Yale *Institute for the Preservation of Cultural Heritage*

Mahogany Species Identification by Chemotaxonomy

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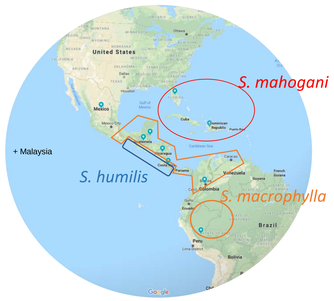
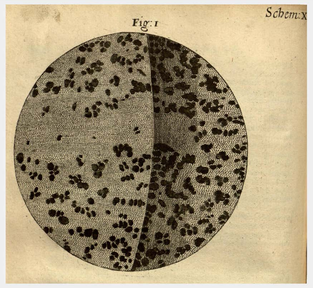
Scholarly Interest in *Swietenia spp.* Identification



Mahogany (*Swietenia spp.*) grows in the Caribbean islands and South and Central America. The map to the left shows the geographic distribution of the three species of mahogany. Mahogany wood became of interest to the West with British and Spanish trade starting in the 18th century; cut into boards, it was a back-up trade good, used to fill in empty space in trading vessels when sugar, rum, and other more regular trade goods were lower in supply than expected. Mahogany was used to make luxury furniture in the 18th and 19th centuries in the American colonies and Great Britain. Historians and curators are interested to know what species the mahogany used in the items they study, as it would inform their knowledge of trade patterns and what parts of South and Central America were logged by colonial powers at that time.

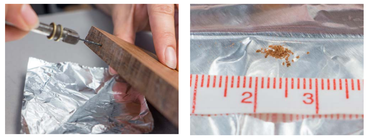


A section of petrified wood. *Micrographia*, 1665. http://biodiversitylibrary.org/page/786478. Digitized by: Missouri Botanical Garden.

Traditional Wood Identification Methods

Starting from harvested wood, as opposed to the tree itself, limits the information available for the identification process. Macroscopic qualities like wood density, hardness, grain, color, fluorescence, and smell are used to distinguish woods from each other. The invention of the microscope sparked the beginning of wood identification using cellular anatomy. As technology improved, more details became visible and were able to be used in the identification process. Chemical extractions of wood have been employed as a way to isolate chemicals that may be of use in the production of pharmaceuticals, wine, and other applications. These "extractives" have been used to a limited extent to differentiate woods, but their isolation can be difficult.

Thermal Desorption Gas Chromatography/Mass Spectrometry



Samples are obtained from wood by drilling into wood blocks to clear any outer coatings, and then collecting 300 µg wood powder for analysis.

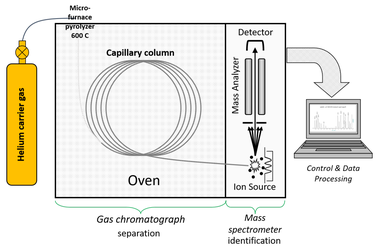
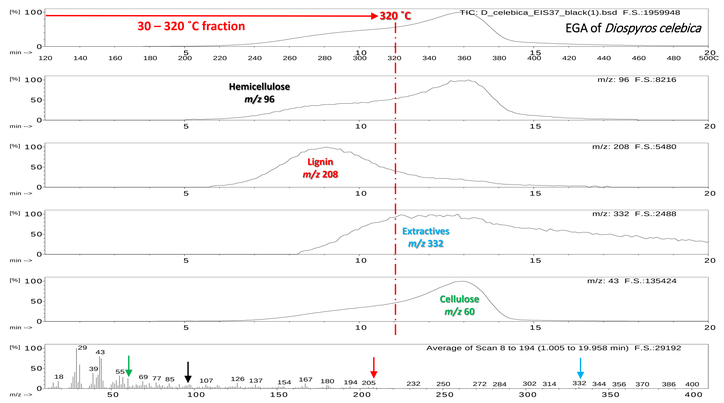


Diagram of the TD-GC/MS setup.

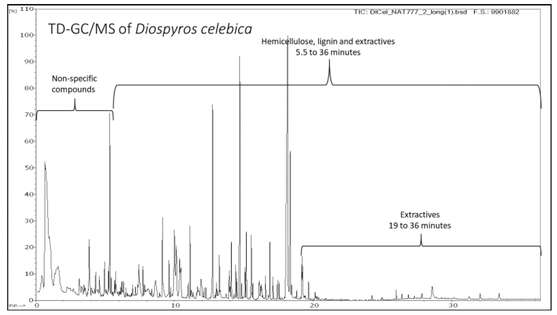
Instrumental Method

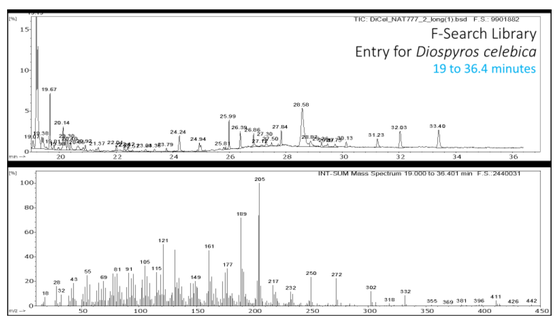
A sample of 300 µg of wood powder is put into a sample cup and pyrolyzed in double-shot mode. The selective sampler (Frontier Labs; 3030 pyrolyzer) is held at 320°C for 30 seconds; vapor is routed into the split/splitless inlet of the GC (300°C, 50:1 split). A DB5-MS column (30 m x 0.25 mm x 0.25 µm; He flow 1.0 L min^{-1}) is heated with the following temperature program: 35°C for 2 min; 60°C min^{-1} to 100°C; 8°C min^{-1} to 240°C; 3°C min^{-1} to 250°C; 20°C min^{-1} to 300°C for 10 min. AUX is held at 250°C, and the quadrupole MS scans from 12-600 amu.



Extracted ion thermograms showing the temperature at which different wood components off-gas. This shows why 320°C serves as an optimal desorption temperature for the extractives fraction, while also accessing lignin and hemicellulose. Lignin content and syringol:guaiacol proportions are valuable pieces of information for identifying hardwoods and softwoods, as well as distinguishing tree species from each other.

Data Processing





This total ion chromatogram of a *Diospyros celebica* sample shows the three chromatographic regions produced by this method: non-specific compounds, hemicellulose and lignin, and extractives. Libraries produced in Frontier Labs' software F Search have thus far been formatted to include hemicellulose/lignin + extractives, and extractives only profiles. Depending on the sample introduction split and timing, the extractives region peak intensity may be enhanced.

The F Search libraries are based on an "int-sum", which is a weighted average mass spectrum for the entire chromatogram. It was developed by Frontier Labs for the compositional analysis of polymer formulations. These int-sum mass spectra have been, for wood identification, created for standards targeting separately the hemicellulose/lignin + extractives region, and only the extractives region. The int-sum is sensitive to the impact of abundant compounds.

Swietenia spp. Standards

Samples of each *Swietenia* species were obtained from the University of Wisconsin – Madison Forest Products Lab, which holds an expansive xylarium. At this time, only a few representatives of each species were obtained, but there are plans to expand the sample set from this and other xylaria.

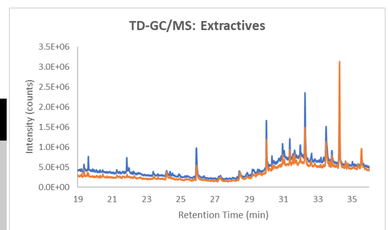
Standards from Forest Products Lab

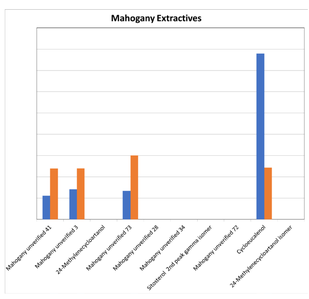
Swietenia species	# of samples	Country of Origin
S. macrophylla	10	Colombia, Guatemala, Belize, Malaysia, Mexico, Peru, Honduras, Costa Rica, Brazil, Nicaragua
S. mahogani	8	USA/Florida, Haiti
S. humilis	5	Unvouchered

Continuing Work

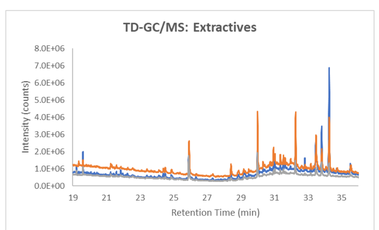
While not shown here, comparable testing of mahogany near-non-matches and look-alikes has been performed, and will continue to be expanded to establish the ability of the method to resolve mahogany species from other woods. Additional testing to expand the library to include additional vouchered samples of mahogany and other wood species will be done. Method development to enhance the detection of extractives will also be performed.

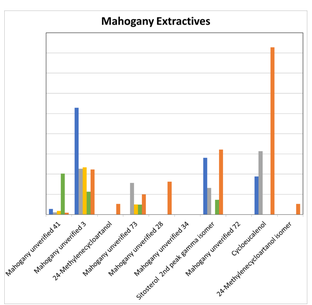
S. humilis



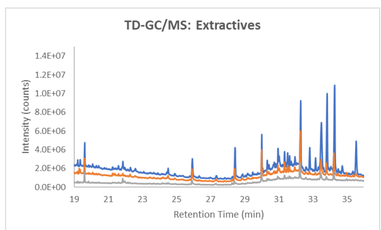


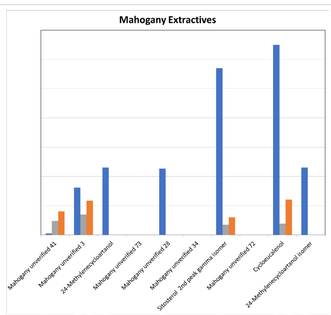
S. macrophylla





S. mahagoni





Example: Yale University Art Gallery Rhode Island Furniture Collection

High Chest, Yale University Art Gallery, Accession Number 1930.2310