ABSTRACT

The thesis aims to investigate waterborne polymers and their nanocomposites for their potential multi-faceted applications to address the drawbacks of solvent borne polymers. Approaches for designing such advanced polymeric materials with low or no volatile organic compounds (VOC) and hyperbranched architectures have significant interest in the current scenario of industry. Among different polymers, polyesters deserve special interest for their intrinsic advantages such as good compatibility with others, good chemical resistance (except alkali), excellent processability, high flexibility, overall low cost, etc. Thus, in the present investigation, two different waterborne hyperbranched polyesters (WHPE) were synthesized through $A_2 + B_3$ approach using multifunctional bio-based and easily available aliphatic and aromatic monomers in absence of solvent, additional catalyst and neutralizing agent. Another, aliphatic WHPE was also synthesized by the same synthetic protocol using citric acid, 2,2-bis(hydroxymethyl)propionic acid and glycerol branch generating moieties along with poly(ethylene glycol). The synthesized polyesters were characterized using various analytical and spectroscopic techniques. Different properties including physical, mechanical, thermal and chemical of glycerol based hyperbranched epoxy and poly(amido amine) cured WHPE thermosets were evaluated. Further, to improve the properties of pristine polyester, WHPE nanocomposites were developed using graphene oxide (GO), carbon dot (CD) and CD-based nanohybrid. The prepared nanomaterials and the nanocomposites were characterized using different spectroscopic, analytical, diffraction and microscopic techniques. The stronger interfacial interactions between dispersed nanoparticles and the polyester matrix resulted drastic improvement in mechanical, physical and thermal properties after formation of nanocomposite. Incorporation of functionalized GO into WHPE matrix showed significant improvement in mechanical and thermal properties along with good biodegradability behavior against gram-negative bacterial strain. Further, it was used as a heterogeneous catalyst for Aza-Michael addition reaction with good recyclability. Again, highly fluorescent WHPE nanocomposite was fabricated by incorporating CD into the polyester matrix through *in-situ* polymerization technique. The nanocomposites emitted different colors under UV light and exhibited wavelength dependent both down- and up-conversion photoluminescence (PL) properties. Further, the significant enhancement of mechanical, rheological and thermal properties along with excellent biodegradability behavior against both gram-positive and gram-negative bacterial strains was also observed for this nanocomposite. Most interestingly, the nanocomposite exhibited self-cleaning activity towards removal of organic dirt on exposure of sunlight. The development of WHPE nanocomposite with clay@CD based nanohybrid exhibited good adsorption capacity for Pb(II) ion along with improvement in mechanical and thermal properties. They also exhibited good transparency under visible light and wavelength dependent PL properties along with biodegradability behavior. Further, to achieve some special properties like anti-fogging, anti-reflecting, antibacterial, anti-icing, anti-counterfeiting, etc., CD@TiO_2 nanohybrid was incorporated into the polyester matrix. In addition to this multifunctional attributes, they also exhibited excellent mechanical, optical and thermal properties as well as good photocatalytic activity under visible light. Most interesting, some of the factors such as recovery, reusability, stability and leaching of the catalyst crucial for practical applications are achieved for this catalyst. Further, the nanocomposite was also used for separation of crude oil and water from their mixture with excellent removal efficiency. They also exhibited significant antibacterial activity towards different bacterial strains such as *P. Aeruginosa, S. aureus, K. pneumoniae* and *B. subtilis*. The presence of adequate amount of TiO_2 nanoparticles (0.5-2.5 wt%) in the nanocomposites helps in acheiving excellent self-cleaning properties. Thus, carbon-based WHPE nanocomposites presented in this thesis can be used as multifunctional materials for different potential advanced applications.