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RAU

40 YEARS OF THE FIRST BRAZILIAN SYNCHROTRON LIGHT SOURCE PROJECTT

ABSTRACT BOOK

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FAPESP

SUMMARY

PLENARY LECTURES

Applications of Spectroscopic Techniques with Synchrotron Light in the Areas of Energy and Cultural Heritage.

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Resumo:

This presentation will explore the application of spectroscopic techniques in different research areas, with an emphasis on the study of nanostructured materials and semiconductor polymers. These projects are being developed at the Surface Chemistry Laboratory of the Chemistry Institute of UFRJ and were initially carried out at the National Synchrotron Light Laboratory (LNLS) using the UVX light source. Examples of more recent studies involving perovskites and paintings from Brazilian colonial art, conducted with the new Sirius synchrotron light source at LNLS, will also be presented.

Operando Studies of the Chemical and Structural State of Active Materials in Li-ion Cells: Contributions of Synchrotron Radiation Techniques.

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Resumo:

The ability to monitor the crystal structure of different phases and the chemical state of elements according to the state of charge of active materials constitutes an advanced tool for the characterization and rational design of new materials.
This experimental approach aims to improve material stability and optimize their capacity a nd charge delivery rate.

Examples are presented on cathode materials such as LMNO and LFP, where results from X-ray diffraction, fluorescence, and absorption are discussed, with a special focus on the original contributions enabled by new experimental beamline facilities offering micrometric or submicrometric spatial resoluti on for the studies described.

Os Plásticos e a Saúde Humana

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Resumo: Nessa apresentação apresentaremos dados mostrando a magnitude da poluição plástica, e os efeitos adversos causados pelos microplasticos e os aditivos do plástico.

Purine-based single crystals as bioinspired materials with tuneable mechanical and optical properties

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Organic single crystals are solid materials with diverse properties and applications, particularly in optics and optoelectronics [1]. Beyond their optical performance, certain mechanical features, such as flexibility, can further expand their functionality. Recently, crystals capable of reversible bending, termed elastic organic single crystals (EOSCs), have attracted significant attention [2]. On the other hand, guanine crystals are the most common organic biogenic crystals. With their exceptionally high refractive index, they contribute to structural coloration and reflective effects in the skin and visual organs of many animals [3].

In our group we optimized reproducible conditions for synthesizing guaninium chloride dihydrate (**1**), which forms elongated crystals with remarkable mechanical and optical properties, functioning as guanine-based bioinspired EOSCs. Doping with acridine orange (**AO**), a DNA-intercalating dye, produced a new material (**1-AO**) with orange coloration and modified properties, despite minimal lattice changes observed by XRD. Spectroscopic analyses confirmed intracrystalline **AO**, while elastic strain reached 1.06% in **1** and 1.37% in **1-AO**, evidencing enhanced flexibility. Optical waveguiding was also demonstrated in **1-AO**, supporting doping as an effective strategy to modulate guanine-based optical systems [4]. Additionally, we propose a model to describe packing in organic ionic crystals and predict mechanical properties, considering attractive and repulsive electrostatic interactions. As case of study, we investigate guaninium chloride dihydrate (**1**)-as flexible material-, caffeine monohydrate (**2**)-as plastic material-, and adeninium dichloride (**3**)-as hard crystalline solid-. Its simplicity and generality make it suitable for a wide range of ionic solids.

We gratefully acknowledge UBA (20020170200295BA), ANPCYT (PICT 2016-621& 2018-04236) and CONICET for funding resources. This work was supported by the Synchrotron Light National Laboratory (LNLS), Campinas, Brazil thought projects ID: MX2 - 20190182 and MX2 – 20180504. The MANACÁ beamline staff is acknowledged for their assistance during the experiments 20232469.

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Unraveling Surface Structural and Chemical Coexistence in Two-Dimensional Materials through Crystal Truncation Rod Analysis

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Resumo: Two-dimensional materials have attracted significant attention over the past decades due to their remarkable physical and chemical properties. Continuous advancements in their optoelectronic, magnetic, and catalytic performance are constantly reported. However, achieving scalability for commercial applications remains a key challenge. In this talk, we demonstrate how Crystal Truncation Rod (CTR) analysis performed on single crystals (exfoliated flakes) offers new insights into the surface structure and chemical composition of these materials, both critical factors for device integration. We also highlight the complementary nature of CTR analysis in relation to spatially/statistically restricted scanning probe and electron microscopy results.

ORAL PRESENTATIONS

Insights into the Molecular Composition of Ethanol-Water Liquid Mixtures through Micro-jet Electron Spectroscopy

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In this presentation, we will analyze cylindrical micro-jet photoelectron spectroscopy (cMJ-PES) along with relevant theoretical simulations. We have investigated the properties of ethanol-water solutions across the entire concentration range, from 0 to 100 MOL% ethanol[1]. Our objective is to gain a deeper understanding of the microscopic structure and intermolecular bonding patterns within these mixtures. Although ethanol-water solutions are extensively utilized and studied, several controversies remain regarding the nature of their hydrogen bonding networks. Our findings indicate that at low concentrations, ethanol molecules form a film on the surface, which is energetically favorable[2]. In bulk, up to 10 M%, ethanol and oxygen atoms tend to establish a third hydrogen bond acceptor with water molecules. At 20 M%, results suggest the presence of clathrate structures. At the surface, ethanol forms a tightly packed layer within the concentration range of 5-25 M%. When concentrations exceed 85 M%, there is evidence that water molecules tend to migrate to the surface, which elucidates the azeotrope effect[3]. We have compared our results with predictions derived from other spectroscopic techniques and emphasized the significance of an integrated approach that combines molecular dynamics with quantum predictions for cMJ-PES measurements[4]. Our protocol is applicable to the investigation of other alcohol mixtures and binary solutions.

We thank CNPq, FAPESP, CAPES, and the support from IPE and PGM beamline staff for their support during several measurements.

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Salinomycin vs. Manganese: A Strategy Against Cancer Progression

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Manganese (Mn) has emerged as a central promoter of malignancy in cancer. Studies from our group revealed that Mn alters gene expression of metal transporters, modulating intracellular accumulation while negatively regulating its main transporter, DMT1, i.e.. When Mn concentration is increased, DMT1 expression is decreased, and when Mn concentration is standard, DMT1 expression recovers/increases. This phenomenon led us to test salinomycin, known to block Fe in DMT1, as a potential disruptor of Mn transport and its malignant effects. Tumor and non-tumor cells were exposed to MnCl2 and salinomycin, and we assessed viability, survival, migration, and intracellular metal content. After 24 h of incubation and recovery in standard medium, clonogenic and migration assays evaluated survival and invasiveness, respectively. Mn levels in media and cells were quantified by ICP-OES, while XRF (Carnaúba beamline, Sirius - CNPEM) provided insights into subcellular Mn distribution. Strikingly, salinomycin induced significant death in tumor cells, while surviving populations displayed a reduced Mn uptake and less aggressive phenotype. XRF analyses revealed that salinomycin intensely altered Mn distribution in tumor cells, reducing focal intracellular accumulation and redistributing the metal within the cytoplasm. In contrast, non-tumor cells maintained a homogenous Mn distribution, showing no detectable changes upon treatment. Maps indicate that Mn might be “leaking” from treated cells, however, further investigations are necessary. These findings highlight salinomycin as a molecular therapeutic candidate capable of modulating Mn uptake and undermining the metal-dependent malignant behavior of cancer cells. Future directions include extending this strategy to additional tumor models and healthy cells. Together, these results support the innovative potential of targeting Mn metabolism as a novel therapeutic avenue against aggressive cancers.

We thank the funding agencies and partner institutions IFRJ, FAPERJ, CAPES and CNPEM for their support. We are also grateful to our collaborators from the Glycobiology and Metallomics Group, PUC-Rio and Carnaúba beamline team for their assistance and contributions to this research.

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Structure Evolution and Thermometric Performance of N3+-Doped Yttrium Oxyfluorides: Insights from Synchrotron XRD, Optical Spectroscopy and Atomistic Simulation

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Lanthanide-doped inorganic compounds have emerged as promising candidates for non-contact luminescent thermometry, particularly within the biological windows (650–950 nm and 1000–1350 nm), enabling deeper tissue penetration and minimally invasive diagnostics. Among these, Nd^{3+} is a key ion, owing to its efficient NIR emission and dual band thermometric potential. In this work, we investigated how oxygen incorporation and phase transitions modulate the optical performance of YF_3:Nd^{3+} nanothermometers [1]. High-resolution synchrotron X-ray diffraction at the PAINEIRA beamline revealed a progressive oxidation of YF_3 into $Y_7O_6F_9$ and YOF-containing mixtures upon annealing at 600 °C. Rietveld refinements demonstrated symmetry lowering and reduced coordination around Y^{3+} sites in $Y_7O_6F_9$, which semiclassical computational modeling confirmed as energetically favorable for Nd^{3+} incorporation (−0.16 eV vs. +0.18 eV in YF_3). The coordination environment of Nd^{3+} in $Y_7O_6F_9$ varies, ranging from two to eight Nd–F bonds, but always maintains four Nd–O bonds. On the other hand, substitution in YF_3 results in nine Nd–F bonds. From an optical standpoint, these sites modulate the local crystal field around Nd^{3+} ions, influencing Stark splitting, phonon-assisted relaxation, and radiative efficiency. As a result, $Y_7O_6F_9$: Nd^{3+} demonstrates up to threefold enhancement in thermometric relative sensitivity compared to YF_3: Nd^{3+} [2], reaching 0.68% K^{-1} under 800 nm and 1.6% K^{-1} under 660 nm excitation. Our findings provide new structural and spectroscopic insights into Nd^{3+}-doped yttrium oxyfluorides and points out to oxygen tuning as a possible strategy to design high-performance luminescent nanothermometers.

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Synchrotron Nanospectroscopy of Magnetic Beads for Biomolecule Purification

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Globalization has heightened the risk of pandemic viruses. To safeguard sanitary sovereignty, countries must develop technologies that enable rapid innovation and local production of diagnostic supplies. In molecular diagnostics, while some methods bypass purification, the most sensitive ones, such as qPCR and isothermal amplification, require efficient RNA/DNA extraction. Thus, robust, high-performance, and cost-effective purification strategies are critical for diagnosis, genetic testing, and research.
Commercial kits face limitations: low throughput, high cost-to-efficiency ratios, and specialized equipment needs (e.g., refrigerated centrifuges). Magnetic nanoparticles (MNPs), functionalized for selective biomolecule adsorption, offer a promising alternative due to their low production cost, scalability, and simple magnetic separation. For recombinant protein purification, His_6-tag affinity systems remain the gold standard, as histidines strongly interact with metals such as Ni^{2+}. Coating MNPs with such ions enables purification methods that are faster, more economical, and more sustainable than conventional chromatography.
We are developing Fe_3O_4@SiO_2-based magnetic beads for the purification of nucleic acids, recombinant proteins, and antibodies [1,2]. Optimizing their performance requires understanding MNP–biomolecule interactions during lysis (binding) and elution (release). Here we present nanospectroscopy results obtained at the IMBUIA-NANO beamline (Sirius), which allowed the characterization of magnetic beads and their interactions with nucleic acids, recombinant proteins, and peptides. These insights pave the way for rational design of efficient purification systems. Ultimately, this knowledge supports the development of scalable, high-performance, locally manufactured kits, strengthening national capacities in diagnostics and biotechnology.

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Visualising Hierarchical Pore Networks in Zeolite Catalysts with Ptychographic X-ray Computed Tomography

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Hierarchical zeolites are benchmark catalysts for processes such as methanol-to-hydrocarbons and selective oxidations, owing to improved molecular transport, greater access to Brønsted sites, and enhanced lifetimes relative to purely microporous analogues. Among them, ZSM-5 combines structural robustness with tunable acidity, yet resolving how porosity is distributed within single crystals remains challenging. Conventional methods either lack internal spatial resolution or rely on destructive preparation, limiting insight into intracrystalline heterogeneity. Here we apply ptychographic X-ray computed tomography (PXCT) to non-destructively visualise and quantify internal porosity in hierarchical ZSM-5. Measurements at the Caterete beamline of the fourth-generation SIRIUS synchrotron (LNLS/CNPEM) achieve a three-dimensional resolution of 40 nm. The reconstructed volumes reveal spatially heterogeneous pore networks, including core-shell-like architectures and gradients introduced by post-synthetic desilication. These results establish PXCT as a powerful tool for advanced characterisation of porous catalysts and open routes to rational design by enabling experimental correlations between synthesis, 3D structure, and catalytic function.

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X-ray Tomography Segmentation Enables 3D Characterization of Root Hairs and Exudates in Beans under Biochar treated soil and ZnO treated seeds

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Biochar and Zinc Oxide (ZnO) Nanoparticles have been studied separately for their potential benefits on plant development. This study investigates whether their combination has synergistic effects on bean root growth by characterizing root structure using X-ray computed tomography (XCT) at the MOGNO beamline from the Brazilian Synchrotron Light Laboratory (LNLS). Four treatments were analyzed: i) regular soil and bean seeds (control), ii) biochar-treated soil, iii) ZnO-treated seeds, and iv) a combination of ii and iii (n=3 per treatment, total of 12 images).

Image segmentation was performed to assess root morphology using Avizo software, combined with machine learning and deep learning tools (Annotat3D and META-Unet), followed by manual refinement. After segmentation was complete, root diameter distribution was analyzed using ImageJ.

Plants grown in biochar-containing treatments showed fewer root hairs and smaller average diameters, suggesting altered growth patterns. Two hypotheses may explain these results. First, biochar can increase soil water retention, reducing root hairs[1], whose role is to explore the soil for water and nutrients. Second, mixing biochar into the soil may compact it, restricting root expansion and the development of fine structures[2]. These mechanisms may act simultaneously, and further experiments under controlled conditions are required to disentangle their contributions.

Additionally, distinct structures were observed at root hair tips, likely root exudates—substances released into the rhizosphere. Their 3D visualization is unprecedented, highlighting a potential new application of XCT segmentation in plant–soil studies. Overall, the results demonstrate the potential of synchrotron-based XCT and segmentation pipelines for revealing subtle morphological changes and biochemical features in roots, while reinforcing the need for studies with larger sample sets and controlled soils.

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POSTERS

3D Histoarchitecture of the Mouse Heart via Synchrotron Tomography

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The heart's ability to pump efficiently depends on the precise three-dimensional organization of cardiomyocytes, yet resolving this architecture across whole organs has long been hindered by technical limitations. We combined Synchrotron Radiation-based X-ray microtomography (SR-µCT) with advanced computational segmentation and deep learning to achieve single-cell resolution imaging of entire mouse ventricles. This approach enabled mapping and analysis of ~1.8 million individual cardiomyocytes in situ, providing an unprecedented quantitative framework for understanding cardiac microarchitecture. High-resolution volumetric data revealed systematic transmural transitions in cell orientation from epicardium to endocardium, with regional differences between anterior and posterior walls. We identified consistent motifs such as transmural bridges and singular points, comprising ~1.5% of cells, that appear to serve as mechanical coupling sites. Notably, obliquely aligned cardiomyocytes—previously regarded as atypical—were found to be critical for synchronized ventricular contraction by bridging parallel-aligned clusters. Additionally, oblique orientations seems to contribute as tangential and radial components balancing the constrictive forces of tangentially aligned midwall cells, thereby supporting cavity expansion and contractile efficiency. Together, these insights provide the most detailed view to date of the heart's cellular histoarchitecture, bridging imaging, computation, and modeling. Beyond cardiovascular biology, our work establishes SR-µCT as a powerful synchrotron-enabled platform for mapping complex three-dimensional cellular organization in intact tissues, with broad implications for physiology, pathology, and computational modeling.

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Advanced characterization of defect energy levels in luminescence materials using synchrotron X-ray spectroscopy.

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Luminescence materials have been widely used to applications such as scintillator, solar cells, dosimeters, LED's, phosphorescence paint, lasers and optical fibers and others [1]. Their properties are strongly influenced by levels inside the bandgap of material which are commonly accessed by optical measurements such as VUV-VIS spectroscopy, radioluminescence (RL) and thermoluminescence (TL) among others. Such techniques provide data to construct luminescence mechanism responsible to describe charge carrier movement in excitation and de-excitation processes. In the context, some empirical models, such as the Host and Vacuum Referred Binding Energy models (HRBE/VRBE) [2,3], can be useful as a tool for optical engineering, providing insights about luminescence mechanism. However, the accuracy of these models fails when an aliovalent substitution happen due to charge compensation defects which create additional electronic states inside the bandgap. In general, these defects are not directly detectable by typical optical measurements but they contribute to the charge carriers. This work intends to employ a suite of synchrotron-based X-ray measurements to investigate the defect energy levels within the bandgap of the material. A platform composed by X-ray photoelectron spectroscopy (XPS), X-ray absorption spectroscopy (XAS) and resonant inelastic X-ray scattering (RIXS) are used to advanced characterization of Ce-doped $KMgF_3$ fluoroperovskite. The samples were synthesised via a microwave-assisted hydrothermal method and previously characterised using standard structural and optical techniques. XAS spectra were acquired at the F, Mg K-edge, K L2 and L3-edges and Ce M4 and M5 edges to map empty levels for each species, while XPS measurements were used to place these levels in relation of fermi energy of material. RIXS measurements provide information about defect levels inside the band gap.

This research used facilities of the LNNano and LNLS/CNPEM, a private non-profit organization under the supervision of the MCTI. The LNNano IPE beamline staffs are acknowledged for the assistance during the experiments (20252259, 20250969, 20250920, 20232971, 20190133, 20190096, 20180491). The authors wish to acknowledge the CNPq (#314664/2025-4 PCI CNPQ/CNPEM), FINEP and CAPES Brazilian agencies.

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"Advanced Characterization of Metal–Organic Nanostructures (Nano-MOFs) and Their Potential for Sustainable Agriculture: An Integrated Approach Using Electron Microscopy and Application Studies."

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This work presents an investigation on Metal-Organic Nanostructures (Nano-MOFs), focusing on their synthesis, advanced characterization, and application in sustainable agriculture. We synthesized MOFs (ZIF-8, ZIF-67, and CuGlu) via solvothermal and room-temperature methods, using metal precursors (zinc nitrate, cobalt nitrate, copper sulfate) and organic ligands (2-methylimidazole and L-glutamic acid). Initial characterization by XRD, FTIR, and TG/DTA provided data on crystallinity, structure, and thermal stability. For morphological and compositional analysis at the nanoscale, we used electron microscopy techniques at LAM/CNPEM. Through SEM with SE and EDS, we analyzed morphology, particle size, and elemental composition. Using TEM/STEM (BF, DF, and HAADF modes), we visualized the internal structure, particle distribution, and defects. Sample preparation via FIB-SEM was crucial for 3D analysis. We discuss applications in agriculture: pesticide remediation through contaminant adsorption; controlled-release systems for agrochemicals; and environmental sensors (Kamal et al., 2024). The correlation between characterization data and functional properties provides insights into how morphology, size, and stability influence remediation, release, and sensing. Nano-MOFs show promise as nanocarriers (Wang et al., 2024). We address challenges related to large-scale synthesis, cost reduction, and field validation, emphasizing the need to optimize properties and ensure environmental safety. This work contributes to advancing nanotechnology in agriculture, offering solutions for food security and mitigation of environmental impacts, serving as versatile platforms for sustainable disease management (Ahmed et al., 2025).

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A multi-scale analysis of the developing *Thoropa miliaris* eye using X-ray ptychography and X-ray fluorescence

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For over a century, amphibians have served as a critical model organism for vision research; however, the relationship between their vast ecological diversity and the adaptive properties of their visual systems remains poorly understood. This study addresses this knowledge gap by investigating the developing eye of Thoropa miliaris, an invaluable model for developmental biology, using a novel combination of advanced synchrotron techniques. Specimens at distinct developmental stages were analyzed using both X-ray fluorescence (XRF) mapping and X-ray ptychography. Low-energy XRF was performed at the Twinmic beamline (Elettra-Sincrotrone Trieste), while XRF and ptychography were conducted at the Carnauba beamline (Sirius, Brazilian synchrotron light source). The preliminary results demonstrate that elemental distribution maps, acquired via XRF, and high-resolution ptychographic maps provide complementary, multi-scale information on the cellular architecture and trace element distribution within the developing eye. This work highlights the power of these combined methods for a comprehensive, nanoscale evaluation of how the eye's optical properties are modified throughout development.

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A operando SOFC cell design for the QUATI beamline

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Solid oxide fuel cells (SOFCs) have emerged as a promising technology for the environmentally friendly conversion of chemical energy of fuels into electrical energy. To enhance SOFCs development, an operando characterization of electrode materials under electrochemical reaction conditions is crucial. In this context, X-ray absorption spectroscopy (XAS) is a powerful tool as it allows data to be collected using user-designed operando cells and follow the oxidation state changes occurring on the working electrode. The ability to distinguish between surface and bulk properties during real reaction environments enables the potential to enhance our understanding of electrochemical processes and design electrodes tailored for specific reactions of interest.In this presentation we show the advances on the cell for IT-SOFC planned at QUATI Beamline.

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Applying new segmentation tools to soil aggregate images acquired at the MOGNO beamline

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Segmentation can be a limiting step in the post-processing of X-ray Tomography data, particularly when phases of interest exhibit overlapping gray levels, making separation based solely on voxel intensity difficult. In soil studies, this challenge is further compounded by the wide variability in the shape and size of constituents such as matrix, pores, roots, and organic fragments. These constituents range from sub-resolution structures to channels spanning hundreds of voxels, while the volumetric imbalance between classes adds further complexity. In this context, new segmentation tools are being explored for the identification of challenging phases, such as particulate organic matter (POM), in soil aggregate images that were acquired at the MOGNO beamline. Two approaches have shown promising results: (1) the Avizo AI Assisted Segmentation Tool, which employs deep learning models (ResNet, VGG12, VGG19, and Shallow Model) trained on annotated regions of interest; and (2) GeoSlicer, which combines manual methods with advanced image segmentation algorithms and pore network extraction techniques. Preliminary results suggest that AI-based methods can improve the accuracy of identifying complex classes such as POM, supporting the development of faster and more robust protocols for these challenging phases. These tools are available to the scientific community at the MOGNO beamline and represent an important step towards overcoming segmentation limitations and achieving more consistent results in identifying poorly defined classes based on gray tons in various scientific applications.

Assessment of the impact of the absence of soluble epoxide hydrolase enzyme in jawbone osteocytes in senescent mice

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Periodontal disease (PD) is a chronic inflammatory condition closely associated with aging, leading to progressive alveolar bone loss and a higher risk of tooth loss in elderly individuals. The role of senescent osteocytes in this process has gained increasing attention, as these cells are not merely passive markers of aging but may actively sustain the inflammatory microenvironment. In parallel, soluble epoxide hydrolase (sEH), an enzyme regulating lipid mediators involved in inflammation, has been implicated in bone remodeling and age-related disorders. Previous evidence indicates that sEH inhibition reduces alveolar bone resorption, yet its effects on osteocyte biology remain poorly understood. In this study, synchrotron-based microCT with submicrometric resolution was employed to evaluate osteocyte lacunae in the maxillae of young and old wild-type and sEH knockout mice. This advanced imaging approach enabled three-dimensional assessment of lacunar density, volume, and morphology with unprecedented detail. The absence of sEH did not affect osteocyte density (number/mm^3); however, it significantly altered lacunar architecture. Knockout animals exhibited reduced lacunar volume along with pronounced changes in shape descriptors, including decreased sphericity and altered perimeter. These findings suggest that sEH influences osteocyte lacunar morphology independently of density, underscoring its potential role in bone quality and resilience during aging. By integrating high-resolution imaging with molecular insights, this study advances the understanding of osteocyte-driven mechanisms in PD and highlights new perspectives for therapeutic strategies aimed at bone preservation in the elderly.

The Synchrotron MicroCT acquisitions were performed at the Mogno beamline of the Sirius synchrotron light source, Brazilian Center for Research in Energy and Materials (CNPEM), Campinas, Brazil, under proposal No. 20235049.

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Characterization of agarose nanoparticles obtained by w/o/w microemulsion

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The present work investigates the physicochemical behavior of aqueous agarose solutions (0.2–10 mg·mL⁻¹) and agarose nanogels produced by W/O/W emulsions, focusing on main-chain dynamics and double-helix formation leading to gelation. Agar, a mix of cell-wall polysaccharides (agarose and agaropectin), is extracted from red algae (Rhodophyta) [1]; the agarose repeating unit comprises β-d-galactose (1,3) and α-1,3,6-anhydrogalactose (1,4) [2]. Agarose has broad biomedical uses including hydrogels, 3D scaffolds, drug delivery, antibody separation and cell encapsulation [3-9]. In solution agarose adopts a random-coil conformation above the gelation temperature; on cooling some segments form helices that aggregate via hydrogen bonds to create network cross-links [10–11]. SANS suggests relatively rigid chains with large persistence length (lp > 9 nm) and helical motifs in gelation [12]. Experimentally, SAXS and XPCS were measured at synchrotron beamlines, complemented by SLS, DLS, TGA, FTIR and circular dichroism (CD); nanocapsules were prepared by W/O/W with a concentrated agarose phase. SLS/DLS reveal organized aggregates even at low concentrations (CAC ≈ 0–0.2 mg·mL⁻¹) and a structural crossover near c* ≈ 0.8 mg·mL⁻¹. Two Rg populations were observed, linked to individual chains and to aggregates; higher scattering anisotropy (IVH/IVV) appears at lower concentrations. Nanogels show Rh ≈ 400 nm (PDI ≈ 0.3), zeta ≈ −30 mV; SLS yields fractal dimension ≈ 3.6, Rg ≈ 89 nm and shape factor ≈ 0.6 ± 0.2, consistent with microgels. FTIR and TGA confirm agarose stabilization in the matrix, while CD evidences helicity onset during cooling. SAXS shows double-helix features with correlation length ≈ 19 nm. XPCS data were acquired and are under analysis to clarify the kinetics and mechanisms of double-helix formation and nano/microstructural self-assembly. These insights will guide design of agarose materials for separation, encapsulation and as soft stabilizers (Mickering).

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Charge ordering of underdoped YBa2Cu3O7-δ thin films probed by Resonant Inelastic X-ray Spectroscopy

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Strongly correlated systems have attracted continuous attention, with complex phase diagrams. In cuprates, the strong Coulomb repulsion has significant impacts on the electronic distribution in the CuO2 planes, where Cooper pairs appear for a given range of temperature and electronic doping. Additionally, the superconductor dome is surrounded by exotic charge ordered phases, most notably 3D or 2D charge density waves (CDW) that may be correlated with superconductivity and nearby states such as the so-called strange-metal and pseudogap regimes. In particular, much work has been done to understand the spontaneous two-dimensional charge-density wave (2D-CDW) order and fluctuations at (H,0) in the reciprocal space with H ~ 0.3 r.l.u. [1,2,3]. In this work, YBa2Cu3O7-δ (YBCO) an epitaxial thin film in the underdoped regime is analyzed by Resonant Inelastic X-Ray Scattering (RIXS) at the Cu L3-edge. By energy-integrating the quasi-elastic region of the RIXS spectra while changing the magnitude of the momentum transfer parallel to the CuO2 planes, we observe a relatively sharp peak at H = 0.31 r.l.u. due to the 2D-CDW order and a second broader component centered at H ~ 0.30 r.l.u., attributed to dynamic short-range CDW correlations. This broad feature persists at least up to T ~ 400 K, with an apparent change of behavior at T ~ 300 K. A more systematic study is being planned to possibly correlate the temperature dependence of the RIXS data with the emergence of the exotic electronic phases of cuprates.

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Chemical Investigation of the Indium–Organic Complex Photoresist/Silicon Interface as a Function of EUV Irradiation and Depth

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In recent years, patterning by extreme ultraviolet (EUV) lithography has been introduced to achieve 3 nm nodes and below due to the demand for miniaturization of electronic device components. At these very thin film resist thicknesses, interfacial effects become increasingly significant, and the properties of the resist films are strongly influenced by both the top and bottom interfaces [1–2].In this work, we report noticeable chemical changes occurring in an organic thin film at the silicon/indium-organic complex photoresist interface, investigated using techniques available at the Brazilian synchrotron light source at the Ipê beamline (100–2000 eV, soft X-ray range). The resist was based on a metal-organic complex containing heavy atoms (indium-methacrylic acid). The thin film was prepared via spin coating on cleaned silicon wafers. The thickness of the prepared films was (11.5 ± 0.1) nm measured by ellipsometry. XPS, XAS, and fluorescence data were collected as a function of EUV irradiation time at 99,4 eV and at XPS excitation energies. Briefly, specific transitions were selected, and the films were irradiated for a fixed period under UHV[3]. After irradiation, samples were transferred to a preparation chamber and exposed to ambient air for 20 minutes. Spectra of pristine regions were recorded outside of the irradiated zones. The results of C 1s and Si 2p XPS spectra as a function of excitation energy and irradiation time revealed clear evidence of chemical reactions at the resist/silicon wafer interface with the formation of silicon carbide and intermediate silicon oxide species. Significant indium oxidation was not observed, possibly due to the high fluorescence yield of indium, which may facilitate rapid energy dissipation of the absorbed EUV photons. Our findings provide evidence of chemical composition changes in the underlayers of the resist film in contact with the silicon substrate following EUV irradiation.

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Circular Dichroism Analysis of Nucleic Acids Purified with Magnetic Beads under Different Lysis Conditions

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Efficient nucleic acid purification is essential for applications ranging from molecular diagnostics to genomics and biotechnology. While commercial kits are widely used, they have limitations in cost, scalability, and requirement for specialized equipment. Magnetic nanoparticles (MNPs), when functionalized appropriately, provide an attractive alternative due to their low production cost, superparamagnetic properties, and compatibility with rapid and scalable workflows[1].

In this work, we explored the use of silica-coated MNPs (Fe_3O_4@SiO_2) synthesized in-house[2] for the purification of DNA and RNA from HeLa cells, with a particular focus on how the chemistry of the lysis step affects biomolecule recovery. Circular dichroism (CD) spectroscopy at the CEDRO beamline was employed to assess both the integrity and purity of nucleic acids obtained with magnetic beads, and to compare them with those recovered using standard commercial kits.

The results revealed that nucleic acid–nanoparticle interactions are strongly buffer-dependent on buffer composition, affecting both the type and quality of recovered material. Importantly, CD provided a sensitive means to distinguish between DNA, RNA, and proteins in complex mixtures, enabling direct evaluation of purification performance. These findings highlight the potential of combining magnetic bead technology with synchrotron-based spectroscopy to optimize purification strategies. Altogether, this work contributes to the development of scalable, efficient, and cost-effective alternatives to commercial kits, supporting innovation in diagnostics and biotechnology.

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Comparação de segmentação automática e manual de imagens de micro-CT provenientes de aquisição esparsa de amostra biológica

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No processo de reconstrução de imagens de micro-CT existe uma faixa ideal de projeções a serem obtidas, para que a imagem gerada tenha sua melhor qualidade com a otimização do tempo de aquisição. Uma maneira de diminuir a dose de radiação é a diminuição do tempo de exposição da amostra aos raios X, que pode ser realizado com a diminuição do número de projeções no processo de aquisição dos dados, também chamado de Aquisição Esparsa (Sparce Projection Aquisition) [1].

Após a aquisição e reconstrução de imagens por micro-CT, um passo subsequente para estudar uma região de interesse da amostra é a segmentação da imagem, onde é necessário decompor essa imagem em partes distintas se utilizando de processos computacionais [2]. Para o processo de segmentação automática de imagens tomográficas, atualmente podem ser utilizadas Redes Neurais Artificiais sendo, as mais indicadas, conhecidas como Rede Neurais Convolucionais (CNN) [3].

Neste trabalho, avaliou-se a capacidade de uma CNN em recuperar informações da segmentação em imagens da mesma amostra, contudo indo de uma maior para uma menor relação sinal-ruído e ainda foi feita a comparação à segmentação manual. A forma utilizada para diminuir a relação sinal-ruído foi através da reconstrução da imagem em conjuntos com menor número de projeções. A reconstrução com N projeções é o conjunto referência e N/2, N/4, N/8, N/16 e N/32 os subconjuntos esparsos.

A rede neural empregada foi a LinkNet ResNet 34, que apresentou resultados relevantes na detecção da região de interesse, mesmo em imagens com até oito vezes menos projeções do que o volume tomográfico original. A qualidade das segmentações foi mensurada pela métrica de similaridade de Dice (DSC), considerando tanto a segmentação manual quanto a automática.

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Correlated electronic and magnetooptical properties in quasi-2D structure of MnGaGe coatings prepared by magnetron sputtering.

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MnGaGe is a room-temperature ferromagnetic compound with a quasi-2D tetragonal crystal structure, studied in magneto-optical applications [1]. It has high saturation magnetization and high magnetocrystalline anisotropy [1], besides the observation of the anomalous Hall effect [2]. Its magnetic and electronic properties are relevant despite its low dimensionality [3], ideal for applications in spintronic devices. In a previous theoretical work [4], the correlation of its electronic structure with the magneto-optical properties in inter-band transitions was investigated, however, the spin-orbit coupling in the valence band (VB-SOC) has not yet been deeply studied experimentally. Thus, this work produced highly oriented MnGaGe samples in a series of four thicknesses in three different situations: individual nanoislands, coalescence, and bulk film on GaAs (001)-oriented surfaces, by sputtering. Therefore, to understand the correlation of these properties in the different coatings, X-ray absorption spectroscopy (XAS) analyses were performed on the 2p → 3d transitions (L3 and L2 edges) of manganese (Mn) at the IPE beamline, LNLS-Sirius. In addition to the multiplet pattern, there are differences in the relative intensities of the spectra according to the measurement angle (nearly parallel and perpendicular to the surface) and the thickness variation. In particular, these differences in the transitions at the L2 edge are more apparent. The branching ratio (BR) [5] was also verified, which provides information on VB-SOC and electrostatic interactions in the final state, with higher values for smaller thickness. The magnetooptical Kerr effect (MOKE) depends on inter-band transitions influenced by VB-SOC [4]. In parallel, changes in the magnetooptical effects of the samples in different hysteresis cycles obtained by polar MOKE were studied. The influence of anisotropic effects and the quasi-2D structure on the inter-band transitions on magneto-optics was investigated.

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Crystal Truncation Rod Study of a Multi-Quantum-Level System on the Surface of $MnBi_2Te_4$ Topological Insulator Thin Films

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Topological insulators are the subject of extensive scientific research and are considered particularly promising for state-of-the-art computational applications. Topological systems are commonly investigated using surface characterization techniques such as scanning tunneling microscopy and spectroscopy (STM/STS).

This work presents an analysis of Crystal Truncation Rods (CTRs), measured at the EMA beamline of the Sirius synchrotron, in thin films of $MnBi_2Te_4$ grown by molecular beam epitaxy (MBE). Morphological and surface characterization techniques were employed, including atomic force microscopy (AFM), Kelvin Probe Force Microscopy (KPFM), and scanning tunneling microscopy (STM). The presence of discrete electronic levels was determined by scanning tunneling spectroscopy (STS).

Finally, the results obtained from CTR fitting using a kinematical model revealed the presence of multiple surface terminations, with the coexistence of crystalline phases of $MnBi_2Te_4$, MnTe, Bi_2Te_3, and Bi_2. These phases form morphologically distinct structures, detectable by KPFM through the appearance of faceted nanostructures with different contact potential differences (CPD). Spectroscopic analysis further reveals confined electronic states emerging from a structural configuration consistent with a thin film with surface quantum dots, corroborating the se

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Quantitative dopant profiling in semiconductors: A new approach to Kelvin probe force microscopy; PhD thesis by Dr. Christine Baumgart

TUNNELING SPECTROSCOPY OF 2D MATERIALS: UNRAVELING THEIR DENSITY OF STATES AND THE RELATIONSHIP WITH LOCAL ATOMIC ENVIRONMENT; PhD thesis by Dr. Thaís Chagas

Decoding Chemical Dialogue at the Root-Fungus-Bacteria Interface via Synchrotron Imaging on a Microchip Platform

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Many plants, including strawberries, benefit from partnerships with arbuscular mycorrhizal fungi (AMF) and beneficial bacteria that improve nutrient use, stress resilience, and fruit quality. Silicon, a beneficial element for many species, further enhances these interactions, but the biochemical signals that drive cooperation or competition among partners in its presence remain poorly understood. To address this, we propose the SymbioChip, a custom microfluidic platform coupled with synchrotron infrared microspectroscopy at the IMBUIA beamline, to spatially resolve the molecular dialogue at the root-fungus-bacteria interface. The device is designed to mimic soil complexity, enabling controlled nutrient foraging by AMF and real-time monitoring of physiological responses such as hyphal branching and growth. Special emphasis is placed on silicon dynamics and the role of silicon-solubilizing bacteria in modulating fungal strategies and plant metabolism through carbohydrates and lipid pathways. By linking microfluidic engineering with high resolution spectroscopy, this work aims to open a new avenue for dissecting tripartite symbioses at the microscale and inspire the rational design of bioinoculants that reduce chemical inputs and promote sustainable strawberry cultivation.

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De morfologia animal à catálise: como a experiência com raios X em síncrotron permite atuar em diversas áreas.

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O Laboratório de Física Aplicada às Ciências Biomédicas e Ambientais (LAB_FisMed) é um laboratório focado em caracterização com radiação síncrotron e teve seu início focado em amostras biológicas, sendo que as técnicas majoritariamente utilizadas eram o espalhamento coerente e a microtomografia por raios X. Com a evolução dos síncrotrons e das técnicas o laboratório foi incorporando aplicações. Atualmente, as técnicas de tomografia, microfluorescência e difração de raios X são as mais utilizadas no LAB_FisMed e fazem parte de técnicas de maior expertise do grupo. Entretanto a técnicas como pticografia, espectroscopia de absorção, função de distribuição de pares de foram ou estão sendo incorporadas no escopo dos estudos, quando necessárias.

Os estudos de morfologia animal com foco em animais que podem ser modelos biológicos, no trabalho de descrição morfológica de espécies – sendo algumas raras – e em estudos de ciência e tecnologia de polímeros a utilização de tomografia com radiação síncrotron torna-se fundamental. Ainda no campo biológico, a técnica de microfluorescência é essencial para compreender não apenas a morfologia dos tecidos, mas também a distribuição dos elementos neles presentes. Serão apresentados resultados recentes da aplicação dessas técnicas em nossos projetos, com medições realizadas no SIRIUS (MOGNO e CARNAÚBA) e no ELETTRA (SYRMEP e TWIMIC).

Nos estudos moleculares de compostos para fotocatálise, materiais luminescentes e candidatos a novos fármacos são priorizadas caracterizações com difração e absorção de raios X. O LAB_FisMed também desenvolve essas linhas de pesquisa, incorporadas aos estudos de materiais não biológicos. Será apresentada a importância da técnica de absorção, especialmente no estudo de materiais amorfos, além de resultados apresentados a determinação de estrutura por difração com amostras em pó e não em monocristal. Apresentarei, por fim, resultados de difração e experimentos de absorção *operando* em fotocatálise.

CAPES, CNPQ, FAPERJ, CNPEM

SnO2-TiO2 materials for photocatalytic degradation of cationic dye under UV and visible light and a chitosan composite film investigation. CATALYSIS TODAY JCR, v. 444, p. 114995, 2025.

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Development of a Multipoint Probe with DS18B20 Sensors for Measuring Soil Heat Flux

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Soil heat flux is one of the elements that compose the surface energy balance, essential for understanding soil–atmosphere interactions and micrometeorological processes (HILLEL, 2004; CAMPBELL; NORMAN, 1998). This work aimed to develop a probe equipped with multiple digital temperature sensors from the DS18B20 model, arranged at depths of 2, 5, 10, 15, 20, 30, 40, and 50 cm, then followed by 20 cm intervals down to 10 m. The system was designed for integration with embedded platforms such as Raspberry Pi, allowing automated acquisition and continuous data storage in CSV format, allowing subsequent statistical analysis (HALFACREE; UPTON, 2016). The prior calibration of the sensors was carried out in a controlled thermal bath, using two CS108 sensors as reference to ensure measurement reliability and the application of thermal conduction models based on Fourier's law to estimate soil heat flux (BRISTOW; CAMPBELL, 1984). DS18B20 sensors are used in monitoring systems due to their ease of use and communication through the 1-Wire protocol (MAXIM INTEGRATED, 2015). These sensors are also suitable for soil temperature monitoring and applicable both in low-cost environmental monitoring systems (MANURUNG et al., 2023) and in IoT architectures associated with Raspberry Pi (DESHPANDE et al., 2022). The preliminary results demonstrated that the probe is capable of capturing daily and seasonal thermal variations, showing the attenuation and delay of the heat wave propagation as a function of depth. In addition, the low implementation cost, combined with ease of replication, reinforces the applicability potential of this technology in environmental monitoring experiments across different ecosystems, as well as in practical applications at precision agriculture.

This work is part of the project Micrometeorological Station for Precision Agriculture, Process FAPEMATPRO 000328/2023 and gives due thanks to the Mato Grosso State Research Support Foundation (FAPEMAT), the Postgraduate Program in Environmental Physics (PPGFA) and the Federal University of Mato Grosso (UFMT).

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Dynamics of magnetic and structural transitions in phase separated system

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The work used the Paineira X-ray diffraction line as a function of temperature aligned with electron magnetic resonance (EPR and FMR) measurements. The measurements collected on the family of Mott insulators strongly correlated LPCMO La5/8-yPrandThat3/8MnO3(y = 35, 40) illustrate structural transitions that can be correlated with magnetic transitions, presenting phase separation. In the measurements, we were able to see the coexistence behavior of different magnetic and structural phases. In the approximate range of (100 - 180) we have a coexistence of ferromagnetic (Pnma) and antiferromagnetic phases with charge ordering (P21/m), between (180 - 220) we have the majority presence of a paramagnetic phase with charge ordering (P21/m) and above 220 only paramagnetic (Pnma). Furthermore, it establishes the basis for a future study: we already proved that it is possible to control the magnetic structure using transport stimuli, possessing memory and volatility [1]. A promising future is the study of x-ray diffraction using current and voltage stimuli to investigate the correlation between electrical, magnetic and structural phenomena in this promising sample family for neuromorphic computing.

This study was mainly supported and performed under the auspices of the São Paulo Research Foundation (FAPESP) through Grant No. 2024/03819-5

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EFEITO PROTETOR DO LOSARTAN NAS ARTÉRIAS DE RATOS SUBMETIDOS À RADIOTERAPIA TORÁCICA

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A radioterapia é um tratamento essencial para o câncer de mama e outras neoplasias torácicas. No entanto, a exposição acidental do coração à radiação ionizante pode levar ao desenvolvimento de doenças cardíacas induzidas por radiação, que incluem pericardite, miocardiopatia e doença arterial coronariana. Estudos clínicos demonstraram que mulheres com câncer de mama submetidas à radioterapia adjuvante apresentam risco reduzido de recorrência local, mas aumento da mortalidade associada à doença arterial coronariana. Nesse contexto, a losartana tem sido investigada como agente protetor, devido ao seu papel como bloqueador do receptor da angiotensina II (BRA) [1].

Neste estudo, dezoito ratos Wistar saudáveis, com oito semanas de idade, foram alocados aleatoriamente em três grupos: controle, irradiados e irradiados tratados com losartana. Aos três meses de idade, os animais dos grupos irradiados foram submetidos a uma dose única de radiação direcionada à região cardíaca. O tratamento com losartana teve início um dia após a irradiação e foi administrado diariamente por dois meses. Após o período de tratamento, os animais foram anestesiados, eutanasiados e seus corações foram preparados para análise. A artéria coronária foi removida, seccionada e fixada em solução de formalina tamponada a 10%.

A microfluorescência de raios X (micro-XRF) foi utilizada para visualizar a distribuição espacial dos elementos químicos na amostra. A partir dos mapas elementares, é possível identificar alterações induzidas pela irradiação e avaliar se a losartana exerce efeito protetor na preservação da composição química do tecido arterial. Os experimentos foram realizados na linha de luz CARNAÚBA, utilizando energia de 10 keV, com o objetivo de analisar a distribuição de elementos como cálcio, ferro e zinco.

Os autores agradecem ao Laboratório Nacional de Luz Síncrotron (LNLS), parte do Centro Nacional de Pesquisa em Energia e Materiais (CNPEM), por fornecer acesso ao síncrotron Sirius e à linha de luz CARNAÚBA, sob a proposta nº 20222159.

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Efficient photocatalytic degradation of methylene blue using wet-chemically synthed CaSnO3 nanoparticles

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En este trabajo, se reporta la actividad fotocatalítica de nanopartículas de CaSnO3 para degradar azul de metileno (MB) en solución acuosa. Este estannato fue obtenido por el método del precursor polimérico. Para los estudios de degradación fotocatalítica bajo irradiación UV, se diseñaron suspensiones de MB-CaSnO3-NP de 14 ppm–14 ppm, 14 ppm–100 ppm, 14 ppm–500 ppm, 9 ppm–100 ppm, 9 ppm–500 ppm, 7 ppm–100 ppm y 7 ppm–500 ppm y estas fueron utilizadas para realizar las pruebas. Los resultados mostraron que el azul de metileno (9 ppm) fue adsorbido más fácilmente en CaSnO3 (500 ppm) activado por irradiación con una lámpara de Hg, que en CaSnO3 en la oscuridad con tiempos de contacto entre 10 minutos y 150 minutos. La tasa de remoción fue aproximadamente del 76% para CaSnO3 irradiado. La cinética del proceso se describió adecuadamente mediante una ecuación de pseudo-segundo orden; la difusión fue intrapartícula y los modelos de Freundlich y Langmuir describieron satisfactoriamente la adsorción de azul de metileno sobre las nanopartículas sintetizadas.

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Enhancing Spatial Resolution in Infrared Microspectroscopy Through Experimental PSF Estimation

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Infrared (IR) microscopy is a label-free tool for chemical imaging of complex materials and biological specimens, yet its spatial resolution is constrained by diffraction. This limitation blurs fine structural details, hindering interpretation in cases where features sizes fall below mid-IR wavelengths.

We present a method for retrieving the point spread function (PSF) of IR microscopes directly from experimental data, enabling informed image deconvolution without hardware modification. Usually in visible confocal microscopy, fluorescent beads are used for PSF estimation, however for infrared microspectroscopy this method is not possible. Our approach reconstructs the PSF by acquiring images of metallic edges at multiple orientations and applying an Inverse Radon Transform to the set of edge derivatives. The retrieved PSF is then used in deblurring algorithms, like Lucy–Richardson, to enhance resolution beyond the diffraction limit. Validation was performed through simulations and experimental measurements in reflection/transreflection geometry using an Agilent Cary 600 microscope with a 25× objective (NA:0.81). The edges and a dot pattern sample were prepared by photolithography with sputtered Au/Cr. All scripts were programmed in python. Preliminary tests were performed at IMBUIA-micro with artificial (dot pattern) and biological samples (zebrafish, *Dapnhia* and fibroblasts).

The major drawback of the method lies in the acquisition time required to capture multiple edge orientations, especially if extended to 3D PSF retrieval via z-stacking. However, this calibration needs to be repeated occasionally if the optical bench is stable. Another limitation is that the method retrieves a global PSF, without capturing local aberrations. Nonetheless, the technique is wavelength-independent and broadly applicable to different imaging systems. Future work will focus on reducing acquisition time and identifying sample classes that benefit from this method.

We would like to acknowledge the IMBUIA beamline and GCC from LNLS-CNPEM for the experiments and theoretical support, the Microfabrication and Microfluidics Laboratory from LNNano-CNPEM for the pattern fabrication and IFSC-USP for the financial support.

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Essential Oils as a Promising Strategy Against *Aedes aegypti*: Insights from Synchrotron Micro-CT

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This study employed synchrotron radiation micro-computed tomography (SR-micro-CT) at the MOGNO beamline of the Sirius synchrotron to investigate the effects of coumarin and thymol essential oils on *Aedes aegypti* mosquitoes. For biological samples, especially soft tissues like those found in insects, traditional absorption-based X-ray imaging often provides insufficient contrast [1]. Therefore, phase-contrast imaging is crucial, as it significantly enhances the visibility of these delicate structures by exploiting the phase shifts induced in X-rays as they pass through different materials [2]. SR-micro-CT images of *A. aegypti* were acquired at the MOGNO beamline using a mean energy of 22 keV with a sample-detector distance of 69.8 mm and effective pixel sizes of 1.27 µm and 500 nm (nanostation). All samples were measured immersed in absolute ethanol. Our findings reveal that coumarin and thymol essential oils, at concentrations of 25 ppm and 30 ppm, induce significant structural collapse and disorganization within the mosquito's internal anatomy, compared to untreated adult controls. High-resolution imaging, including data from the nanostation, provided detailed insights into the tissue degradation caused by the essential oils. These results highlight the potential of coumarin and thymol as effective, environmentally friendly alternatives for *A. aegypti* control, offering a deeper understanding of their larvicidal mechanism. This research contributes to developing sustainable vector management strategies and underscores the value of advanced synchrotron imaging in entomological studies.

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Esteato-Chip: A microfluidic 3D model for investigating NAFLD with FTIR imaging at IMBUIA

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Non-Alcoholic Fatty Liver Disease (NAFLD) is one of the most prevalent liver disorders worldwide, closely linked to obesity and metabolic syndrome, and may progress to cirrhosis and hepatocellular carcinoma. Understanding its mechanisms requires advanced in vitro systems able to recapitulate human pathophysiology.

We developed the Esteato-Chip, using a commercial microfluidic platform, integrating 3D liver spheroids (HepaRG + hepatic stellate cells) and white adipose tissue (WAT) organoids under dynamic perfusion. Within 72 hours, exposure to WAT-derived signaling triggered steatosis in hepatocytes, especially under pro-inflammatory conditions, evidenced by increased lipid accumulation, triglyceride content, AST release, upregulation of PLIN2 and LSS, and inflammatory cytokines (IFN-γ, IL-6, IL-1). This platform successfully reproduced key features of adipose–liver crosstalk and disease progression.

To achieve deeper insights into disease mechanisms, Fourier Transform Infrared (FTIR) spectroscopy at the IMBUIA beamline (Sirius/LNLS-CNPEM) was employed. This label-free and non-destructive chemical imaging of intact spheroids revealed spatially resolved lipid distribution and associated biochemical alterations. FTIR provided a powerful tool to monitor disease stage, complementing conventional assays and enhancing the characterization of the model.

In conclusion, the Esteato-Chip provides a robust and versatile platform to investigate NAFLD, while FTIR spectroscopy added unique, label-free insights into lipid distribution and biochemical alterations. Together, these approaches expand the range of tools available for understanding disease mechanisms and for evaluating therapeutic strategies in metabolic liver disorders.

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Ex situ synchrotron investigation of heterostructured Cerium metal-organic framework photocatalyst systems

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Developing new materials for improved resource management and waste treatment has been a major focus in the scientific community for decades. A key part of this effort is investigating materials that can better use sunlight for photocatalysis. Metal-Organic Frameworks (MOFs), with their flexible reticular design, can be used to create heterostructured materials and composites. This unique ability, combined with their exceptional surface properties and active sites, makes MOFs highly promising for augmented catalysis (1).

Ce-MOFs, more specifically, are suitable for this flexible approach due to the rich coordination chemistry of Ln ions, variations on coordination number and coordination modes, and minor changes on the synthesis conditions reflect on distinct frameworks (2). Moreover, Ce-MOFs context within the UiO-66 defective archetype, Ce redox pairs and spontaneous ligand-to-metal charge transfer are attributes that give rise to plenty of heterogeneity and charge transfer pathways when combined with exogenous nanoparticle phases (3, 4).

Our group has been synthesizing and investigating these novel materials by probing the Ce electronic structure through X-ray Absorption Spectroscopy and crystalline structure using High-resolution X-ray Diffraction at XAFS/Elettra and ID31/ESRF, respectively. The results are meaningful for the ex situ probing of synthesis-related phase transitions, which induce enhanced photocatalytic activity on antibiotic degradation and selectivity on CO2 photoreduction. The development of the QUATI beamline is anticipated to provide opportunities for a more comprehensive investigation of correlations of synthesis-properties-activity of the materials and in situ measurements.

We thank FAPERJ, CNPq and CAPES for the funding. NEPHEWS for the financial assitance on the XAS measurements. We acknowledge the European Synchrotron Facility (ESRF)/ID31 and Elettra/XAFs beamline Transfer for provision of synchrotron radiation facilities. We also acknowledge Momentum Transfer for facilitating the ID31 measurements.

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3. https://doi.org/10.1021/jacs.8b03613

4. https://doi.org/10.1016/j.mtchem.2022.101337

From Conventional CT to Synchrotron Perspectives: Advancing the Study of Female Genitalia in Rare Spiders

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Male pedipalps and female genitalia are key traits for distinguishing spider species and inferring phylogenetic relationships. In Entelegynae, male pedipalps are well studied, while female genitalia remain neglected due to their internal position and the difficulty of visualizing ducts and soft tissues. Knowledge is mostly limited to the sclerotized epigynum, while unsclerotized parts are virtually unknown. Thus, female characters are often absent from analyses, creating imbalance in spider systematics.

Corinninae is a diverse Neotropical group where species richness parallels striking genitalic variation. Despite rarity in collections, they provide opportunities to expand morphological knowledge. Female genitalia, still underexplored, display remarkable diversity with high diagnostic and phylogenetic value.

Within the Stethorrhagus complex, some species show unique traits not found elsewhere in Entelegynae, such as a copulatory chamber and a glandular sternum structure of unknown function. These features highlight the group's potential for studies on homology, functional morphology, and evolutionary novelties.

Previous tests with a conventional micro-CT (Baker-Hughes V|tome|X M Nano-CT) imaged 7 specimens but failed to resolve internal structures due to resolution limits. Using Sirius, the Brazilian 4th-generation synchrotron, we aim to obtain the first detailed 3D descriptions of female genitalia in Corinninae, focusing on the Stethorrhagus complex, through synchrotron-based X-ray microtomography. We will test whether internal structures include synapomorphies clarifying relationships and revealing innovations.

We expect to establish standardized genital characters for taxonomy and phylogenetics. Novel features, such as glandular or muscular connections with ovaries, may emerge as diagnostic. These results will validate our hypothesis, reinforce the female genitalia as key evolutionary evidence, and demonstrate the value of synchrotron imaging in arthropod research.

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High Pressure Single Crystal and Powder X-ray Diffraction comparative study in metal halide Rb2InCl5.H2O perovskite

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This work presents a comparative study of the high-pressure structural evolution of the fully inorganic perovskite-like material Rb2InCl5·H2O using single-crystal and powder X-ray diffraction at EMA beamline. The experiments were designed to verify possible phase transitions observed in pressure dependent Raman study. One of the objectives of this research is to explore the resolving power of SCXRD to definitively characterize the pressure-induced structural modulations of the material.

This study was partially financed by the Brazilian Agencies CAPES (Finance Code 001), FUNCAP (PRONEX PR2-0101-00006.01.00/15, Rede Verdes 07548003/2023), and CNPq (Grants No. 407954/2022-8, 407956/2022-0, INCT MatFerrce 406322/2022-8).

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High pressure study of the halide perovskite Rb3BiCl6.

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Recently, materials with composition of the form A_3BiX_6 have also been gaining attention from the scientific community. These compounds exhibit zero-dimensional perovskite structures, enhancing the quantum confinement effects that favor radiative combination of excitons, causing the appearance of luminescent properties and creating a possible path for the application of these compounds as materials for LED fabrication. In this work, we synthesized the Bismuth-based halide perovskite $Rb_3BiCl_6.0.35[H_2O]$ which its crystal structure adopts an orthorhombic space group Pbnm (number 62) with cell parameters a = 8.1583(3) Å, b = 12.8072(3) Å and c = 25.4587 in the ambient pressure phase. To further understand the structural properties of the $Rb_3BiCl_6.0.35[H_2O]$, we employed pressure dependent Raman spectroscopy and powder X-rays diffraction with the aid of synchrotron radiation. Before the start of the experiment, we compared the diffraction pattern calculated from the structure obtained by single crystal X-rays diffraction and the pattern obtained experimentally with the sample loaded into de diamond anvil cell (DAC) with a residual pressure of 0.3 GPa. This comparison suggests that this residual pressure is enough to induce a structural phase transition from the room pressure phase. Besides this phase transition, we also observed another one at 2.5 GPa, also seen in both experiments.

This work was possible due to the financial resources obtained by CAPES, CNPq and Universidade Federal do Ceará.

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High-Resolution 3D imaging of floral vascularization: Insights into meristc variation and organ fasciation in Solanum species

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Although traditional vascular reconstruction is valuable for understand plant morphological variation, it is often laborious and time-consuming. In this context, Synchrotron X-ray computed nanotomography (SXRCT) emerges as a non-destructive, high-resolution technique for three-dimensional visualization of plant tissues. This is particularly advantageous for investigating floral vascularization. We employed SXRCT to reconstruct the vascular bundles in *Solanum hexandrum* and *Solanum sublentum* (Solanaceae) flowers, two species exhibiting meristic lability across whorls. Buds (<7mm) were treated with a 1% phosphotungstic acid solution (30 days) [1], dehydrated in ethanol series, dried with a Bal-Tec CPD 030 critical point dryer, and mounted on metal stubs using a thermoplastic polymer. Scanning was performed at the MOGNO beamline (Sirius) [2]. Projection data were acquired with a 2048 × 2048-pixel sCMOS detector and a 3× objective lens. Samples were scanned in fly-scan mode, with projections collected over 360° and exposure of 0.6 s. Average scanning time was about 15 min. Images were reconstructed using an in-house implementation of the FDK algorithm. Amira-Avizo 3D 2024.2 software was used for visualization. Reconstructions revealed that supernumerary organs have distinct vascular bundles and that meristic variation is consistent across whorls, with organ numbers remaining stable among the different whorls of a single flower. In cases where an organ was absent in a whorl, residual vascular traces were still evident in the vascular reconstruction. Furthermore, fused anthers in some *S. hexandrum* variants contained two vascular bundles, and its organization could be clearly seen in the whorl, shedding light on the fasciated organs in this species. Overall, this technique proved to be valuable and efficient to endorse the comprehension of atypical floral architectures, representing new possibilities for integrative morphological and developmental studies in flowers.

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In situ and *Operando* Study of Reversible Metal Exsolution in High Entropy Oxides During Ethanol Steam Reforming

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Hydrogen (H_2) is a key energy carrier for a carbon-neutral future, and ethanol steam reforming (ESR) offers a sustainable route for producing clean H_2 using bioethanol. However, large-scale application requires catalysts with enhanced kinetics, coke resistance, and long-term stability. High-entropy oxides (HEOs) with fluorite structure combine thermal stability with tunable defect chemistry, offering a promising platform for ESR catalysis. We investigated undoped and Ru/Ni-doped $Ce_{0.20}La_{0.20}Nd_{0.20}Mg_{0.20}Ca_{0.20}O_{2-\delta}$ fluorite HEOs under redox and ESR conditions using *ex situ*, *in situ*, and operando synchrotron PXRD. *Ex situ* PXRD confirmed single-phase defective fluorites with oxygen-vacancy-driven lattice expansion. Under pure H_2 at 800 °C, Ru- and Ni-doped HEOs showed suppression of the fluorite (111) peak and metal exsolution, strongly coupled to the oxide matrix. These transformations were reversible, as re-oxidation reincorporated Ru or Ni into the lattice. Operando PXRD during ESR revealed divergent pathways: the undoped HEO re-oxidized with vacancy annihilation, while Ru/Ni-doped systems preserved oxygen vacancies and retained exsolved nanoparticles, enabling stable redox cycling under reforming. This adaptability, arising from entropy stabilization, defect chemistry, and reversible exsolution, confers resistance to sintering and coke formation. Our findings highlight reversible exsolution in fluorite HEOs as a design principle for adaptive, durable catalysts for renewable H_2 production.

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In Situ Probing of Structural and Electronic Transformations Driving Iridium Nanoparticle Exsolution

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The exsolution of transition-metal nanoparticles from perovskite oxides (POs) offers a powerful route to design electrocatalysts with enhanced activity and stability. Iridium-based nanoparticles (NPs) are particularly attractive for the oxygen evolution reaction (OER) and understanding their nucleation and growth mechanisms is important to optimize performance while minimizing Ir usage. At LNLS, we combine complementary synchrotron techniques to investigate the exsolution of Ir from Strontium Titanate Perovskite. At the Paineira beamline, in situ powder X-ray diffraction (XRD) enables monitoring of lattice parameter shifts, strain evolution, and phase transformations under reducing and inert atmospheres, allowing us to decouple thermal effects from redox-driven exsolution and to quantify the role of Fe doping in lowering the exsolution onset temperature. In parallel, quasi in situ X-ray photoelectron spectroscopy (XPS) at the Ipê beamline provides element-specific insight into the redox evolution of Sr, Ti, Fe, Ir, and O during stepwise heating up to 700 °C in H2/He atmosphere, revealing the onset of Ir reduction (Ir3+ -> Ir0), electronic reorganization in the PO matrix, and binding energy shifts correlated with NP nucleation. This integrated structural and spectroscopic approach establishes a direct correlation between bulk lattice rearrangements and surface electronic changes, offering mechanistic resolution of diffusion, reduction, nucleation, and growth stages of exsolution. These results provide important guidelines for tuning dopant chemistry, defect distribution, and thermal protocols to engineer socketed Ir NPs with superior anchoring and durability, paving the way for the rational design of highly active, stable, and cost-efficient OER electrocatalysts.

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In-Situ Spatially Resolved Co and Cu K-Edge XANES of Co_3O_4/Cu_xO Catalysts for Electrochemical Nitrate-to-Ammonia Conversion

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Ammonia production is vital for agriculture and energy applications, but conventional synthesis via Haber–Bosch is highly energy-intensive and a major contributor to global greenhouse gas emissions, highlighting the urgency of greener pathways [1]. Electrochemical nitrate reduction (NO_3RR) represents a sustainable alternative, powered by electricity from renewable sources [2]. Cobalt–copper dual-site catalysts have shown promising activity, selectivity, and durability for this reaction [3]. Here, we developed a Co_3O_4/Cu_xO_y electrocatalyst, achieving improved selectivity toward NH_3 formation. *In situ* spatially resolved Co and Cu K-edge XANES were performed at the Carnaúba beamline under OCP and at the potential of maximum Faradaic efficiency (-0.2 V_{RHE}, 94.4 ± 3.1%). Principal Component Analysis (PCA) was used to reconstruct pixel-resolved spectra from X-ray fluorescence (XRF) image stacks of the Co and Cu K-edge XANES [4]. The results revealed the heterogeneous character of the catalyst and the presence of mixed-phase domains. Complementary punctual XANES confirmed these observations, showing decreased Co pre-edge intensity under reductive potentials and a progressive increase in metallic Cu content. The comparison of mapping and punctual measurements with a nanoprobe provides a powerful means to uncover heterogeneities and directly correlate structural evolution with electrochemical performance.

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In situ strain analysis by synchrotron X-ray diffraction, the digital Image correlation technique, and its implementation at PAINEIRA

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Combining stress–strain analysis with X-ray diffraction (XRD) provides valuable insights into how a material's crystalline structure responds to mechanical stress and the resulting macroscopic strain. Synchrotron laboratories such as Bessy II [1], Petra III [2], Soleil [3], APS [4], Max IV [5], ESRF [6] and Chess [7] offer experimental setups for mechanical strain. The EMA beam line at Sirius currently provides this setup[8] and the Canadian Light Source is now implementing it. Each beamline has its own specificities, requiring tailored setups. In this context, the PAINEIRA beamline at Sirius offers both high-resolution and fast acquisition modes. This allows precise analysis of hard materials such as ceramics, which may deform by as little as 0.01% before fracture, requiring high resolution to yield meaningful results. At the same time, PAINEIRA also addresses challenges such as material relaxation, requiring fast acquisition. Nevertheless, it is increasingly critical that strain measurements be accurate and reflect the actual probed region of the sample. In this context, digital image correlation (DIC) has proven highly useful and is being progressively adopted [3–7]. DIC analyzes sample deformation by comparing successive images, dividing them into subsets, and quantifying the displacement and strain of each one. This enables strain measurement specifically within the region illuminated by the X-ray beam, rather than relying on the global deformation typically inferred from the displacement applied by the loading device. Since DIC requires mainly a camera to monitor the sample, and Sirius already provides the necessary mechanical loading equipment[8], this project aims to implement at PAINEIRA an integrated system for in-situ XRD combined with DIC. The work details the designed coupling between the load device and the beamline diffractometer, and describes possible camera mounting positions that enable imaging without obstructing the X-ray beam.

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In-situ X-ray powder diffraction studies of new electrode materials for symmetrical solid oxide fuel cells: phase transitions and chemical stability under both cathodic and anodic conditions

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Solid oxide fuel cells (SOFCs) are efficient electrochemical devices for power generation, offering low environmental impact and flexibility in fuel choice [1-3]. Conventional SOFCs operate at very high temperatures (900–1000°C), but recent efforts aim to lower operating temperatures without sacrificing performance. Intermediate-temperature SOFCs (IT-SOFCs), running between 500 and 800°C, are promising candidates, particularly when electrode materials with mixed ionic–electronic conduction (MIECs) are used. A further advance is the development of symmetrical SOFCs (S-SOFCs), which employ the same material for both electrodes. This configuration addresses technological challenges such as thermal compatibility, fabrication cost, and device maintenance. It also allows reversing the gas input between anode and cathode, helping oxidize carbon deposits during hydrocarbon operation at low temperature. However, S-SOFCs impose stricter requirements on electrode materials, which must function efficiently in both anodic and cathodic roles, maintain electrical conductivity, and exhibit thermal expansion compatible with the electrolyte in both oxidizing and reducing environments.

One strategy to design new electrodes involves evaluating $A(B,B')O_{3-\delta}$ perovskites and $A_2(B,B')_2O_{6-\delta}$ double perovskites, selecting B and B' cations for their stability and catalytic activity. For example, B = Co, Fe, or Mn, with high activity for oxygen reduction, can be combined with B' = Cr, Ti, or Mo, which promote fuel oxidation.

We report in-situ X-ray powder diffraction studies of $Sr_2Co_{2-x}Mo_xO_{6-\delta}$ and $Sr_2Fe_{2-x}Mo_xO_{6-\delta}$ double perovskites. Co- and Fe-rich phases showed good cathodic performance, while Mo enhanced anodic behavior. Tests under both atmospheres up to 800 °C at the PAINEIRA beamline (Sirius, LNLS-CNPEM) revealed stability issues for compositions with $x \approx 1$, relevant for S-SOFCs. To address this, additional B-site cations such as Ni or Cu are being investigated.

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Integration of the high-pressure sample preparation for Oil & Gas experiments at Porous Media support Laboratory and users of the Mogno beamline

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In oil and gas science, coreflooding experiments are typical and commonly used to understand reservoir behavior. These studies are important for both improving oil recovery and mitigating environmental damage and carbon storage. Currently, carbon storage is the main focus of researchers to reduce the carbon footprint of this sector.

However, coreflooding experiments require complex and time-consuming sample preparation. Mogno beamline is developing a laboratory equipped for this sample preparation, including high-pressure and high-temperature aging. This work will present static and dynamic sample aging processes and coreflooding experiments, as well as the infrastructure that will be available for users to perform these procedures. The aging process is performed in a coreflooding apparatus consisting of a coreholder, fluid accumulators, injection pumps, and pressure transducers capable of operating at conditions up to 1000 bar and 90°C. The entire apparatus will be set up inside a walk-in hood, enabling users to use complex fluids such as live oil in the sample aging process. The assembled structure will also allow users to perform coreflooding experiments under the same temperature and pressure conditions using complex fluids and gases. The pressure, temperature, and complex fluid conditions achieved in this laboratory will enable users to conduct research under conditions analogous to those found in Brazilian pre-salt reservoirs.

The purpose of the Porous Media Laboratory, therefore, will be to serve users of the Mogno beamline who require specific sample preparation for oil and gas experiments and similar tests to those of the beamline, both under pressure and temperature conditions of Brazilian pre-salt reservoirs.

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Investigation of Inorganic Nanostructured Sunscreens Formulated with Amazonian Rainforest Oils

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Inorganic sunscreens containing titanium dioxide (TiO_2) nanoparticles provide key advantages, including photostability, broad-spectrum UV protection, and low allergenic potential [1]. To enhance multifunctionality, Amazonian oils and butters such as ucuuba butter, pracaxi oil, and coconut oil were incorporated into formulations due to their antifungal, antibacterial, anti-inflammatory, and moisturizing properties. This study aimed to develop TiO_2-based nanostructured sunscreen formulations and to investigate the influence of oil type and surfactant concentration on liquid crystalline organization and cosmetic performance. Formulations were prepared from ternary mixtures of water, oil, and Tween 80 (30–40%), with oil phases ranging from 10–40%. TiO_2 nanoparticles were incorporated at 15%. Structural characterization was carried out using small-angle X-ray scattering (SAXS), polarized light microscopy, and rheology, while cosmetic performance was evaluated through in vitro occlusion tests. SAXS confirmed the presence of liquid crystalline mesophases, including hexagonal and cubic structures, depending on oil/surfactant ratios. Higher surfactant levels enhanced pseudoplastic behavior, a desirable feature in topical formulations that prevents dripping during application, while increased oil content improved occlusive capacity through hydrophobic film formation [2]. Pracaxi oil formulations showed an additional occlusive effect upon TiO_2 incorporation, whereas coconut oil systems displayed structural modifications suggestive of core–shell micellar organization. The developed formulations demonstrated strong potential as multifunctional sunscreens, combining effective photoprotection with favorable cosmetic properties, making them suitable for sensitive skin and as promising delivery systems.

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Linking soil pore architecture assessed by synchrotron X-ray computed tomography to nitrous oxide pathways under land use systems in the Amazon biome

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Soil structure is a dynamic property strongly influenced by soil management, directly affecting biogeochemical cycling of greenhouse gases such as nitrous oxide (N_2O). Here, we evaluated how long-term land use systems influence soil pore architecture and N_2O production pathways in a tropical Amazonian soil. The study was conducted in a 12-year field experiment following three systems: (i) crop-succession, (ii) integrated crop-livestock system, and a (iii) well-managed pasture. Synchrotron-based X-ray computed microtomography (SRXCT) was used to characterize micro-scale pore architecture, while incubation experiments measured N_2O emissions. Soil aggregates (6 mm in diameter) were scanned using a SRXCT at the MOGNO beamline of Sirius, operating at 22 keV with indirect photon detection via a 2x objective lens, achieving an effective pixel size of 3.35 µm. 3D image analysis, including reconstruction, segmentation, and quantifications, was conducted using Annotat3D, AVIZO, and Fiji software. Results show that, at the micro-scale, the fraction of pores between 10-30 µm (in diameter) and global average pore distance were key drivers in N_2O production by promoting anaerobic microsites favorable to denitrification. The integrated crop-livestock system showed the highest N_2O emissions, attributed to elevated nitrate availability, a greater fraction of 10-30 µm pores, higher global average pore distances, and more connected pore networks. Overall, our findings demonstrate that N_2O production and emissions are fundamentally regulated by soil pore architecture, influencing oxygen availability, microbial activity, and the spatial distribution of nitrogen substrates. These results underscore the impact of soil pore heterogeneity mediating N_2O emissions and reinforce the importance of land use strategies that consider the micro-scale to support climate-resilient agriculture in tropical systems.

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Magnetic Affinity-Based Purification of His-Tagged Proteins Using Ni^{2+}-Functionalized Nanoparticles: Insights from FTIR and Circular Dichroism at Sirius

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Magnetic nanoparticles (MNPs) offer an excellent alternative for protein purification due to their unique properties, such as rapid separation, superparamagnetism, and a high surface-to-volume ratio that facilitates nanoscale functionalization. MNPs provide a fast, efficient, and sustainable method [1, 2].

A key aspect is understanding biomolecule-nanoparticle interactions and ensuring structural preservation. We combined SEM, Micro-FTIR, and circular dichroism (CD) techniques at Sirius, specifically at the IMBUIA-MICRO and CEDRO beamlines. These analyses confirmed binding of proteins to Ni^{2+}-functionalized MNPs and, importantly,showed that the purified proteins retained their secondary structure,.demonstrating the unique value of Sirius techniques to simultaneously probe binding and structural preservation in nanobiointerfaces.

MNPs showed high specificity for His-tagged proteins: selective retention and imidazole-mediated elution from pre-purified samples and complex E. coli lysates; assays with BSA and His6 protein A confirmed selectivity. Furthermore, a scaled-up protocol using 4 mL of lysate yielded approximately 0.6 mg/mL of purified protein, doubling the output obtained via conventional immobilized metal affinity chromatography, while preserving purity. Moreover, the enzymes isolated through this method retained their native biological activity, highlighting the efficiency and reliability of this alternative strategy for protein purification.

Altogether, this study highlights the potential of combining magnetic nanotechnology with advanced spectroscopic techniques available at Sirius to establish a robust, efficient, and scalable platform for protein purification. The simplicity, efficiency, and cost-effectiveness of this method render it a powerful tool for both analytical and preparative-scale protein purification, particularly in low-resource or high-throughput settings.

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Mechanisms of Foliar Uptake of Tannin-Based Colloids for Controlled Nutrient Delivery in Plants.

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The multifunctional properties of polymer-based materials position them as promising candidates for agricultural applications, particularly due to their tunable physical features such as porosity, permeability, diffusivity, chemical reactivity, and stability. In this work, Tannic acid–polyoxypropylene diamine colloids (TAPOL) were synthesized as bioadhesive, carriers for foliar nutrient delivery. TAPOL stable aqueous colloidal complexes were obtained at room temperature by varying the concentrations of polyphenol and diamine stock solutions.1 The pH of the resulting systems was controlled, and their optical properties, particularly opacity, were evaluated to characterize their colloidal nature—consisting of particles small enough to remain suspended yet large enough to scatter light. TAPOL samples show no phytotoxic activity towards the plant cells as there is no evidence for leaf burn or necrosis upon treatment with these formulations. A preliminar data collect from Scanning electron microscopy (SEM) images showed the presence of colloids in trichomes on the adaxial surface of cucumber leaves after applying TAPOL formulations. Surface adhesion and film formation were further evaluated on silicon slides and leaf surfaces, confirming the formation of a thin polymeric film capable of acting as nutrient delivery system. The ability of these complexes to form and be absorbed as polymeric films on leaf surfaces demonstrates their potential as efficient carriers for foliar nutrient delivery. TAPOL colloids were loaded with Fe3+ confirmed by UV-vis spectroscopy (presence of a band at 530 nm). However, the mechanisms underlying foliar penetration, transport pathways (stomatal vs. cuticular), and internal distribution of these colloids remain unknown. Finally, synchrotron radiation is essential to track iron-loaded TAPOL colloids in cucumber leaves at subcellular resolution by complementary experiments at the CARNAÚBA beamline (proposal under review).

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Modulating exsolution dynamics through composition control in high-entropy spinel oxides

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By utilizing entropy as the driving force for engineering oxide materials, the deviation from traditional prediction methods and principles offers a path for new structure–property relations to be discovered. The multi-cation approach inherent to high-entropy oxides (HEOs) allows for tailoring their properties, offering significant opportunities for functional material applications. The intrinsic disorder of HEOs provides an environment where specific elements or phases can segregate from the crystal lattice through exsolution, a process commonly triggered by thermal or chemical treatments. This phenomenon can be compositionally tuned by the high configurational entropy of the oxide matrix, where subtle variations in cation chemistry and oxidation states influence the nucleation and growth of exsolved phases. The tuning of the surface reactivity of exsolved particles can provide promising materials for catalysis, energy conversion, and electronic applications. Here, we have synthesized a series of HEOs in a spinel structure (AB_2O_4) based on 1st-row transition metals (*i.e.*, A site = Co, Ni, Cu; and B site = Cr, Mn, Fe). PXRD measurements were conducted to confirm the formation of single-phase spinel oxides. The exsolution process, in which the A site metals partially or completely leave the spinel lattice, was tracked by *in situ* time-resolved PXRD under reducing atmosphere. We were able to verify that the exsolution process was directly impacted by tuning the B site with different ratios of Cr, Mn, and Fe (*i.e.*, $Cr_{0.5}Mn_{0.5}$, $Cr_{0.5}Fe_{0.5}$, $Mn_{0.5}Fe_{0.5}$, and $Cr_{0.33}Mn_{0.33}Fe_{0.33}$) and keeping the A site constant (*i.e.*, $Cu_{0.33}Ni_{0.33}Co_{0.33}$). HR-TEM/EDS images evidenced the exsolution of trimetallic particles composed of Cu, Ni, and Co, with partial migration of Cu to the exsolved particles at 700 °C. In summary, we demonstrated that optimizing the composition influences exsolution mechanisms by modulating the interplay between entropy and disorder.

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MOGNO Beamline Synchrotron-Based X-Ray Microtomography Applied to Herpetological and Embryological Research

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The introduction of micro-CT techniques in fields of vertebrate zoology, here in special herpetology (study of amphibians and reptiles), was a groundbreaking event, allowing new looks on old problems and even new opportunities of research. The different tissues and organs may source a wide amount of information of different natures, and in this sense and less explored are the ultrastructural and developmental analyses. During a MOGNO commissioning project, we performed a study using two different embryos: an embryo of the direct-developing frog *Eleutherodactylus cochranae*, species without larval phase and another of the viviparous skink *Brasiliscincus agilis*, species that retains the eggs and developing embryos inside the female's body until development is complete. Although SRμCT has been used in descriptive research involving herpetofauna members, developmental studies were carried out only recently. The mineralized structures like bones were more easily observable in both specimens. We identified different bones like the cranial, the appendicular and the axial ones and their state of development. MOGNO beamline also allowed the discrimination of soft tissues. For both samples, we observed in detail the eye and its subunits, such as lens, cornea, retina and their layers and the whole central nervous system, including the brain and some nerves. Specific tissues could be better visualized in only one of the specimens, in *B. agilis* we identified the heart, whereas in *E. cochranae* observed structures of digestive system. The number of studies applying SR-μCT to study embryos and larvae, their development and organogenesis are still scarce. The production of protocols and methodology to measure this type of specimen may open the doors to the use of other model animals among members of herpetofauna in different types of studies and help to reveal more about the biology of these organisms, with applications in morphology, physiology, ecology and evolutionary studies.

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Morphology and chemical composition of biomass burning aerosols

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The chemical and elemental characterization of atmospheric aerosols is essential for understanding their impacts on climate, air quality, and human health[1]. Aerosols derived from biogenic emissions and biomass burning exhibit a complex chemical composition, encompassing a wide range of organic functional groups and trace elements that influence their optical and hygroscopic properties[2,3]. Advanced analytical techniques such as Scanning X-ray Transmission Microscopy (STXM) enable the investigation of the organic and inorganic chemical composition of the carbonaceous fraction of aerosols with nanometric spatial resolution, while synchrotron-based nano–X-ray fluorescence (nano-XRF)[4] provides highly sensitive and accurate elemental maps. The combination of these approaches offers a detailed perspective on the composition of individual particles, allowing for the assessment of their heterogeneity and inference of the atmospheric processes they undergo. Ultimately, this knowledge contributes to improving current atmospheric models.

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Optimizing AFM Tip Geometry for Near-Field Interactions in Nanophotonics: Enhancing IR and THz Response through Modeling

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This project aims to develop an advanced numerical model to study nanophotonic phenomena in two-dimensional (2D) materials, focusing on photonic crystals such as hexagonal boron nitride (hBN) and molybdenum trioxide (MoO_3)[1]. The goal is to accurately predict results from scattering-type scanning near-field optical microscopy (s-SNOM) experiments[2] and directly support the design of optimized s-SNOM tips, a key component in nanophotonics research. Unlike traditional theoretical models, this approach accounts for realistic factors—such as surface roughness, defects, and chemical heterogeneity—that significantly affect tip behavior during measurements. These factors are complex to model analytically and require robust numerical simulation to be realistically represented.

Using COMSOL Multiphysics, simulations include both tip geometry and its interaction with the target materials, allowing for accurate modeling under experimental conditions[3]. The resulting electromagnetic fields undergo post-processing through demodulation, a crucial step to extract higher-order harmonics and enable meaningful comparisons with experimental data. This also provides deeper insights into sub-diffraction wave confinement, expanding the applicability of s-SNOM.

The project goes beyond understanding polaritonic phenomena; it also aims to optimize tip performance for infrared and THz spectroscopy applications. By enabling highly accurate modeling, the project becomes a powerful predictive tool, capable of revealing behaviors previously unobservable or unreliable in simulations. As such, it serves as a foundation for the design and fabrication of high-performance s-SNOM tips. The expected outcomes not only enhance current experimental efficiency but also drive innovation in the field of nanophotonics.

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Porous media study with simultaneous NMR and X-ray tomography experiments using synchrotron light

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The fourth-generation synchrotron at LNLS/Sirius delivers low- to high-energy X-rays with high photon flux, enabling high-resolution 3D tomography within seconds when combined with advanced detectors. The MOGNO beamline at the Brazilian Synchrotron Light Laboratory (LNLS/Sirius), located at CNPEM [1], provides nano- to micrometer-scale computed tomography, focusing on multiscale analysis (including zoom tomography with ~200 nm resolution) and 4D imaging through in situ experiments. Designed to be flexible, it accommodates diverse sample environments and contributes to cutting-edge research in materials and energy sciences. MOGNO operates at three energies (22, 39, 67 keV) with high flux for rapid imaging. Applications include the study of rocks and porous media, highly relevant to the oil industry—one of Brazil's economic pillars—which also invests in CO_2 storage and capture.

NMR techniques are key for analyzing porous media both in the lab and in situ. NMR provides fluid characterization and morphological information such as pore-size distribution and connectivity. Magnetic surface relaxivity, another NMR parameter, arises from rock–fluid interactions and links relaxation times to pore morphology and fluid affinity. Integrating zoom tomography with NMR represents an innovative approach to porous media studies under both static and dynamic conditions. This work presents preliminary applications of synchrotron X-ray tomography for simulating NMR signals in porous media and its impact on estimating magnetic surface relaxivity.

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Precision Anatomy of Drosophila using 3D Synchrotron-Based Microtomography

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Recent advances in synchrotron radiation microtomography have significantly improved the visualization and quantitative analysis of biological structures. In this study, we investigated the internal anatomy of Drosophila melanogaster using Synchrotron Radiation Phase-Contrast Microtomography (SR-PhC-µCT) at the Sirius synchrotron (LNLS/CNPEM, Brazil). This technique provides high-resolution, non-destructive imaging of tissues with similar densities, minimizing sample preparation artifacts and eliminating the need for chemical labeling. Specimens were prepared through controlled freezing, dehydration, and ethanol fixation, followed by scanning under optimized polychromatic radiation. Image reconstruction was performed using the Transport of Intensity Equation (TIE-Hom) algorithm combined with Filtered Backprojection (FBP), enabling phase retrieval and accurate volumetric reconstructions. Segmentation was performed using Dragonfly software, combining manual, semi-automatic, and machine learning–based methods for precise isolation of the brain, reproductive, and other internal structures. The experimental design involved flies reared under three different temperature regimes and three dietary conditions, enabling the investigation of anatomical responses to environmental variation. Morphometric analysis revealed significant changes in the metabolic and reproductive systems, highlighting adaptive plasticity at the anatomical level. These results underscore the potential of synchrotron-based imaging in supporting studies in developmental biology, neurobiology, and reproductive physiology. Furthermore, they emphasize the relevance of Drosophila melanogaster as a model for exploring environmental adaptation, intra- and interspecific competition, and evolutionary trajectories. The combination of synchrotron microtomography and advanced 3D segmentation offers a powerful tool for precision anatomy and opens new perspectives for functional and evolutionary studies.

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Processing Single-Crystal Diffuse Scattering for 3D-ΔPDF Studies

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Diffuse scattering contains critical information on correlated short-range disorders, complementing the average structure obtained from Bragg diffraction. The three-dimensional differential pair distribution function (3D-ΔPDF) formalism [1] enables direct transformation of diffuse features into real-space correlations, but its application depends on accurate preprocessing of single-crystal diffraction data [2].

At the EMA beamline [3], three-dimensional reciprocal space mapping (3D-RSM) provides comprehensive coverage of diffuse intensity. A data treatment pipeline is currently under development to improve the reliability of subsequent ΔPDF analysis. Current efforts focus on implementing intensity normalization schemes, symmetry-based data completion, and algorithms for Bragg peak subtraction. These procedures are designed to minimize absorption effects and variations of the scattered intensities, improving signal-to-noise ratio, and compensate for missing regions caused by detector gaps.

The methodology is being extended to accommodate different space-group symmetries and to prepare for high-throughput data acquisition. Once fully established, this framework will enable robust 3D-ΔPDF workflows and complete reciprocal space reconstructions, significantly advancing the quantitative analysis of diffuse scattering at Sirius.

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Study of microstructural alterations in carbonate rocks through synchrotron X-ray tomography during reactive flow experiments

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The determination of petrophysical parameters is essential for the characterization and exploration of hydrocarbon reservoirs. In carbonates, dissolution processes play a decisive role in controlling these properties, directly influencing fluid flow in porous media. In heterogeneous systems, such as carbonate reservoirs, these properties are strongly conditioned by structural variations at multiple scales. In this study, microstructural alterations in carbonate rock samples subjected to dynamic reactive flow experiments were investigated at the Brazilian Synchrotron Light Laboratory (LNLS), on the MOGNO beamline. The experiments consisted of injecting a 0.25 M HCl solution at a flow rate of 10 µL/min, monitored in situ by synchrotron X-ray microtomography. Six acquisitions were obtained over the course of one hour of reaction, with a spatial resolution of 1.2 µm. The application of segmentation methods enabled the quantification of petrophysical properties and the monitoring of dissolution evolution over time, highlighting progressive modifications in the sample microstructure. These results reveal the correlation between reaction intensity and the formation of heterogeneities, underscoring the role of segmentation in identifying such transformations.

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Surface characterization of Apeiba tibourbou leaves by scanning electron microscopy (SEM) and its relationship with chemical characterization

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Medicinal plants from the Cerrado play a crucial role in biodiversity and human health, being valuable sources of bioactive compounds used by tradicional communities. Given the importance of plants to these communities and the potential for exploiting Brazilian biodiversity to develop new sustainable bioproducts, there is currently no data available in the literature on the correlation between elemental chemical characterization and the micromorphology of leaves from plants in Brazilian biomes.

Therefore, the present work aims to determine the chemical composition of the leaves of Apeiba tibourbou, using the observation of characteristics of the leaf epidermal structures in comparison with the chemical elements observed in scanning electron specificity (SEM) coupled to energy-dispersive X-ray spectroscopy (EDS).

For the SEM-EDS study, dehydrated by ethanol leaf samples measuring 1 × 1 mm^2 were positioned on metal stubs using double-sided tape. The specimens were coated with a thin layer of carbon (20 nm) using sputter coating in a vacuum and observed in a JEOL Inspect F-50 SEM under low vacuum conditions (approximately 5 × 10^{-4} Pa), with an accelerating voltage of 20 kV, using an electron scattering detector for microphotography acquisition and an EDS detector for chemical mapping.

The results obtained by the SEM-EDS technique indicate that the leaf epidermal structures present a rich population of stomata and trichomes, with metal concentrations in the leaves of the plants of: sodium (Na) of 6.2% (± 0.35), calcium (Ca) of 4.0% (± 0.14), magnesium (Mg) of 2.4% (± 0.35), aluminum (Al) (± 0.14) of 2.5%, silicon (Si) of 2.1% (± 0.21), and potassium (K) of 1.4% (± 0.14). The next stages of the work will be conducted to correlate the results obtained with the chemical characterization by spectroscopy in the infrared region with Fourier transform and molecular spectroscopy in the UV-Vis region as suggested by the literature.

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Synchrotron NanoCT and FTIR Spectroscopy for Multiscale Analysis of Enamel Demineralization

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Dental enamel demineralization, or dental caries, is a major global health challenge that affects billions of people, causing pain and functional loss. Enamel is a hierarchical structure composed of hydroxyapatite nanocrystals, water, and proteins, organized into rods and interrod regions highly vulnerable to mineral loss. Caries develops gradually over years, reinforcing the importance of analyzing both intact and affected tissues. To study these changes, synchrotron microcomputed tomography (SMCT) has proven to be a powerful method, capable of mapping submicron features with high precision. Since 2004, SMCT has been applied to measure lesion depth, quantify mineral content, evaluate hardness, and monitor remineralization, demonstrating its value for understanding caries progression. Enamel crystallites are only tens of nanometers in size, assembled into micrometer-scale prisms, making SMCT ideally suited to reveal structural disorganization linked to mineral loss and organic matrix degradation. At MOGNO beamline we used phase-contrast SMCT for high-resolution three-dimensional images of enamel demineralization without additional staining to increase absorption contrast, preserving mineral content for accurate quantification. Additionally, combining MOGNO with the IMBUIA beamline at CNPEM allows a deeper perspective: while MOGNO captures morphological details, IMBUIA, based on FTIR spectroscopy, delivers chemical spectra that reveal alterations in the organic and mineral phases of carious lesions. The preliminary results from experiments performed at MOGNO and IMBUIA show enamel demineralization and tissue disorganization, which are now under advanced processing with Avizo software and spectral analysis. This experiemental approach confirm the critical role of synchrotron-based multimodal imaging for dental research and highlight new possibilities for developing remineralization therapies or synthetic substitutes to replace lost enamel.

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Synchrotron X-ray Microtomography Reveals Structural Basis of Fire Retardant Toxicity in Phaseolus vulgaris Seeds

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The ecological safety of fire retardants remains a major challenge for wildfire management. Here, we evaluated the effects of a long-duration (ammonium polyphosphate-based) and a short-duration (surfactant-based) retardant on carioca bean (*Phaseolus vulgaris*) seeds. Germination assays demonstrated that long-duration retardants completely inhibited seed viability, whereas short-duration retardants, applied at reduced concentrations, preserved germination rates comparable to controls. To investigate the mechanistic basis of this toxicity, we employed synchrotron-based X-ray microtomography (SR-µCT) at the Brazilian Synchrotron Light Laboratory (LNLS). Segmentation and volumetric reconstructions revealed profound internal degradation and embryo collapse in seeds treated with fire retardants. Quantitative analysis indicated a 20% reduction in internal seed volume for the short-duration treatment and a 28% reduction for the long-duration treatment relative to controls, confirming significant differences in tissue preservation. These findings demonstrate the utility of SR-µCT for mechanistic ecotoxicological assessment and highlight the potential of low-concentration short-duration retardants as a sustainable alternative for wildfire suppression.

This research used facilities of the Brazilian Synchrotron Light Laboratory (LNLS), part of the Brazilian Center for Research in Energy and Materials (CNPEM), a private non-profit organization under the supervision of the Brazilian Ministry for Science, Technology, and Innovations (MCTI). The IMX beamline staff is acknowledged for the assistance during the experiments [PROPOSAL NUMBER: 20160838].

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The mobility paradox: tracing calcium foliar absorption and transport in tomato plants

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Calcium (Ca) deficiency can affect fruit quality even under adequate soil Ca^{2+} due to its transpiration-dependent transport, influenced by environmental factors such as temperature and water availability. High leaf-to-fruit ratios and low fruit transpiration may limit Ca^{2+} uptake, reducing fruit quality and shortening shelf life. Foliar Ca^{2+} applications offer an alternative supply independent of transpiration, but low phloem mobility often limits their effectiveness. To investigate Ca^{2+} absorption and transport in tomato leaves, we combined in vivo and synchrotron-based in situ X-ray fluorescence (XRF) spectroscopy, using strontium (Sr^{2+}) as a physiological Ca^{2+} tracer. We also assessed the effect of osmotic regulators—sucrose, mannitol, glycerol, and potassium—on Ca^{2+} movement. Sr^{2+} was efficiently transported to distal tissues. While formulations with K or mannitol did not improve transport, sucrose and glycerol enhanced movement. XRF imaging revealed Sr^{2+} throughout leaf tissues, mainly in cell walls, suggesting apoplastic short-distance transport directed toward leaf edges. In petioles, Sr^{2+} was concentrated in the auxiliary vascular bundle, and in fruits, it accumulated predominantly in seeds and columella, confirming leaf-to-fruit transport. These findings challenge the notion of limited foliar Ca^{2+} mobility, showing that Ca^{2+} applied to leaves can reach distal tissues, including fruit. Importantly, sucrose as an osmotic regulator improved both short- and long-distance transport, highlighting a potential strategy to enhance phloem-mediated Ca^{2+} mobility and improve fruit quality.

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TIME-RESOLVED SYNCHROTRON INVESTIGATION OF ACID-INDUCED MINERAL DISSOLUTION IN RIO BONITO SANDSTONES: IMPLICATIONS FOR CO2 STORAGE

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Understanding how reservoir rocks respond to acidic fluids is key to predicting the long-term stability of CO_2 storage sites. In this study, dissolution mechanisms in Rio Bonito Formation sandstones were investigated under acidic conditions using time-resolved synchrotron techniques: 4D X-ray microtomography (µ-CT), time-resolved X-ray diffraction (TR-XRD), and X-ray fluorescence (TR-XRF). Experiments at the Brazilian Synchrotron Light Laboratory (LNLS) used custom-designed setups enabling real-time imaging during acid injection at varying pH levels relevant to CO_2 sequestration. 4D µ-CT revealed a front-like dissolution pattern that first affected cement-rich regions, increasing porosity heterogeneity before infiltrating primary pores. At higher pH, simulating CO_2-rich brines, cement phases dissolved completely, destabilizing the matrix. This was linked to acid volumes exceeding the buffering capacity of the cements. TR-XRD and TR-XRF confirmed dissolution of calcite and microcline with release of Ca^{2+}, Al^{3+}, and K^+ ions, while quartz remained inert, preserving mechanical stability. Dissolution rates decreased exponentially with increasing pH, aligning with theoretical predictions. While HCl was used instead of CO_2-acidified brine, the range of pH conditions simulated key aspects of reactive transport. These findings highlight the value of time-resolved synchrotron imaging for capturing mineral-fluid interactions and provide insight into CO_2 mineralization processes, emphasizing the importance of mineralogical buffering for the geomechanical stability of storage formations.

Time-resolved tomography of carbonate rock dissolution under dynamic reactive flow at the Mogno beamline

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Reactive flow interactions in porous media are fundamental to understanding processes relevant to CO_2 and hydrogen geo-storage, as well as carbonate acidizing in petroleum engineering. While previous studies have advanced knowledge at the core scale, significant challenges remain at the pore scale, where new insights can improve the comprehension of acidification dynamics. Pore-scale experiments using time-resolved, high-resolution tomography provide valuable information on petrophysical changes in porous media during reactive flow. This study aims to evaluate the evolution of rock petrophysical properties over time during reactive flow using time-resolved synchrotron tomography. Experiments were performed on Indiana limestone and Silurian dolomite samples with cylindrical dimensions of 2.5 x 2.5 mm. A 0.25 M HCl solution was injected at a constant flow rate of 10 µL/min for 1 hour, during which six scans were acquired. The analyses were conducted at the MOGNO beamline of the Brazilian Synchrotron Light Laboratory (LNLS) using a custom-designed fluid flow cell that enabled in situ image acquisition during fluid injection. X-ray microtomography with synchrotron radiation provided a spatial resolution of 1.2 µm, with acquisition parameters of 500 ms exposure time and 2048 projections over a 180° rotation.Our results reveal the dynamic evolution of petrophysical parameters, including porosity, as dissolution progressed through the samples. The formation and growth of dissolution channels were clearly observed, with more pronounced development in Indiana limestone due to its higher reactivity. These findings provide new insights into pore-scale reactive flow mechanisms and offer valuable data to improve predictive models for geological storage and related subsurface engineering applications.

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Tracking the Translocation and Accumulation of Polymeric Nanocarriers Using Vanadium Tracer in Soybean Plants

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In agriculture, polymeric nanocarriers have been proposed as efficient vehicles for the targeted delivery of agrochemicals to plants. However, the potential of polyetheramine–epoxide gel particles (Pgel) for foliar applications remains largely unexplored. In this study, we investigate the use of Pgel as controlled-release systems for plant nutrients, with a focus on foliar nutrition. Pgel was synthesized through the reaction of poly(ethylene glycol) diglycidyl ether with a polyetheramine-PPO-based monomer,1 followed by loading with sodium orthovanadate (Na_3VO_4). Encapsulation efficiency and release kinetics were evaluated by inductively coupled plasma mass spectrometry (ICP-MS), while physicochemical characterization was performed using multiple analytical techniques. Two systems with the same spherical morphology (confirmed by Transmission Electron Microscopy TEM) but distinct sizes were produced as a function of monomer dilution. Dynamic Light Scattering (DLS) measurements revealed hydrodynamic diameters of ~200 nm (Pgel_nano) and >1 µm (Pgel_micro). Both samples exhibited a zeta potential of approximately +22 mV. The foliar uptake and translocation of Pgel in soybean plants are currently being evaluated, with vanadium serving as a tracer element. We anticipate that these small polymeric carriers will be phloem-loaded and exhibit relative mobility within soybean tissues. The fraction of particles loaded into the phloem, together with their final distribution in planta, will be presented. Furthermore, complementary experiments at the CARNAÚBA beamline (proposal under review) are expected to provide new insights into the mechanisms of translocation and accumulation of Pgel particles. This research contributes to the advancement of targeted nutrient delivery systems using polymeric carriers, offering promising applications for sustainable agriculture.

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Tunable of optical properties in quasi-1D V_2O_5 nanostructures by alkali ion intercalation

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One-dimensional (1D) V_2O_5 nanowires and nanoribbons are gaining increasing interest due to their unique nanophotonic properties in the mid-infrared (mid-IR). These materials can act as subdiffraction waveguides, supporting phonon-polaritons such as those observed in the SnO_2 [1] and α-MoO_3 [2] nanostructure. Furthermore, it was recently predicted that the polaritonic properties of V_2O_5 can be tuned by the intercalation of alkali ions (lithium, sodium, and calcium) into the crystal structure. However, studies on how ion intercalation can modify the nanophotonic properties of 1D-V_2O_5 are lacking. We investigated the polaritonic response of V_2O_5 nanowires and nanoribbons with and without Li and Na intercalation using synchrotron infrared nanospectroscopy (SINS). The materials were synthesized by the hydrothermal method, where the reactions occur in a temperature-controlled reactor. We obtained V_2O_5 nanorods in the orthorhombic phase from an experiment at 200 °C for 48 h, while nanoribbons in the monoclinic phase resulted from an experiment at 120 °C for 24 h. X-ray diffraction and electron microscopy confirmed the formation of rod and ribbon structures. By SINS, we observed that the Li and Na intercalations significantly altered the phononic properties of the nanorods compared to the original V_2O_5 nanostructures. In Li:V_2O_5, the band observed at 1005 cm^{-1}, which is attributed to the V−O bond, is observed at 1005 cm^{-1} , while in non-intercalated materials, it appears at 1020 cm^{-1}. For Na:V_2O_5, we observed that intercalation led to a band shift from the non-intercalated band at 1020 cm^{-1} to band lengths near 1005 cm^{-1}, also toward shorter band lengths. Based on these results, we discuss the intercalation-induced effects on the polariton bands and evaluate the corresponding polariton properties.These results indicate that intercalated V_2O_5 nanowires and nanoribbons specifically constitute a new class of one-dimensional nanophotonic platforms potential.

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Unveiling laticifer networks in Swartzia langsdorffii fruit: Non-destructive 3D Imaging using synchrotron X-ray Nanotomography

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Synchrotron X-ray computed nanotomography (SXRCT) is a non-destructive 3D imaging technique that enables high-resolution visualization of plant tissues in their natural state. This approach is particularly useful for studying secretory structures, such as laticifers, which may show complex and branched distribution within tissues and require three-dimensional observation to understand their organization and function. Swartzia langsdorffii (Fabaceae) exhibits laticifers in the stem, leaf, and pericarp. When injured, the pericarp exudes a salmon-colored secretion; however, the structures responsible for this, particularly in the pericarp, have not yet been properly characterized. The aim of this study was to analyze, using SXRCT, the secretory structures present in the pericarp of S. langsdorffii. For this, samples of up to 6 mm were treated with a 1% phosphotungstic acid solution in 70% ethanol (contrast agent) for 30 days [1], dehydrated in ethanol series, dried with a Bal-Tec CPD 030 critical point dryer, and mounted on metal stubs using a thermoplastic polymer. Scanning was performed at the MOGNO beamline (Sirius) [2]. Projection data were acquired with a 2048 × 2048-pixel sCMOS detector and a 3× objective lens. Samples were scanned in fly-scan mode, with projections collected over 360° and exposure of 0.6 s. Average scanning time was about 15 min. Images were reconstructed using an in-house implementation of the FDK algorithm. Amira-Avizo 3D 2024.2 software was used for visualization and quantification. Nanotomography revealed articulated non-anastomosing laticifers forming a network of interconnected cells throughout the mesocarp, occupying about 12% of the total volume. This intricate net-like structure tends to optimize latex distribution within the tissues. Analysis of laticifer density across organs may provide insights into adaptive defense mechanisms and resource allocation strategies, particularly in reproductive structures such as flowers and fruits.

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USAXS and XPCS studies of gold nanoparticles confined into polyelectrolyte complex coacervate

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Complex Coacervates are formed by spontaneous associative liquid-liquid phase separation (LLPS) between oppositely charged polyelectrolytes in aqueous solution, leading to a coacervate-rich phase and a dilute phase [1]. The dense phase provides a confined microenvironment that can affect the diffusion of reactants and the stability of catalysts. Recently, many authors used coacervates to encapsulate enzyme and use them as microreactors [2], [3]. Gold nanoparticles (AuNPs) are well-known for their catalytic properties in reactions such as alcohol oxidation, borohydride-assisted reduction and carbon-carbon coupling [4]. However, their performance can be significantly influenced by the environment in which they are situated. In this work, AuNPs were encapsulated within polyelectrolyte coacervates formed by sodium polyacrylate (PANa) and poly(diallildimethylamonium) chloride (PDADMAC), their catalytic activity was studied using the reduction of 4-nitrophenol as a model reaction. The results were compared to those obtained using free AuNPs in solution. The coacervate were characterized by X-ray Photon Correlation Spectroscopy (XPCS) and Small Angle X-ray Scattering (SAXS) revealing droplets of hundreds of nanometers with high stability, with no coalescence over the probed window. Furthermore, AuNPs can be used as rheological probes to study the viscosity inside the coacervate phase using XPCS and SAXS. The use of coherent X-ray techniques allows us to detect the nanoparticles inside the coacervate phase, giving information about their structure and dynamics in this confined microenvironment. It was observed that the confined environment within the coacervates altered the catalytic reaction kinetics, likely due to changes in local concentration

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USING A FUZZY LOGIC-BASED TEMPERATURE CONTROLLER TO SYNTHESIZE IRON OXIDE NANOPARTICLES

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This work reports the development of a fuzzy logic-based temperature control system (FLTC) for the synthesis of iron oxide nanoparticles (IONPs). The heating unit was first characterized using water and NH_4OH, as these liquids are commonly employed in co-precipitation nanoparticle synthesis. A fuzzy logic algorithm was implemented to regulate the heating profile and final temperature. The system was then applied to synthesize magnetic IONPs at 40 °C, resulting in smaller particle sizes compared to conventional heating. Subsequently, IONPs were synthesized at 40, 60, and 80 °C and characterized by Small-Angle X-ray Scattering (SAXS), revealing distinct structuring in aqueous suspension. The potential of these nanoparticles for magnetic hyperthermia was evaluated through Specific Absorption Rate (SAR) measurements at 100 kHz and varying magnetic field amplitudes. Results demonstrate a strong correlation between nanoparticle structuring and SAR performance, with more structured systems exhibiting higher SAR values.

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Using Synchrotron X-Ray Powder Diffraction to shed light on the phase-separation dynamics of highly-correlated manganites

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Mixed-valence manganites occupy a central role in the studies of condensed matter physics. This is due to their great variety and richness of physical phenomena, resulting from the sensitive balance between different magnetic, electronic, and structural degrees of freedom [1]. Among them, charge and orbital ordering (COO) and phase separation (PS) are of great importance in prototypical systems such as $La_{5/8-y}Pr_yCa_{3/8}MnO_3$ (y = 0.35, 0.40, 0.45) [2]. In this system, ferromagnetic metallic (FMM) regions with orthorhombic Pnma symmetry are nucleated in an insulating antiferromagnetic matrix with COO (AFMI-COO) and monoclinic symmetry $P2_1/m$ [2,3]. In this crystallographic study, synchrotron X-ray diffractograms between ~115 K and room temperature at the PAINEIRA beamline were collected. Both beamline's detectors were used to collect high-angular-resolution, used for quantitative analysis, and high-thermal-resolution, used for qualitative analysis, diffractograms. These results, in combination with temperature-dependent Raman scattering and magnetization studies, enabled a better understanding of the thermal evolution of the different PS regimes of the samples.

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Visualization of intra- and extraradicular structures of arbuscular mycorrhizal fungi by synchrotron X-ray tomography

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The symbiotic interaction between arbuscular mycorrhizal (AM) fungi and plant roots is ubiquitous, with significant implications from the molecular-cellular to the global level, exerting a direct influence on mineral nutrition and plant performance in natural and agricultural environments. However, despite advances in understanding the physiology of AM symbiosis, fundamental aspects, such as the spatial distribution of hyphae in the soil, remain limited. In this context, synchrotron-based X-ray computed tomography (SRXCT) offers a promising opportunity, allowing three-dimensional images of the root system and AM hyphae without structural disturbance, enabling detailed quantification of their properties. The technique can be enhanced with contrasting agents, such as gaseous iodine, which increase the attenuation of X-rays in biological structures [1]. Thus, in this project, we evaluate the feasibility of combining SRXCT with vapor-phase iodine staining for imaging AM fungi–root–soil systems at the MOGNO beamline. Preliminary results revealed very clearly anatomical root details, including xylem vessels, phloem tissue, cortex and epi- and endodermis. The results also revealed filamentous structures consistent with traits of AM fungal hyphae, as well as rounded structures resembling young spores. These findings confirm the high potential of vapor iodine as a contrasting agent for non-invasive investigation of belowground interfaces among soil, fungi and roots. The next steps of this work will focus on refining the methodology established in this pilot experiment to deliver a robust and reproducible imaging protocol for AM fungal studies, integrating SRXCT, chemical contrast enhancement, and an advanced segmentation workflow to facilitate studies on root-fungal interactions, including those with saprophytic, pathogenic, and mycorrhizal fungi, with greater efficiency and precision.

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Visualizing how Mn-rich niches are formed in a cell model of lung carcinoma using Carnauba beamline: understanding the connection between Mn and malignancy in cancer

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The microenvironment (TME) undergoes significant modification in tumor progression. TME comprises locally secreted molecules, cells and metal ions. Metals interact with the cell surface or are internalized, modulating downstream pathways related to adhesion, migration, and proliferation. Our group showed that tumor-bearing mice present altered Mn distribution. Mn-exposed tumor cells showed in vitro higher proliferation and migration, associated with changes in glycocalyx organization. In this work, we simulated a high-Mn environment and evaluated Mn internalization, its cellular distribution and its early effect on migration. Cells were kept in Mn-rich media for 1 and 4h, and the intracellular content was quantified with ICP-OES. From 1h to 4h the Mn group decreased from 11x to 8.5x relative to control, suggesting that Mn cellular secretion takes place even in Mn-rich environment. XRF maps obtained at Carnauba beamline showed that Mn uptake is heterogeneous and mimics Mn-rich niches observed in vivo. Interestingly, from 1h to 4h of incubation, Mn-rich niches become more diffuse in our samples, reinforcing previous results in which Mn is secreted in exosomes, allowing its wide distribution. Finally, we evaluated migration at 4h and 12h. A brief exposure to Mn (4h) was sufficient for cells to relatively migrate 26% more than the control group, while at 12h, cells reached 36% more than the control, as previously reported. Time lapse imaging revealed increased morphological variations during migration, suggesting a more dynamic cell movement compared to control. Our results indicate that an early interaction between Mn and the cell surface, probably the negatively-charged glycocalyx, induces morphological changes that lead to increased invasiveness. Future investigations, especially at Sapoti station, will help to better understand the mechanisms of Mn retention and internalization during tumor progression.

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Water-Based Polymeric Colloids and Plants: A Sustainable Pathway for Agricultural Technologies

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Meeting the rising global food demand while coping with resource constraints imposed by climate change requires innovative strategies for sustainable agriculture. Polymeric materials, owing to their versatility, durability, and tunable physicochemical properties, have emerged as promising tools to enhance crop efficiency and resilience to biotic and abiotic stresses throughout plant development. Among them, polyetheramine–epoxide polymers constitute a unique class of gel-like materials that swell in aqueous environments and can be synthesized under catalyst-free conditions from bisepoxide and aliphatic polyetheramine monomers. In this study, we investigated a colloidal system derived from polyetheramine–poly(propylene oxide) (PPO) and a bisepoxide (hereafter referred to as Col-PPO) as a sustainable platform to optimize seed germination. Application of Col-PPO for seed priming represents a novel approach in agriculture, and our findings demonstrate significant improvements in germination performance, including enhanced root and shoot growth. When integrated with an iron micronutrient source, Col-PPO significantly outperformed Fe-controls, leading to root length increases of up to 40%. Synchrotron-based X-ray fluorescence mapping further revealed ~3-fold higher Fe accumulation and a more homogeneous distribution across internal embryo tissues in Col-PPO–Fe–treated seeds compared with controls. Safety evaluations indicated no toxicity in zebrafish models, while priming experiments in cucumber confirmed beneficial effects without phytotoxicity. Additionally, preliminary foliar application of Col-PPO showed no adverse effects.[1,2] Finally, these results highlight polyetheramine–epoxide colloids as a safe and promising polymeric platform for seed and foliar applications, advancing the development of sustainable agricultural technologies.

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Waveguiding hyperbolic phonon-polaritons in 2D Van der Waals heterostructures

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Polaritons are quasiparticles generated by the coupling of the electromagnetic field and a fundamental matter resonance. In two-dimensional (2D) crystals, the optical field of subwavelength polaritons manifests itself as optically polarized waves that have shown different nano-optical phenomena with great potential in optoelectronics, such as negative refraction [1] and extreme light confinement [2]. Such effects rise with more completeness, in special, in hyperbolic 2D crystals, such as hexagonal boron nitride (hBN), which features a type I hyperbolic band in the 740 – 820 cm^{-1} range supporting out-of-plane polarized phonon-polaritons and a type II hyperbolic band in the 1365 – 1610 cm^{-1} range exhibiting in-plane polarized phonon-polaritons.
In our work, a heterostructure of hBN atop a rectangular micrometer-sized α-MoO_3 crystal, which presents anisotropic in-plane permittivity [3], is analyzed. We investigate the influence of the dielectric anisotropy of MoO_3 to hBN type II polaritons using synchrotron infrared nanospectroscopy (SINS) and scattering-type scanning near field optical microscopy (s-SNOM). Based on experimental data and simulation analyses, a precise characterization of the guidance and dispersion relations were derived for the heterostructure. We show that α-MoO_3 induces waveguiding behavior to in-plane polaritons of hBN only by changing boundary conditions.

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X-ray study of surface structural and electronic fluctuations in the two-dimensional magnetic semiconductor Ni3TeO6

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The compound Ni_3TeO_6 is a semiconductor that has been attracting growing interest due to its promising magnetic and optical properties for various technological applications. This compound has a hexagonal crystal structure, composed of NiO_6 and TeO_6 octahedra. In this work, we investigate the structural and electronic properties of the Ni_3TeO_6 surface. Crystal truncation rods (CTR) analysis, with measurements carried out at the EMA beamline of Sirius, revealed surface desorption of tellurium and the formation of Ni_2 clusters, in addition to the presence of TeO_2. The fitting of the measurements suggests the coexistence of phases and a possible partial reduction of tellurium ($Te^{6+} \rightarrow Te^{4+}$), associated with the presence of oxygen vacancies and local reconstructions. We observed the coexistence of three crystallographic sites with distinct octahedral distortions – Ni(I), Ni(II), and Ni(III) – with Ni(III) sites being predominant.A more detailed understanding of the surface defects is carried out using scanning tunneling microscopy and spectroscopy (STM/STS) measurements, which highlighted the electronic changes due to the existence of vacancies in the system. STM measurements indicate a highly ordered surface, but with local structural modifications reflecting the different coordination of the nickel sites. STS measurements revealed variations in the density of electronic states near the surface, directly related to magnetic anisotropy and to the different Ni–O bonds in the various sites, suggesting an impact of these structural features on the local electronic properties. Finally, implications for the surface potential are discussed through the analysis of Kelvin Probe Force Microscopy (KPFM) measurements. The results show that structural defects, such as oxygen vacancies and local disorder due to Te saturation, induce perturbations in the crystal lattice, potentially affecting the electronic and magnetic behavior of the system.

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