Reinforcing effect of nano kaolin clay on PP/HDPE blends

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Abstract
The reinforcing effect of different nano materials on polymers have been widely studied. This paper highlights the effect of nano kaolinite clay on polypropylene (PP)/ high density polyethylene (HDPE) blends. The PP and HDPE are popularly known as commodity plastics and are used to make the body parts of automobiles, household articles etc. By mixing with nano material strength of the matrix is enhanced thereby making the nano composite suitable for more strategic engineering applications. In this work PP and HDPE are taken in a specific proportion (80/20 by weight) and melt compounded with different compositions of modified nano kaolin clay. The kaolin clay is abundantly available in the coastal regions of Kerala. It is ground into nano sized particle and modified by replacing the inorganic ion by an organic one by ion exchange method to make it more compatible with PP/HDPE blend. The effect of nanoclay content in the blend on mechanical and morphological properties is investigated. Reinforcing with nano fillers proved to enhance the mechanical properties of blends without increasing weight, density etc.

Keywords: Polymer nanocomposites, nano kaolin clay, malt compounding, blending.

1. Introduction
Polymer nanocomposites consist of a polymeric substance and a nanoscale reinforcing material. These materials show substantial improvements in mechanical properties, gas barrier properties, thermal stability, chemical resistance, dimensional stability and fire retardancy [1] over the base polymer. The first successful and significant development of polymer nanocomposites was pioneered by Toyota's researchers in the course of high performance reinforced plastics applications in automobiles [2]. The important advantages of using polymeric nanocomposites over conventional materials are processing ease, manufacturing versatility and low over-head production cost

Polymers are widely used due to their ease of production, light weight and ductile nature. But compared to metals and ceramics, they are inferior in mechanical properties. One way to improve their mechanical properties is to reinforce them with particulate fillers like talc, mica, $CaCO_3$, kaolin, fumed silica or fibres like glass fibres, nylon fibres etc.. Nano fillers have now emerged as the ultimate reinforcing agents for polymers for improving their mechanical properties without affecting density, transparency and processibility. [3-6] Reinforcing polymers with nano sized clay particles yield materials with enhanced performance without recourse to expensive synthesis procedures [7-9]. Polymer nanocomposites (PNC) are a new family of materials that has attracted, and will continue to attract, great interest in industry and academia [10-14]. They are ideal candidates for a vast majority of structural and functional material applications

The blending of polymers provides an efficient way of developing new materials with tailored properties and is often a faster and more cost effective means of achieving a desired set of properties than synthesising a brand new polymer [15]. Among polymer nanocomposites, those based on PP and HDPE and nanoclay have attracted considerable interest [16-21] because PP and HDPE are two most widely used and fastest growing class of thermoplastics, while nanoclay is one of the most widely accepted and effective nano filler. Kaolinite clay is a mineral that has wide variety of applications in industry, particularly as a filler in paper, plastics, paints and rubber. The main challenge facing the preparation of PNCs using nanoclay is that clay is naturally hydrophilic whereas PP and HDPE have no polar groups in their backbone and are two of the most hydrophobic polymers. In order to overcome this difficulty and to ensure proper dispersion organic modifiers are used to replace the inorganic cations (Na^+) with organic cations like alkyl ammonium, alkyl amine etc.[22].

2. Experimental
2.1 Materials
Polypropylene homo polymer (PP): (REPOLH110MA)and **high density polyethylene** (HDPE) (REPOL H110MA) were supplied by M/s Reliance Industries Ltd., Hazira, Gujarat

Nanoclay : Nanocaliber-100,supplied by English Indian Clays Limited ,Veli, Thiruvananthapuram, Kerala ,India. The clay is one dimensionally nano sized, ion exchanged with cationic amino salts and spray dried.

Appearance: Off white powder,
Plate thickness(SEM):<80nm ,
Bulk density:0.2-0.3g/cc ,
BET Specific surface area:28-30m2/g
Moisture:<1 w/w%

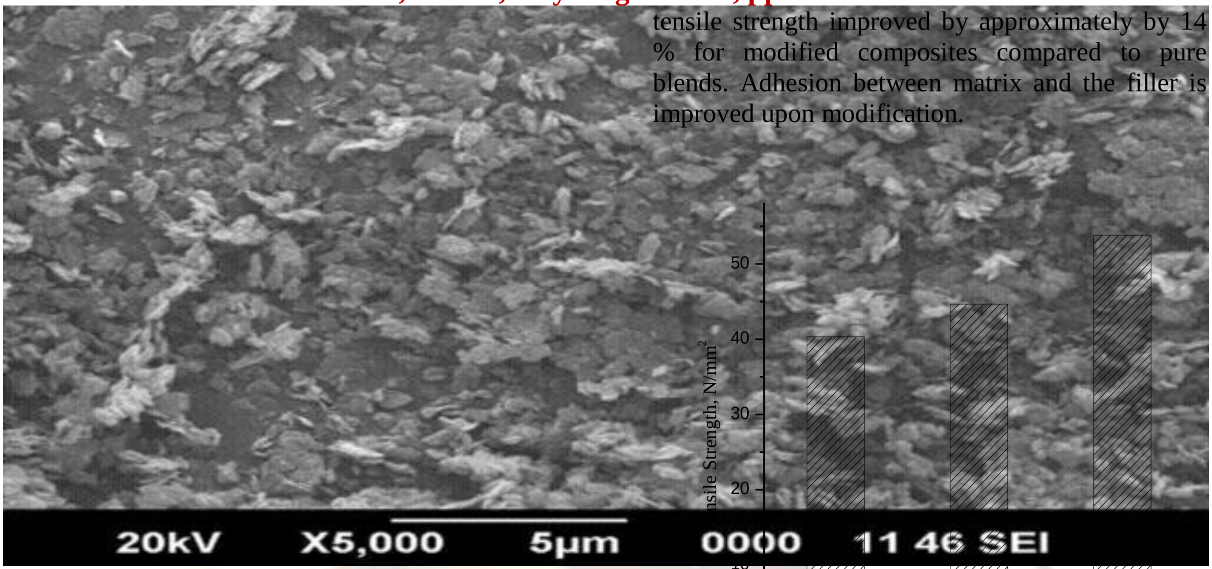

Fig.1 SEM photograph of nano kaolin clay (Nanocaliber-100A).

2.2 Methods

Preparation of hybrid composites: All composites were prepared in an internal mixer Torque Rheometer (Thermo Haake Rheocord 600). The rotor speed was set at 50 rpm. The components of 40 g were loaded to the mixing chamber through the hopper and compounded at 160^0C temperature for 8 minutes , with rotor speed of 50 rpm
Nano clay used was preheated to about 75^0C for 45 minutes to remove moisture content and polymers taken in the 80% PP and 20%HDPE by weight are melt compounded in the Haake melt mixer.
The composites so prepared were hot pressed in a hydraulic press, cut into pieces and moulded using a semi-automatic plunger type injection moulding machine.

Testing of hybrid composites: The specimens obtained after moulding were tested for tensile and flexural properties in a Shimadzu Autograph Universal Testing Machine (UTM)), impact strength
in Resil Impact Testing Machine according to ASTM standards. SEM images were taken with JSM 6390 with an accelerator voltage 20 kV on a vacuum atmosphere.

3. Results and discussion

3.1 Mechanical Properties

The tensile strength of PP/HDPE at various filler loadings of nanoclay and as well of pure blends is shown in Figure 1. Filler loadings were varied from 0 to 3 weight % of blend. The mechanical properties enhancement is found up to a filler loading level of 2% and thereafter a slight decrease is found. At 2% filler loading effective interaction of the filler with matrix occurred. The tensile strength improved by approximately by 14 % for modified composites compared to pure blends. Adhesion between matrix and the filler is improved upon modification.

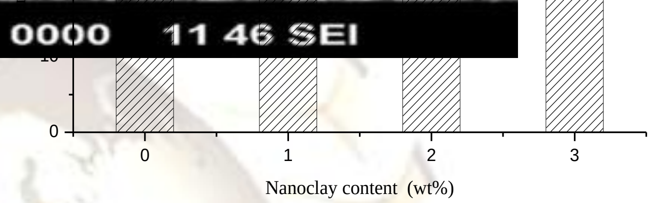

Figure 1. Tensile strength of pure blend as well as nano composites of varying compositions

The flexural strength or three point bending of PP/HDPE at various filler loadings of nanoclay and as well of pure blends is shown in Figure 2. Similar trend as tensile strength is obtained for flexural strength also. Clay layers acts as stress transfer agents and resists breakage while bending. This gives better flexural strength for nanocomposites. The enhancement upon adding 2 wt% nanoclay is about 20% compared to pure blend

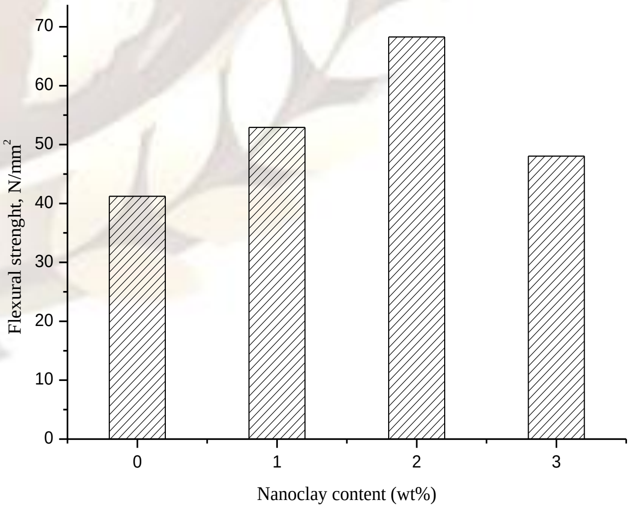

Figure 2. Flexural strength of pure blend as well as nano composites of varying compositions

Impact strength PP/HDPE blends with various loadings of nanoclay is shown in Figure 3. The impact strength is found to increase steadily with increase in filler loading as expected and higher impact strength is for filler loading at 2% as similar to tensile properties. Further higher loading is found to decrease the impact properties. The increase in impact strength is found to be 14 % for the nanocomposites compared to pure blend. Interfacial stress transfer efficiency and extend of induced deformation determines the mechanical performance of a composite material. There will be considerable improvement in these properties if the bonding between filler and matrix is strong. The decrease in strength after a particular composition may be due to poor dispersion of clay particles by the agglomeration within the polymer matrix.

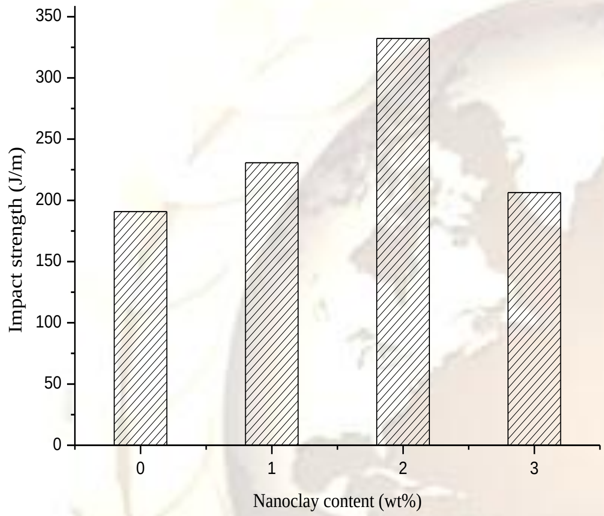

Figure 3. Impact strength of pure blend as well as nano composites of varying compositions

3.2 Morphological Characterization

Figures 4 a, b, c and d illustrate the fracture surface SEM micrographs of pure PP/HDPE blends as well as 1, 2 and 3wt% composites of PP/HDPE/ nano kaolin clay. The trend of the mechanical properties is well explained by observing the SEM micrographs. In figure 4.b we it is seen that there is proper dispersion and wetting of the matrix and this is reason for maximum enhancement of mechanical properties at 2 wt% nano clay containing composites. As seen in the SEM micrographs there is agglomeration and improper wetting in the 1 and 3wt % composites.

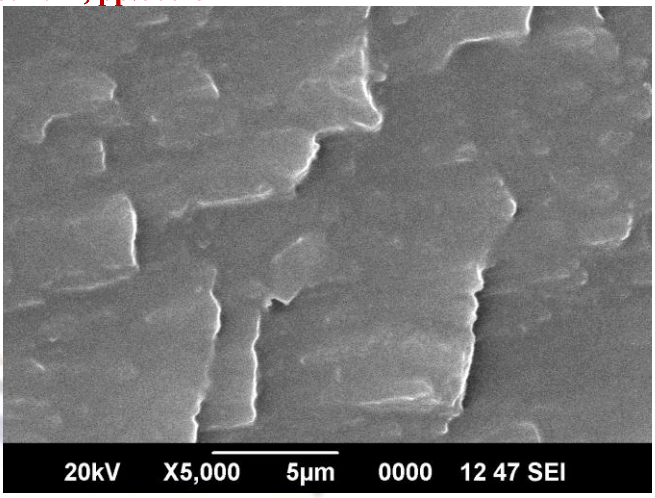

Figure 4.a SEM micrograph of fractured surface of PP/HDPE blend

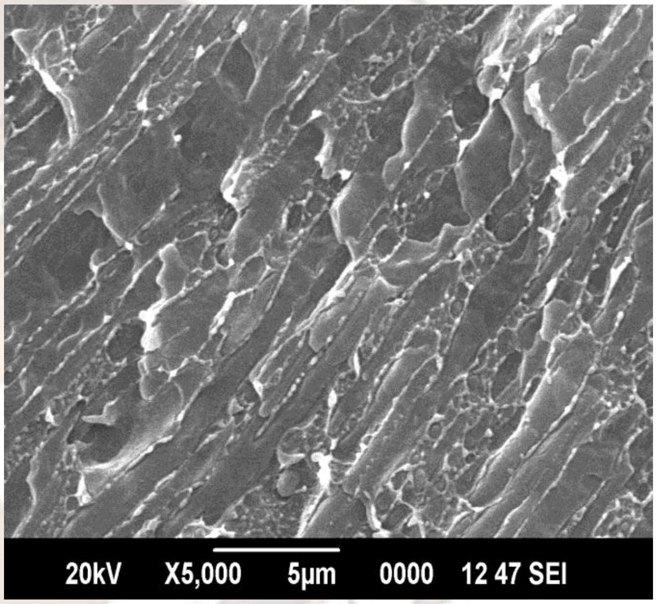

Figure 4.b SEM micrograph of fractured surface of PP/HDPE blend + 1% nano clay

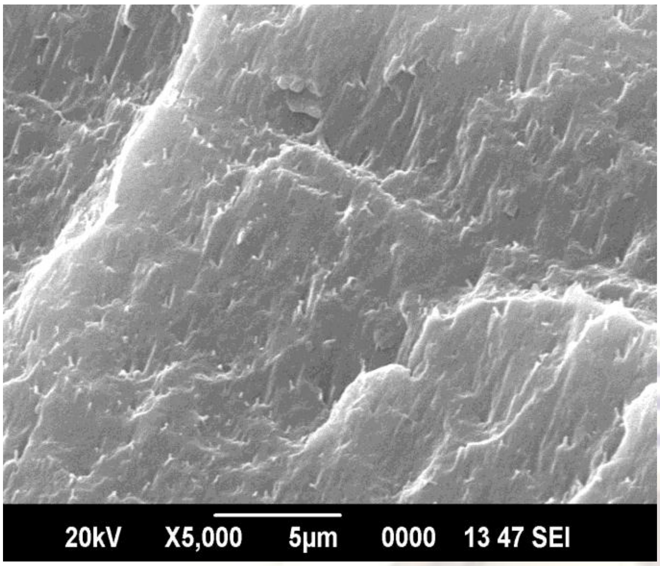

Figure 4.c SEM micrograph of fractured surface of PP/HDPE blend + 2% nano clay

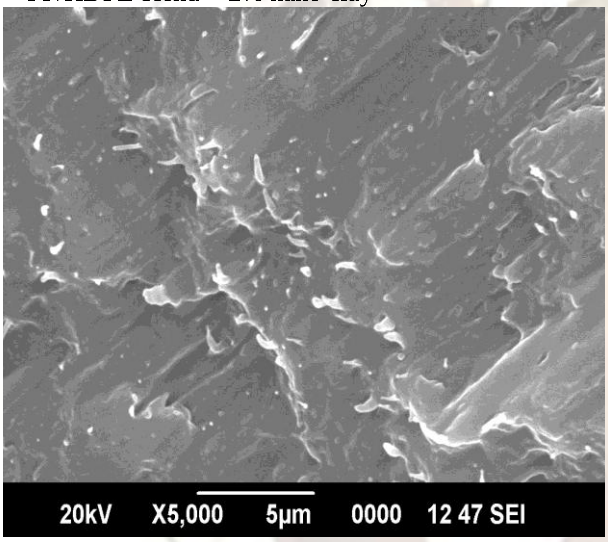

Figure 4.d SEM micrograph of fractured surface of PP/HDPE blend + 3% nano clay

4. Conclusions

The effect of amino modified nanoclay in PP/HDPE (80/20) was studied in this work. The study shows that kaolin clay can act as a cheap and effective reinforcing agent for PP/HDPE blends. The incorporation of nano clay improves the properties of PP/HDPE blends. Incorporation of nano clay at two weight percentage gives maximum improvement in mechanical properties. The enhancement in physical properties is well explained by morphological characterization. PP/HDPE blend can thus effectively upgraded as an engineering material by melt compounding with nano kaolin clay.

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