Interaction between low dimensional boron nitride materials and small molecules

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Low dimensional boron nitride materials, such as hexagonal boron nitride (hBN) and boron nitride nanotubes (BNNT) are becoming increasingly more interesting as an active or passive component of a variety of applications. These applications include supporting insulating components if graphene electronics [1], component of two dimensional heterostructures [2], gas sensors, and biological applications [3]. Since BNNTs (and also hBN) are high bandgap, chemically inert materials, with high temperature resistance, another interesting application is to fill them with smaller molecules and use them as nanoreactors. Similar experiments were conducted with carbon nanotubes (CNT) as well, but as opposed to BNNTs, the much smaller or nonexistent bandgap of CNTs makes it challenging to optically probe the small molecules inside the tubes. Coronene filled BNNTs were successfully turned into concentrical CNT-BNNT heteronanotubes, however the exact interactions between the BNNT and the coronene were not discovered.

In photoluminescence (PL) studies we have shown that coronene and BNNT has a strong, phonon mediated interaction, when in contact with each other. The characteristic PL peak of coronene split up into multiple peaks, with energy difference of the BNNT phonon modes, when the illumination photon energy is comparable to the excitation energy of localized defects in BNNT. Due to the low Debye-Waller factor of the defect-phonon interaction [4] in BNNT, this suggests a localized exciton mediated energy transfer between the nanotubes and the filler material. This interaction is also present on the surface of hBN.

[1] Lee, Kang Hyuck, et al. "Large-scale synthesis of high-quality hexagonal boron nitride nanosheets for large-area graphene electronics." *Nano letters* 12.2 (2012): 714-718.

[2] Lee, Gwan-Hyoung, et al. "Flexible and transparent MoS2 field-effect transistors on hexagonal boron nitride-graphene heterostructures." *ACS nano* 7.9 (2013): 7931-7936.

[3] Ciofani, Gianni. "Potential applications of boron nitride nanotubes as drug delivery systems." *Expert opinion on drug delivery* 7.8 (2010): 889-893.

[4] Wang, Qixing, et al. "Photoluminescence upconversion by defects in hexagonal boron nitride." *Nano letters* 18.11 (2018): 6898-6905.