SBS

SODIUM BATTERY SYMPOSIUM 5

BERLIN 2024

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Dear Participants,

We are pleased to welcome you to the Sodium Battery Symposium (SBS), which takes place from September 23rd to 25th in Berlin Adlershof, Germany's largest science and technology park.

As we gather for the fifth edition of the Sodium Battery Symposium, we are proud to have 32 invited talks and 90 posters presenting the latest advances in both applied and fundamental aspects of the use of abundant and resource-friendly sodium in rechargeable batteries. In total, more than 270 participants are attending this year's event. The conference aims to bring together the research communities working on Na-ion, solid-state and high-temperature batteries, this way providing a unique opportunity to explore the synergies between these technologies.

The main topics to be covered are

- Electrodes and liquid electrolytes for Na-ion batteries
- Materials development for Na solid-state batteries
- Medium and high temperature Na batteries
- Towards commercialization

Currently, the SBS meeting is held annually, alternating between Berlin and Dresden, with a focus on Na-ion (Berlin) and high temperature/ceramic batteries (Dresden). The first SBS meeting took place in 2018 with approximately 40 participants. While the first meeting was largely academic, this time about a quarter of the talks are from companies, underlining the growing reality and potential of sodium batteries in the market.

We also welcome the companies with exhibition stands and thank our sponsors for making this event a pleasant place for fruitful discussions and networking.
Together, let's discuss the future of sodium battery technology and its transformative impact on energy storage! Thank you all for attending this symposium!

If you have any questions or need assistance during the event, please visit the registration desk or contact us directly.

Best regards,

Philipp Adelhelm and Gustav Graeber

Conference Chairs

Conference organization

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Prof. Dr. Philipp Adelhelm, HU Berlin, HZB

Dr. Gustav Graeber, HU Berlin

Local organizing committee

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https://www.helmholtz-berlin.de/events/international-sodium-battery-symposium/index_en.html

Poster session information

The poster session takes place at the Einstein/Newton Kabinett, Volmerstr. 2, in the same building as the presentations, on Monday between 16:30 and 18:30. Please mount your poster before the start of the poster session and be present at your poster during the session to answer questions of your colleagues. You can leave your poster for the duration of the conference but are requested to remove it latest by Wednesday 16:00. Posters that are not picked up will be sent to paper recycling. Abstracts and posters are ordered by topic. A list with your poster number will be available in the Einstein/Newton Kabinett.

Conference dinner information

The conference dinner takes place on Monday at 18:30 in the same building as the presentations, Volmerstr. 2, 12489 Berlin.

Route indications from/to BER Airport

By public transport:

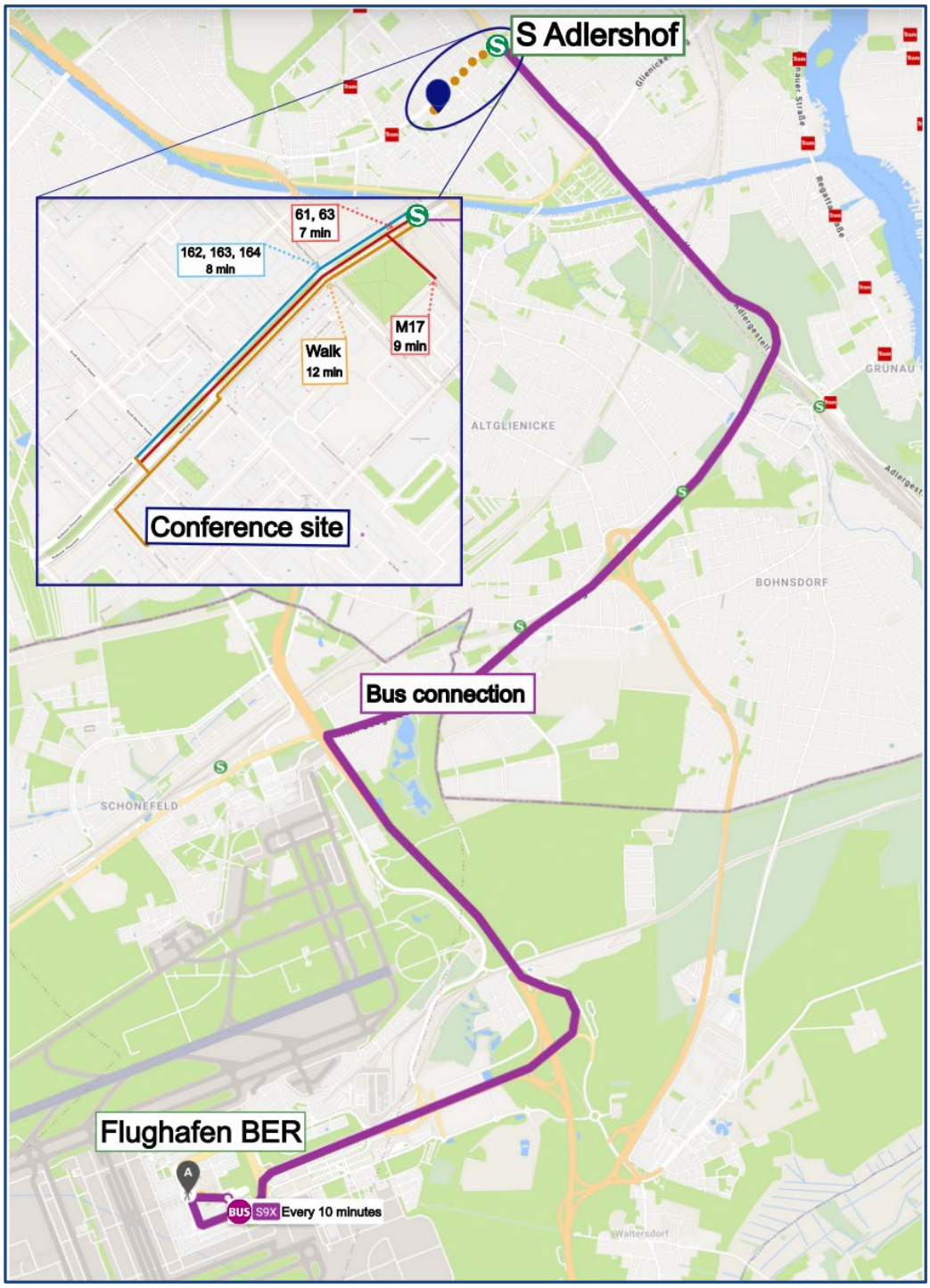
Due to temporary construction, there is currently no S-Bahn connection between BER Airport and the conference site.

Please use the replacement bus **S9X** (direct connection between BER Airport <> S Adlershof every 10 minutes).

Between S Adlershof and the conference site (Volmerstraße 2) walk for 800m or take Tram 63, 61, M17 or Bus 162, 163, 164.

Please check the timetable information before travelling.

Approximate travelling time: **35 minutes**



By Taxi/Uber services:

Taxis are available at the airport (here the relevant informations).

Uber services are also available

Approximate travelling time: **15 minutes**

Technical program

08:00 **Registration, Welcome Coffee**

Session chair: Philipp Adelhelm

09:00 **Welcome by Philipp Adelhelm**

09:15 ***Na-ion battery development at HiNa Battery (ONLINE TALK)***
Yongsheng Hu
Founder HiNa Battery, Institute of Physics, Chinese Academy of Sciences, China

09:45 ***Advancements in Na-ion Battery Electrode Materials: Understanding structure-property correlations and reaction mechanisms***
Montserrat Galceran
CIC Energigune, Spain

10:15 ***Development of sustainable electrolytes for sodium-ion batteries and sodium-ion capacitors***
Andrea Balducci
Friedrich-Schiller-University Jena, Germany

10:45 **Coffee break**

Session chair: Montserrat Galceran

11:15 ***Na ion battery anodes: from fundamentals to scale***
Magda Titirici
Imperial College London, UK

11:45 ***Reaching $V_2(PO_4)_3$ by Sodium Extraction from Single-Phase $Na_xV_2(PO_4)_3$ ($1 < x < 3$) Positive Electrode Materials***
Laurence Croguennec
CNRS, University of Bordeaux, France

12:15 ***Chemical Tuning of NASICON Frameworks for Sodium-ion Batteries***
Premkumar Senguttuvan
Jawaharlal Nehru Center for Advanced Scientific Research, Bengaluru, India

12:45 **Lunch break**

Session chair: Magda Titirici

14:15 ***Potassium Prussian blue analogues as the cathode materials with an increased voltage for sodium-ion batteries***
Yang Xu
University College London, UK

14:45 ***Insights on ion transport and growth of high-energy Na battery interphases***
Jelena Popovich-Neuber
University of Stavanger, Norway

15:15 ***Scrutiny of Electrode/Electrolyte Interfaces Through Integrated In situ Sensing Approaches: Insights for Na-ion Batteries***
Özlem Sel
College de France Paris, France

15:45 ***Exploring an alternative "upside down" cell configuration for sodium-ion capacitors***
Eider Goikolea
University of the Basque Country, Spain

16:30 **Poster Session and Coffee**

18:30 **Dinner**

08:30 **Welcome Coffee**

Session chair: Corsin Battaglia

09:00 ***Single-Ion Conducting Polymer Electrolytes for Sodium Batteries***
Dominic Bresser
Helmholtz-Institut Ulm, Germany

09:30 ***Exploring the potential of solvent co-intercalation in different electrode materials for sodium ion batteries***
Guillermo Alvarez-Ferrero
Humboldt-Universität zu Berlin, Germany

10:00: ***All-solid-state Na-ion batteries based on complex hydride/oxide nanocomposite solid electrolytes***
Peter Ngene
Utrecht University, The Netherlands

10:30 **Coffee Break**

Session chair: Katherine Mazzio

11:00 ***The technology evolution of sodium-ion batteries: past, present & future***
Ruth Sayers
Faradion Ltd., UK

11:30 ***P2-$Na_xMn_{1-y}Ni_yO_2$ cathode materials with controlled particle architecture and their aging phenomena***
Peter Axmann
Zentrum für Solar- und Wasserstoffforschung ZSW, Germany

12:00 ***Sodium-Ion Battery Research and Testing at BAM***
Tim Fellinger
Bundesanstalt für Materialforschung und -prüfung (BAM), Germany

12:30 **Group picture of participants and lunch break**

Session chair: Dominic Bresser

14:00 ***Insight into rapid Na insertion through diluted electrode method and low-cost routes for synthesis of hard carbon for Na-ion batteries***
Shinichi Komaba
Tokyo University of Sciences, Japan

14:30 ***Understanding Ageing in Sodium-ion Batteries***
Reza Younesi
Uppsala University, Sweden

15:00 ***Na-ion battery development @ TIAMAT***
John Abou-Rjeily
Tiamat Energy, France

15:30 **Coffee Break**

Session chair: Shinichi Komaba

16:15 ***Challenges and opportunities of sodium-ion giga-scale production***
Andreas Haas
Northvolt, Sweden

16:45 ***Benefits and Challenges of SIB from an Automotive OEM Perspective***
Julian Wagenschütz
Center of Excellence Battery of Volkswagen AG, Germany

17:15 ***Overview on sodium-ion battery materials from an industrial standpoint***
Tom Bötticher
Litona GmbH, Germany

08:30 **Welcome Coffee**

Session chair: Sonia Dsoke

09:00 ***Sodium Solid State Batteries and their Materials Challenges***
Jürgen Janek
Justus-Liebig-University Giessen, Germany

09:30 ***Revealing the Reaction Mechanism and Chemo-Mechanics of Solid-State Na-S Batteries***
Daniel Rettenwander
Norwegian University of Science and Technology, Norway

10:00 ***Exploring the possibilities of NaSICON solid electrolytes for new generation of low-temperature batteries***
Dina Fattakhova-Rohlfing
Forschungszentrum Jülich, Germany

10:30 **Coffee Break**

Session chair: Gustav Graeber

11:00 ***Correlating cathode microstructure, performance, and cycle life of sodium-zinc chloride (Na-$ZnCl_2$) battery cells***
Meike Heinz
Empa, Switzerland

11:30 ***An old ZEBRA in a New Guise: From Materials Science to Commercial Na-$NiCl_2$ Battery***
Matthias Schulz
IKTS, Germany

12:00 ***High-Energy, Long-Duration Sodium-Sulfur (NAS®) Battery for Stationary Energy Storage***
Florian Dötz
BASF Stationary Energy Storage GmbH, Germany

12:30 **Lunch Break**

Session chair: Matthias Schulz

14:00 ***Advanced Intermediate Temperature Molten Sodium Battery Technologies***
Guosheng Li
Pacific Northwest National Laboratory PNNL, USA

14:30 ***Towards sustainable, grid connected Sodium-Ion stationary storage systems***
Magdalena Graczyk-Zajac
EnBW Energie Baden-Württemberg AG, Germany

15:00 ***Altris Sodium-ion Cell Design, Pure & Powerful***
Ronnie Mogensen
Altris, Sweden

15:30 **Poster Award and Concluding Remarks**

Abstracts of invited talks

Na-ion battery development at HiNa Battery (ONLINE TALK)

Yongsheng Hu

Founder HiNa Battery, Institute of Physics, Chinese Academy of Sciences, China

Advancements in Na-ion Battery Electrode Materials: Understanding structure-property correlations and reaction mechanisms

*Montse Galceran**

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The growing demand for advanced energy storage systems to address future challenges has intensified the search for alternative battery technologies. Sodium-ion batteries have garnered significant attention due to their cost-effectiveness, abundant sodium resources, and potential for wide-ranging applications. This presentation will highlight recent advancements in Na-ion battery electrode materials, focusing on both cathodes and anodes. Key topics include: (1) the influence of synthesis and drying conditions on the electrochemical performance of electrode materials, (2) a detailed analysis of reaction mechanisms during cycling, and (3) the potential of thermally evaporated thin Na films for the development of metal anodes. The emphasis will be on the crucial role that crystal structure plays in determining the electrochemical behavior of these materials.
By deepening our understanding of the structure-property correlations and reaction mechanisms, this research paves the way for the design of next-generation Na-ion batteries with improved energy density, enhanced long-term stability, and greater sustainability. This presentation will offer a comprehensive overview of cutting-edge research in Na-ion battery materials and explore the challenges and opportunities shaping the future of this rapidly evolving field.

Short Bio

Montse Galceran Mestres is a senior researcher at CIC energiGUNE. Since 2013, her research has focused on understanding and developing new, low-cost, and sustainable electrode materials for the next generation of intercalation systems for energy storage. Currently, her main interests are in cathode materials (polyanionic, Prussian blue analogues and layered oxides) and metal anodes. Seeking to understand material properties through multi-technique approaches, she combines material development and direct recycling with a wide range of operando/in-situ characterisations techniques in order to achieve application-targeted tailored optimization.

Development of sustainable electrolytes for sodium-ion batteries and sodium-ion capacitors

*Andrea Hainthaler, Akshaya Sidharthan, Yiyue Lu, Muhammad Nouman Aslam, Christian Leibing, Andrea Balducci**

Friedrich-Schiller University Jena, Friedrich-Schiller-University Jena, Institute for Technical Chemistry and Environmental Chemistry, Germany

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The development of electrolytes displaying good transport properties, high thermal stability, low flammability and high safety is of crucial importance for the realization of sodium-ion batteries (NIBs) and sodium-ion capacitors (NICs) [1]. In this work we report about a series of novel electrolytes for sodium-based system, which have been developed with the aim to match above mentioned characteristics, together with a high sustainability and a low price.

In the case of NIC we consider the use of the solvent Tetraethoxyglyoxal (TEG), which is commercially available, display low toxicity, high thermal stability. We present the use of the electrolytes 1 M NaTFSI in TEG:PC (3:7) in NIC and we show that utilizing these innovative electrolytes, it is possible to realized devices display high performance and good cycling stability [2].

In the case NIB, we consider the use of electrolytes containing imide and borate based salts in combination with PC and γ-valelolactone (GVL) [3]. This latter solvent is bio-derived, and is already produced in large scale. We showed that these innovative electrolytes allow the realization of devices display high performance and high cycling stability.

References:

1. C. Vaalma, D. Buchholz,M. Weil, S. Passerini, *Nat Rev Mater*. **2018,** 3, 18013.
2. C. Leibing, et al. ChemSusChem, **2023**, e202300161
3. K. S. Teoh et al, ChemSusChem, **2022**, *e202201845*

Short Bio

Andrea Balducci is Professor of Electrochemistry at the Friedrich-Schiller University in Jena, Germany. He has been working on innovative electrolytes for sodium-ion batteries and sodium-ion capacitors for several years and his group is currently involved in several German and European projects dedicated to these devices. His research activities focus on the development of innovative electrolytes containing sustainable and bio-derived solvents, and salts with low fluorine content. Furthermore, he is working on the development of in-situ and in-operando techniques suitable for investigation of the degradation processes taking place in these electrolytes.

Na ion battery anodes: from fundamentals to scale

*Heather Au, Zhenyu Guo, Mengnan Wang, Emma Antonio, Magda Titirici**

Department of Chemical Engineering, Imperial College London, South Kensington Campus, SW7 2AZ, London

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In this talk I will present our development of hard carbon and potentially Sn/C anodes for Na ion batteries providing details on our research journey from understanding the fundamentals in half coin cells to full coins and multilayer pouch cells. I will discuss Na storage mechanism, solid electrolyte interface depending on binder and/or electrolyte degradation of NVP cathodes paired with hard carbons in pouch as well as discuss how to achieve an optimized performance at pouch cell level.

Short Bio

Magda Titirici is a Chair in Sustainable Energy Materials at Imperial College London in the Department of Chemical Engineering. Her research is about implementing more sustainable materials choices in emerging energy technologies including batteries beyond Li, fuel cell catalysts for Oxygen Reduction Reaction as well as H_2 production from alternative sources such as biomass. She has published extensively in this field her work being cited over 43.000 times. She is also an Associate Editor with Green Chemistry and holds a 10-years prestigious fellowship from Royal Academy of Engineering called Chair in Emerging Technologies. Her research was recognized by numerous awards from the Royal Society of Chemistry, Royal Society and the Institute of Materials and Mines. She also holds an honorary PhD from Stockholm University where she is currently a WISE guest professor.

Reaching $V_2(PO_4)_3$ by Sodium Extraction from SinglePhase $Na_xV_2(PO_4)_3$ (1 < x < 3) Positive Electrode Materials

Sunkyu Park[1,2,3], Kriti Choudhary[2], Ziliang Wang[4], Jean-Noël Chotard[2], Dany Carlier[1], François Fauth[5], Pieremanuele Canepa[6], Christian Masquelier[2] and Laurence Croguennec[1,]*

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[2] Laboratoire de Réactivité et de Chimie des Solides, Université de Picardie Jules Verne, CNRS-UMR 7314, 15 rue Baudelocque, F-80039 Amiens Cedex 1, France
[3] TIAMAT, 15 Rue Baudelocque, 80000 Amiens, France
[4] Department of Materials Science and Engineering, Northwestern University, Evanston, Illinois, 60208, USA
[5] CELLS-ALBA Synchrotron, Cerdanyola del Vallès, E-08290 Barcelona, Spain
[6] Department of Electrical and Computer Engineering, Houston, Texas, 77204, USA

** laurence.croguennec@icmcb.cnrs.fr*

This study presents a new class of NASICON-related materials. A whole series of new single-phase $Na_xV_2(PO_4)_3$ compositions (x = 1.5, 1.75, 2, 2.25, and 2.5) were discovered using an innovative and straightforward synthesis route. Typically, $Na_2V_2(PO_4)_3$ obtained by annealing an equimolar mixture of $Na_3V_2(PO_4)_3$ and $NaV_2(PO_4)_3$ exhibits a new sodium ion distribution with partial occupation of the Na(1) and Na(2) sites, whereas the Na(1) site is fully occupied in "conventional" NASICON structure. The electrochemical voltage-composition profile of $Na_2V_2(PO_4)_3$ is entirely new: a sloping continuous variation of the voltage when Na^+ is extracted, with two domains at 3.46 V (V^{3+}/V^{4+} couple) and 4.16 V (V^{4+}/V^{5+} couple) vs. Na^+/Na, leading to a reversible capacity of 104.5 mAh/g, with small polarization and great capacity retention. This new $Na_2V_2(PO_4)_3$ phase allows a reduction of the weight penalty typical of "conventional" $Na_3V_2(PO_4)_3$, by eliminating the one "useless" Na^+ ion that remains in the material during battery operation. The significant increase of the average operating voltage due to changes in the extraction/insertion mechanism leads to an increase in energy density of ~10%. Importantly, a new NASICON composition, $V_2(PO_4)_3$, was obtained for the first time, after chemical deintercalation from $Na_2V_2(PO_4)_3$. These experimental results will be discussed with the support of theoretical first-principles calculations.

Short Bio

Laurence Croguennec is CNRS Research Director and Deputy Director at the Institute of the Condensed Matter Chemistry (ICMCB) at the Bordeaux University in France. She has been working for more than 25 years on crystal chemistry of electrode materials developed for Metal-ion batteries (since 2008 for Na-ion batteries), and more recently for all-solid-state batteries, and on the characterization of mechanisms involved upon their cycling, especially for layered and spinel oxides and polyanionic-type positive electrode materials. She is co-editor of the book "Na-ion batteries" (John Wiley & Sons, 2021, Monconduit/Croguennec).

Chemical Tuning of NASICON Frameworks for Sodium-ion Batteries

*Premkumar Senguttuvan**

New Chemistry Unit, International Center for Materials Science and School of Advanced Materials, Jawaharlal Nehru Center for Advanced Scientific Research, Bengaluru, India.

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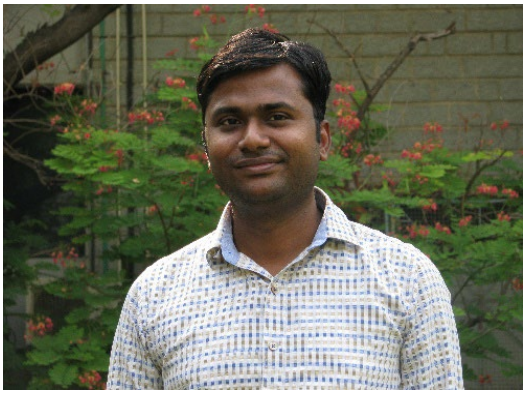
Sodium-ion batteries are emerging as the frontrunner technology for grid storage application due to the low-cost and Earth abundant raw materials. The exploration of Na-ion electrodes and electrolytes has been accelerated based on the design knowledge gained from analogous Li-ion chemistry. Layered transition metal oxides offer higher storage capacity at moderate operational voltages, but they suffer from air/moisture instabilities and limited cycle life due to complex phase transitions during sodium (de)intercalation. On the contrary, phosphate cathodes offer attractive insertion voltages, higher structural and thermal stability. NASICON-$Na_3V_2(PO_4)_3$ cathode exhibits higher insertion voltage (3.4 V vs. Na) and good electrochemical performances through particle nano-sizing and carbon-coating. Alternatively, chemical tunning of NVP cathode modulates insertion voltages, phase transitions, Na-ion insertion kinetics and cycle life. In this talk, we will discuss how the chemical substitutions impact the structural and electrochemical properties of NASICON cathodes and anodes.

References

1. P. Senguttuvan et al., Chem. Mater. 2024, 36, 7, 3107–3119.
2. P. Senguttuvan et al, Adv. Energy Mater. 2024, 14, 2304091.

Short Bio

Premkumar Senguttuvan is an Associate Professor at New Chemistry Unit, JNCASR, Bangalore, India. His research focuses on the exploration of electrode and electrolyte materials for next generation batteries. He utilizes a wide range of (local) structural, spectroscopic, electrochemical and operando tools to understand the structure-property correlation of battery materials. He is the recipient of DST-Early Career Research Award, DAE-Young Scientist Research Award, JMCA - Emerging Investigators 2023, JACS Au - Early Career Advisory Board (ECAB).



Potassium Prussian blue analogues as the cathode materials with an increased voltage for sodium-ion batteries

Yang Xu[*,1], *Runzhe Wei*,[1] *Xingwu Zhai*,[2] *Gopinathan Sankar*,[1] *Min Zhou*[2]

[1]*Department of Chemistry, University College London, London WC1H 0AJ, UK*
[2]*Hefei National Laboratory for Physical Sciences at the Microscale, School of Chemistry and Materials Science, University of Science and Technology of China, Hefei, Anhui 230026, China*

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Conventional sodium-ion battery (SIB) cathodes are pre-sodiated and store Na-ions electrochemically. Interestingly, pre-potassiated materials can be appealing cathodes for SIBs too. Potassium Prussian blue analogue (K-PBA) is an excellent example. We show that in a hybrid SIB cell, where Na^+ is in the electrolyte and K^+ is in the K-PBA cathode, the electrochemical mechanism of cation intercalation in K-PBA is dominated by K-ion instead of Na-ion, which results in incresed intercalation voltages, and the mechanism can be significantly affected by $[Fe(CN)_6]^{4-}$ anion vacancy. K-PBA with a higher anion vacancy content exhibits two cation intercalation steps, and both are dominated by K-ion, displaying a ~0.2 V increase in the intercalation voltage compared to commonly used Na-PBA in a SIB cell. In contrast, K-PBA with a lower anion vacancy content exhibits cpacity contribution of Na-ion intercalation at a lower voltage (<2.8 V). Electrode characterizations and theoretical calculations suggest that the different mechanisms are caused by the K-ion kinetics that is affected by $[Fe(CN)_6]^{4-}$ anion vacancies. A higher vacancy content enhances K-ion diffusion in the PBA framework, which facilitates K-ion intercalation and suppresses Na-ion intercalation.

References

1. R. Wei, X. Zhai, H. R. Tinker, P. He, C. A. F. Nason, Y. Han, V. Celorrio, G. Sankar, M. Zhou,* Y. Xu,* Adv. Funct. Mater., 2023, 2308227.
2. C. A. F. Nason, Y. Xu,* eScience, 2024, 100183.

Short Bio

Dr Yang Xu is an Associate Professor in Energy Storage in the Department of Chemistry at University College London (UCL), UK. His research focuses on next-generation battery materials and chemistries, with special interest in cation intercalation mechanism, metal batteries, and anionic redox activity. He has received research fundings from various funders including the Engineering and Physical Sciences Research Council (EPSRC), the Faraday Institution, the Royal Society, the Science and Technology Facilities Council (STFC), the Leverhulme Trust, and UCL. He is the recipient of MINE Outstanding Young Scientist Award (2019), EPSRC New Investigator Award (2020), and STFC Early Career Award (2023). He is a member of the editorial board of the Journal of Physics: Materials (IOP) and the advisory boards of the Journal of Materials Chemistry A and Materials Advances (RSC).

Insights on ion transport and growth of high-energy Na battery interphases

*Jelena Popovic-Neuber**

University of Stavanger, Department of Energy and Petroleum Engineering, Stavanger, Norway

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Continuous solid electrolyte interphase (SEI) and dendrite growth, as well as formation of ion blocking interfaces are some of the crucial issues preventing the commercialization of high energy density batteries depending on the implementation of alkali and alkaline earth metal anodes.[1,2] Electrochemical impedance spectroscopy is a powerful tool to study processes in full battery cells, but also ion transport in naturally formed and artificial SEIs, and its evolution in time from symmetric cells. The technique can be successfully used in batteries containing liquid, solid-state or hybrid electrolytes. In this talk, an overview on the recent studies on ion transport and evolution of SEIs on Na metal will be given.[3-5] In natural SEIs formed in contact with liquid carbonate and glyme-based electrolytes at open circuit voltage, main findings include high porosity and predominant liquid transport pathways. Artificial sulfide and Al_2O_3-based SEIs on Na metal are porous and reactive in contact with liquid and thiosulphate solid-state electrolytes.[6,7]

References

1. Popovic, J., The importance of electrode interfaces and interphases for rechargeable metal batteries, *Nat. Comm.*, 12, 6240 (2021);
2. Popovic, J., Recent Advances in Understanding Potassium Metal Anodes, *J. Electrochem. Soc.*, 3, 169 030510 (2022);
3. Nojabaee et.al., Solid Electrolyte Interphase Evolution on Lithium Metal in Contact with Glyme-Based Electrolytes, *Small*, 16, 23, 2000756 (2020);
4. Lim et. al., Porosity of Solid Electrolyte Interphases on Alkali Metal Electrodes with Liquid Electrolytes, *ACS App. Mat. & Inter.*, 13 (43), 51767 (2021);
5. Lim et. al., Ion Transport and Growth Behavior of Solid Electrolyte Interphases on Li and Na with Liquid Electrolytes Based on Impedance Analysis, *ACS App. Mat. & Inter.*, 11, 5725 (2023);
6. Lim et. al., Influence of Porosity of Sulfide-Based Artificial Solid Electrolyte Interphases on Their Performance with Liquid and Solid Electrolytes in Li and Na Metal Batteries, *ACS App. Mat. & Inter.*, 14, 14, 16147 (2022);
7. Lim et. al., Chemical stability and functionality of Al2O3 artificial solid electrolyte interphases on alkali metals under open circuit voltage conditions, *App. Phys. Lett.* 122, 093902 (2023).

Short Bio

Jelena Popovic-Neuber is Associate Professor of Battery Technology at University of Stavanger, Norway, and has been working on battery materials since 2011. Currently, her main interest are alkali metals, electrolytes (liquids, polymers and sulfide-based solids) and related solid electrolyte interphase, and electrochemical tools such as in situ electrochemical impedance spectroscopy (EIS) and galvanostatic/potentiostatic polarization.

Scrutiny of Electrode/Electrolyte Interfaces Through Integrated In situ Sensing Approaches: Insights for Na-ion Batteries

Ozlem Sel[a,b]*, Ezzoubair Bendadesse*[a,b], Zhenying Li*[a,b], Jean-Marie Tarascon*[a,b]

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Mastering interface processes through battery interface probing is crucial for understanding performance, degradation mechanisms, optimizing electrolyte composition, and designing advanced electrodes— a significant challenge yet indispensable for further development.
One approach to addressing this problem is to use sensing technologies that facilitate real-time monitoring. In our group, we aim to describe this complex interface by implementing piezoelectric sensors during the electrochemical cycling of battery electrodes to understand the interaction between battery performance and its dynamic interface. This methodology, built upon traditional Electrochemical Quartz Crystal Microbalance (EQCM) interface analysis, offers vital insights into the composition and structure of the electrical double layer (EDL), specifically allowing access to the identity and distribution profile of charge carriers, as well as the role of solvation.
In this contribution, we will demonstrate how this methodology can help address critical interface issues in Na-ion batteries, focusing on two classes of cathode materials: polyanionic Na-insertion compounds and Prussian blue analogs. It will also be complemented by recent advancements in fiber optic-based sensing methodology, in particular Infrared Fiber Wave Evanescent Spectroscopy, which provides information on the chemical evolution of this interface.

Short Bio

Özlem Sel joined the "Centre national de la recherche scientifique (CNRS)" as a principal investigator in 2011 and is currently working at the "Solid-State Chemistry and Energy Lab (CSE)" at Collège de France, Paris. Over the years, she has developed expertise in energy materials and electrochemistry, as well as operando methods for surface and interface characterization. She is particularly interested in piezoelectric sensor-based techniques, such as EQCM, and its coupling with EIS, having actively pursued this research for over 15 years. In recent years, she has expanded her research to include metal-ion battery interface probing, initially focusing on Li-ion battery research and subsequently broadening this scope to address critical interface issues in Na-ion battery cathode materials.

Exploring an alternative “upside down” cell configuration for sodium-ion capacitors

*Eider Goikolea**

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The mismatch between energy production and consumption together with the growing amount of all types of portable devices demanded by our society mean that new forms of energy storage must be found. One of the challenges is to increase both energy and power, and in this scenario, metal-ion capacitors or hybrid supercapacitor-battery systems have found their niche. Earliest systems were based on lithium ion chemistry, but more recently Na ion capacitors (NICs) have also emerged as an attractive alternative. In conventional NICs the battery-type electrode is the negative one, while the positive electrode is typically an activated carbon. However, this configuration exhibits unstable ionic conductivity and poor Na^+ diffusion at high charging/discharging rates, which requires to the use of sacrificial salts, or additional pre-conditioning steps such as the pre-sodiation of the anode. One way to solve the electrolyte depletion issue is flip-flopping the NIC configuration to enable a “rocking-chair” mechanism. Following this strategy, in this talk we will go through the design of AC// $Na_3V_2O_2(PO_4)_2F$ NICs, which can achieve up to 70 Wh kg^{-1} at *ca.* 20 W kg^{-1}, and we will also briefly summarize previous results that have lead us to this very promising cell design.

Short Bio

Eider Goikolea is Associate Professor of Inorganic Chemistry at the University of the Basque Country UPV/EHU, and she has been working in the field of energy storage systems since 2010. She is currently a senior researcher in the Na-ion battery group leaded by Prof. Teófilo Rojo. Her main research activity is related to the field of metal ion capacitors, both from the cell design perspective as well as the development of electrode materials (layered oxides, polyanionic compounds and carbonaceous materials).

Single-Ion Conducting Polymer Electrolytes for Sodium Batteries

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Sodium-ion batteries have attracted extensive attention recently owing to the announcements of several companies to commercialize this technology in the (very) near future. Just like commercial lithium-ion batteries, though, these batteries are comprising and/or will comprise a liquid electrolyte – with all its advantages and challenges. Thinking one step ahead (as also done by a few companies already), the next step might be the transition to ("zero-excess") sodium-metal batteries, which will require fundamentally new electrolyte solutions, and just like for lithium-metal batteries, these might be based, e.g., on polymers.
Herein, we present our latest results on single-ion conducting polymer electrolytes for sodium-metal batteries. These polymer electrolytes do not only show higher ionic conductivity than its lithium analogues (>2.5 mS cm^{-1} at 40 °C), but moreover the same beneficial properties in terms of high electrochemical stability towards oxidation, highly reversible sodium plating and stripping, and excellent cycling stability of Na||$Na_3V_2(PO_4)_3$ cells for more than 500 cycles. The results thus show that single-ion conducting polymer electrolytes are very promising candidates for high-performance sodium batteries.

Short Bio

Dominic Bresser is currently serving as principal investigator at the Helmholtz Institute Ulm (HIU) and Karlsruhe Institute of Technology (KIT), Germany. His research focuses on the development of advanced lithium and sodium batteries. In addition to his role at KIT-HIU, he is serving as editor-in-chief for the Journal of Power Sources Advances (Elsevier). Amongst others, he has been awarded with the Carus Medal for his scientific achievements by the German National Academy of Sciences Leopoldina, the Carus Award by the city of Schweinfurt, Germany, and an ERC Starting Grant by the European Research Council.

Exploring the potential of solvent co-intercalation in different electrode materials for sodium ion batteries

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Sodium-ion batteries (SIBs) is one of the most promising battery technologies that are starting to see commercialisation where the low cost, abundance of necessary raw materials, higher safety and power, and similar energy densities compared to lithium-ion batteries (LIBs) are often mentioned as their key advantages. One of the key differences, however, is the carbonaceous negative electrode, where in the case SIBs is not possible the use of graphite. This is due to Na^+ not forming stable intercalation compounds with graphite unlike for LIBs. Nevertheless, it was discovered by Jache et al.[1] that Na^+ can form stable ternary graphite intercalation compounds by using ethers as the solvent electrolyte through a solvent co-intercalation mechanism, thus enabling the use of graphite. Although the co-intercalation of solvent molecules with sodium cation leads to a large increase in the graphite framework, the cycle life and rate capability of the reaction are excellent.[2]
This presentation aims to summarize the ongoing research endeavors concerning electrochemical solvent co-intercalation. Our exploration spans from fundamental inquiries regarding the nature of the reactions involved to methodologies for detecting solvent co-intercalation.[3] We also present other electrode materials (in the transition dichalcogenide family) that can be identified as “co-intercalation electrode” when using a specific electrolyte composition (otherwise, conventional intercalation process will occur).[4]

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Short Bio

Guillermo A. Ferrero acquired his PhD from the University of Oviedo in 2017 under the supervision of Prof. Fuertes and Dr. Sevilla where he was dedicated to the development of doped carbon materials for supercapacitors and electrocatalysts for oxygen reduction reaction. Afterwards, he worked at Max Planck Institute for Chemical Energy Conversion with Dr. Heumann and Prof. Schlögl on electrocatalysts for oxygen evolution reaction. In 2020, he joined Prof. Philipp Adelhelm´s group at Humboldt University in Berlin where he is working on the solvent co-intercalation in different battery chemistries. His research interests include the development of carbon materials and the study of different anode materials and electrolytes for Na-ion batteries.

All-solid-state Na-ion batteries based on complex hydride/oxide nanocomposite solid electrolytes

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Sodium-based complex hydrides such as $NaBH_4$, $Na_2B_{12}H_{12}$, and $NaCB_{11}H_{12}$ have recently gained attention as solid electrolytes for all-solid-state Na-ion batteries. This is due to their lightweight, and high electrochemical and interface stability arising from their softness[1-2]. However, they exhibit high ionic conductivity mostly at elevated temperatures, hence achieving high ionic conductivity at ambient or moderate temperatures is vital for their application[2]. In this presentation, I will show how nanocomposite formation with mesoporous oxides (such as Al_2O_3 and SiO_2) can lead to several orders of magnitude increase in the ionic conductivity of these complex hydrides[2-3]. Using results from various advanced characterization techniques, I will discuss the origin of the profound increase in ionic conductivity, highlighting the complex interplay between the properties of the complex hydrides and the metal oxides on the conductivity enhancement [3-4]. Finally, the effects of the oxide's properties on the performance of the nanocomposite solid electrolytes in all-solid-state Na-ion batteries will be discussed.

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Short Bio

Peter Ngene an assistant professor at the Debye Institute for Nanomaterials Science, Utrecht University, the Netherlands. His current research focuses on materials for energy storage and conversion, specifically on the development of novel ionic conductors for next generation Li-, and Na-ion batteries and fuel cells, reversible hydrogen storage (in metal hydrides, and NH_3) and electrochemical conversion of CO_2 and N_2 into fuels and chemicals. He is the recipient of the Netherlands Academy of Arts and Science (KNCV) best PhD thesis award for 2012/2013, the recipient of the Next Einstein Forum Fellowship (NEF fellow) from African Union and the Nigerian LNG Science Prize (2018) for his work on the development of novel energy storage solutions.

The technology evolution of sodium-ion batteries: past, present & future

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As sodium-ion batteries have evolved from an R&D lab concept over 10 years ago to now readily available from online retailers, we look at what the key steps to bring it to its present status have been and discuss what the next evolution for the technology might look like.
We will discuss how different sodium-ion chemistries fit into the existing battery ecosphere, and how developments in other technology areas might influence sodium-ion development. We will review the applications that are currently optimal for the technology and what opportunities there are for future applications, and how technology development fits into these.
As we look back on the work that has been undertaken globally, we also look to how innovative R&D is an integral part of the technology's continuing evolution for the future.

Short Bio

Ruth Sayers is Director of Technology at Faradion Ltd, where she leads a team of over 30 researchers, scientists and engineers working on sodium-ion battery technology. Ruth joined Faradion in 2012, as a research scientist, having gained her PhD in cathodes for solid-oxide fuel cells from Imperial College London. Ruth's career has focused on development of technologies for energy storage applications and their productization and commercialization.

P2-$Na_xMn_{1-y}Ni_yO_2$ cathode materials with controlled particle architecture and their aging phenomena

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Among various known cathode active materials for SIB, the family of layered sodium transition metal oxides (Na_xMO_2, 1>x>0) offers promising electrochemical performance. They show a wide structural variety (O3, P3, P2) with a tendency for Na^+/vacancy ordering. We developed low-cost spherical polycrystalline cobalt-free layered $Na_xMn_yNi_{1-y}O_2$ cathode active materials for application in SIBs. The applied synthesis route adapts industrially established processes for NCM production, enables to tune powder properties to technical specifications and is scalable. We will present a synthesis phase diagram for $Na_xMn_yNi_{1-y}O_2$ with *y* = 3/4 over a broad range of sodium *x* for different calcination temperatures. For phase-pure P2-$Na_xMn_{3/4}Ni_{1/4}O_2$, we will show the influence of the calcination process on the structure and discuss the electrochemical properties in half-cells in-depth. For optimized materials, attractive initial specific discharge capacities beyond 220 mAh g^{-1} can be obtained in sodium half-cells between 1.5 – 4.3 V, however with limited cycling stability. Depending on the applied voltage window, capacity and stability vary. In order to get a deeper understanding of the ageing relevant phenomena, we applied HRTEM, EDX, SEM and operando XRD on the materials. As a model cathode material we used micron-sized single crystalline P2-$Na_xMn_{3/4}Ni_{1/4}O_2$. The findings give a clear view on ageing relevant effects and will be discussed in depth. ACKNOWLEDMENTS: This work was supported by the German Federal Ministry of Education and Research (BMBF) in the projects TRANSITION (03XP0186C), Transition-Transfer (03XP0533A) and ENTISE (03XP0579D)

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Short Bio

Peter Axmann has more than 25 years of experience in the development of active materials and their application in electrochemical energy storage systems, with focus on particle design for application, understanding structure-activity relationships, scaling and ageing of materials. At the Center for Solar Energy and Hydrogen Research Baden-Württemberg ZSW in Ulm, he is leading the Accumulators Materials Research ECM department, covering the entire battery value chain from material synthesis, scaling-up, electrode and cell development to the manufacture of pouch cells and round cells in formats from 18650 to 48600. Understanding of ageing and safety as well as growing recycling activities complete the circular economy approach of the department.

Sodium-Ion Battery Research and Testing at BAM

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BAM is a German federal institute for materials research and testing, which is active in research, testing and contributes to regulatory activities. We are driven by the aim to support the economy and contribute to safety in technology and chemistry. Looking forward to the rollout of sodium-ion batteries in Germany we are prepared. Our activities cover the investigation of aging and safety tests of batteries, the identification and tracking of battery components, as well as the research and development of active materials for new cell chemistries. Here safety tests of first commercially available Na-ion cells will be discussed in the context of identified compositional features thereof. Moreover, we developed and investigated novel type of synthetic core-shell negative materials partially within a Berlin project together with our partners at HU Berlin, Helmholtz-Zentrum Berlin and TU Berlin. The proof-of-concept will be presented and a detailed morphological characterisation of those carbon-based materials along with studies of the storage mechanism will be used to estimate the energy densities possible for future materials on the negative electrode of sodium ion batteries.

Short Bio

Dr. Fellinger is heading the Division for Electrochemical Energy Materials at the Federal Institute for Materials Research and Testing (BAM). He is also Speaker of the BAM internal Field of Activity “Electrical Energy Storage and Conversion”. After his PhD in 2011, he was a research group leader with Prof. M. Antonietti until 2017 working on “Carbon and Energy” at the MPI for Colloids and Interfaces. Afterwards he established a project group at the Chair of Technical Electrochemistry with Prof. H. Gasteiger at TUM with a focus on fuel cell catalysts. He published almost 60 peer-reviewed articles (H-index of 40), and his research is focused energy materials, especially the control of morphology and composition for next generation energy applications.

Insight into rapid Na insertion through diluted electrode method and low-cost routes for synthesis of hard carbon for Na-ion batteries

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Hard carbon (HC) with its high energy density, low plateau potential and high reversible capacity has been attracting significant academic curiosity.[1,2] Furthermore, its' fast-charging ability avoids risks of sodium plating as well as thermal runaway which is an essential property for commercialization. To realize the rate capabilities of HC, our group recently succeeded to apply a diluted-electrode method[3] to estimate sodium insertion kinetics.[4] As metallic nickel (Ni) or aluminum oxide (Al_2O_3) particles do not accommodate Na^+ ions in the potential range of 0–2.0 V vs. Na^+/Na, the HC powder is diluted with the addition of these inert particles. This enables the adjustment of the HC concentration while maintaining the composite electrode structure. This method also alleviates Na^+ depletion within the electrode, which improves issues with concentration-related overvoltages and enables a more effective estimation of Na^+ insertion kinetics controlled by the Na^+ mobility in the HC particles and across the HC/electrolyte interface. Our results indicate insertion rates comparable with fast charging of graphite in Li-ion batteries. Despite these promising characteristics, HC's high production cost is still regarded as a major bottleneck.[1] To target this limitation, our group has been exploring new HC syntheses using low-cost lignin for attaining high carbon yields, ca. 40 wt%. Overall, our study reveals promising aspects of HC and a pathway toward developing high power and low-cost anodes for Na-ion battery.

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Short Bio

Shinichi Komaba is a Professor in the Department of Applied Chemistry at the Tokyo University of Science, Japan. From 2003 to 2004, he worked at the Institut de Chimie de la Matieŕ e Condenseé de Bordeaux, France, as a postdoctoral researcher. He joined the Tokyo University of Science as a faculty member in 2005. He was awarded the 2014 Resonate Award from Caltech, USA, and JSPS Prize in 2014. He was selected as Highly Cited Researcher 2019 – 2023. His current research focuses on material science and electrochemistry in rechargeable Li-, Na-, and K-ion batteries, capacitors, sensors, and biofuel cells.

Understanding Ageing in Sodium-ion Batteries

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Short Bio

Reza Younesi is associate professor at Ångström Advanced Battery Centre at Uppsala University, Sweden, and one of the founders of Altris AB company. The research focus at Younesi's team is on interfacial reaction in rechargeable batteries and materials development for sodium-ion & lithium-ion batteries. He is also Director of Materials Technology at NOVO Energy R&D- a joint venture between Northvolt and Volvo Cars.

Na-ion battery development @ TIAMAT

John Abou-Rjeily

Tiamat Energy, France

Challenges and opportunities of sodium-ion giga-scale production

Andreas Haas

Northvolt, Sweden

Benefits and Challenges of SIB from an Automotive OEM Perspective

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The Volkswagen Group is actively involved in pioneering sustainable battery technologies. With the “NEW AUTO” strategy we are providing mobility for generations to come. The aim of this presentation is to unravel the complexity of an automotive battery system by explaining its functions and components and outlining customer expectations in the automotive industry. We will then explore the benefits of SIBs, such as cost efficiency and raw material diversification, as well as the challenges, such as energy density and scalability of the technology, from an automotive OEM perspective. Finally, we will present the minimum requirements for a SIB cell suitable for automotive use.

Short Bio

Julian Wagenschütz is a simulation engineer developing sustainable battery system platforms at Volkswagen. He has been working on battery systems since 2016, starting in Formula Student. He holds a master's degree in mechanical engineering with a focus on simulation and data management. He also worked in consulting and learned how to evaluate and enable new technologies like sodium-ion batteries.

Insights into Prussian White Cathodes for Na-Ion Batteries

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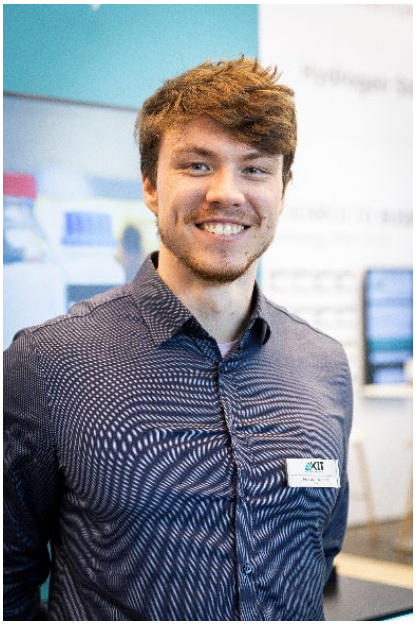
Several classes of materials are suitable as cathode materials in sodium-ion batteries. The class of Prussian White (PW) analogs promises the use of only cheap and widely available raw materials, a potential profile very similar to lithium iron phosphate (LFP) and production without calcination. In this presentation, we show a manganese-iron PW analog and compare its properties to LFP based cathodes.

Short Bio

Tom Bötticher is the co-founder of Litona, a Germany based sodium-ion battery material company, and has been working in battery development at Dalhousie University, Canada, and MEET Battery Research Center, Germany. Currently, Litona develops and sells Prussian White cathode materials to research groups and industry worldwide.

Sebastian Büchele is a mechanical engineer and the founder of Litona. He has been working in battery development at Dalhousie University, Canada, helped set up a cell production at another start-up and developed Litona's first Prussian White product.



Sodium Solid State Batteries and their Materials Challenges

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Solid-state battery cells are considered as an option for future high-performance batteries. In the case of lithium as mobile ion, cell concepts are well advanced, and commercialization is expected. In the case of sodium, solid-state cell concepts are less well developed for several reasons. While solid electrolytes with very high conductivity are available, and β-alumina based cells have been developed decades ago as high-temperature batteries, operation at room temperature has yet not been achieved successfully. The major challenges of sodium SSB will be summarized and compared with the current development of lithium SSB. Results on the kinetics and properties of the sodium metal anode and of reservoir-free anodes (i.e., for “anode free” cells) will be presented, and the choice of cathode materials for sodium SSBs will be discussed.

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Short Bio

Jürgen Janek is Professor of Physical Chemistry at Justus Liebig-University Gießen, Germany, and has been working on cell concepts and materials for sodium-ion batteries since 2010, while most of his work in the last decade is on lithium batteries. His research interests are solid state ionics, solid electrolytes and mixed conductors (oxides, sulfides, halides), and he combines electrochemical measurements with in situ/operando techniques, e.g. in XPS, SIMS or XRD. His favorite research subject is the kinetics of interfaces in electrochemical cells and its detailed mechanistic understanding. He is director of the Center for Materials Research at JLU, and director of the BELLA lab at KIT (joint lab with BASF SE).

Revealing the Reaction Mechanism and Chemo-Mechanics of Solid-State Na-S Batteries

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Solid-state sodium-sulfur batteries show great promise for energy storage applications due to their high energy density, cost-effectiveness, and abundance of raw materials. Despite these promising characteristics, challenges such as the phase evolution of (poly)sulfides and how it is linked to the significant volume expansion occurring in the cathode during cycling are still poorly understood.[1,2] In this talk, I will showcase our recent progress in developing solid-state sodium-sulfur batteries using different solid electrolyte systems, namely Na_3PS_4 and closo-borates. I will discuss how tortuosity impacts sulfur utilization in the composite cathode and provide new insights into sulfur redox chemistry and associated kinetic limitations. Furthermore, I will examine the correlation between phase, volume, and stress evolution.

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Short Bio

Daniel Rettenwander is a Full Professor at the Department of Materials Science and Engineering at NTNU Norwegian University of Science and Technology in Trondheim, Norway. He leads the Battery Materials Team at NTNU and also serves as the Director of the Christian Doppler Laboratory for Solid-state Batteries. His research spans from the development of novel materials, scaling of solid-state batteries to the design of devices for probing solid-state batteries during operation, utilizing both custom-designed, in-house equipment, as well as large-scale user facilities (e.g., ESRF in France and DESY in Germany).

Exploring the possibilities of NaSICON solid electrolytes for new generation of low-temperature batteries

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Correlating cathode microstructure, performance, and cycle life of sodium-zinc chloride ($Na\text{-}ZnCl_2$) battery cells

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Sodium-nickel chloride ($Na\text{-}NiCl_2$) batteries are an attractive technology for stationary energy storage.[1] However, Ni has recently been classified as a strategic critical raw material, which needs to be avoided for large-scale applications.[2] Present $Na\text{-}NiCl_2$ battery cells contain up to 25wt% of Ni, most of it in the cathode. Replacing it by another active cathode metal significantly affects cathode microstructure and the electrochemical reaction mechanisms, and in turn cycle life and specific cell energy.
In this study,[3] we develop sodium-zinc chloride ($Na\text{-}ZnCl_2$) cells operated at 300 °C. We correlate the dis-/charge cycling performance of $Na\text{-}ZnCl_2$ cells with the ternary $ZnCl_2$-NaCl-$AlCl_3$ phase diagram and identify mass transport through the secondary $NaAlCl_4$ electrolyte as an important contribution to the cell resistance. These insights enable the design of tailored cathode microstructures, which we apply to cells with cathode granules and cathode pellets at an aerial capacity of 50 mAh/cm^2. With cathode pellets, we demonstrate >200 cycles at C/5 (10 mA/cm^2), transferring a total capacity of 9 Ah/cm^2 at >83% energy efficiency. We identify coarsening of zinc particles in the cathode microstructure as a major cause of performance degradation in terms of a reduction in energy efficiency. Our results set a basis to further enhance $Na\text{-}ZnCl_2$ cells, e.g., using suitable additives or structural elements to stabilize the cathode microstructure.

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Short Bio

Meike Heinz is staff scientist at Empa, Swiss Federal Laboratories for Materials Science and Technology. Since 2016, she's leading projects on high-temperature and alkali-metal-anode batteries at the laboratory Materials for Energy Conversion. Her current research focuses on the interplay between cell design, electrode microstructure, and electrochemical processes in sodium-metal chloride batteries. Previously, she worked in the fields of solid oxide fuel cells, solid oxide electrolysis, and alkaline electrolysis.

An old ZEBRA in a New Guise: From Materials Science to Commercial Na-$NiCl_2$ Battery.

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ZEBRA ($NaNiCl_2$) batteries have a long history dating back to the 1970s. After initial R&D, the technology experienced a development boost in the 1990s and is since that time available as an industrial product. Today, the marked battery is strongly dominated by lithium-ion technology. However, a number of limitations in terms of raw material abundance or safety aspects are opening up new opportunities even for hitherto niche technologies such as ZEBRA. New developments pursue the adaptation of ZEBRA technology to cost-optimized stationary storage systems with optimized cell and battery designs, cathode and electrolyte materials and highly efficient production technologies.
The talk will give an insight in the development chain for a new $NaNiCl_2$ battery starting from the material over components, cells, modules towards a 1 MWh system. Material scientific aspects of the solid Na ß-alumina electrolyte and the cathode are included and the implications of the laboratory findings for the overall battery efficiency and the sustainability are drawn. Interactions between material and design optimizations and improvements of cell performance and durability will demonstrate the significance of a properly defined process and quality control. Lessons learned from the integration of 240 cells into a 60 kWh battery pack will be presented. This includes results from thermal simulations and real test data and will illustrate impressively the importance of this aspect on performance data and durability of the battery pack. The potential of an updated ZEBRA battery which is being commercialized with partners from industry will be elaborated and a forecast to a 120 MWh pilot production will be given.

Short Bio

Matthias Schulz is senior scientist and head of the “Stationary Energy Storage” department at Fraunhofer IKTS. His team is engaged in the development of sodium batteries with a special focus on ceramic solid electrolytes, high temperature sodium batteries and new concepts for sodium-based cell chemistries and concepts. Starting from fundamental materials science and electrochemistry the team is bringing sodium battery technology to close to industry solutions. This approach is supported by the ability to carry out pilot production of active materials, components, battery cells and fully functional prototype systems.

High-Energy, Long-Duration Sodium-Sulfur (NAS®) Battery for Stationary Energy Storage

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Due to their powerful technical performance as high energy density and long lifetime, a proven track record in the field and a competitive cost/performance ratio, Sodium-Sulfur Batteries (NAS®) are now being increasingly deployed also outside of Japan. In my talk, I will give an update on the current status in the stationary energy storage market and competition, how our latest NAS developments serve these market needs and where we still see potential for product improvement for the future.

Short Bio

Florian Dötz is Head of Technology at BASF Stationary Energy Storage GmbH and leads the joint NAS battery project between BASF and NGK. Trained as an organic/polymer chemist, he spent more than 10 years in research on Organic Electronics in the US, Germany and Asia before moving into energy related technologies as energy transport, conversion and storage. His current focus is stationary energy storage based on the NAS technology aiming at increased market penetration of NAS batteries in industrial applications.

Advanced Intermediate Temperature Molten Sodium Battery Technologies

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As renewable energy sources like wind and solar power become more prevalent, managing their intermittency becomes crucial to maintain the grid reliability and durability. Lithium-ion batteries (LIBs) have been dominant in grid-scale storage and electric vehicles, but concerns over their materials supply chain and safety have led to renewed interest in molten sodium (Na) batteries. Molten sodium batteries, including sodium-sulfur (Na-S) and sodium metal-halide (Na-MH) batteries, offer several advantages. They utilize more abundant and lower-cost raw materials, addressing concerns about material supply chains. One of the key focuses in molten sodium battery research is reducing operating temperatures from 260-350ºC to levels closer to the melting point of sodium (~100°C). This approach maintains the benefits of a liquid sodium metal anode while minimizing thermal management issues and enabling cost-effective large-scale manufacturing. Lower temperatures also improve cell performance, including longer cycle life and greater reliability. The presentation will highlight the latest advancements in Pacific Northwest National Laboratory's (PNNL) Na battery technologies, particularly their suitability for low-temperature operation and long-duration energy storage applications. By optimizing the technology for lower temperatures, PNNL aims to enhance the viability and scalability of molten sodium batteries for grid-scale energy storage, addressing key challenges in the transition to renewable energy.

Short Bio

Dr. Guosheng Li is a Sr. Scientist at Pacific Northwest National Laboratory (PNNL). He received his B.S. degree from the Tsing Hua University, and later achieved his M.S. and Ph.D. degrees in Physical Chemistry from KyungHee University. He completed his postdoctoral training at University of Southern California (USC) before joining PNNL. He has broad knowledge in Electrochemistry, Materials Science, Catalysis, and Spectroscopic Characterization, and currently leads several battery R&D programs supported by Department of Energy. His research focuses on materials development and rechargeable electrical devices for stationary energy storage applications, and he is interested in developing and understanding advanced electrolytes, synthesis of cathode materials, the reaction mechanisms for cathodes, and various interfacial problems encountered in rechargeable batteries. He has published more than 80 research papers (h-index 39) in various professional journals and holds 7 US patents/dozens of US patent applications.

Towards sustainable, grid connected Sodium-Ion stationary storage systems

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Generation and load peaks from renewable energy sources are a challenge for energy grids. There is no single energy storage solution that is ideal for every grid-scale application. Currently lithium-ion batteries are the most well-known and the most efficient representatives for the electrochemical storage of energy. As the growing demand for LIBs is driving the prices for the scarce reserves of lithium up, sodium ion batteries (SIBs) start to shift more into the focus.
Herein the progress of two industrial research projects aiming the implementation and field tests of Sodium-Ion stationary systems will be presented. The first project, ResHy[1], aims a flexible and sustainable electrochemical hybrid storage system containing a 2nd life lithium-ion battery (LiB) and a sodium-ion based component. The developed hybrid storage system of rd. 1.5 MWh will be implemented and tested at a EnBW solar park of 62 MW_p which is under construction in Gundelsheim, proximity of the city Heilbronn. The second project, WINTER[2], aims the development of a sustainable Na-ion home storage of rd. 6 kWh system "made in Germany". Within this project, a first EU sodium-ion home storage system made from non-critical raw materials within a fully EU-integrated value chain will be developed. Furthermore, the gained "know-how" will be extrapolated to future Na-ion storage systems.
Both projects have been granted by Federal Ministry for Economic Affairs and Climate Action.

Short Bio

Magdalena Graczyk-Zajac works on optimization and efficient operation of stationary storage installations including testing and evaluation of innovative storage solutions at EnBW AG in Karlsruhe/Stuttgart, Germany. Sodium-based stationary storage is in a focus of her research and professional interest. She is also involved in the activities of EnBW related to the extraction of lithium from geothermal sources.
She is a deputy coordinator of the Horizon 2020 EU granted project SIMBA (Sodium Ion and Sodium Metal Batteries, Grant Agreement no. 963542). From September 2023 she holds a visiting Professorship in Materials and Resources Division, Material Science Department of TU Darmstadt.
Magda studied Chemistry at Technical University of Gdansk in Poland and received her PhD in Physical Chemistry on electroactivity of organometallics-modified conducting polymers at Burgundy University, Dijon, France in 2007. Then she moved to CEA Liten Grenoble, France to work as a research engineer on novel electrodes and electrolytes for Li-ion batteries. Later, she moved back to academia and continued her research on polymer-derived ceramics for energy-related applications as a postdoc and later Junior Group Leader in Material Science Department of TU Darmstadt, Germany. In May 2020 she joined R&D division of EnBW.

Altris Sodium-ion Cell Design, Pure & Powerful

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The design of batteries is a complex procedure that needs account for many different aspects such as performance, raw material supply security, processability, & sustainability. This presentation will go through many of the decisions made by Altris AB as we seek to introduce a European sodium-ion battery based on Prussian white and hard carbon. Special focus will be given to the selection of raw materials and components as well as issues with cell manufacturing in an attempt to create a truly green battery from all aspects of the value chain. The current state of Altris AB cell performance will also be discussed in the context of suitable application of this particular flavor of sodium-ion batteries.

Short Bio

Ronnie Mogensen is CTO and a co-founder of the Swedish start-up company Altris AB. He has a PhD in Inorganic Chemistry from Uppsala-University in Sweden, and has been working on sodium-ion batteries since 2015. Prior work includes electrolytes, SEI formation, redox flow batteries, and Prussian white synthesis.