PRODUCTS OF RESIN PROCESSING

Ciesla William M
Forest Health Management International, Fort Collins, Colorado, USA

Keywords: *Abies*, *Agathis*, alpha pinene, amber, Araucariaceae, balsam, beta pinene, benzoin, copal, copaiba, damar, dragon's blood, essential oils, fir, fossil resin, gum naval stores, gum resin, hard resin, heptane, lac, mastic, naval stores, oleoresin, perfumes, Peru-balsam, pine, Pinaceae, *Picea*, *Pinus*, resin, resinite, retsina, rosin, shellac, spruce, styrac, sulphate naval stores, terpines, Tolu-balsam, turpentine, varnish, wood naval stores.

Contents

Summary

Resins are sticky, liquid, organic substances that usually harden upon exposure to air into brittle, amorphous solids. They are secreted by a number of plants, especially pines and other conifers and are a major non-wood product of forests.

Historically the major use of resins from conifers, especially pines, was to waterproof wooden ships, hence the name "naval stores" is still used as a designation for pine resins.

Pines are the primary source of resin although other conifers and some broadleaf trees are also commercial resin sources.

Most resins are harvested by a process known as tapping, a fairly labor intensive process that involves wounding live trees and collecting the resin. If done properly, there is little or no injury to the tapped trees.

Overtapping will weaken and kill trees, however, and there are instances, worldwide, where excessive tapping has threatened the sustainability of locally important resin sources.

Present day use of resins includes the manufacture of chemicals, pharmaceuticals, paints, varnishes, lacquers, inks, floor coverings, soaps and essential oils. A particularly interesting resin product is amber or fossil resin, which is made into jewelry and other specialty products.

Some amber contains almost perfectly preserved specimens of insects and other ancient plants and animals.

While synthetic products have replaced some natural resins, the market remains strong for pine and certain other natural resins.

Present day annual world production of pine rosin is estimated to be 1.2 million tonnes per year and world production of pine turpentine is estimated to be about 330 000 tonnes.

1. Introduction

Resins are a group of sticky, liquid, organic substances that usually harden upon exposure to air into brittle, amorphous solids. Natural resins are secreted by a number of plants, especially pines and other conifers.

In one instance, an insect is the source of a resin. Resins sometimes appear on the external surfaces of plants. They form protective coatings over plant wounds and can prevent entry of fungi and other disease causing microorganisms.

If trees are vigorous, a flow of resin caused by attacking insects, such as bark beetles, will repel the attack (Figure 1).

Figure 1. A pitch tube of crystallized resin, in a bark crevasse of a pine, is a natural defense by the tree against tree killing insects.

Resins are among the most important non-wood products harvested from trees. They are also one of the oldest tree products used by humans. Written accounts of the use of resin dates at least to biblical times. According to the King James Version of the Bible, God instructed Noah to "Make thee an ark of gopher wood; rooms shalt thou make in the ark and shall pitch it within and without with pitch."

Today resins are used in the manufacture of a wide range of products including paints and lacquers, rubber, soaps, linoleum, essential oils, furniture polishes and pesticides. Most resins are harvested from trees by a process known as tapping (Figure 2). This involves the labor intensive process of wounding the trunks of living trees to induce a resin flow, installation of a resin collecting system and, in some cases, possible application of a chemical stimulant to maintain resin flow.

Figure 2. A worker in Anhui Province, China, makes fresh wounds on a Masson pine, *Pinus massoniana*, to stimulate resin flow.

Resins are classified according to their hardness and chemical composition into oleoresins and hard resins. Oleoresins are sticky, amorphous liquids that contain essential oils. Hard resins are hard, brittle, odorless and tasteless and exhibit a glasslike character. They are obtained either as fossils or as distillation products of oleoresins.

Conifers, especially pines, are the best-known and most widely used sources of resin. Resins are also harvested from certain broadleaf trees in both tropical and temperate forests. The following sections provide brief descriptions of trees that are important resin sources, the products made from these resins and their ultimate uses.

2. Resins from conifers

2.1. Pines

2.1.2. Sources

Resin products from pines are commonly called “naval stores,” a term that dates back to the days when the British Royal Navy used large quantities of pine resin to waterproof wooden sailing vessels. Today, three classes of naval stores are recognized based on their source:

1. Gum Naval Stores – Obtained by a tapping living pine trees.

2. Sulphate Naval Stores – Obtained during the conversion of pine wood chips to pulp via the sulphate or Kraft pulping process. Sulphate turpentine is condensed from the cooking vapors. A product known as tall oil is obtained from alkaline liquors and fractionated into products such as tall oil resin and tall oil fatty acids.

3. Wood Naval Stores – Obtained from resin saturated pine stumps after a tree has been felled.

2.1.2. Products

Distillation of pine resin yields two products: turpentine and rosin. Turpentine is a clear liquid with a pungent odor and bitter taste and is composed of a number of organic compounds, primarily a series of volatile fractions known as terpenes. The chemical composition of turpentine can vary significantly depending on the species of pine from which it is harvested. In many pines, the terpene composition is simple and consists of two common terpenes: alpha and beta pinenes. Other pine species contain different volatile oils, which may significantly affect the composition and use of the turpentine. The resin of the North American lodgepole pine, *Pinus contorta*, contains phellandrine, a turpentine also contained in plants of the parsley family which has a grassy fragrance. The resin of the Mediterranean species, *P. pinea*, and some North American species contain limonene. Ponderosa pine, *P. ponderosa*, resin contains a sweet smelling terpene, known as carene. Two pines endemic to Pacific coastal regions of North America: Digger pine, *P. sabiniana* and Jeffrey pine, *P. jeffreyi*, have no terpene components in their resin. Instead they contain aldehydes, which are much diluted with a gasoline-like material, known as heptane that has no fragrance but is explosive. Aldehydes mixed with heptane provide the characteristic vanilla-like odor associated with Jeffrey pine forests.

Rosin is the involatile residue that remains after the distillation of turpentine. Rosin is a brittle, transparent, glassy solid insoluble in water but soluble in a number of organic solvents.

2.1.3. Historical Aspects

Pine resin has been an important commodity at least since biblical times as attested to by the story of Noah. The Roman statesman and poet Ausonius wrote about the tapping of pines for resin in Aquitania in southeastern France. The pine he referred to, *P. pinaster*, is now known as the maritime pine (*Pin maritime*).

The importance of pine resin to the British shipbuilding industry has already been mentioned. During the 15th and 16th centuries, when America was a series of British Colonies, the capacity of two indigenous pines: slash pine, *P. elliottii* and longleaf pine, *P. palustris*, to produce resins of excellent quality and quantity was recognized and naval stores became an important export commodity from the South Carolina and Georgia colonies. The tapping of resin from these pines was a major industry in the southeastern USA until recently, when high labor costs reduced its profitability. Today, resin is produced in this region either via the sulphate pulping process or by extraction of resin from saturated pine stumps.

In North America, indigenous people used resin from pines and other conifers to caulk birch bark canoes. Pine resin was used in California long before the territory became part of the USA. The origin of the name “California” may be linked to pine trees and the resin they produced. Padre Arroyo, one of the early priests who converted the indigenous tribes of California to Christianity and ultimately wrote a vocabulary of the California Indian languages, told an officer of Captain Beechey’s expedition in 1826 that the word “California” was a corruption of the Spanish word *colofon* meaning “resin” and that it was suggested by the numerous pines, *P. radiata*, which produced resin around the old Spanish capital of Monterrey.

In India, commercial tapping of resin from pines began in 1896 following a series of preliminary experiments from 1890 to 1895. The development of resin tapping in India has been entirely the work of the State Forest Departments, but the idea for tapping the indigenous pine forests of the Himalayas originally arose after observing the extraction of crude resin by local people.

2.1.5. Resin producing pines

Virtually all pines will yield resin if tapped. Key factors that determine the feasibility for tapping are the quality (terpene content) and quantity of resin obtained. Botanists divide the pines into two large groups; the soft, or hapoxylon, pines and the hard, or dipoxylon, pines. The soft pines have deciduous needle sheaths and most species have needles in clusters of five.

The hard pines have persistent needle sheaths and most species have needles in groups of two and three. Today, only the diploxylon (hard) pines are commercially tapped. Both plantations and natural stands are tapped for resin and in some tropical or southern hemisphere countries where pines are not native, extensive pine plantations have proven to be excellent resin sources. Important resin producing species are summarized in Table 1.

Species	**Common name**	**Natural range**	**Countries where**

			important
P. brutia	Calabrian pine	Crete, Cyprus, Turkey, Black Sea Region	Turkey
P. caribaea	Caribbean pine	Caribbean Islands and Central America	Kenya, South Africa, Venezuela
P. elliotti	Slash pine	Southeastern United States	Argentine, Brazil, Kenya, South Africa
P. halapensis	Aleppo pine	Mediterranean Europe and North Africa	Greece
P. kesiya		Southeast Asia	China
P. massoniana	Masson pine	China	China
P. merkusii	Merkus pine	Southeast Asia	China, Indonesia, Vietnam
P. oocarpa		Mexico, Central America	Honduras, Mexico
P. pinaster	Maritime pine	Southern France, Portugal, Spain	Portugal
P. radiata	Radiata or Monterrey pine	California, USA	Kenya
P. roxburghii	Chir pine	Himalayas	India, Pakistan
P. sylvestris	Scotch pine	Eurasia	Lithuania, Poland, Russia

Table 1. Important commercial sources of pine resin.

2.1.5. Effects Of Resin Tapping On Pines

If done properly, using methods that involve removal of only the bark (see *Structure, Growth, Development and Reproduction of Forest Trees*), tapping trees causes no damage to pines and they may be tapped for up to 20 years or more. Even the more traditional methods of tapping, which involve some removal of woody tissue, such as the cup and gutter system, may not affect tree survival and trees can be seen in the wild with old tapping scars that seem otherwise quite vigorous (Figure 3). The risk of tree damage is heightened if excessive wood tissue is removed.

In the southeastern United States, two native species of insects are attracted to turpentine scars. The black turpentine beetle, *Dendroctonus terebrans*, a bark beetle, is attracted by terpenes released by stumps and injured trees. Trees weakened by fire, logging or adverse climatic conditions or which have exposed resin due to naval stores operations are highly prone to attack. The turpentine borer, *Buprestis apricans*, a wood boring beetle, deposits eggs on exposed wood, especially at the edges of turpentine faces or fire scars. The larvae tunnel in the sapwood and heartwood. This insect was very destructive when turpentine orchards were common in the southeastern USA. Borer-riddled trees were so weakened that they became subject to wind breakage. The lumber value of these trees was virtually destroyed and resin production was reduced.

Sulfuric acid treatment to increase resin flow in naval stores operations eliminated dry faces, which were attractive to these insects, thus preventing attacks.

Figure 3. Old turpentine scars on Scotch pines, *Pinus sylvestris*, near Marcinkonys, Lithuania

-
-
-

Bibliography

Anderson E.F. (1986). Ethnobotany of hill tribes of northern Thailand. II. Lahu medicinal plants. *Economic Botany* **40**, 442-450.

Anderson K.B. and Crelling J.J. (1995). *Amber, Resinite and Fossil Resins*. American Chemical Society, Washington D.C., 297 pp. [Describes the properties, sources and uses of fossil resins].
Balee W. and Daly D. (1990). Resin classification by the Ka'apor Indians. *Advances in Economic Botany* **8**, 24-34.

Bhattarai N.K. (1992). Medical ethnobotany in the Karnali Zone, Nepal. *Economic Botany* **46**, 257-261.

Chandrasekharan C., Frisk T., and Campos Roasio J. (1996). *Desarrollo de productos forestales no madereros en America Latina y el Caribe.* FAO, Regional Office for Latin America and the Caribbean, Santiago, Chile, Serie Forestal #5, 61 pp.

Chaudari D.C. (1995). *Manual of Rill Method of Resin Tapping from Pines.* Forest Research Institute, Indian Council of Forestry Research and Education, Dehra Dun, India, 40 pp.

Ciesla W.M. (1998). *Non-wood forest products from conifers*. FAO, Non-wood Forest Products #12, Rome, Italy, 123 pp. [This publications includes a chapter on resin products from conifers].

Conelly W.T. (1985). Copal and rattan collecting in the Philippines. *Economic Botany* **39**, 39-46. [Describes the impact of excessive tapping for Copal production on trees and a local economy].

Coppen J.J.W. (1993). *Pine and eucalypts - Sources of non-wood forest products in Africa.* Paper given at the FAO/Commonwealth Science Council Regional Expert Consultation Meeting on Non-Wood Forest Products, Arusha, Tanzania, 17-22 October 1993, 7 pp. [Describes present and potential for resin production from pines in Africa].

Coppen J.J.W., (1995). *Gums, resins and latexes of plant origin.* FAO, Rome, Italy, Non-wood Forest Products #6 142 pp. [Global overview of plant resins].

Coppen J.J.W. and Hone G.A. (1995). *Gum naval stores: turpentine and rosin from pine resin*. FAO, Rome, Italy, Non-wood Forest Products # 2, 62 pp. [Overview of resin production from pines].

Critchfield W.B. and Little Jr. E.L. (1966). *Geographic Distribution of the Pines of the World.* USDA Forest Service, Miscellaneous Publication 991, 97 pp. [This publication contains distribution maps of the pines of the world].

Forbes R. and MeyerA.B. (1956). *Forestry Handbook*. (Edited for the Society of American Foresters). New York, Roland Press Company.

Hora B., (ed.). (1981). *The Oxford Encyclopedia of Trees of the World*. Oxford University Press, 288 pp.

Iqbal M. (1993). *International trade in non-wood forest products: an overview.* FAO, Working Paper FO: Misc/93/11, 100 pp.

Kochilas D. (1990). *The Food and Wine of Greece*. St. Martins Press, N.Y. 354 pp. [Describes the Greek traditional wine known as retsina].

Langenheim J.H. (1995). *Biology of Amber-Producing Trees - Focus on case studies of Hymenaea and Agathis.* In: Amber, resinite and fossil resins. American Chemical Society, Washington D.C., pp. 1-42. [Describes the key sources of fossil resins].

Mirov N.T. (1967). *The Genus Pinus.* Ronald Press Company, 602 pp. [This book provides an overview of the pines of the world].

Mirov N.T. and Hasbrouck J. (1976). *The Story of Pines*. Indiana University Press 148 pp. [A popular book about pines that includes some interesting anecdotes about the early days of resin tapping in the United States].

Poinar G.O., Jr. (1993). Insects in amber. *Annual Review of Entomology* **46**, 145-159 [This paper describes the role of amber as a natural media for the preservation of prehistoric insects].

Tang-Shui Liu. (1971). *A Monograph of the Genus Abies.* Department of Forestry, College of Agriculture, National Taiwan University. [A comprehensive worldwide monograph of fir trees, *Abies spp.*].

Whitmore T.C. (1980). Utilization, potential and conservation of *Agathis*, a genus of tropical American conifers. *Economic Botany*. **34**, 1-12. [Includes information on the harvesting of copal].

Biographical Sketch

William M. Ciesla earned undergraduate and graduate degrees from the State University of New York, College of Environmental Sciences and Forestry at Syracuse University. He has worked as a forest health protection specialist with USDA Forest Service in a number of locations in the USA and from 1990-95 served as Forest Protection Officer with the Food and Agriculture Organization of the United Nations. He is presently the owner of Forest Health Management International, an international consulting company specializing in services relating to forest health protection, remote sensing and non-wood forest products. He is the author of several technical and popular articles on non-wood forest products.