Lithium-Ion Battery Recycling Team-1.1

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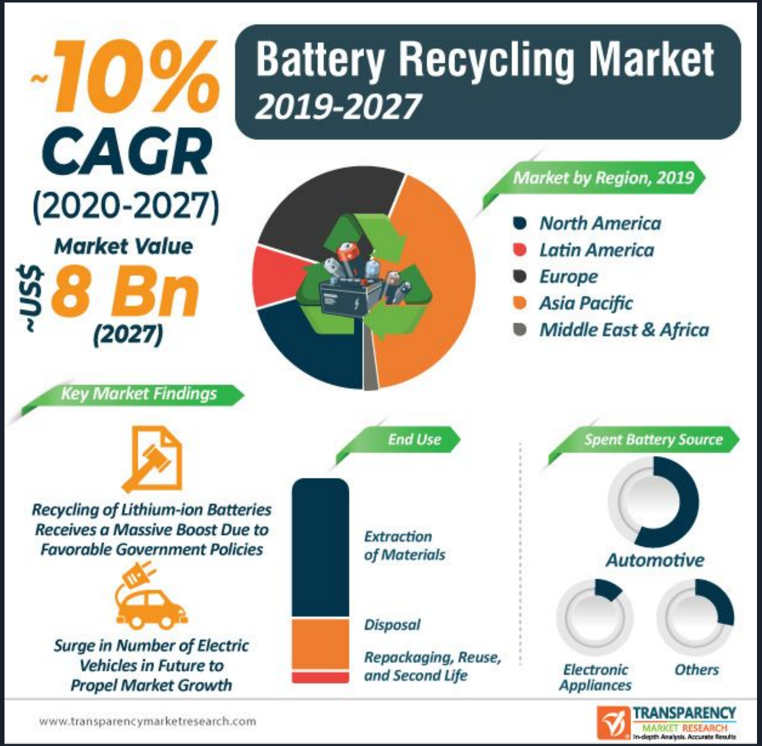
Purpose

- Reduce environmental impact and resource waste.
- Recover spent battery components to be recirculated into fresh batteries.
- Help push clean energy into a more sustainable future.
- Create accurate model to represent battery recycling processes.



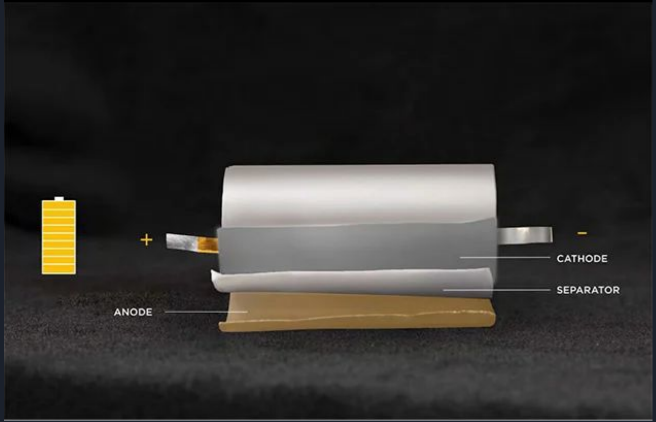
Reference Image: https://www.transparencymarketresearch.com/battery-recycling-market.html

Societal and Environmental Impacts

- On a societal basis, this project would aid in a drive toward cleaner energy by allowing us to reuse and recycle batteries and the means of energy storage.
- The modern electric vehicle greatly reduces our vehicle emissions and cuts our reliance on petroleum.
- With a cost effective processing plant the recycling of the battery packs that fuel them could greatly boost the electric car development and increase the shift toward EV only transportation.
- A large portion of our separation processes were focused on using as few chemical separations as possible, focusing on more mechanical separation to avoid toxic chemical use.

Process Introduction

- Process Design
  - Tesla 4860 dry battery
  - Cobalt-free Li-Ion Battery
- Battery
  - LiNiMnAlO (or NMA) Cathode
  - Raw Metallic Silicon Anode
  - Steel Casing
- Sizing of Plant
  - Designing for 10,000 metric tons per year
  - Plant design easily scalable linearly



Reference Image: https://eepower.com/new-industry-products/teslas-4680-a-cobalt-free-silicon-battery-solution/#

Inerting

- Nitrogen Inerting
  - Storage container containing specialized equipment
  - Batch inerting
  - Goal of process is to decrease human interaction as much as possible
- Cryogenic freezing
  - Freezing batteries will fully deplete battery

Reference Image: https://www.denios-us.com/storage-process-technology/technical-and-safety-buildings/li-ion-battery-storage-testing-building/

Shredding

- Knife System
  - Shreds to specified size
  - Cooling veins to decrease chance of combustion
- Filter after Shredding
  - Filter size to 250 microns to ensure proper separation
  - Large particles will be routed back through shredder

Reference Image: https://www.wastetodaymagazine.com/article/lithium-ion-battery-shredding-recycling-bca-low-torque/

Material Separations

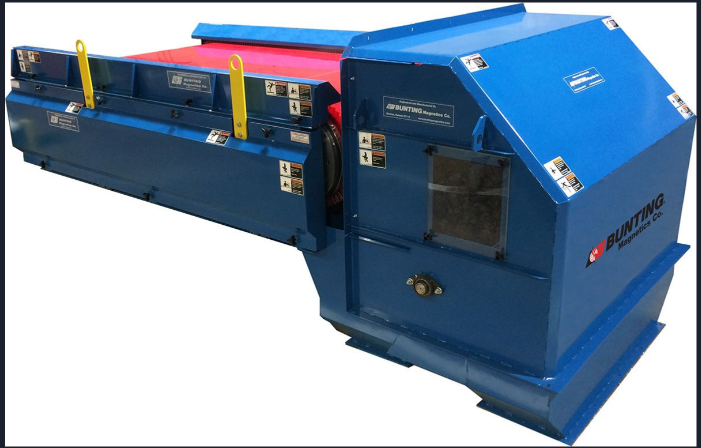
- Once materials have been sufficiently broken down to a micron level, separation of those materials can begin to gather recyclable materials into individual streams.
- Two primary processes for separating desired components from material stream.
- Ferrous metal separation via magnetic drum separation.
- Non-Ferrous metal separations through an eddy current separation process.

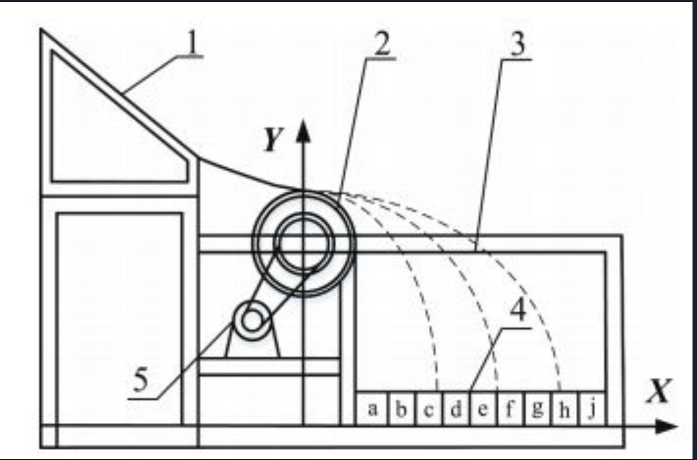
Magnetic Separation

- Steel being the only ferrous metal in the process stream.
- Magnetic drum rollers at the end of a conveyor will separate out the steel particles.
- Steel will cling to the drum roller until it passes the magnetic portion and fall onto a collection belt below while the other materials travel further on to a belt to proceed further separation.

Eddy Current Separation

- Eddy currents are an effect produced from magnetic fields inducing a current into the metal particles.
- Each of the non-ferrous metals has a slightly different level of conductivity/density ratio, magnetic induction, and particle size causing them to travel slightly different distances coming off an eddy current drum.
- This allows us to calculate the distance each metal will travel given our system parameters and collect specific metallic components without the use of solvents, solutions, or any invasive separation process.
- Eddy Current Separations with modern machinery and techniques can provide separation efficiencies between 85% and 97% depending on various system settings and material properties.





Leaching Process

Leaching Acid

Deep eutectic acid dissolves cathode into solution

Reducing agents allow the cathode to act as lewis base that balances charge as new bonds are formed

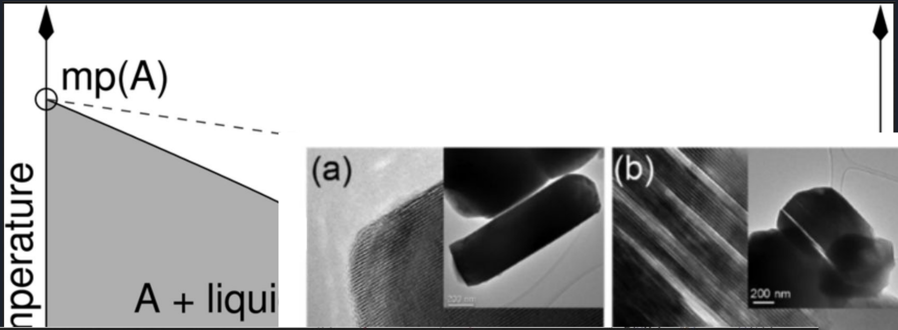
Citric acid and hydrogen peroxide

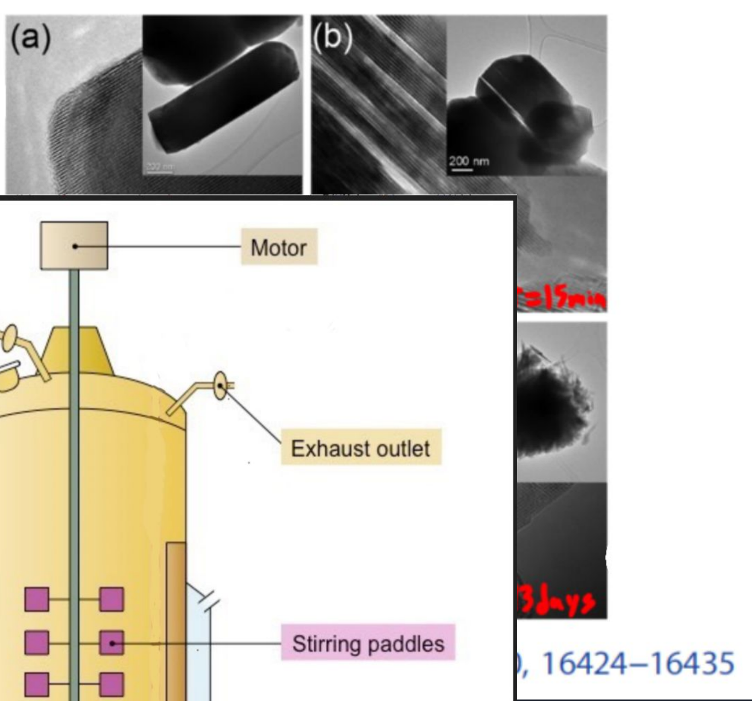
Cheap, widely available, NONTOXIC

~100% Efficiency of dissolution

Reactor

Currently in development - Batch Reactor





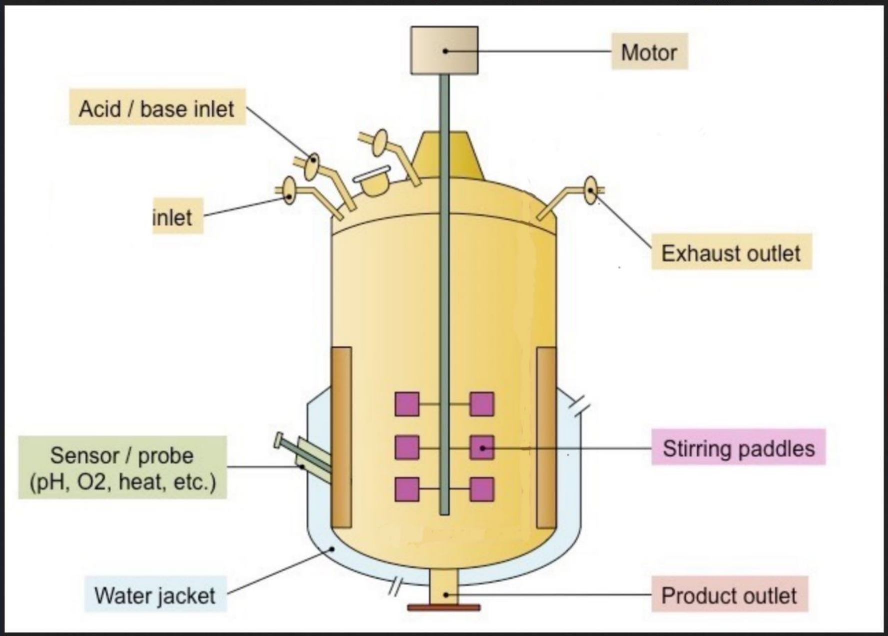


Photo references: Phase eutectic chart
Electron Microscope image of nanostructure in dissolution
Batch reactor example

Precipitation

Selective precipitation to remove ions can involve evaporation, pH control, or salt precipitation

Here pH controlled precipitation using NaOH produces metal hydroxide products

Lithium is precipitated by sodium carbonate

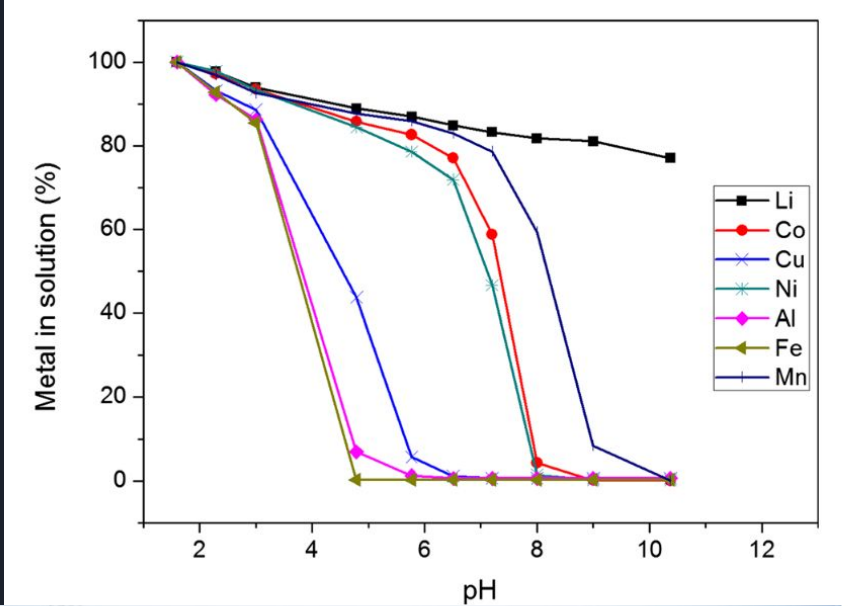


Photo references: pH chart
Metal hydroxides

Recovery and separation

With the target metals in solution, a series of filters and a controlled release of sodium hydroxide and sodium carbonate precipitate and can be collected in separate pressed cakes.

Al/Fe cake

Co,Ni, and Mn cake

Lithium carbonate

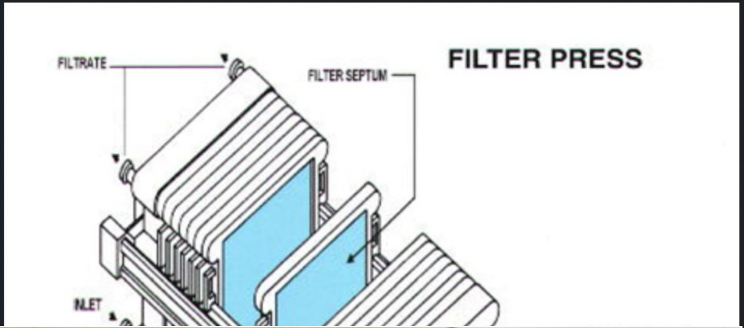


Image references:
https://www.perlite.org/filtration/

http://oilfieldpix.com/photo/679/Mud-filter-cake.html

Conclusion

- An efficient and relatively non-toxic separation of materials.
- A design to recycle and reuse spent battery components in a rising market.
- Adaptable plant design that can be adjusted for multiple battery types.
- Increase in sustainability for EV and clean energy storage.