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matriks

KJEMISK TEKNOLOGI

Metal organic frameworks for sustainability

Petra Agota Szilagyi, University of Oslo

Metal-organic frameworks (MOFs) are interesting materials for sustainability as they offer multiple ways of converting, storing, and generating energy. While allowing for their integration in devices, such as fuel-cells. I will present my group's latest results focussing on sustainable MOF synthesis and how to modulate the interaction strength between the metal-organic framework hosts and guest molecules/ions with potential applications in sustainability.

MOFs are porous crystalline inorganic-organic hybrid materials with tuneable chemistry and textural properties. [1] We have previously demonstrated that the interaction of small molecules [2], metal atoms [3] and metal nanoclusters [4] may result in altering the properties of the guests. This change consequently can be exploited to tune the properties of the guest for particular functions, such as applications for sustainability, of which a few examples will be given. MOFs with pore sizes near and below 1 nm (UiO-66, ZIF-8) have been synthesised and functionalised directly or post-synthetically by grafting various functional groups on the organic linker and/or embedding metal nanoclusters in their pores. The samples were screened for their interaction with reactants and electrolytes to uncover the relevant host-guest interactions and their impact on the materials' function.
I will be reviewing our latest results on MOFs' potential applications for sustainability as heterogenous catalysts for small-molecule conversion and solid-state ion conductors.

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Insights into MOF synthesis with combined in situ approach: Raman scattering, X-ray absorption, X-ray diffraction

Olena Zavorotynska, University of Stavanger

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Metal–organic frameworks with a Zr-oxo cluster [(Zr6O4(OH)4)]12− are exceptionally stable and offer vast potential for a wide range of applications. Synthesis parameters strongly affect the quality, stability, morphology, etc., of the MOFs calling for elucidating of the various reaction steps.

Figure 1 top: Reaction kinetics of Zr-oxo-cluster formation in DMF based on LCF of the in-situ XAS data: effect of temperature, modulator, and water concentration [1]; middle: in-situ synchrotron PXRD data of water-based synthesis of Zr-fumarate; bottom: in-situ Raman spectra of Zr-fumarate synthesis at HT and growth of 1666 cm^{-1} peak[3]. In this study, we present a combined approach of three in situ techniques: X-ray diffraction, X-ray absorption, and Raman spectroscopy, that allows for integrated monitoring of MOF synthesis in different solvents and at variable temperatures. In the early pre-crystalline synthesis phase, the local (∼2–5 Å) environment around Zr4+ ions and the Zr-oxo cluster formation is addressed by element-specific X-ray absorption at Zr k-edge. Raman scattering provides evidence of coordination between inorganic and organic blocks in the synthesis reaction. Owing to week scattering from water, Raman scattering is much more suitable for the in-situ studies of the water-based synthesis than infrared spectroscopy. Crystallization onset of the MOFs was evidenced by the appearance of the scattering peaks in the in situ patterns.

The kinetics of the various steps of the synthesis reaction can be studied using linear combination fits (LCS, X-ray absorption data, Figure 1a [1]), growth of PXRD reflections (PXRD data [2], Figure 1b), and the intensity growth of the cluster–linker coordination vibrational mode (Raman scattering, Figure 1c [3]). The dependence of the reaction kinetics on water, modulator concentrations, solvent, and metal precursor were studied as well. The results of the in-situ experiments were correlated with post-synthetic characterization of the resultant MOF products.

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Alkali-resistant MOFs with ion conductivity for alkaline anion exchange membrane applications

Qingqing Shao, University of Oslo

Metal-organic frameworks (MOFs) represent an attractive choice for alkaline anion exchange membrane (AAEM) fuel cells due to their innate electrical insulating characteristics, adaptable ion-conduction pathways, and suitability for processing. In this study, we investigate the MOF CoTBT (TBT = 4,4'-thiobisbenzenethiol), a 2D anionic framework synthesised according to the previous report. The structure consists of negatively charged layers and interlayer cations originating from the ionic liquid used during synthesis. CoTBT demonstrates excellent chemical stability, maintaining its crystallinity upon exposure to 20 M alkaline solution for at least five days, in addition to superior electrochemical stability. This behaviour is likely related to the strong Co^{2+}-S coordination bonds and the possible stabilising role of hydrophobic interlayer species. Despite its relatively low BET surface area, CoTBT exhibits appreciable ion conductivity in both its pristine (as-synthesised) and alkali-treated forms.

Humidity-dependent conductivity measurements revealed a strong sensitivity to moisture, suggesting that water-mediated proton or hydroxide transport plays a significant role in conduction. This behaviour is consistent with the Grotthuss-type mechanism involving hydrogen bonding with surface-adsorbed water. Additionally, differences in the ion conductivity among the pristine CoTBT and its alkali-treated analogues (CoTBT-NaOH and CoTBT-KOH) were observed under identical conditions. I will discuss the origin in these variations, which may be attributed to the interplay between the type of interlayer cations, their hydration behaviour, and ion mobility after alkali treatment.

This study highlights the potential of CoTBT as a chemically robust and intrinsically ion-conductive MOF for AAEM applications. The findings underline the importance of tuning ionic species and hydration behaviour alongside MOF design to achieve high performance in applications, such as fuel cell membranes.

Coupled transport in battery electrolytes using Molecular Dynamics simulations

Sondre Schnell, NTNU

Transport in battery electrolytes take place under gradients in chemical potential, temperature, and with an electric field. Ions will move due to these gradients, but they will also have a coordinated movement based on other ions moving. Using molecular dynamics simulations, we have studied the transport in electrolytes due to various field, and with different degrees of concentration. We find that the effects of coupling can be significant. Use of molecular simulations allow us to deconvolute the various effects, describe how they result in the well-known Soret and Seebech koefficients.

Developing materials-based solutions for a hydrogen-driven green transition: challenges and opportunities with metal hydrides

Stefano Deledda, IFE

Hydrogen is expected to play a crucial role in the transition to a climate-neutral economy and zero-emission transport, particularly where batteries or CO_2-neutral fuels are impractical. However, its widespread adoption faces challenges in production, distribution, and storage. Metal Hydrides (MHs) offer a promising storage solution by reversibly absorbing and releasing hydrogen through reactions with selected metals and alloys. These materials enable safe, compact hydrogen storage at ambient temperatures and low pressures, eliminating the need for compression or liquefaction. Additionally, MHs can serve as solid-state hydrogen compressors, leveraging their thermodynamic properties to desorb hydrogen at higher pressures when heated. Despite their potential, commercialization is hindered by the high cost of raw materials and processing. Advancing cost-effective synthesis methods and optimizing material selection is essential to unlock MH-based technologies as viable, sustainable components of the hydrogen value chain. This contribution showcases how these approaches are implemented in two research European collaboration projects: REMEDHYS and HESSENSE.

Additives in TiFe metal-alloy systems: Effect on crystal structure and hydrogen storage

Abhishek Banerjee, *Stefano Deledda, Sato Toyoto, Olena Zavorotynska*, University of Stavanger

Hydrogen storage remains a challenge in the hydrogen economy due to its light weight and density. Metal alloys, particularly titanium-iron (TiFe), have emerged as a viable option for hydrogen storage at ambient conditions. TiFe is known for its ability to reversibly store hydrogen at room temperatures, with comparable volumetric capacities as that of liquid H2 (~100 kgH2 m-3)1. However, its relatively low gravimetric capacity and oxide formation present drawbacks for TiFe as a standalone storage material. To overcome these challenges, researchers have proposed elemental doping and post mechanical processing. Theoretical studies have suggested that incorporating transition elements (for ex: Cr, V, Nb, Mn) as dopants in TiFe can enhance its hydrogen storage properties2. By replacing Fe and Ti in the lattice, these dopants induce changes in lattice size and strain, creating favorable diffusion pathways for H2. To our best knowledge, there are limited research on TiFe doped with transition elements Ta, Nb3,4, and a clear correlation between its crystallographic structure and hydrogen storage properties is still lacking.

In this study, TiFe samples with transition elements V, Nb and Ta with varying stoichiometries were synthesized using vacuum arc melting (VAM). Characterization techniques including powder X-ray diffraction (XRD) and Extended X-Ray Absorption Fine Structures (EXAFS) analysis were employed. The results demonstrated high correlation between structural refinement achieved through PXRD and EXAFS analysis. H2 absorption and pressure-composition-temperature (PCT) measurements were conducted, which showed that precise doping of TiFe with transition element dopants significantly improved activation and kinetics. These findings contribute to a better understanding of dopants occupancy in the crystallographic structure of TiFe and its impact on hydrogen storage properties.

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Innovative design of CRM-lean steam electrode architectures for proton conducting ceramic electrolysis

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The SUSTAINCELL project targets the development of next-generation electrolyser and fuel cell technologies—both low- and high-temperature—through the creation of a sustainable European supply chain for materials, components, and cells. The objective is to reduce dependence on critical raw materials (CRM), lower environmental impact and cost, and deliver improved performance and durability compared to current solutions. This strategy is built on breakthrough innovations in eco-design and green manufacturing routes for CRM-lean or CRM-free materials and architectures that maximize functionality while minimizing CRM content per cell.

In this presentation, we report our approaches to reduce cobalt and rare-earth elements in steam electrodes for Proton Conducting Ceramic Electrolysers (PCCEL). The electrode architectures include single layer of $PrBa_{0.5}Sr_{0.5}Co_{1.5}Fe_{0.5}O_{5+}$ (PBSCF), and bi-layer and tri-layer configurations combining with a thin CeO_2 interlayer deposited by magnetron sputtering on dense $BaZr_{0.7}Ce_{0.2}Y_{0.1}O_{3-}$ (BZCY) electrolytes. PBSCF layers were fabricated either by spin-coating commercial PBSCF ink or by electrospinning 3D nanofiber mats pre-annealed in air. Multiple combinations were explored to assess the impact of interfacial ceria, PBSCF morphology, and graded porosity. Characterization revealed that spin-coated PBSCF electrodes exhibit ~40 % porosity, while electrospun architectures reach ~60 %, combining micro- and macroporosity. Electrochemical tests in humidified and dry air showed a dramatic reduction in total polarization resistance —up to 97 % at 600 °C—compared to the benchmark single-layer PBSCF electrode. These findings highlight the potential of CRM-lean designs for high-performance PCCEL systems. Detailed results and insights into interfacial layer effects will be presented.

Acknowledgements
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Proton uptake mechanisms in triple conducting oxides

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Co-authors:

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The performance limitations of proton ceramic electrochemical cells are primarily attributed to slow kinetics at the air/steam electrode. Triple conducting oxides (TCOs), which simultaneously exhibit bulk conduction of protons, oxide ions, and electronic charge carriers (typically electron holes), represent a promising materials solution. The bulk ionic conduction in these materials accelerates oxygen-related reaction kinetics by distributing the adsorption process throughout the electrode surface, potentially enhancing both efficiency and reaction rates in positrode applications.

This work investigates the fundamental proton uptake mechanisms in the triple conducting perovskite $Ba_{0.95}La_{0.05}(Fe_{0.8}Ni_{0.2})O_{3-\delta}$. Beyond conventional hydration, which is an acid-base reaction, this research provides direct evidence for an hypothesized proton incorporation pathway involving a redox process, here denoted hydroxidation.

Thermogravimetric analysis (TGA) using isotope-labeled water (D_2O) enabled direct quantification of proton uptake, providing mechanistic insight through comparing isotopic and water mass changes. X-ray absorption near-edge spectroscopy (XANES) and diffraction (XRD) measurements conducted at the European Synchrotron Radiation Facility (ESRF) BM31 beamline reveal a significant increase in Ni oxidation state and lattice constant, respectively, following steam exposure. These findings support the hydroxidation mechanism as a distinct proton uptake pathway in triple conducting oxides with redox-active B-site substituents.

A triangular lattice using model candidate

Øystein Slagtern Fjellvåg, IFE

Rare-earth trihalides are attracting attention in the field of quantum matter for their potential to exhibit exotic ground states arising from interactions among magnetic moments, including competing interactions or geometrical frustration. Compounds such as YbBr and ErBr exemplify this interest with their unique 2D honeycomb structures, where magnetic anisotropy can be tuned by varying the rare-earth ion, enabling the study of 2D magnetism in various regimes, including XY, Ising, and Heisenberg limits. These attributes make rare-earth trihalides versatile systems for probing the fundamental physics of 2D magnetism.

In contrast, early rare-earth halides with a 3D UCl-type structure adopt a honeycomb-like topology in the ab-plane. We have investigated a cerium trihalide that displays an antiferromagnetic ordering wave-vector of k=(1/3, 1/3, 1/2). Recent single-crystal diffraction and spherical polarimetry studies have further elucidated the magnetic properties of this system. The cerium sublattice splits into two orbits, and we find the compound to be a triangular lattice Ising model candidate. These findings highlight the complex interplay between 1D and 2D magnetic behaviors in rare earth trihalides, enriching our understanding of magnetic anisotropies and order parameters in quantum materials.

Piezoelectric Coefficient and Dielectric Relaxation in Molecular Ferroelectric [HDabco]ClO_4

Shuaib Bolaji Issa, NTNU

Mari-Ann Einarsrud, Julian Walker

Molecular ionic ferroelectrics, also known as plastic crystals, are emerging as promising lead-free alternatives to ceramic counterparts for high-energy-density storage capacitors, owing to their structural flexibility, low-temperature processability, and improved recyclability. Among them, [HDabco]ClO4 (Dabco = 1,4-diazabicyclo[2.2.2]octane) is notable for exhibiting room-temperature polarization switching and promising pyroelectric behavior, despite a relatively low spontaneous polarization (~6 μC/cm2), highlighting the need for property enhancement. However, its piezoelectric response, quantified by d33 (piezoelectric coefficient), and its dielectric relaxation behavior, which governs polarization dynamics and influences AC-field performance, have not yet been reported. Understanding these properties is important to evaluate its utility in energy storage capacitors. Therefore, in this study, we report a reversible ferroelectric-piezoelectric coupling in [HDabco]ClO4 with a measured d33 of ~4 pm/V at room temperature, confirming weak but measurable piezoelectricity. Temperature-dependent dielectric spectroscopy reveals quasi-Debye-type relaxation behavior, with three distinct relaxation processes identified below, near, and above the Curie temperature. These results indicate complex polarization dynamics, while maintaining a structurally consistent dipolar relaxation across the studied temperature range. In addition, its switchable polarization, low d33, and low-intermediate tan δ indicate a possibility to enhance its energy storage density while having minimal detrimental mechanical strain and maintaining a low loss.

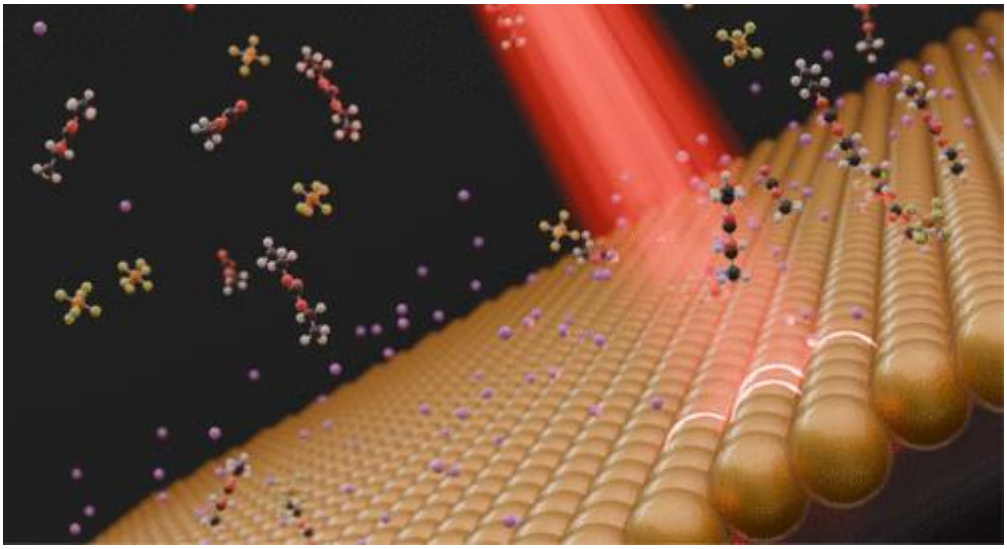
Studying battery interfaces with operando SHINERS

Matthijs Holthuijsen, *David Hall*, University of Stavanger/Beyonder

Gold nanostructures display localized surface plasmon resonance with light in the visible range. This resonant effect strongly enhances the Raman signal of nearby molecules. Applying this principle to an electrochemical system requires the nanostructures to be insulated with an ultrathin dielectric shell, to prevent interference from the conductivity of gold. This technique is known as Shell-Isolated Nanoparticle-Enhanced Raman Spectroscopy (SHINERS).

We have attempted to simplify the technique by using commercial nanoparticles and developing Raman alternatives for complex nanoparticle analysis. We then applied our SHINERS method *operando* to track lithium-ion concentrations at battery interfaces, study ion solvation, and answer questions about the chemistry of passivation layers on graphite electrodes in lithium-ion batteries.

Our first publication on this technique recently appeared in ACS Electrochemistry. DOI:10.1021/acselectrochem.5c00234



Understanding interphases in alkali metal batteries with focus on potassium

***Kaan Kizmaz**, Jonas Grill , Jelena Popovic-Neuber,* University of Stavanger

Next generation batteries with alkali metal electrodes promise higher energy density compared to contemporary cell technology based on intercalation-anodes and are hence attracting academic and industrial attention. Despite their potential, the implementation of metal electrodes faces significant challenges including substantial electrode volume expansion or contraction upon cell cycling, the emergence of non-passivating or ion-blocking interphases and undesired instances of electrodeposition.[1,2] Alkali metal electrodes react vigorously with battery electrolytes to form the solid electrolyte interphase (SEI), which plays a dominant role in the complex interplay of the abovementioned processes. Thus, understanding of the ion transport in and evolution of the SEI is crucial as it may enable a rational design of alkali metal cells, as well as electrochemical responses in half-cells. Electrochemical impedance spectroscopy (EIS) is a powerful method giving access to individual impedance responses of physical processes in-situ, circumventing common experimental difficulties such as handling or perturbation of air-sensitive materials. In addition, EIS gives insight into meaningful performance parameters such as resistances, and their evolution upon battery degradation. In context of planar electrodes (Li, Na, Mg, Al, Si), EIS can be employed to gain information on ion transport mechanism[3,4] and the morphological evolution of the SEI[5]. In this work we will demonstrate the capability of EIS towards a thorough understanding of interphase stability of potassium metals with solid-state (for example K_3SbS_4[6]), liquid-solid (AAO infiltrated with liquid electrolyte)[7] and liquid-state (for example KTFSI and potassium triflate in triglyme) battery electrolytes.

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Pre-combustion carbon capture on activated carbon

Ashika Dilshani Wackwella Gamage, University of Stavanger

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Pre-combustion carbon capture involves the removal of CO_2 before fossil fuel combustion. For instance, the gasification of feedstock such as coal, and biomass, produces syngas containing hydrogen (H_2) and carbon monoxide (CO). The CO is converted into CO_2 via a water-gas shift reaction. The resulting CO_2 is separated and captured, while H_2 can be used as a fuel. This CO_2 can be separated via physical adsorption by using pressure swing adsorption (PSA), which is a widely used technique for separating CO_2 from H_2. PSA can produce H_2 with high purity above 99.9%, which is critical for industries such as fuel cells and semiconductors (Lider et al., 2023). Traditional adsorbents used in PSA include activated carbon, zeolites, and silica gels.

This study focuses on separating hydrogen from CO_2 by utilizing a commercially available activated carbon (AC). Figure 1 (a) illustrates the single-component adsorption isotherms of CO_2, CH_4, H_2, and N_2 on the AC measured at 303.15 K. The results show that hydrogen has the least affinity toward carbon material,while CO_2 has the highest affinity. The amount of CO_2 adsorbed at 303 K and 7 bar is 6.32 mmol/g, which is higher compared to BPL-activated carbon (Delgado et al., 2014) and also previously reported by Lopes et al. (2009). This higher adsorption capacity for CO_2 of this AC has been tested and reported (Kozak-Jagieła et al., 2024; Yu et al., 2015). However, few studies have explored the use of this AC for CO_2 capture, specifically in the Pressure Swing Adsorption (PSA) process (Kozak-Jagieła et al., 2024). Therefore, the present study focuses on utilizing this AC in a two-column PSA system (Figure 2 (b)) to separate CO_2. The experiments were conducted at 3 bar and 30°C, with cycle steps including adsorption, blowdown, evacuation with purge, and backfill. The cycle incorporating the backfill step resulted in high purities of H_2>99.9%. To align with real-world pre-combustion CO_2 capture scenarios, an Aspen Adsorption™ model will be simulated at higher pressures (15-20 bar). In addition, an Artificial Intelligence (AI) model will be developed to understand the structure-property relationship of the various materials for adsorption and predict the best adsorbent for CO_2 capture.

Flexibility in Prussian blue analogues

Hanna Boström, Stockholm University

Prussian blue analogues (PBAs) show promise for a variety of applications, from energy storage to catalysis.[1,2`] Structurally, they can be likened to cyanide versions of double perovskites, with the extra possibility to vary the stoichiometry from the porous and defective $M[M'(CN)_6]_{2/3}$ to $A_2MM'(CN)_6$ (A is an alkali metal, M/M' are transition metals). Although the synthesis of Prussian blue predates the discovery of Perovskite, their crystal chemistry is less well explored than that of perovskites.

This contribution discusses the flexibility and phase behaviour of PBAs in two short chapters. First, the similarity of Prussian blue analogues with (double) perovskites means that concepts developed for the latter, such as octahedral tilting, can be transferred to the cyanide counterparts. Using literature studies[3] and high-pressure diffraction,[4,5] we have investigated the propensity for tilting in PBAs and the functional implications. Second, numerous beamtimes have shown that the lattice parameters of metal cyanides are not only sensitive to pressure and temperature, but also to the X-ray radiation dose. We recently performed a systematic exploration of X-ray induced strain as a function of composition and temperature; and some preliminary results constitutes part II of the talk.

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Domain wall properties from first principles calculations

Kristoffer Eggestad, Ida Cathrine Skogvoll, Benjamin Williamson, ***Sverre Magnus Selbach****,* NTNU

Realistic simulations of interfaces such as domain walls from density functional theory simulations (DFT) are challenging due to the computational cost of electronic structure calculations. In this talk, recent work on twin walls and ferroelectric domain walls is presented. Intrinsic point defects as predicted to segregate to, and reduce the mobility of, ferroelectric domain walls in $LiNbO_3$ [1]. No such effects are found at the domain walls of ferroelectric $CsGeX_3$ (X = Cl, Br, I) and the reasons for this are briefly discussed [2]. Physical properties not found in bulk are predicted to arise at certain ferroelectric and ferroelastic domain walls due to broken space inversion and translational symmetry:

- Net magnetization and electric polarization in the bulk centrosymmetric antiferromagnet $CaMnO_3$ [3]
- Altermagnetism at ferroelastic domain walls in $BiCoO_3$ and twin walls in $LiCoO_2$ [4]

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Symmetry influence on functional properties of H-DABCO based ferroelectric ionic plastic crystals

Sindre Mjøen Svendsen, NTNU
Co-authors: *Mari-Ann Einarsrud, Sverre Selbach, Didrik Småbråten, Julian Walker*

Organic ferroelectric materials have gained traction in the last decades due to their low fabrication temperature compared to traditional ceramic material. A class of organic ferroelectric material, ionic plastic crystals also have the unique advantage of being easy to recycle due to their solubility in organic and aqueous solutions. Recyclability is of particular interest in the current push towards more sustainable electronics and reduction of electronic waste. Plastic crystals are characterized by the molecules having rotational degree of freedom in the solid phase. However, what influence this rotation has on the functional properties is not well understood. Selecting the ionic molecule H-DABCO as a basis component for material selection, the two isostructural orthorhombic crystals H-DABCOClO and H-DABCOBF were compared to the monoclinic crystal H-DABCOReO. These systems are ferroelectric, where the anion and cation sublattices are displaced, and the organic molecules are connected through a NH•••N chain. Molecular Dynamics simulations with Machine Learning Force Field trained on Density Functional Theory data were used to study these materials in terms of electronic densities, free energies, polarization and molecular rotational freedom. H-DABCOReO showed the highest retention of molecular order of the investigated systems, both with respect to anion rotation and proton transfer. All systems showed proton transfer occurring in the THz frequency range from 300 to 500K, but retaining some preferential site in the hydrogen bonded chain. Our study points out that careful consideration of anion species, tuning the molecular disorder can increase the polarization and Curie temperature in these systems. Thus, a deeper understanding of the functional properties of ferroelectric ionic plastic crystals can increase the viability of the materials for use in more sustainable electronic components.

Chromium(II) fluoroperovskites - Jahn-Teller active materials

Øystein Slagtern Fjellvåg, IFE

Chromium(II) compounds are well known for exhibiting strong Jahn–Teller distortions due to their electronic configuration, which leads to pronounced structural anisotropy and complex dynamic behavior in both molecular and extended inorganic systems. In fluoroperovskites containing Cr(II), such distortions play a crucial role in determining lattice symmetry, magnetic exchange interactions, and temperature-dependent phase transitions.

In this context, we have recently studied a variety of Cr(II) in fluoroperovskites. By a wet-chemical approach, we have prepared large quantities of CrF, with = K, NH, Rb, and Cs. For the first time, we describe the structural chemistry and magnetic properties of NHCrF, RbCrF, and CsCrF. NHCrF displays hydrogen bonding between H and F, which distorts the structure and leads to anisotropic negative thermal expansions. RbCrF displays stacking faults based on the - and -type polymorph, while CsCrF adopts a two-phase mixture similar to KCuF. For KCrF, we show that the reported reentrant tetragonal phase is absent and is most likely reported due to challenges with thermalization.

Electrocatalytic CO_2 reduction with a Cu(I) metal-organic framework

Julie Brun, University of Oslo

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The metal-organic framework (MOF) Qc-5-Cu has been synthesised for electroreduction of CO_2 to methanol. CO2 utilization is a massive effort to stem the increasing amounts of CO_2 in the atmosphere. The product, methanol, has been proposed as an energy carrier in the methanol economy.(1) It is both a good fuel and a platform chemical, which is largely being produced from fossil sources.

The MOF has two polymorphs, square layered, Qc-5-Cu-sql, or diamonoid, Qc-5-Cu-dia.(2) The polymorphs have different Cu coordination, which may influence their catalytic properties. This work has produced insight into the synthesis conditions to produce the chosen polymorph. Qc-5-Cu has been characterized with PXRD and gas adsorption. Qc-5-Cu-sql has been characterized by cyclic voltammetry (CV). The material has confirmed CO2 porosity and does interact electrocatalytically under CO2 flow.

References:
(1) Olah, G. A. Beyond Oil and Gas: The Methanol Economy. International in English ed.; Weinheim, 2005; pp 2636-2639.
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Selective aqueous chemical solution deposition using self-assembling monolayers

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A new thin-film deposition process has been developed that combines the utility of selective-area deposition and the ease of fabrication of aqueous chemical solution deposition to directly deposit microscale BaTiO structures in a sustainable manner. Platinum substrates we successfully functionalised by patterning 1-octadecanethiol self-assembling monolayers using DUV-photolithography, creating a hydrophobic/hydrophilic pattern on the substrate before film deposition. Altering the wetting behaviour of the substrate resulted in a high selectivity of the precursor solution for the hydrophilic regions of the substrate, allowing for precise deposition of the CSD precursor. Test structures were successfully deposited down to a size of 15.6 μm, showing good potential for micropatterning applications.