Physical Sciences

Technology Available for Licensing

DARTMOUTH
Technology Transfer

2020-014

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US PATENT APPLICATION 17/766,121

Handheld, Inexpensive, Side-by-side Transmission Probe

PRINCIPAL INVESTIGATOR: Paul M. Meaney, Professor of Engineering, Dartmouth
CO-INVENTORS: Timothy Raynolds, Lead Senior Systems Engineer, Dartmouth | Dr. Robin Augustine, Associate Professor of Electrical Engineering, Uppsala University

VIEW PUBLICATION

DESCRIPTION

- Critical to clinical diagnosis and monitoring of conditions such as lymphedema, edema and skin wound is an **accurate picture** of all the diseased and injured tissues.
- Current technologies such as commercial reflection-based dielectric probes include **inadequate penetration** for interrogating deeper tissues and **high sensitivity** to movement during measurements, rendering them less suitable for dynamic or point-of-care applications.
- This **handheld, inexpensive, side-by-side transmission dielectric probe** builds upon the principles of **oversized coaxial probes and transmission techniques**, combining deeper signal penetration with reduced susceptibility to artifacts and improved clinical usability.
- The probe operates using an **"open-circuit" coaxial interface**, where a signal fringes out from one open-circuit coax and is coupled to an adjacent receiving open-circuit coax, propagating through the intervening tissue for interrogation.

ADVANTAGES AND BENEFITS:

- **Enhanced penetration:** This technology achieves penetration depths of **several centimeters**, far surpassing the sub-millimeter range of existing probes.
- **Motion artifact reduction:** Its transmission-based design is far **less susceptible to cable motion artifacts** than current technologies.
- **Improved clinical applicability:** The **side-by-side layout mitigates multi-path signal corruption**, enhancing clinical versatility.
- **Broadband capability:** An "open-circuit" coaxial interface enables **very broad bandwidth** and rich spectral content for diagnosis at varying tissue depths.
- **Portability and cost:** The probe pairs with emerging **handheld Vector Network Analyzers (VNAs) operating up to 3 GHz for under $500**.
- Prototypes have been fabricated using **advanced CAD and metal 3D metal printing**, showing strong early promise. The design has evolved from earlier concepts, now potentially using **elliptical coaxes** to better confine fields and focus the interrogation zone.

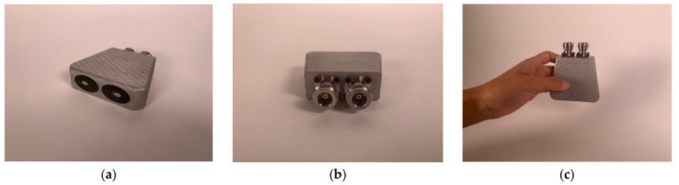

Figure. 1: Preliminary design of the probe.

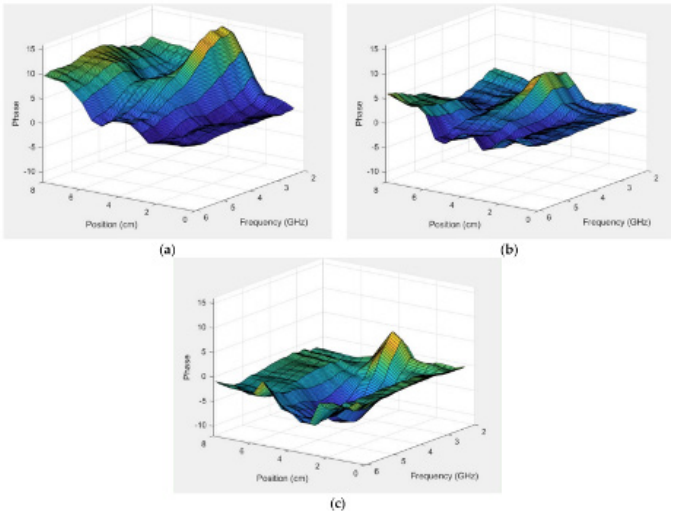

Figure. 2: Normalized phase plots as a function of horizontal position above muscle phantom for all frequencies: (a) 4.32, (b) 2.54, and (c) 1.78 cm diameter. The fat rod was clearly visible for a relatively large frequency range (2-4 GHz).

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Sr. Business Development and Licensing Manager

2020-015

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US PATENT 12,116,579
US PATENT APPLICATION 18/440,756

Modulation of Fungal Oxygen Consumption via Expression of a Novel Gene Cluster

PRINCIPAL INVESTIGATOR: Dr. Robert A. Cramer, Professor of Microbiology and Immunology

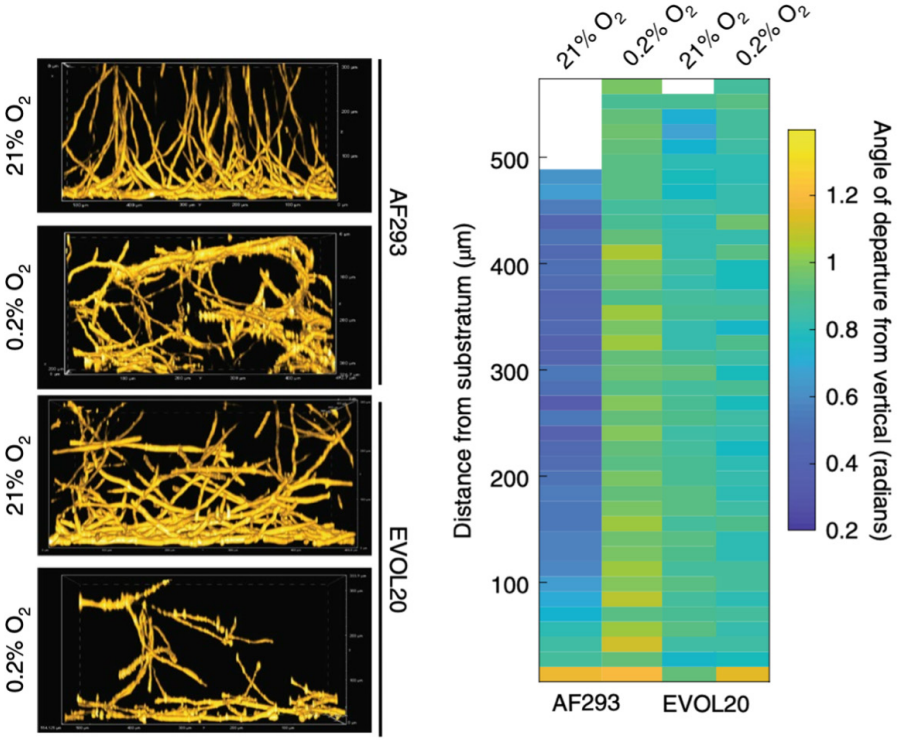
DESCRIPTION

The current industrial enzymes market relies heavily on fungal bioproduction via large-scale fermentation with a $10 billion market growing at 7% annually. Producing enzymes requires large, dense fungal cultures that demand proper aeration. Researchers at Dartmouth have identified **targeted genetic modifications in commercial fungal strains** that will improve characteristics beneficial for industrial fermentation, including reduced oxygen consumption and increased adherence. Either inserting the hypoxia responsive morphology factor A (*hrmA*) associated (HAC) cluster or making a specific mutation in the regulatory gene (*hrmA*, D304G) within the HAC is sufficient to produce the beneficial phenotypes in commercial fungal strains even if the cluster is already present in the strain but normally silenced.

ADVANTAGES AND BENEFITS

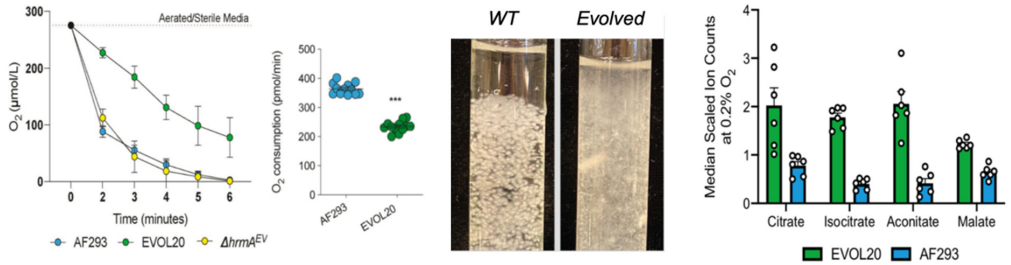
- **Reduced oxygen consumption:** Introducing the discovered gene cluster or a specific mutation into fungal strains can reduce 0_2 consumption by 50%.
- **Increased biomass:** The technology achieves decreased oxygen consumption while maintaining and even increasing the amount of biomass the fungus produces.
- **Reduced adherence:** Expression of the novel gene cluster or introduction of the A. fumigatus baf protein reduces fungal adherence to surfaces, which improves the fermentation process.
- **Improved fermentation:** The invention confers a diffuse mycelial morphology, which is a desirable trait in fungal biomanufacturing, unlike the adherent, biofilm-prone cultures that are problematic in large-scale fermentations.

VIEW PUBLICATION



[Top]: Comparison of mutant EVOL20's loose, non-pelleting mycelial network with wild-type AF293's dense pellets, showing a morphology that diffuse oxygen more efficiently.

Kowalski, C. H., Kerkaert, J. D., Liu, K. W., Bond, M. C., Hartmann, R., Nadell, C. D., Stajich, J. E., & Cramer, R. A. (2019). Fungal biofilm morphology impacts hypoxia fitness and disease progression. Nature microbiology, 4(12), 2430-2441. https://doi.org/10.1038/s41564-019-0558-7



[Left]: Mutated strains display significantly decreased oxygen consumption.

[Center]: Mutated strains exhibits diffuse mycelial morphology, a desirable trait in fungal biomanufacturing.

[Right]:Evolved strains increase secretion of industrially-relevant chemicals in hypoxia.

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Deputy Director

2020-027

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PCT/US2021/014145
US PATENT APPLICATION US17/759,045

Immunologically Optimized Botulinum Toxin Light Chain Variants

PRINCIPAL INVESTIGATOR: Dr. Karl Griswold, Professor of Engineering

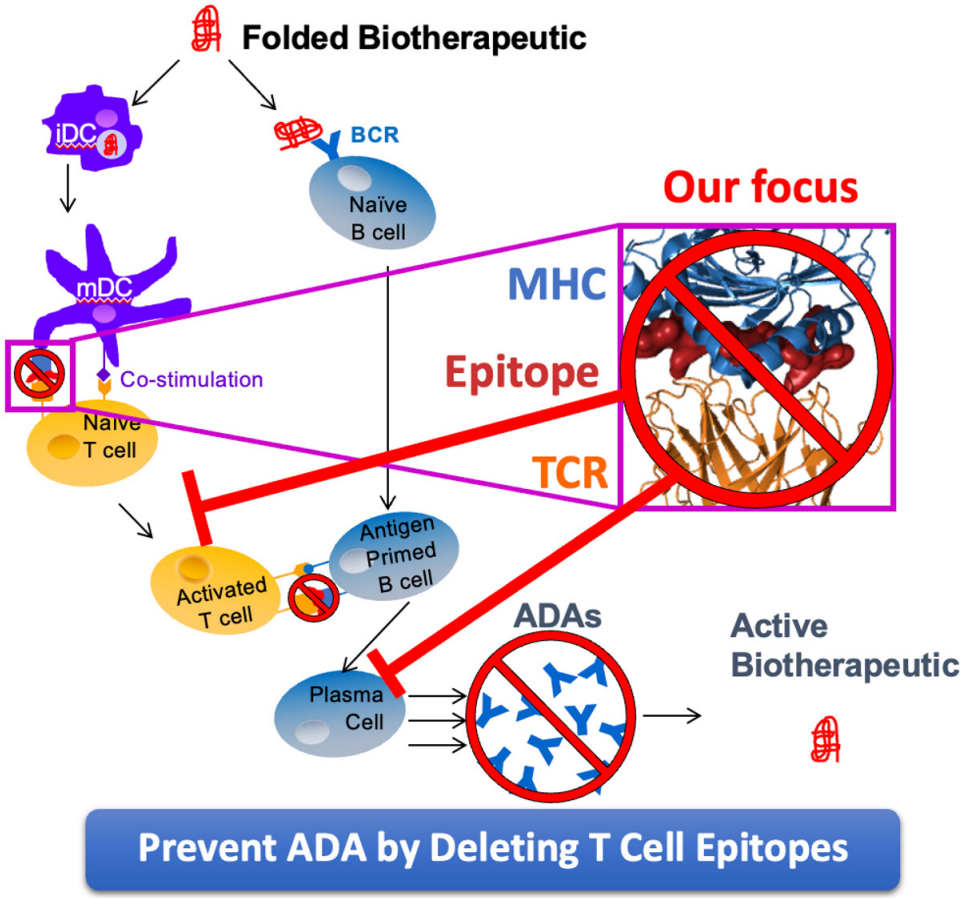
VIEW PUBLICATION

DESCRIPTION

- Botulinum neurotoxin serotype A (BoNT/A) is a biotherapeutic used for both cosmetics and for the treatment of diseases.
- BoNT/A, however, is immunogenic and its use can result in adverse immune responses resulting in various consequences.
- This technology leverages a computationally-driven design of deimmunized BoNT/A LC libraries.
- Using this approach, the immunogenicity of BoNT/A is overcome by preventing anti-drug antibodies (ADAs) via T cell epitope deletion.

ADVANTAGES AND BENEFITS

- This novel method for deimmunizing BoNT/A results in reduced immunogenicity of the botulinum toxin light chain or fragment.
- By utilizing computational protein library design coupled with ultra-high throughput screening, highly deimmunized yet highly active BoNT light chain variants are produced.
- Botulinum toxin has many therapeutic applications, and this mechanism has the potential to improve this drug's utility to improve patient outcomes.



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2020-034

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US PROVISIONAL APPLICATION 17/782,952
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Polyester-based solid polymer composite electrolyte for electro-chemically superior and high-performance sodium metal batteries

PRINCIPAL INVESTIGATOR: Dr. Weiyang (Fiona) Li, Professor of Engineering

VIEW PUBLICATION

INVENTION OVERVIEW

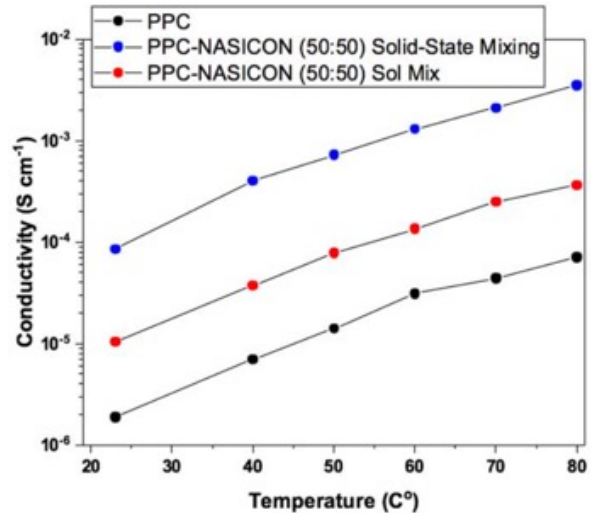
- Novel solid polymer composite electrolyte enabling the fabrication of **safe, electrochemically stable, high energy density, and high-performance** all-solid-state sodium metal batteries.
- Solid-state electrolytes, particularly ceramic ones, suffer from issues such as poor scalability, high manufacturing costs, and structural inflexibility, while conventional solid polymer composite electrolytes have issues with ionic conductivity and interfacial resistance between the electrolyte and electrode.
- Dr. Li's solid polymer composite electrolyte solves the challenges of both existing technologies.

ADVANTAGES

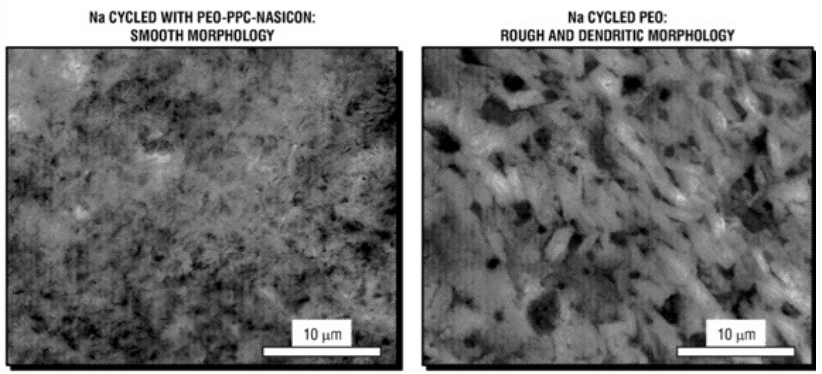
- **Performance:** Significant improvement in ionic conductivity (**100x higher**) and interfacial impedance (**10-fold reduction**) compared to conventional solid polymer composite electrolytes. Better mechanical strength, scalability, environmental friendliness, and cost compared to conventional solid polymer composite electrolytes.
- **Better stability:** Addresses major issues in sodium metal battery commercialization, such as metallic dendrite formation, unstable solid-electrolyte interphase, and large volume expansion.
- **Enhanced Efficiency:** Allows for improved sodium metal plating/stripping behavior, with a significantly smaller voltage overpotential (**0.3 to 0.4 volts compared to 2 to 4 volts** with conventional electrolytes), and remarkably smoother post-cycling electrode morphology.
- **Cost Benefits:** The use of low-cost, environmentally friendly polyester and a scalable manufacturing process make this electrolyte commercially viable for next-generation, high-performance sodium metal batteries.

MORE DETAILS

- This innovative electrolyte is synthesized using a **solid-state mixing method** via high-energy ball milling, ensuring a homogenous mixture of polyester, polyether, and ceramic materials.
- The proposed solid polymer composite electrolyte has a high ionic conductivity of **1.5 * 10-4 S/cm**.



The proposed solid polymer composite electrolyte demonstrates ~100x higher ionic conductivity than conventional counterparts across various temperatures, showcasing superior performance in all conditions.



Left: Na metal electrode cycled with proposed solid polymer composite electrolyte exhibited very smooth and dendrite-free morphology.

Right: Na metal electrode cycled with conventional solid polymer composite electrolyte exhibited rough dendritic morphology.

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2020-039

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PCT/US2020/067713
US PATENT APPLICATION US18/709,497

Novel Cathode Material to Improve Capacity & Life Span of Li & Na Batteries

PRINCIPAL INVESTIGATOR: Dr. Weiyang (Fiona) Li, Professor of Engineering

VIEW PUBLICATION

INVENTION OVERVIEW

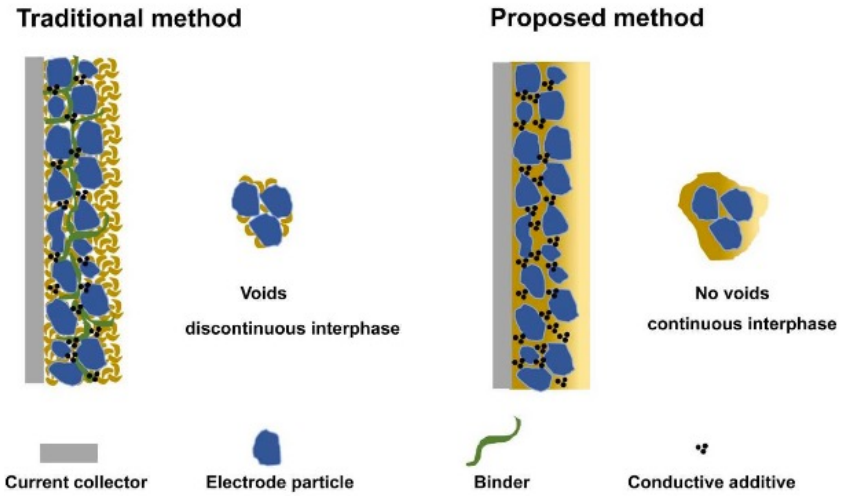
- The invention provides **a metal-sulfur battery, where the cathode/catholyte is a metal-phosphorothioate**.
- The melt phase can be used as a binder and ion-conducting buffer for battery electrodes.
- Synthesis is a simple two-step mixing process; forming a metal polysulfide followed by mixing with phosphorus pentasulfide to form the metal phosphorothioate. Compatible with both Li- and Na-Sulfur batteries.
- Cathode is formed from a combination of the metal phosphorothioate, electroconductive carbon black, and a salt.

ADVANTAGES

- **Improved Performance:** Use of Li or Na Phosphorothioate improves energy density, diffusion rate and electrochemical kinetics by creating a continuous interphase and removing voids.
- **Superior electrochemical performance:** 25% greater initial capacity with significantly greater Coulombic efficiency compared to conventional metal-sulfur battery.
- **Cost-effective:** The raw materials of sodium phosphorothioates are inexpensive and the fabrication method uses a scalable and time-saving process.

MORE DETAILS

- The core innovation is a complexation-precipitation method to produce sodium/lithium phosphorothioates by reacting sodium/lithium sulfide, phosphorus pentasulfide, and sulfur powders in a solvent such as diglyme.
- The solid-state electrolyte (P_2S_5-Na_2S_8) exhibits an ionic conductivity of **3.04×10^{-2}** mS cm^{-1}, while its melt phase shows a conductivity of **5.70×10^{-3}** mS cm^{-1} and maintains this conductivity even after cooling as measured using electrochemical impedance spectroscopy (EIS).
- Low temperature battery performance shown down to −60°C with long-term operability down to −40°C.



Comparison of electrode preparation for solid-state batteries in traditional method and proposed method. Note that the P2S5-Na2S8 melt works as binder and ion-conducting buffer. (patent no. 63/278,700)

Prototype test results and comparisons for NaS battery

	NaS catholyte w/ Na anode	Conventional NaS battery
Cyclic Retention	80% over 400 cycles	n/av
Coulombic Efficiency	> 95% over 200 cycles	< 50% over < 50 cycles
Initial Capacity	440 mAh/g active sulfur	350 mAh/g active sulfur

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2020-075

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PCT/US2024/055039
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Acyclic/cyclic ether-based electrolyte that outstretches the low temperature limit of sodium metal anode

PRINCIPAL INVESTIGATOR: Dr. Weiyang (Fiona) Li, Professor of Engineering

VIEW PUBLICATION

INVENTION OVERVIEW

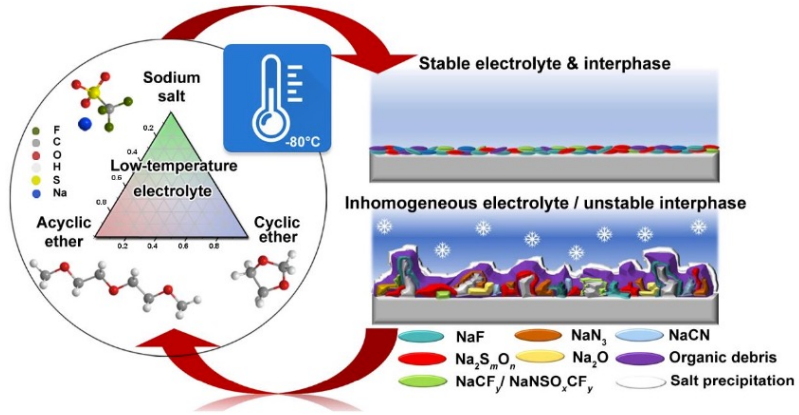
- Novel **low-temperature electrolytes** designed for sodium metal batteries using acyclic and cyclic ether solvents.
- Compatible with Na, Li and K based batteries.
- Customizable electrolyte composition for efficient operation at ranges between **–20°C and –150°C**.
- Lithium-ion batteries (LIBs) suffer from significant energy losses below 0°C, with commercial LIBs delivering only 5% of their energy density and 1 .25% of their power density at –40°C.
- There is a need for alternative battery technologies that can operate effectively at extreme low temperatures.

ADVANTAGES

- **Low temperature performance:** Stable operation of sodium metal batteries at temperatures below –80°C without salt precipitation or solvent freezing.
- **Enhanced stability:** Reduced dendrite formation = lower incidence of battery failure.
- **Improved efficiency:** Low electrolyte resistance and high ion transfer/migration at low temperatures, showing small overpotentials of less than 50 mV and stable cycling for more than 2000 hours in Na/Na symmetric cells.
- Broad applications: Applicable to portable devices, scientific tools in polar regions, or space exploration where temperatures can drop to –125°C.

MORE DETAILS

- The electrolytes consist of sodium conducting salts such as sodium trifluoromethanesulfonate (NaOTf) and/or sodium hexafluorophosphate (NaPF6) combined with organic ether-based solvents.
- The use of a binary solvent electrolyte consisting of 0.5M NaOTf in DEGDME/DOL (was shown to enable stable sodium plating and stripping with a low overpotential of 50mV even at a temperature of **–80°C** for over **2000** hours.



Low-temperature electrolytes consist of sodium conducting salts and unary/binary solvent including acyclic ethers and/or cyclic ethers in a range of mixing ratios. (patent no. PCT/US2021/045,949)

Comparisons between acyclic/cyclic ether-based electrolyte battery against existing battery solutions

	Acyclic/Cyclic ether-based	Standard Li-ion	Low-Temp Li-ion
Temp Range (°C)	–150 to –20	–40 to 0	–50 to –10
Capacity Retention	>95% @–40°C	5% @–40°C	80% @–40°C
Low-Temp Efficiency	<50mV overpotential	>200mV polarization	100-150mV polarization
Dendrite Formation	Low	High	Low

Source: Benzo energy, Sunpower, UFine battery, Wang et al. (2022)

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2021-026

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US PATENT NO 11,771,323
US PATENT APPLICATION 18/229,086

Optical time-of-flight imaging methods and systems for surgical guidance and fluorescence depth estimation in tissue

PRINCIPAL INVESTIGATORS: Dr. Brian W. Pogue, Adjunct Professor of Engineering | Dr. Petr Brůža, Assistant Professor of Engineering

VIEW PUBLICATION

DESCRIPTION

- Critical information about the depth and shape of targets in florescence-guided surgery procedures is limited by the **one-millimeter visualization** barrier that hampers objectivity and utility.
- This invention introduces an **optical imaging system** that leverages time-of-flight data to precisely determine the depth and shape of fluorescence-tagged targets, such as tumor tissue, embedded within scattering media like healthy tissue.
- The technology addresses limitations in current surgical tumor guidance by **enabling subsurface imaging through diffuse radiation transport**.

ADVANTAGES AND BENEFITS:

- **Enhanced visualization:** The technology provides surgeons with crucial information about the depth and shape of fluorescent targets in vivo or ex vivo, offering guidance during procedures like fluorescence-guided surgery.
- **Improved accuracy:** By integrating multi-wavelength time-of-flight data, the invention calculates the target's surface topology, optical properties, and fluorophore depth, enhancing the precision of depth localization and shape evaluation.
- **Signal discrimination:** The technology reliably distinguishes the primary fluorescence signal from reflected secondary signals using time-of-flight information.

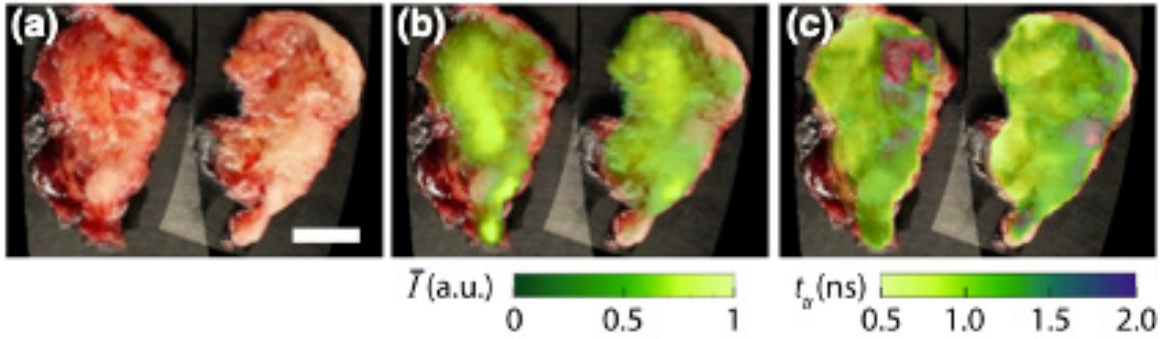

Figure 1: *In vivo* fluorescence LiDAR imaging of a resected head and neck tumour using time of flight data reveal picomolar ABY 029 fluorescence and map margins beneath the surface.

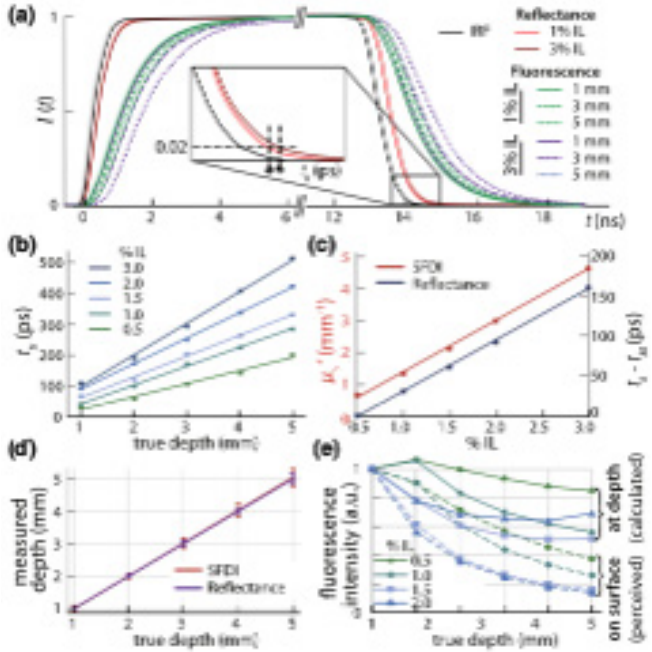

Figure 2: (a) shows depth dependent fluorescence/reflectance traces; (b) converts rising edge delay into a linear depth ruler; (c) retrieves tissue scattering and kernel width; (d) validates depth estimates within ≈0.3 mm across 1–5 mm; and (e) corrects surface measured intensity to the true subsurface fluorophore signal.

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2021-049

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US PATENT APPLICATION 18/514,761

NEMO protein engineering for NMR and Structural Biology

PRINCIPAL INVESTIGATORS: Dr. Maria Pellegrini, Research Professor | Dr. Gevorg Grigoryan, Research Associate Professor of Computer Science

VIEW PUBLICATION

DESCRIPTION:

- This invention introduces novel variants of the natural NEMO protein to enable the development of new therapies targeting the NF- κB pathway in cancer. Existing technology could not utilize NMR and X-ray techniques effectively in the study of wild-type (WT) NEMO for drug discovery efforts. Current solutions faced significant limitations, as WT-NEMO exhibited conformational heterogeneity and line broadening in NMR spectra, hindering its use in NMR-based screening and structure determination. These modifications are specifically designed to achieve improved structural characteristics, enhanced stability and solubility, higher quality NMR spectra, and suitability for X-ray crystallography, all while maintaining crucial biological activity, such as IKK binding.

ADVANTAGES AND BENEFITS

- **Enables structural studies:** The modified NEMO proteins are suited for NMR and X-ray techniques, enabling structure determination of NEMO in both the apo-form and in complex with ligands/inhibitors, which was not achievable with WT-NEMO.
- **Improves NMR screening quality:** Mutant NEMO proteins like MP12 generate high-quality, well-dispersed NMR spectra, compared to the diffuse density spectra of WT-NEMO, thereby enabling effective NMR-based screening and lead validation.
- **Enhanced properties:** The modifications improve helical content, coiled-coil structure, dimerization propensity, and protein stability, reducing aggregation and conformational exchange compared to wild-type NEMO.
- **Enhanced drug discovery:** Improved properties facilitate structure-based rational design, screening, and validation of inhibitors targeting the NEMO-IKK interaction, accelerating the development of potential therapies.

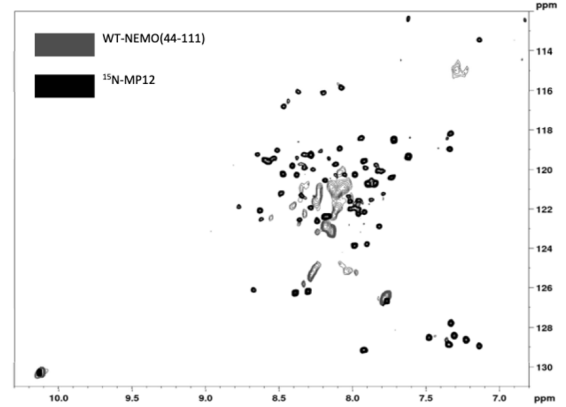

Figure 1: Comparison of wild-type NEMO(44-111) and the engineered ^{15}N-MP12 mutant

Source: WIPO Patent PCT/ US2022/072671

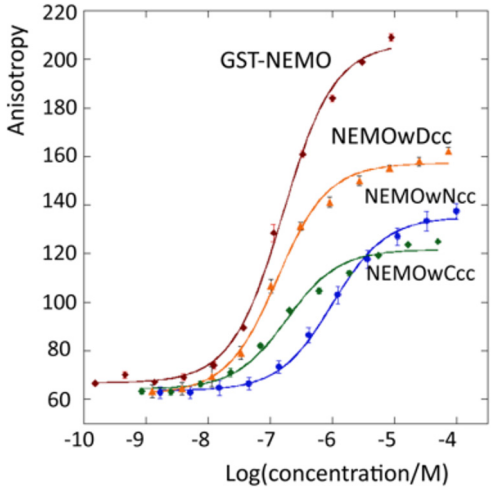

Figure 2: FA curves for direct binding of IKK βKK/RR to the engineered NEMO constructs and GST-NEMO(1–196), demonstrating structural stabilization of redesigned NEMO.

Guo, B., Audu, C. O., Cochran, J. C., Mierke, D. F., & Pellegrini, M. (2014). Protein engineering of the N-terminus of NEMO: Structure stabilization and rescue of IKKβ binding. *Biochemistry*, 53(43), 6776–6785. https://doi.org/10.1021/bi500861x

DARTMOUTH
Technology Transfer

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2022-020

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US PATENT APPLICATION 18/849,436

Clay Minerals to Sequester Carbon from the Ocean Surface

PRINCIPAL INVESTIGATOR: Dr. Mukul Sharma, Professor of Earth Sciences

VIEW PUBLICATION

INVENTION OVERVIEW

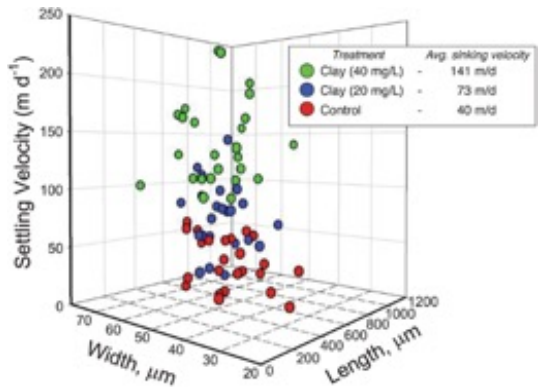
- Current atmospheric CO2 removal technologies **lack the scale and cost-effectiveness** needed to accelerate transition to a low-carbon economy.
- The marine biological pump processes significant atmospheric carbon (25 Pg/year as DOM, 5-12 Pg as POM), but the majority oxidizes back to CO2 in the upper ocean, limiting long-term sequestration potential.
- **The invention proposes the use of clay minerals** to enhance natural carbon sequestration in the ocean by converting dissolved organic matter into sinking organoclay flocs, driving the efficiency of DOM to POM conversion.

FEATURES AND OPERATING PRINCIPLES

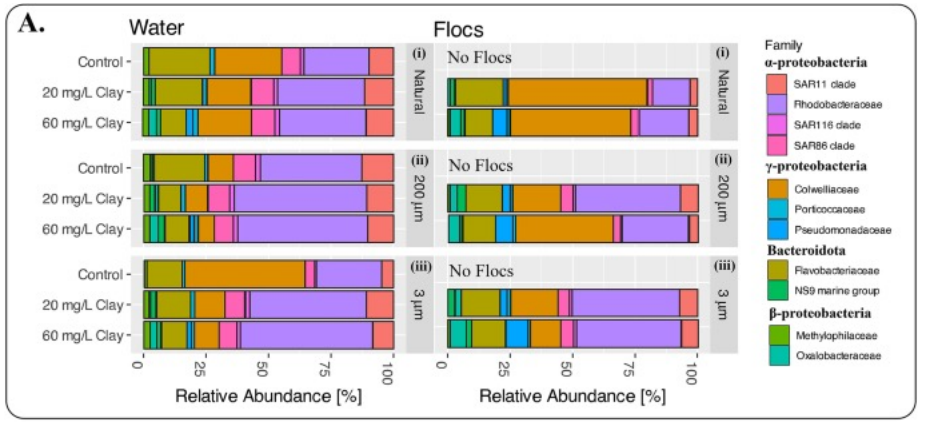
- A mixture of clay minerals, specifically palygorskite, are applied to the surface of the ocean, where they act as a ballast, increasing the density and sinking velocity of organic matter.
- These organoclay flocs are then consumed by zooplankton, which package them into dense, rapidly-settling fecal pellets that enhance carbon transport to deeper waters, particularly during zooplankton diel vertical migration.
- This process enhances the biological pump, removing carbon from the surface waters and preventing its oxidation back to CO2.

ADVANTAGES

- The invention has the potential to remove over **1 billion metric tons of atmospheric carbon per year** by sprinkling 10 million tons of clay, removing 10 g of carbon per 0.1g of clay.
- The method focuses on existing natural processes and present no adverse impact on the growth of marine bacteria and photosynthetic microalgae.
- Clay materials are inexpensive and readily available. They can also be derived from wasteful by-products of mining and phosphate processing, turning a liability into a potential resource.



Sinking velocity of fecal pellets produced by *Calanus finmarchicus* following feeding on a diet comprising algae Rhodomonas salina supplemented with varying concentrations of clay for control and treatment groups.



Relative abundance and beta diversity from the 16s rRNA gene amplicon sequencing of bacterial communities in water and floc samples. Clay supplementation leads to floc formation with no change in bacterial population.

DARTMOUTH
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2022-043

AVAILABLE FOR LICENSE

US PATENT APPLICATION 18/521,285

A Method to Diagnosis Infants and Children with CF at Risk for Respiratory Infections Using Stool Composition Data

PRINCIPAL INVESTIGATORS: Dr. George A. O'Toole, Professor of Microbiology & Immunology
Juliette Madan, MD, Associate Professor, Pediatrics, Epidemiology, Quantitative Biomedical Data Science

VIEW PUBLICATIONS

DESCRIPTION

Gut microbiota dysbiosis in cystic fibrosis (CF) patients can alter a host's inflammatory status, showing distinct microbial compositions between children with low versus high intestinal inflammation, which affects lung disease risk. Traditional diagnostic methods often involve uncomfortable oropharyngeal sampling or respiratory lavage. This invention introduces **machine learning-based diagnostic tool for identifying CF patients at high risk for upper respiratory infections (URIs) or systemic inflammation**. The system employs random forest machine learning models trained on stool microbiota data to classify patients' risk. Once identified, a clinician has a broad range of **therapeutic interventions to address the risk**, including altering the intestinal microbiome through bacterial compositions (e.g., Bifidobacterium, Bacteroides), probiotics, prebiotics, fecal microbiota transplantation (FMT), or conventional treatments such as antibiotics, anti-inflammatory medications, and CFTR modulators.

ADVANTAGES AND BENEFITS

- **Non-invasive diagnosis:** This invention uses **stool compositional data** from easily collected diaper samples to **accurately identify children most likely to experience respiratory events**, replacing uncomfortable and invasive sampling methods.
- **High predictive accuracy:** The machine learning model **predicts high upper respiratory infection frequency (URIfreq) with only 16% error** and **high neutrophil-to-lymphocyte ratio (NLR), a marker for systemic inflammation, with 27% error**.
- **Actionable insights:** By identifying specific gut microbiota profiles associated with negative health outcomes, this technology **provides physicians with crucial understanding to determine the need for therapeutic interventions**.

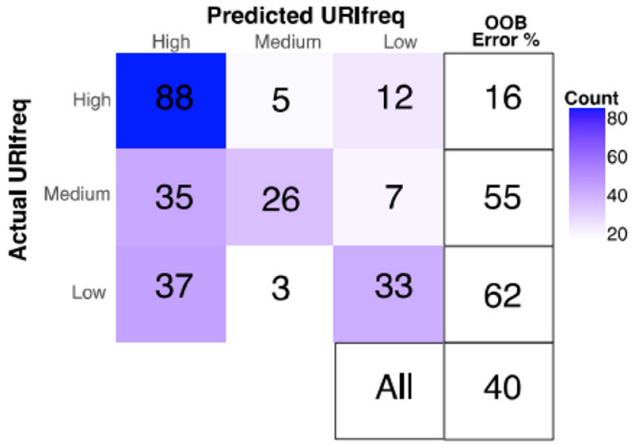

Figure 1 [top]: Predicted vs Actual URI with the OOB estimate of error rates for predicting age from stool microbiota being 40%.

Source: Valls, R. A., Hampton, T. H., Price, C. E., Barrack, K. E., O'Toole, G. A., Coker, M. O., & Madan, J. C. (2022). Predicting clinical outcomes in infants with cystic fibrosis from stool microbiota using random forest algorithms [Preprint]. bioRxiv. https://doi.org/10.1101/2022.08.06.503028

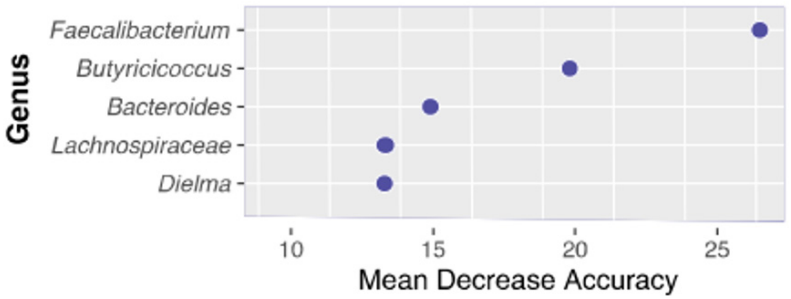

Figure 2: [left]: Model identified *Faecalibacterium*, *Butyricicoccus*, and *Bacteroides* as the top genera driving prediction.

Source: Valls, R. A., Hampton, T. H., Price, C. E., Barrack, K. E., O'Toole, G. A., Coker, M. O., & Madan, J. C. (2022). Predicting clinical outcomes in infants with cystic fibrosis from stool microbiota using random forest algorithms [Preprint]. bioRxiv. https://doi.org/10.1101/2022.08.06.503028

DARTMOUTH Technology Transfer

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2023-003

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PCT APPLICATION PCT/US2024/030955
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Discovery and Development of Novel Small Molecules with Antifungal Properties

PRINCIPAL INVESTIGATOR: Dr. Robert A. Cramer, Professor of Microbiology and Immunology

VIEW PUBLICATION

DESCRIPTION

Antifungal drug discovery against molds has lagged other pathogens due to their complex multicellular lifestyles. Currently, pathogenic filamentous fungi are exceedingly difficult to treat due to resistance to all three main classes of contemporary antifungals and rising drug resistance in susceptible strains. Researchers at Dartmouth have identified novel compounds and methods for treating fungal infections through a high-throughput screening platform specifically designed to find small molecules synergistic with fluconazole and/or those with preferential activity under low oxygen conditions, leveraging a sensitive luminescence-based reporter assay. Preliminary data from testing suggests some of these compounds may act through the SrbA-dependent hypoxia response pathway, a known virulence factor and regulator of azole resistance, representing a potentially novel mechanism of action.

ADVANTAGES AND BENEFITS

- **Targeting difficult infections:** The proposed compounds specifically addressed infections caused by Aspergillus species, including azole-resistant strains which are particularly challenging.
- **Enhanced efficacy:** The identified compounds inhibit fungal growth more effectively, including with lower concentrations of antifungal agents, and specifically potentiate antifungal agents like azoles, demonstrating synergy and increased efficacy against drug-resistant strains.
- **Hypoxia-specific activity:** The invention identifies molecules with preferential activity under low oxygen (hypoxic) conditions, which mimics the microenvironment found at the site of established infections and in biofilms, thereby targeting a crucial resistance mechanism.

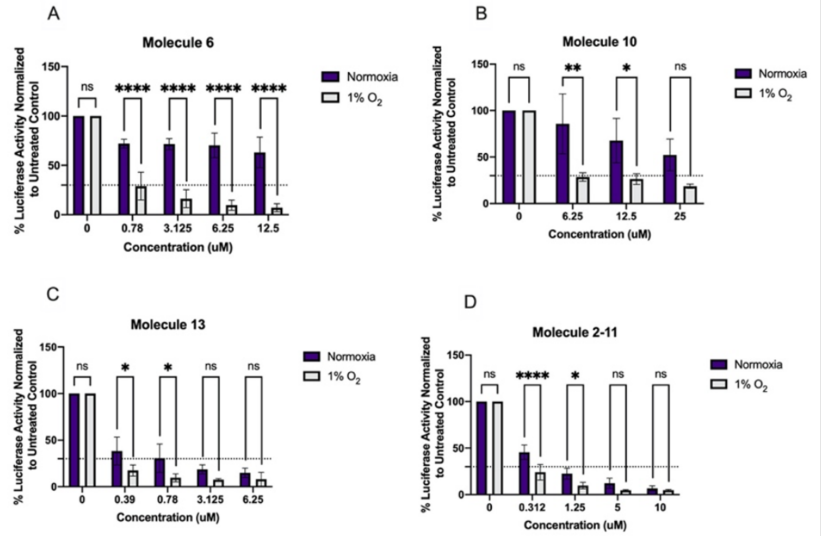

Figure 1 [top]: Example of novel small molecules that significantly reduce A. fumigatus growth under hypoxic (1% oxygen) conditions.

Source: Sophia patent application: [Invention 2023-003] R33 Transition Narrative_FINALSUBMIT_113020.pdf

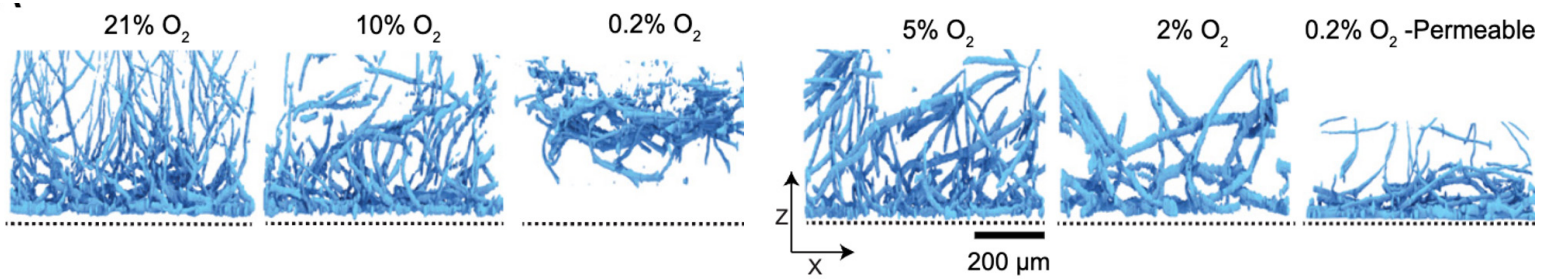

Figure 2 [left]: 3D renderings of A. fumigatus biofilms under varying oxygen levels, revealing how oxygen availability shapes fungal growth and drives antifungal resistance.

Source: C.H. Kowalski, K.A. Morelli, D. Schultz, C.D. Nadell, & R.A. Cramer, Fungal biofilm architecture produces hypoxic microenvironments that drive antifungal resistance, Proc. Natl. Acad. Sci. U.S.A. 117 (36) 22473-22483, https://doi.org/10.1073/pnas.2003700117 (2020).

DARTMOUTH
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Deputy Director

2023-006

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PENDING APPLICATION PCT/US23/077930

Nitrogen and Sulfur co-doped MXene compounds for improved hydrogen evolution reaction

PRINCIPAL INVESTIGATOR: Dr. Will Scheideler, Assistant Professor of Engineering

VIEW PUBLICATION

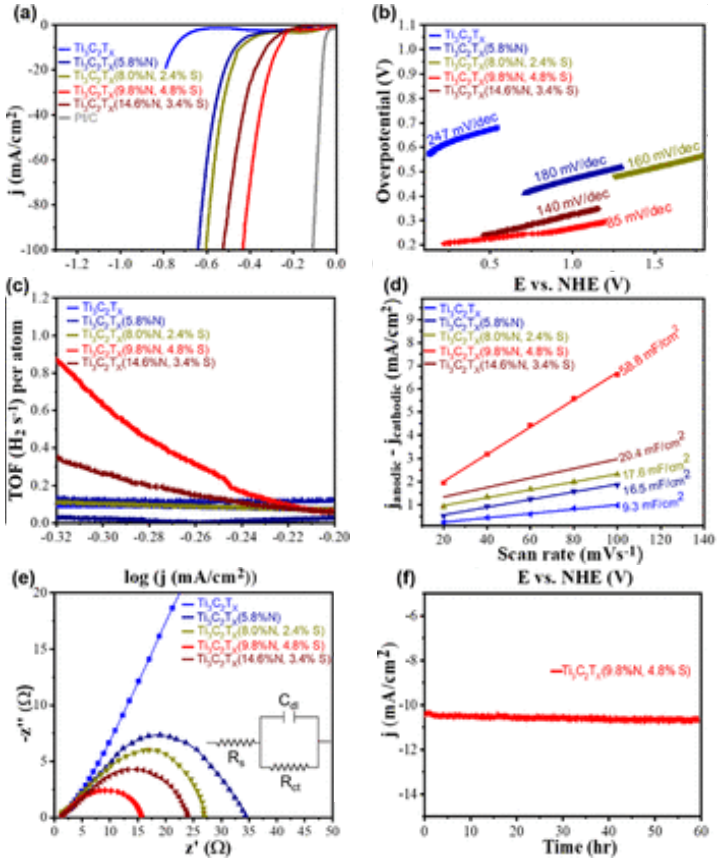
INVENTION OVERVIEW

- N- and S- co-doped MXene compounds offer improved performance and stability in hydrogen evolution reaction compared to existing MXene materials which are limited by poor intrinsic chemical activity and limited active site densities
- Simple thermal annealing process using solid thiourea at 300-700°C for 1-3 hours; allows for controlled surface modification of MXenes and the creation of new chemical bonds.

MXene	Standard Li-ion	Low-Temp Li-ion
Co-doped Ti3C2Tx	260mV	85mV/dec
Pristine Ti3C2Tx	~770mV	247mV/dec

ADVANTAGES AND SCOPE

- **Enhanced performance:** This technology overcomes the limitations of poor intrinsic chemical activity and the limited active site densities of pristine MXenes by tuning the interfacial chemical co-doping with anions and is more stable than Mxenes with metallic electron donors (Fe, Ni, and Co).
- **Improved electrocatalytic activity:** The modified MXenes show significantly reduced overpotential for the hydrogen evolution reaction, achieving 260 mV at 10 mA/cm² which is three times lower than pristine Ti3C2Tx (-770 mV).
- **Broad applicability:** The technology is generally applicable to electrocatalytically accelerating hydrogen evolution activity and could be extended to other MXenes and to enhance their performance in other electrochemical device applications such as supercapacitors and fuel cells.



Electrocatalytic performance of pristine and doped MXene

DARTMOUTH
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2023-035

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PCT/US2024/025537

Novel Soil Amendment to Remove Atmospheric Carbon Dioxide

PRINCIPAL INVESTIGATOR: Dr. Mukul Sharma, Professor of Earth Sciences

VIEW PUBLICATION

INVENTION OVERVIEW

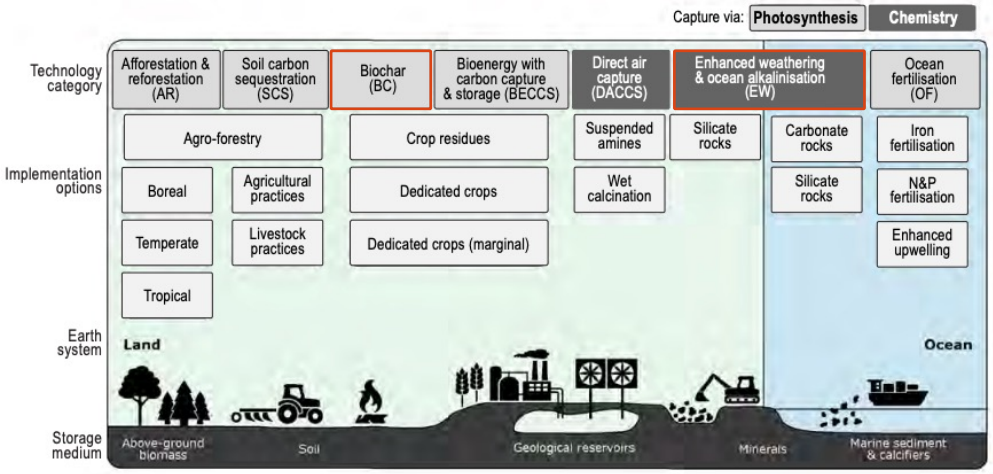
- Two current approaches to carbon dioxide removal (CDR) — enhanced silicate rock weathering (EW) and the application of biochar (BC) — **both have individual limitations**.
- **A novel soil amendment**, Altered Basalt with Fortified Biochar (ABFB), is a composite material consisting of both biochar and basalt that can simultaneously **reduce atmospheric CO_2 and increase soil fertility**.
- This technology **addresses the limitations of EW** by accelerating basalt weathering kinetics and also **mitigates the drawbacks of BC** by minimizing the release of CO_2 during production and avoiding the synthesis of pollutants.

FEATURES / OPERATING PRINCIPALS

- ABFB consists of generating an altered basalt through heating and mixing it with BC, which can be derived from various biomass sources.
- This new material becomes a pool of recalcitrant carbon that can reduce atmospheric CO_2 and increase soil fertility by sequestering mineral bound refractory carbon in soil and producing soluble bicarbonate ion (HCO_3^-) that has a mean residence time of 10,000 years in the environment.

ADVANTAGES / SCOPE

- **Reduced Material Usage**: The invention requires about 100 times less basalt than traditional EW.
- **Enhanced CO_2 Removal**: ABFB is projected to remove 0.3-0.5 tons of CO_2 per ton of ABFB per year.
- **Soil Health**: ABFB improves soil fertility by providing nutrients, decreasing soil acidity, and increasing soil carbon and water content.
- **Reduced Pollutants**: ABFB does not contain harmful organic pollutants that can be present in BC.
- **Scalability**: The reduced material requirements and enhanced reaction rates make the technology more scalable than traditional EW.
- **Cost Efficiency**: The technology is estimated to cost less than $100 to remove a ton of CO_2.
- **Resource Utilization**: The process utilizes waste heat and liquid from BC production, increasing efficiency.



Proposed technologies to get to net-zero. This invention proposes the combination of both Biochar (BC) and Enhanced Weathering (EW).

Figure credit: Baker S.E. et al., 2020, Lawrence Livermore National Lab.(LLNL), Livermore, CA (United States). Retrieved: https://gs.llnl.gov/sites/gs/files/2021-08/getting_to_neutral.pdf

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2023-036

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PENDING APPLICATION PCT/US24/33807

Micro-lattice transition metal oxide materials and structures for efficient electrocatalysis

PRINCIPAL INVESTIGATOR: Dr. Will Scheideler, Assistant Professor of Engineering

VIEW PUBLICATION

INVENTION OVERVIEW

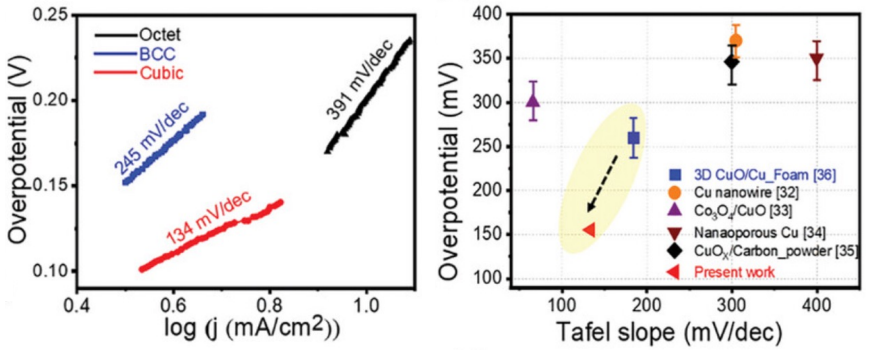
- Novel materials, structures and fabrication processes for highly stable and efficient electrocatalysts for hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) processes.
- Current nickel- and transition metal oxide-based electrocatalysts in alkaline media suffer from sluggish kinetics, stability issues, and low active site density, severely limiting their efficiency. Platinum group metal electrocatalysts are efficient and stable but expensive.

FEATURES

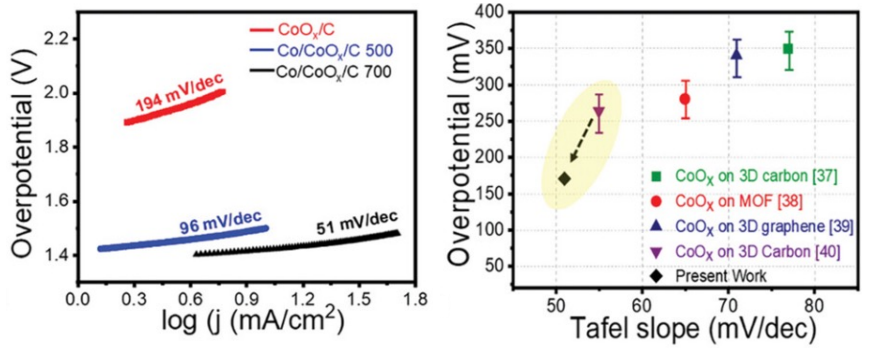
- The innovation uses 3D-printed, lattice-based mesoporous electrodes that provide a high density of electrochemically active sites, facilitate reactant transport, and enhance stability via efficient bubble evolution. The electrodes are fabricated using a polymer infusion additive manufacturing (PIAM) technique.
- The 3D electrodes showed promising performance metrics: an overpotential of **155 mV at 10 mA/cm² for HER and 1.42 V at 10 mA/cm² for OER**.
- The electrodes also exhibit superior durability, with up to 240 hours of continuous hydrogen evolution without significant performance changes.

ADVANTAGES AND SCOPE

- **High stability:** This invention overcomes the limitations of low stability and activity of traditional earth-abundant electrocatalysts through 3D structuring and chemical modification via a simple heat treatment.
- **Scalability and cost:** 3-D printing manufacturing methods are low-cost and use earth-abundant materials, offering a significant cost advantage over precision metal catalysts.
- **Improved performance:** Superior overpotential for OER and HER compared to existing solutions and benchmark noble metal-based electrocatalysts; improved stability over 3D catalysts and powder electrocatalysts.
- **Design flexibility:** The process allows for greater design freedom in electrode architecture and the mixing of multiple transition metal precursors to form complex alloys for various catalytic reactions (HER, OER, CO2 reduction, etc). The pore structure facilitates bubble release, preventing blockage of active sites.



Electrocatalytic performance for HER of different microlattices in 1.0 M KOH solution. Left: Tafel plots. Right: Comparison of overpotential at 10 mA cm−2 and Tafel slopes between 3D microlattices of Cu/CuOx/C and other 3D structured electrocatalysts



Electrocatalytic performance for OER of Co/CoOx/C and CoOx/C cubic microlattices catalysts in 1.0 M KOH solution. Left: Tafel plots. Right: Comparison of overpotential at 10 mA cm−2 and Tafel slopes between 3D microlattices of Co/CoOx/C and other 3D structured electrocatalysts.

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2024-004

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US PATENT APPLICATION 18/883,022

Enhanced magnetic performance of Manganese Aluminum alloy via Titanium addition

PRINCIPAL INVESTIGATOR: Dr. Ian Baker, Professor of Engineering

VIEW PUBLICATION

INVENTION OVERVIEW

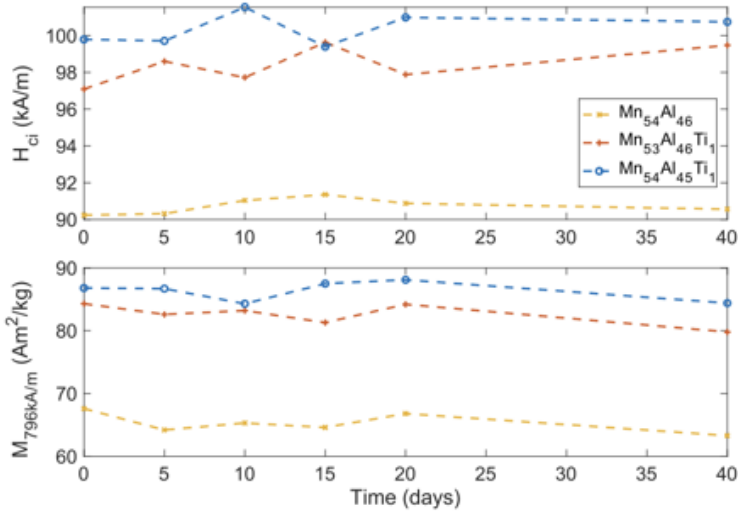
- This invention is a permanent magnet (PM) composed of a manganese-aluminum-titanium (**Mn-Al-Ti**) alloy, designed to improve upon existing magnet technology.
- Current permanent magnets with the highest performance are based on neodymium-iron-boron (Nd-Fe-B) and samarium-cobalt (Sm-Co), which have high raw material costs, scarcity, and require extractive mining.
- Manganese and aluminum are cheaper and more abundant, but current Mn-Al PMs do not perform as well as rare-earth magnets due to limitations in achieving both high coercivity and remanence, and issues with anti-phase boundary (APB) defects.

FEATURES AND OPERATING PRINCIPLES

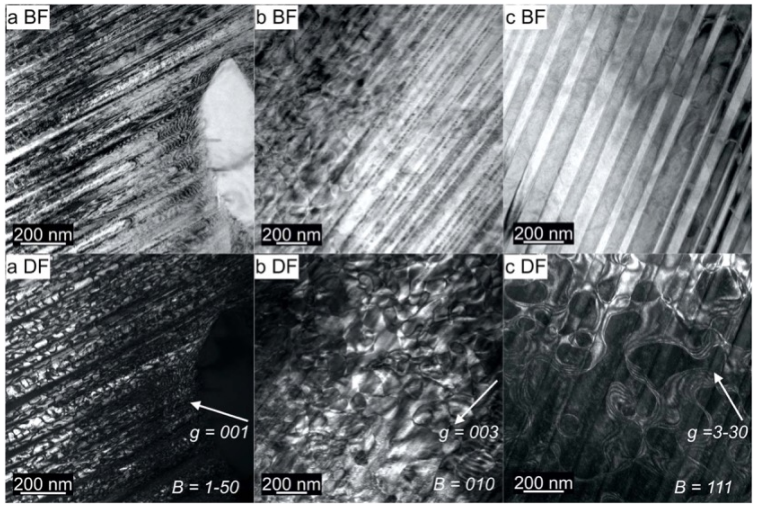
- The core of the innovation is a Mn-Al-Ti alloy, with a targeted composition of about **1% of titanium**, which is found to preferentially sit on APBs to enable better ferromagnetic pairing across the APB.
- Experimental results demonstrate that a composition of $Mn_{54}Al_{45}Ti_1$ exhibits a **33% improvement** in the base magnetic performance factor (BHmax), as well as increased remanence and equivalent or greater coercivity compared to the standard $Mn_{54}Al_{46}$ alloy.

ADVANTAGES

- **Improved performance:** The Mn-Al-Ti magnet exhibits higher magnetic remanence, equivalent or greater coercivity, and more stable coercivity at high temperatures compared to the standard Mn-Al alloy.
- **Reduced defects:** The invention significantly lowers the density of APB defects and increases the size of anti-phase domains, leading to improved properties.
- **Enhanced stability:** The titanium stabilizes the coercivity of the magnet at high temperatures and enables high temperature processing without losing coercivity.
- **Cost-effective alternative:** The Mn-Al-Ti alloy provides a potential replacement for expensive rare-earth magnets by utilizing cheaper and more abundant materials such as manganese and aluminum.



H_{ci} and M as a function of time at 250ºC in air. Samples were not demagnetized corrected, so M values are relative and not absolute.



TEM BF and DF images of Mn-Al-Ti alloys showing how the density of APBs decreases with Ti addition. (a) $Mn_{54}Al_{46}$ (b) $Mn_{54}Al_{46}$ Ti1 (c) $Mn_{54}Al_{45}Ti_1$. *B* is the beam direction and g is the diffraction vector.

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Technology Transfer

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2024-005

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PCT APPLICATION PCT/US2024/055735
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Creation of Anti-Canine PD-1 Monoclonal Antibodies to Treat Cancer

PRINCIPAL INVESTIGATORS: Hugo Arias-Pulido, Senior Research Scientist, Microbiology & Immunology | Dr. Randolph J. Noelle, Emeritus Professor of Microbiology & Immunology

VIEW PUBLICATION

DESCRIPTION

- **HugPet9** is a novel antibody for detecting or treating canine cancers, alone or in combination therapies. The invention includes antibodies or antibody fragments binding to canine PD-1, comprising the same CDRs as HugPet9 (77A6H9) or 77A6H7, or possessing at least 98–99% sequence identity in their VH and VL polypeptides to these antibodies. These antibodies or fragments can be engineered to include various Fc regions (murine, human, feline, canine, optionally canine IgGA, IgGB, IgGC, or IgGD) and framework regions (canine or murine). The invention extends to nucleic acids encoding these antibodies, expression vectors designed to express them, and recombinant cells (including mammalian cells like CHO, BHK, COS, Hela, HEK; yeast; fungal; plant; insect; or bacterial cells) capable of producing the antibodies.

ADVANTAGES AND BENEFITS

- **Binding Specificity:** HugPet9 binds specifically to canine peripheral blood mononuclear cells (PBMCs) and different canine tumor tissues expressing PD-1 protein.
- **Diagnostic Specificity:** HugPet9 provides clear and specific detection of PD-1 protein levels in archival canine paraffin-embedded tissues, unlike a commercial antibody (JC053) which shows non-specific staining of multiple cell types in the same tissues.
- **Demonstrated Safety and Efficacy:** Intratumoral (IT) HugPet9 immunotherapy showed safety in a proof-of-concept trial and preclinical studies for canine mammary cancer patients, resulting in observed partial responses in one dog and stable disease in two dogs in a small cohort.
- **Reduced Toxicity:** The IT administration route for HugPet9 is estimated to require significantly lower doses (e.g., 2 mg total for a 4-week course vs. potentially 4–60 mg for systemic administration).

Figure 1A

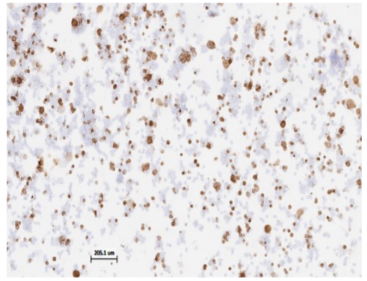

Figure 1B

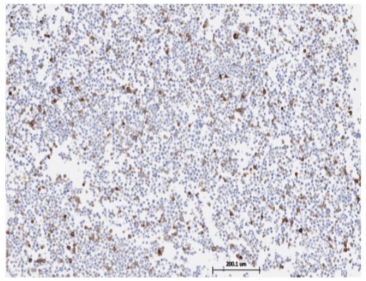

Figure 1: Detection of HugPet9 in 293T cells. The 293T cells were transfected with canine PD-1, expanded and used to detect PD-1 levels in these cells by immunocytochemistry (A) or in embedded in paraffin by standard IHC with HugPet9 (B). The two formats reflect fresh-frozen tissues and archival paraffin-embedded samples, respectively.

Figure 2A

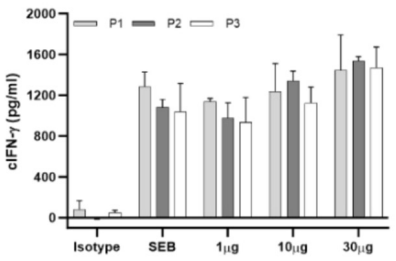

Figure 2B

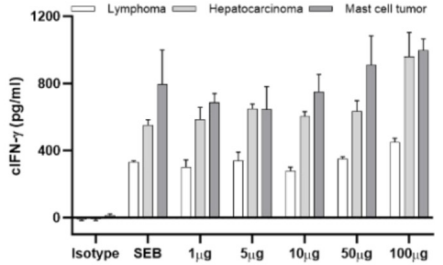

Figure 2: Effect of HugPet9 on IFN-g expression in PMBCs from healthy and cancer dogs. Canine PMBCs from healthy (left) and cancer-bearing dogs (right) were activated with an isotype IgG1 antibody (isotype), staphylococcal enterotoxin B (SEB, 50ng/ml) and SEB plus HugPet9 at the doses indicated in the x-axis. The IFN-g levels are indicated in the y-axis.

Figures from Sophia's patent application (filename: 1143252.007213 Fig 1-18A-C)
https://dartmouth.wellspringsoftware.net/kms/patent/detail/4714/

DARTMOUTH
Technology Transfer

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2024-029

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US PROVISIONAL APPLICATION 63/730,661
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Inhibition of Oligosaccharyltransferase (OST) as Therapy for Prion Disease

PRINCIPAL INVESTIGATOR: Dr. Surachai Supattapone, Professor of Biochemistry and Cell Biology

DESCRIPTON

Prion diseases are fatal neurodegenerative diseases caused by the misfolding of the prion protein PrPC, leading to severe neurological dysfunction. Currently, no approved treatments exist for prion diseases, and non-toxic drug treatments show limited efficacy lifespan in animal models. They also face challenges such as strain-dependent activity and administration at late clinical stages. Researchers at Dartmouth have shown that administering an oligosaccharyltransferase (OST) complex inhibitor which blocks N-glycosylation of PrPC and its cell surface expression, inhibits the replication of disease-causing PrPSc.

ADVANTAGES AND BENEFITS

- **Targeted mechanism:** The method directly targets the cell surface expression of PrPC and inhibits the replication of disease-causing PrPSc by inhibiting the attachment of the glycosylphosphatidylinositol anchor to PrPC and/or its attachment to the outer surface of the plasma membrane.
- **Broad strain efficacy:** OST complex inhibition of PrPC, achieved complete removal of PrPSc from cells infected with three or four different types (strains) of prions in laboratory testing.
- **Significant PrPC reduction:** Treatment effectively lowers PrPC levels on the surface of cells by over 50%.
- **Superior cellular outcomes:** OST complex inhibition demonstrates the unique capability to fully cure cells infected with every prion strain tested, a significant advantage over previously tested N-glycosylation inhibitors that exhibited strain-dependent results.

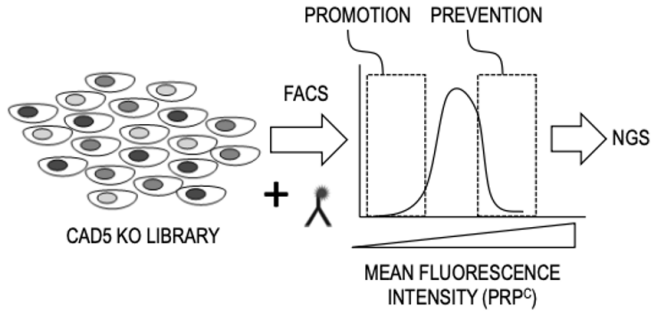

Figure 1: Schematic of the CAD5 knockout (KO) library screening process to identify genes involved in the surface expression of PrPC.

Source: USPTO 63/730,661 (Filed 12/11/2024)

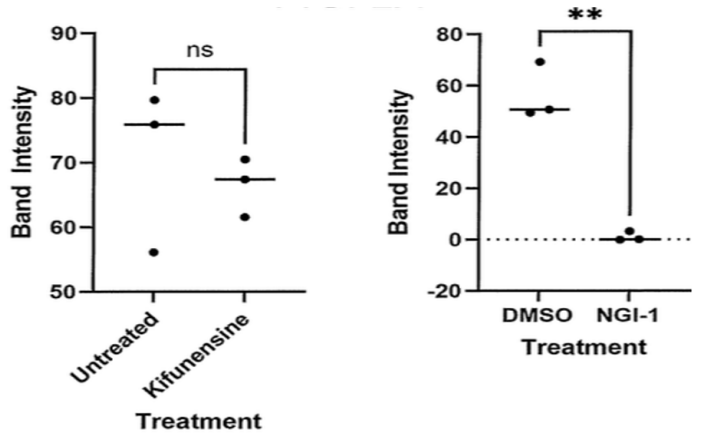

Figure 2: Comparison of untreated cells and cells treated with kifunensine (Fig. 2B), and comparison of cells treated with DMSO and NGI-1 (Fig. 2C)

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Technology Transfer

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2024-038

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US PROVISIONAL APPLICATION 63/753,628
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Evolved Bacteroides Strains for Use as a probiotic in Cystic Fibrosis and Inflammatory Bowel Disease

PRINCIPAL INVESTIGATOR: Dr. George A. O'Toole, Professor of Microbiology & Immunology

DESCRIPTION

While life changing the new cystic fibrosis (CF) therapeutics have demonstrated little to no positive impact on the CF gut, whose altered intestinal microbiome can lead to nutritional deficiencies and an increasing burden of linked obesity. The gut conditions of these patients, such as excess mucus, increased fat content, acidic pH, and heightened inflammation are not amendable to modification with standard probiotics either. Through evolutionary development using a serial adjusted cell culture media, a set of evolved strains that can survive the CF and other guts altered by inflammation was identified and shown to be viable in the gut and still producing the anti-inflammatory factors. Compositions containing these evolved bacteria can be formulated as nutraceutical or pharmaceutical products for oral or nasogastric administration, and are envisioned for use in subjects with low abundance of target bacteria like Phocaeicola and Bacteroides, including pediatric CF patients as young as 0 days old, potentially in conjunction with existing CF therapies.

ADVANTAGES AND BENEFITS

- **Increased viability in CF and inflamed GI tract:** Evolved bacterial cells exhibit significantly higher viability in CF-like gastrointestinal conditions.
- **Retained immunomodulatory function:** The evolved strains continue to produce short-chain fatty acids (SCFAs) at levels comparable to the ancestral bacterial strain, which is a key compound known to drive anti-inflammatory effects and modulate inflammation.
- **Effective colonization:** The evolved bacterial cells have demonstrated the capability to colonize the GI tract in mammalian CF models at levels similar to ancestral strains, providing similar immunomodulatory effects.
- **Wide commercial potential:** This technology possesses potential for other inflammatory gut conditions such as inflammatory bowel disease (IBD), ulcerative colitis, and Crohn's disease.
- **Non-engineered development:** These evolved strains were not genetically engineered but arose naturally through adaptive evolution in a laboratory medium designed to mimic the inflamed CF gut.

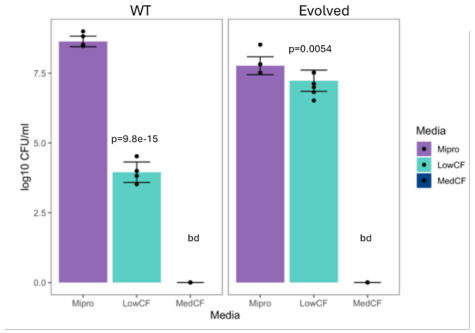

Figure 1: The evolved strains maintain viability in LowCF-MiPro, showing less than 0.5 log10 CFU/ml decrease, in contrast to the wild-type strain's >4 log10 CFU/ml drop, showing that the evolution of P. vulgatus strains are capable of surviving CF-like gut environments.

Source: Patent manuscript

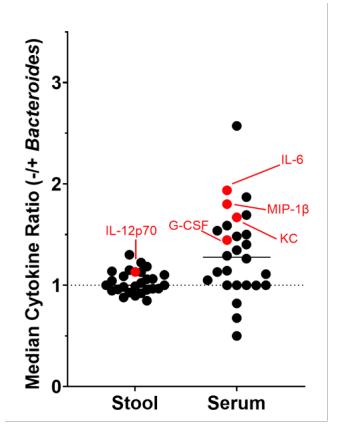

Figure 2: Fold-change in 32 cytokines across stool, serum, and intestinal tissue, showing that without Bacteroides pro-inflammatory signals rise systemically and locally, showing its crucial role in dampening CF-associated inflammation.

Source: Price, C. E., Valls, R. A., Ramsey, A. R., Loeven, N. A., Jones, J. T., Barrack, K. E., Schwartzman, J. D., Royce, D. B., Cramer, R. A., Madan, J. C., Ross, B. D., Bliska, J., & O'Toole, G. A. (2024). Intestinal Bacteroides modulates inflammation, systemic cytokines, and microbial ecology via propionate in a mouse model of cystic fibrosis. mBio, 15(2), e0314423. https://doi.org/10.1128/mbio.03144-23

DARTMOUTH
Technology Transfer

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2024-046

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US PATENT APPLICATION 63/688,132

A New Class of Stable and Earth-Abundant Thin Film PV Materials

PRINCIPAL INVESTIGATOR: Dr. Geoffroy Hautier, Hodgson Family Professor of Engineering

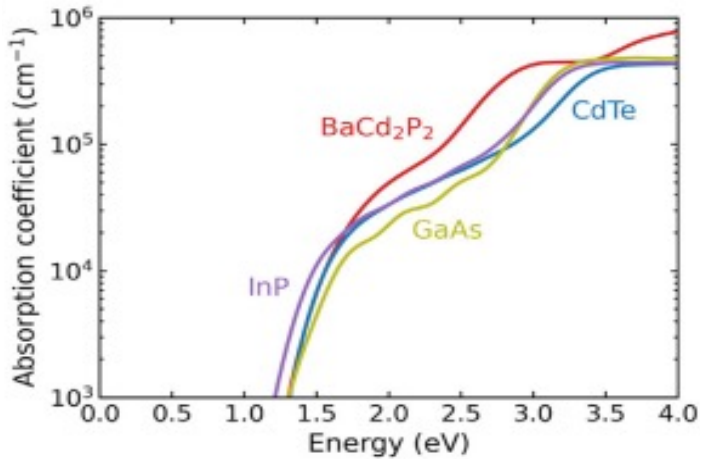
VIEW PUBLICATION

INVENTION OVERVIEW

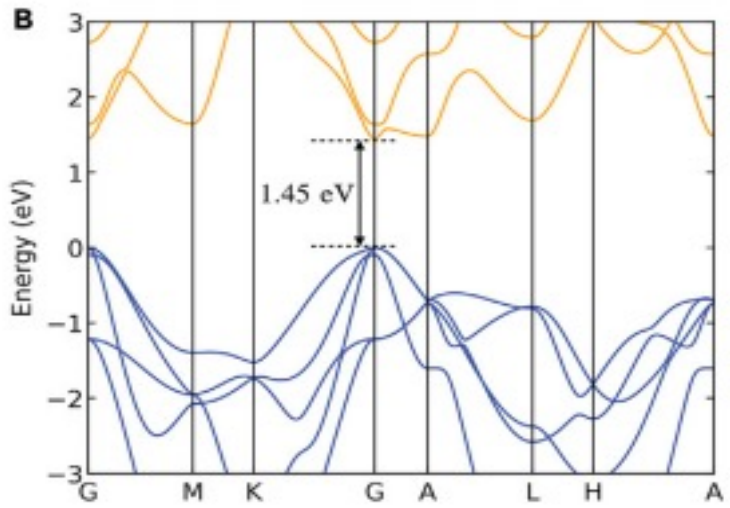
- The technology provides **a new class of materials, Zintl phosphides**, for thin-film solar applications; AM_2X_2 family where A & M are +2 ions and X is a pnictogen.
- A synthesized and tested example, **$BaCd_2P_2$**, exhibits an optimal band gap, favorable charge carrier properties, and high stability.
- Zintl phosphides offer **tunable electronic and optical properties**, earth-abundant compositions, and environmental stability providing new avenues for developing high-performance, stable, and cost-effective thin-film photovoltaic devices.
- Novel **computational screening process** predicts materials properties to support a highly-focused, efficient development effort.

FEATURES AND BENEFITS

- **Earth-Abundant and Low-Toxicity Elements:** Ba, Cd, P; potential for cadmium-free alternatives like $CaZn_2P_2$.
- **Experimental Verification:** Successful synthesis and empirical confirmation of $BaCd_2P_2$ properties including strong photoluminescence, long carrier lifetimes of up to 30 ns, and exceptional stability in air and water.
- **High-Efficiency Potential:** Optimal band gap ~1.45 eV; favorable carrier mobilities with effective masses for electrons: 0.11–0.74 m_0, holes: 0.44–0.63 m_0.
- **Environmental Stability:** Stable in air and water; thermal stability up to 425°C; resistant to acids and bases.
- **Defect Tolerance:** Low concentrations of deep-level defects; long carrier lifetimes up to 30 ns.
- **Versatility and Band Gap Tunability:** Band gap tuning through elemental substitution within AM_2X_2 family.



Improved optical absorption of $BaCd_2P_2$



Optimal Electronic band structure

DARTMOUTH
Technology Transfer

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2024-049

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US PATENT 18/776,887

A Dynamic Framework for Managing an Integrated Energy System Under Uncertainty

PRINCIPAL INVESTIGATOR: Dr. James E. Smith, Professor in Decision Science

VIEW PUBLICATION

INVENTION OVERVIEW

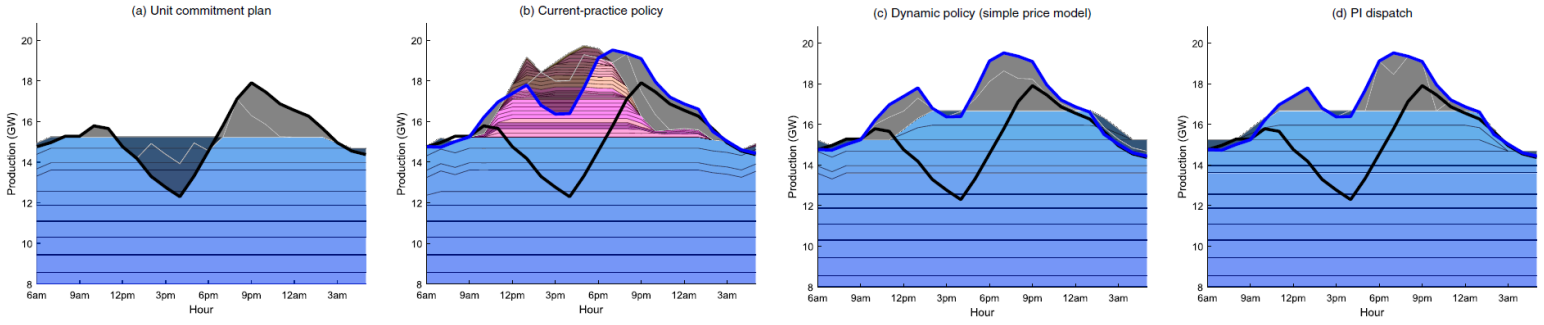
- This invention provides a **dynamic framework for managing an integrated energy system** using a novel approach based on weakly coupled stochastic dynamic programming.
- Current practices in energy management involve solving "unit commitment" and"economic dispatch" optimization problems, which, while complex, do not explicitly **incorporate uncertainty**.
- The increasing use of renewable energy sources has exacerbated issues related to variability and uncertainty in power systems, creating a need for better management techniques.

FEATURES AND OPERATING PRINCIPLES

- The model decomposes an integrated energy system across its various units, then uses a price model to describe the marginal value of energy production, allowing each unit to maximize its expected profit given uncertain prices.
- The system operator can start up or shut down slow-start units and deploy storage as desired, and the ramping constraints are fully respected in this dynamic approach. The unit-specific value functions from the dynamic program are used to incorporate longer-term effects in dispatch decisions.

ADVANTAGES

- **Addresses uncertainty:** This dynamic programming method incorporates uncertainty in energy demand and renewable supply, enabling more efficient energy system operation.
- **Improved efficiency:** The dynamic approach can reduce operational costs by ~2% on average in the present Duke Energy Carolinas system and can reduce costs by 4–5% on average in a future system with increased solar and storage capacity.
- **Near-optimal performance:** The dynamic approach performs, on average, within 0.2–0.3% of production plans based on perfect foresight about future net demands.
- **Scalability:** This method is computationally feasible at an industrial scale and can solve the Lagrangian dual problems on a desktop computer in seconds to minutes.



Unit commitment plan to meet deterministic demand forecast (shown with black line).

Given this plan, system response to higher than expected demand (shown with blue line); the unexpected peak is covered using peaking units. Costs are 12.4% more than with perfect information (PI).

Dynamic plan adjusts forecasts mid-morning and starts slow-start units and uses storage to cover unexpected peak. Costs are 0.3% more than PI.

With perfect information about demand. It is optimal to start slow-start units earlier and use less storage in the morning.

Key:

Blue = production from slow-start units
Pink = production from fast-start units (peakers)
Gray= into storage (dark gray) or from storage (light gray)

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2025-021

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US PATENT APPLICATION 63/777,912

Lymph Node (LN) Resident Memory (Trm) Cells for the Treatment of Cancer

PRINCIPAL INVESTIGATOR: Mary Jo Turk, Professor of Microbiology and Immunology

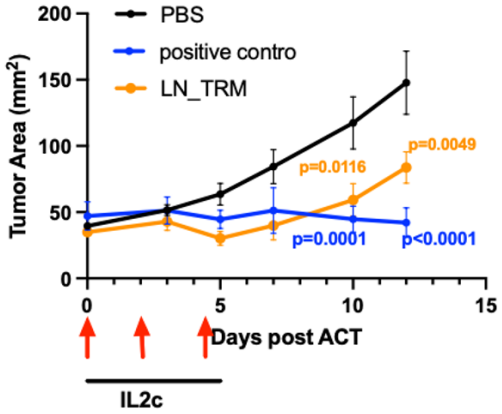
VIEW PUBLICATION

DESCRIPTION

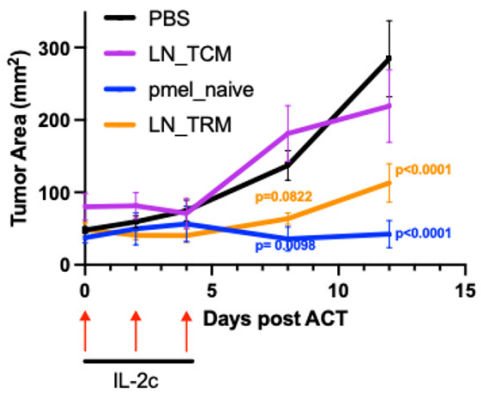
- CD8+ tissue-resident memory (Trm) cells are essential to the immune responses against cancer and can be identified by surface expression of specific proteins.
- The Turk lab determined that a Trm population resides in tumor draining lymph nodes (TDLNs) and often has specificity for tumor-expressed antigens.
- This innovative approach sorts LN Trm cells using cell-surface markers to selectively capture and expand this functional, tumor antigen-specific population of cells for immunotherapy.

ADVANTAGES AND BENEFITS

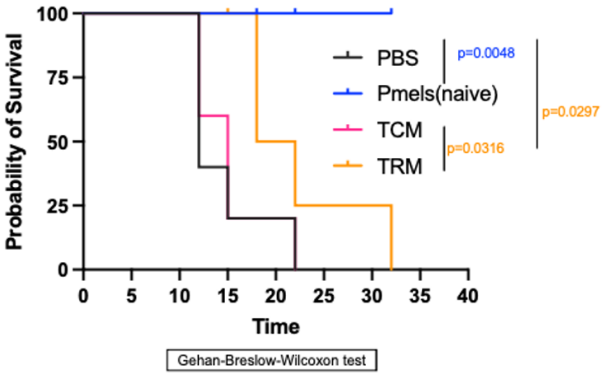
- The field has utilized TDLN-derived CD8 T cells for adoptive immunotherapy, but this method is limited due to lack of tumor antigen specificity.
- This method allows for the selection of cells that harbor tumor antigen specificity to overcome this challenge.
- Preliminary data shows that these cells can be cultured ex vivo and transferred into mice (B16F10-KVP model) to restrain growth of established melanoma tumors.



LN Trm cells mediate significant tumor growth inhibition in mice bearings established B16 melanomas. Mice were transferred with no cells, 20,000 LN Trm cells, or 1.5x10⁶ pmel cells (positive control) and treated. Error bars depict SEM of n=7 mice per group for PBS and positive control and n=4 for LN_TRM group. Statistical significance was calculated by 2-way ANOVA.



Second study demonstrating significant tumor growth inhibition with 20,000 LN Trm cells. B16F10-KVP tumor bearing mice were treated with PBS, LN TRM, TCM or naïve pmels . LN TRM demonstrate significant tumor growth inhibition and improved survival in mice bearing B16F10 KVP tumors. Error bars depict SEM of N=5 mice per group. Statistical significance was calculated by 2-way ANOVA.



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