PAUL SCHERRER INSTITUT

ELECTROCHEMISTRY LABORATORY

BATTERIES

New composites for lithium-sulfur batteries

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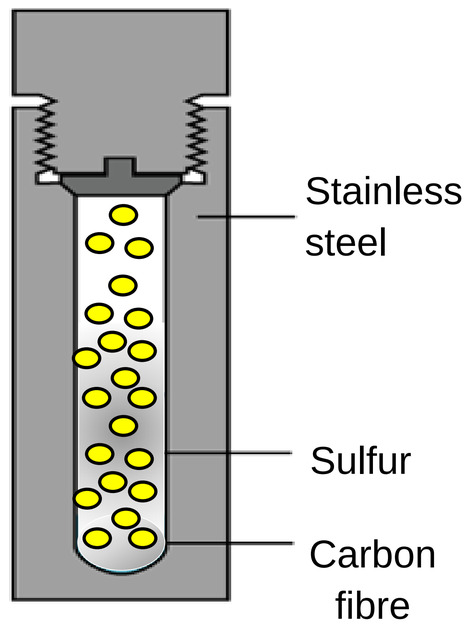
Properties & Challenges

- **Lithium-sulfur batteries, properties:**
  - Safe, low-cost, high energy density
  - Insulating sulfur particles
  - Theoretical specific charge 1675 mAh/g of sulfur
- **Lithium-sulfur batteries, challenges:**
  - Improve the conductivity
  - Suppress polysulfide shuttle

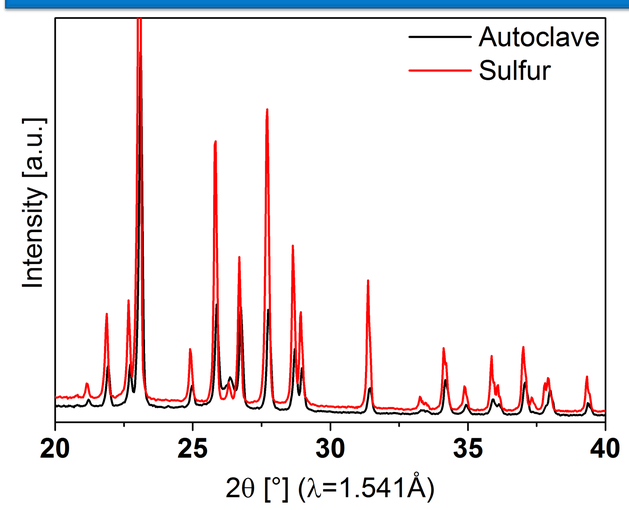
Synthesis

- Autoclave
- Carbon fibres
- Sulfur refined (>70%)
- 24 h
- 125ºC

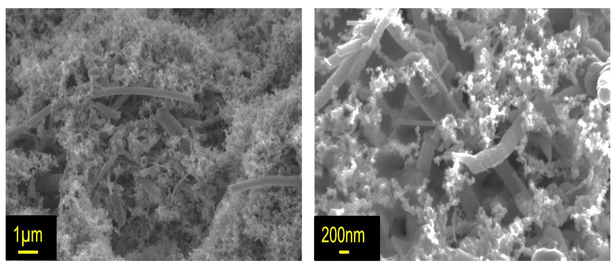


Easy to synthesize

Bulk characterization



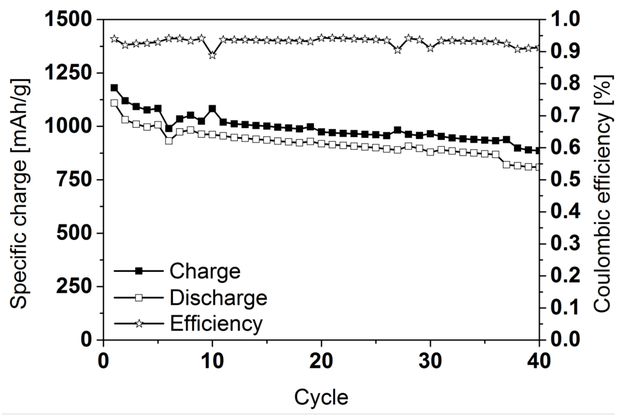
No structural modification



Carbon network around sulfur

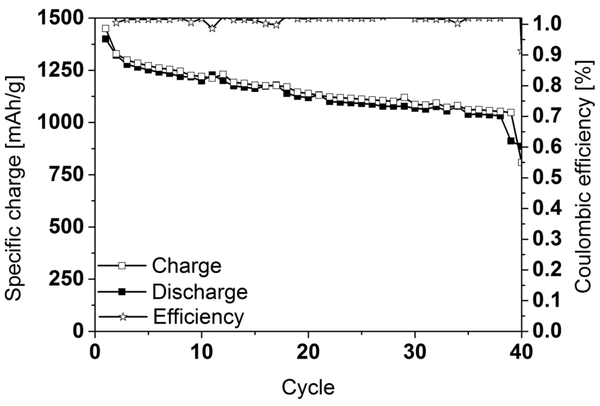
Perfect conductive network around sulfur particles

Electrochemical behavior



Reference sample

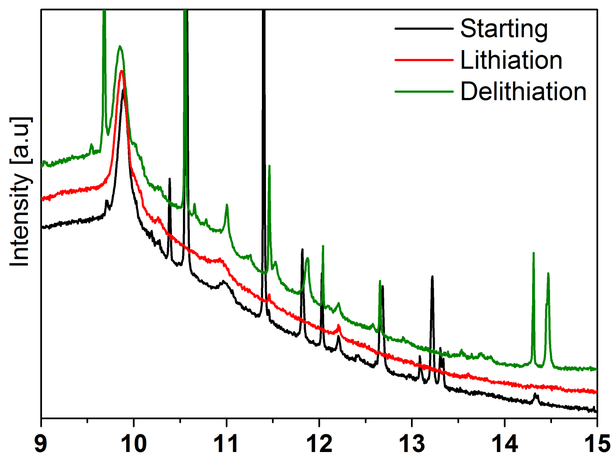
Specific charge ~ 1000 mAh/g
CE ~ 90%



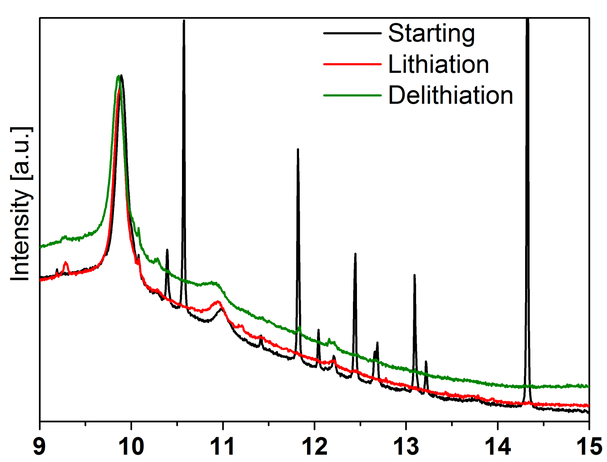
Composite sample

Specific charge ~ 1250 mAh/g
CE ~ 100%

High resolution *in situ* XRD



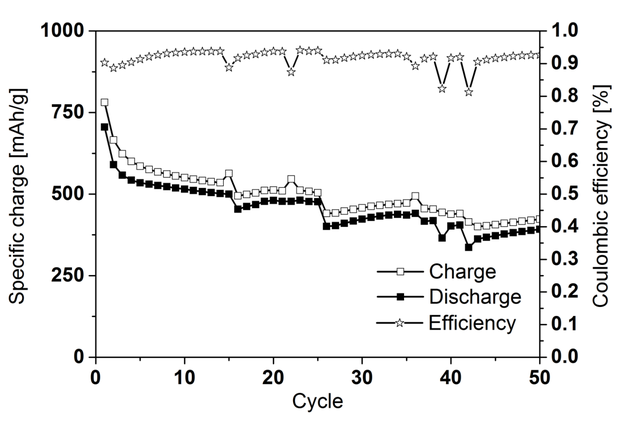
Reference sample

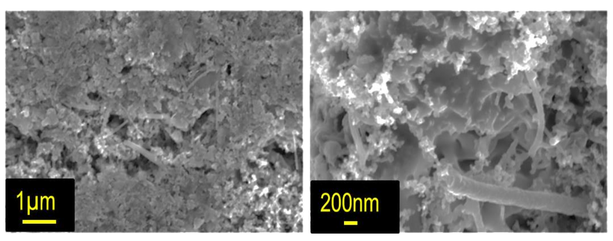


Composite sample

Small shift on delithiation→ β-sulfur phase

Aging after 3 months





Surface alteration

Decrease of efficiency

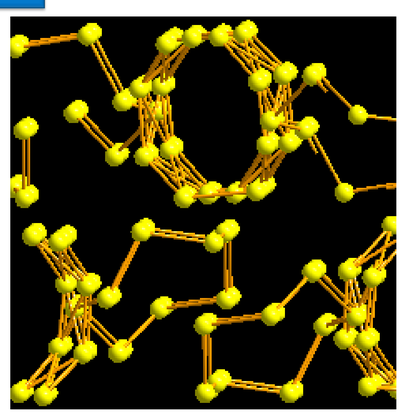
No alteration of the bulk

Half of the specific charge loss in 3 months, storage in the air

Structure of β-sulfur phase

Phase	a (Å)	b (Å)	c (Å)	β (˚)	Space group
α-Sulfur	10.48	12.92	24.55	/	Fddd
β-Sulfur	10.92	10.85	10.79	95.92	$P2_1/c$

- β-Sulfur phase only stable at 95˚C
- Density of the material 1.94 g/cm^3
- 12% smaller than the α-sulfur phase



β-Sulfur

Conclusions

Sulfur/composite electrode:

- Easy and fast to synthetize
- Perfect conductive network around the particles
- Specific charge up to 1200 mAh/g
- β-Sulfur phase identified during cycling

Acknowledgments

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