ABSTRACT

Development of bio-based, biodegradable, eco-friendly smart polymeric material is desirable for advanced applications, which can address cocktail of challenges ranging from sustainability, economy to environmental footprints. Hence, the entitled thesis concentrates on fabrication of eco-friendly hyperbranched polyurethane nanocomposites, their characterization, property evaluation and applications. In brief, the whole work can be divided into four parts: (a) eco-friendly polymer synthesis and characterization, (b) nanomaterial synthesis and characterization, (c) fabrication of polymer nanocomposites and characterization and (d) application of the nanocomposites in different domains. According to the primary objective, a low VOC containing, biodegradable, water dispersible hyperbranched polyurethane system was synthesized using tannic acid as a bio-based component. This polymeric material was then developed as advanced material with fascinating properties by using nanotechnology based modification. Different nanomaterials and nanohybrid systems were prepared, which include carbon dot, carbon dot decorated hydroxyapatite and nickel ferrite decorated reduced graphene oxide. These nanomaterials were used in the fabrication of waterborne hyperbranched polyurethane matrix. Waterborne hyperbranched polyurethane/carbon dot nanocomposite was developed as an optically active, cytocompatible and highly luminescent polymeric material. The nanocomposite was tested for its suitability in anti-counterfeit application, as a scaffold material in bone tissue engineering application and as a photo-catalyst in solar driven hydrogen peroxide production. Waterborne hyperbranched polyurethane/carbon dot decorated hydroxyapatite nanocomposite was used as a biomaterial in bone tissue engineering application. Waterborne hyperbranched polyurethane/nickel ferrite decorated reduced graphene oxide nanocomposite was developed as multi-stimuli responsive smart shape memory material for advanced application. Parts of the thesis also deal with the bio-functionalization of carbonaceous nanostructures, especially carbon dot. Accordingly, covalent functionalization of carbon dot with certain peptides was performed, which was used to fabricate the polyurethane system and used as non-invasive delivery vehicle for *in vivo* bone tissue engineering application.

Thus, the overall work showed how different properties can be imparted to a single polymeric material by using nanotechnology based modification. Among different applications, we found the biological applicability of the nanocomposites particularly interesting. Biological evaluation confirmed suitability of carbon dot, bio-functionalized carbon dot and carbon dot based nanohybrids as suitable nano-filler for polyurethane based scaffold material. Similarly, photo-catalytic application of waterborne hyperbranched polyurethane/carbon dot nanocomposite was attractive, which may pave direction in the domain of heterogeneous photo-catalysis.

Thus, the overall work demonstrated the development of nanotechnology based multifunctional materials for various utility.