Microporous Graphene Frameworks For Gas and Energy Storage Applications

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Microporous polymers attracted [1,2] significant deal of attention in recent years due to their permanent porosity, chemical tunability, physicochemical stability and exceptional gas sorption properties.[2] Incorporation graphene nanoribbons (GNRs) or graphene sheets into porous polymers, however, has been a significant challenge mainly due to their low solubility and high affinity to restack to form graphitic layers due to interlayer π-π stacking and van der Waals interactions. Graphene is composed of single-atom-thick, sp^2 hybridized carbon atoms that are bonded together in a two-dimensional (2D) hexagonal honeycomb lattice, and presents high π-surface area, excellent chemical, thermal, mechanical stability along with superior thermal and electrical conductivities. Importantly, the resulting microporous polymers incorporating either graphene or GNRs are expected to inherit some of their unique properties. In order to prevent restacking and to take full advantage of high π-surface area, we proposed to introduce a permanent 'spacer' such as porosity between GNRs and graphene layers within the microporous polymers. We utilized both noncovalent [3] and covalent [4,5] approaches to form three-dimensional graphene frameworks. Recently, we also utilized [4] bottom-up approach (**Figure 1**) to introduce graphene nanoribbons up to 2 nm in length and 1.1 nm in width into graphene nanoribbon frameworks (GNFs). These frameworks showed high thermal stability up to 400oC in air with relatively narrow pore size distribution and exhibited BET surface areas up to 700 m2 g-1 and promising gas separation

properties. More recently, in an effort prepare 3D all sp2-hyridized graphene-like frameworks, we utilized [6] highly pre-organized monomers with curvature to form the corresponding carbon frameworks. These materials have been shown to be efficient for gas storage, heterogeneous catalyst for the hydrogen evolution and CO_2 conversion reactions and also utilized as supercapacitors for energy storage applications.

References

[1] Patel, H. A.; Je, S. H.; Park, J.; Chen, D. P.; Jung, Y.; Yavuz, C. T.; Coskun, A., *Nature Commun.*, 4 (2013) 1357.

[2] Je, S. H.; Buyukcakir, O.; Kim, D.; Coskun, A., *Chem*, 1 (2016) 482.

[3] Srinivasan, S.; Je, S. H.; Back, S.; Barin, G.; Buyukcakir, O.; Guliyev, R., Jung, Y.; Coskun, A., *Adv. Mater.*, 26 (2014) 2725.

[4] Talapaneni, S. N.; Hwang, T. H.; Je, S. H.; Buyukcakir, O.; Choi, J. W.; Coskun, A., *Angew. Chem. Int. Ed.*, 55 (2016) 3106.

[5] Byun, Y.; Coskun, A., *Chem. Mater.*, 27 (2015) 2576.

[6] Talapaneni, S. N.; Lee, J. H.; Je, S. H.; Buyukcakir, O.; Kwon, T.; Polychronopoulou, K.; Choi, J. W.; Coskun, A., *Adv. Funct. Mater.*, 27 (2017) 1604658.
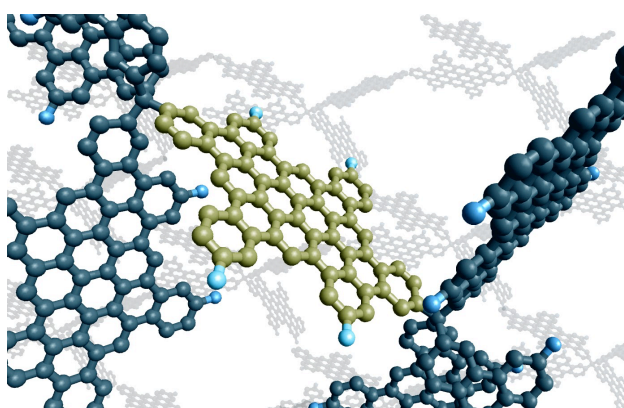
Figure 1: Graphical representation of graphene nanoribbon frameworks prepared via bottom up synthetic routes.