CHAPTER 1

INTRODUCTION

Material obtained by the combination of two or more materials without dissolve or blend into each other is known as composite material. This composite usually offers very different properties than the individual material used. Here each of the materials work together to give the unique properties to the final composite material. However, within the composite, the different materials can be easily distinguished [1]. Composites that forms heterogeneous structures which meet the requirements of specific design and function, imbued with desired properties.

Fibers or particles embedded in matrix of another material would be the best example of modern-day composite materials, which are mostly structural. In matrix-based structural composites, the matrix serves two paramount purposes viz., binding the reinforcement phases in place and deforming to distribute the stresses among the constituent reinforcement materials under an applied force [2]. The first modern composite material was fibreglass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. The matrix is a plastic and the reinforcement is glass that has been made into fine threads and often woven into a sort of cloth. On its own, the glass is very strong but brittle and it will break if bent sharply. The plastic matrix holds the glass fibres together and also protect them from damage by sharing out the forces acting on them. Some advanced composites are now made using carbon fibres instead of glass. These materials are lighter and stronger than fibreglass but more expensive to produce. They are used in aircraft structures and expensive sports equipment such as golf clubs [1].

Nanotechnology has real commercial potential for the textile industry due to the fact that conventional materials and methods used to prepare composite textile materials often do not lead to permanent effects and will lose their properties after laundering or wearing. In some typical textile applications nano particles can substantially alter surface properties and also confer different structural changes to the textile materials as per Li, Lokyuen and Junyan [3]. The nano size particles offer a larger surface area compare to that of bigger particles. The high surface area to volume ratio and small size, nano particles give better binding to the material compare to micro fillers and due to high binding rate the quantity of nano particles required is very less and also highly miscible as compare to micro particles. [4-11].

The Nanocomposites 2000 conference (In November 2000, was held in Brussels. Organised by Emap's 'European Plastics') has revealed clearly the property advantages that nano-material additives can provide in comparison to both their conventional filler counterparts and base polymer. Properties which have been shown to undergo substantial improvements include: mechanical properties e.g. strength, modulus and dimensional stability, decreased permeability to gases, water and hydrocarbons, thermal stability and heat distortion temperature, flame retardancy and reduced smoke emissions, chemical resistance, surface appearance, electrical conductivity, optical clarity in comparison to conventionally filled polymers, etc.

Recently, many more literature is available related to the use of nanotechnology to change or improve the mechanical properties of textile materials. Such properties include increased tensile strength, elasticity or fiber stiffness [12-15]. These properties can lead to the production of stronger or more elastic textiles or increase the wear and tear resistance of a fabric. The probably most investigated way of improving the mechanical properties of textiles trough nanoengineering is the integration of CNT which was found to increase tensile strength or elasticity significantly as observed by Chang, et al., 2005; Hagenmueller, et al., 2003; Dalton, et al., 2004; Poncharal, et al., 1999; Miaudet, et al., 2005 [12-18]. Hagenmueller, et al., 2003 [13] stated that CNT reinforced fibers were produced by melt compounding CNT with polystyrene (PS) and polypropylene (PP) or the production of a CNT-PP Masterbatch, Chang, et al., 2005 [16], both followed by melt spinning. Miaudet, et al., 2005 [18] uses the co-flowing of a CNT dispersion during solution spinning to produce reinforced polyvinyl-alcohol (PVA) fibers. Dalton, et al., 2004 [17] reports the production of PVA-CNT-composite fibers with increased strength by a modified solution spinning process. CNT can also be applied to the fabric by spray-coating or simply dipping the textile into a CNT solution Hecht, Hu, and Gruner, 2007 [19]. Apart from CNT, also other NPs were reported to alter or improve the mechanical properties of the textile fibers. The appliance of a ZnO nanoparticle based coating was observed to increase the stiffness of a fabric. The coating was thereby applied by dipping the fabric into a nanodispersive ZnO solution and a subsequent pad- dry-cure process by Yadav, et al., 2005 [20]. Kalarikkal, Sankar, and Lfju, 2006 [15] used a similar process to provide different textile materials with a nanoparticulate Al_2O_3 coating which led to an increase in fracture toughness. To optimize the mechanical properties of carpet backings, Campos, et al., 2006 [21] used a PS - composite containing polybutylacrylate (PBA)-NP as coating. Mahltig, Haufe, and Bottcher, 2005 [22] furthermore report the possibility to increase the abrasion stability of polyester by treating the finished fabric with a SiO_2 coating. The coating is produced through a sol-gel process which involves the production of nanoparticulate SiO_2 dispersion.

Reinforced fibers could find applications in the apparel industry, the fabrication of upholstery, in geotextiles Lubben, 2005 [23], industrial textiles or the production of protective clothing by Mahltig, Haufe, and Bottcher, 2005 [22]. In the apparel industry and upholstery sector, such fibers might be used to produce wear and tear resistant clothes or furniture textiles. Their application in the production of protective clothing could furthermore lead to the development of stronger and more lightweight safety harnesses and bullet proof vests, Ward, 2003 [24]. In a lightweight military battle suit which able to withstand blasts and which is currently under development, reinforced fibers would fulfill a similar function as web.mit.edu [25]. Nano-reinforced fibers could also be used to produce stronger and more durable geotextiles which are used in the construction sector for sealing, isolation or erosion control by Lubben, 2005 [23]. In industrial textiles, the nano-reinforced fibers could find applications in filters or sieves with improved abrasion stability, as they are used in paper production as per Mahltig, Haufe, and Bottcher, 2005 [22]. In the conducted Internet research, the following two commercially available products could be found: CNT-reinforced fibers for antiballistic purposes (e.g. bullet proof vests or doors) US global Nanospace, 2007 [26] and CNT containing polymer additives for the production of reinforced textiles Zyvexpro Materials, 2007 [27].

From the literature it is quite clear that the use of nano-sized materials not only improves the existing properties but also introduces special properties to textile materials. Thus the main purpose of this doctoral thesis is to study the structural and mechanical changes in different polymers like polyamide, polypropylene and polyester in different forms like film, filament and fabric respectively due to the loading of silica nano particles. Polymer-silica nanocomposite materials have been studied for the structural transformations by SEM, FTIR, EDX, XRD and DSC. Due to loading of silica nano particles there is improvement in mechanical properties like tensile, young's modulus, work of rupture, etc.

In agreement with the aims defined for the present thesis, in the general introduction corresponding to chapter 1 and chapter 2 deals with brief bibliographic revision concerning the most relevant topics related to needs of industrial textiles, composite materials, polymer nanocomposites and different methods to prepare polymer nanocomposite textiles, methods for testing and evaluation. Chapter 3 deals with preparation of polymer silica nano composites like film, filament & fabric and the testing & analysis of these prepared nanocomposites for structural and mechanical performance. Chapter 4 deals with the results and discussion of these polymer silica nanocomposites in three different parts individually for film, filament and fabric. Chapter 5 deals with summery and conclusion based on the results and discussion made in previous chapter.