Highly microporous carbon aerogels encapsulating sulfur as cathodes for lithium-sulfur batteries

**INTRODUCTION**

Carbon aerogels (CAs) are highly promising materials as matrices for sulfur to act as cathodes in metal-sulfur batteries. Resulting from organic resorcinol-formaldehyde aerogels, CAs exhibit highly porous structures with porosities up to 97%, high surface areas of about 500-2000 m²/g, large pore volumes of about 0.1-2.5 cm³/g, and significant electrical conductivities of about 80-150 S/m. Additional important advantages of CAs are their tunable porous structures and pore size distributions. Their microstructures are adjustable during the synthesis of organic aerogels and their subsequent carbonization. Moreover, the elastic compressibility of CAs prevents the formation of cracks as a result of changes to the sulfur volume.

**SYNTHESIS**

Carbonization conditions: Ar: 1 h, 1000°C. Argon atmosphere N₂/CO₂: 5 h, 800°C, N₂ atmosphere

**MICROSTRUCTURE**

Two-step infiltration process:
1. Gas Phase Infiltration
   - 600°C (6h) under vacuum in a sealed glass ampule
   - evaporated sulfur enters the micropores (>2nm)
2. Evaporation of excessive sulfur from aerogel surface
   - 300°C (1.5h) under argon in glass tube with condensation trap
   - increases electrical conductivity of carbon
   - prevents undesired reactions with electrolyte

**PERFORMANCE**

- Electrolyte 1: 1M LiTFSI (lithium bis(trifluoromethylsulfonyl)imide) in DOL/DME (1.3-dioxolane / dimethoxy ethane), 25°C
- Electrolyte 2: 1M LiPF₆ (Lithium hexafluorophosphate) in EC/DEC (ethylene carbonate / diethylene carbonate), 25°C
- Sulfur-loading: 0.7–0.8 mg/cm²

**CONCLUSION**

- Synthesis of the CAs with controlled and defined pore sizes and structures
- Increased surface area due to carbonization with N₂/CO₂
- Increased micropore volume in aerogel structure due to carbonization with N₂/CO₂
- Infiltration of short chain sulfur in the micropores through gas phase process
- Higher sulfur loading in CA (N₂/CO₂) due to higher micropore volume
- Higher cyclability of the Li-S cell via the encapsulation of sulfur in carbonate- and ether-based electrolytes