



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The present thesis, entitled as “Application of Reconstructed Layered Materials for Environmental Energy harvesting” is divided into six chapters. Chapter 1 contains a general overview of 2D materials, exfoliation techniques and their application in energy harvesting systems. Chapter 2 elaborates the fabrication of multifunctional soil membranes by tuning the structure of ubiquitous soil components, viz. clay and humic acids. Crosslinking of exfoliated clay layers with purified humic acids not only conferred mechanical strength but also enhanced chemical robustness of the membranes. The percolated network of molecularly sized channels of the soil membranes exhibits characteristic nanofluidic phenomena which is exploited to harvest energy from salinity gradient. Electrical conductivity is induced to otherwise insulating soil membranes by heating in an inert atmosphere, without affecting their nanofluidic ionic conductivity. Strips of heated membranes shown to exhibit excellent sensitivity towards NH_3 gas under atmospheric conditions. In chapter 3, the complementary charge transfer activities of boron (B-r-GO) and nitrogen (N-r-GO) doped reduced graphene oxide (r-GO) flakes are exploited to extract energy from serene water resources. B-r-GO and N-r-GO samples prepared by annealing graphene oxide sheets with boric acid and urea were individually coated on cellulose membranes to fabricate B-r-GO/N-r-GO devices. DFT calculations were carried out to study charge transfer activities with water molecules. In chapter 4, we demonstrate the fabrication of a highly robust, inflammable, and pressure-responsive energy device. The energy device was prepared by pressing a polydiallyldimethylammonium chloride (PDDA) doped nanofluidic membrane of natural vermiculite clay (PDDA-VM) on kitchen-grade aluminium foil (PDDA-VM/Al) consumes atmospheric water molecules as the cathode reagent and aluminium atoms at the anodic reaction. Remarkably, the clay-based energy devices exhibit excellent resistance to fire. Moreover, multiple devices can be assembled to add up the output current and voltage generated by the individual devices to power electronic equipment. In Chapter 5, the principles of metal-water batteries were applied to develop a sustainable pressure-responsive energy delivery system. Application of a humble pressure of 56 kPa on agar and glycerol-based hydrogel membrane sandwiched between aluminum foil and nanofluidic V_2O_5 membrane (Al-gel-VO device) generate open-circuit voltage up to 1.3 V accompanied by an output current of 85 μA (power density = 0.45 Wm^{-2}). Unlike typical humidity powered energy systems, the energy output of the current device is resistant towards the diurnal variations in environmental conditions. Remarkably, both gel and V_2O_5 membrane can be completely regenerated after damage caused by prolong use or accidents without any deterioration in the energy-efficiencies. Chapter 6 consist of an overall conclusion of the work done during my PhD tenure and the future perspective of the work.

