A Closed Loop Process for the End-of-Life Electric Vehicle Li-ion Batteries

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Project ID #: es293

Overview

Timeline

- Project start date: Feb 2, 2016
- Project end date: Jan 15, 2018
- Percent complete: 10%

Barriers

- Barriers addressed
  - Cost
  - Performance

Budget

- Total project funding: $1,024,740
  - DOE share: $512,370
  - Contractor share: $512,370
- Funding for FY 2016: $344,505

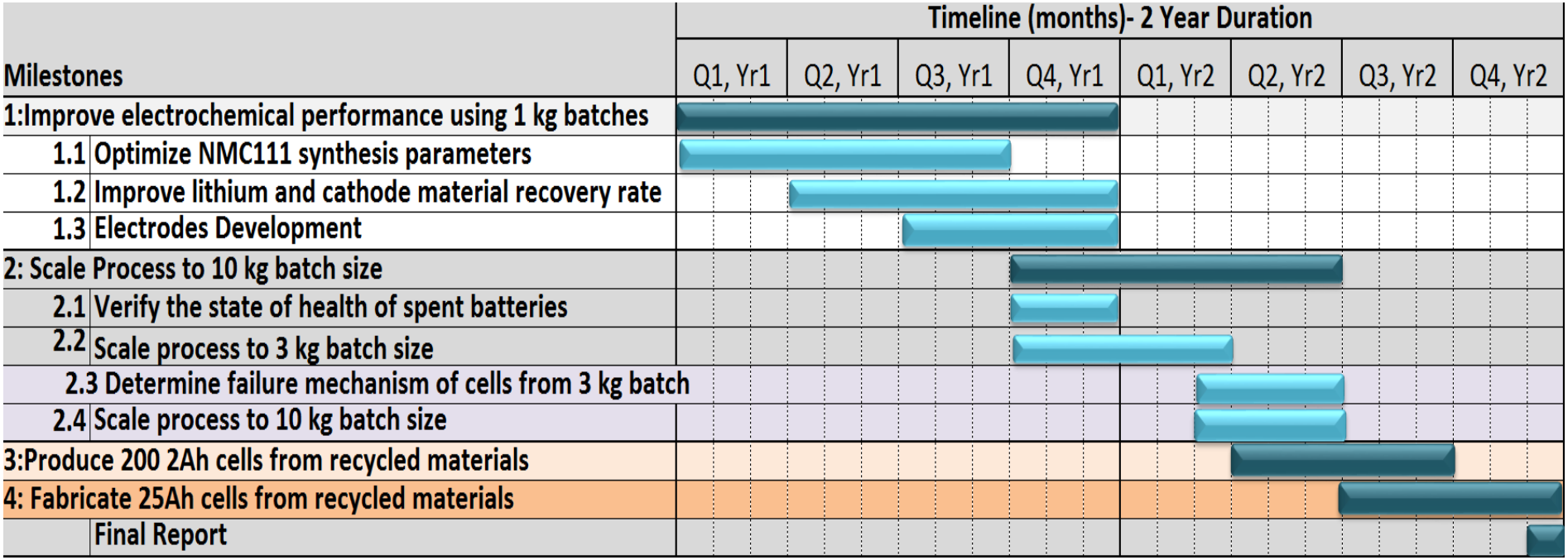
Partners

- Interactions/ collaborations: A123 Systems, Argonne National Laboratory, General Motors, Ford, FCA, SNT
- Project lead: WPI

Relevance and Project Objectives

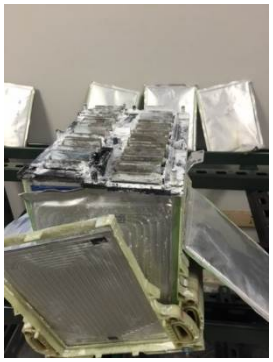
- Recycle multiple 10 kg size batches of end of life EV batteries consisting of different incoming cathode chemistries
- Produce cells of a single chemistry that could be used in a PHEV battery, to be tested according to USABC's PHEV test methods
- Improve the performance of the recovered cathode materials so that they exhibit performance on level with current commercial materials
- Recycle other materials including steel, copper, aluminum, etc.

Milestones


Timeline (months)- 2 Year Duration
Milestones
Q1, Yr1
Q2, Yr1
Q3, Yr1
Q4, Yr1
Q1, Yr2
Q2, Yr2
Q3, Yr2
Q4, Yr2
1:Improve electrochemical performance using 1 kg batches
1.1 Optimize NMC111 synthesis parameters
1.2 Improve lithium and cathode material recovery rate
1.3 Electrodes Development
2: Scale Process to 10 kg batch size
2.1 Verify the state of health of spent batteries
2.2 Scale process to 3 kg batch size
2.3 Determine failure mechanism of cells from 3 kg batch
2.4 Scale process to 10 kg batch size
3:Produce 200 2Ah cells from recycled materials
4: Fabricate 25Ah cells from recycled materials
Final Report

Approach: a Close Loop Process

Spent EV battery pack



Shredded pack

Recovered cathode powder

25Ah

Advantages:

- Any lithium Ion battery
- Any size
- Any shape
- No sorting
- Synthesize new $LiNi_xMn_yCo_zO_2$ directly
- Ratio of Ni, Mn and Co can be specially tailored to customer demands

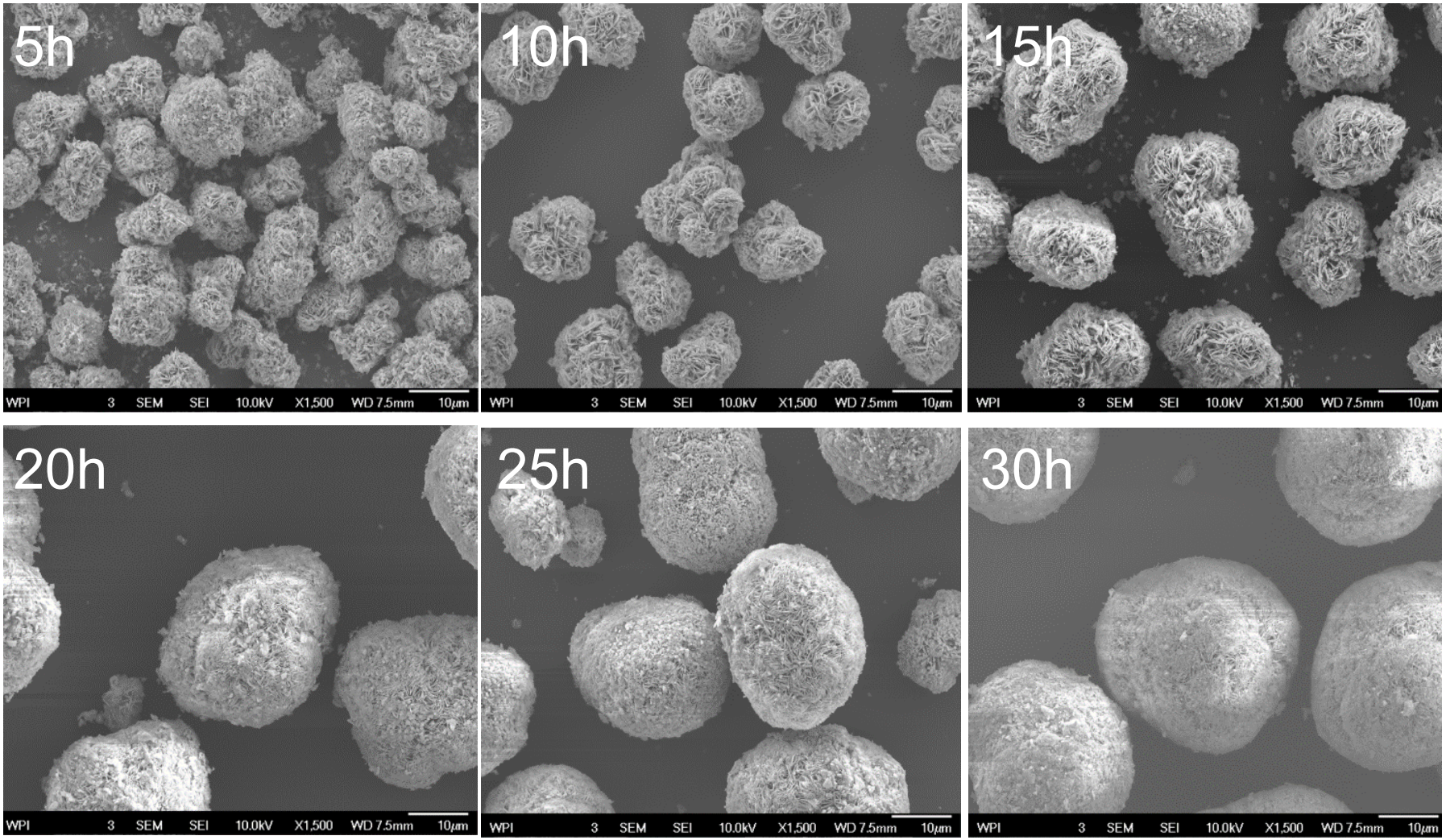
Technical Accomplishment and Progress

pH	Molar ratio of NH_4OH to MSO_4	Stirring speed (rpm)	Precursor tap density (g/cm^3)	Cathode tap density (g/cm^3)
9.8	1	350	0.85	1.44
9.8	0.4	700	1.2	1.9
10.2	1	750	1.03	1.55
10.2	2	750	1.01	1.51
10.8	1	750	0.9	1.49
10.0	0.5	750	1.37	2.02
10.0	1	750	0.98	1.58
10.0	0.25	750	1.58	2.38

All above experiments are conducted with virgin chemicals.

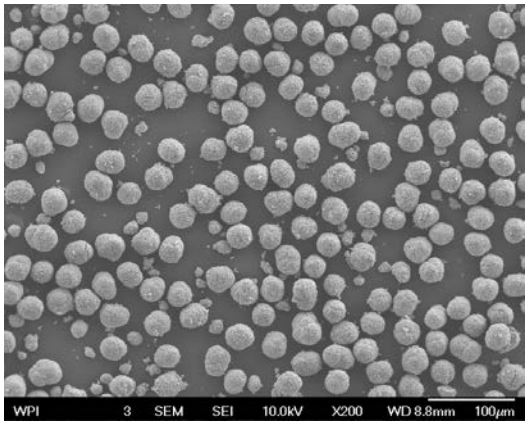
Parameters are optimized to obtain high tap density precursor ($Ni_{1/3}Mn_{1/3}Co_{1/3}(OH)_2$) and cathode ($LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$) powders.

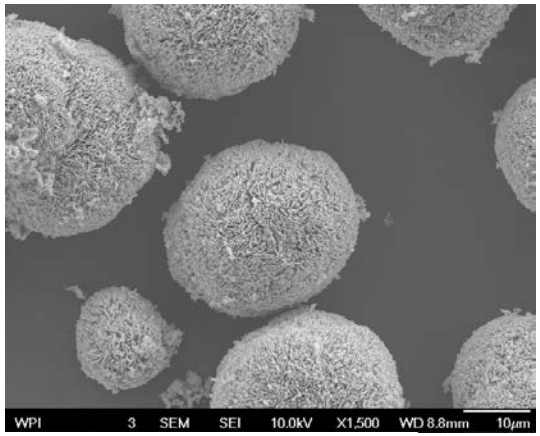
Synthesized $Ni_{1/3}Mn_{1/3}Co_{1/3}(OH)_2$

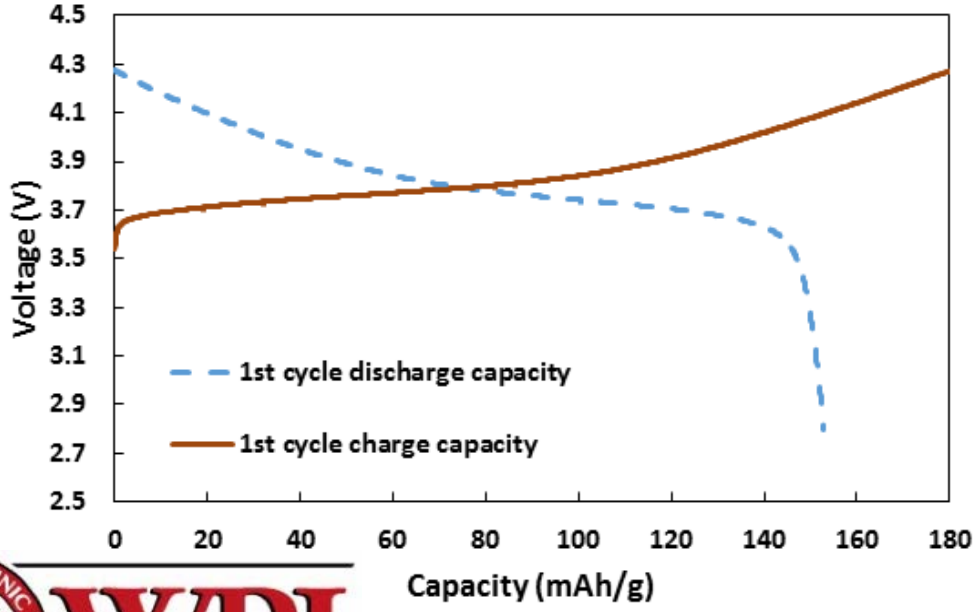


- High tap density, uniform spherical precursor powder.
- With the experimental progress, the particles become spherical.

Synthesized $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ Shows Good Performance



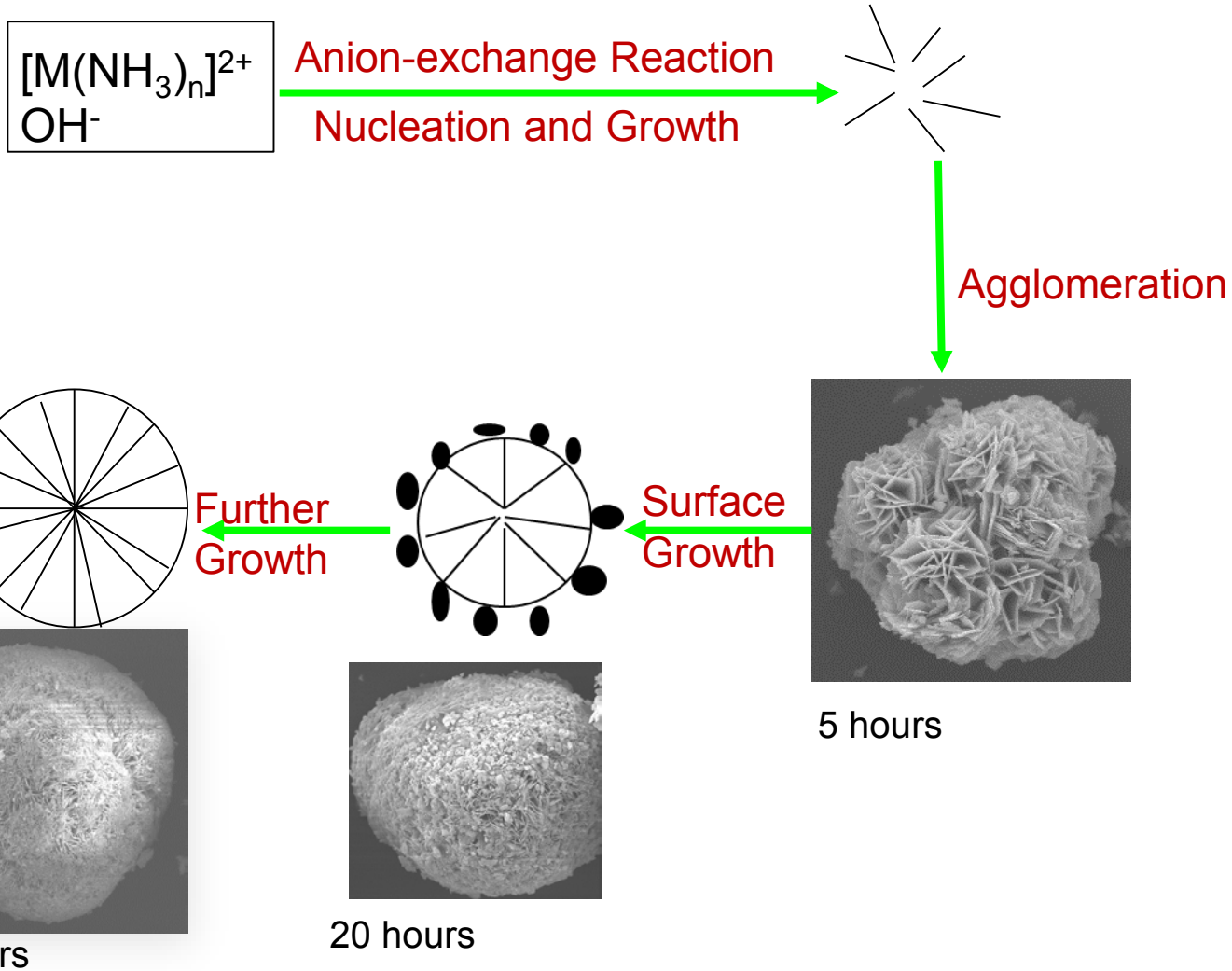




- Highly uniform cathode powder
- Good electrochemical properties

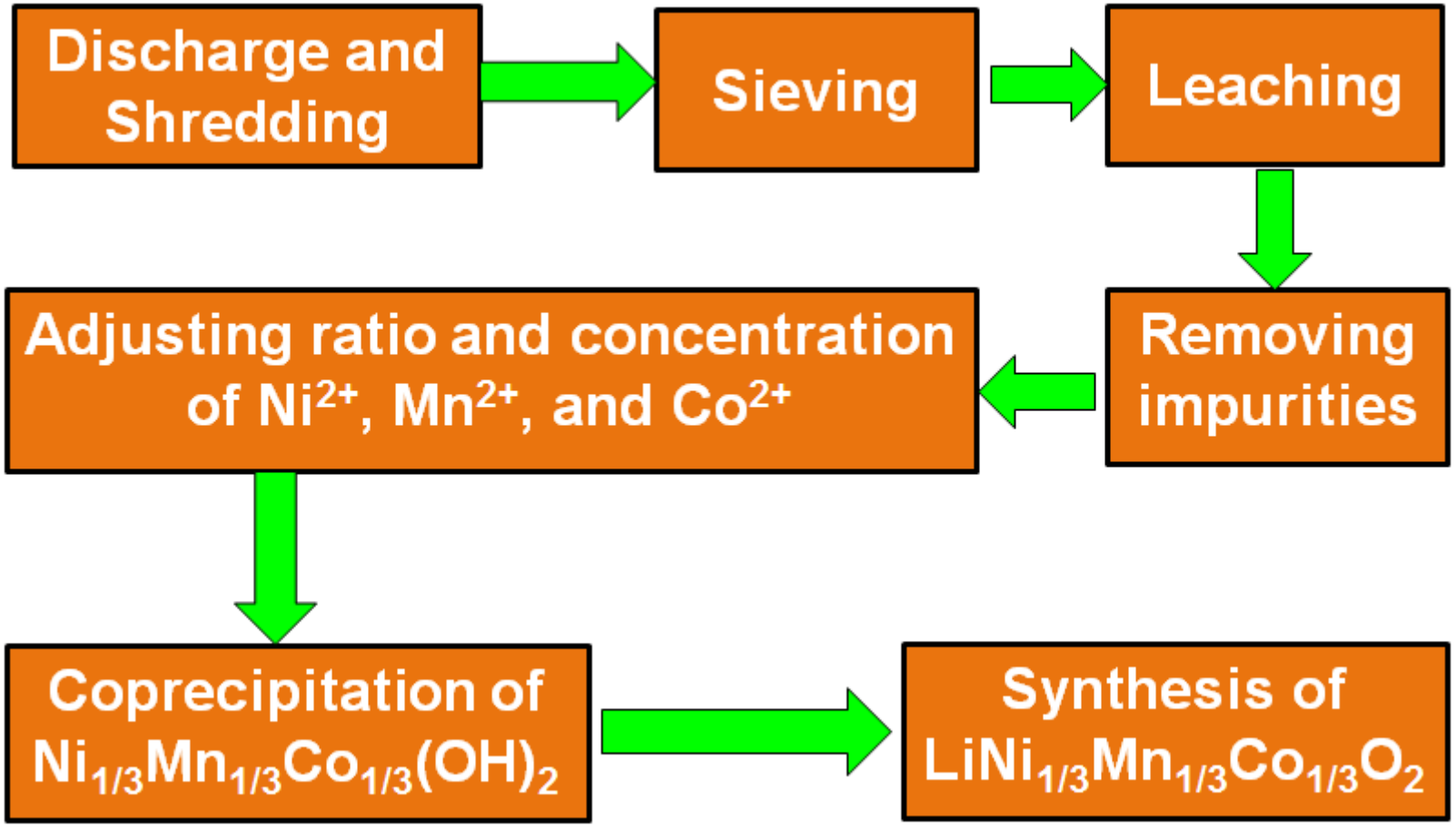
0.1C, half cell

Particle Nucleation and Growth Mechanism



Nucleation and growth mechanism of $Ni_{1/3}Mn_{1/3}Co_{1/3}(OH)_2$ is proposed.

Recycling Process Has Been Developed



Recycling process is developed to offer a close loop process for the end of life EV batteries.

Collaboration and Partners

Fabricate commercial cells

Disassemble EV battery packs

Evaluate cells fabricated with recycled materials

Go Further

Provide battery packs

Remaining Challenges and Barriers

- Cathode material performance is slightly lower than the commercial materials

  Working on the parameters for co-precipitation and sintering

- Recovery efficiency is less than our target (>80%).

  Lithium: optimize the water evaporation and try to use lithium hydroxide to adjust pH number

  Ni, Mn, Co: optimize the pH number

- Scale up

  Scale up the process from 1kg to 10kg

Proposed Future Work

- Compare the discharge methods
- Receive spent GM and FCA EV battery packs from SNT
- Further optimize the precursor synthesis
- Conduct the entire recycling process with GM and FCA battery packs
- Deliver material to A123 Systems for cell fabrication

Summary

- A new technology has been proposed and developed by the researchers at WPI which is capable of recovering $LiNi_xMn_yCo_zO_2$ cathode material.

- The recycling technology offers a close loop process and can recycle Li-ion batteries with any shape, size and chemistry and sorting is not needed.

- $Ni_{1/3}Mn_{1/3}Co_{1/3}(OH)_2$ has been optimized and high tap density, uniform spherical shape particles have been synthesized.

- The synthesized $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ shows promising material and electrochemical properties.