Preparation and Characterization of High-Strength Multifunctional Nanomembrane

By

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Abstract

Robust ultrathin porous polymer films would be gradually regarded as the enabler of next generation technologies, including flexible sensors, artificial skins, separators, antireflection and self-cleaning films. Nevertheless, both the creation and the application of these films have been extremely challenging owing to the insufficient mechanical strength of all reported ultrathin films. The fabrication of a new ultra-strong and highly flexible ultrahigh molecular weight polyethylene (UHMWPE) porous membrane is reported in this thesis. Both SEM and TEM evaluations of film morphology reveal a 2D Delaunay fibrous structure with randomly triangulated pores. Moreover, the tensile property of this film is at least twice as strong as that of solid stainless steel, with a measured in-plane tensile strength and ductility approximate to 1400 MPa and 50%, respectively. Its top surface was further aligned a monolayer graphene to be invented as a fully conformable piezoresistive skin sensor and a nano-vibrational diaphragm of clarity electrostatic speaker. More excitingly, the Young’s modulus and tensile strength of as-prepared graphene-PE nanomembrane are in accord with the upper bound predictions of the classical theory of mixtures corroborating graphene’s maximum limit in mechanical property reinforcement. Simultaneously, the graphene’s toughening effect was discovered via a six-fold crack-propagation-rate retardation method. In addition, other applications such as skin conformable sweat sensors, antibacterial films, turing pattern structures based on this nanomembrane were also elucidated in this thesis.