SUMMARY

There has been tremendous use of nanomaterials to prepare high performance products for various industries like electronics & photonics, automobile, coatings, structural materials, packaging and medical/biomedical. The high performance properties of products can be achieved using small amount of nanoparticles. This is due to the nanoparticles have very high surface area and volume to size ratio. In recent years, use of nano particles as filler and reinforcement in polymer to prepare nanocomposite has gained lot of research interest in industries as well as in academia. Use of nanoparticles and nanocomposite materials as dielectric materials for electrical industries is yet at a beginning stage.

This thesis contains the efforts made to prepare dielectric nano particles like aluminium trihydroxide, calcium carbonate and indigenous montmorillonite clay available in Kutchh region, Gujarat. It has been used to prepare nanocomposites. Nanocomposite materials have been prepared using modified organoclay with Highdensity polyethylene, Polypropylene and Epoxy resin in view to use these materials in electrical industries. Attempts have been made to synthesize some Organo titanates useful as modifier for nanoparticles. Effect of treatment of silane and titanate to organically modified clay in various concentrations on nanocomposite properties has been studied. These nanocomposite materials have been characterized for their electrical properties, mechanical properties, thermal properties, morphological properties etc. Nanocomposite materials show better electrical properties and pass standard tests (Glow wire test and Ball Pressure test) which make them potential materials for manufacturing products for electrical industries.

The work carried out is given in five chapters. The brief of findings are mentioned chapter wise as under.

Chapter 1: This chapter contains the exhaustive literature available on composite, types of composite, basic polymers for composites, nanotechnology, nanoparticles and nanocomposites. The structure of nanocomposite, preparation techniques and importance of melt compounding technique is described. It has been found that, at
present, there are four principle methods for producing nanocomposites, namely in situ polymerization, solvent intercalation, sol-gel templating and melt compounding. Melt compounding technique is environmentally sound since no solvents are required. It gives freedom to end use manufacturers, and minimizes capital costs due to compatibility with existing processes. The advantages, mechanism and applications of surface modifiers are discussed. Surface treatment of nano particles reduces the surface energy and improves the dispersion of nanoparticles in the polymer. The literature indicates that, in the majority of the polymer clay nanocomposites, clay has been organically modified by quaternary ammonium or phosphonium salt alone. But here, we attempted treatment of organoclay with other surface modifiers such as silane and titanate to ease the processing and improves the clay dispersion in polymer matrix.

Chapter 2: This chapter deals with preparation of surface modifiers, nanoparticles and nanocomposites. Nano particles of aluminium trihydroxide, calcium carbonate have been prepared. Several techniques such as high energy ball milling, precipitation, matrix mediated growth method etc. have been used to prepare nano particles. Nanoparticles are characterized by XRD, SEM and TEM for their morphology and particle size. Some organotitanates useful as surface modifier like Titanium butoxide, Titanium isoproopoxide and Titanium acetylacetonate have been synthesized and characterized by FT-IR. The indigenous raw montmorillonite clay has been modified with Hexadecyl trimethyl ammonium bromide. Raw clay and modified clay have been characterized by FT-IR. The nanocomposites of HDPE with organoclay modified by Hexadecyl trimethyl ammonium bromide were prepared in Brabender Plastograph EC using 1, 3, 5, 7 and 10 wt % organoclay content. 5 wt % organoclay was selected as optimum clay content for nanocomposite depending on the properties obtained and organoclay is further treated with silane and combination of silane and titanate (organomettalic compounds) in different concentrations. Organoclay was treated with silane in concentration of 1, 3 and 5 %. Organoclay was also treated with combination of silane and titanate, in which concentration of silane and titanate was kept 0.5, 1.5 and 2.5 % each. Nanocomposites of HDPE with 5 wt % organoclay treated with different concentration of silane and combination of silane and titanate have been prepared. Nanocomposites of PP with 5 wt % raw clay,
organoclay and organoclay treated with silane and combination of silane and titanate have been also prepared in Brabender Plastograph EC.

Epoxy clay nanocomposites were prepared by melt mixing organoclay and Bisphenol A based Epoxy in 1 to 10 wt % organoclay content. Nanocomposites of epoxy with organoclay treated with 0.5 and 1 % silane were prepared with 3 to 10 wt % clay content. Nanocomposites of epoxy with organoclay treated with 0.5 and 1 % titanate were prepared with 3 to 10 wt % clay content. These all compositions of nanocomposites were characterized for electrical properties like dielectric strength, volume resistivity, surface resistivity, comparative tracking index and mechanical properties like tensile strength, elongation at break, impact strength and hardness etc. Thermal analysis was carried out using TGA technique. Morphological studies were carried out using scanning electron microscopy and elemental mapping analysis by EDXS. The nanocomposites of HDPE and PP have been characterized for the glow wire test and ball pressure test.

CHAPTER 3: This chapter deals with the analysis of the results obtained related to the characterizations of nanocomposites.

The IR spectra of the modified clay confirm the absorption of quaternary ammonium compound between the clay galleries. The SEM and TEM images show the nanometric dimensions of the aluminum trihydroxide and calcium carbonate nano particles. Results obtained for electrical properties such as dielectric strength (ASTM D149), surface/volume resistivity (ASTM D257), comparative tracking index (IEC 60112-2003) and mechanical properties such as tensile strength (ASTM D638), impact strength (ASTM D256), Hardness (ASTM D224) have been discussed. Morphological analysis, thermal analysis and thermal tests like glow wire test (IEC – 695 -2 – 1) and ball pressure test (IS – 3854 – 1997) have also been explained

CHAPTER 4: This chapter draws the conclusions from the data of analysis. From the data of analysis it can be concluded that the treatment of silane and titanate coupling agents to the organoclay has the synergistic effect for the formation of nanocomposite. The treatment of coupling agents improves the dispersion of the clay in the polymer matrix. Use of combination of silane and titanate gives better
improvement in nanocomposite properties than the use of silane alone. Use of silane and titanate improves the electrical properties of the nanocomposites very significantly. E.g. dielectric strength of the HDPE 5 wt % organoclay nanocomposite is 55.7 KV/mm whereas on treatment of 5 % silane it increased to 66.5 KV/mm. On treatment of 5 % of combination of silane and titanate, dielectric strength of the HDPE 5 wt % nanocomposite increased to 68.7 KV/mm. Similar trends is observed for volume and surface resistivity. Volume and surface resistivity improves by more than $10^2$ powers when nanocomposites are treated with coupling agents. Improvement in mechanical properties like tensile and hardness is also observed. In epoxy clay nanocomposite, with silane treatment, improvement in properties increases with concentration while with titanate alone improvement gets level of at 1 % concentration.

CHAPTER 5: This chapter describes the applications of the prepared nanocomposites based on the properties. It was ascertained that the nanocomposites of HDPE and PP with clay, calcium carbonate, aluminium trihydroxide have wide applications in manufacturing electrical and wiring accessories because of better dielectric and mechanical properties.

Epoxy nanocomposites were prepared using modified organoclay along with the titanates and silane compounds and characterized for electrical properties such as dielectric strength, comparative tracking index, surface/volume resistivity. The electrical and mechanical properties were significantly improved. These nanoclay composites may find wide applications in insulators and dry type transformer. The modified clay may also find applications in cables for improving dielectric properties.

There are many areas of applications other than electrical industries, where these nanocomposite materials can be used for better performance properties like coating, packaging, automobile etc. Organoclay treated with silane and titanate may be advantageous for the improvement in performance properties of the products for these industries. The usage of nanocomposite with thermosetting and thermoplastics is a beginning for electrical applications. Power industries are using several kinds of polymers in large quantity for manufacturing several products. The mechanical, electrical as well as thermal properties are improved significantly using
nanocomposites. The work presented in this thesis is a new research area for using nanocomposites in electrical industries. This work further can be extended to other polymer matrixes such as ABS, Polycarbonate, PVC, phenol formaldehyde, epoxy, furan resins etc. for industrial applications.