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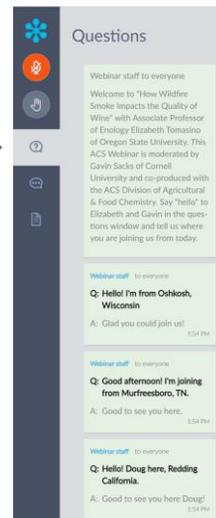
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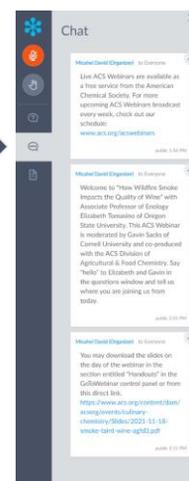
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Announcements and hyperlinks from our team



2

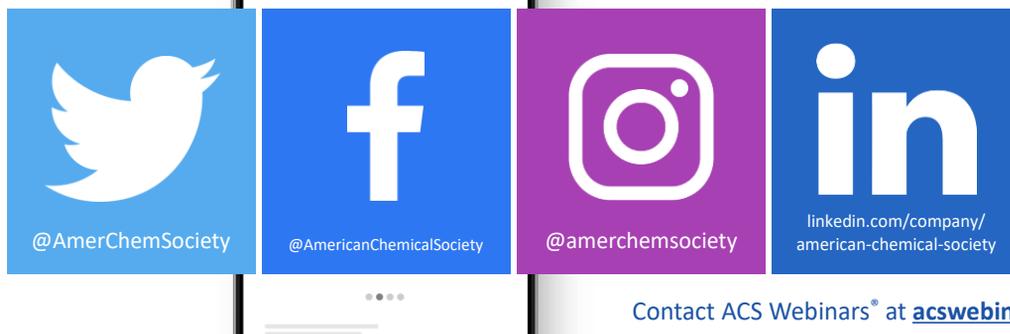


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Career Consultant Directory



- ACS Member-exclusive program that allows you to arrange a one-on-one appointment with a certified ACS Career Consultant.
- Consultants provide personalized career advice to ACS Members.
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www.acs.org/careerconsulting

6

ACS Career Resources



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ACS Scholar Adunoluwa Obisesan

BS, Massachusetts Institute of Technology, June 2021
(Chemical-biological Engineering, Computer Science & Molecular Biology)

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**Adapted from definitions from the Ford Foundation Center for Social Justice:

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Seeks to ensure fair treatment, equality of opportunity, and fairness in access to information and resources for all. We believe this is only possible in an environment built on respect and dignity. Equity requires the identification and elimination of barriers that have prevented the full participation of some groups.

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Inclusion**

Builds a culture of belonging by actively inviting the contribution and participation of all people. Every person's voice adds value, and ACS strives to create balance in the face of power differences. In addition, no one person can or should be called upon to represent an entire community.

Respect

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December 6, 2022



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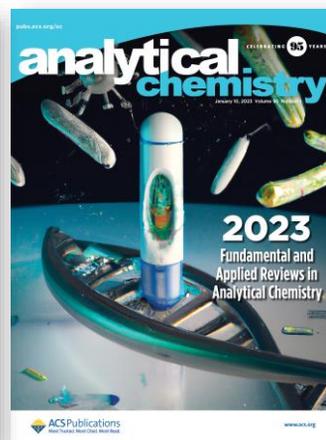
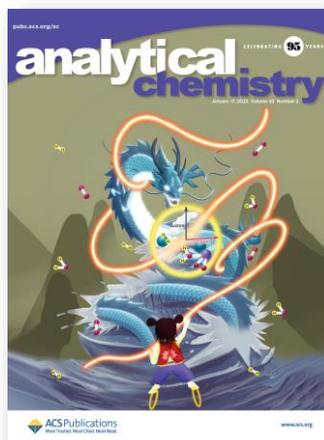
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Shining a Nanofocused Light on the Hidden Secrets of Stradivari's Violins



CHIARAMARIA STANI, PhD

CERIC-ERIC Scientist, Elettra Sincrotrone
Trieste



GIACOMO FIOCCO, PhD

Postdoctoral Researcher, Arvedi Laboratory
of Non-Invasive Diagnostics, University of
Pavia



JONATHAN SWEEDLER, PhD

Editor-in-Chief, *Analytical Chemistry* and James R. Eiszner
Family Endowed Chair and Professor in Chemistry,
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Wednesday, January 18th, 2023 | 2pm – 3pm ET

Shining a Nanofocused Light on the Hidden Secrets of Stradivari's Violins

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Laboratorio
Arvedi di
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UNIVERSITÀ
DI TORINO



Cremona and the violin tradition



The building and the "treasure room" of the Museo del Violino in Cremona

The Santa Maria Assunta cathedral and the "Torrazzo" of Cremona

Stradivari and the historical Cremonese violin making

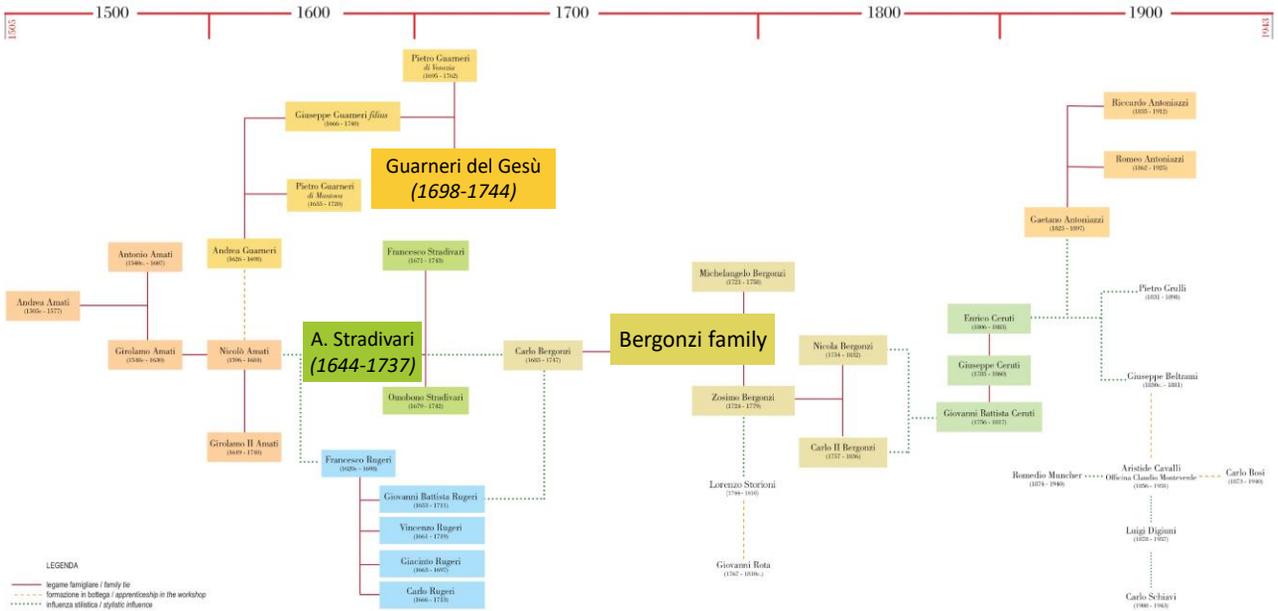
19th century portrait of Antonio Stradivari



The workshop of Antonio Stradivari
Alessandro Rinaldi, 1886



Lutherie workshop



[Cacciatori et al., 2018, La Materia e il Suono]

Scientific research and violins

Nagyvary, 1988

Von Bohlen et al, 1997

Bertrand et al, 2011

Cai and Tai, 2020

Barlow, 1988

Echard, 2004

Invernizzi et al, 2016

The multi-layered coating system

Bracco 1793 small violin, Storioni

Provigny 1716 violin, Stradivari

1790 small violin, Storioni

[Fiocco et al, 2019, Coatings]

[Echard et al, 2010, Angew. Chem.]

[Albano et al, 2021, Eur. Phys. J. Plus.]

[Cai and Tai, 2020]

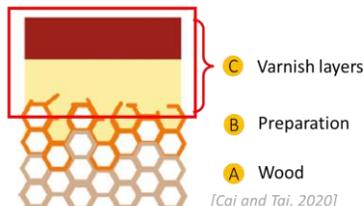


Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

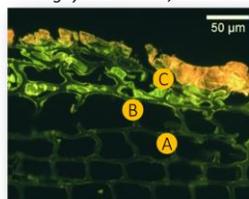
What is the composition of the Stradivari varnish?

- Spirit varnish
- Shellac
- Glue
- Oil-resin mixture
- Wax



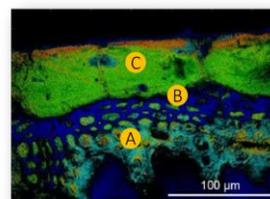
[Cai and Tai, 2020]

Provigny 1716 violin, Stradivari



[Echard et al, 2010, Angew. Chem.]

1790 small violin, Storioni



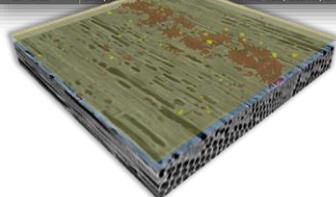
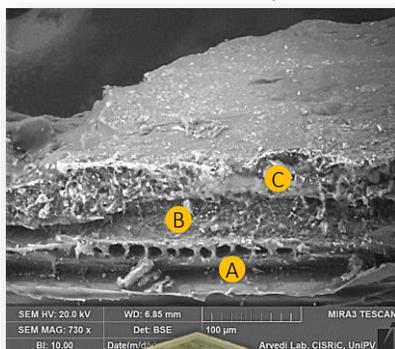
[Albano et al, 2021, Eur. Phys. J. Plus.]

* If your answer differs greatly from the choices above tell us in the questions window!

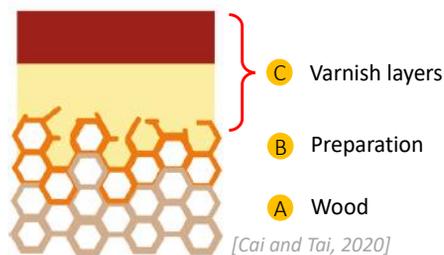
27

The multi-layered coating system

Bracco 1793 small violin, Storioni

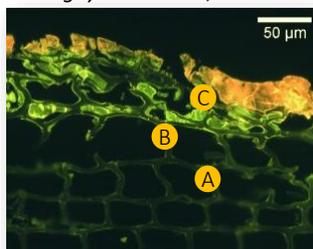


[Fiocco et al, 2019, Coatings]



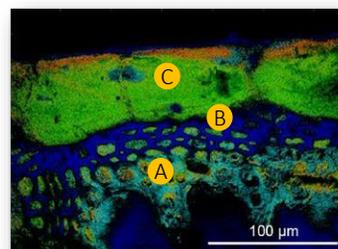
[Cai and Tai, 2020]

Provigny 1716 violin, Stradivari



[Echard et al, 2010, Angew. Chem.]

1790 small violin, Storioni



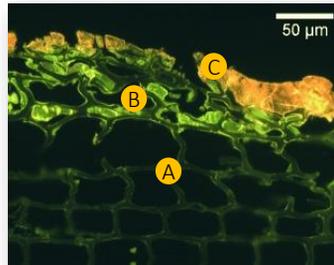
[Albano et al, 2021, Eur. Phys. J. Plus.]

Is there a preparation under the varnish?

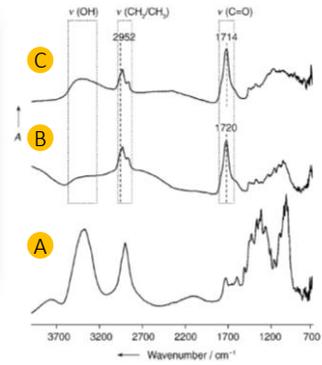


Photo by Jan Röhmann

Provigny 1716 violin, Stradivari



(A) Spruce wood substrate
(B) Ground coat
(C) Varnish



[Echard et al, 2010, Angew. Chem. Int. Ed.]

Is there a preparation under the varnish?

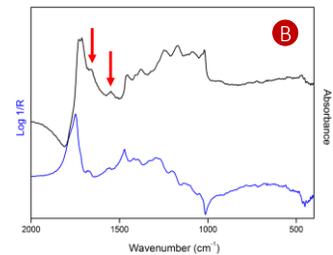
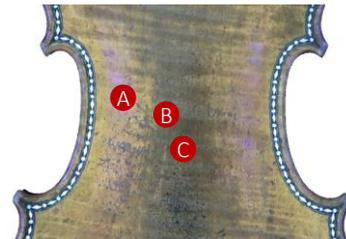
The Arvedi Lab of the University of Pavia



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Hellier 1679 violin, Stradivari

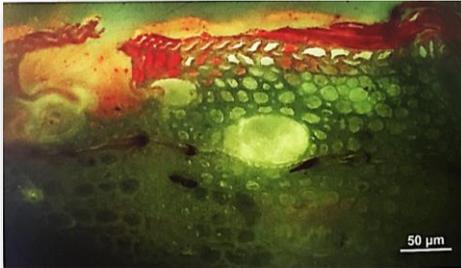


Proteinaceous material
 1660 cm^{-1} $\nu\text{C=O}$ (Amide I)
 1550 cm^{-1} νCN and δNH (Amide II)

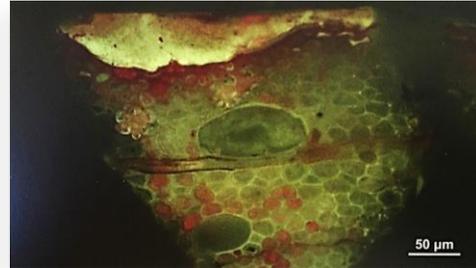
[Invernizzi et al, 2016, Microchem. J.]

Is there a preparation under the varnish?

1730 violin, Stradivari



1730 violin, Stradivari



[Brandmair and Grainer, 2010, Stradivari Varnish]

Stradivari's case studies

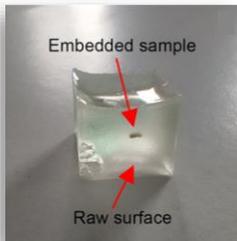
Toscano 1690 violin, Stradivari



San Lorenzo 1718 violin, Stradivari



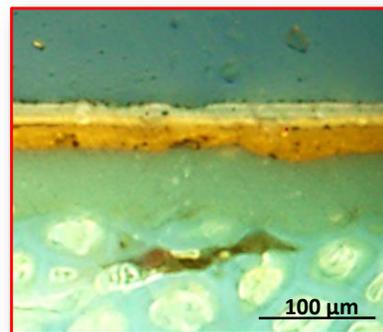
How to prepare the samples



- Detaching the fragments from the front plate
- Embedding the samples in cubes of epoxy resin (1x1x1 cm)
- Cutting away the excess of epoxy resin
- Polishing the resin cube until a complete exposure of the sample surfaces on the transversal side
- Observing the sample stratigraphy by VIS-UV microscope

Cello, Ruggeri "Il Per"

An ideal case



Epoxy resin
Restoration
Varnish layer
Preparation
layer
Wood

[Fiocco et al., 2017, Applied Spectroscopy]



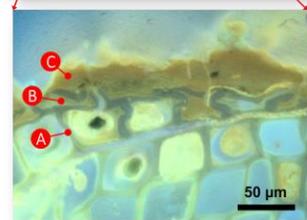
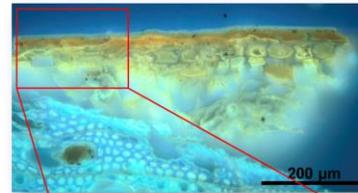
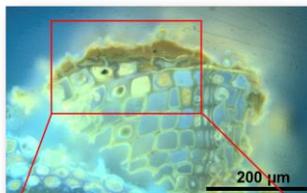
Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

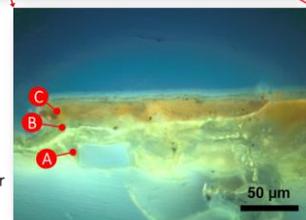
What do you think these wood cells are?

- A further wood type used by Stradivari for building the violin
- A contamination occurred during the sample preparation
- A piece of toothpick
- A degraded part of the original wood
- An old restauration work

Toscana 1690



C Varnish
B Preparation layer
A Wood



* If your answer differs greatly from the choices above tell us in the questions window!

FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

ELETTRA Synchrotrone Trieste

CERIC Research Infrastructure Consortium

SISSI

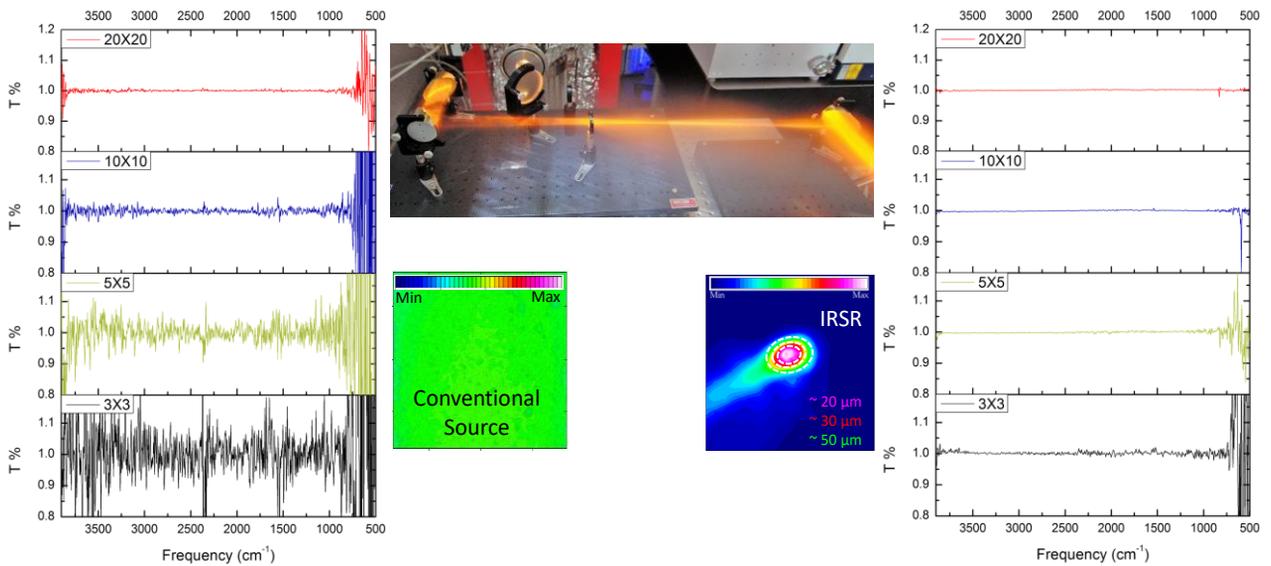
Synchrotron Infrared Source for Spectroscopy and Imaging

Credit @ CERIC

SISSI-Bio branch

FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

S/N ratio at SISSI for diverse knife-edge aperture settings (lateral resolution)



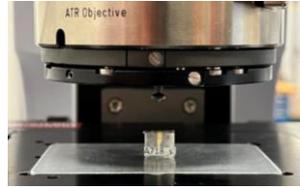
Diffraction Limited FTIR Microscopy is practically achievable only with IRSR

FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

The measurement approach



Transmission mode



Credit @CERIC



μ -ATR mode

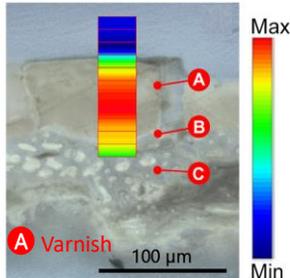


Reflection mode

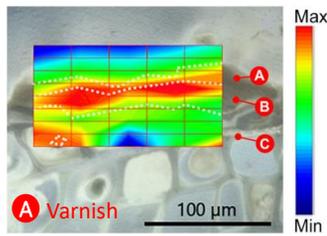
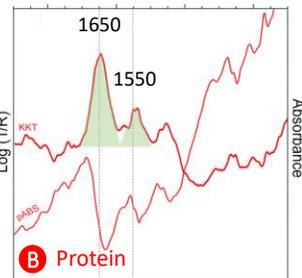
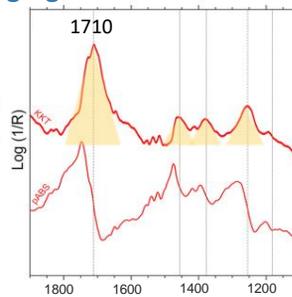
FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

Non-damaging reflection measurements

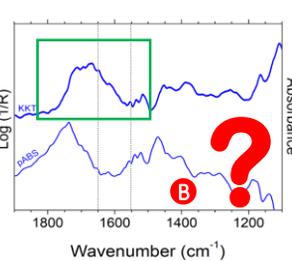
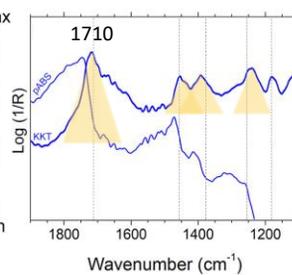
False-color maps obtained by integrating the ν C=O at 1710 cm^{-1}



Bracco, 1793 small violin, Storioni



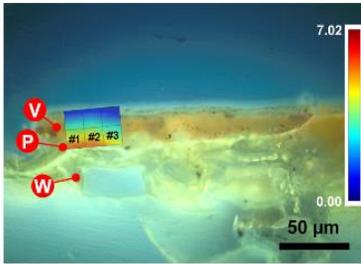
Toscano 1690, Stradivari



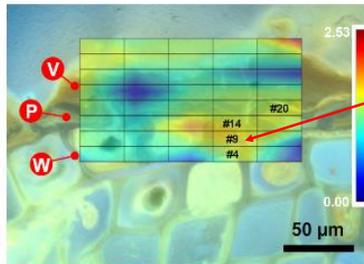
[Fiocco et al., 2021, Spectrochimica Acta]

FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

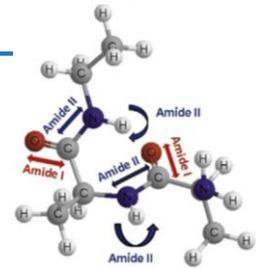
San Lorenzo 1718



Toscana 1690



Proteins ?

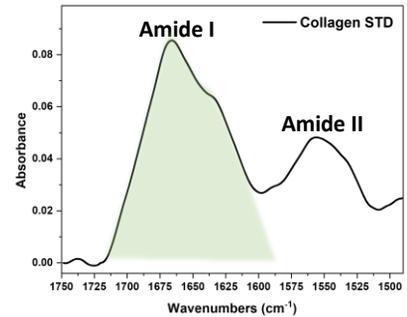


Amide I $\rightarrow \nu\text{C=O}$ at 1660 cm^{-1}

Amide II $\rightarrow \nu\text{CN}$ and δNH at 1550 cm^{-1}

Color-scale maps obtained by integrating the spectral range $1700 - 1610\text{ cm}^{-1}$

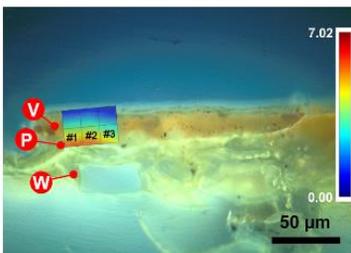
Possible distribution of proteinaceous material at the ground level, deeply penetrated into the first row of wood cells.



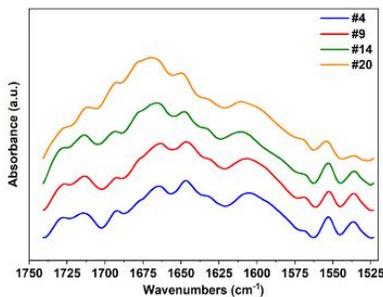
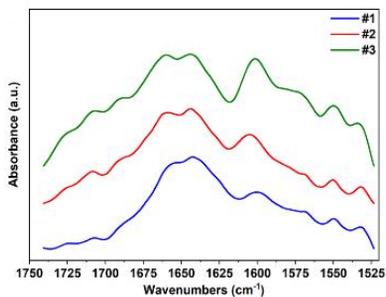
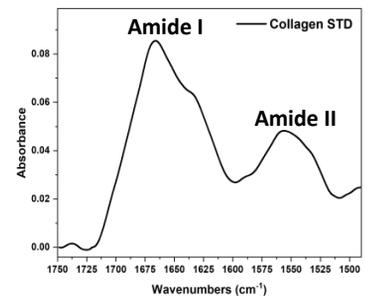
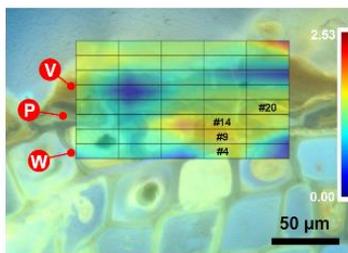
[Stani et al., 2022, Analytical Chemistry]

FTIR microscopy with IR Synchrotron Radiation at SISSI-Bio

San Lorenzo 1718



Toscana 1690



- The spectra collected at the interface between the varnish and the wood show deviations from the typical shapes and proportions of Amide bands
- The “undulated profile” could be due to a no-ideal behaviour of the surfaces and/or to an intrinsic chemical complexity of the samples

[Stani et al., 2022, Analytical Chemistry]



Audience Survey Question

ANSWER THE QUESTION ON THE INTERACTIVE SCREEN IN ONE MOMENT

How familiar are you with the IR s-SNOM technique?

- Today is the first time I heard of it
- I am familiar with it
- I have read a fair amount about it
- I have used it before when conducting research

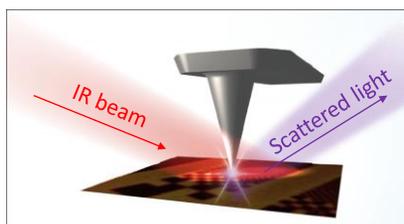
* If your answer differs greatly from the choices above **tell us in the questions window!**

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IR s-SNOM

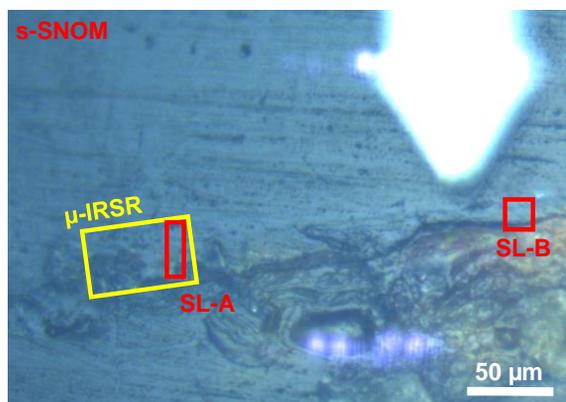
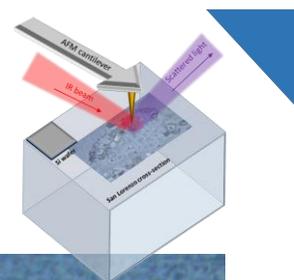
IR scattering-type Scanning Near Field Optical Microscopy

IR nano-spectroscopy at SISSI-Bio

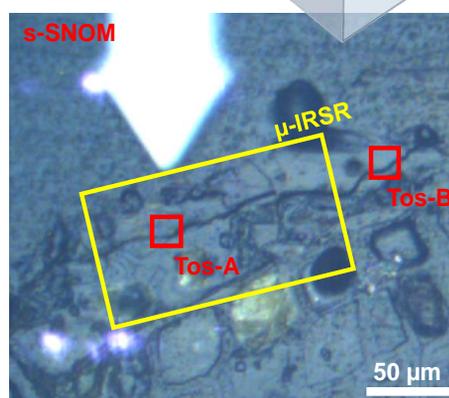


IR nano-spectroscopy at SISSI-Bio

Optical images collected with the optical microscope integrated in the s-SNOM system



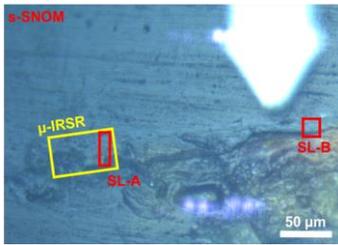
San Lorenzo 1718



Toscano 1690

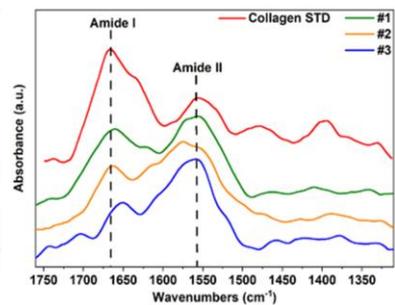
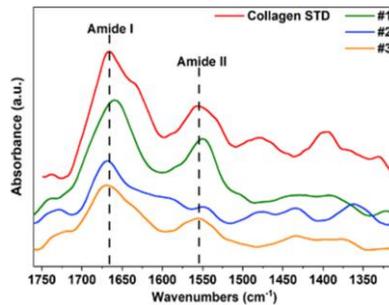
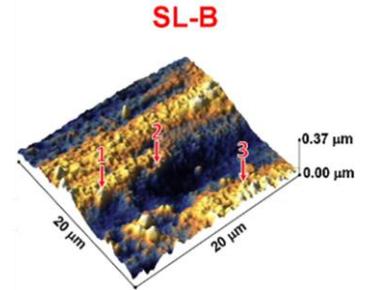
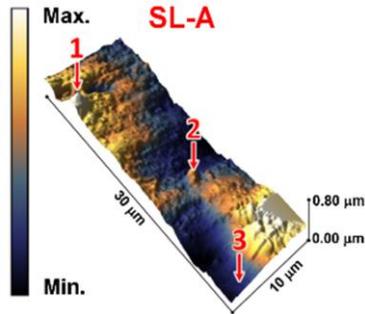
[Stani et al., 2022, Analytical Chemistry]

s-SNOM results



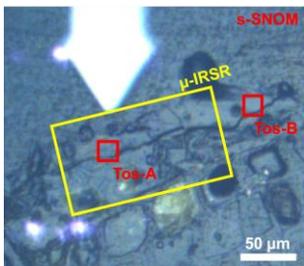
San Lorenzo 1718

- Wavy-like surfaces at the micrometric scale with an average roughness of 3 nm
- Clear Amide I and II features
- Inversion of the Amide I/Amide II ratio → due to light polarization



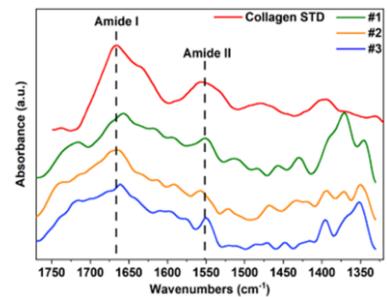
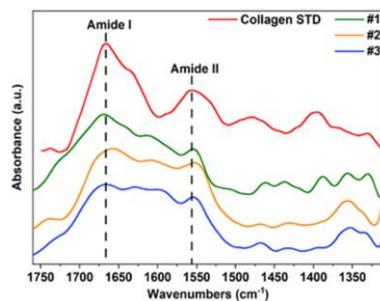
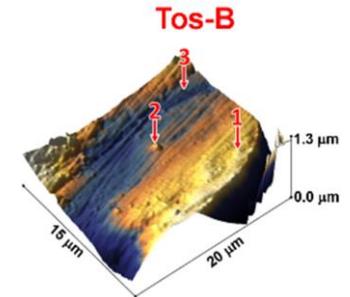
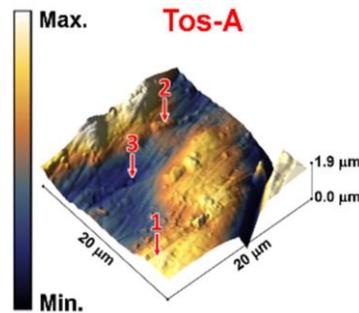
[Stani et al., 2022, Analytical Chemistry]

s-SNOM results



Toscano 1690

- Wavy-like surfaces at the micrometric scale with an average roughness of 3 nm
- Amide features are distinguishable but not isolated
- Additional spectral contribution by diverse sources



[Stani et al., 2022, Analytical Chemistry]

Conclusions

The combination of SR-FTIR Microscopy and FTIR Nano-spectroscopy was fundamental for studying these complex and precious samples



SR FTIR microscopy provides an effective view of the sample surface and guides the selection of the ROIs for the nanoscale analysis



IR nano-spectroscopy punctual analyses clearly highlights the spreading of a thin proteinaceous layer between the wood and the varnish in both the violins

The application of an analytical approach maximizing the level of attainable details, by enhancing the spatial resolution and surface sensitivity has been essential for dissecting the morpho-chemical complexity characterizing our samples

New scenarios for the application of this technique in the field of Cultural Heritage.



Dr. Giovanni Birarda



Dr. Lisa Vaccari



Prof. Marco Malagodi



Laboratorio
Arvedi di
Diagnostica
non Invasiva



Dr. Claudia Invernizzi



Prof. Monica Gulmini



Dr. Patrizia Davit

**Thank you for
your kind attention!**

CERIC

Central European
Research Infrastructure
Consortium



Dr. Chiaramaria Stani



Dr. Giacomo Fiocco



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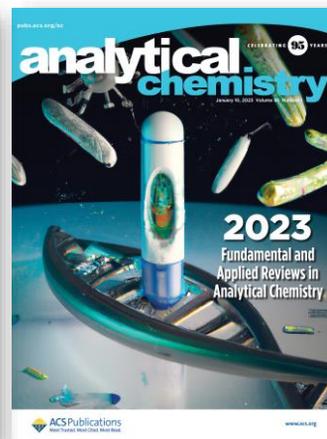
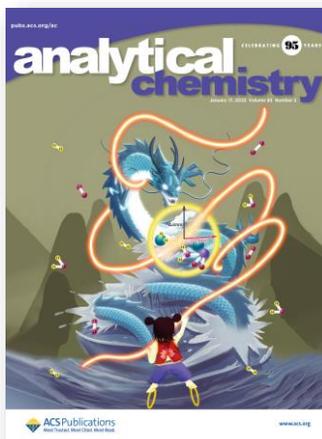
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