Novel and Functional Carbon Aerogel Networks by Templating with Polystyrene Latex Spheres

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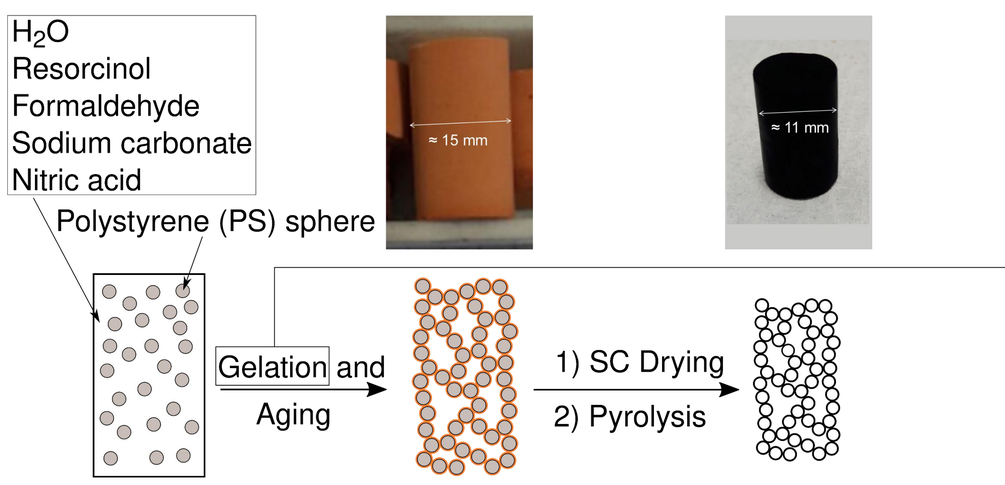
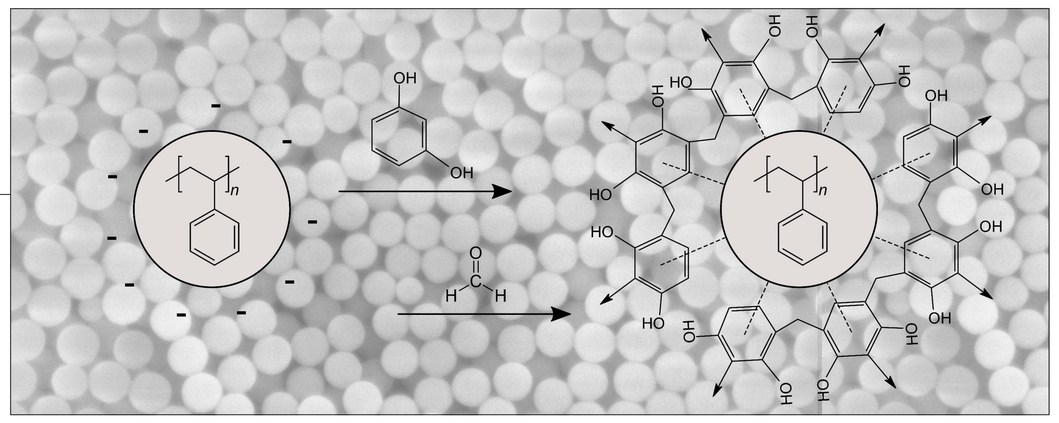
Introduction and Motivation

• Carbon aerogels are synthetic materials (typically produced by a sol-gel process), with low densities (0.01 – 0.1 g/cm^3), high porosities (up to 99%) and surface areas (500 – 2500 m^2/g). Due to their electrical conductivity in addition, they are used in high tech energy storage applications, e.g. electrodes in supercapacitors, Lithium-ion batteries or fuel cells, catalyst supports or capacitive desalination and separation systems. [1]
• Typically, carbon aerogels are composed of a microstructure of irregularly shaped, interconnected bead-like chains [1]
• This work introduces a new and unique microstructure for freestanding and monolithic carbon aerogels by templating with polystyrene nanospheres: a microstructure built-up of homogeneously sized hollow spheres (“nanocapsules”), which we describe with the term “spherogel”.
• This new approach yields a uniquely homogeneous and tailorable (sphere thickness and size) aerogel microstructure, improved capacitance and cyclability in electrochemical tests compared to pristine carbon aerogels as well as the possibility to incorporate species into the carbon network. [2,3,4]

Synthesis





* with the potential for PS or resorcinol functionalization for hybrid materials

Results

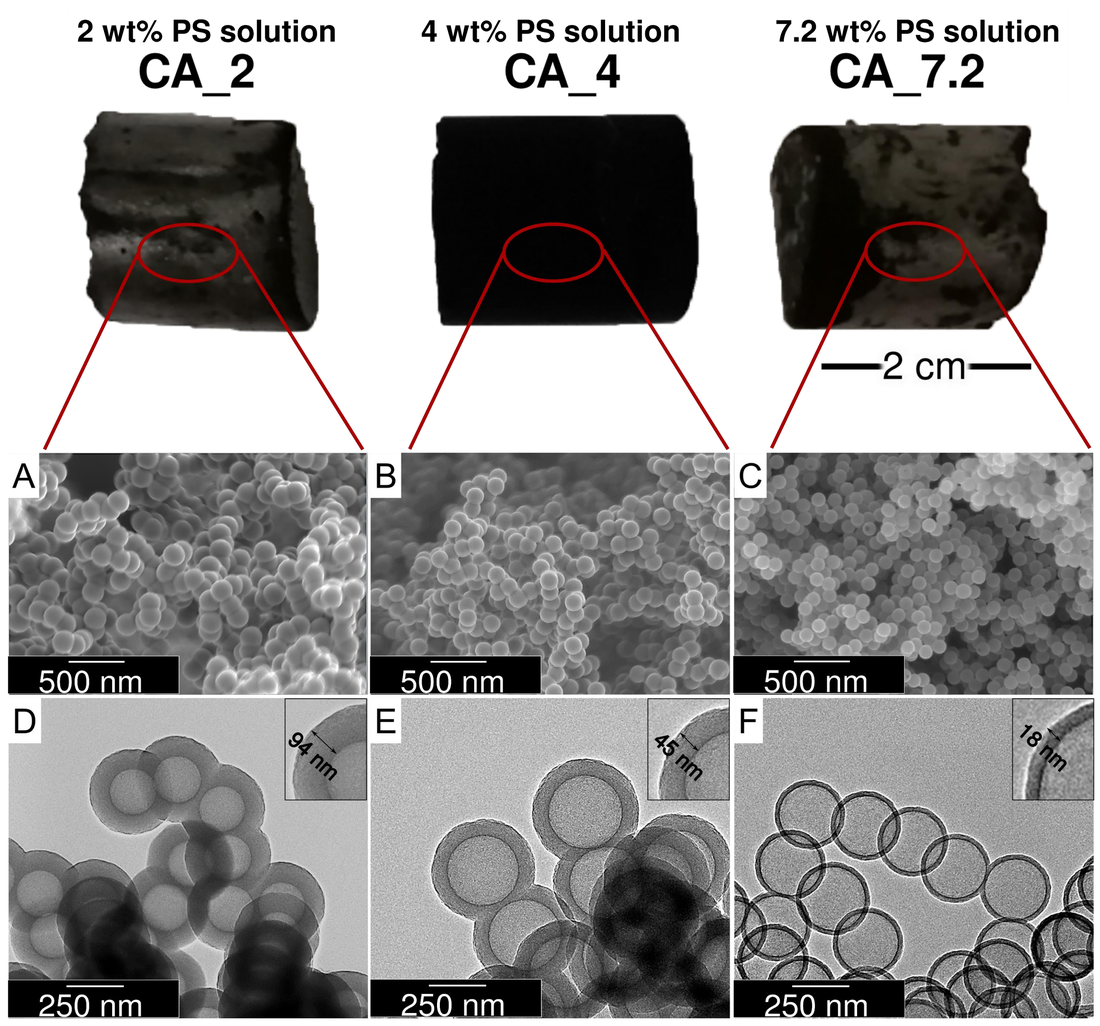


Fig. 1. Scanning electron micrographs (SEM) (**A,B,C**) and corresponding transmission electron micrographs (TEM) (**D,E,F**) of polystyrene-templated carbon spherogels with 2 wt% (CA_2), 4 wt% (CA_4), and 7.2 wt% PS solution (CA_7.2) as the templating agent. [2]

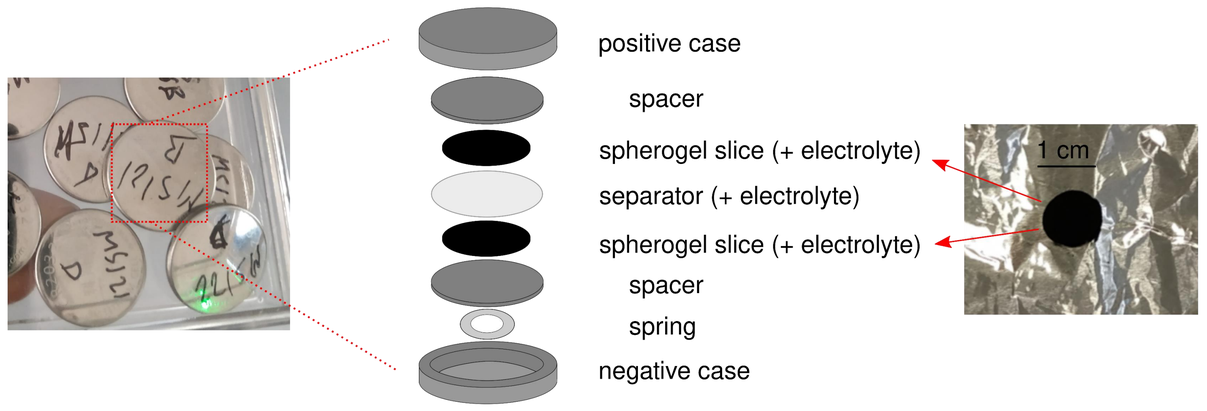


Fig. 2. Direct application of a carbon spherogel sample as the electrode material in a supercapacitor. Results show increased capacitance (up to 30% beyond 100 F/g) measured at a high current density (10 A/g) compared to pristine carbon aerogels. [3]

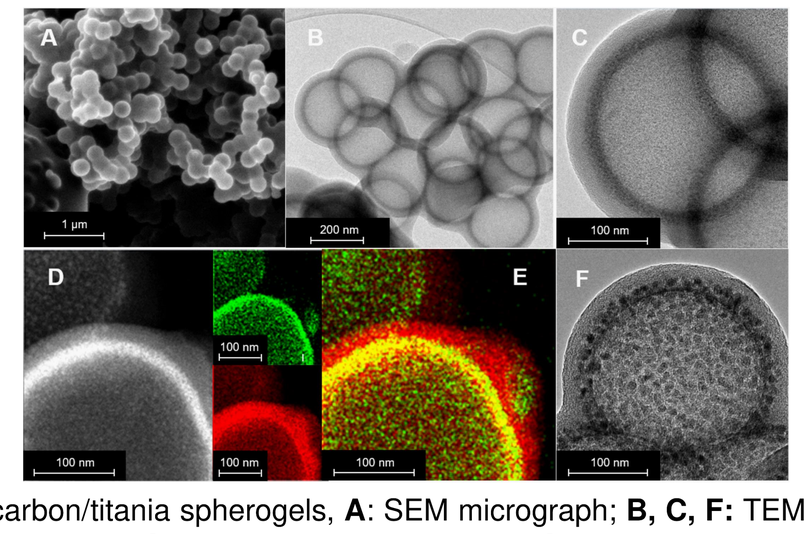


Fig. 3. Hybrid carbon/titania spherogels, **A**: SEM micrograph; **B, C, F:** TEM micrographs. **C** was carbonized at 800°C, **F** was carbonized at 1100°C, showing the formation of rutile/ anatase crystallites (size: approx. 25 nm)
D, E: STEM EDX images: green: titanium, red: carbon; yellow color due to overlap of green and red right side [4]

Conclusions and Outlook

• Sphere templating with polystyrene is a powerful strategy to tailor the morphology and pore structure of unique freestanding and monolithic carbon aerogels built-up of hollow spheres which show improved electrochemical performance ("spherogels").
• Outlook: further investigations on the relationship of morphology to electrochemical behavior or mechanical properties, and fabrication of hybrid carbon spherogels. Further research for different applications in energy storage systems (e.g. fuel cells, batteries).

References
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Freestanding and Monolithic Carbon Spherogels as Electrode Materials for Supercapacitors (publication in preparation)
[4] M. Salihovic, G.A. Zickler, G. Fritz-Popovski, A. Cherevan, N. Hüsing, M. S. Elsaesser. *(publication in preparation)*

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