

Wax Emulsions

Definitions

Acid-Stable Wax Emulsion	Good tolerance to acidic and alkaline solutions; good tolerance to hard water.
Alkaline-Stable Wax Emulsion	Good tolerance to alkaline solutions; poor tolerance to acidic solutions; poor tolerance to hard water.
Alum	Aluminum potassium sulfate, used in paper making as a coupling agent between rosin sizing and fibers. The alum precipitates the rosin dispersion, and the positively charged aluminum ions and aluminum hydroxide flocs attach the size firmly to the negatively charged fiber surface. It also controls foam, pitch and sticking and helps in the retention of the filler.
Beater	A device in paper making which mechanically splits and mashes the fibers, causing fibrillation. In paper making it can also be used for the addition and mixing of other materials such as sizing, fillers and dyes.
Calendering	Passing a substance between a series of pairs of heated rollers, which squeeze it to form a smooth or textured sheet.
Dusting	The shaking of excess filler which is insufficiently bonded in the paper sheet.
Filler	Finely powdered mineral material which improves printing properties of paper by increasing opacity, decreasing show-through, improving ink receptivity and giving more body and better formation to the sheet.
Pitch	A substance which comes from unbleached sulfite used in paper making.
Sizing	Used in the preparation of paper to prevent water or ink absorption, due to capillary attraction.

Wax Emulsions

Page 2

Description

The name "wax emulsion" is in some sense a misnomer, because the product is really a dispersion of solid wax particles in a continuous phase of water. The emulsion (as defined as two immiscible liquids) exists only when the wax is in a molten form as the emulsion is formed. As mentioned above, a wax emulsion consists of wax, surfactants and water. Other ingredients may be added as preservatives or to help stabilize the dispersion.

Wax emulsions provide a useful means of delivering wax to a product. Wax emulsions are used in the manufacture of paper, paperboard and boxboard. It is also used in the production of insulating board, hardboard and particleboard in the building products industry. Wax emulsions are used to coat the surfaces of fruits to reduce moisture loss, extend storage life, impart gloss and protect the fruit from decay.

In paper coatings, the wax emulsion is added to the coating mixture to reduce dusting (from excess filler) during calendering, to increase water repellency, to improve flexibility and to raise gloss. When used as sizing in paper, the wax emulsion helps prevent aqueous solutions, such as ink, from soaking into the paper and paperboard. The emulsion is added continuously to the beater after the rosin size and alum and preferably just ahead of the paper machine.

When used in the making of gypsum, fiber and particle board, the wax emulsion gives water repellency to the fibers in the board. The emulsion is usually sprayed on the wood particles, before the resin (which binds the fibers together) is applied and before the pressing of the fibers into board.

Different types of waxes are used to make wax emulsions. The basic types are listed below.

Paraffin Wax
Microcrystalline Wax
Semimicrocrystalline Wax
Polyethylene Wax

These waxes differ in refractive index, type of hydrocarbons, congealing point and viscosity. The paraffin waxes can differ due to oil content, color, purity, etc. For example, slack wax would have a higher oil content than would refined paraffin wax.

Objective

The objective is to prepare a wax emulsion that has a small, uniform particle size; has good mechanical stability and long term shelf life; and, if so required, has stability in an acidic solution.

As mentioned above under "Definitions", a wax emulsion can be formulated to be acid stable or alkaline stable. For example, when the wax emulsion is to be used with phenolic resins in the making of particle board, the emulsion should be acid stable. If it is not, the emulsion will break prematurely and will not be effective. The desired action is to have the wax attach to the fibers to give water repellency to the board.

Wax Emulsions

Page 3

In paper making the addition of alum and rosin sizing causes the wax particles of an acid-stable wax emulsion to become "concentrated" but to remain emulsified. In this way the wax particles coat the fibers and give the paper resistance to liquid penetration. An alkaline emulsion can be used in the preparation of paper coatings, but the acid-stable emulsion is preferred as sizing in the paper itself.

There are many formulations for wax emulsions given in the literature and in patents. Obviously, the type of wax and the end use will dictate the best formulation. However, two generalized formulations can be given for acid-stable and alkaline-stable emulsions.

Acid-Stable Emulsion:

Wax	47%
Sodium lignosulfonate	2%
Gum ghatti	1%
Water	50%

Other ingredients, such as preservatives or soluble salts of polyvalent metal (such as zinc sulfate), may be added. The salt enhances the mechanical stability of this type of emulsion most likely by inhibiting the coalescence of wax particles. The sodium lignosulfonate is a water-soluble surfactant which does not possess a hydrophobic-hydrophilic molecular structure. It stabilizes the emulsion as a result of adsorption at the interface, establishing an electrokinetic charge and a semi-rigid film. The concentration of the lignosulfonate can be varied and may be as high as 6%. Quite often a good "rule-of-thumb" is to make the surfactant level equal to 10% of the amount of disperse phase. The pH of this type of emulsion would be about 5 to 7. More information on lignosulfonate can be found at www.lignin.info/01novdialogue.html web page.

Alkaline-Stable Emulsion:

Wax	50.00%
Oleic Acid	3.27%
Triethanolamine (TEA)	1.73%
Water	45.00%

The emulsifier is the soap produced by the in situ reaction of oleic acid and TEA. The oleic acid is dissolved in the wax phase, and the TEA is dissolved in the water phase. The ratio of amounts used relates to the stoichiometry of the reaction between one mole of oleic acid reacting with one mole of TEA, forming one mole of soap at the wax/water interface. This formulation produces a very fine emulsion; but, obviously, it does not have good acid stability. In place of oleic acid, stearic acid could be used, and morpholine, sodium hydroxide or potassium hydroxide could be used in place of TEA. The pH of this type of emulsion is about eight to ten.

Most wax emulsions contain wax levels equal to or less than 50%, because exceeding that amount of wax may greatly increase the viscosity of the emulsion from a free-flowing emulsion to a thick, slow-flowing emulsion.

Preparation

Wax emulsions can be prepared by either a batch method or continuous method.

A. **Batch Method**

1) Acid-Stable: Dissolve the gum into the water phase, being sure that the gum becomes completely hydrated. Inferior grades of gum may contain sand or other insoluble impurities, which must be separated from the water, to avoid excessive wear of the homogenizer. The lignosulfonate is then dissolved into the water. The water is heated to a temperature dependent on the melting point of the wax. The molten wax is slowly added to the water phase with good agitation. The agitation should be adequate to efficiently disperse the molten wax, but any vortex should be minimized to avoid entraining large amounts of air.

After a good premix has been produced, preferably less than 10 micrometers, the hot wax/water mix is homogenized at 3000-5000 psi, one or two passes, depending on the particle-size range desired. After homogenization, the emulsion is quickly cooled to "set" the wax particles. In most cases, an emulsion with all wax particles below three micrometers and, preferably, below two micrometers is desired. This will give good mechanical stability and will produce good fiber coatings.

2) Alkaline Stable: Dissolve the fatty acid into the molten wax and the TEA into water. Heat the water phase to the appropriate temperature and proceed as described above.

B. **Continuous Method**

In the 1960s, Gaulin Corporation developed a technique for making wax emulsions continuously. Although this method is not used as often as the batch method, it is described here as reference to another protocol to prepare wax emulsions. Using the alkaline-stable wax emulsion as an example, the fatty acid would be added to the molten wax and the TEA added to the water phase, which are in two separate tanks. The water phase would be heated by passing it through a plate heat exchanger. The wax would be melted in its kettle. The two phases are continuously mixed by combining them in a mixing device.

Of the two phases, only one needs to be regulated with respect to flow rate. For example, if the wax phase flow rate is regulated, then the water phase need not be. The homogenizer is a positive displacement pump; and, therefore, the amount of water phase injected at the nozzle is the difference between the total output of the homogenizer and the amount of wax being used.

The mixing device consists of a jet nozzle inside a chamber. The wax is injected through the jet nozzle, and the water flows into the chamber, surrounding the wax stream. This will produce a good premix to the homogenizer. The premix is homogenized at 3000-5000 psi. The emulsion is then cooled in the plate heat exchanger and is stored in an emulsion tank.

Wax Emulsions

Page 5

Testing

The wax emulsion can be evaluated microscopically, preferably using a phase-contrast microscope at 1000X magnification. Other types of analyses would include a simple, turbidimetric technique or the more sophisticated (also more expensive) dynamic laser light-scattering instrument.

Also, shelf-life tests could be done, and the stability of the emulsion in acidic solutions with alum might be evaluated.

References

R. C. Barras, et al., "Petroleum Waxes: Characterization, Performance and Additives," TAPPI STAP No. 2, Proceedings of the ASTM-TAPPI Symposium on Petroleum Waxes.(New York: Technical Association of the Pulp and Paper Industry, 1963).

G. Colgan, et al., "Paper Coating Additives", TAPPI Monograph No. 25. (New York: Technical Association of the Pulp and Paper Industry, 1963).

J. C. Johnson, Emulsifiers and Emulsifying Techniques. (New Jersey: Noyes Data Corporation, 1979).

O. F. Neitzke, (to Bennett Inc.), U. S. Patent 2,096,129; October 19,1937.

E. R. Kolodny, (to American Cyanamid Company), U. S. Patent 2,797,167; June 25, 1957.

H. R. Rafton, (to Rafton Laboratories, Inc.), U. S. Patent 1,803,644; May 5, 1931.

H. R. Rafton, (to Raffold Process Corp.), U. S. Patent 1,848,659; March 8, 1932.

W. R. Willets, et al., "Paper Loading Materials", TAPPI Monograph No. 19. (New York: Technical Association of the Pulp and Paper Industry, 1958).

APV, An SPX Brand
Phone: 1-888-278-4321 Email: answers.us@apv.com

For more information about our worldwide locations, approvals, certifications, and local representatives, please visit www.apv.com.

SPX reserves the right to incorporate our latest design and material changes without notice or obligation. Design features, materials of construction and dimensional data, as described in this bulletin, are provided for your information only and should not be relied upon unless confirmed in writing.

Issued: 02/2009 3066-01-07-2008-US

Copyright © 2008 SPX Corporation

