ABSTRACT

Advancement of smart, bio-based, biodegradable, biocompatible polymers is imperative for breakthrough applications in the world of material science, to address the major challenges stretching from sustainability to environmental footprints. Therefore, the entitled thesis focuses on the fabrication, characterization and prospective applications of starch modified hyperbranched polyurethane and their nanocomposites using different carbon-based nanomaterials. With respect to the primary objective of the work, a smart, biocompatible, biodegradable hyperbranched polyurethane system was synthesized using a starch-based hyperbranched polyol as a bio-based component by an $A_x + B_y$ (x, y $\geq$ 2) technique. The starch modified hyperbranched polyurethane was developed as an advanced smart, biocompatible and biodegradable material, suitable for prospective applications in the biomedical domain. The synthesized polymer was subsequently fabricated using diverse carbon-based nanomaterials with remarkable attributes. In recent times, extensive research endeavors are being made to employ the unique attributes of diverse carbon-based nanomaterials in numerous domains from industrial to academic. Different carbon-based nanomaterials and their nanohybrid systems such as reduced graphene oxide, carbon dot, reduced carbon dot, carbon dot-silver nanohybrid *etc.* were prepared to fabricate hyperbranched polyurethane matrix. This can lead to significant enhancement in numerous desired attributes of the pristine polyurethane even at very low content of nanomaterial. Hyperbranched polyurethane/carbon dot-silver nanocomposite was developed as an implantable, smart material with multifaceted properties of potent biocompatibility and high performance with inherent antibacterial activity, predominantly against infection-resistant bacteria. The nanocomposites were tested for their applicability as an infection-resistant, rapid, self-expandable stent for potential endoscopic surgeries. A part of the thesis also focuses on the reduction of carbon-based nanomaterial, especially carbon dot. Facile and eco-friendly reduction of carbon dot was conducted using aqueous phytoextract to produce luminescent reduced carbon dot that was subsequently used to fabricate hyperbranched polyurethane/reduced carbon dot nanocomposites as advanced non-contact triggered, rapid, self-tightening surgical sutures for potential biomedical applications. Hyperbranched polyurethane/reduced carbon dot-zinc oxide nanocomposites were designed as visible light assisted heterogeneous photocatalyst for degradation of organic pollutants. Incorporation of reduced graphene

oxide-silver-reduced carbon dot within the hyperbranched polyurethane matrix resulted in the combined multifaceted attributes of improved mechanical performance, self-healing, self-cleaning and antimicrobial activity.

Therefore, the work revealed the importance of nanotechnology and nanoscience in imparting various unique attributes to a single polymeric material and their exploration in different spheres of material science and industry. Amongst the diverse applications, the biological use of nanocomposites in the domain of biomedical is established to be predominantly fascinating. Biological assessments substantiate the appropriateness of employed carbon dot, reduced carbon and their nanohybrids as fitting nano-reinforcing agents for design of advanced smart, biocompatible non-contact triggered smart polymeric biomaterials. Likewise, the suitability of utilizing reduced carbon dot-zinc oxide and reduced graphene oxide-silver-reduced carbon dot within the hyperbranched matrix forwards the nanocomposites in the field of solar-assisted heterogeneous photocatalysis.

Therefore, the comprehensive work presented in the thesis demonstrated that the synthesized hyperbranched polyurethane and its fabrication of nanocomposites using carbon-based nanomaterial can be employed as prospective modern high performing multifaceted materials in the realm of material science.