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Graphene-based aerogels for high performance sensing and catalytic applications

Two-dimensional (2D) nanomaterials, such as graphene, boron nitride, and transition metal dichalcogenides (TMD), exhibit a wide range of distinct optical, electronic, and thermal properties, which make them attractive for a number of applications, such as energy storage, sensing, and catalysis. Catalytic and sensing applications, in particular, have attracted a great deal of interest from researchers seeking to capitalize on the unique surface properties of these novel single- or few-atomic layer thick materials. Unfortunately, in many cases, these 2D nanomaterials are limited to low surface area forms like thin films and coatings. These forms are inefficient for sensing and catalytic applications as they lack the additional active sites a high surface area form would provide. Assembling 2D nanomaterials into monolithic porous structures, such as an aerogel, provides such a high surface area architecture with the potential to fully unlock the exciting new sensing and catalytic properties and features only available in an aerogel form. Here we present our recent work to create graphene aerogels, which serve as a basis for a number of different 2D nanomaterial-based aerogels such as BN, BCN, and TMD/graphene aerogels. The 2D nanomaterial-based aerogels possess unique properties not observed in the bulk or thin film forms such as super-hydrophobicity, high surface area, and high electrocatalytic activity. Hydrogen evolution reaction studies show that the TMD/graphene aerogel exhibits a low onset potential and high current density. (Figure 1) Gas sensors based on these 2D nanomaterial aerogels show extraordinary speed, sensitivity, and selectivity while operating at extremely low power, opening up the possibility for wireless, battery-powered gas sensors for mobile applications. (Figure 2)

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Figures

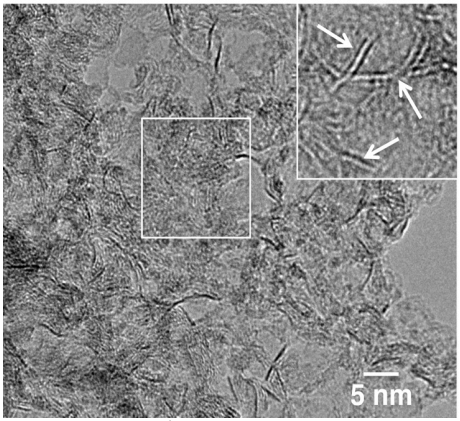

Figure 1: TEM of MoS_2/graphene aerogel that exhibits enhanced hydrogen evolution reaction activity. Inset shows magnified image section in box. Arrows denote single layer MoS_2.

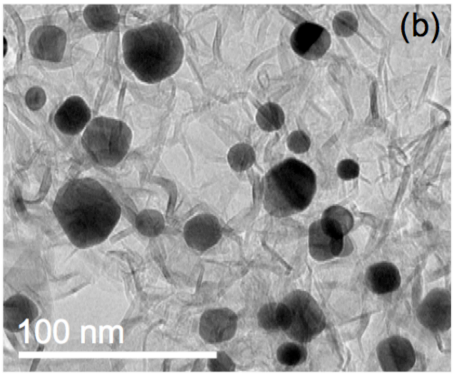

Figure 2: TEM of Pt/BN aerogel that exhibits high sensitivity and selectivity to sensing combustible gases (e.g. propane).