

MATERIALS INFORMATION and TECHNICAL RESOURCES for ARTISTS

Solvents and Diluents

SOLVENTS AND DILUENTS

Artists today have a wide range of solvents and thinners available to them for use. Navigating the names and properties-- toxicity, evaporation, solubility-- of the various solvents and thinners can be confusing. However, an understanding of the properties of groups of solvents helps the artist to select materials and follow safe studio practices.

PETROLEUM-BASED SOLVENTS

Petroleum-based solvents fall into the chemical class of hydrocarbons -- compounds that are comprised solely of carbon and hydrogen atoms. The manner in which those atoms are arranged directly influences the level of toxicity, rate of evaporation, and solubility parameter of a solvent. Large petrochemical and art supply companies often use proprietary names to describe certain blends of hydrocarbon solvents, so it is important to check the MSDS or SDS sheet (see the Health and Safety section) for specific information on the types of solvents that may be present in a proprietary product.

In the 19th century, hydrocarbons were divided into two sub-classes: aliphatic hydrocarbons and aromatic hydrocarbons. Aliphatic hydrocarbons (from the Greek word *aleiphar* meaning "fat") were byproducts of the chemical degradation of fats or oils. Aromatic hydrocarbons were byproducts of the chemical degradation of certain pleasant-smelling plant extracts. These terms are still used today, but the compounds they describe are distinguished by structure rather than origin. Aromatic hydrocarbons tend to evaporate more slowly and are more toxic than aliphatic hydrocarbons.

Boiling points are often used to categorize various blends and types of petroleum-based products. It is important to note that the evaporation rate of a solvent is inversely related to its boiling point. Thus, the higher the boiling point, the slower the rate of evaporation.

Aliphatic hydrocarbons are commonly found in mineral spirit blends. There are three types of aliphatic hydrocarbons:

- 1) n-paraffins (straight chain)
- 2) iso-paraffins (branched chain)
- 3) cycloparaffins/naphthenes (cyclic)

The term "**Odorless**" on a label indicates that the product is 100% aliphatic with no addition of aromatic hydrocarbons.

Aromatic hydrocarbons are based on the structure of benzene (a cyclic hydrocarbon with the formula C_6H_6) and may or may not contain one or more methyl groups (one carbon atom bonded to three hydrogen atoms). The basic rule of aromatics is the more methyl groups present, the less toxic the product and the slower its evaporation rate. These are the most commonly used aromatic hydrocarbon solvents in order of decreasing toxicity:

- 1) Benzene (C_6H_6) – No methyl groups
- 2) Toluene (C_7H_8) – Benzene ring with one methyl group
- 3) Xylene (C_8H_{10}) - Benzene ring with two methyl groups
- 4) Trimethylbenzene (C_9H_{12}) - Benzene ring with three methyl groups

The following are petroleum-based blends often used by artists:

Mineral Spirits/Odorless Mineral Spirits/Paint Thinner are generic terms used to describe a variety of aliphatic mixtures which are composed of a large amount of hexane and a small amount (as low as 0.1%) of aromatic hydrocarbons. Their boiling point ranges are low and can begin around $65^\circ C$. Odorless Mineral Spirits (OMS) has no aromatic component. Paint thinners include a wide range of less refined grades of mineral spirits, and may contain small amounts of aromatics as well as other classes of chemicals.

White Spirits are complex mixtures of aliphatic hydrocarbons containing some amount of aromatic hydrocarbons. They are available in high aromatic white spirit grades (HAWS) containing about 50% aromatics and low aromatic white spirit grades (LAWS) containing about 20% aromatics. Their boiling range is $135-270^\circ C$. It is important to note that in the United Kingdom, this term is often used to describe mineral spirit mixtures or Stoddard solvent.

Stoddard Solvent is a specific mixture of hydrocarbons that was developed in 1924 by Atlanta dry cleaner W. J. Stoddard and Lloyd E. Jackson of the Mellon Institute of Industrial Research as a less volatile petroleum-based dry cleaning solvent. Today, in the United States, Stoddard Solvent is a generic term used to describe any hydrocarbon solvent used for dry-cleaning, while in the United Kingdom, Stoddard Solvent refers to lab-grade white spirits, usually containing 17-19% aromatic hydrocarbons. Stoddard Solvent contains a maximum of 25% aromatic hydrocarbons and has a boiling range of $154-202^\circ C$.

Petroleum Spirits/Petroleum Benzine/Petroleum Ethers/Specific B.P. (Boiling Point) Solvents are names for completely or almost completely aliphatic mixtures of hydrocarbons like hexane, heptane, and pentane which have small boiling point ranges (e.g. $60-80^\circ C$, $80-100^\circ C$, $100-140^\circ C$). The solvent mixtures with boiling ranges below $80-100^\circ C$ are called Petroleum Ethers or Ligroin (see Naphtha).

Naphtha is the ancient Persian name for petroleum. In current usage, Naphtha refers to the fraction of petroleum or coal-tar distillate with the boiling range of $30-200^\circ C$. Light Naphtha (or Petroleum Ether) has a boiling point range of $35-60^\circ C$. Petroleum Naphtha,

Ligroin, or VM&P Naphtha has a boiling range of 90-150°C. “Heavy” Naphtha has a boiling range of 150-200°C. Naphtha contains both aliphatic and aromatic hydrocarbons.

Essential Oils are oils or solvents that are distilled from natural, organic sources like flowers or wood. The most common essential oil used in art making is turpentine. The term turpentine originally referred to unrefined balsams or tree saps (as in Venetian turpentine) but today generally describes the distilled volatile component that is used as a solvent.

Essential Oil of Turpentine, Gum Spirits of Turpentine, and Spirits of Turpentine

These are names for the volatile, flammable liquid that is obtained from the distillation of the balsam from living conifer trees. It is a mixture of α -Pinene and β -Pinene. Turpentine has been used since as early as the 1300s as a solvent for artist paints and varnishes and as a cleaner for paint brushes. It is a good solvent for many natural resins, waxes, oils, plastics, and rubber. Turpentine is flammable and should not be used near sources of ignition. It has a higher solvency than mineral spirits and is capable of dissolving many natural resins. The boiling point of turpentine is recorded to be in the 149- 180°C range. Turpentine should be used when fresh as it can thicken and darken overtime especially when left in clear, partially filled containers for extended periods of time. The residue from severely deteriorated turpentine evaporates very slowly and can inhibit the drying of oil paint. Essential oil of turpentine is considered the purest form of turpentine and decomposes less rapidly than less pure wood turpentine.

Wood Turpentine is turpentine that is distilled from shredded dead ground conifer wood and not tree sap. It has always been considered inferior and less pure than essential oil of turpentine. Modern processes have likely diminished this difference but wood turpentine still lacks the β -Pinene component found in gum spirits of turpentine.

Double and Triple Rectified Turpentine

Rectification is another term for distillation. Double and triple rectified is a designation that suggests that the turpentine was redistilled to further purify the final solvent. This terminology was once used as an indication of quality but today is more of a marketing term. On their own, these terms do not indicate if the initial turpentine was distilled from the sap from living trees or from ground wood.

Spike Lavender Oil (Aspic Oil) is an essential oil distilled from *lavandula spica* a relative of the lavender plant used to create perfume. It dries very, very slowly, so much so that it can readily dissolve earlier applications of oil paint. Despite the documented use of spike lavender oil in early oil painting practice, it is generally considered inferior to turpentine and mineral spirits as a solvent for oil paint.

Essential Oil of Cloves or Clove Oil has been used as a preservative in emulsions and as an additive to mediums to substantially slow down their drying rate. There are far better preservatives available today. The use of clove oil as a drying retarder is greatly discouraged as its addition tends to substantially weaken the dried paint film.

Other Essential Oils and Extracts are also periodically used in art making. Oil of rosemary sometimes served as a substitute for clove oil and as a component in the creation of complex oil-hard resin mediums. Like clove oil, artists should forgo the use of these materials as their dangers far outweigh and perceived benefits.

OTHER SOLVENTS

Acetone is a byproduct of the distillation of wood and of the fermentation of corn mash. It has been known since the 19th century and is used as a solvent for paints, varnishes, and plastics. It has a boiling point of 56°C, so it evaporates easily and is highly flammable. Classified as a ketone, this solvent is miscible in water, alcohols, and hydrocarbons.

Ethyl alcohol/ Ethanol/ Grain alcohol is produced from the fermentation of beets, sugarcane, and grains like corn or by the hydration of ethylene. It is used as a solvent for resins such as shellac and mastic. It has a boiling point of 78.5°C and is highly flammable. It is miscible in water, acetone, and methanol. Ethyl alcohol intended for industrial use and is more commonly available. It is usually denatured (rendered unfit to drink and therefore toxic) by adding materials such as methanol, benzene, or kerosene. “Anhydrous” alcohol is nearly chemical pure and must be purchased from a chemical supplier while Grain alcohol (190 proof) contains about 5% water. All grades of ethanol are hygroscopic and will readily accumulate water if the container is not tightly sealed.

Isopropyl alcohol/Isopropanol/Rubbing alcohol is manufactured by the indirect or direct hydration of propylene or by the hydrogenation of acetone. It has a boiling point of 82.6°C and is highly flammable. It is miscible in water, ethanol, acetone, chloroform, and benzene. It is used as a solvent for many nondrying oils, alkaloids, gums, inks, and certain resins.

Citrus-based solvents like Limonene are extracted from the oil of lemons, oranges, caraway, dill, and bergamot. Citrus-based solvents can be used to dissolve alkyd resins, rosin, waxes, and rubber compounds. Limonene is miscible in ethanol and has a boiling point of 175.5°C and is flammable. Citrus-based solvents can be used in place of certain petroleum-based products.

Soy-Based solvents contain methyl soyate and are produced from the transesterification of soybean oil and methanol. While they are considered to be safer to use than other categories of solvents they evaporate very slowly (so the solvent action is of long duration) and tend to be more viscous. Methyl soyate is insoluble in water and has a boiling point of 216°C.

ADDITIONAL RESOURCES AND REFERENCES

Dow Chemicals/The Rohm and Haas Paint Quality Institute – Solvents Used with Paints and Coatings

http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_0943/0901b80380943884.pdf?filepath=coatings/pdfs/noreg/884-00545.pdf&fromPage=GetDoc

CAMEO: Conservation & Art Materials Encyclopedia Online – Properties of Common Solvents http://cameo.mfa.org/images/f/fe/Download_file_140.pdf

Letterpress Commons – Solvents <https://letterpresscommons.com/solvents>

“Solvents and Thinners,” in *The Painter’s Handbook: Revised and Expanded*, by Mark David Gottsegen (New York: Watson-Guption, 2006), pp. 95-110.

Golden Artist Colors – Solving the Solvents <http://www.justpaint.org/solving-the-solvents/>

Gamblin Paints – Oil and Solvents: The Proper Balance
<https://www.gamblincolors.com/oil-and-solvent-the-proper-balance/>

PPG TrueFinish -Solvent Properties
http://www.ppgtruefinish.com/getattachment/dcedc83d-2282-41ad-9feb-f399c118d20b/SolventsPropertiesTF1047_408.pdf

Martin/F. Weber Co. - Oil Painting Solvent Comparison
<http://www.weberart.com/assets/asaferartstudio.pdf>

Generic Hydrocarbon Solvents. A Guide to Nomenclature by Alan Phenix, Western Association for Art Conservation Newsletter, May 2007 <http://cool.conservation-us.org/waac/wn/wn29/wn29-2/wn29-204.pdf>