

ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

TURPENTINE ENTRY

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COMPILERS/EDITORS:

ROY J. IRWIN, NATIONAL PARK SERVICE

WITH ASSISTANCE FROM COLORADO STATE UNIVERSITY

STUDENT ASSISTANT CONTAMINANTS SPECIALISTS:

MARK VAN MOUWERIK

LYNETTE STEVENS

MARION DUBLER SEESE

WENDY BASHAM

NATIONAL PARK SERVICE

WATER RESOURCES DIVISIONS, WATER OPERATIONS BRANCH

1201 Oakridge Drive, Suite 250

FORT COLLINS, COLORADO 80525

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This document was put together by human beings, mostly by compiling or summarizing what other human beings have written. Therefore, it most likely contains some mistakes and/or potential misinterpretations and should be used primarily as a way to search quickly for basic information and information sources. It should not be viewed as an exhaustive, "last-word" source for critical applications (such as those requiring legally defensible information). For critical applications (such as litigation applications), it is best to use this document to find sources, and then to obtain the original documents and/or talk to the authors before depending too heavily on a particular piece of information.

Like a library or many large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...

No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil, sediments, tissues, and air.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uninformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it

simply means that during our efforts, the editors found none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even without updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes or summaries as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability

on the internet or NTIS: 1998).

Turpentine (CAS number 8006-64-2)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Turpentine is a thin volatile essential oil, C₁₀H₁₆, obtained by steam distillation from the wood or the exudate of pine trees [492]. Although not a petroleum hydrocarbon product, turpentine is a common oil which is commonly spilled into surface waters. According the US Coast Guard Emergency Response Notification System (ERNS), turpentine is one of the most commonly spilled items the U.S. [635].

Main uses of turpentine include as a solvent thinner for paint, varnishes, and lacquer, and as a vehicle for paints [608,609]. Turpentine is also used in perfumery, sprays, and deodorizers [609].

Information on terpenes, a major component of turpentine:

Terpenes are plant-derived hydrocarbons. They have been used for years in a variety of applications including fragrances, food additives, even insecticides, but in the last few years (with the phase-out of CFCs and trichloroethane), more interest has been focused on terpene cleaners. The most common ingredient in terpene cleaners is D-limonene, a derivative of orange peels. Alpha and beta pinene (Pine-Sol) are derived from wood turpentine and are also commonly used as cleaners. The majority of literature on terpene cleaners deals with D-limonene-based products and, in fact, the terms "terpene" and "D-limonene" are often used interchangeably (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

Br.Haz: General Hazard/Toxicity Summary:

Potential hazards to fish, wildlife, and other living things (other than humans).

Coating action of resins can destroy water birds, plankton, algae and fishes [608].

Penaeid shrimp given abdominal injections were highly sensitive to turpentine. Induced cellular inflammatory response was fibrous scar tissue in

all tissues, early gill & hepatopancreas tissue destruction, & extensive heart & abdominal tissue destruction. (Fontaine et al, J Invertebr Pathol 25 no. 3: 321, 1975 [609].

Potential hazards to humans:

Will cause taste and odor problems before reaching toxic levels [608].

Characteristic odor, can cause serious irritation of kidneys [608].

In humans, turpentine is considered to be slightly toxic when used properly and poisonous if taken internally [758]. It can be absorbed through the skin. Some people develop an allergic reaction to turpentine with extended use. Mineral spirits, or paint thinner, can be used in place of turpentine because it has equal solvent properties and evaporates completely [758].

As little as 15 ml has proven fatal to a child, but a few children have survived...3 Ounces... Mean lethal dose in adults probably lies between 4 & 6 ounces. (Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-157) [609].

Probable routes of human exposure include inhalation and ingestion of contaminated water. (NIH/EPA; OHM/TADS, 1984) [609].

Turpentine exposure can lead to eye irritation, headache, dizziness, and nausea in humans; inhalation & ingestion can cause bladder irritation [609]. Inhalation of turpentine can have a number of negative effects on animals [607].

Toxic Hazard Rating [609]:

Acute local: irritant 2. Acute systemic: inhalation 2; skin absorption 2. Chronic local: irritant 2; allergen 2. 2= Moderate: may involve both irreversible & reversible changes not severe enough to cause death or permanent injury. [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984. 2705].

Acute local: allergen 1. Chronic systemic: ingestion 1; inhalation 1; skin absorption 1.

1= Slight: causes readily reversible changes which disappear after end of exposure. Acute systemic: ingestion 3. 3= High: may cause death or permanent injury after very short exposure to small quantities. [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984. 2705].

Symptomatology: 1. Burning pain in mouth & throat, abdominal pain...Vomiting... Diarrhea. 2. Mild resp tract symptoms are often noted...Coughing, choking, dyspnea...Cyanosis. Aspiration...Systemic absorption may lead to pulmonary edema & pneumonitis. [Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-394] [609].

Terpenes (a key component of turpentine) are flammable so spraying is not recommended, except in specially designed equipment. Terpenes are not highly volatile, but they are VOCs and may be regulated under the new Clean Air Act. Some salesmen are quick to point out that terpenes are "generally recognized as safe" by the FDA and that they are found in a myriad of products, from food additives to toothpaste. Unfortunately, toothpaste is not often used for industrial cleaning. Yes, terpenes are safer to use than many solvents, but to compare a terpene food additive to a terpene paint stripper is not only misleading, it is reckless. Terpene cleaners are mildly neurotoxic. They are known to cause respiratory distress and/or irritation and that "pleasant citrus fragrance" can very quickly become nauseating. There is a controversy about the carcinogenicity of D-Limonene. One preliminary study linked D-limonene to testicular cancer in male rats. Another study indicates that those results do not apply to humans. Who knows? The good news is that detection limits (by smell) are orders of magnitude below the recommended exposure limits so, for safety, try to use terpenes in a manner that minimizes odor. And wear your gloves (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

Br.Car: Brief Summary of Carcinogenicity/Cancer Information:

Equivocal tumorigenic agent by RTECS criteria; Skin and appendages - Tumors; Reference: Cancer Research 19:413, 1959 [607]. Some cancer studies have been performed on

human exposure to terpenes [609] and turpentine exposure to mice [607].

A possible association between respiratory cancer and chemical exposure in the wood industry was investigated in a nested case-control study of 57 men with respiratory tract cancer and 171 sex and age matched controls without respiratory cancer. Cases and controls taken from an original cohort of 3805 men with 1 or more years of employment in the particleboard, plywood, sawmill, or formaldehyde glue factories between 1944 and 1965 were followed until 1981. Twelve prevalent exposures were determined thru work histories and job exposure matrices for each plant. Exposure levels were available for wood dust (1.0 mg/cubic meter). ... Exposure to terpenes and other heating products of coniferous woods was significantly associated with a risk of respiratory cancer when the duration of exposure exceeded 5 yrs (OR=9.71, p<0.05)./turpenes/ (Kauppinen TP et al; Br J Ind Med 43:84-90, 1986) [609].

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

Occupational exposures involving primarily airborne contaminants /including turpentine/ may affect the course of pregnancy, the development of the embryo and fetus, or both. The contaminants are found in industry in the chemical trades. A chief danger period in any pregnancy occurs during organogenesis (principally the first trimester); lower standards of exposure or temporary retirement from potentially hazardous situations should be considered for protection of the developing embryo. [Kuntz WD; Am Ind Hyg Assoc 37(7): 423-426 (1976)] [609].

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

Bioconcentration: Potential for accumulation: negative [NIH/EPA; OHM/TADS (1984)] [609].

Turpentine includes mainly C10-terpenes, especially alpha-pinene and beta-pinene, and is typical of the volatile oil portions of various oleoresins [609]. The ratio of the number of carbon atoms to the number of hydrogen atoms in turpentine is 5:8. Other natural products with a carbon-to-hydrogen ratio of 5:8 were then classified as terpenes. The original definition of terpenes was then expanded to include all compounds containing isoprene skeletal units (therefore, terpenes can also be called isoprenoids) [757]. By comparison, crude oil is a complex mixture of approximately 11% to

13% hydrocarbons and 84% to 87% carbon by weight [745]. Turpenes [sic] are one of the 18 series of hydrocarbons identified in crude oils [745]. (NOTE: The word "turpenes" in the previous sentence should be correctly spelled "terpenes").

Terpenes are biodegradable, perhaps too biodegradable. Terpenes are often discharged to sewers, but the biological and chemical oxygen demands (BOD/COD) are exceptionally high, possibly leading to sewer surcharges. Don't wait for a surprise. Check with your local waste water authority BEFORE purchasing a terpene-based cleaning system. Even better, design a closed-loop system that doesn't require disposal. Terpenes also have a very high BTU value as a fuel source, so incineration as waste oil is an option (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

Synonyms/Substance Identification:

Oil of turpentine [609]
Oil of turpentine, rectified [609]
Spirit of turpentine [609]
Spirits of turpentine [609]
Terebenthine (French) [609]
Terpentin oel (German) [609]
Turpentine oil [609]
Turpentine oil, rectified [609]
Turpentine oil, rectifier [609]
Turpentine spirits [609]
Turpentine steam distilled [609]
Gum turpentine [607]
Turpentine (ACGIH, OSHA) [607]
Turpentine substitute (UN1300) (DOT) [607]
Turpentine (UN1299) (DOT) [607]
UN1299 (DOT) [607]
UN1300 (DOT) [607]
Wood turpentine [607]

Associated Chemicals or Topics (Includes Transformation Products):

Site Assessment-Related Information Provided by Shineldecker (Potential Site-Specific Contaminants that May be Associated with a Property Based on Current or Historical Use of the Property) [490]:

Raw Materials, Intermediate Products, Final Products, and Waste Products Generated During Manufacture and Use:

- Alpha pinene
- Beta pinene
- Camphene

- Monocyclic terpenes
- Terpene alcohols

Metabolism/Metabolites [609]:

Part of.../Inhaled turpentine/ is eliminated unchanged in expired air & in urine, but most...is metabolized & excreted in urine conjugated with glucuronic acid. [Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963].

Terpenes: Watch for metals and other contaminants which may exceed discharge or incineration limits (Florida Department of Environmental Protection, as distributed on the EnviroSense Home Page, July 14, 1997).

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

No information found.

W.High (Water Concentrations Considered High):

No information found.

W.Typical (Water Concentrations Considered Typical):

No information found.

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

Information from OHM/TADS [608]:

Water uses threatened:

Recreation, potable supply, fisheries.

Coating action of resins can destroy water birds, plankton, algae and fishes.

Industrial fouling potential: Boiler water feed should be limited to 7 ppm or less. Resin can result in poor heat transport,

blistering, overheating and foaming. In reused cooling water, no resin is acceptable. Resin causes tastes in food processing water and is especially detrimental to cement and paper making operations.

W.Plants (Water Concentrations vs. Plants):

No information found.

W.Invertebrates (Water Concentrations vs. Invertebrates):

No information found.

W.Fish (Water Concentrations vs. Fish):

One hundred ppm toxic to fish, no time period given [367].

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

No information found.

W.Human (Drinking Water and Other Human Concern Levels):

No information found.

W.Misc. (Other Non-concentration Water Information):

No information found.

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (Sediment Concentrations Considered Low):

No information found.

Sed.High (Sediment Concentrations Considered High):

No information found.

Sed.Typical (Sediment Concentrations Considered Typical):

No information found.

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data and Other Sediment Benchmarks:

Sed.General (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic

Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota):

No information found.

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

No information found.

Sed.Fish (Sediment Concentrations vs. Fish):

No information found.

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

Sed.Misc. (Other Non-concentration Sediment Information):

No information found.

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil.):

Soil.Low (Soil Concentrations Considered Low):

No information found.

Soil.High (Soil Concentrations Considered High):

No information found.

Soil.Typical (Soil Concentrations Considered Typical):

No information found.

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil Quality Standards, Screening Levels, Dose/Response Data and Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus

Mixed or General Soil-dwelling Biota):

No information found.

Soil.Plants (Soil Concentrations vs. Plants):

No information found.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

No information found.

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found.

Soil.Human (Soil Concentrations vs. Human):

No information found.

Soil.Misc. (Other Non-concentration Soil Information):

No information found.

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found.

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found.

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for Fish and Similar Benchmark Levels From Other Countries):

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Fish:

No information found.

C) Body Burden Residues in Fish: Typical, Elevated or of Concern Related to the Well-being of the Organism Itself:

Information from OHM/TADS [608]:

At 100 ppm turpentine is toxic to freshwater fish.

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Wildlife, Birds, or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

Information from RTECS [607]:

LD50/LC50 - Lethal dose/conc 50% kill
rat: LD50; Route: Oral; Dose: 5760 mg/kg;
Reference: Pharmazie 14:435, 1959.

C) Body Burden Residues in Wildlife, Birds, or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found.

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

LDLO, Human, oral, 500 mg/kg. [General Electric Co; Material Safety Data Sheet #375 (1981)] [609].

NOTE: LDLO = Lowest published lethal dose/conc

TDLo, Woman; Route: Oral; Dose: 560 mg/kg; Toxic effects: Kidney, ureter, and bladder - Other changes. [Reference: Archives of Disease in Childhood 28:475, 1953] [607].

TDLo, Infant; Route: Oral; DOSE: 874 mg/kg; Toxic effects: Behavioral - Antipsychotic. [Reference: Archives of Disease in Childhood 28:475, 1953] [607].

LDLo, Infant; Route: Oral; DOSE: 1748 mg/kg; Toxic effects: Behavioral - Convulsions or effect on seizure threshold; Gastrointestinal - Nausea or vomiting; Kidney, ureter, and bladder - Other changes. [Reference: Archives of Disease in Childhood 28:475, 1953] [607].

NOTE: LDLo = Lowest published lethal dose/conc

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

No information found.

Tis.Misc. (Other Tissue Information):

No information found.

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

Bioconcentration: Potential for accumulation: negative [NIH/EPA; OHM/TADS (1984)] [609].

Interactions:

Interactions [609]:

Turpentine at 1.8 Mg/kg/day orally for 3 days in the rat was observed to stimulate microsomal enzymes & reduce the toxicity toward parathion. In guinea pig, it protected the hypersensitivity to 6-mercaptapurine. [Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3245].

In turpentine-pretreated rats, the development of carageenan induced edema is reduced. ... [Deflandre E et al; Prostaglandins Leukotrienes Med 12(2): 179-188 (1973)
Ethionine administered ip to rats /with/ turpentine-induced inflammation preferentially reduced incorporation of 14C-leucine into fibrinogen, haptoglobin, and other acute-phase proteins. ... [Kasperczyk KH, Koj A; Br J Exp Pathol 64(3): 277-285 (1983)].

Induction of alpha-2- macroglobulin acute phase protein in rats by injection of turpentine revealed strain and sex differences in the amounts of this protein detected in the sera by rocket immunoelectrophoresis. Studies in vivo with ... non-steroidal anti-inflammatory drugs (NSAID) ... aspirin, indomethacin, BW 755C, colchicine, clofibrate, clozic inhibited serum concentrations of the acute phase protein 48 hr after turpentine injection. ... [Baldo BA et al; Agents Actions 11(5): 482-489 (1981)].

Uses/Sources:

Major Uses [609]:

Solvent for oils, resins, varnishes, vehicle for paints. [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

In perfumery, sprays, deodorizers [Fenaroli's Handbook of Flavor Ingredients. Volume 1. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975. 482].

Steam-distilled turpentine...used in... candy, 11 ppm; baked goods, 10-20 ppm; chewing gum, 7.1 PPM. [Fenaroli's Handbook of Flavor Ingredients. Volume 1. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975. 483].

Chem int for synthetic pine oil [SRI].

Chem int for polyterpene resins [SRI].

Chem int for pinene-based perfumes & flavors [SRI].

Chem int for other terpenes used in pharmaceuticals [SRI].

Component of polishes, oils, & inks [SRI].

Used in expectorant formulations. [Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 9:543].

As constituent of stimulating ointments. [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 1403].

Insecticide. [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 1403].

In production of synthetic camphor. [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 1403].

Chemical feedstock for manufacture of ... cleaning materials, putty, mastics, cutting and grinding fluids [SITTIG. HDBK TOX & HAZARD CHEM & CARCINOGENS 2ND ED 1985 p.906].

Information from OHM/TADS [608]:

Common uses

Medicine; solvent thinner for paint, varnishes, and lacquer; rubber solvent; and reclaiming agent.

Information on terpenes, a major component of turpentine:

Terpenes have very high solvency and clean very well, often better than chlorinated solvents. Greases, oils, fluxes and adhesives are easily removed using terpenes and blends have been developed which remove resins, paints and carbon deposits. As with most cleaning chemicals, straight terpenes are stronger than the water/terpene blends. Terpenes have really caught on for cleaning electronic assemblies and printed circuit boards. If properly rinsed, terpenes are compatible with painting and plating operations and are now commonly used in machine shops and engine rebuilding operations, especially in solvent sinks. High purity terpene solutions are popular for cleaning precision parts and high voltage electrical parts. Because of terpenes' low volatility, a rinse and/or dry step may be necessary. Experts debate whether unrinsed terpenes leave residues. The answer is -- some do, some don't. High purity

terpenes don't leave a residue but do take longer to dry than chlorinated solvents. Low purity terpenes also dry slowly, but the impurities will remain as a residue. At 80/20, a terpene/water mix may turn to a paste, so if you are making a 10% terpene/water mix, make sure to add the terpene to the water instead of the other way around. Also be aware that terpene cleaners or terpene rinse water may attack PVC plumbing in your cleaning equipment (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

At Motorola's portable radio plant in Plantation, they've been cleaning circuit board assemblies with terpenes for about three years. Says Tony Suppelsa, Sr., a project engineer with Motorola, "It started back in 1989. We were looking for a way to get away from cleaning with CFC-113. We evaluated a number of cleaning chemicals including terpenes. The terpenes worked OK, but weren't necessarily the best at that time. But we found one company that made a machine to clean PC boards using terpenes, while the rest of the equipment industry was still tripping over itself. I loaded up some PC boards on a plane and flew to their test facility to do some test cleaning. When I got back, we ran accelerated life tests on the boards and they performed beautifully. They were actually cleaner than with the CFC-113. We put in an order for the equipment, installed it, and it ran without a glitch!" The equipment consists of a special terpene spray chamber (with a fire suppression system), an air knife (to reduce dragout), 2 recirculating spray rinses, a hot de-ionized water rinse and a dryer (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

In step 2 of the project, Motorola began to recycle rinse water from the system. "We were using about 5 gallons per minute and the water and sewer bill just skyrocketed. So we installed a system that skims off the terpene from the rinse water, and now we reuse the water. That brought our water consumption down to about 80 gallons per day, mostly used to make-up for evaporation, and no discharge of pollutants." With these 2 steps, Motorola reduced the cost of cleaning PC boards by 85%. Step 3 according to Tony: "A lot of Motorola facilities are using terpene cleaning as a stepping stone towards the ultimate goal: no-clean. Little by little, products are showing up that don't require cleaning; for example we now use no-clean fluxes. We're applying these new products to more and more processes. Now that's the ultimate answer" (Florida Department of Environmental Protection, as distributed on the Enviro\$en\$e Home Page, July 14, 1997).

Forms/Preparations/Formulations:

Turpentine is manufactured by first gathering the thick, resinous sap that exudes from the loblolly pine and the longleaf yellow pine [758]. This sap, also known as oleo resin or balsam, is tapped from live pine trees in much the same way that syrup is taken from maple trees. Steam-distilled, or wood, turpentine is made from wood chips and stumps rather than balsam. It has a more aggressive odor and contains residue not found in fresh gum spirits [758].

Equine leg paint contains 1.0% Wt/vol turpentine: a medium strength soln for use when counterirritant-stimulant action falling between stimulating liniment & blistering ointment is desired. (Aronson, C.E., ed.,. Veterinary Pharmaceuticals & Biologicals, 1980-1981. Media, Pa.: Harwal Publishing Co., 1980.,p. 16/135 [609].

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Typical composition from USA Southern Pine: from 1) Gum - 60 to 65% alpha-pinene, 25-35% beta-pinene, and 5-8% other terpenes; 2) Wood- 75 to 80% alpha-pinene, 0-2% beta-pinene, 4-8% camphene, and 15-20% other terpenes; 3) Sulfate- 60 to 70% alpha-pinene, 20-25% beta-pinene, and 6-12% other terpenes. [General Electric Co; Material Safety Data Sheet #375,1981 [609].

Turpentine includes mainly C10-terpenes, especially alpha-pinene and beta-pinene, and is typical of the volatile oil portions of various oleoresins. (Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 20:20) [609].

See also: Br.Class information section above.

Information from OHM/TADS [608]:

Mixture of resins; principally C10H16

Specific gravity [608]: 0.87

Information from HSDB [609]:

Density/Specific Gravity:

0.854-0.868 @ 25 DEG/25 DEG C [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Solubilities:

Insol (sic, actually "relatively insoluble") in water; sol in 5 vol alcohol [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Miscible with benzene, chloroform, ether [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Miscible with carbon disulfide, petroleum ether & oils [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Color/Form:

Colorless liquid [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Odor:

Characteristic odor ... Becoming more pronounced & less agreeable on aging or exposure to air [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Taste:

Characteristic ... Taste, ... Becoming more pronounced & less agreeable on aging or exposure to air [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 978].

Boiling Point:

154-170 DEG C [Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2705 Melting Point: 1. -50 TO -60 DEG C [Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1209].

Vapor Density:

4.7 (air=1 at boiling point of turpentine) [National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 7th ed. Boston, Mass.: National Fire Protection Association, 1978].

Other Chemical/Physical Properties:

Yellowish, opaque, sticky masses. /Oleoresin/ [The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 1403].

136 (approx mol wt) /undefined mixtures/ [Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) PublicationNo. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981. 2

5 mm Hg at 25 deg C /Unspecified mixtures/ [National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 7th ed. Boston, Mass.: National Fire Protection Association, 1978. 2].

Information from OHM/TADS [608]:

Physical parameters:

Location/state of material: Colorless-amber liquid. Will float in slick on surface.

Color in water: Yellow

Chemical parameters: Solubility (ppm 25 degrees C):

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

Absorption, Distribution and Excretion [609]:

Turpentine is readily absorbed from gastrointestinal tract...& Resp tract. [Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-157].

Principle portal of entry ... In industrial use is inhalation. Part ... Is eliminated unchanged in expired air & in urine, but most ... Is metabolized & excreted in urine conjugated with glucuronic acid. [Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1214].

Elimination /of absorbed turpentine/ in the urine is manifested by an odor resembling that of violets. [International Labor Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 1447].

Chronic inhalation of commercial turpentine by adult male rats gave accumulation of the solvent in perinephric fat & brain. Body solvent content remained stable during 8 weeks. [Savolainen H & P Pfaffli, Chem-Biol Interact 21(2-3) 271 (1978)].

Laboratory and/or Field Analyses:

Due to the volatility of many compounds in turpentine, precautions need to be taken during sampling to prevent loss of VOCs (see lab section in trichloroethylene entry for typical precautions to be taken with volatiles. No information on methods for pinenes or other terpenes found in EPA EMMI database [861].

Terpenes are non-reactive with metals and most types of plastics. Strong terpene solutions can swell or degrade some types of plastic and rubber (Florida Department of

Environmental Protection, as distributed on the EnviroSense Home Page, July 14, 1997).

No other information found.