

# Bat448 - Advanced Electrolyte Supporting 500 Wh/kg Lithium-Carbon/Nickel

# Manganese Cobalt (NMC) Batteries



Date/Time: 6/3/2020 5:30 PM



#### **Project Objective**

Project goal is to develop electrolytes that can form lithiophobic LiF-rich solid electrolyte interface (SEI) on Li anode surface and LiF-rich cathodic electrolyte interphase (CEI) on NMC cathode surface and enable Li/NMC batteries to achieve an energy density of 500 Wh/kg and a cycle life of 1000. The lithiophobic LiF SEI combining with lithiophilic carbon substrate significantly suppresses the Li dendrite and dead Li formation, which enables Li anode to achieve a recorded high Li plating/stripping coulombic efficiency of 99.8% at a current of 0.5 mA cm<sup>-2</sup> and a capacity of 1.0 mAh cm<sup>-2</sup>.

#### Milestones

- 1) All fluorinated electrolytes allow LiNiO<sub>2</sub> to have Coulombic efficiency >99.9% for 1000 cycles. (Completed)
- 2) Cycle life of thick NMC 811, NMC622 and LiNiO<sub>2</sub> in all fluorinated and ionic liquid electrolytes. (Completed)
- 3) Bi@graphite for Li anode with high CE. (Completed)
- 4) Energy density of Li-C@NMC full cells or Li-C@LNO >500 Wh/kg, and cycle life of Li-C@NMC or Li-C@ cobalt free full cells >500 cycles. (On Track)
- 5) Li/LiNiO<sub>2</sub> or Li/NMC811 pouch full cell test. (**On Track**)

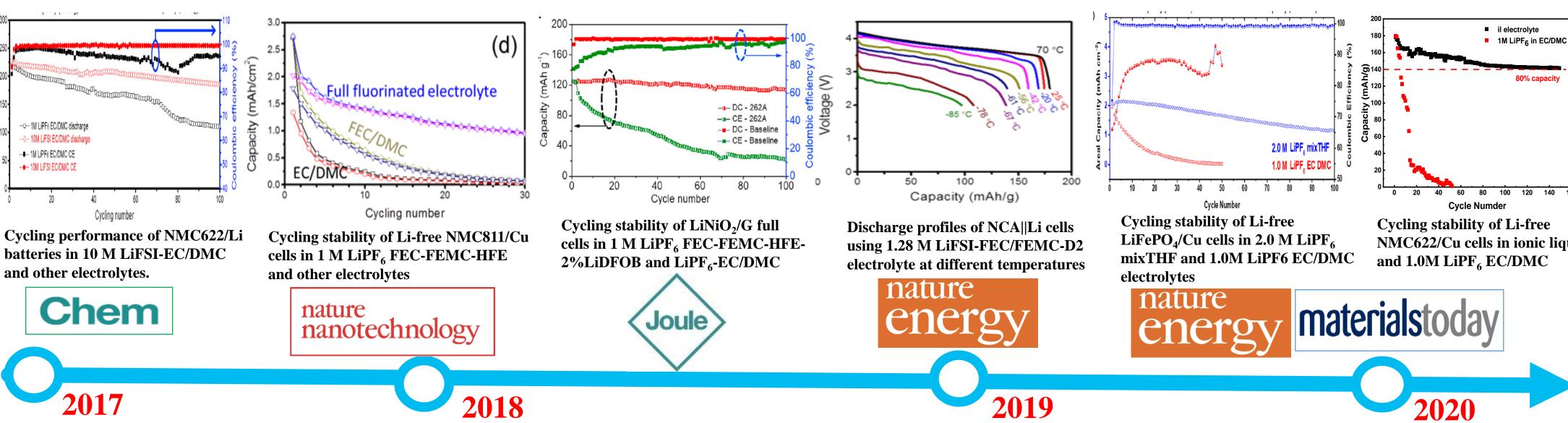
### . Electrolyte Design for High Capacity **Electrodes**

- > The great success of graphite/LiCoO<sub>2</sub> batteries in carbonate electrolytes is attributed to the formation of organic-inorganic solid electrolyte interphase (SEI) on graphite and organic-inorganic cathodic electrolyte interphase (CEI) on LiCoO<sub>2</sub> cathodes. The organic-inorganic SEI and CEI with strong bonding to the active materials tolerate small volume change of graphite and LiCoO<sub>2</sub> cathode.
- For Li and Si anodes and Ni-rich cathodes with a large capacity, a LiF SEI and a CEI with weak bonding to the electrodes are desired, so LiF layer will not deform along with the large volume change of these high-capacity electrodes, thus enabling the electrode to achieve a high Coulombic efficiency.
- > LiF SEI on anode and CEI on cathode can be formed by promoting the reduction of fluorinated inorganic salts, but suppressing the reduction/oxidation of organic solvents through addition of highly fluorinated anti-solvents.

## 2. Research Progress of Advanced Electrolytes

Increasing LiF content in SEI and CEI, and improving cycling Coulombic efficiency

#### Enhancing electrochemical performance



stripping due to

and Li can be stripped entirely before the delithiation of LixSi.

Li depositing on the surface of LixSi that has strong bonding with Li,

1) 10 M LiFSI-EC/DMC: Promoting the reduction of LiFSI to form LiF SEI/CEI

2) 1 M LiPF<sub>6</sub> FEC-FEMC-HFE (2:6:2): Forming LiF SEI/CEI by reducing the solvation energy and solvent reduction using HFE anti-solvent

3) 1 M LiPF<sub>6</sub> FEC-FEMC-HFE - 2% LiDFOB additive: Forming F, B-rich SEI/CEI₁with a stability voltage of > 5.5V

4) 1 M LiFSI FEC-FEMC-D2 (1:2:7): Minimizing the solvation energy and solvent reduction by increasing of D2

mixTHF (1:1) with Bi-Graphite substrate to form a lithiophilic substrate and lithiophobic LiF SEI.

Li Dendrite-free growth

Under Lithiophobic LiF SEI

materialstoda

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Nucleation with Strong

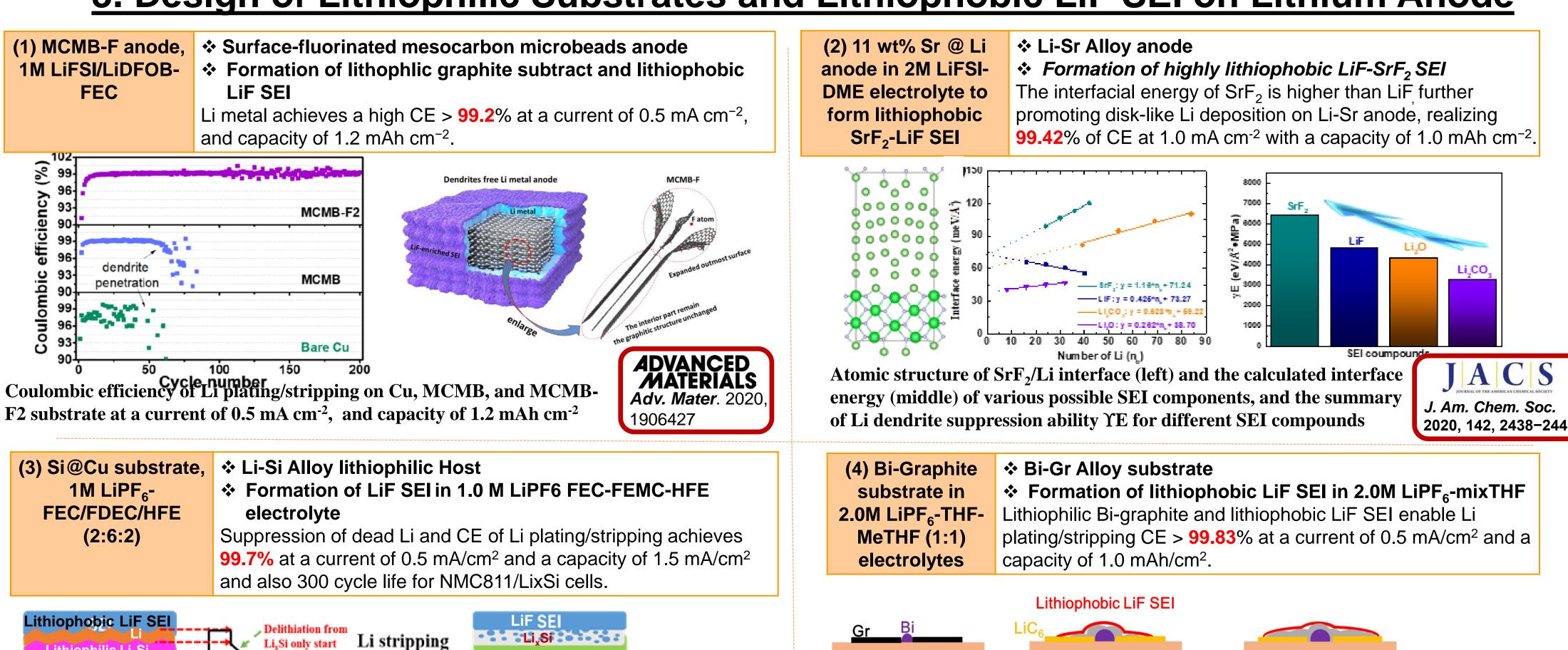
Bonding to Bi-Gr

Lithiophilic Bi-G subtract promotes uniform Li nucleation and

growth, while lithiophobic LiF SEI suppresses Li dendrite growth.

6) Ionic Liquid electrolyte without organic solvents can avoid the formation of inorganic SEI but only LiF SEI

### 3. Design of Lithiophilic Substrates and Lithiophobic LiF SEI on Lithium Anode

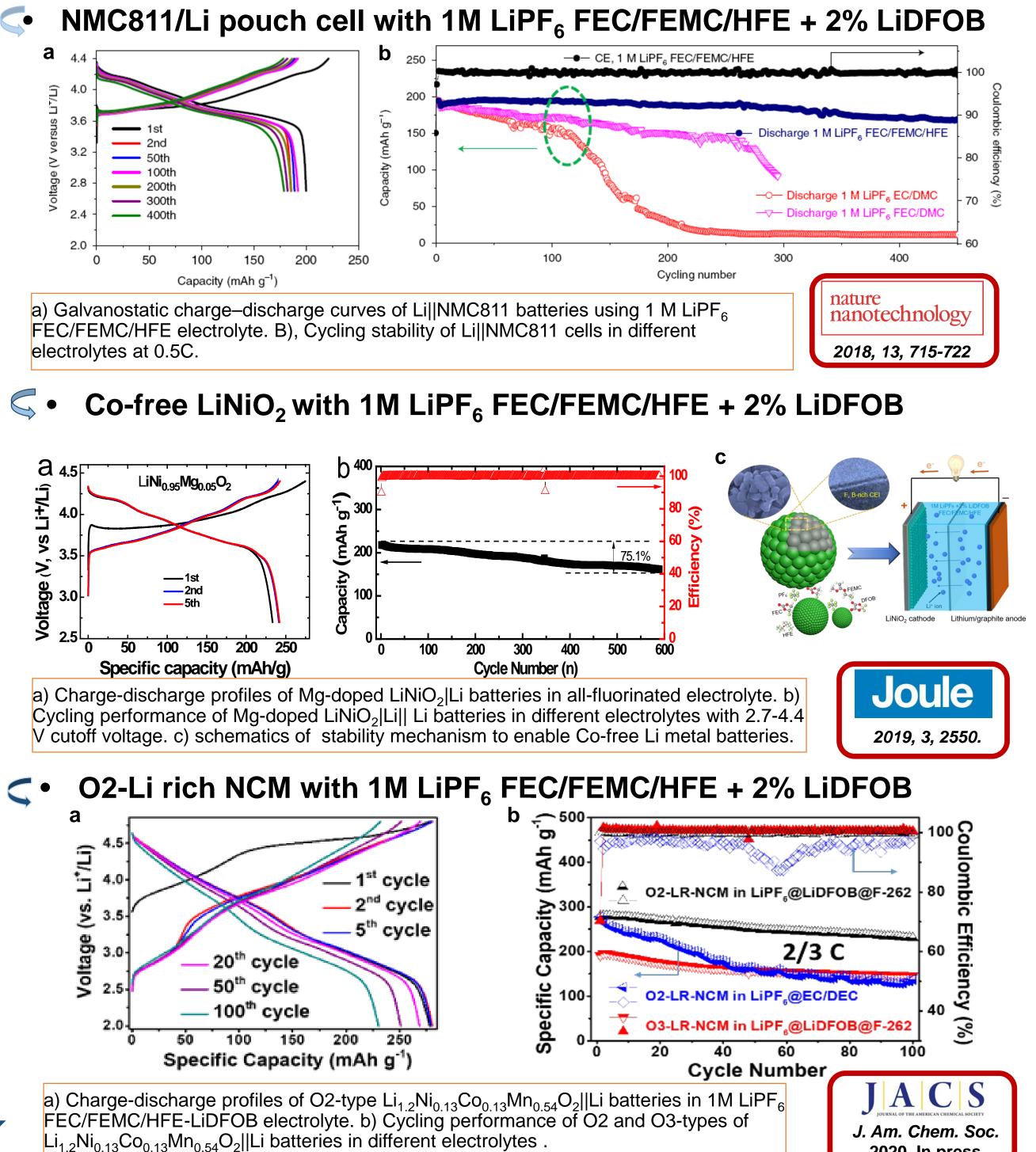


*Joule,* 2019, 3, 732

Lithiophilic Bi-Gr layer

on Cu Foil

# 3. High Performance Ni-rich Cathodes



### 4. References & Acknowledgement

**2020**, In press

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