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ABSTRACT BOOK

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Tuning Wettability of Copper-Silver Coatings by Constant Magnetic Field During Electrodeposition

Anne-Lise Daltin [1*], Sofya Effimova [1], Florica Lazar[1], Jean-Paul Chopart[1], François Debray[2]

[1] *MATIM Université de Reims Champagne-Ardenne, 51100 Reims, France*

[2] *LNCMI-EMFL, CNRS, univ. Grenoble Alpes, Univ. Toulouse, Univ. Toulouse 3, INSA-T, Grenoble and Toulouse, France*

**corresponding author: anne-lise.daltin@univ-reims.fr*

Magnetoelectrodeposition (MED), consisting in the superimposition of a magnetic field during electroplating, is a well-established method for enhancing coating properties of metallic alloys. This technique has proven effective in improving deposition rate, modulating composition, and tailoring surface properties due to magnetohydrodynamic (MHD) effects [1].

The electrodeposition of Cu–Ag alloys has received considerable attention due to their excellent mechanical and electrical properties [2]. In this study, the influence of a constant magnetic field (up to 1 Tesla) applied parallel to the electrode surface was investigated during the potentiostatic electrodeposition of Cu-Ag alloys on Ti6Al4V substrates. Electrodeposition was performed using ammonium hydroxide-based electrolytes with varying compositions. The application of a magnetic field significantly changed the alloy composition, as evidenced by Energy Dispersive X-ray Spectroscopy (EDS), showing an increase in silver content with rising field amplitude.

X-ray diffraction (XRD) analysis revealed changes in crystallographic texture. While one electrolyte composition showed an increased texture coefficient (TC) for the (200) peak, another indicated a decrease in the same orientation, suggesting that magnetic field effects depend on the bath chemistry. Morphological observations using scanning electron microscopy (SEM) highlighted a transition from octahedral to treelike crystal structures under magnetic influence.

A key finding of this study relates to the wettability of the electrodeposited Cu–Ag coatings. In the absence of a magnetic field, the surfaces exhibited hydrophilic behavior, with a water contact angle of approximately 63°. However, when a 1 T magnetic field was applied during electrodeposition the resulting surfaces displayed pseudo-superhydrophobic properties, with a contact angle reaching 156°. This behavior is reminiscent of the Rose petal effect, where water droplets adhere to the surface despite their high contact angle. These results highlight the capability of magnetoelectrodeposition (MED) to precisely tailor surface wettability, offering promising opportunities for applications in sensing, electrical interconnections, catalysis, and antimicrobial surfaces.

[1] A.L. Daltin, M. Benaissa, J.P. Chopart, IOP Conference Series: Materials Science and Engineering (2018) p. 012022.

[2] S. Efimova, F. S. Lazar, J. P., Chopart, F. Debray, A. L. Daltin (2024), Compounds, 4(3), 453-478.

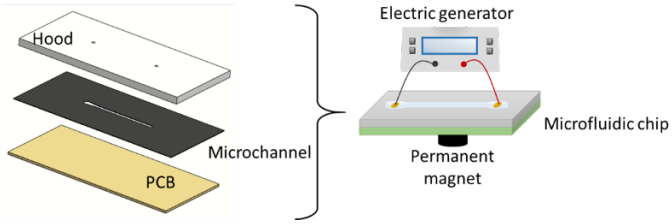
On the cooperative role of DC electric and magnetic fields in micro-stirring

Léna Gonzalez[1], Clémence Biscara[1], Jean-Maxime Roux[1] & Laurent Davoust[2,*]

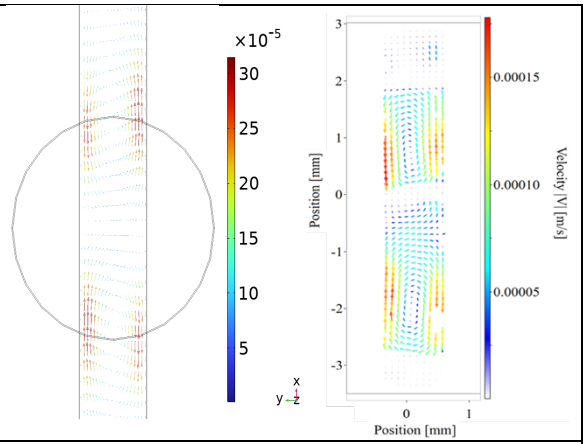
[1] Univ. Grenoble Alpes, CEA, LETI, 38000 Grenoble, France.
[2] Univ. Grenoble Alpes, SIMaP Laboratory, EPM Group, 38402 Saint Martin d'Hères, France.

*Corresponding author: Laurent.davoust@simap.grenoble-inp.fr

Effective stirring at microscale remains a challenge despite the need for enhancing molecular transport in biological microsystems. In this paper, a method is proposed to generate controlled micro-stirring by exploiting the respective assets of a uniform DC electric field and a non-uniform static magnetic induction. When an electric field is applied all along a microchannel filled with a ionic liquid buffer, an electroosmotic flow arises when the Debye thickness of the electric double layers along the walls remains smaller than the transverse size of the channel. Because an axial electric field acts on the non-uniform space charge across the EDL, a Coulombic force is generated that generates a liquid plug motion under viscous shear. We present comprehensive numerical simulations of such an electroosmotic flow that is modified by the local presence of a permanent magnet located beneath the bottom wall of a microchannel. This configuration allows for the exploration of magneto-electro-osmotic-induced micro-stirring. A companion experimental device (fig. a) is developed with a microchannel equipped with a permanent magnet. The latter introduces a non-uniform magnetic field that, in combination with the axial electric field, generates low magnetic Reynolds number vortices (fig. b). Such patterns are relevant for micro-stirring applications requiring stirring or collection of biological targets. Fluorescent microparticle image velocimetry (μPIV) confirms their presence within the microchannel. The vortices are driven by a spatially varying Lorentz force, the curl of the latter being identified as the mechanism responsible for micro-stirring so observed. This work provides a basic understanding of how controlled electric and magnetohydrodynamic forces can be harnessed to achieve efficient mixing at microscale, offering new avenues for applications in microfluidic systems, biological transport and detection.



(a) Device to promote a magneto-electroosmotic channel flow.



(b) Velocity fields obtained from numerical simulations (left) and Particle Image Velocimetry (PIV) (right) under a voltage of 20 V, with a 3mm-sized cylindrical magnet located just beneath the microchannel.

LNCMI – Static and Pulsed High Magnetic Field Facility

François Debray [1*]

[1] *CNRS/LNCMI, Grenoble France*

**corresponding author: francois.debray@lncmi.cnrs.fr*

The LNCMI [1] is one of the few facilities worldwide to offer access to magnetic fields in excess of what is made available by commercial companies.

LNCMI is the founder of the European Magnetic Field Facility (EMFL) [2] that gathers the four high field facilities in Europe: Dresden-Germany and Toulouse-France for pulsed field , Grenoble-France and Nijmegen-Netherlands for DC fields.

The LNCMI is a two site facility. In Toulouse, pulsed magnetic field are available with fields up to 100T produced by non destructive magnets.

In Grenoble DC magnetic fields up to 42 T are available for long duration experiments (several hours) thanks to the recent achievment of the hybrid magnet and of the upgrade of the power supply.

DC high field magnets available in Grenoble are modular. Consequently a wide range of space (diametre from 800 to 34 mm) are available for science.

We present the status of the facility and some examples of experiments performed at LNCMI in the domain of Magnetoscience

[1] www.lncmi.cnrs.fr
[2] https://emfl.eu/

Research progress on magnetic ultrafine grain/homogenization melting and casting technology for high-performance copper alloys

Biao Ding, Zhe Shen, Tianxiang Zheng, Peijian Shi, Qiang Li, Zhongze Lin, Bangfei Zhou, Wenhao Lin, Yunbo Zhong*.

(State key laboratory of Materials for Advanced Nuclear Energy & School of Materials Science and Engineering, Shanghai University, 333 Nanchen Road, Shanghai, 200444, PR China).
**corresponding author: Yunbo Zhong, E-mail: yunboz@shu.edu.cn*

Abstract: This study addresses the challenges in metallurgically preparing high-strength, high-conductivity, and high-elasticity copper and copper alloys. Leveraging the unique multi-mode non-contact force/energy effects of electromagnetic fields, we apply key multi-scale effects-including electromagnetic separation/purification, stirring/oscillation, and thermoelectric magnetic currents/forces-to their fabrication. During continuous casting, these electromagnetic interventions promote the refinement of grains, dendrites, and precipitates within the solidification microstructure, alongside enhanced compositional homogeneity. This approach enables the production of high-performance master alloy ingot characterized by exceptional cleanliness/purity, ultrafine grains, and high uniformity. These advanced copper materials hold significant potential for applications in aerospace, 5G communications, and new energy sectors, contributing to energy conservation, circular economy practices, and the advancement of carbon peaking and carbon neutrality goals.

Keywords: Magnetic solidification; Ultrafine grain; Homogenization; High-strength, high conductivity, and high elasticity copper alloy.

Acknowledgements

This study was financially supported by the National Natural Science Foundation of China (No. 52204392, 52474411, 52474413, 52274385, 52004156, and 52204347) and the National Key Research and Development Program of China (No. 2022YFC2904900).

Optimization of Environmental Conditions for Magnetic Alignment of Carbon Crystallites under a 6-Tesla Field and Its Potential Impact on Graphite Preparation Energy

Atom Hamasaki [1,*], Yuta Matsuo [1,] Yuka Takeuchi [2], Akio Katsuki [3], Sumio Ozeki [1]

[1] *Faculty of Science, Shinshu University, Matsumoto, Nagano 390-8621, Japan*

[2] *Muroran Institute of Technology, Muroran, Hokkaido 050-8585, Japan*

[3] *Center for General Education, Shinshu University, Matsumoto, Nagano 390-8621, Japan*

* *atom@shinshu-u.ac.jp*

Graphite production often requires temperatures as high as 3000 K, which leads to significant energy consumption. Reducing this energy demand while maintaining material quality is essential for sustainable graphite production. We have previously reported that energy consumption can be reduced by approximately 10% by applying a magnetic field to a portion of the graphite production process [1]. In this process, carbon microcrystals, the building blocks of graphite precursors, were effectively oriented in the early stages and their interconnections were strengthened during graphite formation at temperatures above 1000 K. This behavior suggests that the amount of energy required for graphite production decreases. Herein, we aimed to accelerate the orientation of carbon crystallites under a magnetic field. During the carbonization of coal tar pitch, low-molecular-weight hydrocarbons (LMwHCs) melt, and the carbon crystallites aggregate into spherical domains behaving as single units. Magnetic orientation of the spherical domains occurs readily in the liquid phase, which solidifies to yield highly oriented graphite precursors. Optimizing the amount of carbon microcrystals and low molecular weight hydrocarbons (LMwHC) in the coal tar pitch during the carbonization process at 600-800 K increased the size of the spherified particles and improved the orientation of the carbon microcrystals under the influence of magnetic fields. Spheronization increased the magnetic torque acting on these domains, improving their response to the applied magnetic field and facilitating orientation. Carbonization of this highly oriented precursor by heat treatment at up to 1523 K reduced energy consumption by more than 25%, demonstrating the potential for lower energy graphite production.

[1] A. Hamasaki, *et al.*, AIP Adv. **11**, 025041 (2021).

Behaviors of magnetic particles during high gradient magnetic separation

Noriyuki Hirota [1*], Gou Takano [2], Towa Ito [2], Misaki Suda [2], Tsutomu Ando [2],

[1] *National Institute for Materials Science, 3-13 Sakura, Tsukuba, 305-0003 Japan*

[2] *Nihon University, 1-2-1 Izumi-cho, Narashino, 275-8575 Japan*

**corresponding author: hirota.noriyuki@nims.go.jp*

High gradient magnetic separation (HGMS) is the way to separate particles dispersed in a fluid depending on the difference of their magnetic susceptibilities using magnetic filters. Since particles are captured on the filter wire by the magnetic force acting on each particle, the filter openings can be made much larger than the particle size, which makes it possible high-speed separation with low pressure loss. In addition, when the magnetic field is removed, the deposited particles can be detached from the filter, making it possible to reuse the filter, which reduces costs and is also environmentally friendly. However, details of the particle deposition in the separation process are not well understood, therefore, the separation process is often performed under extreme conditions than necessary. If the particle deposition process on the magnetic wires and the behaviors of particles in a fluid are well understood, it may contribute to optimize the separation condition and is expected to lead the further applications of HGMS into wide range of fields. Therefore, in this study *in-situ* observations of particles deposition process during HGMS have been investigated.

Two CCD cameras were set parallel and perpendicular to the fluid flow, respectively, to observe the deposition process. In this study, two filters were set in the transparent filter housing. As a result, magnetic particles introduced into the filter housing formed chain-like structures or the bundles of such chain structures before reaching the magnetic filters due to their magnetization caused by the externally applied magnetic fields. Thus formed chains and bundles were captured at the first filter and, as a result, spike-like structures formed on the upper stream side of the first filter. At the second filter, particles deposited uniformly on the filter wires. Many particles are also held in the space between two filters. In fact, as particle deposition progresses, the top surface of the deposition moves upward as time passes, and accumulation of particles at the tip of already deposited structure were observed.

In this presentation, details of the experimental observations will be reported.

Magnetic-field-induced novel phenonmenon of the phase transformation in Fe-based alloy

Tingping Hou[1*], *Kaiming Wu*[1]

[1,*]*Wuhan University of Science and Technology, China*

[1*]*Houtingping@wust.edu.cn*.

[1]*Wukaiming@wust.edu.cn*.

Abstract.

Nuclear fusion reactors, often referred to as "artificial suns," have the Tokamak as their core device, which features both fully superconducting magnets and active cooling structures. In Tokamaks, the toroidal magnetic confinement of plasma utilizes low-activation steel, which operates under conditions of high temperature and steady strong magnetic fields (300 – 550 ° C, 3 – 4 Tesla). Thus, understanding and controlling the magnetic behavior and phase evolution of iron-based materials under high temperatures and strong magnetic fields are key to unraveling their mechanical and magnetic properties.

Experimental observations have also proven that the microstructures in steels including ferrite, martensite, autenite and precipitates are influenced by high magnetic fields which has a great effect on the stability. This work breaks through the limitations of first-principles calculations under zero magnetic field, absolute zero temperature, and the absence of magnetic fields. By incorporating the effects of magnetic field and temperature within the framework of Weiss molecular field theory, it was found that a strong magnetic field significantly influences atomic diffusion behavior, carbide nucleation, bainite transformation, martensite recovery, and austenite nucleation. The investigation of magnetism evolution could contribute to a better understanding of physical mechanism underlying magnetic field phase transformation in Fe-based materials.

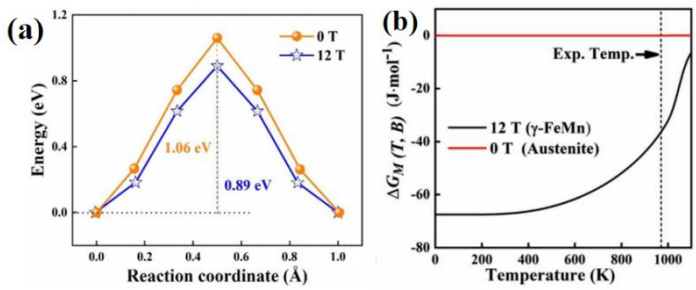


Figure 1. Under zero and high magnetic fields: (a) the energy barrier for carbon atoms transitioning between octahedral interstitial sites; (b) the energy variation of austenite.

[1] D. Zhang, T. Hou, X. Quan, J. Zhou, C. Yin, H. Lin, Z. Lu, K. Wu, Journal of Materials Research and Technology, 25 (2023) 210-221.

First-Principles Study on Ordered Layers of Metal Melts at Magnetic Solid-Liquid Interfaces

Weida Fu [1], Tao Hu [1*], Guicheng Zhang [1], Sheng Qian [1], Weidong Xuan [1], Yang Yang [2*], David J Singh [3], Zhongming Ren [1*]

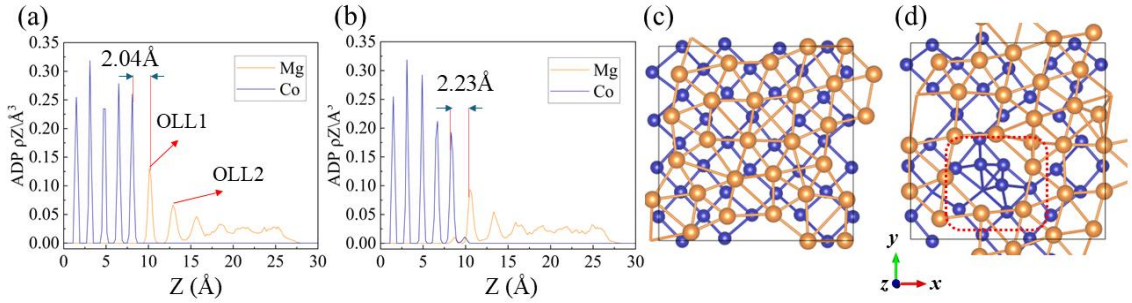
[1] *State Key Laboratory of Advanced Special Steel, School of Materials Science and Engineering, Shanghai University, Shanghai 200444, China*

[2] *State Key Laboratory of Precision Spectroscopy, School of Physics and Electronic Science, East China Normal University, Shanghai 200241, China*

[3] *Department of Physics and Astronomy, University of Missouri, Columbia, Missouri 65211-7010, USA*

**Corresponding author: taohu@shu.edu.cn, yyang@phy.ecnu.edu.cn, zmren@shu.edu.cn*

We investigated the magnetic effects at the interface between a ferromagnetic cobalt (Co) substrate and liquid magnesium (Mg), as well as their influence on heterogeneous nucleation, using first-principles molecular dynamics simulations. The study found that Mg atoms at the interface exhibit an induced magnetic moment of approximately 0.02 μB/atom. Magnetism increases the solid-liquid interface distance by about 10%, reduces the atomic order of the ordered liquid layer (OLL1) at the interface, and decreases the coverage (θ) of Mg atoms on the substrate in the OLL1 layer (non-magnetic θ=0.81 vs. magnetic θ=0.75). Additionally, the unique interfacial structure and increased roughness under magnetic influence suggest that magnetism may induce roughening of the solid-liquid interface, thereby affecting the heterogeneous nucleation process. Charge analysis reveals that magnetism suppresses interfacial charge transfer (reduced by 0.15 e/Co atom), leading to weakened Co-Mg interactions (binding energy increases by 0.35 J/m²). This work elucidates the regulatory mechanism of magnetic substrates on the ordered layers at liquid metal interfaces through interface coupling effect, providing a theoretical basis for external field-controlled heterogeneous nucleation.



[1] W. Fu, T. Hu, G. Zhang, S. Qian, W. Xuan, Y. Yang, D. Singh and Z. Ren, Strong Effect of Magnetism at the Cobalt-Magnesium Solid-Liquid Interface, Scripta Materialia (2025) 268, 116892. https://doi.org/10.1016/j.scriptamat.2025.116892

Single Crystal Growth of Inorganic Salts in a Magnetically Levitated Aqueous Droplet Using Small Permanent Magnets

*Yasuhiro Ikezoe, Tomoaki Suzuki, Tomoya Naito
Department of Applied Chemistry, Nippon Institute of Technology

Using the microgravity environment inside the space station, numerous important studies are being conducted that are difficult to achieve on Earth. In particular, for protein crystal growth, the microgravity environment suppresses convection caused by density differences within liquids, enabling the formation of high-quality crystals. This has stimulated extensive research into potential applications in the medical and biological fields. However, in addition to the enormous cost of conducting experiments in space, there are various limitations in terms of human resources, available time, and experimental equipment. Therefore, several technologies have been explored to reproduce microgravity-like environments on Earth, one of which is diamagnetic levitation. In general, diamagnetic levitation requires large superconducting magnets and thus has not become a highly versatile technique. However, we have recently discovered that placing two pairs of small permanent magnets in a specific configuration makes it possible to levitate diamagnetic substances such as water and sodium chloride [1].

In this study, we levitated an aqueous solution of an inorganic salt and carried out its recrystallization by evaporating the solvent (water). As a result, it was found that controlling the crystallization conditions makes it possible to grow only a single crystal. In the experiment, small plate-shaped magnets (depth 5 mm, width 1 mm, height 10 mm; Type A) and cylindrical magnets (diameter 1 mm, length 3 mm; Type B) were fixed in pairs (Fig. 1-(a)). Under conditions of room temperature (24.6 °C) and 10% humidity, microdroplets of a 4.5 M NaCl solution generated by an ultrasonic humidifier were introduced into an acrylic case through a silicon tube. The microdroplets slowly fell inside the case and gathered at levitation points in the narrow valley between the Type A magnets, forming droplets with a diameter of about 100 μm. As the solvent evaporated, seed crystals formed at the bottom of the droplets, and the crystals grew as the water evaporated (Fig. 1-(b)). When the water completely evaporated, transparent cuboid crystals remained levitated. Similar results were obtained using a KCl solution, and it was found that the timing of seed crystal formation could be controlled.

This method offers extremely low initial and operating costs, minimal restrictions on experimental time, space, and energy consumption, and broad applicability. In the future, this method is also expected to find applications in protein crystallization and in experiments involving supercooled melts.

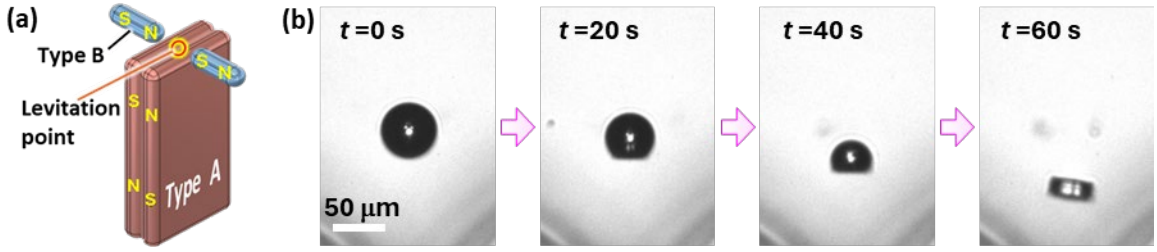


Figure 1. (a) Schematic illustration of the magnet configuration. Magnetic levitation of objects is observed in the narrow valley between the Type A magnets. (b) A series of photographs showing the recrystallization process. During evaporation of the levitating aqueous droplet, nucleation occurred, resulting in the growth of a single transparent cuboid crystal of sodium chloride.

[1] T. Naito et al., *Appl. Phys. Lett.* 125, 264102 (2024)

Multifluid Magnetohydrodynamic Modeling of Cathode Spot Dynamics

Abdellah Kharicha, Ebrahim Karimi-Sibaki, Menghuai Wu

Montanuniversität, Leoben, Austria

*abdellah.kharicha@unileoben.ac.at

A cathode spot is a small, highly localized region on the cathode surface in an electrical arc discharge where intense electron emission occurs, characterized by extremely high temperatures and current densities. These spots rapidly move across the cathode, sustaining the arc by continuous electron emission, while causing local melting and evaporation of the cathode material. Magnetic fields influence cathode spot motion and distribution through the Lorentz force, affecting arc stability, spot lifespan, and heat transfer patterns.

This study presents a comprehensive vacuum arc cathode spot model that couples full magnetohydrodynamics (MHD) with free surface dynamics, evaporation processes, and multifluid modeling of ionic and electronic species. By treating ions and electrons as separate interacting fluids, the model captures their distinct dynamics, including charge transport, diffusion, and recombination, which are crucial for accurately describing plasma behavior near the cathode. The effects of magnetic fields on cathode spot behavior will be presented and analyzed.

Key features include simulation of plasma formation, electromagnetic effects, and deformation and evaporation of the cathode surface, processes critical to spot stability and dynamics. Preliminary results reveal the strong impact of surface evolution, evaporation, and multifluid interactions on the cathode spot's spatial and temporal development, emphasizing the essential role of MHD and detailed plasma chemistry in plasma/surface interactions.

Keywords: Magnetohydrodynamics, Cathode Spot, electric arc, Free Surface Dynamics, Evaporation, Plasma Modeling, Numerical Simulation

Localized‐Gradient Magnetic Field as a Tool for Tailoring Dealloying and Galvanic Ag Replacement on Multicomponent Ferromagnetic Alloys

Dawid Kutyła [1*], Katarzyna Skibińska[1], Piotr Żabiński[1]

[1] *AGH University of Kraków, Faculty of Non-Ferrous Metals, Mickewicza Ave. 30, 30-059, Kraków, Poland*

**corresponding author: kutyla@agh.edu.pl*

Spontaneous electrochemical reactions like selective dealloying and galvanic metal replacement offer simple, current-free routes to engineer high-surface-area and bimetallic coatings. Yet the influence of static magnetic fields on these processes remains largely unexplored, particularly for multicomponent ferromagnetic substrates that can themselves reshape the external field.

Here we investigate the effect of a ≈ 0.4 T permanent magnet on Ni–Co–Fe and high-entropy Co–Ni–Fe–Mo–W alloy films immersed in 0.1 M HNO_3, for dealloying or containing 1 mM $AgNO_3$ for galvanic replacement modification. Open-circuit potential is monitored in real time to capture field-dependent reaction kinetics, while X-ray fluorescence and X-ray diffraction performed before and after immersion quantify elemental redistribution and lattice distortion.

We hypothesize that:

(i) Strong local magnetic-field gradients, arising from flux-line distortion by the ferromagnetic alloy itself, generate additional force-driven micro-convection that accelerates selective dissolution of Co, Ni and Fe.

(ii) The same gradients enhance mass transport of silver ions toward the surface, increasing nucleation density and coverage despite Ag^+ weak magnetic susceptibility.

(iii) The combined effects yield measurable shifts in OCP profiles, greater compositional contrast in XRF, and broadened or shifted diffraction peaks associated with lattice depletion and Ag incorporation.

The study provide the systematic evidence that a small, static magnetic field can act as an effective “field catalyst” for zero-current surface transformations on complex ferromagnetic alloys, opening a new pathway for controlled corrosion, catalyst design and functional surface modification without external power input.

Keywords: magnetic field, dealloying, galvanic replacement, Ni–Co–Fe alloy, high-entropy alloy, Ag deposition, magnetohydrodynamics

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Effects of High Magnetic Fields on Electrical Resistivity of Molten Pb and Sn

Tie Liu[1*], Wenzhao Liu[1], Peng Miao[1], Qiang Wang[1]

[1] *Key Laboratory of Electromagnetic Processing of Materials (Ministry of Education), Northeastern University, Shenyang 110819, China*

**Corresponding author: liutie@epm.neu.edu.cn (Tie. Liu).*

High magnetic fieldsaffect the solidification structure and properties of materials by Lorentz force and thermo-electromagnetic force during metal solidification, the quantitative description of these two forces is related to the resistivity parameters under magnetic field [1-3]. In this study, a metal melt resistivity test platform under high magnetic field was independently developed. The four-electrode method was used to obtain the resistivity variation of Pb and Sn melts under 6 T magnetic field for the first time. The results show that when the magnetic induction intensity is constant, the resistivity of pure metal melt increases with the increase of temperature. When the external magnetic induction intensity is 2 T, the resistivity changes less than that of 0 T, When the magnetic induction intensity is 4 T, the resistivity increases significantly; under the condition of certain temperature, the resistivity of pure metal melt decreases first and then increases with the increase of magnetic induction intensity in the 0-6 T magnetic field, and the resistivity returns to the initial value after demagnetization. Meanwhile, after applying a magnetic field above 2 T, the resistivity basically increases linearly. Sn increases by about 46.1 % at 6 T near the melting point compared with 0 T, and Pb increases by about 29.1 % at 6 T near the melting point compared with 0 T.

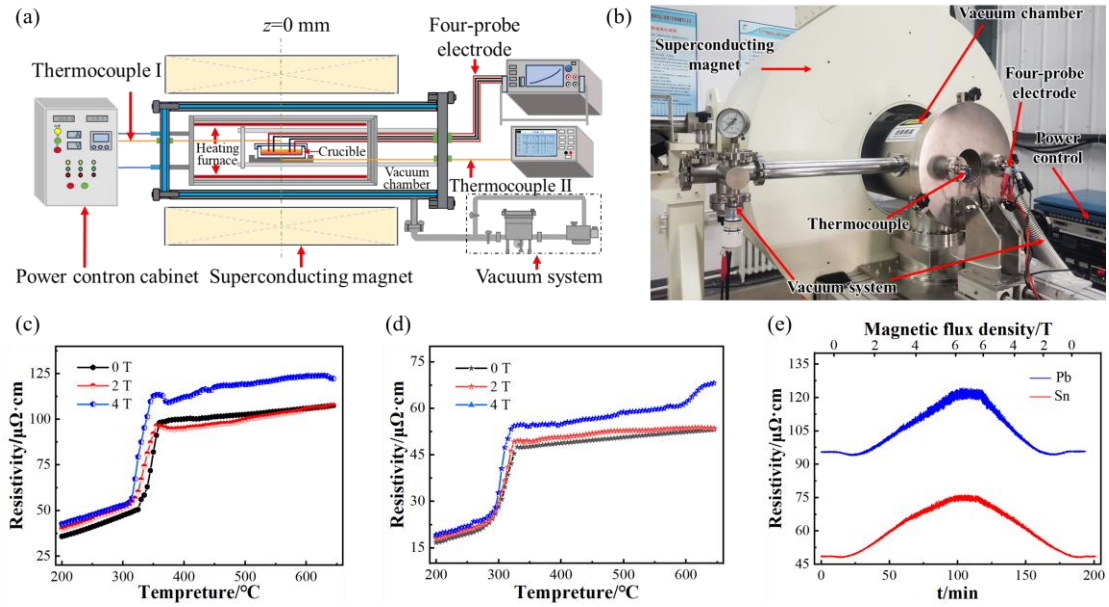

Fig. Resistivity test under high magnetic field: (a)diagram of test platform (a) test platform physical graph (b) Pb melt resistivity with temperature (c) Sn melt resistivity with temperature (d)Pb and Sn melt resistivity with magnetic field

[1] C. S. Lou, T. Liu, M. Dong, C. Wu, J. G. Shao, and Q. Wang, J. Magn. Magn. Mater. 424, 365–370(2017).

[2] S. Tu, Y. Mai, Y. Tong, T. Liu, M. Dong, and Q. Wang, J. Alloys Compd. 741, 1006–1011 (2018).

[3] S. L. Dong, T. Liu, M. Dong, X. Y. Guo, S. Yuan, and Q. Wang, Appl. Phys. Lett. 116, 053903 (2020).

Mechanical properties of magnetically aligned cellulose nanocrystals/polymer nanocomposites

Asahi Maeda [1*], Kayoko Kobayashi [1], Ryosuke Kusumi [2], Noriyuki Hirota [3], Masahisa Wada [1]

[1] *Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto, 606-8502, Japan*

[2] *Forestry and Forest Products Research Institute, 1 Matsunosato, Tsukuba, Ibaraki, 305-8687, Japan*

[3] *National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047, Japan*

**corresponding author: maeda.asahi.27c@st.kyoto-u.ac.jp*

Cellulose is the most abundant macromolecule on Earth and has gained significant attention in recent years due to its sustainable properties. Cellulose nanocrystals (CNCs), obtained through the acid treatment of natural cellulose (Fig.1), are being explored as reinforcing fibers for nanocomposites due to their high aspect ratio, crystallinity, and stiffness. The orientation of CNCs within a matrix can create anisotropy in nanocomposites, paving the way for new applications. Earlier studies have demonstrated that when exposed to magnetic fields, the hard magnetization axis of CNCs aligns with the *c*-axis (fiber axis) of cellulose, causing the long axis of the CNCs to align perpendicularly to the applied magnetic field [1]. In this study, we prepared anisotropic CNC nanocomposite films by dispersing CNCs in aqueous polyvinyl alcohol (PVA) and cellulose acetate (CA) / acetone solutions, and then casting them in a static magnetic field. We investigated the relationship between the strength of the magnetic field and the orientation of the CNCs, and we evaluated the mechanical properties of the resulting nanocomposites.

Cellulose was treated with sulfuric acid to prepare a CNC suspension. Polyvinyl alcohol (PVA) was added to the suspension, and then CNC/PVA dispersions were prepared. The carboxyl groups were introduced onto the surface of the CNC and subsequently replaced with tetrabutylammonium groups through an ion exchange [2]. Using this surface-modified CNC, a CNC/cellulose acetate (CA) acetone suspension was prepared. These CNC/polymer suspensions were cast at 35°C under a horizontal magnetic field of 0–7 T to create nanocomposite films. The structure of the nanocomposites was evaluated using X-ray diffraction, and their mechanical properties were assessed through tensile testing.

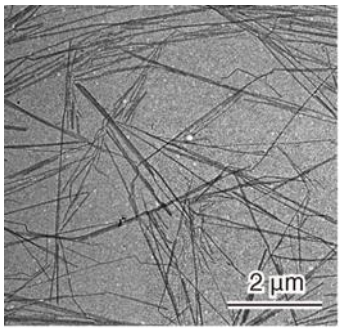

Fig. 1 TEM image of CNC

The X-ray diffractogram of the CNC/PVA nanocomposites indicated that the degree of orientation increased with the strength of the applied magnetic field. Additionally, a linear relationship was observed between the half-width of the azimuthal angle plot of the diffraction peaks and the inverse of the magnetic field strength. The findings also revealed that the cellulose fiber axis was aligned perpendicular to the applied magnetic field. A similar orientation was observed in the CNC/CA nanocomposites, and the magnetic alignment of the CNCs was successfully achieved even in organic solvents. Mechanical tests demonstrated that the addition of CNCs to the nanocomposites improved the elastic modulus, even at random orientations (0 T), thereby confirming the reinforcing effect of the CNCs. Moreover, it was determined that the elastic modulus further increased as the degree of orientation intensified with rising magnetic field strength.

[1] M. Wada et al., *Cellulose* **28**, 6757–6765 (2021)
[2] M. Shimizu et al., *Biomacromolecules*, **15 (5),** 1904–1909 (2014)

Stable levitation of permanent magnet above cryocooler-cooled superconducting bulk magnet and non-contact stirrer

Tetsuo Oka [1*], Kazuya Yokoyama [2], Naomichi Sakai [1], Yoshikazu Kato [3], and Tomokazu Hemmi [4]

[1] *Shibaura Institute of Technology, 3-7-5 Toyosu, Koto, Tokyo 135-8548, Japan,*

[2] *Ashikaga University, 268-1 Ohmae, Ashikaga, Tochigi 326-8558, Japan,*

[3] *SATAKE MultiMix Corporation, 66 Niizo, Toda, Saitama 335-0021, Japan,*

[4] *Thermal Block Co. Ltd., 681-4 Kizoro, Kawaguchi, Saitama 333-0831, Japan*

**corresponding author: okat@shibaura-it.ac.jp*

In pharmaceutical manufacturing, single-use manufacturing, which eliminates external contamination, is gaining attention. Stirring wings placed inside pharmaceutical tanks need to be held and moved without touching the walls. Non-contact magnetic levitation, one of the unique properties of high-temperature superconductivity, has already been utilized for non-contact mixing. By cooling a high-temperature superconducting sintered pellet (referred to as bulk) to temperatures lower than liquid nitrogen using a refrigerator and capturing the magnetic flux distribution from an external magnet, we achieved levitation of up to 30 mm above the magnetic pole. We evaluated the horizontal drag of the magnet at a levitation distance of 10 mm from the bulk, and achieved levitation stability of 10 N. We rotated the HTS bulk magnet along the central axis of the refrigerator to evaluate its magnetic field capture performance. Utilizing this performance, we successfully created a non-contact stirrer.

Ever-changing nature of graphene oxide

Hayato Otsuka[1*], Katsumi Kaneko [2]

[1] *Faculty of engineering, Shinshu university, 4-17-1 Wakasato, Nagano, Japan*

[2] *Institute for aqua regeneration (ARG), Shinshu university, 4-17-1 Wakasato, Nagano, Japan*

**hayat_o@shinshu-u.ac.jp*

Graphene oxide (GO)—the oxidized form of graphene—is actively studied in various fields. One major drawback of GO is its instability [1], which leads to the difficulties in product management. Despite their importance, the structural changes that occur in colloidal dispersions of GO has not been well understood. Optical absorption spectral and magnetic property analyses of GO can provide structural information on the electronic state and sp^2/sp^3 ratio of GO. We accelerated the ripening process of GO by elevation of the temperature to elucidate the unstable nature from the structural aspect. This presentation will show the structurally different GO three states exhibiting inherent magnetic and electrical properties. A physicochemical understanding of the ever-changing nature of GO can promote the establishment of GO science

GO was prepared through the improved Hummers' method. GO dispersions were ripened at different temperatures of 298, 308, 333, and 348 K for up to 2 weeks and an ultraviolet–visible (UV-vis) absorption spectrum of GO dispersions was measured. Magnetic and electrical properties of the freeze-dried GO powders were investigated and the freeze-dried GO powders were also characterized by X-ray diffraction and X-ray photoelectron spectroscopy. Transmission electron microscopic (TEM) images of the freeze-dried GO powders were observed after annealing at 2073 K in Ar. Electron energy-loss spectroscopy was conducted on a specific area on the TEM image.

The three GO states, intrinsic, metastable and transient GO states, are identified using a π-π^* transition peak of UV-Vis absorption spectra [2]. The intrinsic GO exhibits a π-π^* transition at 230.5 ± 0.5 nm and stable only for 5 days at 298 K. The composition of oxygen functional groups from XPS measurement and magnetic properties changes with ripening. The paramagnetic nature of GO dynamically changes with ripening (Figure 1). The ripening of GO reduces the radicals on the GO sheets. An optimum choice among the three states of GO can accelerate GO research and applications.

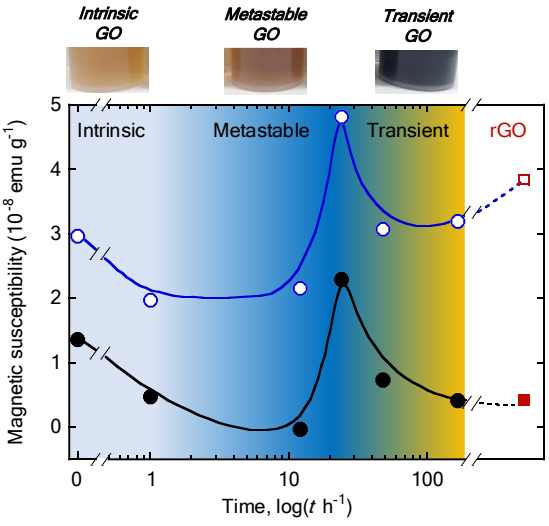

Figure 1. Magnetic property changes with ripening and corresponding GO color.

[1] Kumar, P. V., Bardhan, N. M., Tongay, S., Wu, J., Belcher, A. M. & Grossman, J. C. *Nature Chem.*, **6**, 151-158 (2014).

[2] H. Otsuka, K. Urita, N. Honma, T. Kimuro, Y. Amako, R. Kukobat, T. J. Bandosz, J. Ukai, I. Moriguchi, K. Kaneko, Nat. Commun. 15, 1708, (2024).

The influence of magnetic field on the heterogeneous nucleation behaviour of metals

Zhongming Ren*, Sansan Shuai, Chengling Huang, Rong Fu

[1] *State Key Laboratory of Advanced Special Steel, School of Materials Science and Engineering, Shanghai University, Shanghai, China, 200444*

**corresponding author: zmren@shu.edu.cn*

Nucleation plays important role in the solidification process of metals and largely determines the microstructure of metal solidification. As a non - contact physical field, the magnetic field has become one of the key technologies for regulating the preparation of metal materials. Research results show that the electromagnetic field can significantly affect the metal solidification process, including nucleation and grain growth. Based on the classical solidification theory, the melt structure and the solid - liquid interfacial energy are the key factors determining grain formation, and they significantly influence the thermodynamics and kinetics of metal nucleation and grain growth. Based on this, this paper carried out investigation from two aspects: the influence of the magnetic field on the metal melt structure and the solid - liquid interfacial energy. First, synchrotron radiation X - ray diffraction is used to study the structural transformation of the metal melt under the electromagnetic field. It is found that the electromagnetic field can change the short - range order structure (SRO) of the metal melt, resulting in a shortening of the average bond length, a decrease in the coordination number, and a decline in the local order degree of the SRO. Furthermore, by combining the machine - learning force field and the reinforcement - learning - weighted reverse Monte Carlo method, the three - dimensional atomic structures of the eutectic Ga85In15 liquid metal in a 0 T and a 0.2 T static magnetic field environment are reconstructed. The Voronoi geometry and the local bond - orientation order method is used to analyze the characteristic changes of the local short - range order (SRO) clusters in the sample with and without a magnetic field. The results of the cluster geometric configuration distribution show that the 0.2 T static magnetic field does not induce the formation of a new geometric structure of the SRO clusters but promotes the rearrangement of the configurations and tends to form low - coordination SRO clusters. In addition, the solid - liquid interfacial energy and its anisotropy under the electromagnetic field are measured through experiments, and the variation laws of the solid - liquid interfacial energy and its anisotropy of metal solidification under the magnetic field are explored. On this basis, a magnetic - coupled phase - field crystal model is developed to reveal the physical mechanism by which the electromagnetic field affects the solid - liquid interfacial energy and its anisotropy at the atomic scale.

Experimental study on the effect of magnetic field on the metal melt structure

Sansan Shuai, Zhouqing Xu, Jiang Wang, Zhongming Ren*

State Key Laboratory of Advanced Special Steel, School of Materials Science and Engineering, Shanghai University, Shanghai 200444

The formation of ordered structures within the melt can act as nucleation sites, thereby altering the nucleation pathway [1]. The magnetic fields, known to influence structure-sensitive properties of melts such as electrical resistivity [2], magnetic susceptibility [3], and diffusion coefficient [4, 5], could potentially modify the melt microstructure. However, direct experimental evidence supporting this hypothesis is currently lacking. Therefore, this study investigated the atomic-scale structural evolution of liquid zinc (Zn) and aluminum (Al) under the influence of a 0.3/0.4 T static magnetic field using in situ high-energy X-ray diffraction. Our results reveal distinct responses to the magnetic field: the first coordination shell of liquid Zn expands, while that of Al contracts, indicating that the magnetic field differentially affects atomic aggregation in these metals, which further influences the solid-liquid interfacial energy (γ) during the subsequent nucleation process. Specifically, the magnetic field increases γ in Zn, hindering nucleation, while decreasing γ in Al, thereby promoting nucleation. This contrasting behavior arises from the distinct magnetic properties of the two metals and their corresponding responses to the magnetic field, consistent with the magnetic dipole theory. By elucidating the atomic-scale mechanisms through which magnetic fields influence nucleation, this study provides a foundation for tailoring solidification microstructures through the controlled application of magnetic fields.

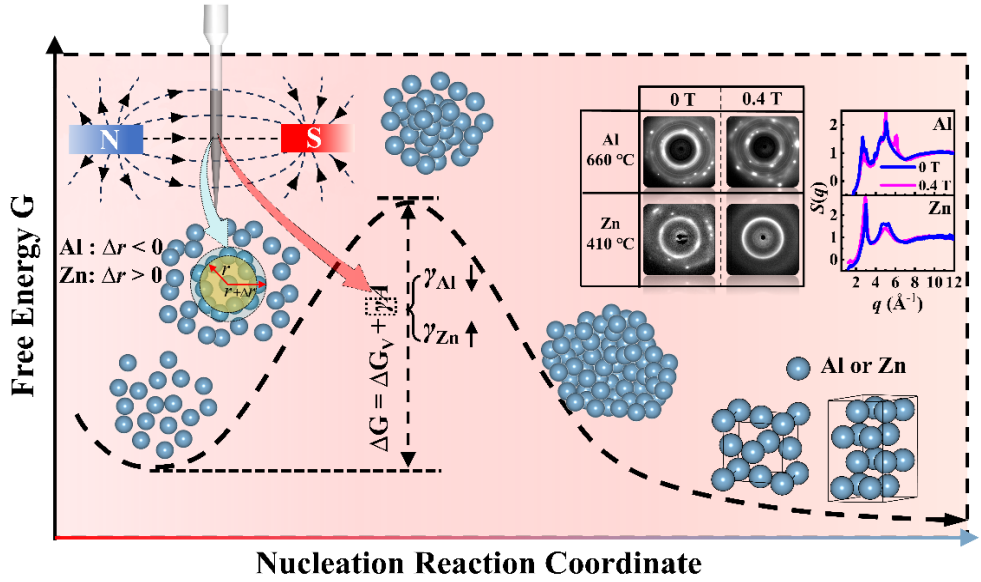

Fig.1 The schematic of the impact of magnetic field on the melt structure

References

[1] Y.X. He, J.S. Li, J. Wang, E. Beaugnon, T. Nonferr. Metal. Soc. 30 (2020) 2293-2310.

[2] M. Khlifi, E. Dhahri, E.K. Hlil, J. Alloy. Compd. 587 (2014) 771-777.

[3] J. Wang, Y.X. He, J.S. Li, R. Hu, H.C. Kou, E. Beaugnon, Rev. Sci. Instrum. 86 (2015) 025102

[4] K. Zhang, X.F. Bian, Y.M. Li, Y. Liu, C.C. Yang, X.L. Zhao, Phys. Lett. A 379 (2015) 1464-1466.

[5] Z.W. Zhang, X. Zhao, S. Tsurekawa, Mater. 14 (2021) 3014.

Growth and Functional Regulation of Inorganic Nanomaterials under Magnetic Fields

Mahmoud A. Khalifa, Luo Jialiang, Ding Wei, Sheng Zhigao*

[1]*High Magnetic Field Laboratory, HFIPS, Chinese Academy of Sciences, Hefei 230031, China*

Email: zhigaosheng@hmfl.ac.cn, Tel. +86-13395518022

Abstract

At first, I will briefly introduce the Chinese Steady High Magnetic Field Facility (SHMFF) and the accompanied experimental equipments, the focus is on the material synthesis and processing equipments under magnetic field.

Then, this report will introduce our recent research progress of inorganic nanomaterial growth and functional regulation under high magnetic field using SHMFF. It mainly introduces a novel method of magnetoinduced synthesis of heterogeneous Co_xSe nanosheets, and it is found that this method has a significant magnetic field effect on composition, morphology, magnetism, dielectric constant and microwave absorption performance. The study found that a strong magnetic field of 10 T can regulate the element ratio of the reaction products and reduce the x value of some Co_xSe from 0.85 to 0.5. Therefore, $Co_{0.85}Se/Co_{0.5}Se$ heterophase was prepared with the assistance of strong magnetic field. It is worth noting that the lateral size and thickness of Co_xSe nanosheets change simultaneously with the strong magnetic field, and the lateral size increases from nanometer to micrometer. Along with the changes in magneto-induced composition and morphology, it is interesting to find that the Co_xSe nanosheets transform from paramagnetism to ferromagnetism. In addition, the addition of a strong magnetic field significantly improves the magnetic loss, dielectric constant, and microwave absorption performance. Specifically, in the C band, the reflection loss increases more than tenfold, from -6.3 dB at 0 T to -66.3 dB at 10 T. These results indicate that the strong magnetic field-assisted synthesis technique can simultaneously regulate multiple structural and physical parameters of the material, which has great application prospects for multi-parameter materials engineering and may be used in a wide range of materials research.

Keywords: high magnetic field; inorganic nanomaterials; improved microwave absorption performance; Co_xSe nanosheets

References:

[1] Sheng Z., Luo J. L. et al, CrystEngComm, 2025, 27, 3971

[2] Sheng Z., Ding W. et al, Nanotechnology 35, 385707(2024)

[3] Sheng Z., Ding W. et al, Chin.Phys.Lett, 2023, 40, 118101.

[4] Sheng Z., Ding W. et al, J. Mater. Res. Technol. 2023,22, 2328-2337.

[5] Sheng Z., Ding W. et al, Ceram. Int. 2021,47, 27496–27502.

Biography:

Prof. Zhigao Sheng is the vice director of the Chinese High Magnetic Field Laboratory (CHMFL) of Chinese Academy of Sciences. He got Ph.D from Institute of Solid State Physics, CAS in 2007, and then be a postdoctoral fellow in the University of Hong Kong (07-08), the University of Tokyo (08-10), and the RIKEN in Japan (10-13). He focused on the research of spectrum technology, spectrum materials and spectrum devices under magnetic field, published more than 100 papers (Nature Phys., PRL, Nature Comm., Adv. Mater., etc.).

Influence of the magnetic field on the properties of Ni, Cu, and Fe as the components of High-Entropy Alloys

Katarzyna Skibińska [1*], Dawid Kutyła [1], Piotr Żabiński [1]

[1] *Faculty of Non-Ferrous Metals, AGH University of Krakow, Kraków, Poland;*

**corresponding author: kskib@agh.edu.pl*

High-Entropy Alloys (HEAs) are defined as solid-solution alloys that contain more than five principal elements in equal or nearly equal atomic percentages (at.%) [1]. Its final composition should also be tailored as a function of intended final uses. For example, if the material needs to be resistant to high temperatures, it is advisable to use refractory elements such as Hf, W, V, Zr, Ta, Nb, Ti [2]; or if magnetic properties are crucial, Fe, Ni, and Co can be present [3]. The composition, morphology, and, therefore, catalytic properties of electrodeposited Ni-Cu [4] and Cu-Fe [5] alloys depend on the applied magnetic field.

In this work, the influence of the applied magnetic field on the properties of Ni, Cu, and Fe was analyzed using various techniques, including Scanning Electron Microscopy, Atomic Force Microscopy, X-ray diffraction analysis, contact angle measurements, and Double-Layer Capacitance measurements. The catalytic activity was tested in 1M NaOH. These results are valuable information for the future design of HEAs for catalytic applications.

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[1] Y. Zhang et al., Progress in Materials Science 61 (2014) 1-93.
[2] M. Ciurans-Oset, J. Mouzon and F. Akhtar, Advanced Materials Technologies 2401643 (2025).
[3] K.X. Zhou et al., Intermetallics 122 (2020) 106801.
[4] K. Skibińska et al., Metals 14 (2024) 281.
[5] K. Skibińska et al., Transactions of the IMF 102 (2024) 290-296.

Evaluation of Urea Crystals Grown under High Magnetic Force Fields by Physical Vapor Transport

Kohki Takahashi *, Satoshi Awaji

High Field Laboratory for Superconducting Materials, Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

**corresponding author: kohki.takahashi.e5@tohoku.ac.jp*

Producing high-quality and/or high-performance materials is essential across various fields. Materials processing under external fields, such as magnetic fields, represents one promising approach to address these challenges. In high magnetic fields exceeding approximately 10 T, magnetic field effects, such as magnetic orientation, can be observed even in paramagnetic or diamagnetic materials. The magnetic force acting on such feeble magnetic materials in large magnetic field gradients can be comparable to the gravitational force. When the upward repulsive magnetic force cancels out the downward gravitational force, the material experiences a quasi-microgravity condition. Conversely, if the magnetic force acts in the same direction as gravity, the material can be regarded as being in a hypergravity state. Materials processing under such conditions is attracting attention as a novel technique, as both magnetic field effects and microgravity or hypergravity effects can be simultaneously utilized.

Urea, a transparent diamagnetic organic compound, holds significant promise for nonlinear optical applications. The fabrication of large, optically high-quality crystals is the key to realizing these applications. In our pursuit of high-quality urea crystals, we have demonstrated a physical vapor transport method under high magnetic and magnetic-force fields. To investigate crystal growth, a custom-built transparent glass heater furnace was employed, enabling in-situ observation during heating and cooling. Crystal growth experiments were conducted in magnetic fields of up to 25 T and magnetic force fields of up to ±1750 T^2/m using 15-T and 25-T cryogen-free superconducting magnets (CSMs) installed at High Field Laboratory for Superconducting Materials, IMR, Tohoku University. A commercially available test tube (OD: 12 mm) was used as a growth chamber, and the open end was connected to a vacuum pump to reduce pressure. Urea crystallized on a quartz plate placed inside the test tube, which could be removed for subsequent observation. We found that the crystallized position shifted depending on the direction and magnitude of the magnetic force, indicating that the temperature distribution within the furnace influences crystal growth. In fact, differences in magnetic force conditions resulted in variations in crystal size. In this study, we discuss the relationship between magnetic force and the obtained crystals, based on observation using an optical microscope, X-ray pole figure measurement, and polarized light microscopy.

Directional Solidification of a Ternary Cu-Fe-Co Alloy under Magnetic Fields

Jun Wang [1*], Zichen Sun[1], Jinshan Li[1], Eric Baugnon[2]

[1] *State Key Laboratory of Solidification Processing, Northwestern Polytechnical University, Xi'an 710072, China*

[2]*Univ. Grenoble Alpes, INSA Toulouse, Univ. Toulouse Paul Sabatier, EMFL, CNRS, LNCMI, 38000 Grenoble, France*

**corresponding author: nwpuwj@nwpu.edu.cn*

Applying a magnetic field during metal solidification influences the microstructure and properties by inducing solute convection and affecting crystal orientation [1-3]. This study investigated the solidification behavior of directionally solidified immiscible Cu-Fe-Co alloys [4] under magnetic fields (0-1 T) at pulling speeds ranging from 5 to 100 μm/s. Increasing the pulling speed transformed the microstructure from cellular to fibrous, increasing the Fe–Co phase fraction by 13% and decreasing the phase size. Magnetic fields produced rate-dependent effects: at low pulling speeds (5 μm/s), dendrites coarsened with irregular interfaces and Cu-rich segregation due to magnetic damping, at high speeds (100 μm/s), enhanced thermo-electromagnetic convection refined the dendritic spacing. Magnetic fields suppressed solute transport, resulting in increased Cu entrapment within Fe–Co dendrites, as confirmed by EDS analysis. They also induced crystallographic reorientation, with a transition from <114> to <104> at 5 μm/s and from <104> to <100> at 100 μm/s. The dominance of the <001> texture was attributed to magnetocrystalline anisotropy. Performance improvements included increased strain gradients at phase interfaces, which enhanced ductility by modifying crack propagation at 100 μm/s. Additionally, room-temperature saturation magnetization increased by 40% due to accelerated <001> magnetization kinetics under a 1 T magnetic field at 100 μm/s. These findings demonstrate the synergistic role of magnetic fields in controlling phase alignment, solute distribution, and overall performance in directionally solidified Cu–Fe–Co alloys.

[1] C. Wei, J. Wang, Y. He, J. Li, E. Beaugnon, Metals 11(3) (2021) 525.

[2] C. Wei, J. Wang, Y. He, Y. Yan, E. Beaugnon, J. Li, Appl Phys Lett. 123 (2023) 254101.

[3] Y. Yan, J. Wang, C. Wei, Y. He, E. Beaugnon, J. Li, Appl Phys Lett. 124 (2024) 222402.

[4] Z. Sun, J. Wang, Y. He, C. Wei, Y. He, J. Li, Journal of Alloys and Compounds (2025) 182917.

Development of a Laser Scanning Confocal Fluorescence Microscope compatible with a Florida-Bitter Magnet

Hannah Willenberg [1,2*], Hans Engelkamp [1,2], Peter Albers [1], Michel T. J. M. Peters [1], Eric Jansen [3], Corette J. Wierenga [3], Marjon Bloemen [4], Ingrid de Grijs [4], X. Frank Walboomers [4], Lorenzo Moroni [5], Peter C. M. Christianen [1,2]

[1] High Field Magnet Laboratory, Nijmegen, The Netherlands
[2] Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands
[3] Donders Institute for Brain, Cognition and Behaviour, Radboud University, The Netherlands
[4] Department of Dentistry-Regenerative Biomaterials, Research Institute for Medical Innovation, Radboud University Medical Center, The Netherlands
[5] MERLN Institute for Technology-Inspired Regenerative Medicine, Maastricht University, The Netherlands
**corresponding author: hannah.willenberg@ru.nl*

Regenerative medicine addresses the significant imbalance between the supply of organs and the need for transplants. A novel method for scaffold- and label-free biofabrication is the use of levitational assembly in high magnetic fields [1]. Living cells organized into tissue spheroids are preferred building blocks to form organ-like constructs. Since living cells are exposed to static magnetic fields for extended periods of time during this type of assembly, it is important to understand what effects these fields have on living cells. In cell biology and biofabrication, confocal fluorescence microscopy is an established method for visualizing cell morphology, functionality, their viability and following the formation of 3D bioconstructs. Here, we present the development of a customized, multicolor, laser scanning, confocal microscope that is compatible with a Florida-Bitter magnet (30 T, 50 mm bore). The design is based on a non-magnetic piezo-scan head, a telecentric optical relay line and a non-magnetic, sterile sample mount on a piezo nanopositioner in a fully temperature-controlled environment. We will describe the technical layout of the entire system and initial imaging experiments of fluorescent markers at different magnetic field strengths up to 25 T, which prove that our microscope design is viable (see Fig. 1). We will also present our first *in situ* studies of living (MC3T3) cells in magnetic fields, where we have labeled the cell nucleus and the tubulin cytoskeleton. Minor modifications of the microscope will also enable other types of experiments on soft matter with high magnetic fields or at magnetic field induced microgravity.

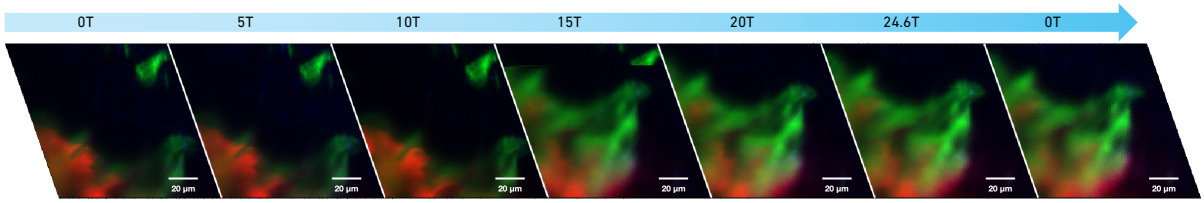

Figure 1: *Multicolor images of fluorescent marker excited at 375, 488 and 633nm, recorded with the homebuilt laser-scanning confocal microscope (40 x, 0.75 NA). From left to right images are shown of the sample exposed to increasing magnetic field strength (0 T to 24.6 T).*

[1] V. A. Parfenov *et al.* Biofabrication. 12 (2020).

Inhibition Effect of Magnetic Field on Liquid-Liquid Phase Separation of Tau-441 and Its Perspectives

Wen-Juan Lin, Wen-Pu Shi, Wan-Yi Ge, Liang-Liang Chen,
Wei-Hong Guo, Peng Shang, and Da-Chuan Yin*

School of Life Sciences, Northwestern Polytechnical University, Xi'an 710129, Shaanxi, China

**corresponding author: yindc@nwpu.edu.cn*

The biological effects of magnetic fields (MFs) have long been controversial, with their underlying physical mechanisms remaining elusive. In this report we will show that a 16 T static MF reduces apoptosis by suppressing Tau-441 LLPS, thereby providing a novel mechanism for understanding magnetobiological effects and potential therapeutic strategies for LLPS-related diseases.

Alzheimer's disease (AD) and other neurodegenerative disorders are closely linked to abnormal aggregation of Tau proteins, with LLPS acting as a critical early step in this process. Our research shows that, upon arsenite induction, Tau-441 undergoes LLPS in the cytoplasm, forming droplets that recruit hexokinase (HK). This reduces the pool of free HK, which normally competes with Bax for binding to the voltage-dependent anion channel (VDAC I) on mitochondrial membranes. A decrease in free HK increases Bax-VDAC I binding, promoting Bax-mediated apoptosis.

The major findings include:

1) MF inhibition of LLPS: A 16 T MF significantly reduces the number and size of Tau-441 droplets, decreases solution turbidity, and a 0.48 T permanent magnet yields similar effects. Circular dichroism (CD) and thioflavin T (ThT) fluorescence analyses confirm that MFs reduce LLPS-induced β-sheet formation, stabilizing Tau-441 secondary structure.

2) Reduced HK recruitment and improved metabolism: MF-suppressed LLPS decreases Tau-441-mediated HK sequestration, increasing free HK levels and activity. This enhances glucose metabolism, as evidenced by increased glucose consumption and glucose-6-phosphate production.

3) Apoptosis suppression: Elevated free HK enhances VDAC I binding, reducing Bax-VDAC I interactions. This mitigates mitochondrial membrane potential damage, reactive oxygen species (ROS) production, and caspase-3 activity, ultimately decreasing apoptosis.

To explain our findings, we propose that MFs affect LLPS through two pathways: (1) When droplet size exceeds a critical value, magnetic energy overcomes thermal energy to disrupt LLPS; (2) Lorentz forces decrease diffusion of charged molecules (e.g., Tau-441, HK), thereby inhibiting LLPS process.

Our study links the MF effect to LLPS and proposes a new physical mechanism of magnetobiological effects. It confirms that MFs can modulate apoptosis by modulating LLPS, providing potential for non-invasive physiotherapy (e.g., the use of permanent magnets) for LLPS-related diseases such as AD.

[1] W. J. Lin, W. P. Shi, W. Y. Ge, L. L. Chen, W. H. Guo, P. Shang, D. C. Yin, Research 6 (2023) 0146.

Influence of superimposed magnetic field on electrochemical synthesis of multimetallic structures obtained by one-step method

K. Skibińska[1], K. Kołczyk-Siedlecka[1], D. Kutyła[1], P. Żabiński[1*]

[1] *Faculty of Non-Ferrous Metals, AGH University of Krakow, Poland*

* *zabinski@agh.edu.pl*

One-step method consist of single electrodeposition process from an electrolyte containing an addition of crystal modifier. This component allows to synthesize various shaped-structures. It is based on blocking a horizontal direction of growth and promoting of a parallel one. This effect is connected with the screw dislocation driven crystal growth theory [1]. Under certain conditions, it is possible to obtain conical metal and alloy structures. This method does not require to pre-prepared substrate in any way. This method is fast and ensures covering large areas during one, single process.

Co-Fe alloy coatings were synthesized using one-step method from electrolyte containing NH4Cl as a crystal modifier. It allowed to obtain conical structures successfully. The superimposed magnetic field with different directions was applied. The change in alloy composition and morphology of cones was expected due to the ferromagnetic properties of Co and Fe. This influence was investigated using Scanning Electron Microscope photos. XRD analysis was performed to check if there is any change of sample crystal system. The electrocatalytic properties of samples were measured in 1 M NaOH methods and compared with bulk material ones.

The SEM photos of cones obtained in magnetic field are shown in Figure 1.

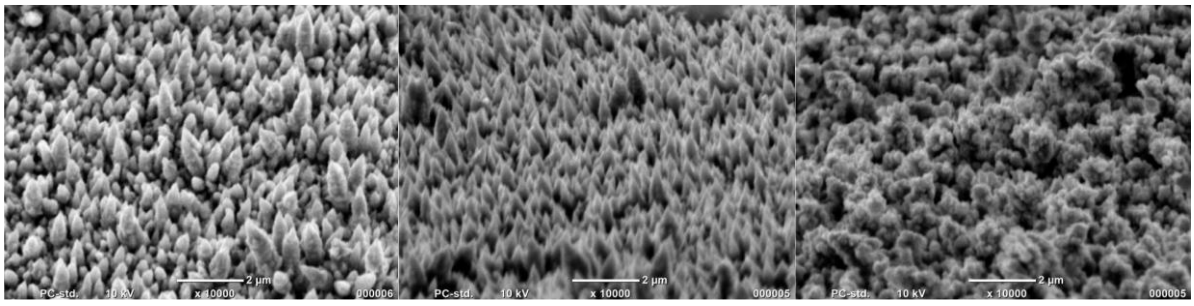

Figure 1. SEM photo of samples obtained a) without magnetic field and at 500 mT in b) perpendicular magnetic and c) parallel magnetic field

There is noticeable influence of magnetic field on coatings morphology. In case of perpendicular magnetic field, the cones shows the best quality. There are sharp-ended with uniform height. The application of parallel direction of field caused a disappearance of conical shape. Structures are complex and round-ended.

REFERENCES

[1] J. M. Lee, K. K. Jung, S. H. Lee, J. S. Ko, Appl. Surf. Sci., 2016, 369, 163-169

Static Magnetic Field bioeffects：from mechanism to biomedical applications

Xin Zhang

[1] *High Magnetic Field Laboratory, Chinese Academy of Sciences, Hefei, China*
xinzhang@hmfl.ac.cn

Nowadays, people are exposed to various types of magnetic fields, which include static magnetic field (SMF), whose magnetic flux density and distribution do not change over time, as well as time-varying magnetic field of different frequencies, which will not be discussed in my talk. On one hand, WHO (World Health Organization) and ICNIRP (International commission on non-ionizing radiation protection) have published some guidelines for the SMF exposure of human bodies to ensure that people are not overexposed. On the other hand, magnetic therapy, although not in the mainstream medicine, has been widely used by many people worldwide as alternative or supplementary treatments.

The goal of my presentation is to synthesize current scientific evidence on the biological effects of SMFs, covering a broad range of intensities from millitesla (mT) to 33 tesla (T). This will include observed phenomena and their underlying mechanistic bases. While the existing literature on magnetic field bioeffects contains numerous reports that lack reproducibility across independent laboratories, we now understand that this variability stems from a combination of factors: magnetic field parameters (e.g., flux density, direction, duration) and inherent biological sample heterogeneity. Crucially, the magnetic properties of biological systems themselves play a pivotal role in driving differential responses to SMFs. Recent advances demonstrate that disease-associated perturbations in redox homeostasis and iron metabolism can markedly alter the magnetic properties of tissues and cells, thereby modulating their sensitivity to SMFs. Importantly, identical SMF exposure conditions may yield divergent effects—not only across in vitro and in vivo models but also, as we hypothesize, in human applications.

[1] Xin Zhang*. Biological effects of static magnetic fields, 2nd edition. *Springer.* **2023**. ISBN: 978-981-19-8868-4.
[2] Shiyu Lu, Junjun Wang*, Xin Zhang*. Effects of Static Magnetic Fields on Metabolic Diseases. *Health and Metabolism*. **2025**,2(1):3.
[3] Chuanlin Feng, et al. Redox imbalance drives magnetic property and function changes in mice. *Redox Biology.* **2025**, 81: 103561.
[4] Ruowen Guo, et al. Endogenous iron biomineralization in the mouse spleen of metabolic diseases. *Fundamental Research*. **2024**, DOI:10.1016/j.fmre.2024.07.004.
[5] Chao Song et al. Magnetic Fields Affect Alcoholic Liver Disease by Liver Cell Oxidative Stress and Proliferation Regulation. *Research*. **2023**, 6: 0097.

MC-Supernormal Metallurgy & Processing—

Recent EPM Activities in Shanghai University

Yunbo Zhong*, Tianxiang Zheng, Peijian Shi, Zhe Shen, Biao Ding, Qiang Li, Bangfei Zhou, Wenhao Lin, Zhongze Lin.

(State Key Laboratory of Materials for Advanced Nuclear Energy & School of Materials Science and Engineering, Shanghai University, 333 Nanchen Road, Shanghai, 200444, PR China).

*Corresponding author: Yunbo Zhong, E-mail: yunboz@shu.edu.cn

Abstract:

This report reviews recent advances in magnetically controlled supernormal metallurgy at Shanghai University. By applying contactless and clean electromagnetic forces along with electromagnetic energy effects to the continuous casting and purification processes of ferrous, non-ferrous, and rare scattered metals, heat and mass transfer as well as momentum transport have been significantly enhanced. This approach has achieved purification, refinement, grain refinement, homogenization, and high performance of metallic materials while reducing production costs. The study offers new insights and technical pathways for the preparation of high-performance metal materials.

Keywords: Electromagnetic metallurgy, Materials preparation.

Acknowledgements

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Influence of Magnetic Field on the Kinetics of Ho(III) Solvent Extraction Using D2EHPA

Konrad Wojtaszek[1*], Piotr Żabiński[1], Marek Wojnicki[1]

[1]AGH University of Krakow, al. Mickiewicza 30, 30-059 Krakow, Poland
*corresponding author: kwojtasz@agh.edu.pl

This study presents a comprehensive kinetic analysis of Ho(III) extraction using di-(2-ethylhexyl)phosphoric acid (D2EHPA) in the presence and absence of an external magnetic field. Aqueous solutions of Ho(III) chloride and organic D2EHPA solutions in Orlesol 110/170 were tested under varied experimental conditions, including pH, temperature, extractant concentration, and initial metal ion concentration. Spectrophotometric methods enabled determination of the reaction kinetics, with emphasis on distinguishing between diffusion and chemically controlled regimes.

In the absence of a magnetic field, the extraction process was found to follow reversible pseudo-first-order kinetics with a low activation energy (Ea = -0.79 kJ mol^{-1}), indicating interfacial reaction control. However, application of a heterogeneous magnetic field (up to 0.42 T, Halbach configuration) significantly altered the kinetic profile. The activation energy increased to 167.7 kJ mol^{-1}, suggesting a mechanistic shift driven by magnetic field-induced changes in interfacial transport and complexation dynamics. Numerical simulations confirmed a radial magnetic field gradient within the cuvette, which could influence mass transport via magnetically induced convection.

The formation of a third phase at the aqueous-organic interface, identified as a flocculent Ho-D2EHPA-rich precipitate, was investigated using XRD, XRF, FTIR, XPS, and NMR. Its composition (approximate Ho:P = 3:2) and magnetic susceptibility imply its role as both a kinetic barrier and field interaction zone. Notably, NMR analysis showed substantial line broadening, confirming paramagnetic complexation and P-OH group participation in coordination.

This work demonstrates that magnetic fields can significantly influence REE solvent extraction, not only by accelerating kinetics but also by inducing new extraction pathways. These findings provide a foundation for magnetically assisted separation techniques and pave the way toward energy-efficient, selective rare-earth recovery systems.

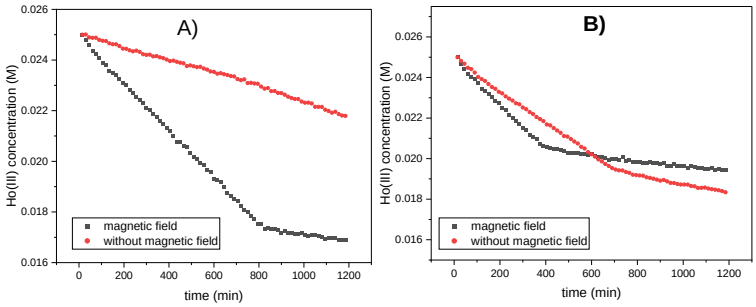

Figure 1. Comparison of the kinetic curves of the Ho(III) ion extraction process for temperatures of 30℃ (A) and 35℃ (B) in a field and without a magnetic field.

[1] K. Wojtaszek et al., Small Methods 2025, 2402002.

Fabrication of magnetically bi-axial aligned Dy123 green compact by colloidal solution with various viscosities and evaporation times

F. Fukuyama[1*], T. S. Suzuki[2], S. Adachi[1], F. Kimura[1], N. Hirota[2], T. Uchikoshi[2], and S. Horii[1]

[1] *Kyoto University of Advanced Science (KUAS), Kyoto 615-8577, Japan*

[2] *National Institute for Material Science (NIMS), Ibaraki 305-0047, Japan*

**corresponding author: f.fukuyama.ac@gmail.com*

Densification and bi-axial grain alignment are essential for $REBa_2Cu_3O_y$ (RE123) superconductors (SCs) with practical critical current (I_c). Conventionally, thin-film epitaxial technology has provided high critical current density (J_c). However, it has a practical problem on I_c due to the restriction on thickness. Our group focuses on the magnetic alignment for fabricating densified thick RE123 films (> 100μm[t]) with bi-axial aligned microstructures. The bi-axial alignment of RE123 grains with twinned microstructure in epoxy resin has been achieved under the modulated rotating magnetic field (MRF) of a solenoidal SC magnet (SC-MRF) [1] and linear drive type MRF (LDT-MRF) [2, 3]. As the next step, our group aims at development of the biaxial aligned RE123 ceramics by the colloidal process and LDT-MRF. A colloidal solution having the appropriate viscosity with considering magnetic alignment time into account, which is depending on magnetic anisotropy, is essential in this context [4]. Our group found that a binder (Hydroxypropyl cellulose, HPC-H) in ethanol can control of the viscosity of the $DyBa_2Cu_3O_y$ (Dy123) colloidal solutions. In this study, the magnetically aligned Dy123 green compacts are fabricated from the Dy123 colloidal solution with various viscosities and evaporation time.

Dy123 (y ~ 7) polycrystals were synthesized by the standard solid-state reaction and oxygen annealing, then pulverized by the ball-milling. Incidentally, its average particle size is ~ 0.5 μm. Dispersant (polyethyleneimine, 1 wt%, PEI) is mixed with ethanol or butanol. Then, the binder and fined Dy123 powder (5 – 15 vol%) were added to the PEI mixtures. Prepared Dy123 colloidal solutions were dried in a rectangular mold under LDT-MRF at RT. The static field and rotating field in the LDT-MRF equipment generated by the permanent magnet array were approximately 0.9 T and 0.8 T, respectively. The orientation degrees of the magnetically aligned Dy123 samples were evaluated by the (103) pole figure measurements.

Figure 1(a) shows the (103) pole figure of green compact of magnetically aligned Dy123 with ethanol . Its initial viscosity of Dy123 colloidal solution is roughly 500 mPa・s, and it was evaporated in 2 h. Note that the measurement plane for the (103) pole figure is normal to the direction of the static field component and is equivalent to the top surface of the Dy123 green compact. Four-fold symmetric spots with broad streaks along ψ and ϕ directions were obtained, meaning that Dy123 grains were partially bi-axially aligned in ethanol. Figure 1(b) shows the (103) pole figure of the green compact of magnetically aligned Dy123 with butanol. Its initial viscosity is roughly 500 mPa・s, however it was evaporated in 5 h. In contrast, more obvious four-fold symmetric spots were observed, indicating that Dy123 grains were bi-axially aligned in butanol. Figs. 1(a) and 1(b) suggested that the bi-axial orientation degrees were improved by using the solvent with longer evaporation time. In this presentation, we will show the change in bi-axial orientation degrees on the magnetically aligned Dy123 green compacts as functions of viscosities and evaporation times of Dy123 colloidal solutions.

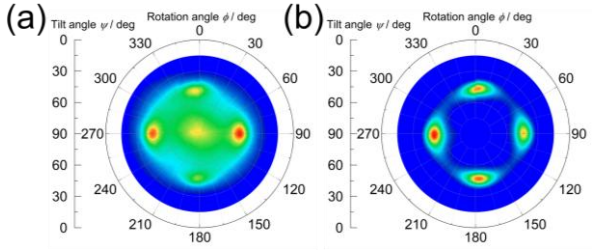

Figure 1. (103) pole figures of the magnetically aligned Dy123 ceramics prepared with (a) ethanol and (b) butanol as solvent.

References: [1] Horii et al., SuST **29** (2016) 125007. [2] Ali et al., J. Appl. Phys. **134** (2023) 163901. [3] Horii et al., J. Ceram. Soc. Jpn. **126** (2018) 885. [4] Kimura et al., CrystEngCom **20** (2018) 861.

Investigation on the effect of static magnetic field on liquid-solid phase transition of α-Synuclein protein

Wan-Yi Ge [1], Da-Chuan Yin[1*]

[1] *School of Life Sciences, Northwestern Polytechnical University, Xi'an 710129, Shaanxi, China*

**corresponding author: yindc@nwpu.edu.cn.*

In recent years, liquid-liquid phase separation (LLPS) and liquid-solid phase transition (LSPT) have been found of important physiological or pathological significance in biological systems, among which aberrant LSPT is often a key process in major diseases such as neurodegenerative diseases. Once it occurs, it is often characterized by slow but persistent irreversibility, which is one of the fundamental reasons for the lack of effective treatment for these diseases. Therefore, in-depth research into this process is expected to provide a breakthrough in the development of new therapies. We recently discovered that the magnetic field can significantly inhibit the LSPT process of α-Synuclein protein, which is closely related to Parkinson's disease (PD). This finding suggests that special environments such as magnetic fields can serve as new options for intervening in LSPT and play an important role in the treatment of neurodegenerative diseases or other major diseases. Based on this, we proposes to systematically study the effect of magnetic field on LSPT and its underlying mechanism. The researches include: 1) the effect of magnetic field on the LSPT of α-Synuclein amyloid fibers, 2) theoretical mechanism by which magnetic fields affect α-Synuclein LSPT. *In vivo* experiments demonstrated that A53T transgenic PD mice exposed to a 10 T static magnetic field (SMF) for 14 consecutive days exhibited improved motor function, as evidenced by reduced descent latency in the pole test at days 7 and 14 post-treatment. *In vitro* studies further revealed that 10 T SMF significantly suppressed α-Synuclein amyloid fibrillization, attenuating both the kinetics and extent of aggregate formation. These findings collectively indicate that high-intensity SMF modulates protein phase transitions, thereby inhibiting pathological aggregation.

This research is expected to provide new therapeutic opportunities and a theoretical foundation for interventions targeting neurodegenerative diseases such as PD and other related disorders.

Anisotropic $CaCO_3$ particles hybridized with PLLA and magnetic field orientation

Keiya Kawamura [1*], Astushi Furukawa [1], Shuta Hara [2], Kohki Takahashi [3], Akihiro Fukawa [1], Koichi Takase [1], Mitsuaki Kogo [1], Yoshiyuki Kojima [1], Shigeru Shimizu [1], Hiroki Ikake [1]

[1]*Grad. Sch. of Sci. and Eng., Nihon Univ., Kandasurugadai, Chiyoda-ku, Tokyo 101-8308, Jpn.*

[2]*Dept. of Mater. and Life Chem., Kanagawa Univ., Rokkakubashi, Kanagawa-ku, Yokohama, Kanagawa 221-8686, Jpn.*

[3]*Inst. for Mater. Res., Tohoku Univ., Katahira, Aoba-ku, Sendai, Miyagi 980-8577, Jpn.*

**Corresponding author:* cske24013@g.nihon-u.ac.jp

1. Introduction Although organic-inorganic hybrid materials, which combine polymers and inorganic fillers, have gained significant attention as next-generation functional materials, issues such as reducing environmental impact and uniform dispersion of fillers have hindered their practical use. In this study, we aimed to solve these issues by developing a hybrid material that combines poly(L-lactied) (PLLA), a biodegradable and environmentally friendly polymer, with calcium carbonate ($CaCO_3$), which is commonly used as a nucleating agent. Of particular note is that such hybrid systems can be given anisotropy by controlling the orientation of the inorganic filler. Therefore, we attempted to improve the mechanical properties of the resulting hybrid film by orienting the $CaCO_3$ filler within the PLLA matrix using a magnetic field.

2. Experimental Section and Results To enable magnetic alignment, the surface of $CaCO_3$ particles was functionalized with Fe_2O_3 nanoparticles, resulting in magnetically responsive $CaCO_3$@Fe_2O_3 composite particles. These particles were incorporated into PLLA, and hybrid films were fabricated under a magnetic field strength of 1.5 T to induce anisotropic alignment. The dispersion and orientation of the fillers within the PLLA matrix were analyzed using optical and electron microscopy.

Mechanical performance was assessed through tensile testing, and the results are summarized in Figure 1. The control sample without magnetic alignment (0 T) exhibited modest improvements in tensile strength compared to neat PLLA, confirming the reinforcing effect of the filler. Notably, the film in which the fillers were aligned parallel to the tensile direction (Parallel sample) demonstrated significant enhancements in both stiffness and ductility, with the toughness increasing by approximately tenfold relative to the pristine PLLA. In contrast, the sample with filler alignment perpendicular to the tensile direction (Vertical sample) showed a reduction in stiffness, while ductility was still improved.

These contrasting results can be attributed to the interaction between interfacial interactions and load transfer mechanisms. In the Vertical sample, shear displacement likely occurs more readily at the PLLA–particle interface due to poor stress transfer across the perpendicular alignment, resulting in reduced tensile strength. However, the improvement in ductility is thought to stem from the ordered alignment of fillers, which facilitates deformation under tensile stress by providing a more compliant microstructure at the macroscopic scale.

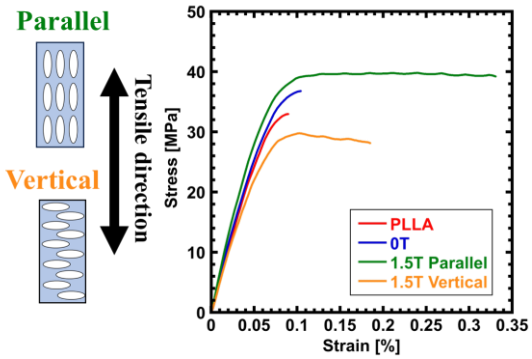

Figure 1. Stress–strain curves of hybrid films.

Magnetic domain structure and evolution behaviour of directionally solidified Tb-Dy-Fe alloy with high magnetic fields

Yanxin Liu [1, 2], Tie Liu [2*], Baoze Zhang[1, 2], Qiang, Wang[1]

[1] *Key Laboratory of Electromagnetic Processing of Materials (Ministry of Education), Northeastern University, Shenyang 110819, People's Republic of China*

[2] *School of Metallurgy, Northeastern University, Shenyang 110819, People's Republic of China*

**Corresponding author: liutie@epm.neu.edu.cn*

The magnetic domain structure of magnetostrictive materials can intuitively reflect the change of magnetostrictive properties during the magnetization process [1-3]. Therefore, we investigated the effect of high magnetic field on the magnetostrictive properties, static magnetic domain structure, and dynamic magnetic domain evolution of directionally solidified Tb-Dy-Fe alloys, as well as the intrinsic connection between high magnetic field and domain structure. First, we prepared the directionally solidified Tb-Dy-Fe alloys with a high magnetic field and characterized their magnetic domain structures by Magneto-optical Kerr microscope. The observed domain patterns variation with magnetic field of the cross-section surface are shown in Fig. 1. Two distinct structures which include the typical striped magnetic domain and labyrinthine domain are observed in all directionally solidified samples with 0 T and 6 T magnetic fields. When the driving magnetic field increases from 0 mT to 1200 mT, both the domain wall annihilation and magnetic domain merging appear in the samples prepared with 0 T and 6 T magnetic fields. With a 1200 mT driving magnetic field, the striped domains in the sample prepared with 0 T magnetic field almost disappeared, but the point-like labyrinth domains could not reach the saturation state; but the magnetic domains in the sample prepared with 6 T magnetic field almost completely disappeared, which indicated magnetic domains reached saturation state. Based on the above results, under the same driving magnetic field, the magnetic domain of the sample prepared with 6 T magnetic field is more easily magnetized and reaches the saturation state.

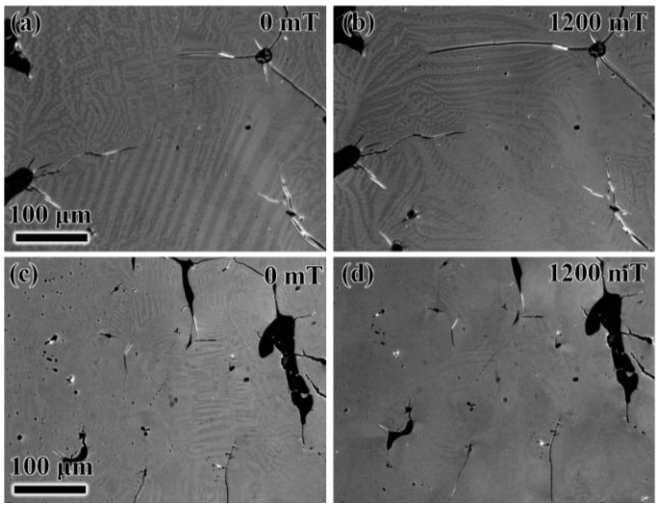

Fig. 1 Magnetic domain morphologies of directional solidified Tb-Dy-Fe alloy with different magnetic fields: (a) and (b) 0 T; (c) and (d) 0 T

[1] X. Guo, T. Liu, and B. Zhang, et al, Journal of Magnetism and Magnetic Materials 588 (2023) 171472.

[2] T. Ma, C. Zhang, and R. Qian, et al, Journal of Materials Research 26 (2011) 31-35.

[3] H. Jiang, J. Zhu and C. Yuan, Journal of Magnetism and Magnetic Materials 486 (2019) 165274.

Magnetic Field Effects on the Corrosion Behavior of Pure Copper in Mild Aqueous Media

Meroua Salhi[1], Florica Lazar[1], Jean-Paul Chopart[1], Anne-Lise Daltin[1]*

[1] *MATIM Université de Reims Champagne-Ardenne, 51100 Reims, France*

**corresponding author: anne-lise.daltin@univ-reims.fr*

Copper is widely used in industry due to its excellent electrical and thermal conductivity. It is a key material in various devices subjected to intense magnetic fields, such as superconducting coils, electromagnets, and components in electric generators or motors [1]. However, in aqueous or humid environments, copper is vulnerable to corrosion, which can significantly degrade its long-term performance. The influence of magnetic fields on corrosion mechanisms remains underexplored and raises both scientific and industrial questions. In this context, the aim of this study is to evaluate the influence of a high static magnetic field on the corrosion behavior of pure copper, in order to determine whether this parameter can enhance the passivation of the metal in low acidic medium. The study was conducted in a slightly acidic environment (0.1 M KNO_3 solution at pH 4) using high-purity copper bars (99.99% copper). The samples were mechanically polished and partially coated with an insulating varnish (Blocjelt) to define an exposed surface area of 0.71 cm^2. Electrochemical tests, controlled by a PGZ100 potentiostat, were carried out at ambient temperature using a three-electrodes electrochemical cell consisting of a copper working electrode, a platinum counter electrode, and an Ag/AgCl (in KNO_3) reference electrode. Cyclic voltammetry showed no significant variation in corrosion kinetics under low magnetic field intensities (0.05 T to 1 T). However, at 11 T, electrochemical impedance spectroscopy (EIS) revealed a marked increase in polarization resistance, indicating the formation of a more protective passive layer. X-ray diffraction (XRD) analysis confirmed the presence of cuprite (Cu_2O) as the main corrosion product of pure copper surface at pH 4. These findings suggest that strong magnetic fields can enhance the stability and the protective quality of oxide films on pure copper, offering a promising approach to corrosion control in technological applications [2].

[1] C. Zhu, L. Miao, J. Xie, H. Xu, Y. Han, J. Liu, M. P. Ryan, L. Guo, J. Alloys Compd., 968 (2023) p. 171901.

[2] C. Igreja Nascimento Mitre, B. Ferreira Gomes, E. Paris, C. M. Silva Lobo, C. Roth, L. A. Colnago, Magnetochemistry, 8, 4 (2022) p. 40.

Development of a Rotating Magnetic Field Generator for Real-time Observation of Orientation Processes

Yuka Takeuchi [1*], Rintaro Kimoto[1], Hideki Kawaguchi[1], Atom Hamasaki [2]

[1] *Muroran Institute of Technology, 27-1, Mizumoto-cho, Muroran 050-8585*

[2] *Shinshu University, 3-1-1, Asahi, Matsumoto 397-0877*

**corresponding author: yuka0122@muroran-it.ac.jp*

When a magnetic field is applied to diamagnetic materials with anisotropic magnetic susceptibility, the crystalline inside the materials are oriented in the direction of axis of easy magnetization. This phenomenon is called magnetic field orientation. When a rotating magnetic field is applied to the diamagnetic materials, both of the easiest and second easiest magnetization axes are aligned, and magnetic field orientation occurs efficiently. Controlling diamagnetic crystal orientation is crucial for enhancing metal and ceramic materials, with rotating magnetic fields proving to be vital for complete alignment. Until now, the mainstream method has been to rotate the sample in a static magnetic field; however, we designed and manufactured a quadrupole electromagnet to rotate the magnetic field directions themselves as shown Fig.1[1]. The developed device simplifies the process and does not affect the suspension convection, even during high-speed or repeated rotation. Fig. 2 shows micrographs of cellulose microcrystals, illustrating their state before and after the application of a rotating magnetic field. The rotating magnetic field was applied with an angle interval of 1 degree and a period of 80 seconds. It is known the long direction of cellulose crystals is the hard axis of magnetization. Consequently, the application of this rotating magnetic field caused the crystals' hard axis of magnetization to orient perpendicular to the plane of rotation field.

From the above, we have successfully developed a system capable of applying a rotating magnetic field simply by placing the sample, simultaneously enabling comprehensive in-situ observation of the process. It achieves this by allowing for the real-time control of various parameters like magnetic field strength, rotation direction, period, and angle interval, which in turn enables the determination of the most efficient alignment conditions.

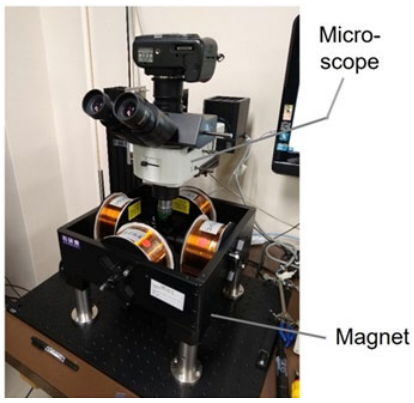

Fig. 1 The rotating magnetic field generation system

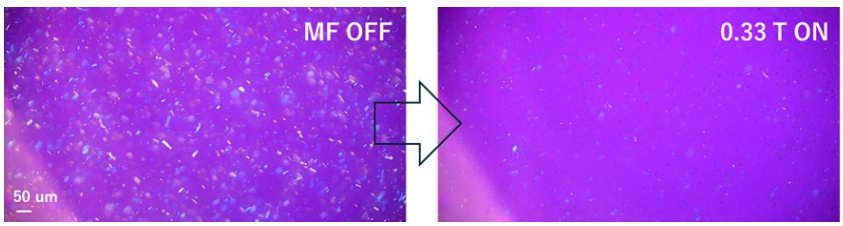

Fig. 2 The micrograph of cellulose crystals under a rotating magnetic field

[1] Y. Takeuchi, H. Kawaguchi, M. Matsuda and A. Hamasaki, Appl. Phys. Express 14 (2021) 057002.

Structure Library of Magnetically Levitated Self-Assemblies

Hannah Willenberg [1,2*], Hans Engelkamp [1,2], Lorenzo Moroni [3], Peter C. M. Christianen [1,2]

[1] *High Field Magnet Laboratory, Nijmegen, The Netherlands*

[2] *Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands*

[3] *MERLN Institute for Technology-Inspired Regenerative Medicine, Maastricht University, The Netherlands*

**corresponding author: hannah.willenberg@ru.nl*

Regenerative medicine addresses the significant imbalance between the supply of organs and the need for transplants. A novel method for scaffold- and label-free biofabrication is the use of levitational assembly in magnetic fields. Parfenov *et al.* used this method to assemble living cells into a spheroid [1], but more advanced shapes are required to allow for applications in regenerative medicine.

For weakly diamagnetic materials such as living cells or plastics suspended in a paramagnetic medium, the gravitational force and the magnetic force can be balanced so that the material levitates. In a table-top setup consisting of two neodymium permanent magnets in an anti-Helmholtz configuration, a low magnetic field gradient can be compensated by high paramagnetic salt concentrations. Although the paramagnetic salt, gadolinium, is approved by the FDA for MRI studies, high concentrations of it are toxic to cells. To compensate for lower paramagnetic salt concentrations, Florida-Bitter magnets can be used to generate a stronger magnetic field gradient. Here, we demonstrate that in such an environment the shape of the self-assembly can be varied by choosing the actual position in the so-called stable levitation zone, which is defined by vertical and horizontal stability parameters of the field gradient [2]. We show that tuning the magnetic field strength and the height of the sample in the Florida-Bitter magnet allow the self-assembly of polystyrene beads to form oblate spheroids, spheroids and prolate spheroids (see Fig. 1). We will also present the technical layout allowing for optical imaging during the levitation process.

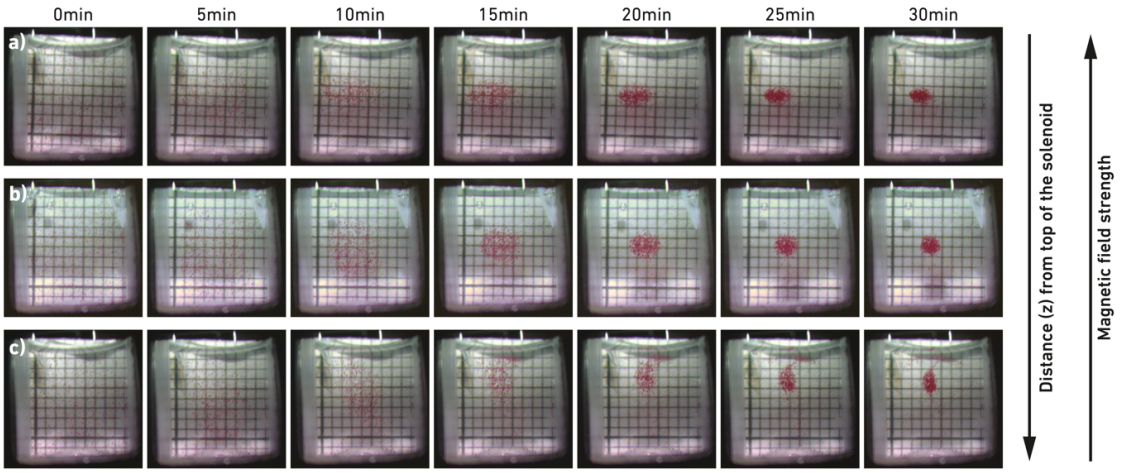

Figure 1: Snapshots of polystyrene beads (100µm) in 25mM $MnCl_2$ solution, levitated at various distances from the top of the Bitter magnet and magnetic field strengths showing the accumulation of beads in the shape of (a) an oblate spheroid, (b) a spheroid and (c) a prolate spheroid.

[1] V. A. Parfenov *et al.* Biofabrication. 12 (2020).

[2] M. V. Berry and A. K. Geim Eur. J. Phys. 18 (1997).

A magnetic responsive ovalbumin cryogel for rapid wound healing

Xiao-Li Xi[1], Ting-Xiao Jin[1], Yi-Ming Tong[1], Shu-Peng Cao[1], Xiu-Lan Jia[1], Jia-Yi Cheng[1], Da-Chuan Yin[1,*]

[1]*School of Life Sciences, Northwestern Polytechnical University, Xi'an 710129, Shaanxi, China*

Wound healing is an important process that helps restore the function of damaged tissues, including the skin. In the era of global aging and rising incidence of chronic diseases such as diabetes, advanced wound healing strategies are becoming increasingly important. While there are many existing and developing wound dressings available, there is still an urgent need for more alternatives to choose from. In recent years, the emergence and development of new wound dressings show a trend from "passive protection" to "active repair", significantly improving wound healing performance. In this report, we adopt the concept of "active repair" and propose a new strategy of using a rotating magnetic field to stimulate an ovalbumin sponge embedded with magnetic nanoparticles at the wound site, which can significantly enhance wound healing.

A protein-based magnetic response composite sponge was developed. Combined with a self-designed miniaturized rotating magnet device, a "magnetic stimulation - material response" synergistic treatment system was constructed, effectively accelerating wound healing. The composite sponge mainly composed of ovalbumin, tannic acid and Fe_3O_4 nanoparticles was prepared by a secondary cross-linking process. It innovatively integrates three key wound-healing strategies into one platform: ideal microenvironment (porous sponge structure), antibacterial and antioxidant properties, and magnetic response mechanical stimulation. This multifunctional approach successfully overcomes the limitations of traditional wound dressings. In rat skin wound models, the composite sponge significantly accelerated the wound healing process by promoting angiogenesis and regulating related inflammatory factors. For liver penetrating injury models, it demonstrated excellent hemostatic and pro-coagulation capabilities, outperforming commercial gelatin sponges. Collectively, this "material-device" integrated composite platform shows great promise in promoting wound healing, and the composite sponge also exhibits remarkable advantages in treating internal non-compressible bleeding.

Magnetic Orientation and Alignment Control of LDH-Containing Composite Membranes for Enhanced Anion Conductivity

Masafumi Yamato [1*], Khoki Takahashi [2]

[1] *Department of Applied Chemistry, Tokyo Metropolitan University, 1-1 Minami-Ohsawa, Hachioji, Tokyo 192-0364, Japan*

[2] *Institute for Materials Research, Tohoku University, 1-1 katahira, Aoba, Sendai, Miyagi 980-8577, Japan*

**corresponding author: yamato-masafumi@tmu.ac.jp*

1. Introduction

Layered double hydroxides (LDHs) are inorganic particles with exceptionally high anion conductivity, and their incorporation can enhance the performance of polymer-based anion exchange membranes. However, since anion exchange in LDHs primarily occurs along the interlayer direction, randomly oriented LDHs may hinder efficient anion transport. In this study, we aim to clarify the magnetic responsiveness of LDHs and to achieve orientation control of LDHs within composite membranes using magnetic fields.[1]

2. Experimental

MgAl-LDH and NiAl-LDH were used as the LDH fillers, and composite membranes containing 10 wt% of each LDH were prepared under both magnetic field and no-field conditions. The orientation of the LDH within the composite membranes was evaluated by wide-angle X-ray diffraction (WAXD).

3. Results and Discussion

As shown in Figure 1, magnetic orientation was observed for both MgAl-LDH and NiAl-LDH, with each exhibiting a different easy axis of magnetization. As shown in Figure 2, the membranes in which LDHs were properly aligned by the magnetic field demonstrated superior anion conductivity. These results indicate the effectiveness of magnetic processing for LDH-containing anion-conducting composite membranes.

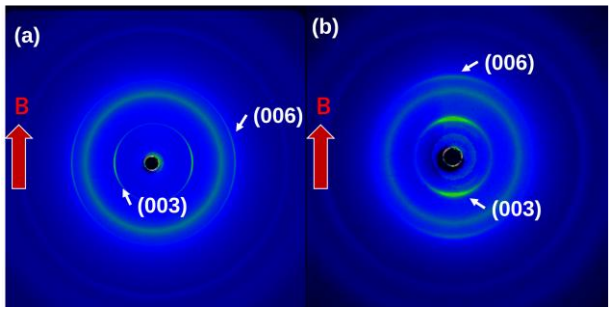

Fig. 1. The 2D-WAXD patterns of composite membranes of Mg-Al LDH (a) and Ni-Al LDH (b) with PVA/PDDA fabricated in a 10 T magnetic field.

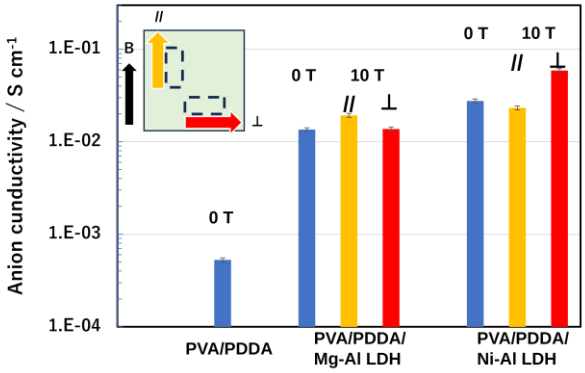

Fig. 2. The anion conductivity for the PVA/PDDA membrane and the PVA/PDDA/LDH membranes prepared outside and inside a magnetic field. The inset shows the direction of the applied magnetic field during the preparation of the composite membrane and the direction of anion conductivity measurement.

Refference:

[1] Yamato, M., Shinada, Y., Ushijima, E., Takahashi, K. (2025). *Chemistry Letters*, *54*(1) upae250.