ABSTRACT

High performance with novel function is the key factor of a polymer for its applications. Thus, to increase the functional areas or applications of polymeric materials, they have to design or tailor-fit properly. Hyperbranched polymer is one of the most attractive macromolecules because of its unique and useful properties and hence applications. Again, combination of polymer science and nanotechnology is one of the most promising approaches of this century to achieve extraordinary performance and thereby broadening the functions of the polymeric materials. The formation of nanocomposite provides a dramatic improvement in performance as well as offers a new set of properties to expand the application area of the pristine polymer. Thus, in the present investigation for the development of epoxy thermosets three different high performance hyperbranched epoxy thermosets were synthesized using three branch generating moieties to overcome the shortcomings like low toughness or flexibility, high dielectric constant and non bio-degradability of conventional epoxy thermosets. These hyperbranched epoxy resins were synthesized by polycondensation reaction using pentaerythritol, triethanol amine and castor oil based polyester polyol as the branch generating moieties along with other conventional reactants like bisphenol-A and epichlorohydrin. The synthesized resins were characterized by different analytical and spectroscopic techniques. The performance including mechanical, thermal and chemical properties of the hyperbranched epoxy thermosets, cured by poly(amido-amine) hardener were evaluated. The prominent role of the amount of branch generating moieties on the properties of the hyperbranched epoxies was also investigated. Again, to expand the functional area of the epoxy thermosets, different nanocomposites were fabricated with several types of nanomaterials. The nanocomposites were characterized through different spectroscopic, microscopic and diffraction techniques. Dramatic improvement in performance like tensile strength, elongation at break, toughness, thermal stability, etc. were observed after the formation of hyperbranched epoxy nanocomposites with first generation of poly(amido-amine) dendrimer modified bentonite and neem oil modified OMMT nanoclays. Hyperbranched epoxy/neem oil modified OMMT nanocomposites exhibited potential antimicrobial activity towards both gram positive and gram negative bacterial as well as a fungal strains. Further, along with high performance interesting optical properties like photoluminescence, color emission, etc. were achieved by the formation of hyperbranched epoxy nanocomposite with bio-based carbon dot, synthesized from banana juice by simply

heating. These nanocomposites were obtained through *ex-situ* and *in-situ* techniques. The *in-situ* fabricated hyperbranched epoxy/carbon dot nanocomposite exhibited superior performance including mechanical, thermal and optical properties compared to the nanocomposites obtained through *ex-situ* technique. Furthermore, carbon dot reduced Cu_2O nanohybrid was fabricated for obtaining high performance hyperbranched epoxy nanocomposites as a heterogeneous photocatalyst for the degradation of organophosphate pesticide under solar light. Moreover, the biocide immobilized OMMT-carbon dot reduced Cu_2O/hyperbranched epoxy nanocomposites were also exhibited excellent performance as well as antimicrobial activity towards different bacteria and a fungus. Thus, the synthesized hyperbranched epoxies along with their different nanocomposites presented in this thesis can be potentially used as advanced high performing functional polymeric materials in the domain of material science.