically united in definite percentages by weight that are separable only by chemical means.
- Compound Oils*—Oils made by mixing mineral oils with other oils, vegetable or animal.
- Concentration of Emulsion*—Volume percent (or volume fraction) of the internal or dispersed phase.
- Concentration of Emulsifying Agent*—Amount of surface-active agent in the emulsion. May be based on the volume or weight of the total emulsion or on one phase.
- Conjugate Layers*—Coexisting layers in an extraction—the solvent and the diluent.
- Conradson Test*—Method for the determination of the percentage by weight of carbonization residue left from burning a petroleum product according to an ASTM standard method.
- Consistency*—Resistance of a fluid to deformation. For simple (Newtonian) fluids the consistency is identical with the viscosity, for complex (non-Newtonian) fluids, identical with apparent viscosity.
- Contact Surface*—Area of a phase interface.
- Continental Method*—Procedure for preparing emulsions whereby the oil and surfactant(s) are thoroughly mixed and water is added to the mixture. As progressively more water is added, the emulsion will invert and water will become the continuous phase.
- Continuous Phase*—External phase of an emulsion.
- Convection*—Natural or forced motion in a fluid induced by heat or the action of gravity.
- Copolymer*—Compound resulting from the chemical reaction of two different monomers or polymers with each other.
- Couette Viscometer*—Rotational type of instrument for the measurement of viscosity. A fluid is placed in the annular space between two concentric cylinders, one of which is rotated. The measurement of torque and velocity gradient can be correlated with viscosity.
- Coulomb Viscometer*—Instrument that measures the damping effect produced by a fluid upon a vibrating reed.
- Covalent Molecule*—Molecule in which the bond between two atoms is a shared electron pair.
- Creaming*—Separation of an emulsion into two distinct phases, one of which has a higher concentration of the dispersed phase than the

- original emulsion; the other contains more of the continuous phase.
- Critical Micelle Concentration (CMC)*—Saturation point of a surfactant in a water system. The CMC is observable by discontinuities in the curves of physical properties of the system as a function of the amount of surfactant added.
- Critical Quantity*—Minimum or maximum amount of a blended or homogenized material needed to obtain a desired result.
- Critical Surface Tension*—Surface tension of a solid equal to that of the liquid of highest surface tension that will wet the solid.
- Critical Velocity*—Transitional velocity at which the flow of a fluid changes from laminar to turbulent.
- Crosslinks*—Bonds linking molecular chains.
- Cut-Back Product*—Material that has been diluted by adding a solvent.
- Dead Oils*—Tar distillates that are heavier than water.
- Deblooming*—Bleaching of oils to reduce fluorescence.
- Deflocculate*—Converse of clumping or clustering of particles.
- Defoamer*—Substance of low intrinsic surface tension that reduces or destroys frothing.
- Denaturing*—Making a product unfit for human consumption, as by the addition of chemicals influencing the taste or toxicity.
- Densimeter*—Instrument for measuring the density or specific gravity of liquids.
- Detergent*—Surface-active material or combination of surfactants designed for removal of unwanted contamination from the surface of an article.
- Dialysis*—Separation of colloids from dissolved substances by selective diffusion through a semipermeable membrane.
- Diffusion*—Mixing of molecules or atoms by random molecular or atomic motion.
- Dilatant*—Increasing instantaneously the apparent viscosity of a fluid with increasing rate of shear.
- Diluent*—Diluting agent.
- Dilution*—Act of reducing the proportion of a substance in a solution by addition of more solvent.
- Dilution Ratio*—Volume of solute divided by volume of solvent.
- Dipole*—Molecule that has an electrical moment (charge separated by a distance).
- Dispersed Phase*—Dissolved or suspended phase in a colloidal solution or suspension.
- Dispersing Agent*—Surfactant that is used to separate, or keep separated, aggregations of particles by reducing the cohesive attraction between the particles.
- Dispersion*—Physical, usually temporary, mixture of two insoluble

phases.

Dispersing Medium—Continuous phase of a dispersion.

Dissociation—Breaking up a molecule or associated species into smaller entities.

Dissolving—Formation of a solution by dispersion of one material (solute) at a molecular (or less) level in another material (solvent).

Distribution Ratio—Ratio of concentrations of a dissolved substance in two immiscible solvents.

Double Layer Potential—Electrical potential difference between a substance and a solvent.

Dropping Point—Temperature at which a grease passes from a semi-solid to a fluid state.

Dual Emulsion—Emulsion in which both the internal and external phase contain portions of the opposite phase instead of being homogeneous.

Dynamic Similarity—Condition in which all corresponding forces between two systems are proportional.

Dynamics—Behavior of bodies under the action of forces that produce changes of motion in them.

Dynamic Viscosity—An index of molecular friction within a fluid that is proportional to the rate of deformation and the viscosity coefficient of a fluid (absolute viscosity).

Ebullioscopy—Determination of the concentration of materials in a solution based upon boiling point deviations.

Eddy Viscosity—Turbulent viscosity based upon ratio of shear stress to a velocity gradient.

Elastic Fluid—Fluid in which elastic stresses and hydrostatic pressures are large compared with viscous stresses.

Elasticity—Recovery of the original size and shape of a material after deformation.

Electrophoresis—Migration of the electrically charged particles toward the oppositely charged electrode.

Electroviscous effect—Lyophobic particles that bear an electrical charge and therefore exhibit a viscosity exceeding that of a similar system of uncharged particles.

Emulsifying—Process of uniformly dispersing one mutually insoluble material in another.

Emulsifying Agent—Surface-active agent that is primarily used to effect the stability of an emulsion system. Emulsifying agents may be ionic (anionic, cationic, amphoteric) or nonionic in solution.

Emulsion—Beta-glucose.

Emulsion—System consisting of two incompletely miscible liquids, one being dispersed as finite globules in the other. A small amount

of a third substance may render the dispersion stable. The liquid broken up into globules is the dispersed (discontinuous) phase; the surrounding liquid is the external (continuous) phase.

Emulsion Polymerization—Polymerization of a water insoluble monomer that takes place in the presence of water to form a latex. The monomer is usually emulsified and polymerization occurs within the emulsion system.

Emulsoid—Colloidal system in which there is a strong attraction between the disperse substance and the dispersing liquid.

Emulsoid Sol—Colloidal suspension in which both dispersion medium and dispersed phase are both liquids.

Endothermic Process—Process that absorbs heat.

Engler Degree—Measurement of kinematic viscosity that is obtained by dividing the outflow time of a specified amount of liquid through a standard orifice by the outflow time of water at 20°C.

English Method—Procedure for the preparing of an emulsion whereby a small portion of the water and the surfactants are mixed. The oil and remaining water are then added in successive small portions.

Eucolloid—Colloid composed of relatively large particles (larger than 0.25 μ).

Exothermic Process—Process that liberates heat.

External Phase—Dispersing medium of a colloidal suspension; the continuous phase of an emulsion.

Extrusion—The process of forcing a material in plastic condition through an orifice.

Falling-Body Viscometer—A device that utilizes a sphere, falling through a mass of the test fluid inside a cylindrical tube. The time for the sphere to fall a certain distance is measured and correlated with viscosity.

False Body—Reversible work-softening that causes a high apparent viscosity of a material.

False Gel—Unstabilized gel that breaks down upon standing.

Fire Point—Lowest temperature of an oil at which it will ignite and continue to burn for at least 5 seconds.

Flash Point (Cleveland Open-Cup Test)—Lowest temperature of an oil at which it gives off vapors that will ignite when a small flame is passed over the surface of the oil.

Fitzsimmons Viscometer—Device that determines the kinematic viscosities of transparent Newtonian liquids in the 0.6-1200 cS range.

Flocculation—Process in which the disperse particles in a liquid medium display a tendency for mutual adhesion.

Flotation—Ore-dressing method in which surface-active additives cause one of the constituents to float to the surface in the froth

- produced by aeration and agitation.
- Fluid*—Substance that cannot sustain shear forces when in static equilibrium. Real fluids in motion sustain shear forces because of the property of viscosity.
- Fluidity*—Reciprocal of viscosity, expressed in inverse poise.
- Fluxing*—Thinning of heavy oil by the addition of a more fluid oil.
- Foaming Agent*—Surface-active material that is used specifically to form a dispersion of a gas in a liquid or solid medium.
- Force-Type Viscometer*—Instrument that measures force at constant shear rate. Units of force can be converted directly into viscosity units.
- Formula Weight*—Sum of the atomic weights of all the atoms in an empirical formula.
- Friction Factor*—Used in the Fanning equation to compute the friction loss through a length of tube and is a function of Reynolds number.
- Frothing Agent*—Surface-active material that is used specifically to stabilize the dispersion of a gas in a liquid or solid medium.
- Galling*—Metallic binding or seizure under load and relative motion.
- Gardner Mobilometer*—Instrument used to determine the thixotropy of a material.
- Gel*—Semisolid system that consists of a solid held in a liquid; a more solid form than a sol.
- Gelometer*—Instrument used to measure the time required for a fluid to gel.
- Gibbs Absorption Law*—When the concentration of a substance in the interfacial layers between two phases exceeds that in the bulk of either phase, the substance is absorbed at the interface.
- Gouy Diffuse Double Layer*—The gradual, exponential electrical potential drop from the interface of an emulsion into the bulk of the phase.
- Gum*—Class of colloidal substances that is exuded by plants.
- Hallikainen Shell*—Type of viscometer that yields continuous values of a pressure differential maintained in a capillary tube for the determination of fluid viscosity.
- Hegman Gage*—Arbitrary scale for comparing fineness of grind, expressed in “mesh.”
- Helmholtz Double Layer*—The sharp and continuous decrease into the bulk of the fluid of the electrical potential of a single layer of oriented, ionized surfactant molecules at the interface. This effect can exist on both sides of the interface in an emulsion.
- HLB Number (Hydrophile-Lipophile Balance)*—System for the selection of emulsifying agents. *Lipophilic* (nonpolar) emulsifiers have HLB numbers below 9; *hydrophilic* (polar) have HLB numbers

above 11. The HLB of an emulsifier (or blend of emulsifiers) may be related to its performance in an emulsion system.

Holdup—Amount of liquid retained by a piece of equipment when the equipment is emptied.

Homogeneous Fluid—Substance that is identical throughout.

Homogenization—The process of making incompatible or immiscible components into a stabilized uniform suspension in a liquid medium.

Homogenizer—Mixing machine used for the preparation of emulsions of fine particle size. The emulsion is forced at high pressure through the annular space between an adjustable valve and its seat.

Homopolymer—Polymer that is produced from a single monomer species.

Hydrometer Densimeter—Device used for the measurement of specific gravities.

Hydrate—Crystallized substance that contains water of hydration.

Hydration—Attachment of water molecules to ions or molecules.

Hydrogel—Colloidal gel in which water is the solvent.

Hydrolysis—Splitting of a chemical bond(s) by the addition of water.

Hydrophilic—Attracted to water; water-soluble.

Hydrotopy—Effect of large additions of various substances to water in increasing the solubility of other substances therein.

Ideal Fluid (Perfect Fluid)—Hypothetical liquid (or gas) that offers no resistance to shear and has zero consistency.

Impeller—Rotating member of an agitating or pumping device.

Implosion—Inward collapse.

Inhibiter—Substance that prevents or slows down a chemical reaction.

Initiator—Substance that starts a polymerization reaction.

Interfacial Film—A film of material (usually liquid) that forms at the point of contact of two immiscible liquids. The film may prevent coalescence.

Interfacial Viscometer—Instrument used for the measurement of the physical properties of surface and interfacial films.

Internal Phase—Dispersed or discontinuous phase of an emulsion.

Intumesce—Foaming, swelling, or bubbling that may be a result of heating.

Inversion—Transposition of the two phases of an emulsion (internal phase becomes external phase and vice-versa).

Ion—Electrically charged portion of matter of atomic or molecular dimensions.

Ionic Surfactants—Surfactants that dissociate in solution into an organic lipophilic group and a hydrophilic group. The molecules produce two ions, one positively charged (cation), the other negatively charged (anion).

- Ionic Solutions*—Solutions of substances such as acids, bases, and salts that dissociate in solution into charged particles called ions.
- Iso*—Prefix meaning equal.
- Isoelectric Point*—pH value of a hydrophilic sol (electrolyte) at which it will not migrate in an electrical field.
- Isotropic Fluid*—Fluid whose properties are independent of the rotation of the axis of reference along which the properties are measured.
- Key Material*—In a blend of two or more materials, material whose uniform dispersion is most important to the success of the operation.
- Kinematic Eddy Viscosity*—Ratio of eddy viscosity to density.
- Kinematic Viscosity*—Ratio of viscosity to density; the unit of kinematic viscosity is the stoke.
- Kinematics*—Motion of bodies without reference to the forces producing the motion.
- Krebs Units*—Arbitrary scale used for the comparison of viscosities.
- Laminar Flow*—Streamline flow of a fluid. The mass of fluid advances in separate sheets with simple shear existing at the surface of contact of different layers if the layers move at different speeds.
- Lantz-Zeitfuchs Viscometer*—Reverse-flow viscometer that permits the measurement of kinematic viscosities of opaque Newtonian liquids of 60-120,000 cS.
- Latex*—Any stable dispersion of insoluble polymer particles in a water system. Generally an emulsion of a high molecular weight polymer in water, often formed by emulsion polymerization of the monomer(s).
- Leaching*—Washing operation that removes a certain amount of dissolved substance(s) from a material.
- Levigation*—Grinding of a solid to a fine smooth powder while in moist condition.
- Lipophilic*—Attracted to oil; oil-soluble.
- Liquid*—Substance that undergoes continuous deformation when subjected to shearing stress.
- Livering*—Coagulation of a paint or enamel into a viscous rubbery mass.
- Lubricating Greases*—Solid or semifluid products of the dispersion of a thickening agent in a liquid lubricant that may contain ingredients to impart special properties.
- Lyophilic*—Pertaining to a colloidal system of the emulsoid type.
- Lyophobic*—Pertaining to a colloidal system of the suspensoid type.
- Lyophobic Colloid*—Irreversible colloid; the disperse phase when removed from suspension does not return to the colloidal state upon simple remixing.

- Lypophilic Colloid*—Reversible colloid; the dispersed phase when removed from suspension returns to the colloidal state on remixing with the dispersion medium. The suspension is a reversible sol.
- MacMichael Viscometer*—Viscometer that consists of an outer cylinder rotated by a variable-speed motor; the measured torque exerted on an inner cylinder is a function of the viscosity of the test fluid. It is suitable for non-Newtonian suspensions.
- Macromolecule*—Very large molecule, generally of polymer.
- Master Batch*—Blend of several minor ingredients that is used later in the compounding of a product.
- Master Viscometer*—Glass viscometer (capillary) with a liquid driving head of 400 mm or better, designed to minimize errors due to surface tension, kinetic energy, and capillary end effects.
- Maximization*—Concerted effort to increase the efficiency of a process through the most appropriate combination of instruments and techniques.
- Maxwellian Fluid*—Viscous fluid in which the stress-strain relationship includes the relaxation effect (time of relaxation of elastic stresses set up by sudden deformation).
- Mayonnaise Technique*—Emulsification procedure in which the ingredients are added alternately.
- Micron*—Unit of length, equals 1 micrometer or 0.001 mm.
- Milling*—Final “polishing” operation (prior to packaging) to improve the stability of a grease by modifying its gel structure.
- Miscella*—Solvent-oil solution obtained in the extraction of certain oil seed and containing mucilaginous materials that may be difficult to separate.
- Micelle*—Small aggregation of surfactant molecules in a suspension. If water is the dispersing medium, the molecules are orientated with the hydrophilic end toward the water phase and the lipophilic ends together.
- Mixture*—Material composed of two or more substances, each of which retains its own characteristic properties.
- Modifier*—Additive that changes the nature of a product or the process by which it is produced.
- Modulus of Elasticity*—Ratio of stress to strain in a material that is elastically deformed.
- Molar Volume*—Molecular weight of a substance divided by its density.
- Molecule*—The smallest theoretical quantity of a material that retains the properties exhibited by the material.
- Molecular Association*—Aggregation of single molecules into complexes containing two or more molecules.
- Molecular weight*—Sum of the atomic weights of all the atoms in a

- molecule.
- Mole*—Mass numerically equal to the sum of the atomic weights of all the atoms in a molecule.
- Monomer*—Simple form of a compound that is the building block of a polymer.
- Multiple Emulsion*—Emulsion in which the dispersed phase contains globules of the continuous phase.
- Natural Gums*—Plant (usually tree) exudations such as gum arabic, gum tragacanth, gum karaya, and guar that are high-polymer saccharides.
- NF*—National Formulary
- Neutralization Number*—mg of KOH required to neutralize the acid in 1 g of oil.
- Newton Viscometer*—Instrument that measures the resistance of a fluid to motion between two parallel sliding plates. A Newton viscometer is often used on high-viscosity materials.
- Newtonian Fluids*—Fluids whose viscosity is independent of the rate of shear. Pure liquids, true solutions, and dilute suspensions are generally Newtonian.
- Newton's Law of Similarity*—Material systems are dynamically similar when the ratio of forces acting upon corresponding mass elements at corresponding times is constant. Such forces include pressure, inertia, gravity, viscosity, elasticity, and surface tension.
- Nip*—Distance between rolls in mill or calender.
- Nonelectrolyte*—Substance whose water solution will not noticeably conduct an electric current.
- Nonionic Surfactants*—Covalent emulsifying agents that will not ionize in solution; they include alkyl ethers, alkylaryl ethers, thio-ethers, esters, and amides.
- Non-Newtonian Suspensions*—In viscous flow, the viscosity of a non-Newtonian suspension is a function of the rate or shear and duration of the shear. Non-Newtonian classes of materials include Bingham plastics, pseudoplastics, dilatants, thixotropes, and rheopectics.
- Nonpolar Liquids*—Liquids whose molecules possess little or no dipole moment.
- Normal Hydrocarbons*—Hydrocarbons with straight, not branched, molecular chains.
- Oil*—Common shorthand in emulsion technology referring to the water-insoluble phase of an emulsion. The oil phase may be a fluorocarbon, silicone, or wax, in addition to or instead of a conventional oil.
- Organosol*—Colloidal suspension in which the continuous phase is an organic compound.
- Osmosis*—Diffusion between two miscible fluids separated by a permeable wall.

- O/W Emulsion*—Oil-in-water emulsion; oil is the internal phase, water the external phase. An O/W emulsion is dispersible (dilutable) in water, but not in oil.
- Parasitic Reaction*—Side reaction that may interfere with a process and reduce its yield.
- Partial Pressure*—Portion of the total pressure of a system that is the pressure contribution of a specific component of the gas mixture.
- Penetrant*—Surface-active agent used in the textile industry to aid dyeing and sizing operations.
- Penetrometer*—Instrument for determining the consistency of high-viscosity materials such as asphalts, greases, waxes.
- Peptization*—Dispersion of a substance into particles of colloidal size, caused by addition of a peptizing agent.
- Peptizing Agent*—A protective colloid.
- Percolation*—Extraction process, usually of a liquid acting upon a solid.
- Perfect Fluid*—Fluid of zero viscosity.
- Permanent Emulsion*—Emulsion in which the droplets of the dispersed phase do not coalesce or coagulate in time; a stable emulsion.
- Phase Interface*—Boundary surface between two phases or films.
- Phase Rule*—For a heterogeneous system in equilibrium, the sum of the number of phases plus the number of degrees of freedom equals the number of components plus two.
- pH Value*—Negative logarithm of the hydrogen ion concentration and hence the acidity or alkalinity of a solution. The scale ranges from 1 (highly acidic) through 7 (neutral) to 14 (highly basic.)
- Phase-Volume Ratio*—Ratio of the volume of the internal phase to that of the external phase in an emulsion.
- Photomicrograph*—Photograph of the emulsion that is used for particle size determinations or other visual observations of the emulsion. Agglomeration can be seen if the particles are stabilized by the addition of a thickener, e.g. gelatin, to the continuous phase.
- Physical Change*—Change in which the identifying chemical properties of a substance remain unchanged.
- Pigment*—Finely divided insoluble substance that imparts color to the material to which it is added.
- Pipeline Mixer*—Device for continuous mixing and/or homogenizing within a transfer pipe.
- Pitting*—Spot corrosion that is caused by chemical or galvanic effects.
- Plastic Deformation*—Change in the dimensions of a material load that is not recovered when the load is removed.
- Plasticizer*—Chemical agent added to plastics to make them softer and more flexible.
- Plastisol*—Suspension of resin(s) in plasticizer(s).

- Plastic Solid*—Substance that does not deform under a shearing stress until the stress attains the yield stress, at which point the solid deforms permanently.
- Plug Flow*—Flow characterized by an almost square velocity profile. Under certain pressure conditions prevailing in closed tubes, mass in the middle of the pipe moves like a solid plug, with laminar flow along the wall.
- Poise*—Unit of viscosity, equivalent to 1 dyne/sec/cm².
- Poiseuille's Equation*—Relation between liquid flow through a tube, pressure, and length and cross-section of path, assuming uniform streamline flow.
- Poiseuille Viscometer*—Instrument to measure viscosity based on out-flow measurement of fluids. Commercial Poiseuille viscometers include Engler, Barbey, Redwood, and Saybolt units.
- Polar Bond*—Essentially covalent chemical bond that results from the unequal sharing of valence electrons between atoms.
- Polar Compound*—Substance that possesses a permanent electric moment.
- Polar Liquids*—Liquids whose molecules possess a dipole moment, such as alcohols, acids, aldehydes, etc.
- Polydisperse Systems*—Systems that consist of various size particles or droplets.
- Polymer*—Compound formed by polymerization, characterized by a high molecular weight (usually over 1000) and a repeating chemical structure.
- Polymerization*—Formation of large molecules from smaller ones (monomers).
- Polyphase Emulsion*—Mixed, multiple, or dual emulsion that has no well-defined internal and external phases; each phase contains droplets of the other phase.
- Pour Point*—Lowest temperature at which an oil will pour.
- Precipitate*—Substance separated from a solution, suspension, dispersion, or emulsion as a result of chemical or physical change.
- Pressure Drop*—Difference in force on unit areas on the two sides of a barrier.
- Protective Agent*—Colloidal substance that stabilizes the suspension of the particles when adsorbed on suspended particles.
- Protective Colloid*—Material that stabilizes a particular disperse system against coagulation or coalescence. It is usually a lyophilic colloid that forms a protective film (by adsorption) around each particle.
- Pseudoplasticity*—Property of a fluid whose consistency decreases instantly with increasing rate of shear.
- Pseudostable*—State of a material that causes a change of its physical

- properties over a period of time.
- Quiescent Flow*—Condition existing when the degree of turbulence is less than that indicated by the Reynolds number.
- Random Distribution*—Arrangement of particles in a mixture so that the probability of a single particle being at any one location is the same as that of its being at any other location.
- Rao Birefringence Viscometer*—Couette-type viscometer that is used for low-viscosity fluids.
- Relative Viscosity*—Viscosity of a liquid in terms of the viscosity of some standard liquid, such as water at 20°C.
- Relative Volatility*—Volatility of one component divided by volatility of the other components; the pressure ratio for components following Raoult's law.
- Resolving Power*—Ability of a microscope to produce separate images of particles very close together.
- Reynolds Number (Re, dimensionless)*—Measure of the degree of turbulence of a fluid flowing in a pipe: diameter times velocity times density and divided by absolute viscosity.
- Rhe*—Unit of fluidity; 1 rhe = 1 poise⁻¹.
- Rheological Properties*—Flow properties of a system, e.g. plastic flow, thixotropy, and pseudoplasticity.
- Rheology*—Study of the deformation and flow of matter.
- Rheopectic*—Pertaining to a fluid whose apparent viscosity increases with time to some maximum value at any constant rate of shear.
- Rigidity*—Reciprocal of mobility.
- River-Water Die-Away Test*—Proposed test to determine the biodegradability of surface-active agents.
- Roller Mill*—Two or more rolls, usually revolving at different speeds, between which the materials to be mixed are passed.
- Rotational Flow*—Flow that exhibits appreciable vorticity.
- ROV (Refined Oil Viscosity)*—Viscosity of lamp oils and naphthas as measured by a Saybolt Thermo-viscometer.
- Rupture Stress*—Shear stress.
- Salting Out*—Precipitation of a material from its dispersion.
- Saponification*—The process of hydrolysis of fats or oils by an alkali of a fluid to form soap.
- Saybolt Universal Seconds (SUS)*—Kinematic viscosity of a fluid as determined by the time in seconds required for 60 cm³ of liquid to flow through a standard orifice.
- Saybolt Viscometer*—Transpiration type of viscometer primarily used to determine viscosity of petroleum products.
- Scattering*—Deflection of light rays by particles of suspended matter.
- Sedimentation*—Spontaneous separation of two or more materials

- (liquids, solids, or gases).
- Segregation*—Separation of the constituents of a mixture, e.g. by electrostatic charges.
- Seizing*—Metallic freezing together of materials under load.
- Shake Flask Test*—Screening test for the determination of biodegradability, proposed by the Soap and Detergent Association.
- Shear Stability*—Ability of a grease to withstand repeated working with minimum change in structure or consistency.
- Shear Viscometer*—Instrument for measuring viscosities of complex fluids at different shear rates.
- Shelf Life*—Period of time during which an undisturbed emulsion retains its type and essential properties.
- Shock Chilling*—Addition of a cold fluid to a hot fluid in order to obtain rapid cooling of the blend to a given temperature.
- Sil Viscometer*—Instrument used for the determination of viscosities of Newtonian fluids in the 0.6-10,000 cS range.
- Simple Liquid*—Liquid in which the rate of shear is proportional to the shearing stress. The constant ratio of shearing stress to rate of shear of a simple liquid is the viscosity of the liquid.
- Soap*—Metallic salt of a fatty acid.
- Slip*—Displacement loss in a pump that is affected by the viscosity of the liquid being pumped and the pressure differential.
- Solid*—Substance that undergoes permanent deformation only when subjected to shearing stress in excess of some finite value characteristic of the substance (yield stress).
- Solids*—Active ingredients of a mixture. In the emulsion the “solids” includes the internal phase and the emulsifiers, stabilizers etc; all of the system except the continuous phase or solvent.
- Solubility of an Emulsion*—Dispersibility of an emulsion as determined by the nature of the continuous phase.
- Solute*—Substance that is dissolved in a solvent; the substance in lesser concentration in a solution.
- Solution*—Homogeneous mixture of two or more substances. It is characterized by an ionic or molecular-level subdivision of the components that will not become heterogeneous upon standing.
- Solvation*—Adsorption of molecules of a dispersing liquid by the dispersed particles.
- Solvent*—Constituent of a solution present in the larger amount.
- Space Velocity*—Product of the feed rate times specific volume of feed divided by volume of vessel used in a converting operation, expressed in volume processed per unit time. It is the reciprocal of hypothetical retention time.
- Specific surface*—Surface area of a substance per unit volume.

- Specific Viscosity*—Relative viscosity of a fluid.
- Specific Volume*—Reciprocal of density; volume per unit mass, as cm³/kg, ft³/lb, etc.
- Speed Velocity*—see *Space Velocity*.
- Spreading Coefficient (Harkins)*—Number describing the decrease in the total interfacial energy of an aqueous system by the addition of a specific surface active substance.
- Stable Emulsion*—Emulsion that retains its form and condition and in which the particles of the internal phase do not coalesce.
- Stabilizer*—Ingredient that is added to a system to maintain the physical and chemical properties of the product throughout its processing and service life.
- Stagnation Point*—Point at which the fluid velocity of a system is zero.
- Standard Deviation*—Statistical measure of the scattering of data from the average; equal to the root mean square of the individual deviations from average.
- Stern Diffuse Double Layer*—Presence of a sharp Helmholtz layer of ionic thickness at the interface followed by a Gouy exponential electrical potential drop into the bulk of the fluid. This effect is two-sided; it exists on both sides of the interface in an emulsion.
- Stoke*—unit of kinematic viscosity, symbol S.
- Stokes' Law*—A small sphere falling under the action of gravity through a viscous medium reaches a constant velocity that is a function of the radius of the sphere, its density, the density of the medium, and its viscosity coefficient.
- Stormer Viscometer*—Viscometer in which the fluid is placed between two cylinders. The inner cylinder rotates by the action of a falling weight. The rotational speed is determined by measuring the time required for a definite number of revolutions of the inner cylinder. The torque is determined from the weight and radius of the pulley. The viscosity of the fluid is a function of the rotational speed and torque.
- STP*—Standard Temperature and Pressure: 0°C, 760 mm pressure.
- Strain Deformation*—Change in the dimensions of a body under stress.
- Stratification*—Formation of layers in a fluid mixture.
- Streamline*—Line that gives the velocity direction of a fluid (number of particles) at each point along the line.
- Streamline Flow*—Flow where fluid particles move along the streamlines.
- Stress*—Internal force exerted by one part of a body upon an adjoining part.
- Structural Color*—Color due to the physical structure of the mass and not dependent upon the electronic configuration of the substance.

- Substance*—Any form of matter that is homogeneous throughout, i.e. solid, liquid, gas.
- Supersaturated Solution*—One that contains more solute in solution than is present in a saturated solution of the same substance at the same temperature and pressure. A supersaturated solution is usually formed by reducing the temperature or removing some of the solvent from a saturated solution.
- Surface-Active Agent*—Substance that affects the surface tension of a liquid. They include emulsifying agents, detergents, suspending agents, wetting agents, etc.
- Surfactant*—Surface-active agent.
- Suspensoid*—Colloidal suspension in which there is little attraction between the dispersed substance and the dispersing liquid; a lyophobic colloid.
- Syneresis*—Exuding of small amounts of liquids from gels by contraction.
- Thermoplastic*—Resin that can be readily softened and resoftened by heat.
- Thickner*—Device that produces separation of solids from liquids by sedimentation; material that increases the viscosity of a fluid.
- Thick Phase*—Increase in viscosity found in an emulsion before inversion. The close packing of the internal phase results in a high viscosity. The thick phase is often used to maximize the shear on an emulsion by mixing the emulsion into a thick phase or causing inversion by mixing the thick phase.
- Thixotropy*—Reversible gel-sol-gel transition that is characterized by a reduction in viscosity upon the application of shearing stress.
- Time-Measuring Viscometer*—Instrument measuring the time needed for efflux of a liquid through an opening, rise of an air bubble, fall of a steel ball, revolution of a paddle driven by a constant torque, or slide of a plate.
- Torr*—Unit of pressure, same as millimeter of mercury.
- Turbidimeter*—Instrument that measures the reduction in light transmission caused by interposing a suspension between light source and observer.
- Turbulence*—Flow caused by superimposing irregular currents on a uniform flow.
- Turbulent Flow*—Motion of a fluid in which its velocity at a fixed point fluctuates randomly with time.
- Tyndall Effect*—Light-scattering that is visible when a beam of coherent light passes through a colloidal system.
- Ubbelohde Viscometer*—Suspended level instrument that determines kinematic viscosities of transparent Newtonian liquids in the 2-

10,000 cS range.

Ultrasonic Emulsifier—Machine that is used for the preparation of fine-particle-size emulsions. The emulsion is forced at high velocity against the edge of a blade. The acoustical waves of the vibration of the blade produce cavitation, which accomplishes the emulsification.

Unstable Emulsions—Those emulsions that separate into two immiscible phases, or otherwise lose homogeneity.

USP—United States Pharmacopeia.

Valence—Number of electrons gained, lost, or shared by an atom in bonding to one or more other atoms.

Velocity of Approach—Average velocity of fluid in a duct ahead of the point considered.

Vinyl—Class of resins containing materials such as polyvinyl chloride, polyvinyl acetate, etc.

Viscometer (Viscosimeter)—Instrument for measuring the viscosity of a fluid. Types of viscometers are: 1) Poiseuille, 2) Stokes, 3) Couette, 4) Newton, 5) Coulomb, according to the effect used to measure the viscosity.

Viscosity Breaking (Visbreaking)—Thermal treatment (cracking) of petroleum fractions, with or without catalyst.

Viscosity Gravity Constant—Correlation of specific gravity and viscosity: low for paraffinic, high for naphthenic oils.

Viscosity Index—Relationship between viscosity change of an oil with change in temperature; an empirical measure of the temperature coefficient of viscosity.

Viscosity—Property of resistance offered by a fluid to relative motion of its parts.

Viscosity Range—Ratio of viscosity of a fluid at its lowest temperature to that at its highest temperature, or lowest to highest shear.

Viscous Fluid—Fluid having appreciable fluid friction.

Viscous Forces—Tangential frictional forces. The action of such internal shear forces results in a conversion of mechanical energy into heat or unavailable thermal energy.

Volatility—Relative tendency of a substance to evaporate. Controlled by vapor pressure for components in a homogeneous liquid obeying Raoult's Law.

Vortex Swirl—Rotation of a liquid as if it were a solid body; there is no interchange of position between particles.

Wax Distillates—Neutral petroleum distillates that contain paraffin.

Weber Number—Dimensionless parameter concerning surfaces or interfacial tension forces.

Wetting Agent—Surface-active agent that is widely used in the textile

industry to aid dyeing and sizing operations by making the textile absorbent and thus easier to "wet" with the dye or size.

W/O Emulsions—Water-in-oil emulsion in which the water is the internal phase and the oil is the external or continuous phase. The W/O emulsion may be diluted by the addition of an oil and retain its homogeneity.

Yield Strength—Lowest stress at which a material undergoes plastic deformation. Below this stress the material is elastic; above it, viscous.

Yield Value of Plastic—Minimum stress required to start flow.

Zeitfuchs Crossarm Viscometer—Instrument used to determine kinematic viscosities of transparent or opaque Newtonian liquids in the 0.3-10,000 cS range.

Zeitfuchs Viscometer—Instrument used to determine kinematic viscosities of transparent Newtonian liquids in the 0.6-5,000 cS range.

Zeta Potential—Measure of the speed with which charged oil droplets travel under the influence of a unit electrical field.

Zwitter Ions—Molecular units containing groups that are ionized cationically and groups that are ionized anionically, both present in approximately the same numbers so that the molecule as a whole is electrically neutral.

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