PhD course "Focal Plane Array (FPA) Imaging FTIR: principles and applications"

Syllabus

1) Name and surname: Dr. David Chelazzi

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DC discussed his "Laurea" Thesis (equivalent to Master Degree) in Chemistry in 2003, at the University of Florence (Italy) with an evaluation of 110/110 "cum laude". The work was developed in the European Laboratory for Nonlinear Spectroscopy (L.E.N.S.), in Florence. He then won a national scholarship for a PhD thesis on Science for Cultural Heritage Conservation, at the University of Florence. The PhD scholarship was developed at the University of Florence, Department of Chemistry and C.S.G.I (Consorzio Interuniversitario per lo Sviluppo dei Sistemi a Grande Interfase), and lasted for three years, ending in 2007 with a final exam, which was successfully passed with a dissertation titled "Development of chemico-physical methodologies for the conservation of paper and wood artworks". The activities included: A) Synthesis and applications of alkaline nanoparticles, gels, micellar solutions and microemulsions for the consolidation, cleaning and preservation of artworks (mainly paper, wood, canvas and painted surfaces). B) Characterization of chemical compounds and artworks materials by FT-IR, XRD, SEM/EDS, thermal analysis (DTG, DSC), SAXS and viscosity measurements (DP determination). C) *In situ* conservation and preservation activities, and collaboration with restorers.

Post-doc experience included an 11 months scholarship (2007) entitled "Characterization of the physico-chemical reactions occurring inside films of paste glue, acrylics or vinyls. Representativeness of accelerated aging", developed at the Centre de Restauration des Musées de France (C2RMF) of Paris, under the supervision of Michel Menu (head of the research department at C2RMF). Activities focused on: A) Study of the natural and accelerated aging of natural and synthetic adhesives used for the lining of paintings, using the following techniques: FT-IR, XRD, SEM/EDS, thermal analysis (DTG, DSC), gas chromatography (Py-GC), colorimetry and micro-topography. B) Development of innovative methods for the removal of aged adhesives from paintings of the XIXth and XXth century, using chemical gel and micellar solutions.

He is currently a researcher at the Department of Chemistry (University of Florence), focusing on the development of nanomaterials and green chemistry for the conservation and preservation of movable and immovable artworks. Examples of research topics include: *(i)* dispersions of nanoparticles for deacidification and pH adjustment (paper, parchment, canvas, leather) and consolidation (wall-paintings, plaster, stones); *(ii)* fluid nanostructured systems (micellar solutions, microemulsions) for the cleaning of paper, parchment, canvas, paintings, plastics, plaster and stones; *(iii)* chemical and physical gels for the confinement of cleaning fluids and their application on water- and solvent-sensitive surfaces, or as sorbents of pollutants; *(iv)* consolidants for painted layers and supports; *(v)* FTIR analysis and 2D Imaging of artistic surfaces (cellulose- and protein-based, plastics, stone, easel and wall paintings) and microplastics.

He has been (and still is) involved as coordinator contact and in the scientific management of the H2020 EU 3-years project APACHE (Active & intelligent PAckaging materials and display cases as a tool for preventive conservation of Cultural Heritage), (January 2019-June 2022), and H2020 EU 3.5-years project NANORESTART (NANOmaterials for the RESToration of works of ART), (June 2015-Nov 2018) (http://www.nanorestart.eu), and in the scientific management of the FP7 EU 3-years project NANOFORART (NANOmaterials FOR the conservation and preservation of movable and immovable ARTworks), (Dec 2011-Nov 2014) (http://www.nanoforart.eu). He also carried out research work in the context of the TeCon@BC project (Tecnologie innovative per la conservazione e la valorizzazione dei Beni Culturali - Innovative technology for the conservation and valorization of Cultural Heritage, http://www.icvbc.cnr.it/tecon/default.htm), focusing on the study of nanocomposite systems based on calcium hydroxide nanoparticles and acrylic-vinyl polymers, their application on stone, and physico-chemical characterization of the treated surfaces.

He is author and co-author of 93 publications, 2 books and 15 book chapters, and editor of one book on Cultural Heritage conservation.

-Bibliometric data: WOS and SCOPUS

SCOPUS: 78 documents, 2105 citations, h-index 26

-Selection of the 10 most relevant publications and/or patents

1) V. Rosciardi, D. Chelazzi*, P. Baglioni*. “Green” biocomposite Poly(Vinyl alcohol)/starch cryogels as new advanced tools for the cleaning of artifacts. Hournal of Colloid and Interface Science 2022, 613, 697-708.
2) C. Cianci, D. Chelazzi*, G. Poggi, F. Modi, R. Giorgi, M. Laurati. Hybrid fibroin-nanocellulose composites for the consolidation of aged and historical silk. Colloids and Surfaces A: Physicochemical and Engineering Aspects 2022, 634, 127944.
3) A. Casini, D. Chelazzi*, R. Giorgi*. Jin Shofu nanoparticles for the consolidation of modern paintings. ACS Applied Materials and Interfaces 2021, 13(31), 37924-37936.
4) R. Mastrangelo, D. Chelazzi, G. Poggi, E. Fratini, L.P. Buemi, M.L. Petruzzellis, P. Baglioni*. Twin-chain polymer hydrogels based on poly(vinyl alcohol) as new advanced tool for the cleaning of modern and contemporary art. PNAS 2020, 117(13), 7011-7020.

5) D. Chelazzi*, D. Badillo-Sanchez, R. Giorgi, A. Cincinelli, P. Baglioni*. Self-regenerated silk fibroin with controlled csystallinity for the reinforcement of silk. Journal of Colloid and Interface Science 2020, 576, 230-240.
6) N. Bonelli, G. Poggi, D. Chelazzi, R. Giorgi, P. Baglioni*. Poly(vinyl alcohol)/poly(vinyl pyrrolidone) hydrogels for the cleaning of art. N. Bonelli, G. Poggi, D. Chelazzi, R. Giorgi, P. Baglioni. Journal of Colloid and Interface Science 2019, 536, 339-348.
7) D. Badillo-Sanchez, D. Chelazzi*, R. Giorgi, A. Cincinelli, P. Baglioni. Characterization of the secondary structure of degummed Bombyx mori silk in modern and historical samples. Polymer Degradation and Stability 2018, 157, 53-62.
8) G. Poggi, N. Toccafondi, D. Chelazzi, P. Canton, R. Giorgi, P. Baglioni*. Calcium hydroxide nanoparticles from solvothermal reaction for the deacidification of degraded waterlogged wood. Journal of Colloid and Interface Science 2016, 473, 1-8.
9) P. Baglioni*, E. Carretti, D. Chelazzi. Nanomaterials in art conservation. Nature Nanotechology 2015, 10(4), 287-290.
10) D. Chelazzi, A. Chevalier, G. Pizzorusso, R. Giorgi, M. Menu, P. Baglioni*. Characterization and degradation of poly(vinyl acetate)-based adhesives for canvas paintings. Polymer Degradation and Stability 2014, 107, 314-320.

2) Title of the course: Focal Plane Array (FPA) Imaging FTIR: principles and applications

3) Course content detailed per lesson of 2 h (possibly with dates and room real and virtual)

Lesson 1 (2h, 14 March): multi-element detectors in IR spectroscopy; Reflectance and ATR (Attenuated Total Reflectance) IR microscopy.

Lesson 2 (2h, 21 March): FPA-FTIR: detection limit and practical applications (part 1, spectral deconvolution)

Lesson 3 (2h, 28 March): FPA-FTIR: practical applications (part 2, spectral deconvolution)

Lesson 3 (2h, 13 April): FPA-FTIR: practical applications (part 3, design of materials).

4) Course program (150-200 words)

Coupling microscopy with Fourier Transform Infrared Spectroscopy (micro-FTIR) enables the non-invasive and non-destructive detection of molecular functional groups. The use of Focal Plane Array (FPA) detectors allows the simultaneous acquisition of spatially resolved IR spectra on an array of n x n pixels, each pixel corresponding to an independent spectrum. This technique can thus be used for the identification of low amounts of analytes that are heterogeneously distributed on relatively large areas (e.g. from millimeters to centimeters), with high spatial resolution (few microns), using arrays of 64x64 and 128x128 pixels. The possibility of working in transmittance, reflectance and ATR (Attenuated Total Reflectance) mode, makes the technique highly versatile: possible applications cover a wide range of fields, from biomedicine (analysis of tissues) and pharmaceutical research, to environmental chemistry (detection/identification of microplastics), and conservation of cultural heritage (assessment of the degradation and cleaning of artifacts). The course will focus both on fundamental principles and practical aspects, including some demonstration of the technique on a selection of samples.

5) Suggested reading: handouts and research articles provided by the teacher

6) Learning Objectives: providing the students with fundamental knowledge on the potential and practical use of IR microscopy and 2D imaging for the characterization of materials.

7) Knowledge and skills to be acquired: principles of IR spectroscopy and 2D imaging for the characterization of materials; ability to read and critically use IR microscopy data in research on materials science.

8) Prerequisites: only the fundamental math+physics courses of the first 2 univeristy years (e.g. chemistry, physics, …)

9) Teaching Methods: lectures (with slides)

10) Further information

11) Type of Assessment: written test: written critical discussion (short essay) of a case-study/literature article that involves the techniques explained in the course). Max 5000 words.

The final evaluations will have to be validated maximum 1 month after the end of the course.

Total hours must be: 8h frontal lessons (3 ECTS)

Period: May 2022

The lessons must be delivered online or both online and in presence. The lessons must be recorded and available to all the students that cannot take part to the lessons in streaming.

The Webex platform must be used