Three-dimensional mesoporous graphene for energy applications

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As an analogy to fullerenes and carbon nanotubes, three-dimensional (3D) graphene frameworks have been theoretically proposed by introducing carbon 7- or 8-membered rings to create negative Gaussian curvature in single graphene walls. Since then, the synthesis of 3D graphene frameworks has become a significant goal in both supramolecular chemistry and materials chemistry. However, most of the materials reported as "3D graphene" or "nanoporous graphene" face several challenges: (i) the presence of stacked graphene structures, (ii) the inclusion of graphene edges, and (iii) the presence of macropores. These issues result in (i) low specific surface area, (ii) poor oxidation resistance, and (iii) low volumetric energy density for battery-related applications, respectively. In our group, we have developed a novel synthesis pathway to create mesoporous graphene frameworks that avoid these problems, as illustrated in Figure 1. This method involves three steps: (1) uniform coating of metal oxide nanoparticles via chemical vapor deposition (CVD) using specific surface catalysis, (2) template removal through chemical etching, and (3) high-temperature annealing to induce zipping reactions without collapsing the mesopores. The resulting material is termed graphene mesosponge (GMS). Due to its enhanced nanoporosity, oxidation resistance, high electrical conductivity, and unique mechanical flexibility, GMS exhibits exceptional functionality and performance in a wide range of applications, such as high-voltage supercapacitors [1], new type of heat pumps [2], fuel cells [3], Li-S batteries [4], and Li-O_2 batteries [5,6].

References

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Figures

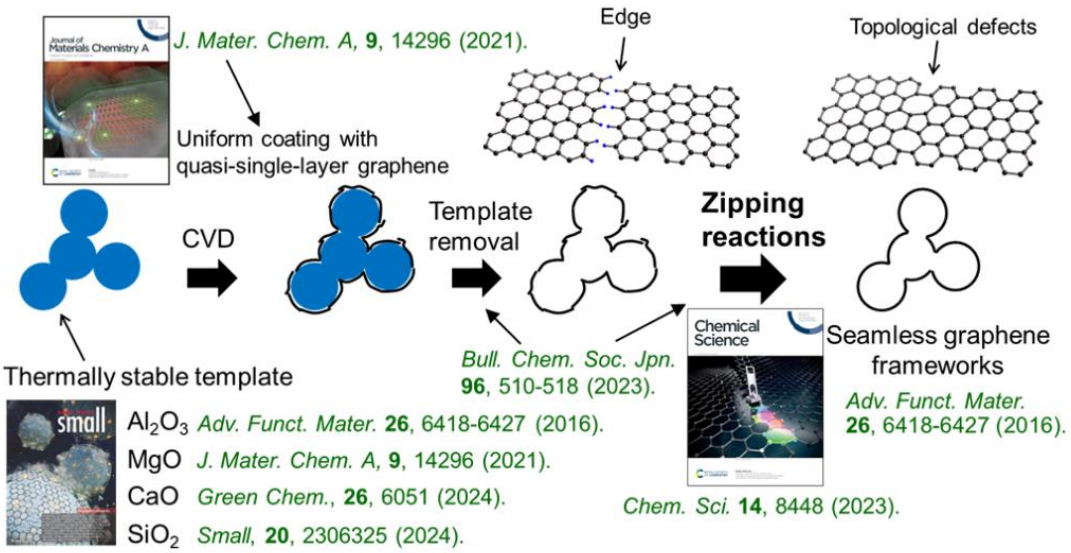

Figure 1: Strategy to synthesize 3D graphene frameworks via zipping reactions.