

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Polyesters (PEs) are one of the most versatile synthetic copolymers. They are hetero chain macromolecules that possess carboxylate ester groups as an integral component of their polymer backbones. PEs are extensively used as fibres, plastics, composites and for coatings applications as well (Goodman and Rhys, 1965; Goodman, 1968; Morgan, 1965; Wen et al., 2011; Albdiry and Yousif, 2013).

Unsaturated polyester resins (UPRs) are more readily processable than metals and ceramics. They are widely used as thermosetting resins in various sectors. Usually, UPRs are solidified with cross-linking agents to produce cross-linked UPRs, which have limited structural reliability for engineering applications. Therefore, they are frequently reinforced with macro, micro and nanofillers to boost up their desired properties. Successful incorporation of fillers in UPR composite has enabled new combinations of mechanical, electrical, magnetic, optical, chemical and surface properties. As a result, they are found in wide applications in the arena of construction, marine, automotive, aerospace, packaging, electronics, information, pharmaceuticals, biomedical, energy, sports goods and personal care sectors (Genhua et al., 2004; Gojny et al., 2005; Marco et al. 2011; Wen et al., 2011; Albdiry and Yousif, 2013).

At the beginning, blending of different polymers was conducted to fabricate composite materials for unique properties. However, blending lead to marginal improvement in properties which were not suitable as engineering materials. Therefore to improve the strength and stiffness of polymer materials different kinds of organic and

inorganic silicate, carbon and metal compound were blended as filler with polymer matrix (Barrau et al. 2003). Moreover to achieve desired mechanical and other properties, it was necessary to load high amount of filler which increase cost and processing become difficult. Therefore, currently nanofillers are very popular to get high mechanical as well as other properties at lower concentration of filler. The nanofiller reinforced polymer matrix is known as polymer nanocomposite (Bellayer et al., 2005).

Polymer nanocomposite is a new arena of composite materials, which is receiving significant attention both in academia and industry. The nano filler can provide ultra-large interfacial area per volume between the nano-element and polymer matrix. As a result, the reinforced composites exhibited superior toughness without giving up stiffness or optical clarity. It also possesses greater thermal and oxidative stability, better barrier, mechanical properties and self-extinguishing behavior as unique properties. Carbon nanotubes (CNTs) are emerged as the most promising nanofiller for polymer nanocomposites because of their outstanding properties compared to other fillers. The fantastic properties of individual CNT make an ideal reinforcing agent in the arena of polymer nanocomposites (Iijima, 1991; Kayatin and Davis, 2009; Spitalsky et al., 2010).

Besides, CNT is geometrically distinctive due to its structure as well as surface area which provides vast opportunity for interaction with any continuous phase (Gojny et al., 2004). Moreover, a small amount of CNTs with sound dispersion in polymer matrix exhibits abundant enhancement of different properties (Kota et al., 2007). Therefore, incorporation of carbon nanotubes (CNTs) is an attractive alternative filler to reinforce polymer matrix.

However, CNT reinforced nanocomposite properties are dependent on the degree of dispersion, interfacial adhesion with matrix in the composite system (Singh et al. 2013). The curing process of filler incorporated UPR is delayed due to free radical scavenging nature of carbon nano materials (Monti et al., 20011). Additionally several phenomena limit the promising application of CNT in nano composite technology. For instance, the main drawbacks of CNT are dispersion and compatibility with polymer

matrices, their morphology and Van der Waal's forces are aggregated them into bundles as like as ropes which are stabilized by numerous π - π interactions (Gryshchuk et al., 2006). Moreover, not only potential energy but also the aspect ratio and flexibilities of CNTs are responsible for their entanglements as a consequence difficult to separate into individual nanotube (Breton et al., 2004; Quanxiang et al., 2014). Therefore they are restricted to homogeneous dispersion in polymer matrix.

Extensive effort has been applied to break the nanotube bundles for using individual nanotube as potential reinforcing filler. For this reason, destructive and nondestructive modification techniques are employed to overcome these drawbacks. Nondestructive technique such as non-covalent functionalization attracts attention to modify the nanotube side wall without any defect which can be carried out by physical and chemical methods (Chen et al., 2001; Britz and Khlobystov, 2006; Nanda Gopal Sahoo et al., 2010). Physical method involves shear mixing of CNTs in matrix. These have been carried out at room temperature with different non hydrogen bonding Lewis base solvents to take away the nanotube surface interaction (Ausman et al. 2000; Lau et al., 2005; Liu and Choi, 2012).

Chemical methods are carried out by action of surfactants, surface modification and polymer wrapping technology (Barber et al. 2003; Myung et al. 2012, Kim et al., 2012). This modification can be carried out with synthetic and natural polymers which contain functional end groups (Xu et al., 2004; Singh et al., 2004; Pan et al., 2009; Soradech et al., 2013).

Multi functional hyper branched polyesters are emerged as incredible Dendron for functionalization of CNT. Hyper branched polymers are highly branched macromolecules with three-dimensional dendritic architecture. Because of their high solubility, and abundance of functional groups, hyper branched polymers have potential applications in wide range of fields from drug delivery to material coatings (Bifeng Pan et al., 2009; Caminade and Majoral, 2010; Siqueira Jr et al., 2012;). Besides the large number of reactive end-groups of hyperbranched polymer capable for rapid cross-linking, therefore, they are potential to design thermosetting network (Gao and Yan 2004; Voit 2005; Carlmark et al., 2009).