Developing sustainable synthetic routes to lithium-ion battery electrodes

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UC SANTA BARBARA MATERIALS

Batteries meet the demand for energy storage

Applications

Benefits

- Reduce effects of global warming
- Portable energy
- High charge efficiency (~99%)
- Long service life

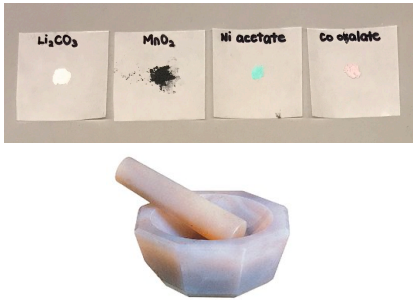
Problem

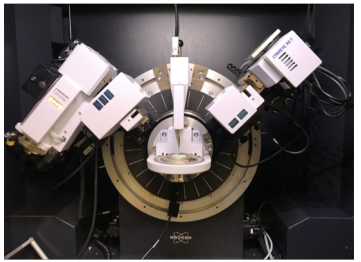
Battery system **energy cost must be reduced from $400-600 to $125 per kW/h** to support electric vehicle commercialization.

D.L. Wood III et al., *J. Power Sources*, **275**, 234-242 (2015).
K. J. Rao and P. D. Ramesh, *Bull. Mater. Sci.*, **18**, 447-465 (1995).

How are battery materials synthesized?

Optimization of Material





Weigh & Grind Reagents

Prepare reagents based on computed ratios and grind to ensure homogeneity

Pellet Press

Compresses reagents into a pellet to support crystallization

Tube Furnace

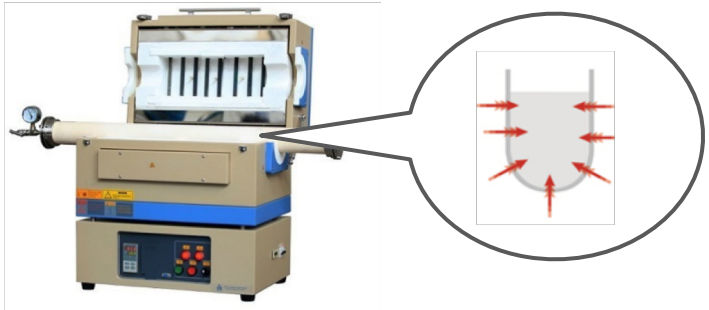
Heats material to 1000 °C for 20-30 hours to form crystalized material

X-Ray Diffraction (XRD)

Gives information on the 3D structure and composition of the material

How can battery cost be reduced?

Conventional



- Surface-to-core heating
- 20-30 hours
- 6-8 kW/h

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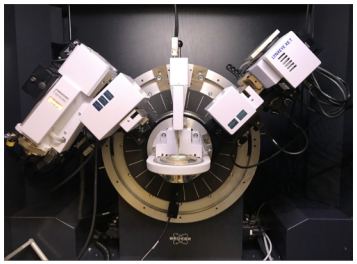
Microwave

- Homogeneous heating
- 10-15 mins
- 0.25-0.5 kW/h

How is microwave synthesis determined complete?

Optimization of Material



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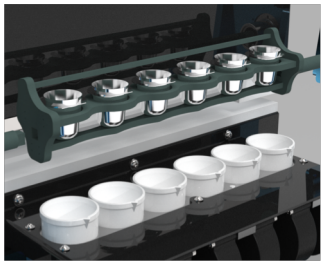
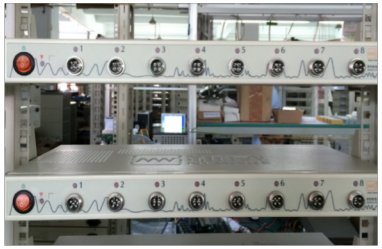


Atomic Emission Spectroscopy (AEP)

Quantifies material composition more precisely

Nuclear Magnetic Resonance (NMR)

Shows accurate material structure

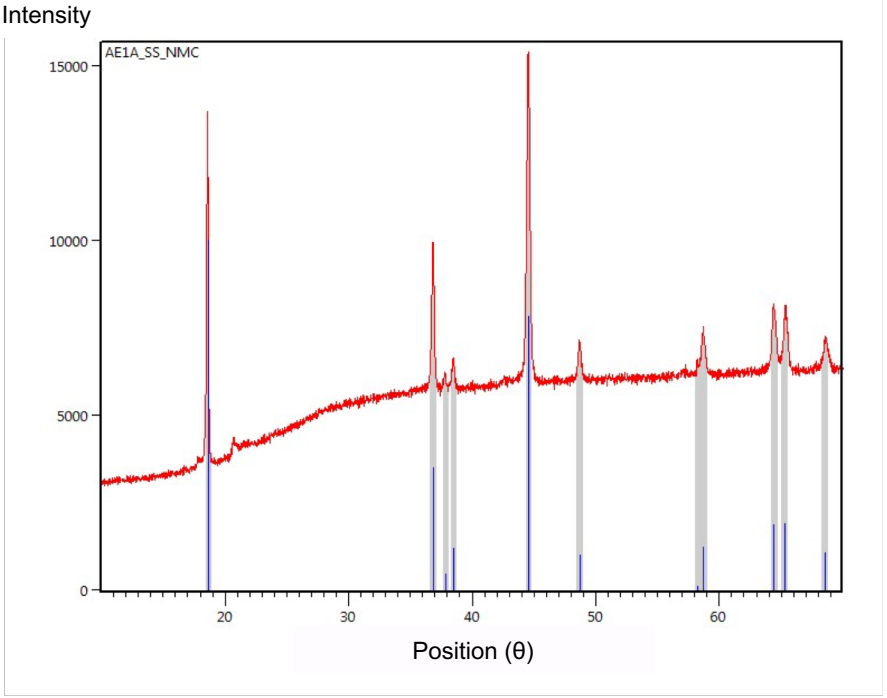


Battery Cycler

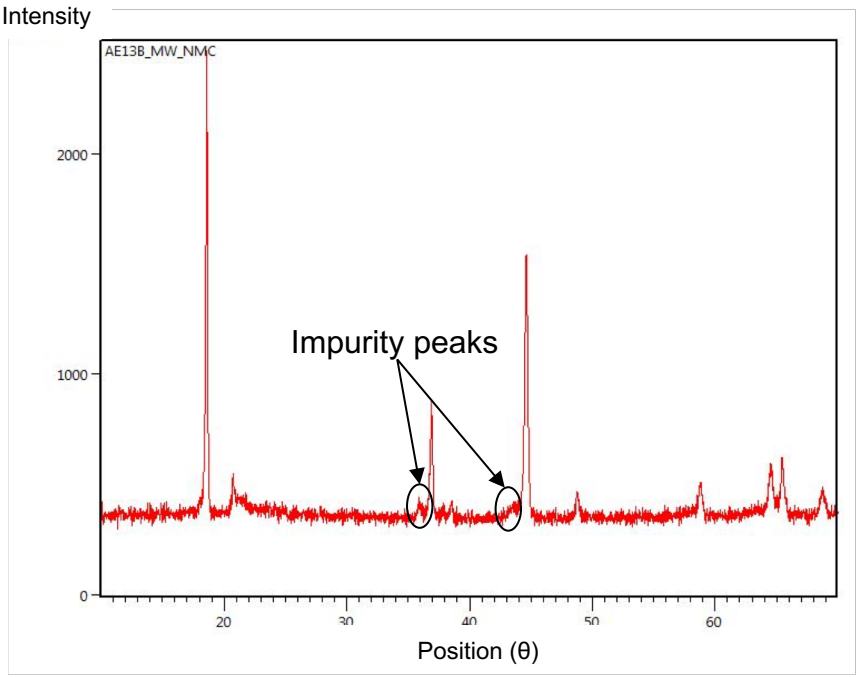
Determines electrochemical properties of material

Microwave synthesis of a battery material shows issues with phase purity

Conventional XRD



Microwave XRD



Peaks show structure of material, combination of peaks estimate composition of material

Microwave synthesis is a promising method to reduce battery costs

Through microwave synthesis...

- Nearing phase purity
- Reduce energy consumption significantly
- 120x faster creation of battery materials

In the future...

- Further characterization using AEP and NMR
- Battery performance testing and comparison
- Tesla for everyone!

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