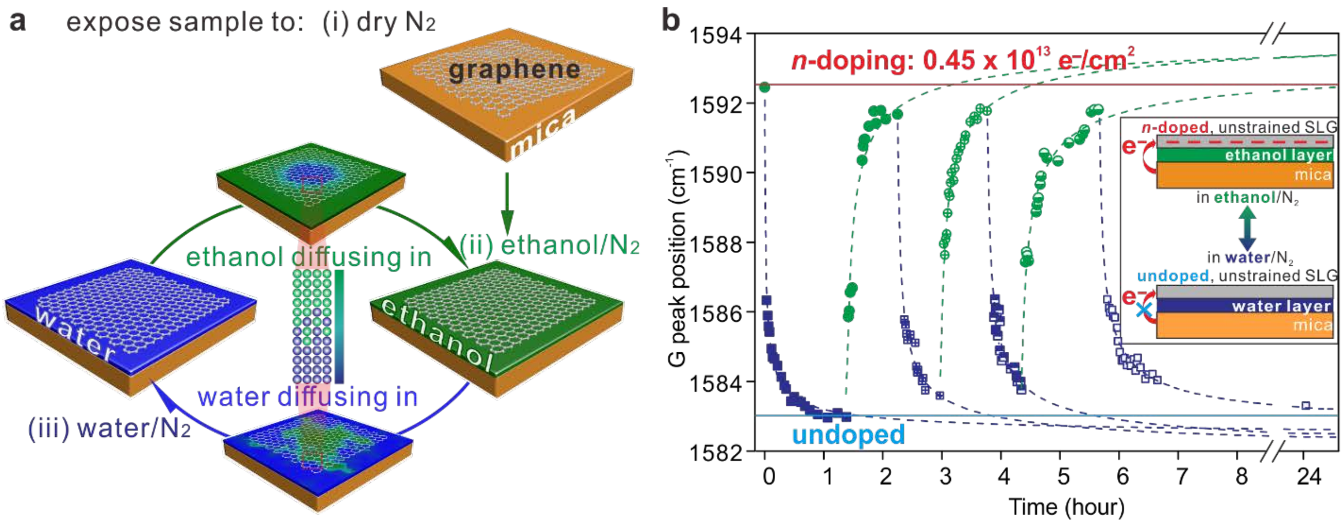
Reversible Switching of Charge Transfer at the Graphene-Mica Interface with Intercalating Molecules

Understanding and controlling charge transfer through molecular nanostructures at interfaces is of paramount importance, particularly for hybrid systems for optics and electronics but also generally for contact electrification or in bio-electronics. In a recent publication, Hu Lin et al. [1] reveal the influence of intercalation and exchange of molecularly thin layers of small molecules (water, ethanol, 2 propanol and acetone) on charge transfer at the well-defined interface between an insulator (muscovite mica) and a conductor (graphene) through probing graphene doping variations by Raman spectroscopy. While a molecular layer of water blocks charge transfer between mica and graphene, a layer of the organic molecules allows for it. The exchange of molecular water layers with ethanol layers switches the charge transfer very efficiently from OFF to ON and back. This observation is explained by charge transfer from occupied mica trap states to electronic states of graphene, controlled by the electrostatic potential from the molecular layers wetting the interface. This is supported by molecular dynamics simulations. The sensitivity of graphene doping to the composition of confined molecular films may be used to investigate the structure of the films and diffusion of the molecules in the nano-confinement, e.g., their miscibility; furthermore, potential molecular sensor and actuator applications can be envisioned. The demonstrated role of molecular layers in the charge transfer will aid in understanding of graphene wetting transparency, and it will facilitate the development of electronic devices, e.g., triboelectric generators.



a) Schematic diagram of (i) an initially dry graphene-mica interface becoming intercalated with molecular (ii) ethanol or (iii) water layers, upon exposure to ethanol and water vapors, respectively. Water and ethanol molecules can diffuse into the interface and replace each other. b) Dependence of the graphene G peak position on time for alternating exposures to ethanol (green) and water vapor (blue). The light blue and red lines are G peak positions for unstrained/undoped and n-doped graphene on water and ethanol layers, respectively.

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