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FT-MIR-ATR of Organic Residues From Inside Peruvian Sacrificial Jars

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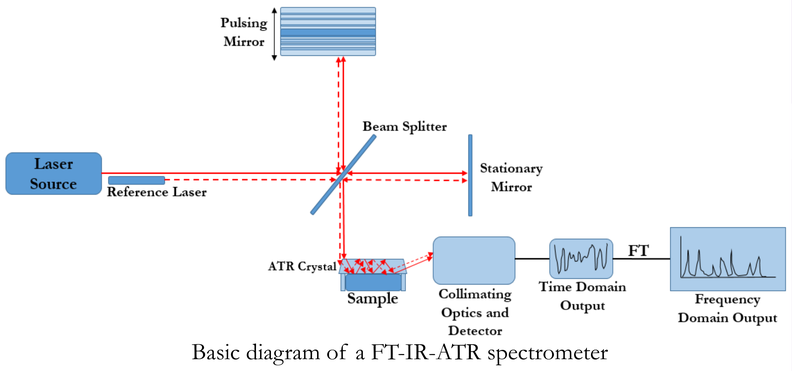
Introduction

- **Background:** Sacrificial jars from Lima and Juliaca, Peru, home of the Nazca culture[1].
  - Culture rich with agricultural, war, and rite of passage rituals
  - Often the hallucinogenic San Pedro cactus was consumed and "Trophy Heads" of enemies were made[2]
- **Previous Work:** Similar residue analysis using similar solvents as below but destructive techniques and a variety of instrumentation used[3-7]
- **Purpose:** Determine the identity of their original contents to give the UNI Museum insight into the original purpose of their artifacts

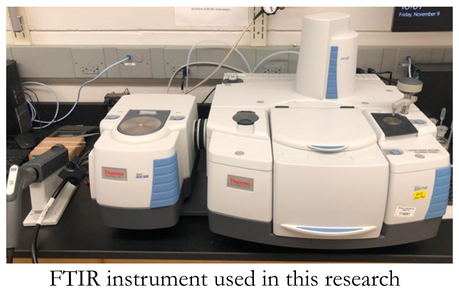
Ratio (V:V)	1:1	1:1
Solvents	Acetone : Methylene Chloride	Methanol : Methylene Chloride

Instrumentation

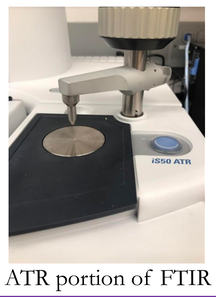
- Fourier Transform mid infrared attenuated total reflectance spectroscopy (FT-MIR-ATR).
- Three infrared regions, this work focused on mid (4000-400cm^{-1})
- Probes the bending and stretching of vibrational and rotational states unique to individual molecules
- The ATR method used to decrease sample prep and improve weak transitions of thin film residues.



Basic diagram of a FT-IR-ATR spectrometer



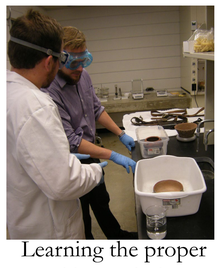
FTIR instrument used in this research



ATR portion of FTIR

Extraction Methods

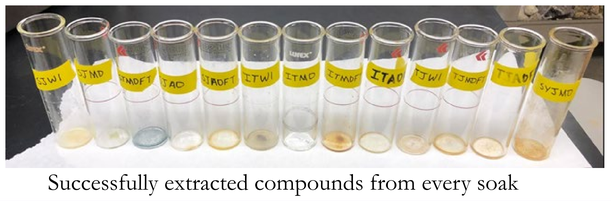
- All jars leaked because of condition and or low fire hardening method
- Water soaks removed original and contaminating salts
- MeOH:DCM soaks extracted the most compounds
- Acetone:DCM soaks extracted fewer compounds but different ones
- Tall Jar Acetone:DCM soak dissolved glue and PVC stability ring giving spectra characteristic of contaminating compound



Learning the proper soaking technique

First water soak

Jars containing water soak

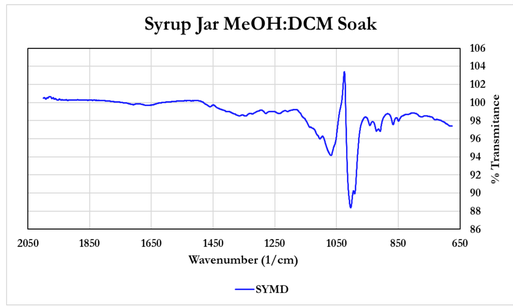


Successfully extracted compounds from every soak

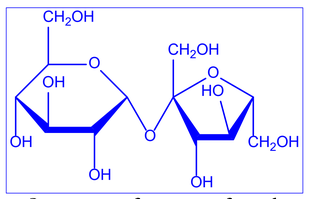
Proof of Concept Soaks

Proof of concept pot sherds

- Proof of concept soak on similar pottery used to boil maple syrup.
- Only the MeOH:DCM soak produced a usable residue
- IR spectrum characteristic of sucrose, a main ingredients in syrup



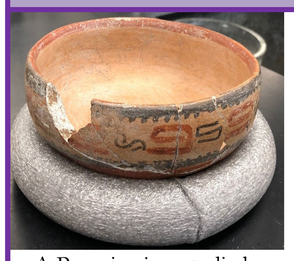
IR spectrum from the syrup jar soak in MeOH:DCM



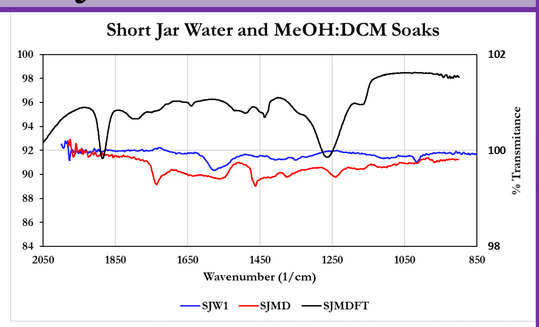
Structure of sucrose found in the syrup jar residue

- Proved solvents would extract compounds without damaging artifacts

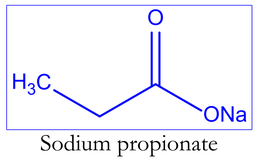
Short Jar Soaks



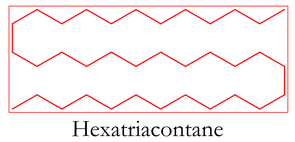
A Peruvian jars studied. Referred to as short jar



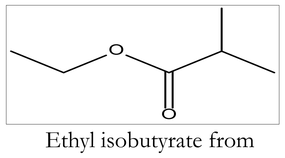
IR spectrum of water soak in blue. MeOH:DCM soak "in jar" in red and "flow through" in black



Sodium propionate from water extract

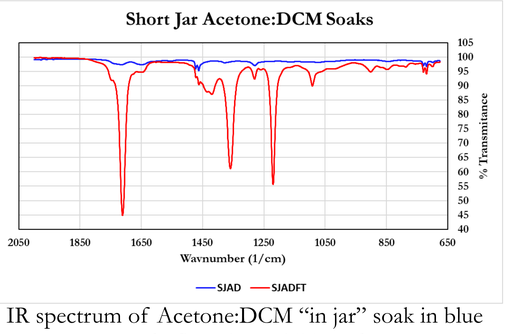


Hexatriacontane from "in jar" extract

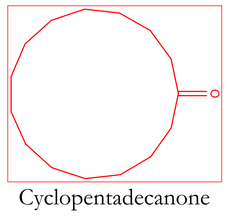


Ethyl isobutyrate from "flow through" extract

- These molecules are a plant and animal metabolite, a wax found on many plants, and a metabolite found in alcohol and fruits respectively



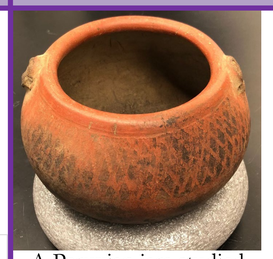
IR spectrum of Acetone:DCM "in jar" soak in blue and "flow through" in red



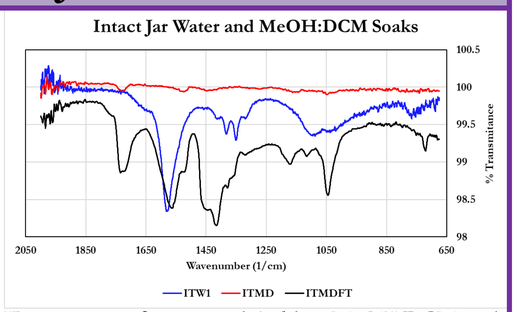
Cyclopentadecanone from "flow through" soak

- The "in jar" soak spectrum characteristic of natural wax from Brazilian palm oil, a combination of fatty acids from the plant
- The "flow through" spectrum characteristic of molecule producing a musky smell in the glands of certain animals

Intact Jar Soaks

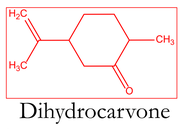


A Peruvian jars studied. Referred to as intact jar

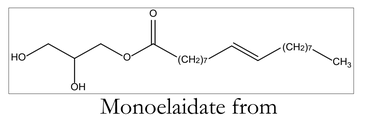


IR spectrum of water soak in blue. MeOH:DCM soak "in jar" in red and "flow through" in black

Water soak only contained modern, contaminants

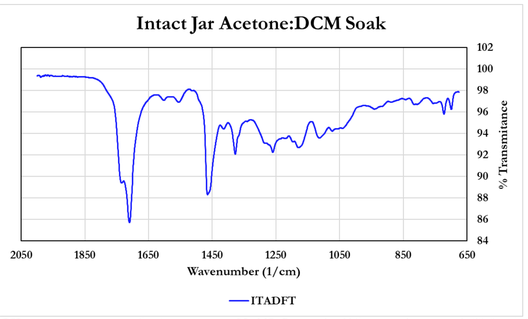


Dihydrocarvone from "in jar" extract

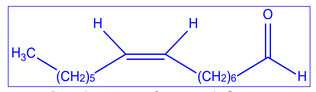


Monoelaidate from "flow through" extract

- Molecules are plant metabolite and is a glycerol/acyl glycerol respectively



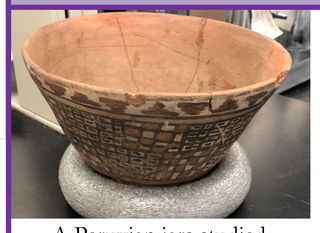
IR spectrum of Acetone:DCM soak "flow through" in blue



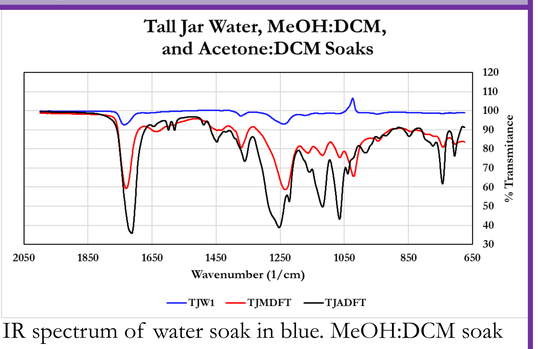
Cis-9-Hexadecenal from "flow through" residue

- This molecule is a human metabolic intermediate of glycosphingolipids

Tall Jar Soaks



A Peruvian jars studied. Referred to as tall jar



IR spectrum of water soak in blue. MeOH:DCM soak "flow through" in red. Acetone:DCM soak "flow through" in black

- All soaks produced modern, contaminating compounds only

Acknowledgements

- Dr. Joshua Sebree
- Nathan Arndt
- University of Northern Iowa Museum
- University of Northern Iowa Department of Chemistry and Biochemistry

References

(1)Donnan, C. B. In The Northern dynasties: kingship and statecraft in Chimor: a symposium at Dumbarton Oaks, 12-13 October 1985; HRAF: New Haven, CT, 1990; pp 243–274.

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(7)Gregg, M. W.; Slater, G. F. *Archaeometry* **2009**, *52*(5), 833–854.