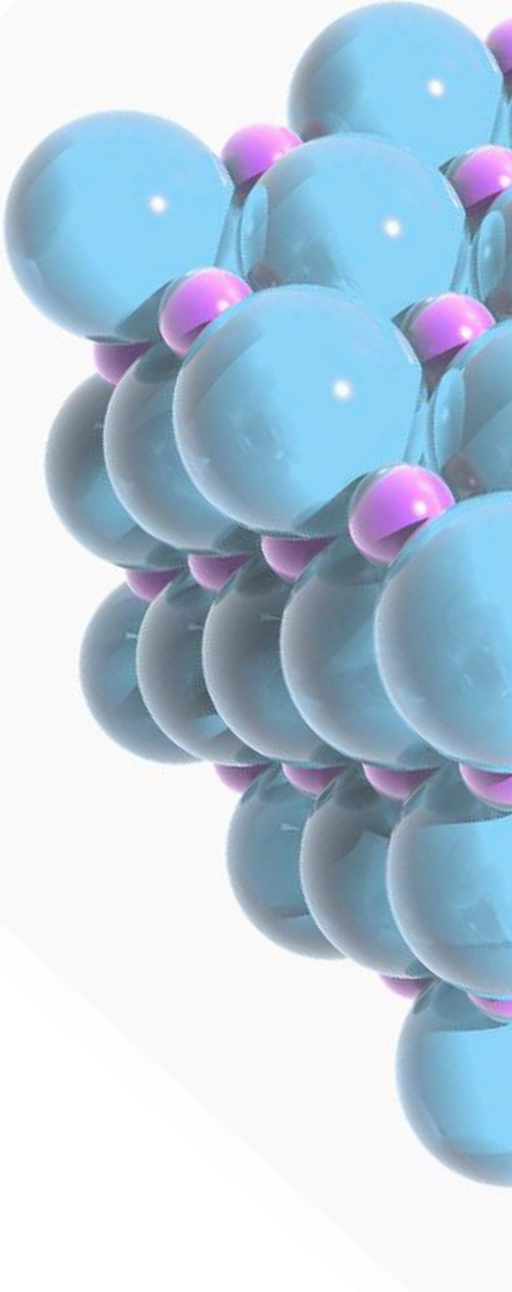
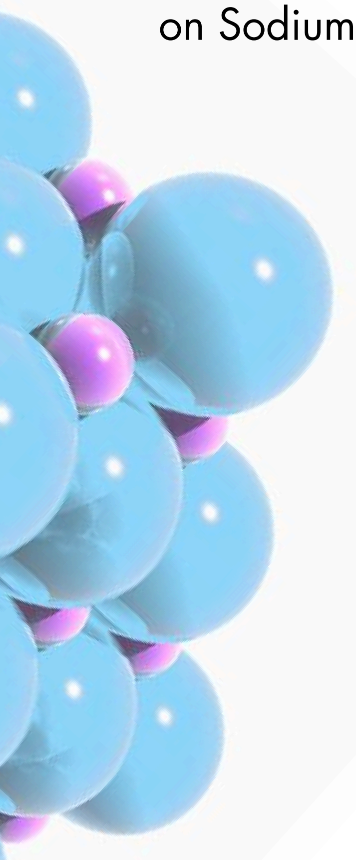
IIT Bombay Research Hub for
Green Energy & Sustainability
GESH IITB

Roadmap for Na-ion Battery Technology Development in India

Round Table Discussions

Conducted as Part of the 1st National Meeting
on Sodium(-ion) Batteries (NMSB-1)





Indian Institute of Technology Bombay
October 4-6, 2024

Participating Organizations

Academia

IIT Bombay, IIT Hyderabad, IIT Kanpur, IIT Delhi, IIT Kharagpur, IIT Roorkee, IIT Indore, IIT Madras, IISc, JNCASR, IACS, IISER Tirupati, IISER Thiruvananthapuram, Banaras Hindu University, TCG-CREST, BARC Mumbai, Shiv Nadar University.

Industries

Ola Electric, Amara Raja Advanced Cell Technology, Reliance Industries Limited, Aditya Birla Science & Technology Company, Log 9 Materials, KPIT, Tata Steel, Tata Motors, Cygni Energy.

National Labs

CSIR-CECRI Karaikudi, CSIR-CLRI Chennai, CSIR-NCL Pune, ARCI Hyderabad

Government of India Agencies

DST, MNRE

Event Summary

The inaugural session of NMSB-1, held at IIT Bombay, began with welcome remarks from the Convener of NMSB-1, Prof. Amartya Mukhopadhyay, followed by an inaugural address by the Director, IIT Bombay, Prof. Shireesh B. Kedare. This was followed by a presentation on the recently established Green Energy and Sustainability Hub (GESH) by Prof. Sanjay Mahajani, and an overview of the Department of Metallurgical Engineering and Materials Science by the Head of the department, Prof. N. N. Viswanathan. The session also featured i) Launch of the website of the 'Battery Research Society' by Dr. K. Ramesha, Director, CSIR-CECRI, ii) an Overview of Battery R&D at IIT Bombay by Prof. Amartya Mukhopadhyay, and iii) a vote of thanks by the Co-Convenor of NMSB-1, Prof. Srinivasan Ramakrishnan.

The inaugural session was followed by thematic technical sessions spread over two and a half days, featuring experts from academia, National laboratories and industries. The technical sessions covered diverse aspects of Na-ion battery research and development, which can be broadly classified into i) technology development and commercialization (higher TRL levels), ii) cathode and anode materials discovery, advancements, and optimization, iii) electrolyte and interfacial engineering, as well as iv) recycling. The poster session of NMSB-1 showcased state-of-the-art Na-ion battery research carried out by research scholars (PhD students) and Postdoctoral researchers from across the country. A valedictory session was conducted on the last day of NMSB-1 which featured poster prizes and acknowledgements to sponsors.

NMSB-1 also featured a unique 2-day Round Table Discussion session with selected participants and stakeholders (by invitation only) to brainstorm on the roadmap for Na-ion battery technology for India.
The discussions, conclusions and recommendations are summarized in the following.

1. Background

India's "Panchamrit" strategy underlies its commitment towards addressing climate change and transitioning towards cleaner and sustainable energy systems. The goals of this mission include net-zero emissions by 2070, 500 GW of non-fossil fuel energy capacity by 2030 with 50% renewable energy contribution, and reduction of the total projected carbon emissions by 1 billion tons by 2030. However, the intermittent nature of renewable energy sources such as solar and wind necessitate the deployment of efficient, cost-effective energy storage at the GW scale. Furthermore, efficient-cum-cheaper energy storage system is also needed to make the grid more robust. The reduction of air pollution in the cities also necessitate widespread development of electric vehicles (EVs) and significantly enhanced adoption by the common people, which is possible only when less expensive battery storage system for EVs gets developed.

India has been making significant strides in the development and adoption of sodium-ion (Na-ion) batteries (SIBs) as a promising alternative to lithium-ion (Li-ion) batteries (LIBs). Sodium is one of the most abundant elements on earth, whereas lithium is associated with global supply-chain constraints and risks, due to its limited availability in countries such as Chile, China and Australia. Furthermore, high-capacity Na-ion battery cathodes do not require the usage of Co. There is also no need for the usage of relatively expensive Cu as current collector in Na-ion cells. In addition to the benefits in terms of cost and sustainability, Na-ion batteries also render storage/transportation more facile and safer since Na-ion cells can be stored at zero state-of-charge, unlike their Li-ion counterparts. Na-ion batteries are also capable of operating over a wider temperature window (in principle, -40 to 70 oC). Hence, a transformation from the Li-ion battery technology to the more sustainable-cum-safer Na-ion battery technology is a need of the hour.

While sodium-ion batteries hold considerable promise, there are several challenges that need to be resolved for their large-scale adoption, which include enhancing their cycle life and achieving high energy density. Each of these targets requires dedicated, collaborative, state-of-the-art R&D efforts to realize market-ready, indigenously developed SIBs at the GW scale for grid-scale storage. Furthermore, with a selected class of high energy cathode materials, SIBs can even displace LFP-based Li-ion batteries that are currently ubiquitous choices for low-cost energy storage for grid scale as well as electric transportation applications.

Given the potential for disruption in the energy storage sector with low cost, energy dense SIBs, innovative modes of R&D and policy support are essential for the commercialization of indigenously developed SIB technology to meet India's energy needs in the next decade.

2. Key Discussion points

2.1. Identification of state-of-the-art in Na-ion Technology

The current advancements in SIB technology and its readiness for large scale commercialization were discussed, including targets for gravimetric and volumetric energy density, cycle life and cost. Currently the maximum achievable energy density of SIBs is approximately 130-150 Wh/kg, which is still inferior to that of LIBs (~160-300 Wh/kg, depending on the choice of the cathode material). Hence, from the research and developmental perspective, there has to be a push towards developing high energy density Na-ion battery chemistry; targeting, 200 Wh//kg and beyond (at cell level) within the next couple of years. This will necessitate advancements and breakthroughs with respect to the cathode materials, anode materials, as well as the electrolytes.

2.2. Global front vs. Indian scenario

Currently China is developing SIBs aimed at both grid storage as well as electric vehicle (EV) applications with sizable subsidies to boost technology adoption. Companies such as CATL and BYD are scaling-up and commercializing SIBs for the Asian as well as international markets. In Europe, companies such as Faradion and Tiamat are at the forefront of Na-ion R&D and technology development. While Faradion has developed a layered oxide-based cathode which yields high energy density (~160 Wh/kg), Tiamat has achieved extended cyclability with NASICON type of cathode materials, but which offer relatively lower energy density.

Several of the material compositions in these classes of cathode materials are patented.
In India, various institutes are working on state-of-the art R&D in Na-ion battery technology to boost the energy density and cycle life, spanning materials discovery, electrolyte and interface engineering, and circularity. Different groups have expertise and breakthroughs in different areas related to the Na-ion battery chemistry.

Furthermore, several startups, along with major companies are working towards the scale-up of SIBs. This calls for an integrated approach to take the developments forward at a rapid pace; which can render India self-reliant in battery technology.

2.3. India’s Opportunities and Challenges

Opportunities

The high and ever-increasing demand for batteries, coupled with supply chain risks associated with LIB technology, presents a unique opportunity for India to invest its financial, technological, and human capital resources towards rapid development of the SIBs as a sustainable technological alternative at the GWh scale, especially given the high abundance of sodium and other necessary resources in India. With India's ambitious clean energy goals, viz., 500 GW renewable energy capacity by 2030, SIB technology is well suited and, in fact, is ready for immediate applications in grid scale and other stationary storages (where energy density is relatively less critical compared to cyclic stability and safety). In principle, SIB may also be used right now in EVs for operation with limited miles (say, within cities), with proper charging infrastructure.

Challenges

However, the relatively lower energy density of SIBs compared to LIBs limits their applicability in long distance transportation applications when used in EVs. Further, fluctuations in global LFP based LIB prices are a threat to SIBs, but which is likely to be temporary. A major impediment in rapid development of TRLs of SIBs in India is very limited access to battery cell prototyping/manufacturing facilities, as well as advanced battery research specific characterization facilities for further development. Given the patent rights around certain classes of SIB materials, R&D efforts need to be suitably tailored as part of the domestic SIB development roadmap.

3. Recommendations

3.1. Regional Technology Accelerators:

Advanced cell level prototyping, materials processing, characterization and training facilities, with qualified manpower and, preferably, privately managed, providing no bias access to all, need to be set-up with government support for collaborative development of SIB technology between industry, academia and national labs. The accelerator facilities should be located at different regions of the country so that all researchers and developers across the country can have easy access and get benefited.

3.1.1. Cell technology development

Scale-up facilities that enable a rapid increase in TRL levels from lab scale to large format cells, spanning battery materials, as well as active and passive components.

3.1.2. Advanced Characterization:

Facilities that enable rapid materials discovery and optimization, advanced tools and techniques (relevant to battery research and development) to deepen understanding of material properties, electrode/electrolyte interfaces, and battery degradation under various use case conditions need to be set-up.

3.1.3. Industrial Manpower Training

Targeted training modules in cell technology, characterization, modeling, and scale-up for industrial professionals to meet the growing demand of the national battery sector.

3.2 Revamping Current R&D Schemes and focus

- There has been generous governmental support for battery R&D through schemes such as the New and Emerging Energy Storage Technology (NEST) call from DST to upgrade lab-scale technologies (TRL 3-4) to prototypes (TRL 5 and beyond) as well as the recent “Maha EV” call from ANRF. Energy density targets in such calls for indigenous Sodium-ion battery development should target at least 160-200 Wh/kg as the energy density, given the state-of-the-art, with a targeted cycle life of 2000-4000 cycles to encourage wider participation from academia, startups, as well as industries.
- In terms of cell chemistry, this calls for the development of electrochemically stable high capacity ‘layered’ Na- transition metal oxide cathode materials, while also rendering them, at least, air stable and work towards water-stability, which can save additional cost by ~15%, save energy consumption, lower greenhouse emissions, and render the process health and environment-friendly.
- Simultaneously, to address the variability and low volumetric capacity of hard carbon based anodes (which, of course needs to be worked on), efforts also need to be directed towards developing stable ‘alloying reaction’ based anodes. ‘Alloying reaction’ based anodes would also facilitate significant enhancement of the volumetric energy density of SIBs, which will be very important for application in EVs. The electrolyte compatibility is also important here.
- Considering the complexities of battery technology development, and the decades long development cycle that it took for LIBs to mature, a 5-year development timeline for indigenous SIB is suggested.

- Due to the frantic pace of disruption in battery technology worldwide and the potential contribution of SIBs towards India's energy security, it is strongly recommended that SIB technology development be given immense priority. A dedicated 'Fast-track' submission, approval and disbursement process for sodium-ion related projects is recommended, along with relaxations in procurement related stipulations. Parallelly, focused consortium mode research and development (including scale-up) via formation of pan-India consortiums, which includes academia, national laboratories, start-ups and industries, should take also priority.

3.3. Policy Interventions: Government may consider additional tariffs on imported lithium-ion cells and materials to boost indigenous development of sodium-ion batteries.

Amartya Mukhopadhyay

Prof. Amartya Mukhopadhyay, IIT Bombay
[Convener, NMSB-1 and Vice President,
Battery Research Society (of India)]

Prof. Srinivasan Ramakrishnan, IIT Bombay
[co-Convener, NMSB-1]

Prof. Yogesh Kr. Sharma, IIT Roorkee
[Secretary, Battery Research Society (of India)]

Prof. Tata Narasinga Rao, IIT Hyderabad
[President, Battery Research Society (of India) &
former Director, ARCI]

List of Attendees at the Round Table Discussions

(Contributors to this Proposed Roadmap Document)

Sl. No.	Name	Organization	Email
1	Prof. Amartya Mukhopadhyay	IIT Bombay	amartya_mukhopadhyay@iitb.ac.in
2	Prof. Srinivasan Ramakrishnan	IIT Bombay	sriniramk@iitb.ac.in
3	Prof. Bharatkumar Suthar	IIT Bombay	bharat.k.suthar@iitb.ac.in
4	Prof. V. Ramadesigan	IIT Bombay	venkatr@iitb.ac.in
5	Prof. Tata Narasinga Rao	IIT Hyderabad	tatanrao@gmail.com
6	Prof. Katchala Nanaji	IIT Bhilai	nanaji@iitbhilai.ac.in
7	Prof. Rajendra S Dhaka	IIT Delhi	rsdhaka@physics.iitd.ac.in
8	Prof. Sunil Kumar	IIT Indore	sunil@iiti.ac.in
9	Prof Palaniselvam Thangavelu	IIT Madras	palaniselvam@iitm.ac.in
10	Prof. Yogesh K Sharma	IIT Roorkee	yksiitr@gmail.com
11	Prof. Shobit Omar	IIT Kanpur	somar@iitk.ac.in
12	Prof. Sudarshan Narayanan	IIT Kanpur	sudarshan@iitk.ac.in
13	Prof. A J Bhattacharya	IISc, Bengaluru	anindajb@iisc.ac.in
14	Prof. Sai G Gopalakrishnan	IISc, Bengaluru	saigautamg@iisc.ac.in
15	Prof. Premkumar Senguttuvan	JNCASR, Bengaluru	prem@jncasr.ac.in
16	Prof. M M Shaijumon	IISER Thiruvananthapuram	shaiju@iisertvm.ac.in
17	Prof. V Aravindan	IISER Tirupati	aravindan@iisertirupati.ac.in
18	Prof. Urmimala Maitra	IACS, Kolkata	urmimala.maitra@iacs.res.in
19	Prof. Rajendra K Singh	BHU, Varanasi	rajendrasingh.bhu@gmail.com
20	Dr. Kuldeep Rana	MNRE, GOI	kuldeeprana.mnre@gov.in
21	Dr. Ranjith Krishna Pai	CEST Divison, DST, GOI	ranjith.krishnapai@gov.in
22	Dr. K Ramesha	CSIR-CECRI, Karaikudi	director@cecri.res.in
23	Dr. A S Prakash	CSIR-CECRI, Karaikudi	prakash@cecri.res.in
24	Dr. Mudit Dixit	CSIR-CLRI, Chennai	dixitmuditk@gmail.com

25	Dr. Manjusha Shelke	CSIR-NCL, Pune	mv.shelke@ncl.res.in
26	Shri. B A Sawale	CPRI, Bengaluru	dgcpri@cpri.in
27	Dr. P. Chandra Sekhar	CPRI, Bengaluru	pcs@cpri.in
28	Dr. Bijoy K Das	ARCI, Hyderabad	bijoydas@arci.res.in
29	Dr. Sarada BV	ARCI, Hyderabad	sarada@arci.res.in
30	Prof. Priya Johari	Shiv Nadar University	priya.johari@snu.edu.in
31	Prof. Abhik Banerjee	RISE, TCG CREST, Kolkata	abhik.banerjee@tcgcrest.org
32	Dr. Sarika Phadke-Kelkar	KPIT	Sarika.Kelkar@kpit.com
33	Dr. Raghuveer Vadari	Reliance Industries Limited	raghuveer.vadari@ril.com
34	Dr. Sushobhan Kobi	Amara Raja Adv. Cell Technology	sushobhan.kobigcect@gmail.com
35	Dr. Rajesh Mekkat	Ola Eletcric	rajesh.mekkat@olaelectric.com
36	Dr. Chandan Ghanty	Tata Steel	chandan.ghanty@tatasteel.com

IIT Bombay Research Hub for
Green Energy & Sustainability
GESH IITB