ISSN 2321-807X
Volume 13 Number6
Journal of Advances in chemistry

A CRITICAL REVIEW ON POLYURETHANE POLYMER HYBRID NANO COMPOSITES

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ABSTRACT

Critical review on polyurethane hybrid nano composite paper gives knowledge on its techniques and their applications. In addition to the scientific framework for the advancement in the polymer matrix hybrid nano composite research, the critical review provides an ample discussion on technology, characterization, processing and its applications on polyurethane hybrid nano composites.

KEY WORDS: Polyurethane, X-ray diffraction, carbon nanotubes, nanoparticles.

Introduction

The fascinating synthetic materials in Industries is Polyurethane, that has been commonly used as adhesives, synthetic leather, coatings, automatic applications and construction etc,. Hybrid nano composites are having polymers contain nanofillers within the PU matrix. The microstructures of nano composites have heterogeneous in the scale range of nanometers. Nowadays on Polyurethane applications, researchers are starting to explore the higher performance polyurethane. Polyurethane matrix based nanocomposites reveal remarkable improvements in mechanical, magnetic, dielectric, optical, thermal and acoustic properties are compared with pure polymers (Karim, 2000).

The present paper describes a brief review on the literature and some declaration of polyurethane matrix nanocomposites studies. Hybrid nanocomposites demonstrated often unusual & beneficial for the consumer properties. Technical and scientific literature report shows the enhancement of properties of polymer hybrid nanocomposites compared with pure polymers.

LITERATURE SURVEYS

Cao & Jana (2007) studied on "Nano clay-tethered shape memory polyurethane nanocomposites", polyurethanes is composed from poly capro lactone (PCL) diol, methylene diisocyanate, and butane-diol. Bulk polymerization was used to prepare nanocomposites of reactive nanoclay. Shape fixity and shape recovery stress values were calculated as function of clay content. The melting point of the crystal-like soft segment was used as the transition temperature for actuating the shape memory actions. The clay particles well dispersed in the polymer reduced the crystalline phase of the soft segment. These particles helped to mix the hard and soft segment phases. In this case, the soft segment crystallinity was enough and sometimes increased due to stretching which reveal excellent shape fixity and profile recovery ratio. Due to the addition of 1 wt. % nanoclay, the magnitude of shape recovery stress was 20% increased. Soft segment crystallinity and the clay content influence the tensile properties at room temperature. It facilitates to measure the tensile modulus at room temperatures about the melting point of the matrix crystals which indicate the continuous increases with clay content.

Dorigato et al (2011) analyzed on "Effect of the polymer–filler interaction on the thermo-mechanical response of polyurethane–clay nanocomposites from blocked pre polymer". Commercial organo-modified clay was dispersed in cycloaliphatic amines at different amounts to prepare thin transparent films of polyurethane–clay nanocomposites. These were used as chain extender of an obstructive pre polymer which helps to investigate the thermo-mechanical behavior of the composites by adding the filler content. The formation of an intercalated structure influenced clay content measured by X-ray diffraction. Nanofiller addition was not enough to compromise the optical clarity of the samples even at elevated clay amounts. The relative thermal lifetime was influenced by clay content up to 7 wt. %. Finally, increase in elastic modulus was evidenced, which was influenced by clay concentration, while uniaxial tensile tests were taken under quasi-static and impact conditions.

(Messori 2011) studied about "In situ synthesis of rubber nano composites". In this study, In situ generation of inorganic oxides of hydrolytic sol-gel process was used for the preparation and characterization of rubber based nano composites, similar to the preparation of reinforced vulcanized and non-vulcanized rubbers. Morphological properties, investigated by scanning electron microscopy and X-ray diffraction, were used for the investigation of the different preparation conditions and the filler content. In situ filled nanocomposites consist of excellent mechanical properties (modulus, strength and extensibility) than the particulates (or) elastomers obtained by conventional mechanical mixing were identified from the analyses. It induced tendency of filler–filler aggregation of the sol–gel process, due to a particle surface interaction which was resulting from the 'bottom-up approach'.

Mishra et al (2011) investigated on "Structure property of thermoplastic polyurethane–clay nano composite based on covalent and dual-modified laponite". Ionic and covalent modification techniques were applied for the surface modification of clay platelets which help to disperse easily in polymers such as thermoplastic polyurethane (TPU). But it was not enough to attain uniform dispersion of laponitenano particles (synthetic hectoritenanoclay) in TPU. So morphology, thermal and rheological behaviors were observed by adding the dual modification of laponite i.e., both ionic and covalent. Due to this dual modification, it exhibited different morphological properties. From this analysis, the exfoliation grade of clay platelet in TPU matrix was higher for dual functionalized nanoclays when compared to single modified counterparts. Then the dual modified laponite in TPU nanocomposite, the storage modulus in the glassy region (at −60^{o}C) and in the rubbery region (at +98^{o}C) was increased by 172.8% and 85% respectively than the neat TPU.

Mazurkiewicz & Porębska (2010) researched about “The methods of evaluation of mechanical properties of polymer matrix composites”. The mechanical properties of 10, 20, 30, 40 and 50% of glass fiber in polyamide (PA) , poly oxy methylene (POM) with 15, 25 and 35% glass fiber and also 10, 15, 25% of mineral filler and the same contents of mineral filler in polypropylene (PP) was determined. The changes in dissipated energy and modulus of elasticity were estimated with the function of number of cycles. Three levels of load were observed in this investigation. Due to adhesion between the polymer and fillers, the changes in internal stress were enhanced from the values of dissipated energy. By the elimination of stressed areas through cracking of adhesive contacts between the reinforcement and the matrix, the quality of the composite at its first loading conditions was obtained.

Khudyakov et al (2009) explained about “Polyurethane nanocomposites”. This study described the current status of photo polymerizable (UV-curable) polyurethane (PU) nanocomposites such as nanosilica and organically-modified clay (organoclay). PU could be obtained by two ways, by radiation cure of urethane acrylates oligomers (pre-polymers) or by dark reactions between di-isocyanates and polyols. Many data on the structure and properties of PU nanocomposites were gathered by SEM, TEM and XRD methods. Under high load at 10–50 wt. %, properties of PU nanocomposites were improved with silica. Similarly, at the level of 3–10 wt. %, properties of PU nanocomposites were improved by the addition of organoclay.

Li et al (2009) worked on “Effects of ZnO nanoparticles on the mechanical and antibacterial properties of polyurethane coatings”. Polyurethane coatings strengthened by ZnO nanoparticles of 27 nm were fabricated via solution blending. The solution casting and evaporation methods were used for synthesization of the ZnO/PU films and coats. The universal material test was used to investigate the mechanical properties of film, and a pencil-abrasion-resistance tester was also used to evaluate the abrasion resistance of coats. It was observed that young’s modulus and tensile strength has significant improvement with ZnO nanoparticles addition up to 2.0 wt. % in PU films and also in PU coats because of ZnO nanoparticles addition, abrasion resistance was greatly enhanced. Furthermore, the agar dilution method was used to carry out the antibacterial property test and its result showed excellent antibacterial motion for the ZnO nanoparticles addition in PU films.

Joulazadeh & Navarchian (2011) observed from “Study on elastic modulus of cross linked polyurethane/organoclay nanocomposites”. In situ polymerization method was used to synthesize a polyether and polyester based pre polymer with methylene-bis-ortho-chloroanilline (MOCA) to form polyurethane/clay nanocomposite with cross linked structure. Different organic transformers with two modified clays were used to see the influence of compatibility between polymer matrix and clays for determining the elastic modulus of nanocomposites. XRD and microscopic techniques were used for the investigation of the dispersion of clay layers and their morphology in polyurethanes. The observed elastic modulus changes of nanocomposites with their clay content were compared with the conventional preparation of composites. In this work, the clay content exceeded up to 1.5 wt. % was observed that elastic modulus was reduced experimentally due to inadequate diffusion of silicate layers all over the cross-linked matrix which was not anticipated with the conventional composites. Finally, a new Wu model was developed which fitted reasonably with the experimental results for predicting the reduction of elastic modulus at different clay contents in cross-linked PU matrix.

Markus Rampf et al (2012) works on “Structural and mechanical properties of flexible polyurethane foams cured under pressure”. Flexible two-component polyurethane foam was prepared via various extents of over pressure up to 2 bars. On shrinkage, the effect of the pressure conditions was studied. The basic foam properties such as the relative density, microstructure were investigated and also examined the ratio of open to closed pores as well as the elastic properties of the foam. There was a linear relationship between the comparative foam density and the applied overpressure. An immediate change of the primarily open pore structure to basically closed-cell foam was found in the fine range between 50% and 60% specific gravity. During the foam synthesis, the controlled method on the shrinkage properties of closed cell foam through the extent and time period of overpressure applied was determined and a hypothetic qualitative model describes the basic mechanism. Finally, the foam obtains the interesting potential for the manufacturing application (e.g. gasket material).

Song et al (2010) investigated on “A study of the tribological behavior of nano-ZnO-filled polyurethane composite coatings”. The two dissimilar morphologies of ZnOnano elements and ZnO whiskers were used as the friction modifiers for improving the tribological characteristics of the polyurethane (PU) coated composite. Under dry friction condition, a ring-on-block wear test was conducted and also by using SEM and optical microscope (OM), the worn surfaces and the transfer film surface were examined. It was found that the addition of the low inclusion of ZnO nanoparticles and ZnO whiskers could improve the reducing-friction and anti-wear abilities of the PU coatings and also enhance the adhesion of the transfer films of the PU coating to the surface of counterpart ring. Finally, the wear rate of the PU coating was significantly compacted.

Wacharawichanant et al (2010) works on “Effect of Zinc Oxide on the Morphology and Mechanical Properties of Poly (Styrene-co-Acrylonitrile)/Poly (Methyl Methacrylate)/Zinc Oxide Composites”. The effect of zinc oxide (ZnO) on the morphology and mechanical properties of poly (styrene acrylonitrile) (SAN) and poly methyl methacrylate (PMMA) blends was encountered. Composite blends of SAN and PMMA (20/80 wt. %) with ZnO were synthesized by melt mixing in a twin screw extruder and then molded by compression molding method. The dispersion of ZnO particles in the matrix polymers was investigated using SEM. Because of the low ZnO content, ZnO particles were dispersed as well. On the other hand, the aggregates of ZnO particles in a polymer matrix increased with increasing ZnO content. The mechanical test results showed that the tensile strength and stress at break of SAN/PMMA blends decreased slightly with increasing ZnO content up to 1.0 wt. % which also increased the Young's modulus and impact strength of SAN/PMMA blends. But the addition of ZnO beyond 1.0 wt. % decreased the Young's modulus and impact strength.

Morfologi & Mekanik (2013) explained about "Glass fiber and nanoclay reinforced polypropylene composites: morphological, thermal and mechanical properties". Through extrusion and injection molding, Poly Propylene (PP) / Glass Fiber (GF) / Nano Clay (NC) hybrid composites were synthesized. Prepared specimens were investigated by TEM, TGA, tensile and flexural tests. TEM results showed that NC particle intercalation. TGA results explained that the incorporation of clay into the glass fiber composite enhanced the thermal stability of the hybrid composites. The early thermal decomposition temperatures also increased to higher values. The tensile strength of the binary composite was lowered due to the incorporation of GF into PP, which indicated a poor fiber-matrix interfacial adhesion. From the analysis, it was found that the strength of the ternary composites material was increased by the addition of new NC. Tensile modulus of the hybrid material was enhanced with the combination of GF and further increased with an addition of NC. The flexural strength and flexural modulus was also increased.

Saengsuwan & Saikrasun (2012) worked on "Thermal stability of styrene-ethylene butylene-styrene-based elastomer composites modified by liquid crystalline polymer, clay, and carbon nanotube". The thermal decomposition behaviors of styrene-ethylene butylene-styrene (SEBS) thermoplastic elastomer filled with liquid crystalline polymer (LCP), organomontmorillonite (O: MMT), and carbon nanotube (CNT) as a heat stabilizing filler, were investigated using non isothermal and isothermal-thermo gravimetric analyses in air. The iso conversional method was employed to evaluate the kinetic parameters (Ea, IDA, and n) under dynamic heating. From the analyses, the isothermal decomposition stabilities of the neat SEBS and its composites containing the different fillers were associated with those of the non-isothermal investigation.

Bazhenov & Goncharuk (2013) worked on "The criterion of particle-induced cracking of filled polymers". From the research work, it was observed that ground rubber particles filled on high (or) low density polyethylene and polypropylene had failed to sustain tension. In tension, particles were unbound from the matrix and initiated the presence of pores. Small particles lead to development of elliptical pores. In contrast, larger particles began appearance of diamond cracks lead to the failure of filled polymer. The intermediate size of elliptical pores transformed into diamond crack. When the elongation of an elliptical pore reached the critical crack tip opening of the unfilled polymer, the diamond crack appeared. Depending upon the polymer yielding or with necking, ductile or brittle behavior of rubber particles filled polymer was observed. If the neck did not appear, filler particles on polymer had brittle fracture.

Atta et al (2013) studied about "Corrosion inhibition efficiency of modified silver nanoparticles for carbon steel in 1 M HCl". The coated silver nanoparticles were synthesized with polymerizable surfactants which acted as a dispersing agent. For the purpose coating, by esterification method Noigen R-N10 with maleic anhydride was modified. The morphology of the nanoparticles had been determined by TEM. Silver nanoparticles were prepared with the size of 25 to 80 nm and the diameters of 2 to 18 nm. These silver nanoparticles were applied as a corrosion inhibitor for carbon steel in 1M HCl solution by using electrochemical impedance spectroscopy (EIS) technique. Finally, this result showed that silver nanoparticles reduced the corrosion rate of carbon steel and exhibited the barrier property in HCl solution.

Sharma et al (2012) observed on "A study on luminescence enhancement in ion irradiated TiO_2/poly (methyl methacrylate) nano composites". Heavy ion induced adaptation in the optical properties of TiO_2 with poly methyl methacrylate nanocomposites were investigated. By solution casting method, TiO_2 nanoparticles were homogeneously dispersed in PMMA matrix. These nanocomposites were irradiated with $Ag+_{12}$ ion beams and characterized by XRD, SEM, UV and PL spectroscopy. Enriched broad emission peak was exhibited by PL spectra in visible region (400 nm - 750 nm) while UV spectroscopy revealed an improved absorption in the visible region.

Zhang et al (2012) explained about "Improvements of mechanical properties and specular gloss of polyurethane by modified nanocrystalline cellulose". 3-Glycidoxypropyltrimethoxysilane (GPTMS) and 3-Methacryloxy-propyltrimethoxysilane (MPS) were used to modify the surface of Nano crystalline cellulose (NCC) in order to overcome the shortage of compatibility with polyurethane. Polyurethane with modified nanocrystalline cellulose was characterized by wetting property, XRD, and TGA. The wetting property of nanocrystalline cellulose modified by GPTMS increased by 25.9% and by MPS decreased 22.5 % of the contact angle. The crystal structure and thermal stability of polyurethane had been affected more by NCC modified - MPS than GPTMS. Thus, the optical and mechanical properties of polyurethane were improved by modified NCC.

(Eggersdorfer 2012) explained about "Nanoparticle agglomerates and aggregates in aerosols by coagulation and sintering". The formation of silica nanoparticles was simulated at high temperatures in the free-molecular regime under dilute conditions. Inter-particle collisions were calculated by an event driven method to simulate realistic volume fractions ($\varphi s = 10^{-7}$). Particle structure evolution by viscous flow sintering was determined with multi-particle sintering simulations. The sintering time increases, with particle radius and particles start to form aggregates, if the collision and sintering time were of the same order of magnitude. This enhances the collision frequency, as the particle collision radius increased faster than spheres while the particles had the same relative velocity as with full-coalescence.

Pan et al (2013) studied about "Preparation and characterization of TiO_2 nanoparticles surface-modified by octadecyltrimethoxysilane". Titanium dioxide (TiO_2) nanoparticles surface modified by octadecyltrimethoxysilane are prepared via in situ surface-modification in dehydrated ethanol at room temperature. As obtained TiO_2 nanoparticles were characterized by means of FTIS, TGA, XRD and TEM. The tribological properties of TiO_2 nanoparticles surface attained by octadecyltrimethoxysilane as an additive in liquid paraffin were determined with a four-ball friction and wear tester. It was found that octadecyltrimethoxysilane chemically bounded to the surface of TiO_2 nanoparticles during the surface modification process. Resulting in increased dispensability of TiO_2 nanoparticles in liquid paraffin was over 99%, it improved the anti-wear ability of liquid paraffin.

Mazrouaa et al (2012) investigated on “Synthesis and characterization of poly o-anisidine nanoparticles and their nanocomposite”. In this work, poly o-anisidine nanoparticles with addition of 1.0 wt. % of Ag_2O, ZnO, CuO and TiO_2 powder had been prepared. Its microstructure was determined by FTIR spectroscopy and TEM. This result showed that they had good effects to sulfate reducing bacteria than POA nanoparticle. Similarly, the polymer nanoparticles converted from insulator behavior 10-16(S/cm) to semiconductor behavior by adding metal oxides while 10-11(S/cm) of POA/Ag_2O and 10-12 (S/cm) of POA/ZnO.

Hanemann & Szabó (2010) worked on “Polymer-nanoparticle composites: From synthesis to modern applications”. Micron-sized fillers in nanocomposites, the interface between the nanoparticle and the polymer matrix played an important role due the large filler specific surface area such as SiO_2, Al_2O_3, ZrO_2, TiO_2, Fe_2O_3, SnO_2, or ZnO. Quite often a nanofiller surface hydrophobization using chemi- or physisorption helps for composite property tailoring. Due to the huge surface area of the filler and its interfacial polymer layer, the maximum filling content was limited. As there was a complex interplay between matrix, interface and filler a targeted physical property design of new materials could only be analyzed with a control on a molecular level.

Jeon & Baek (2010) studied about “Nanocomposites derived from polymers and inorganic nanoparticles”. Generally, organic polymers had good process ability and long-term stability. Inorganic nanoparticles held outstanding optical, electronic and magnetic properties, which were considerably different at their bulk states. The combination of both components, i.e., nanocomposites derived from organic polymers and inorganic nanoparticles were expected to achieve improved properties. They had potential applications in various fields like automotive, aerospace, opt-electronics, etc.

Sudheer et al (2013) worked on “Mechanical and abrasive wear behavior of metal sulphide lubricant filled epoxy composites”. The work revealed that the abrasive wear behavior of epoxy matrix with and without reinforcement of glass fiber and also mechanical properties were studied with the addition of commercial MoS_2 (10wt %) particles. The solid lubricants such as MoS_2 and glass fibers play an important role in inducing the performance of polymer in a beneficial manner. Solid lubricant, namely, MoS_2 showed to be advantageous in abrasive wear approach, and acted to weaken the mechanical performance.

Theiler et al (2002) experimented on “Friction and wear of PTFE composites at cryogenic temperatures”. At cryogenic temperatures, the tribological performance of PTFE composites was examined against steel. The coefficient of friction decreased with temperature down to 77^oK and there was no linear advancement further down to low temperatures. The cryogenic atmosphere had a substantial influence on the tribological behavior of the polymer composites. Hence, PTFE matrix composites were investigated by SEM and AFM analysis under these experimental conditions had shown the transmitted material onto the record down to very low temperatures.

Mello et al (2009) worked on “ The effect of post-consumer PET particles on the performance of flexible polyurethane foams”, which dealt with the use of post-consumer PET (polyethylene terephthalate), PET, as reinforcement filler in flexible polyurethane foams was studied, with the aim of finding alternatives for the recycling of polymer packaging. Post-consumer PET particles with controlled granulometry (0–297 mm) and concentration (1.5 ph of PET pc in relation to polyol) were added to flexible PU foams and the physical, mechanical and morphological characteristics of the foams were evaluated. The filled foam yielded better wear, compression set and compression resistance than the standard foam.

Iqbal et al (2010) studied about polystyrene-metal powder conductive composites”. Melt processing technique was the method used for the preparation of conductive polymer composites with different metallic fillers added in the polystyrene matrix at 230^oC and the spindle speed of 120 rpm. One micron sizes of different fillers such as carbon black, nickel powder, copper and iron powders were used. Samples were prepared for thermal, tensile, and resistivity test by using hydraulic press under a pressure of 220 bars, at 220^oC for 5 minutes and then cooled in atmospheric air. Optimization of mechanical, conductive and thermal properties composite was explained. Even though improvement of a definite property by using specific filler was possible, improving a number of preferred properties in a particular composite was a challenge.

Panigrahi &Pathak (2012) studied about “Aqueous medium synthesis route for randomly stacked molybdenum disulfide synthesis of poorly crystalline”. Rag-like structures of randomly oriented molybdenum disulfide was prepared from ammonium molybdate solutions and thioacetamide in the existence of sodium dodecyl sulfate via calcination of the shapeless precipitates. Through acidification of the in situ produced transitional of ammonium tetra thiomolybdate was obtained. X-ray photoelectron spectroscopy, XRD and UV-visible spectroscopy methods revealed that the formation of single-phase MoS_2, whereas a mixture of MoS_3, Mo_2S_5 and an amount of H_2MoS_4 were found in amorphous precipitates. An aqueous solution-based precipitation method was used for the preparation of MoS_2 by using some existing laboratory reagents. As all reagents used in this method were fairly solvable in water and there was less impurities in the final products.

Pradhan & Nayak (2012) investigated that castor oil using hexa methylene diisocyanate (HMDI) and naturally modified clay were used to synthesize polyurethane nanocomposites. Some refined techniques like SEM, XRD, TGA and FTIR were used for testing the properties of polyurethanes and their nanocomposites. At ambient temperatures, modified PU nanoparticles with hexa methylene diisocyanate (HMDI) nanocomposite had synthesized. SEM results revealed that HMDI modified nanocrystals were pseudo spherical and the concentration of diisocyanate increased or decreased the nanocrystals size. The resulting hydrophobic starch nanoparticles were versatile precursors to the development of nanocomposites.

Nuruzzaman & Chowdhury (2012) explained on “Friction and wear of polymer and composites”. When there was a contact between sliding pairs, then friction and wear occurred simultaneously. The coefficient of friction was calculated for different types of polymer and composite materials by varying the duration of rubbing between the surfaces. At initial stage of rubbing, friction force between superficial layer of pin and disc was low and then, roughening of disc surface was caused by an increase in friction coefficient. In sliding contacts between the surfaces, sliding speed had a significant role on friction and wear of different polymer and their composite materials. Finally, the result showed that the friction and wear of polymer and composites were significantly influenced by normal load, sliding velocity, frequency, direction and its amplitude of vibration.

Pettarin et al (2010) studied about “Changes in tribological performance of high molecular weight high density polyethylene induced by the addition of molybdenum disulphide particles”. The high molecular weight high density polyethylene (HMW-HDPE) polymer tribological behavior was determined by adding commercially available molybdenum disulphide. TEM, SEM and EDS were the refined techniques used for examining the tribological factors and microscopically interpretations to reveal the influence of MoS_2 in composites. The wear behavior of HMW-HDPE/MoS_2 composites under sliding and abrasive conditions was studied. The incorporation of MoS_2 to HMW-HDPE improved its sliding and abrasive wear performance with a content of MoS_2 for minimum wear rate around 10 wt. %. Under sliding conditions, no lubricant effect of MoS_2 particles was found as COF did not diminish. However, MoS_2 changed the main wear mechanism of HMW-HDPE from severe melting wear to mild adhesive wear, which was characterized by the development of a uniform and member transfer film on the counter face.

Luo et al (2010) investigated “The Effect of nano-Si_3N_4 surface treatment on the tribological performance of epoxy composite”. Chemical grafting method was used to synthesize polymer composites with addition of modified nano-Si_3N_4 by covalently bonding glycidyl methacrylate (GMA) onto the particles. This method was used to overcome the drawbacks generated by the loose nano-particle agglomerates dispersed in polymer composites. The worn surface of the filled epoxy composite and the surface roughness of the composite materials after the sliding wear test were examined by SEM and AFM. They concluded that grafting of GMA onto nano-Si3N4 increased the interfacial interaction between the particles and the epoxy matrix through chemical bonding and compared with the unfilled and nano-Si3N4 filled epoxy, the epoxy filled with low content Si3N4-g-PGMA exhibited lower friction coefficient and higher wear rate.

Zhang & Singh (2004) studied about “Mechanical reinforcement of unsaturated polyester by Al_2O_3 nanoparticles”. Here nanometer-sized Al_2O_3 particles (15 nm average diameter) were used as reinforcements to enhance the fracture toughness of a highly, nominally brittle, thermosetting-unsaturated polyester resin. It was observed that the addition of untreated, as-received Al_2O_3 particles did not result in enhanced fracture toughness. Instead, the fracture toughness decreased by 15% as the volume fraction of the particles was increased from 0% to 4.5%. Similar degradation in fracture toughness was observed for reinforcement by 1 and 35-nm Al_2O_3 particles. The lack of reinforcement was attributed to poor particle-matrix bonding, as observed from SEM of the fracture surfaces. However, considerable reinforcement was observed when the nano composites were fabricated using an organo functional silane to enhance particle-matrix interface strength. In the case of a 4.5% volume fraction of well-bonded Al_2O_3 particles added to the unsaturated polyester, the fracture toughness increased by almost 100%.

Paul & Robeson (2008) investigated on “Polymer nanotechnology: Nanocomposites”, that field of nanotechnology having polymer matrix based Nanocomposites was the current area of research and development. Exfoliated clay-based nanocomposites had dominated a large number of other significant areas such as flammability resistance, biomedical applications, barrier properties, electrical/electronic applications and fuel cell interests. The ‘‘nano-effect’’ of nanoparticle or fiber inclusion relative to their larger scale counterparts was relative to crystallization and glass transition behavior. Thus, other polymer and its composites based properties derived benefits from nanoscale filler or fiber inclusion.

CONCLUSIONS

In this literature review, it is evident that researchers have studied about the synthesis and characteristics of polyurethane matrix composites with the addition of organic and inorganic particles in varying percentage of composition. From the literature review, it is very clearly seen that research is done on the polyurethane matrix composites and some researchers are done on the other polymer matrix hybrid composites. Thus, molybdenum disulphide is added for enhancing the wear property of the hybrid composites and titanium dioxide nanoparticles are added for improving the mechanical properties of the polyurethane matrix hybrid nanocomposites.

Polyurethane matrix hybrid composites materials are used in various fields of engineering applications. Specifically, gears and rollers are used in high speed applications such as, printers, scanners and Xerox machines etc., and its products are also used as mating parts.

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