

# Solid-State NMR Investigation into the Violins of Stradivari & Guarneri

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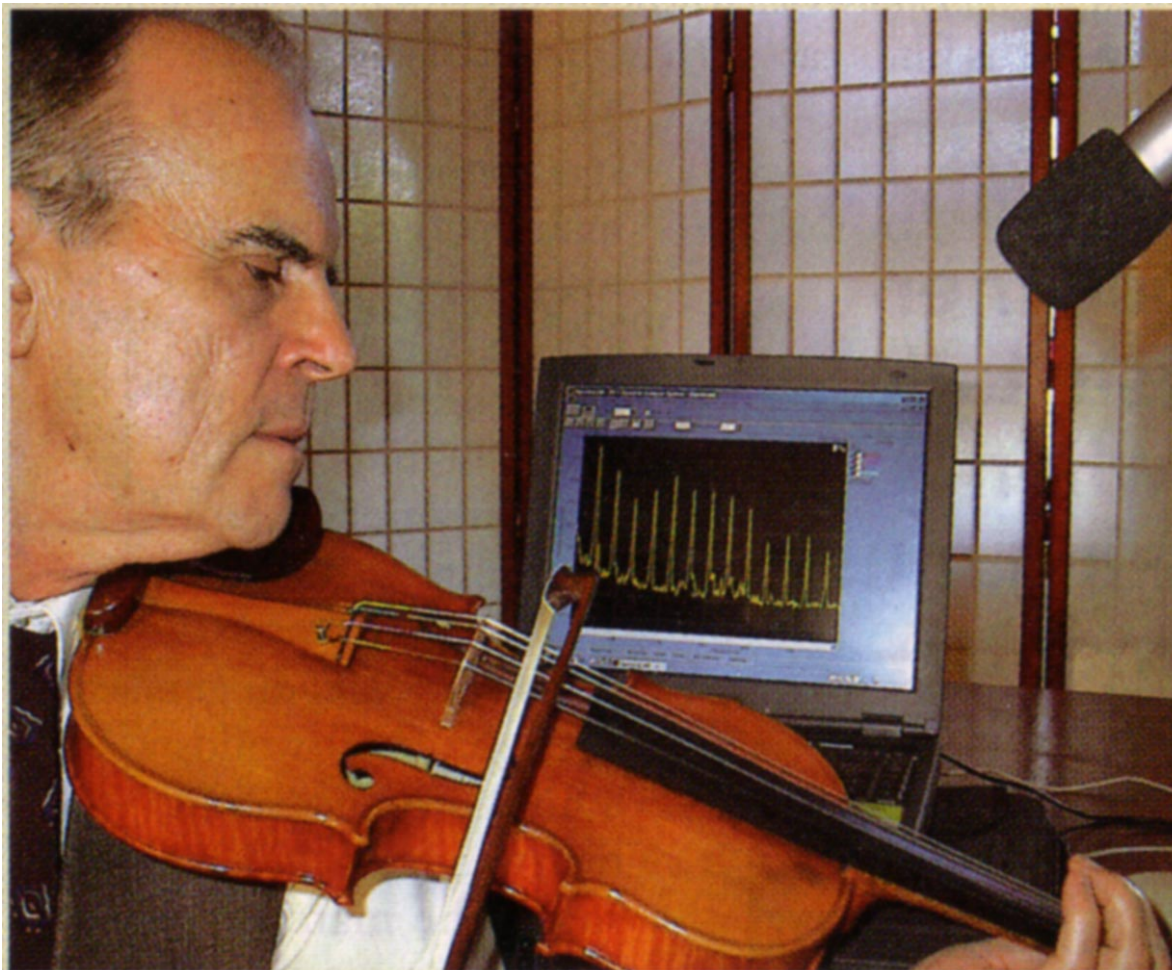
## Background & Goals:

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- A Project of Opportunity
- Approached by Joseph Nagyvary
  - Emeritus of Texas A&M - Biochemistry & Biophysics
- Violinist & Private Luthier
  - Nagyvary Violins Company
  - Interested in Making Great Violins
    - A Very Complicated Materials & Engineering Project
    - Desired to Learn About Materials & Materials Treatments Used by Old Masters
    - Already Using Anecdotal Information & Modern Techniques
      - Craftsmanship, Playing, & Audio Analysis
    - Already Making Good Violins
      - Publicized Recital with Expert & Lay Audience
        - Could Not Identify Stradivarius and Nagyvarius in Blind Cross-Comparison

# The Maestro – Joseph Nagyvary

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## Tough Problem:

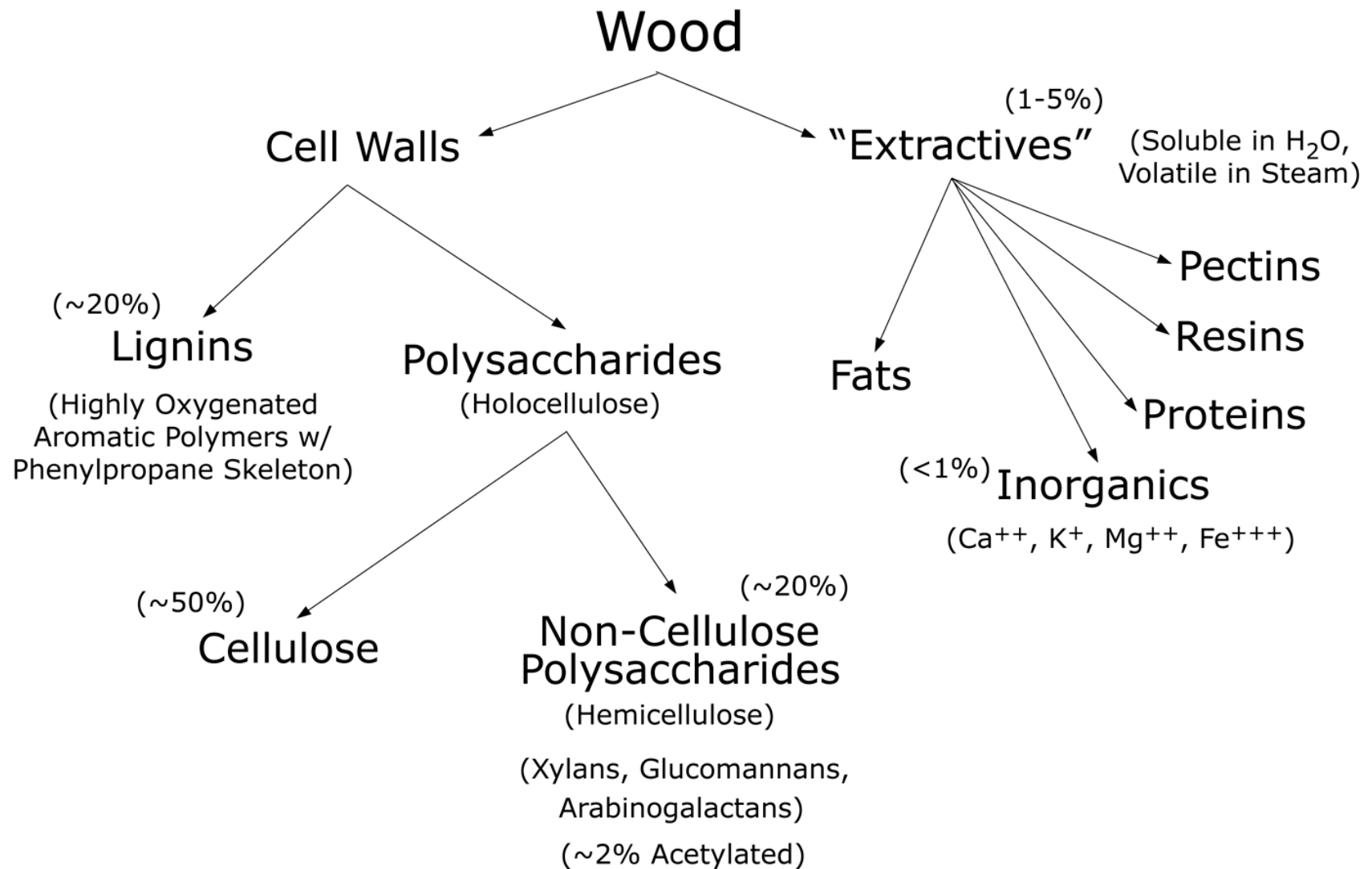
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- Geometric Design Considerations
- Multi-Layered, Multi-Component Materials
  - Agricultural in Origin
- Raw Material Treatments
- Post-Assembly Treatments
- Less-Than-Tangible & Intangible Listening Qualities
  
- Design Informed by Analysis of Old Masterworks
  - Examination of Certain Critical Raw (?) Materials
  - Examination Using Non-Destructive Techniques
  - Wade Through the Misinformation



# Complex Raw Material

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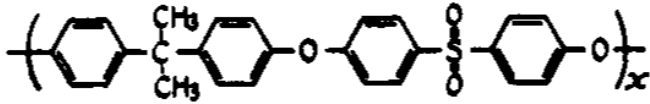
## The Sample – 117 mg of Stradavarius Wood

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# Solid-State NMR Methodology

polysulfone



wood (ebony)

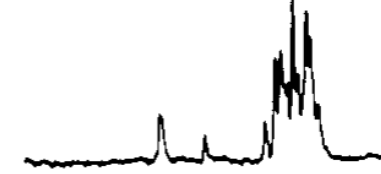
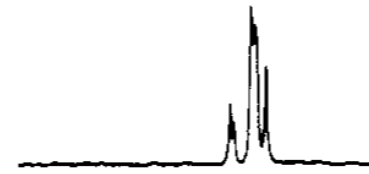
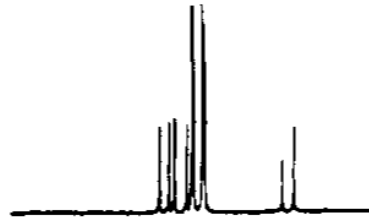
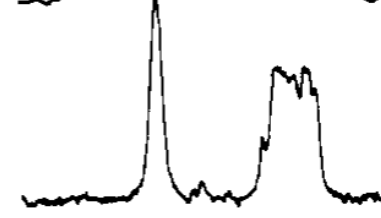
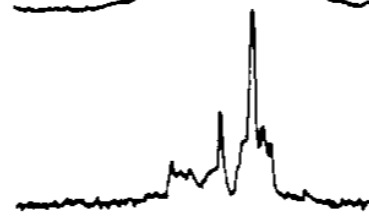
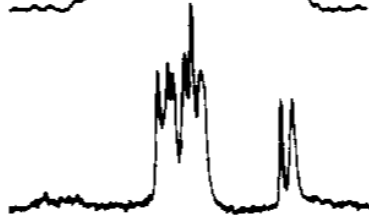
collagen (ivory)

100 ppm

CP of solid



with spinning



FT (polysulfone in solution)

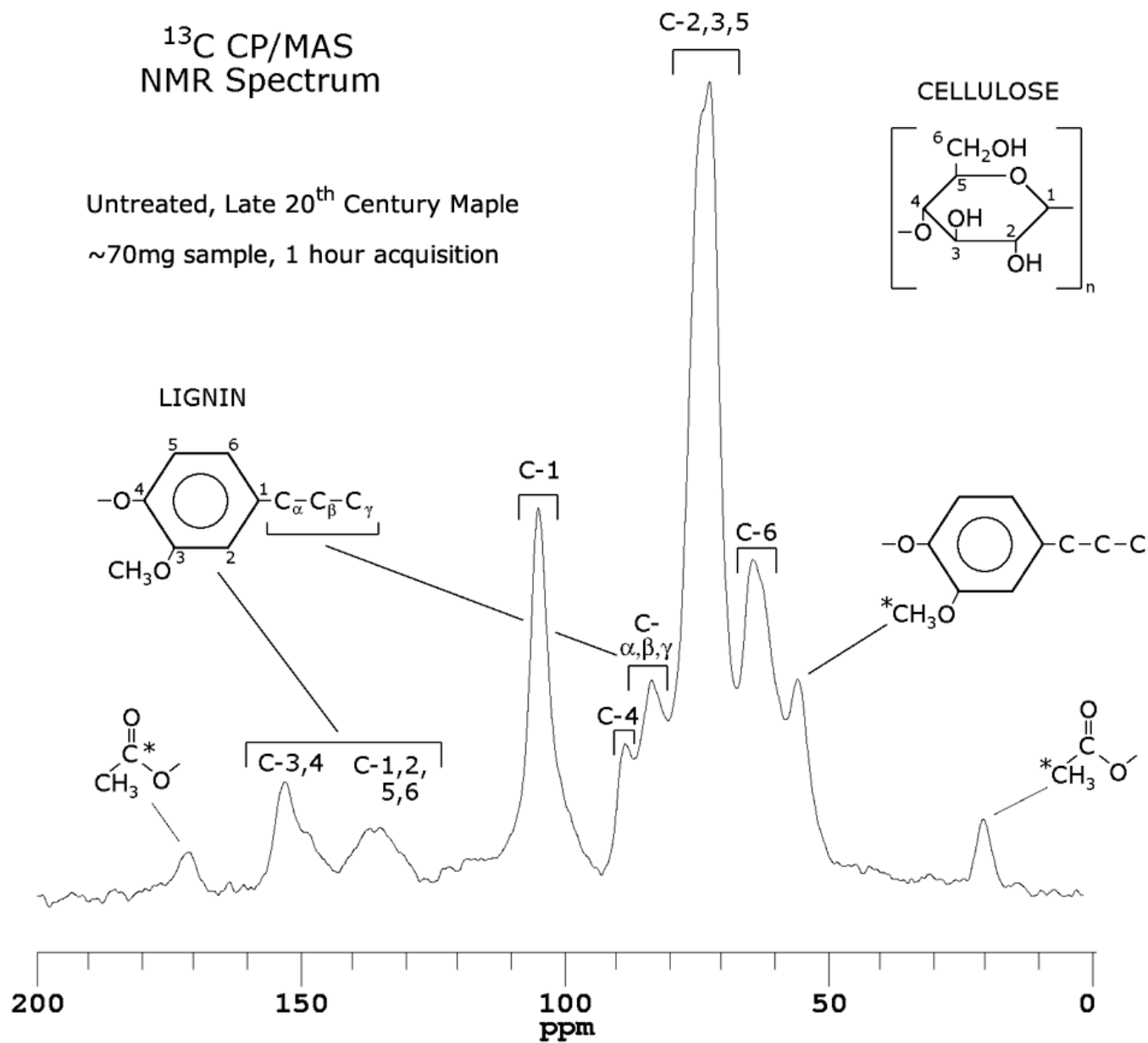
FT (glucose in solution)

FT (denatured rat-skin collagen gel)



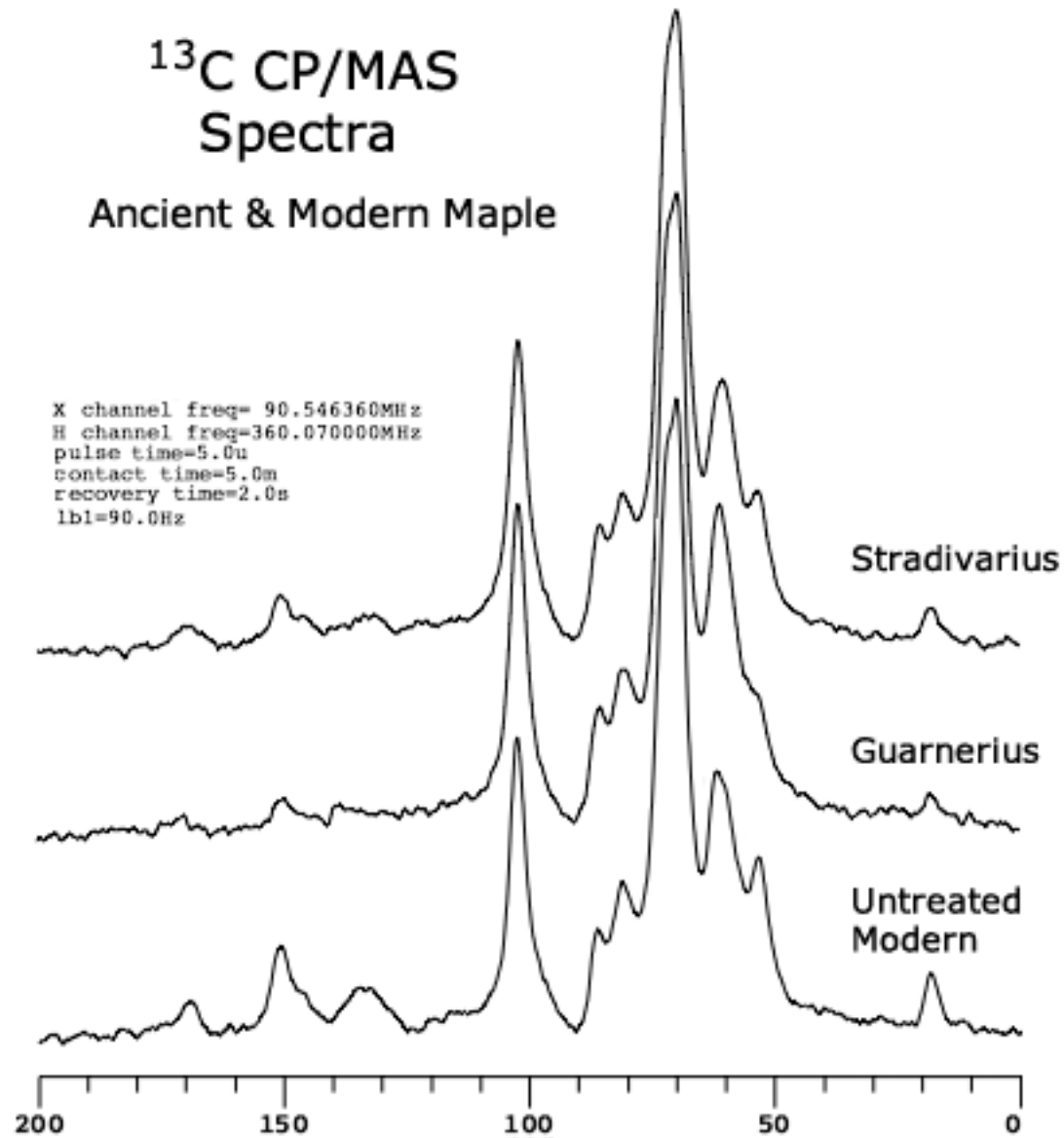
# $^{13}\text{C}$ CP/MAS NMR Spectrum

Untreated, Late 20<sup>th</sup> Century Maple  
~70mg sample, 1 hour acquisition

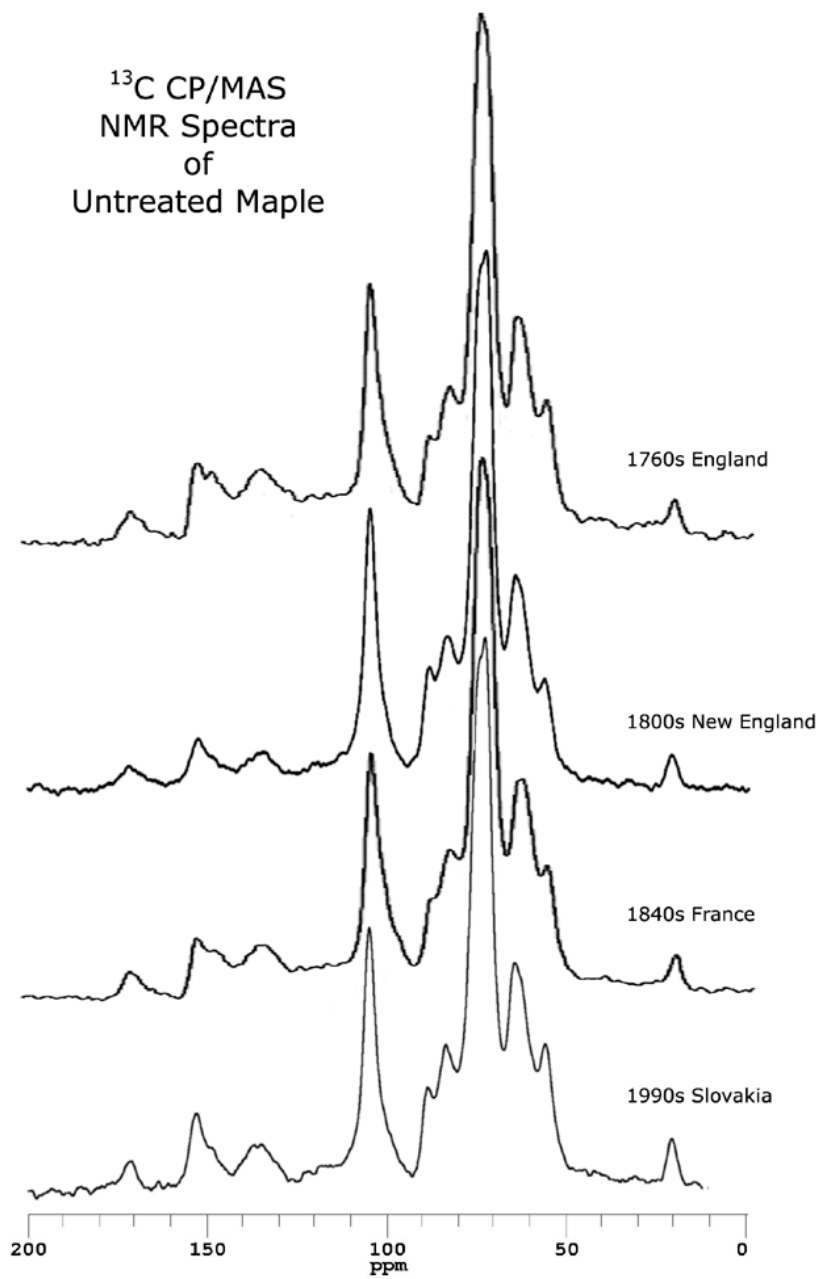


# $^{13}\text{C}$ CP/MAS Spectra

## Ancient & Modern Maple

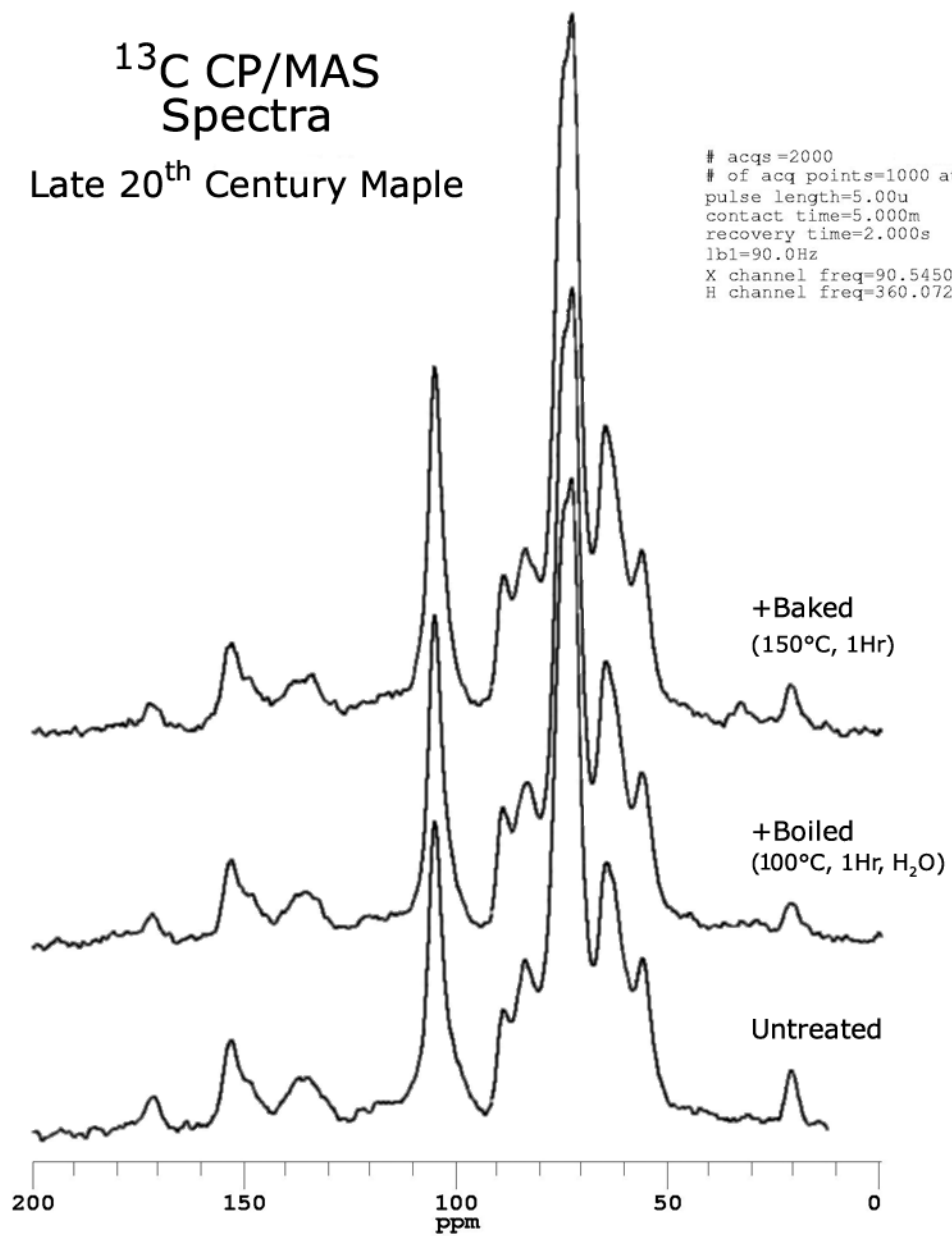


$^{13}\text{C}$  CP/MAS  
NMR Spectra  
of  
Untreated Maple

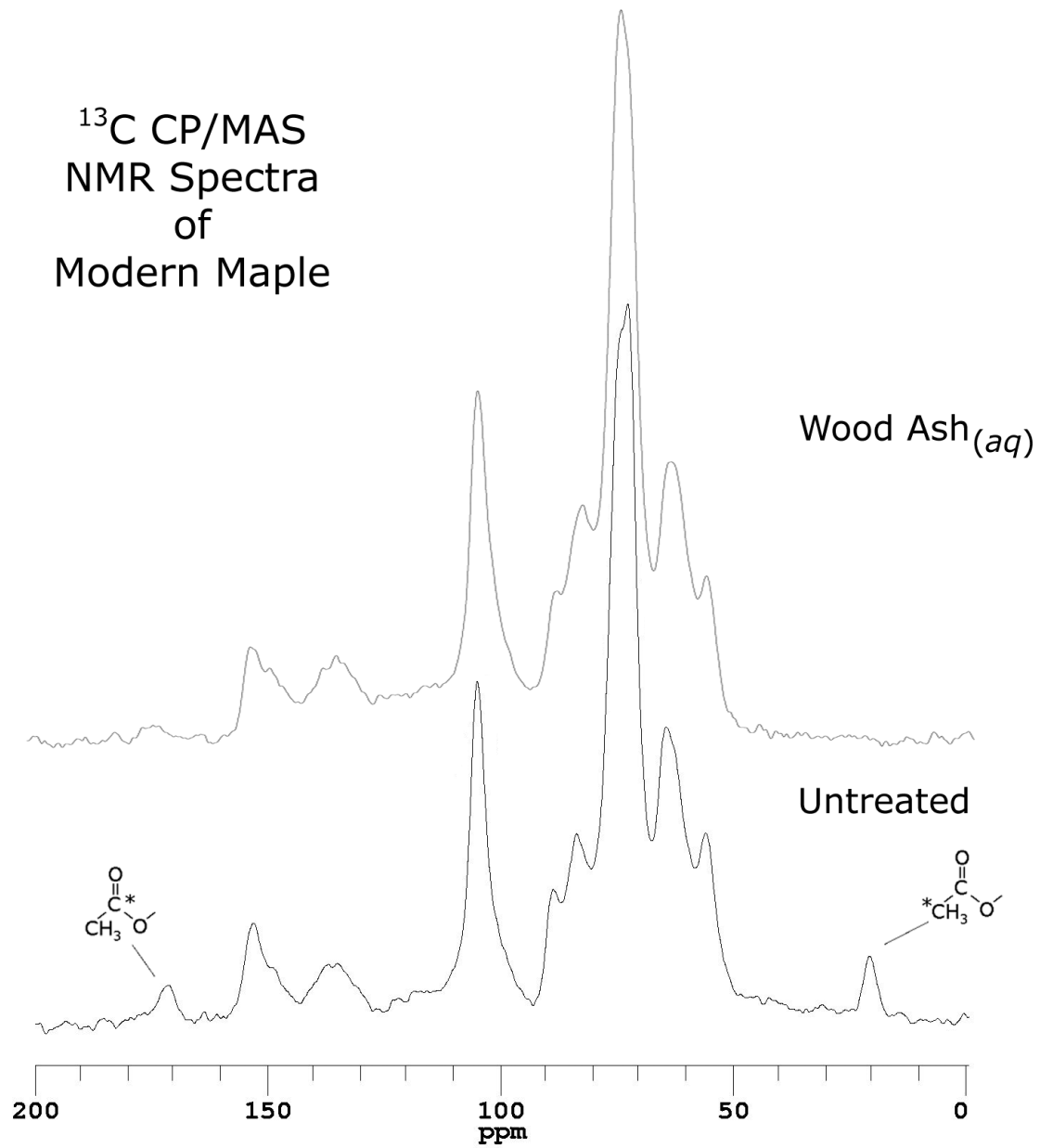


$^{13}\text{C}$  CP/MAS  
Spectra  
Late 20<sup>th</sup> Century Maple

# acqs=2000  
# of acq points=1000 at 6.9kHz  
pulse length=5.00u  
contact time=5.000m  
recovery time=2.000s  
lb1=90.0Hz  
X channel freq=90.545000MHz  
H channel freq=360.072200MHz



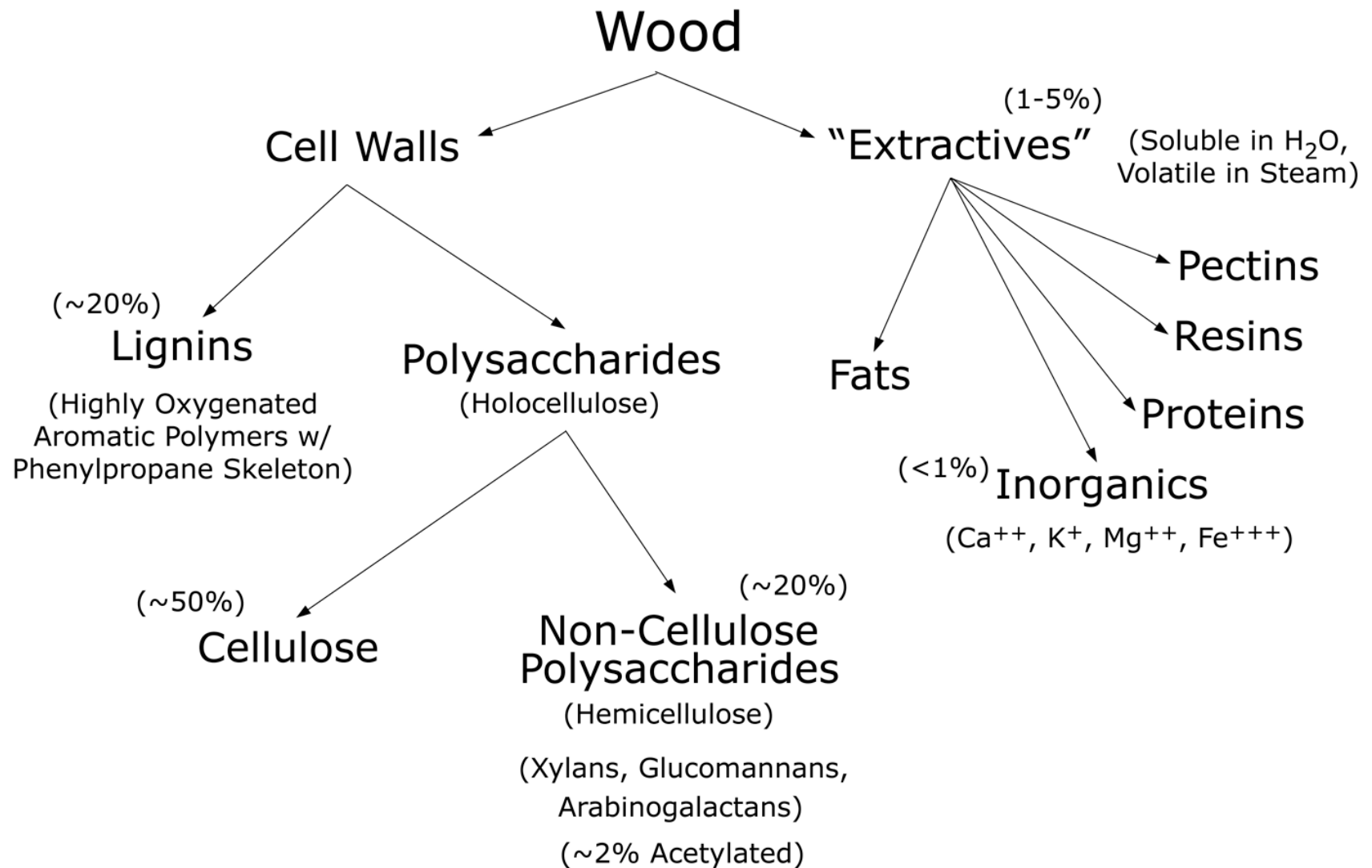
$^{13}\text{C}$  CP/MAS  
NMR Spectra  
of  
Modern Maple





# Complex Raw Material

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# Acknowledgements:

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Support from the Gary E. Maciel NMR Laboratory at CSU



David Lewis - Revolution NMR, LLC

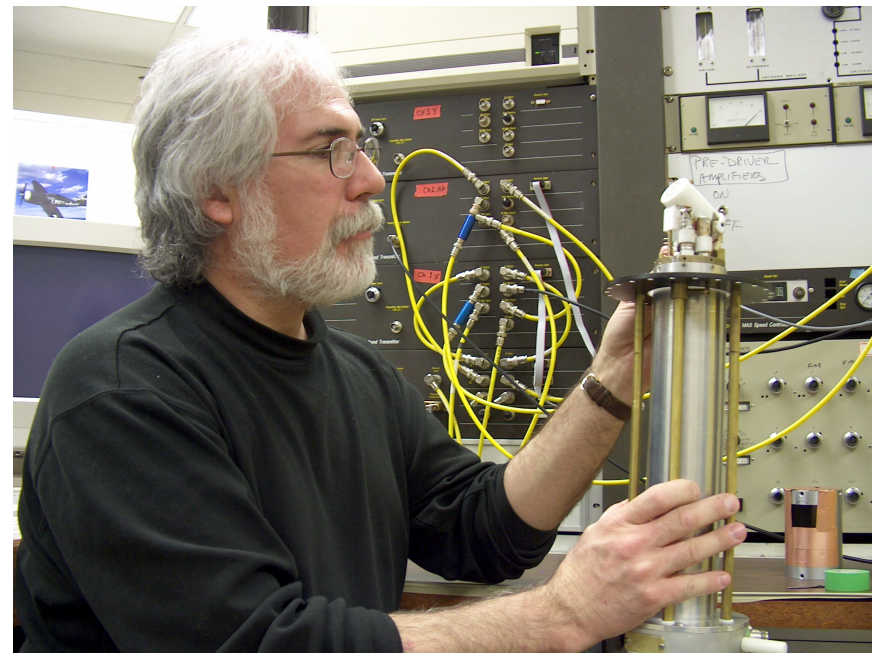
Joseph Nagyvary - The "Nagyvarius" Violin

# Coincidence?

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Giuseppe Verdi (1813-1901)



Joseph DiVerdi (1953-)