EMERGING TECHNOLOGIES FOR LARGE SCALE ENERGY STORAGE - TOWARDS LOW TEMPERATURE SODIUM BATTERIES

JUN LIU

PACIFIC NORTHWEST NATIONAL LABORATORY, RICHLAND, WA 99252

PNNL: Zhenguo Yang, Yuliang Cao, Xiaolin Li, Lifeng Xiao
Sandia: Bruce C. Bunker

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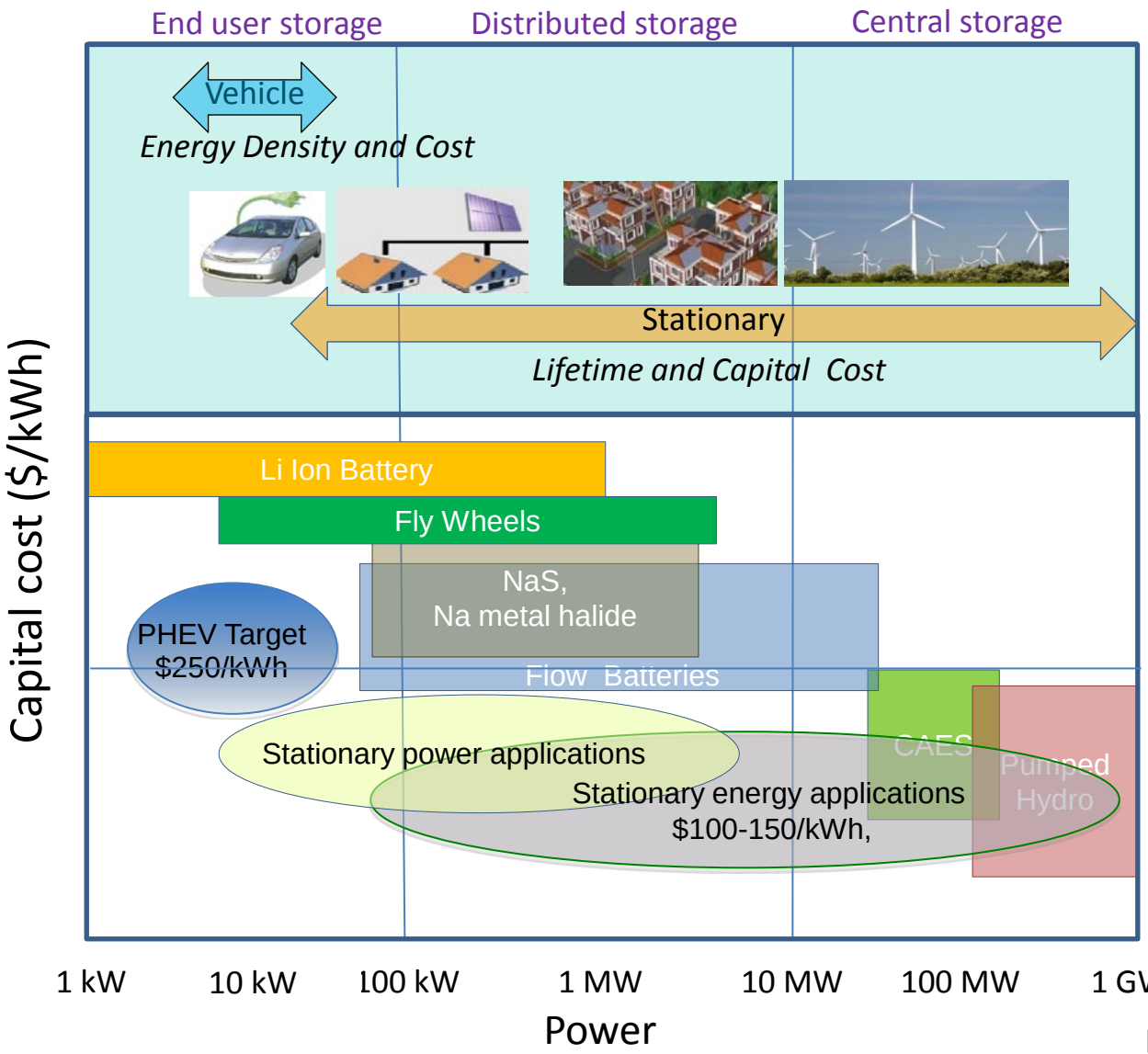
Significant challenges for meeting the long term low cost and reliability requirement for stationary energy storage.



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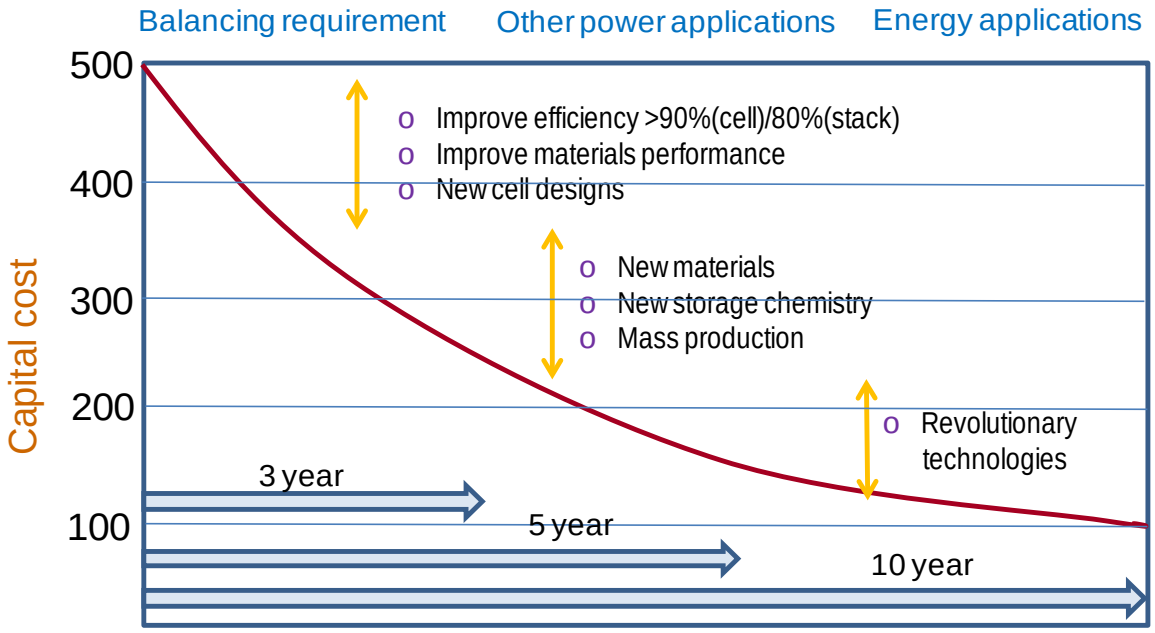
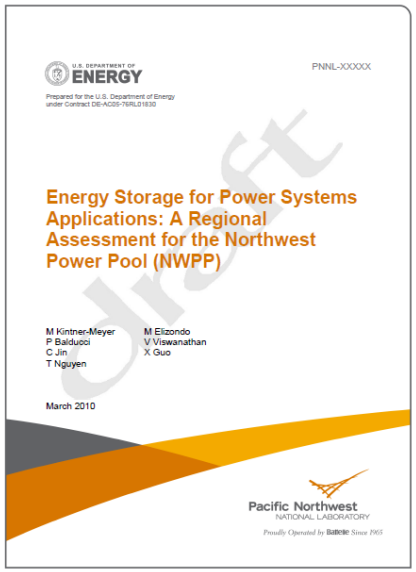
Current technologies are expensive for energy applications

a) Balancing requirement has a big market;
b) Current practice is not the least expensive option;
c) Electrochemical storage can be cost competitive;
d) Possible solutions:
NaS, NaS+DR, NaS+PH, Li-ion+DR, NaS+PH+DR
e) Arbitrage not economical in the near future (by 2019).





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Grand Challenges for Large Scale Energy Storage

Energy storage is application and system dependent;

Fundamental understand of the materials properties and chemical processes in complex, reactive environments and systems;

New materials, chemistry and components to significantly improve the efficiency, reliability, safety and life span of current and future storage systems;

Revolutionary designs, concepts, architectures and hybrid systems that can significantly reduce the system and maintenance cost: of large energy storage systems;

Novel energy storage mechanisms, energy storage technologies that are environmentally friendly and that are not dependent on materials and chemicals of limited supply.

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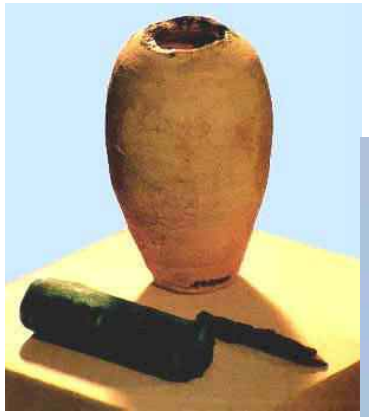
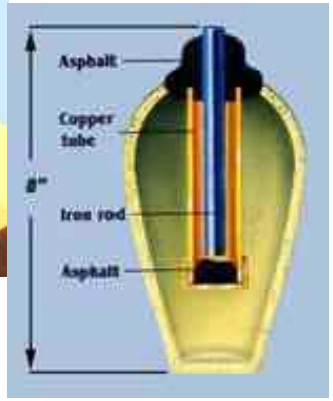
Batteries have been around for a long time, and Li-ion batteries are strong candidates for transportation applications.

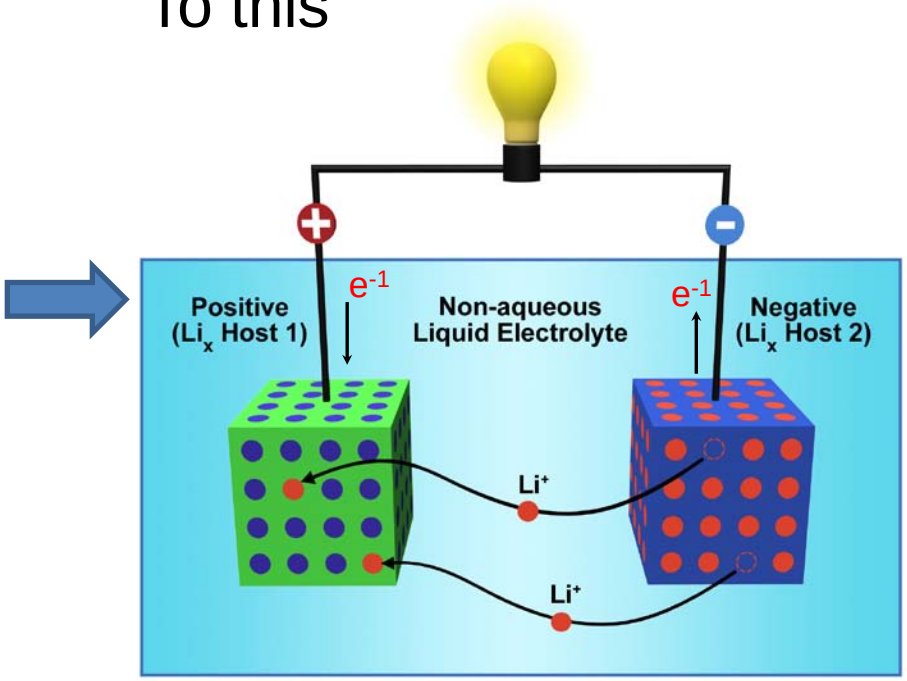
From this





2000 year old
Baghdad “battery”

To this



Significant cost and safety challenges for large scale applications

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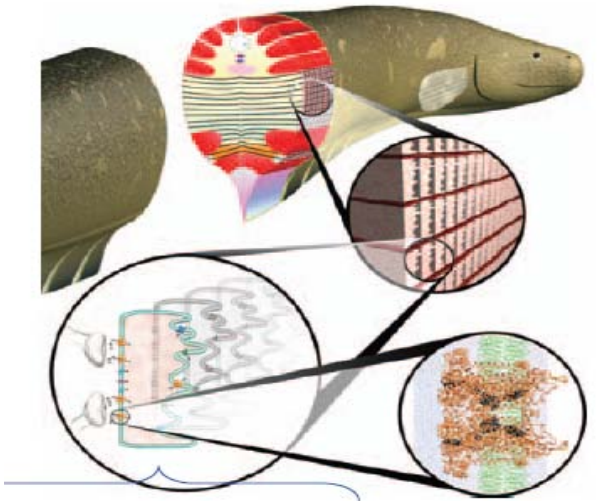
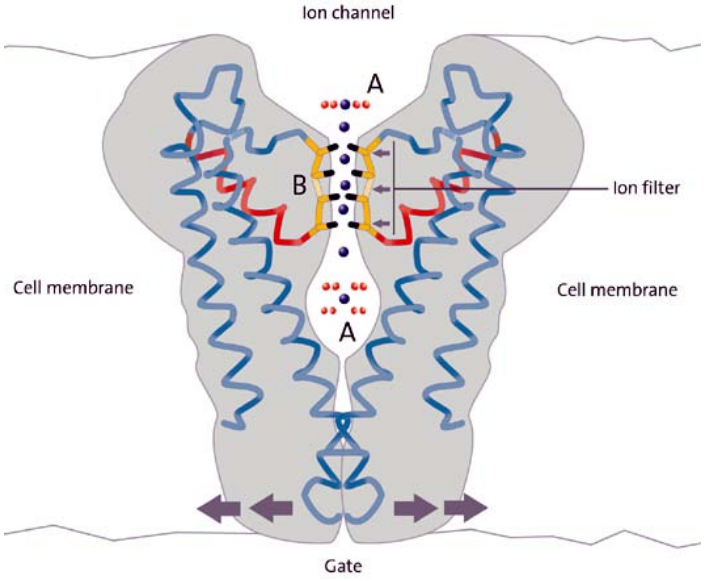
Biology stores energy with Na, K, Ca ions, not Li ions (electrical eels).

Storing large amount of energy using NaCl?

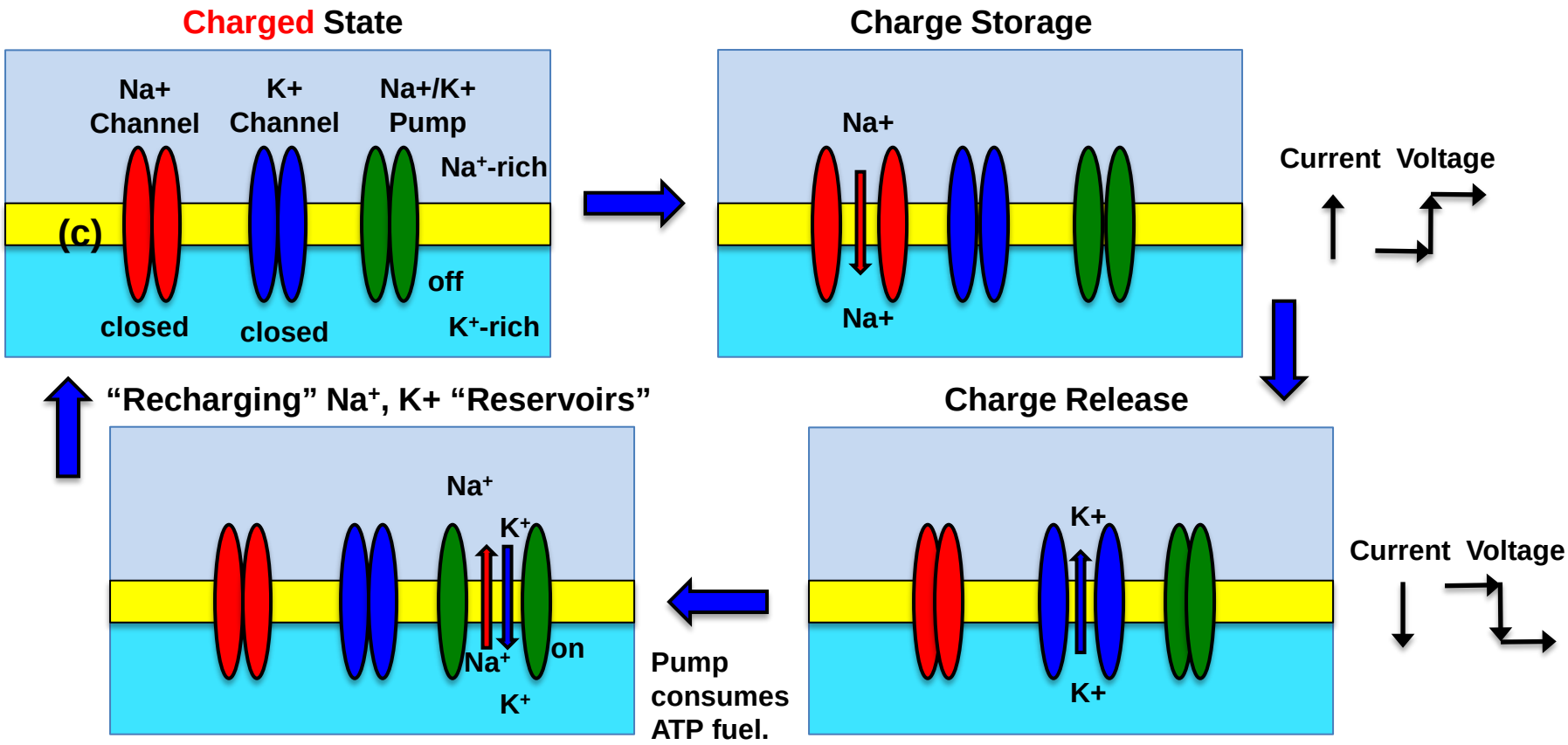




J. Xu, D. A. Lavan, *Nature Nanotechnology* ***2008, 3, 666.***

Ion channels in biology

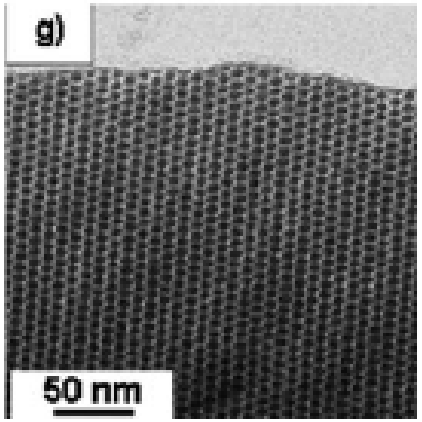
Charge-discharge processes in biological channels

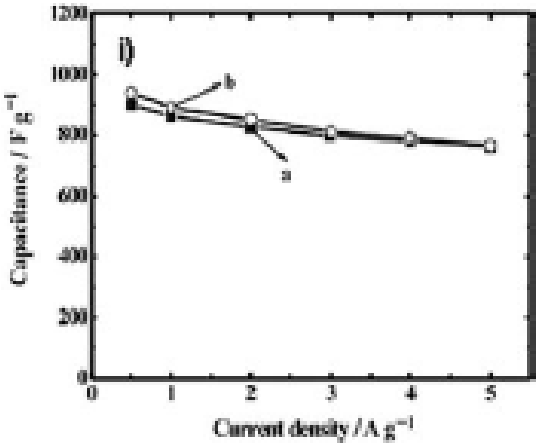


Important properties of ion transport:
Fast transport, high selectivity, and ion pumping (charge) and gating (prevent discharge)

A wide range of open structures can be explored as the host materials for Na ion

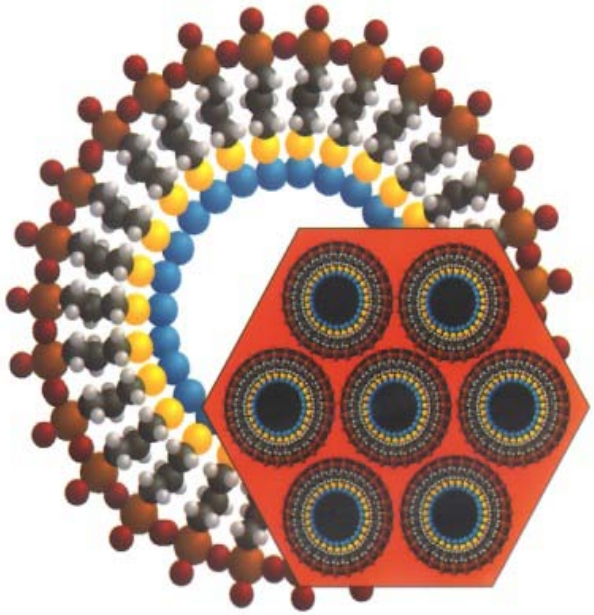
Mesoporous carbon





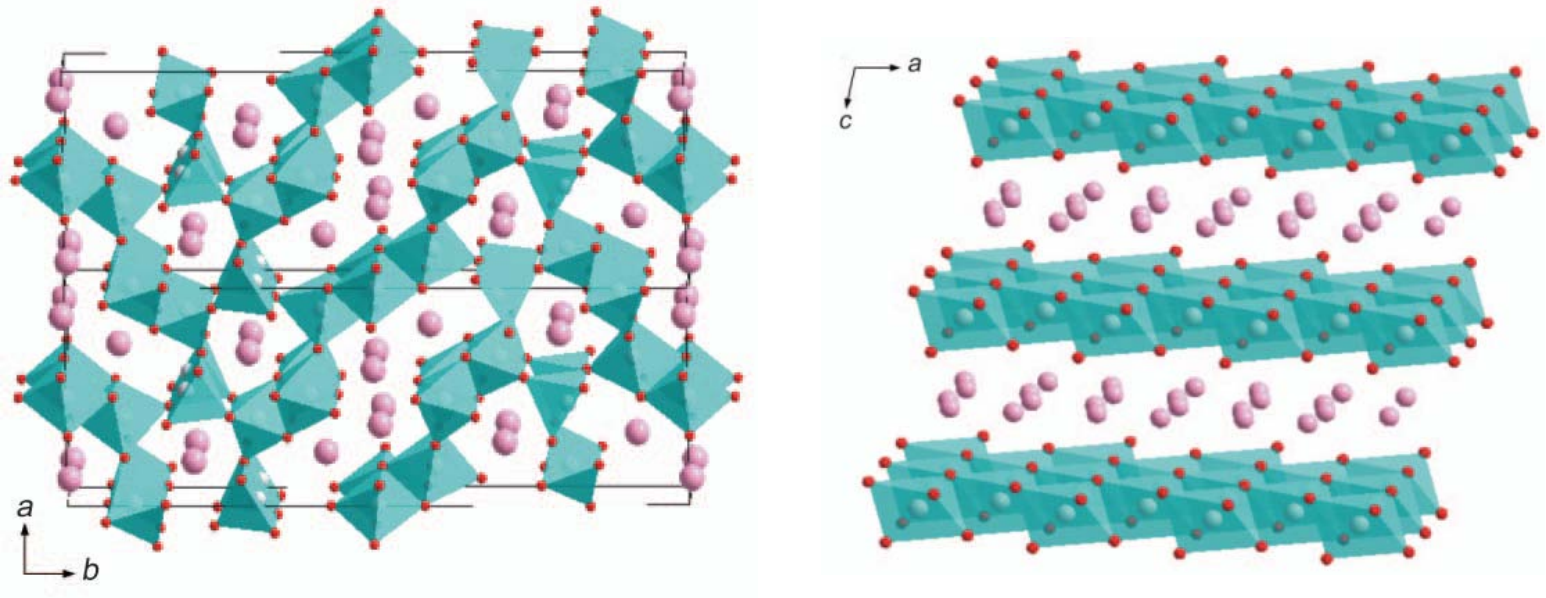
Y. G. Wang, H. Q. Li, Y. Y. Xia, *Adv. Mater.* **2006**, *18*, 2619.

Artificial channels based on functionalized mesoporous materials



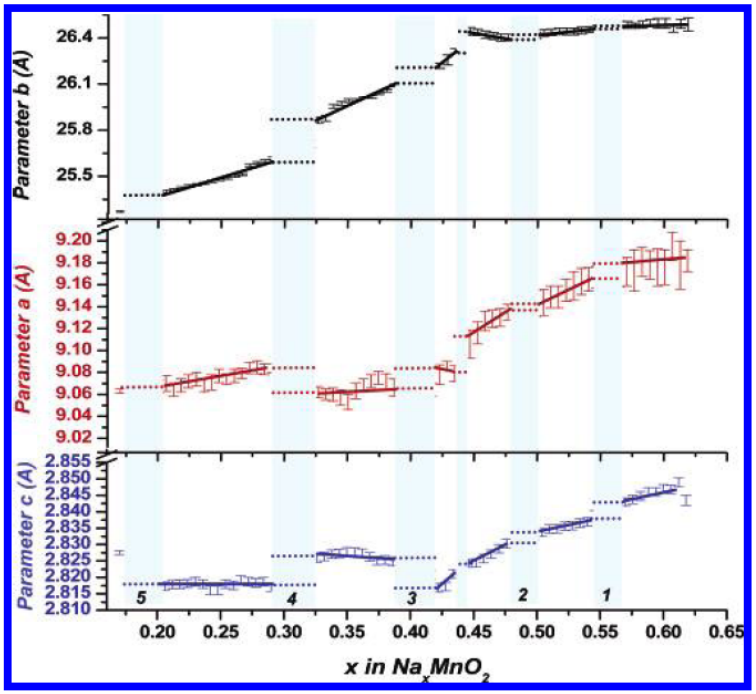
X. Feng, G. E. Fryxell, L.-Q. Wang, A. Y. Kim, and J. Liu, K. M. Kemner, *Science*, 276, 913, 1997.

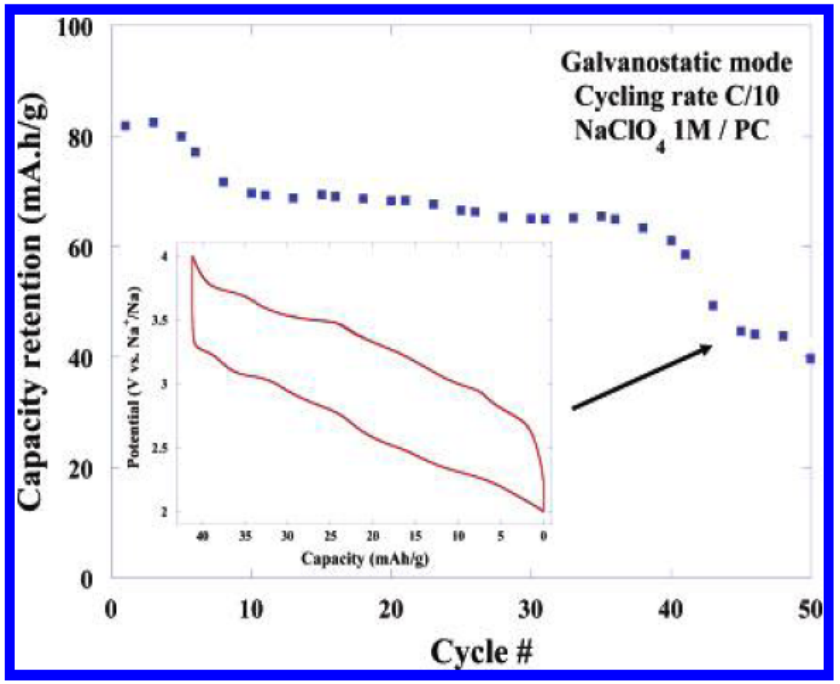
Open inorganic crystalline structures



Layered and crystalline Na_XMnO_2

The Na ion insertion in Na_xMnO_2 is complex, and the stability remains a big issue.

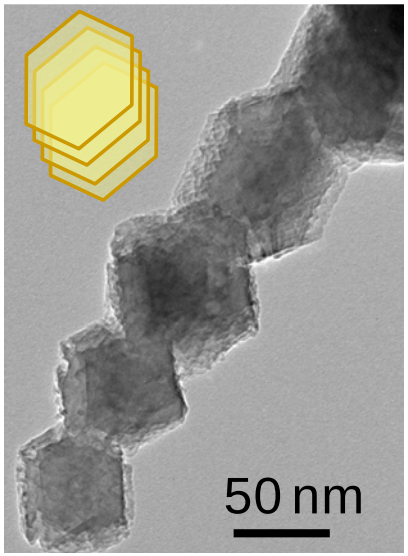


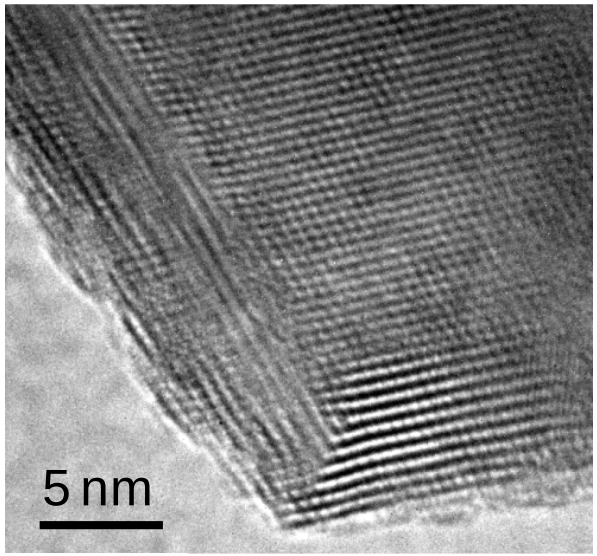


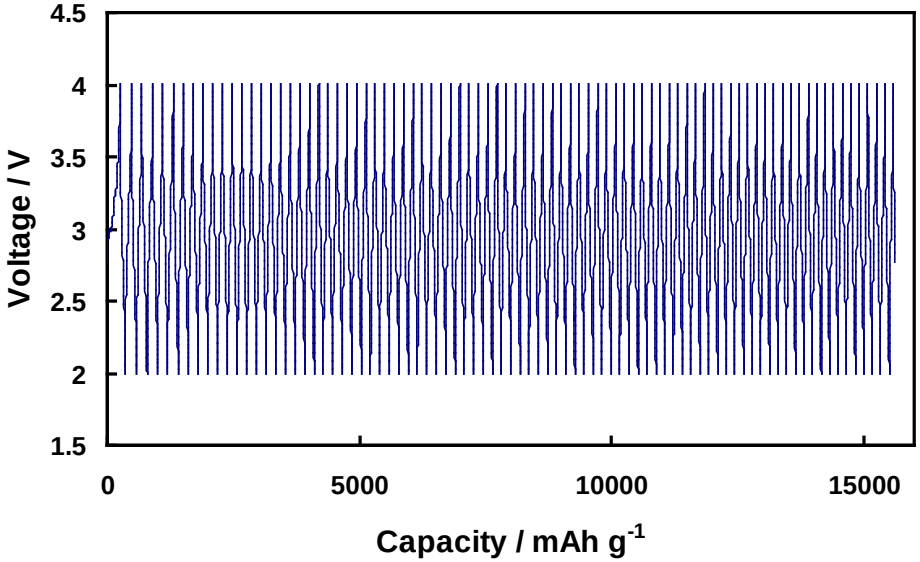
F. Sauvage, L. Laffont, J.-M. Tarascon, and E. Baudrin

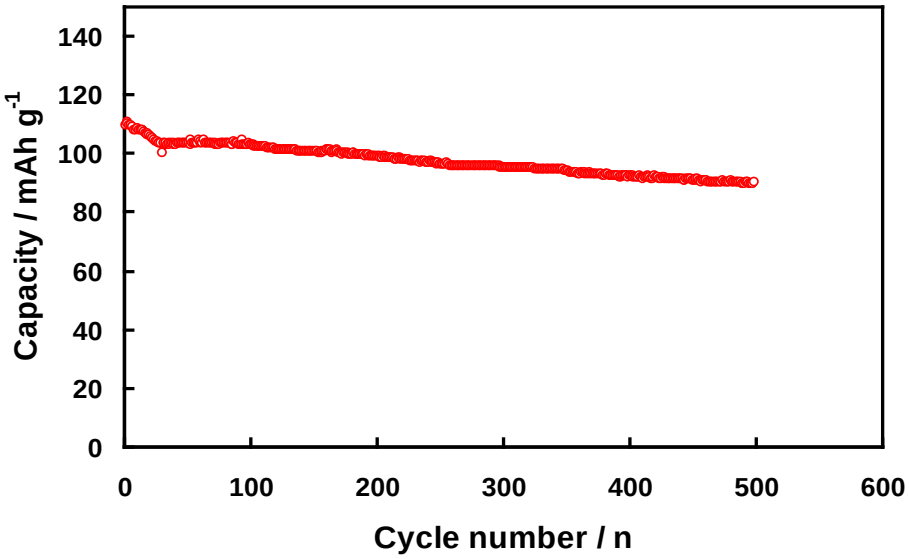
Inorg. Chem. **2007**, *46*, 3289–3294

New cathode materials based on Na_xMnO_2 by controlling the chemistry and the particle morphology









Reasonable stability and capacity are possible.

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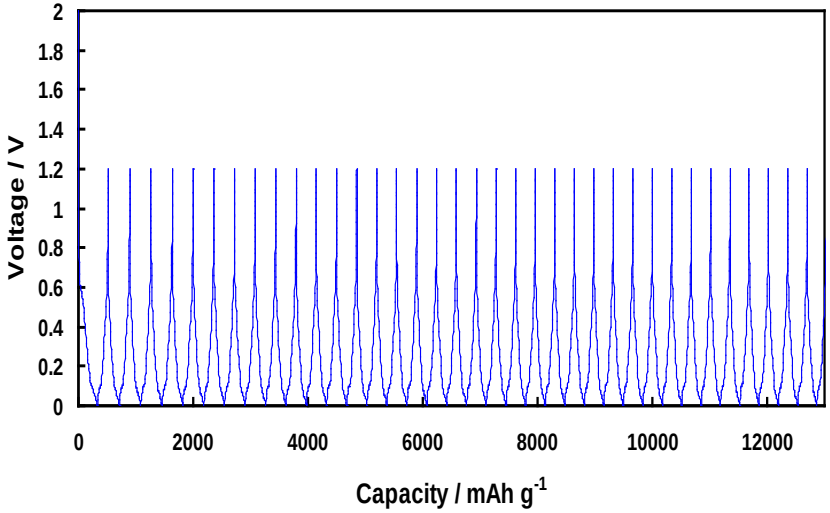
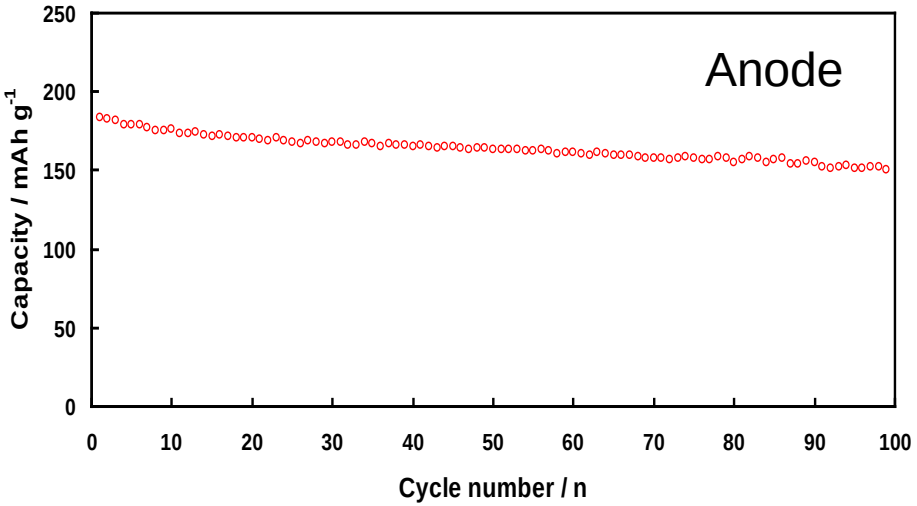
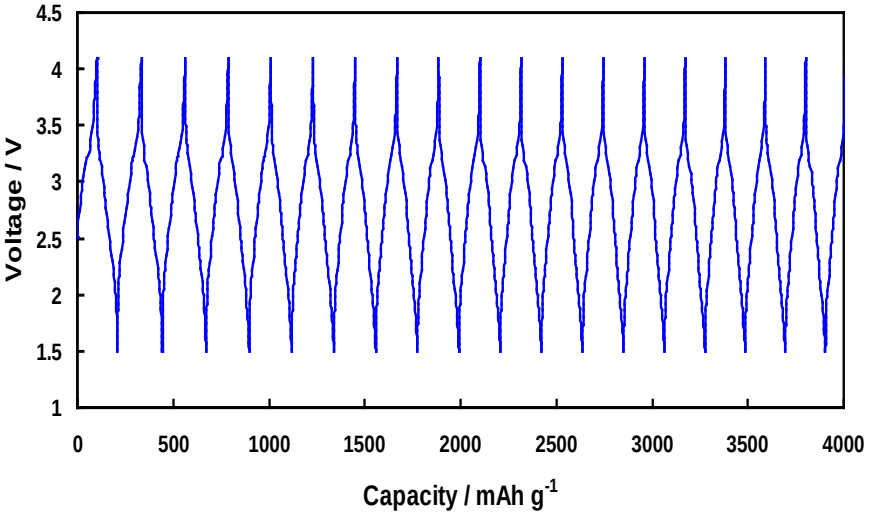
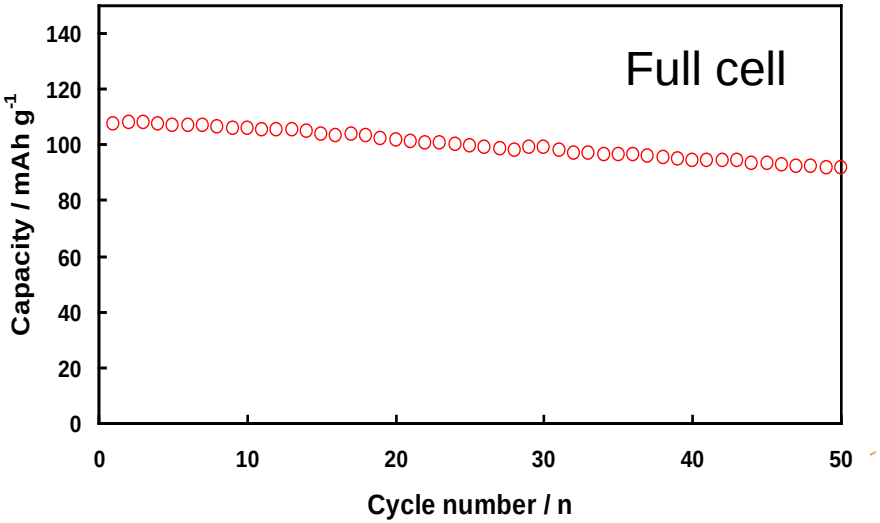
Anode and full cell behavior for Na-ion









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Summary

It is possible to achieve good capacity and stability for room temperature Na ion battery using the appropriate ion transport materials for the cathode and anode.