High Surface Area, Inorganic Composite Aerogels Produced by Room Temperature Freeze Casting

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Ultra-low density, highly-porous aerogels of 2D materials are promising electrodes for electrochemical energy storage. We have recently developed the production of such materials through the temperature freeze gelation (RTFG) in which the 2D material is dispersed in a solvent above its melting point (typically 80 – 120 °C) and cooled to form a solid at room temperature [1]. The solvent (e.g. camphene) is selected to have a high vapour pressure above the solid at room temperature and thus rapidly sublimes at room temperature under ambient atmospheric conditions, leaving a porous solid of the original material (Figure 1). The key advantages of this route over conventional aqueous freeze casting are that it allows the production composite aerogels of all 2D materials (e.g. BN, TMDs, graphene) and the solid can be formed through conventional techniques such as 3D printing, injection moulding and extrusion.

The pristine graphene aerogels produced had a conductivity of 10 S/cm at a density of just 20 mg/cm^3. For use in energy storage, it was found that the addition of nanotubes to the 2D materials led to a higher surface area aerogel. Graphene oxide-nanotube composite electrodes gave the highest capacitance at low scan rates, whereas the more conductive graphene nanotube electrodes performed better at higher rates (Figure 2.)

We have recently shown that MoS_2-graphene electrodes give higher capacitance than the corresponding MoS_2 or graphene electrodes [2]. We will show how this phenomenon extends to the aerogels to give high performance, composite graphene-TMD capacitors.

References

[1] Y. Lin, F. Liu, G. Casano, R. Bhavsar, I. A. Kinloch, B. Derby, Advanced Materials, 36 (2016) 7993
[2] M. Bissett, I.A. Kinloch, R. Dryfe, ACS Appl. Mat. Interf., 7, 17388

Figures

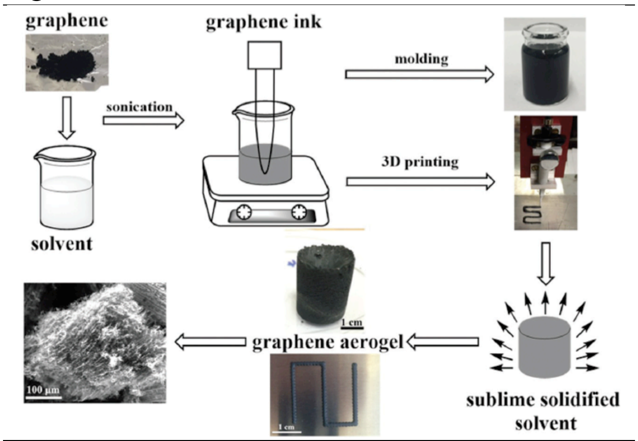

Figure 1: The room temperature freeze gelation (RTFG) process.

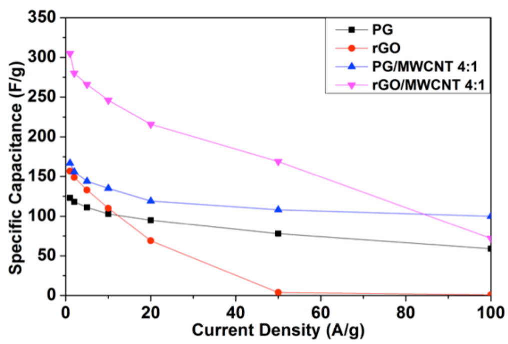

Figure 2: The capacitance of the aerogels as a function of current density (PG = pristine graphene, rGO = reduced graphene oxide)