# *ABSTRACT*

The persistent technological upturns stemming from mindful innovations in the realms of 'science and technology' have furnished today's society with affordable and hassle-free lifestyles. Synthetic polymers are the fascinating precedents of such ground-breaking innovations, which, on account of their intriguing facets, have swapped conventional structural materials like glass and metals. Epoxy resins that are mainly derived from naphtha products (bisphenol A, BPA) have been one of the most prominent contenders among synthetic polymers, successfully infiltrating nearly every integral domain of engineering. Among the charming characteristics of epoxy, superior mechanical and thermal properties, excellent adherence, corrosion resistance, high specific strength, zero loss of volatiles, ease of processing, low shrinkage during the cure process, numerous curing options, etc. are worthy to mention. The rising environment-protective legislations, on the other hand, are instigating the curtailment of exploration of such epoxies and incentivizing the use of bio-resources as the precursor for their production. Taking into account the above-mentioned facts, the thesis entitled *"Bio-based epoxy thermosets and their composites"* directs attention to the design and fabrication of sustainably derived epoxy composites intended for future applications in the field of coatings and structural materials. To fulfill the core objectives of the investigation, a bio-based epoxy was synthesized employing tannic acid and epichlorohydrin as the prime reactants. The synthesized epoxy resin was critically examined using different spectroscopic and analytical techniques, while the thermomechanical properties it owned were contrasted with other epoxies prepared by amalgamating tannic acid with BPA, a commercialized reactant for epoxy. The various other traits of the bio-based epoxy, inclusive of adhesive strength, biodegradability, chemical resistance, antioxidant activity, etc., were further assessed.

To further meliorate the performance and pertinency of this bio-based epoxy, different carbon-based sustainable reinforcing agents were merged with it to fabricate biocomposites and nanocomposites. Assorted cellulosic reinforcing agents such as microfibers (MTFs), amine-functionalized cellulose nanofibers (CNFs), iron oxide decorated CNFs (IONP@CNFs), and so on, sourced from waste biomass, were utilized in this context and delivered exhilarating repercussions. The reinforcement of these foreign agents significantly altered the characteristics of the pristine epoxy. The biocomposites fabricated by utilizing MTFs possessed excellent environmental durability when exposed to harsh conditions. The impression of the functionalized CNFs into the bio-based epoxy was reflected in the mechanical and thermal performances, as significant enhancement was recorded in the tensile strength and glass transition temperature of the nanocomposites. The observed anticorrosive activity in these nanocomposites was “a cherry on top”, further widening their utility in corrosion-resistant coatings. The latter section of the thesis dealt with the exploration of IONP@CNFs included nanocomposite within the realm of biomedical sciences. The robust nanocomposites, encompassing biocompatible and biodegradable behaviors, were tailored for the release of a potential antibiotic under different pH conditions, which enabled their use as infection-resistant systems.

Thus, the thesis addressed the wide scope of tannic acid-derived bio-based epoxy thermosets and their high-performance composites in assorted applications. The exciting contributions of multifunctional micro- and nano-structured reinforcing agents in rendering versatility to these epoxy composites for multitudinous applications are evident from the current research findings.

**Keywords:** Bio-based epoxy, Sustainable reinforcing agents, Composites, High-performance, Advanced applications