ABSTRACT

The thesis aims to explore a castor oil based hyperbranched polyurethane (HPU) and its graphene based nanocomposites for prospective applications as smart materials. Recently, graphene carves immense attraction in both academic and industrial fields due to its outstanding and unique properties. Utilization of graphene and graphene-based materials in the fabrication of nanocomposites with different polymer matrices are explored continuously over the decade. It can provide a dramatic improvement in properties of pristine polymers at low nanomaterial content. Amongst the various types of polymers, HPU is one of the most attractive ones because of its useful and easily tunable properties. Thus, in the present investigation, HPU was synthesized by an A_2 + B_3 approach using castor oil or its monoglyceride as a bio-based multifunctional moiety (B_3) with the other conventional reactants. Different analytical and spectroscopic techniques were employed to confirm the structure of the synthesized HPU. The performance including mechanical, thermal and chemical properties of HPU was evaluated. Again, graphene oxide (GO) was prepared from graphite by modified Hummers' method and reduction of GO was carried out by different phytoextracts such as *Colocasia esculenta*, *Mesua ferrea* L. leaf and *Citrus sinensis* peel (in presence and absence of metal ions) to obtain reduced GO (RGO). Different RGO based nanohybrids with iron oxide, sulfur and titanium oxide nanoparticles were prepared by using eco-friendly techniques. An effort was also made for the fabrication of different HPU nanocomposites with GO, RGO and these prepared graphene based nanohybrids, separately to address the cutting-edge demands of smart materials. The effect of incorporation of such nanomaterials on the properties of HPU nanocomposites was comprehensively investigated. The prepared nanohybrids and nanocomposites were characterized through different spectroscopic, microscopic and analytical techniques. Dramatic improvements in the performance like tensile strength, elongation at break, toughness, thermal stability, etc. were observed after the formation of HPU nanocomposites. HPU/functionalized RGO nanocomposite demonstrated superior shape memory effect, electrical conductivity and mechanical properties over the other prepared nanocomposites. Incorporation of iron oxide/RGO nanohybrid in HPU matrix resulted in rapid and repeatable self-healing abilities of the nanocomposite under exposure of MW and direct sunlight. In addition, the fabricated nanocomposite exhibited good thermal and mechanical properties with excellent shape-recovery under the same stimuli. Furthermore, an antimicrobial HPU nanocomposite was fabricated with shape memory and self-healing attributes using sulfur nanoparticle decorated RGO nanohybrid. This study showed a profound microbial inhibitory effect against *Staphylococcus aureus*, *Escherichia coli* and *Candida albicans*. Sunlight-induced self-cleanable HPU nanocomposite with multistimuli responsive shape memory and self-healing attributes was also achieved by the incorporation of TiO_2-RGO nanohybrid. These properties of the nanocomposite can be tuned by judicious choice of amount and composition of TiO_2-RGO nanohybrid. Presence of an adequate amount of RGO (0.5–1 wt%) in the nanocomposite helps in rapid and efficient healing, whereas a relatively high amount of TiO_2 nanoparticles (5–10 wt%) aids in achieving good self-cleaning properties. Thus, graphene based HPU nanocomposites presented in this thesis can be endorsed as multifaceted smart materials with shape memory, self-healing, photo-induced self-cleaning, etc. attributes.