Amber - the stone that ages
By Charles Gray

Chemical Constituents

Amber is a naturally occurring plastic, it is a polymer of resinous acids, some sources consider it a mineral. It is likely to have formed, over a long period of time, from the hardened sap of ancient pine trees and is viewed as a fossil. It has no consistent chemical formula though several chemical definitions have been published, amongst them being: **$C_{10}H_{16}O^{12}$ - $C_{12}H_{20}O^{13}$ - $C_{40}H_{64}O^{14}$ - $C_{10}H_{16}O$**

No formula is absolute for all amber as amber has no set chemical configuration, it varies, and is not easily quantified. The three elements: Carbon, Oxygen, and Hydrogen are mainly present in the following proportions: 67-87% Carbon, 15% Oxygen, 8.5-11% Hydrogen. Sulphur is present in small quantities from 0.26% to 0.34% together with 0.5% of inorganic matter, but the latter can vary depending on the amount of flora or fauna inclusions present in the amber.

The name amber relates specifically to fossilized resin which has succinic acid - $COOH(CH_2)_2COOH_{15}$ - present in its chemical makeup. Baltic amber, the most sought after amber, has succinic acid present between the ranges of 3 to 8 percent and is generally classified as succinite or succinct. Amber which is clear usually has lower percentages of succinic acid and as the percentage of succinic acid increases the amber becomes more opaque. Succinite is between 20 to 60 million years old. Fossilized resins that possess no succinic acid are officially classified as retinite.

General Characteristics

The melting point of Baltic amber is relatively low, from 290 to 380 degrees C, depending on the variety. Amber becomes plastic at about 120 to 135 degrees C and can be freely shaped under pressure. The term “natural” amber is used to differentiate naturally occurring amber from amber that has been altered by heat and pressure methods. This processed amber is generally called “pressed” amber. Pressed amber is nearly indistinguishable from natural amber. Using ultraviolet light, natural amber can be differentiated from pressed. Recently published standards for use of the term amber now include “real” amber whereby material with amounts of succinic acid as low as 10 parts per 1000 can be represented as amber.

Amber is a weak conductor of heat and feels warm to the touch. This distinguishes it from other gem stones and is one reason why amber is popular as jewelry. As a poor conductor of heat, care must be taken when raising or lowering the temperature of amber. Warming or cooling too quickly may cause the material to fracture.

Amber rubbed with woolen fabric obtains a negative charge and attracts small paper pieces.

Amber is heterogeneous in composition, but consists of several resinous bodies more or less soluble in alcohol, ether, and chloroform, leaving an insoluble bituminous substance. Heated below 300EC, amber suffers decomposition, yielding an "oil of amber", and leaving a black residue which is known as amber colophony, or amber pitch; when dissolved in oil of turpentine or in linseed oil this forms amber varnish or amber lac.

Amber is most frequently found as rough lumps in mines or pits. Amber is often collected from beaches in the form of rounded pebbles or ‘‘cobbles’’ that can range in size from tiny grains up to larger pieces 40cm across at their broadest part. Baltic amber, having washed ashore, is found from England to Russia and Norway to Germany.

Hardness

On Moh's scale of hardness amber has a hardness of 1.5 - 2.5. This varies according to the origin and type of amber.

Moh's Scale	Fossil Resin Hardness
1 - Talc	Colombian Copal 1 - 1.5
2 - Gypsum	Dominican Republic 1.5 - 2
3 - Calcite	Baltic Amber 1 - 2.5
4 - Fluorite	Borneo Retinite 1.5 - 2.5
5 - Apatite	Burmite 3
6 - Orthoclase	
7 - Quartz	
8 - Topaz	
9 - Corundum	
10 - Diamond	

Optical Qualities

The refractive index of amber is 1.54. The refractive index measures the level to which light is bent as it passes through the material under examination. The refractive index of amber remains fairly constant regardless of its type or geographic origin.

Specific Gravity

The specific gravity of amber is relatively low, approximately 1.05 - 1.10. Amber floats in heavily saturated salt water. It will not float in sea water, but is easily rolled and moved even in mild sea currents, provided it is loose.

Structure

Amber does not posses any crystalline structure and has no cleavage. It fractures conchoidaly and will not take a facet easily. It is not always homogenous in nature. Pieces can be found which consist of a series of concentric rings or layers. This reflects the way in which the original resin was laid down in successive layers. Amber of this type is called "shelley" amber. Where the fossil resin is free of any layers the general term to describe this kind of formation is "massive" amber.

Fluorescence

Amber has fluorescent qualities but is often difficult to detect. The oxidized surface of amber can occasionally fluoresce more than the un-oxidized amber beneath, though this can be reversed in other samples from the same source. Pictures will often be displayed in books which show pieces of amber fluorescing an electric blue, what is often not explained is that the exposure time for these photographs was in excess of 2 minutes.

Appearance

Discussions of the color of amber could occupy an entire book. Nearly every book written on amber contains a section, or numerous references to the color of amber, sometimes referring to about 250 distinct colors and appearances. For the most part color is described in two ways; turbidity and hue.

Turbidity is the extent to which it is clear or cloudy. Usually the more cloudy amber is the nearer to the color white it becomes. An entire language has grown up to describe the different gradients between just

white and clear amber. The following list contains some examples:

Clear	Water Clear (Completely Transparent)
	Yellow or Red Clear (Transparent but with a slight color hue)
	Cloudy, Fatty or Flohmig (Transparent but with a fine clouding)
	Kapusciak or Cabbage-Leaf (Clear and cloudy swirls)
	Clouded Bastard (Transparent but some dense clouding)
	Bastard Proper (White/grey clouding throughout)
	Kumst (Yellow & brownish-yellow clouding throughout)
	Semi Bastard (Dense clouding and osseous patches)
	Osseous, Bone or Pearl (Dense white coloring throughout)
	Frothy (White and extremely soft)
White	

The turbidity, which is the key factor in defining names given to amber, is not the result of any chemical nor the affect of any inclusion trapped in the resin. The turbidity is a result of thousands of tiny air bubbles held in the amber. The size and density of the air bubbles results in different shading. The size of the air bubbles range between 0.00017 mm - 0.02 mm. The smaller air bubbles packed densely together, about 9,000,000 per square millimeter produces the bastard forms of amber. Electron microscope studies at the Museum of the Earth in Poland discovered that osseous or bone amber was not due to trapped bubbles but a dense formation of tiny cracks which was only intermittently dispersed with bubbles.

Hue or color is also a major consideration for all afficionados of amber. The color range is extraordinarily wide, from clear to black, extending far beyond the typical reddish-yellow we are familiar with. The color of amber also changes over time due to the effects of oxygen upon the resin. Pieces of fine translucent yellow amber when exposed to air will gradually darken, becoming red and eventually completely dark.

Arnold Buffum, in his famous work, ‘‘The Tears of the Heliades’’ has a picture of a fine amber necklace he purchased in Sicily. The book was published in 1896. The colors of the various amber pieces are remarkable. They range through yellow, blue, green and red. The same necklace is photographed in Grimaldi’’s book, ‘‘Amber - Window to the Past’’, published in 1996. Each of the pieces now has a uniform brown hue.

Blue amber can be found, predominately in the Dominican Republic. It is also found in the Baltic. Amber researcher Sawkiewicz determined that Baltic blue amber was formed through the optical effect of closely concentrated bubbles of the same size, 0.00007 mm. Green fossil resin can be in the Dominican Republic and also in copal from Colombia. Burmite from Burma has a deep red color.

Some pieces of amber can appear black, this is due to soil which was absorbed into the resin at the time of its formation.

Oxidation

Often the surface color of a piece of amber is considerably darker than that of its interior. This is due to the oxidization of the amber in contact with air over time. The oxidation layer is sometimes referred to as a “shell” or “patina”.

Reaction to Solvents

Several amber researchers have noted the reaction of amber to various organic solvents, the following list is an amalgamation of the work of Rice, Fraquet and Bauer. Amber will dissolve in the following:

Solvents Concentration

Alcohol solution of potash 40-55%
Alcohol 20-25%
Amyl alcohol 20%
Benzene <1%
Benzol 10%
Carbon Disulphide 24%
Chloroform 21-26%
Ether 18-23%
Methyl alcohol 13%
Oil of Turpentine 25%
Petroleum Ether 3%

Bauer notes that amber will dissolve in sulphuric ether and acetic ether. He also states that concentrated sulphuric acid will dissolve amber but only when the resin has been granulated. He goes onto to say that boiling nitric acid will completely dissolve amber.

Baltic Amber, Locations of Origin

Baltic Sea area, Europe - The most prolific amber collecting location are mines on the Samland Peninsula, around Kaliningrad in the North-Western Region of Russia extending into the Baltic Sea. This 400 square mile peninsula is the surface expression of an ancient forest which extended across the Baltic Sea area. Amber comes from a formation, called ‘‘Blue Earth’’, which lies mostly below the sea surface. The formation can be reached by mining. While the formation is called Blue Earth, it is actually a greenish color, due to the inclusion of glauconite. Glauconite is a geological marker clay which is unique to saline marine environments, always forming under anaerobic conditions (without oxygen).

Exposure of the amber on the sea floor explains why, after a major storm, amber can often be found washed up on the shores throughout the Baltic. This is undoubtedly how it was first collected. Later, fishermen began finding it in their nets and a new industry was born. While diving would often bring up some amber, it is not an efficient method of amber collecting. The amber generally lies at about 80 to 90 feet, although near Palmnicken, Russia the formation is much nearer the surface.

Amber from the Baltic Sea area comes from forests which grew about 20 to 60 million years ago. The resin comes from a pine tree called Pinus succinifera [or Pinites succinifer], now represented by the Pseudolarix genus of pine tree. It is believed to look like the modern spruce tree. The Baltic Sea area stretches from the east coast of Britain to Estonia, and is the largest amber area yet discovered.

Bending and Processing

When gradually heated in an oil-bath, amber becomes soft and flexible. Two pieces of amber may be united by smearing the surfaces with linseed oil, heating them, and then pressing them together while hot. Cloudy amber may be clarified in an oil-bath, as the oil fills the numerous voids to which the turbidity is due. Around 1900 a process was found whereby small fragments, formerly thrown away or used only for varnish, could be utilized on a large scale in the formation of "ambroid", “real amber” or "pressed amber". The pieces are carefully heated, with exclusion of air, and then compressed into a uniform mass by intense hydraulic pressure; the softened amber being extruded through holes in a metal

plate. This product has been used for the production of jewelry and, until about 1945, articles for smoking. Unlike natural amber, pressed amber yields brilliant interference colors in polarized light. True amber can be colored artificially.

Imitations

Amber has been imitated for hundreds of years. Amber is a valuable item and there have been many attempts to cheaply copy it. There are both natural and synthetic polymer imitations.

Some of the natural resins, similar but less old than succinite amber, are:

Copal resin from Angola

Rumanite from Roumania

Kauri gum from Australia

Burmite from Burma

African amber from Africa

Some of the synthetic products are:

Plastics of all types, elastomers, plastomers, amnioplasts, polyesters, and phenoplasts; bakelite, celluloid, casein, perspex, resolan, redminol, urea-formaldehyde, polystyrene, plexiglass

Glass

Minerals

Wax

Many of the imitations are easily detected, many are not. Some of the tests used to distinguish imitations are:

Solubility

Ultraviolet light

Friction

Scratch

Burn

Taste

Weight

Inclusions and fractures

Refraction

Polarized light

These tests are generally inconclusive, but some are useful in ruling out some materials as amber. The drawback to many of these tests is that often part of the sample tested is destroyed.

An accurate test to conclusively identify amber is Infrared Spectroscopy. However, this method requires specialized equipment, expert interpretation of the results, is destructive, and is expensive.

History

Depending upon the historical source, amber has been worked by early man anywhere from 7000 to as much as 11,000 years ago. The occurrence of amber with human artifacts goes even further back, possibly to 30,000 years in Germany. From the first time man found amber lying in a stream-bed or on a

beach, he undoubtedly viewed it as unique and valuable. Imagine his surprise when the special ‘‘rock’’ melted if placed too near a fire, or when kept for decades how it aged along with its keeper.

The amber trade has reached all corners of the world. Baltic amber pieces were found with Pharaoh Tutankamon, dating from 1400 BC. Amber from 900 BC has also been found in Mesopotamia.

Amber is extensively used for beads, jewelry, ornaments, and from about 1750 to the present, for cigar-holders and the mouth-pieces of pipes. Some of the best quality Baltic amber was sent to Vienna for the manufacture of smoking instruments. It was regarded by the Turks as especially valuable, when used as a mouthpiece it is said to be incapable of transmitting disease as the pipe passes from mouth to mouth. The variety most valued in the East is the pale straw-colored, slightly cloudy amber. Due to its scarcity and high price it has fallen out of favor for smoking articles since about 1945.

Today strict export laws, and government control in many producing countries, limits the availability of Baltic amber for export to predominately finished jewelry.

Working with Baltic Amber

The first thing to remember when working is that Baltic amber is a relatively soft material and can fracture easily from heat, cold, pressure, and vibration.

Cutting: When filing or cutting amber, fracturing will occur if too much stress it put upon the material. Fine tools used slowly can be used to cut and shape amber. Amber breaks like glass, do not use excessive pressure during working or make heavy movements.

Drilling: Amber can be drilled with regular metal drill bits, but one should drill from both ends to prevent the end hole breaking out. Work up one drill size at a time to make larger holes. Use slow speeds to reduce heat and vibration.

Grinding: Amber can be ground with wet/dry oxide sandpaper you can buy in any hardware store. Start with 100 or 120 grit to grind away the surface and make the form you desire. Use 400 to 600 grit to sand away the heavy scratches before finishing

Bending: Amber is a poor conductor of heat so one must slowly raise the temperature throughout the entire piece. Use an oil bath with an accurate thermometer and control the temperature to +/- 2 degrees Fahrenheit. Your heat source must be stable and you must be able to balance the heat calories in to the heat calories lost in your process. Amber bends at a temperature only 3 degrees below that which its exposed areas caramelize (approx. 250-270 degrees F), when caramelization starts you must back down the temperature or the piece will be ruined. Small amounts of carmelization can be removed with sanding. Since amber has no set chemical makeup, the temperature that a given piece bends vs caramelizes is different for any given piece. It is best to bend amber stems at their rough shape stage, not as the final step, so any carmelization can be worked out. Do not use great force when bending amber as it will break. Allow ample time for the piece to cool naturally for shape to set. Never immerse hot amber in cold water, it will fracture.

Bending or straightening old stems of oxidized amber is not advised, since the shell and the interior are

chemically different and usually have different bending points. Amber has a poor shape memory, so as you approach the bending temperature you may not see any straightening of the stem. You must apply some pressure to straighten it at the right moment between the bending point and the carmelization point. Too soon, it breaks, too late it caramelizes.

Tapping: Amber takes threads reasonably well. Be sure to drill the exact size hole for tapping, any extra force can result in fracturing.

Bonding: Broken amber pieces can be bonded with cyanoacrylate glue.

Polishing/Finishing: Amber can be polished with a buffing wheel, do not apply excessive pressure/heat as fracturing may result. Car polish and beeswax worked by hand will also finish amber.

List of Information Sources

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