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Utilisation of Nanosize Powder (Montmorillonite) for Compounding Lightweight Polymer Products

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ABSTRACT

In this study, polymer nanocomposites were prepared using various nanosized powder clay content (montmorillonite) and compatibilizers. The compatibilizers used in this research were maleic anhydride(MA). The importance of this compatibilizer was also discussed. Polypropylene(PP)/ montmorillonite(MMT) were prepared by compounding process and was fabricated by using injection moulding machine. The effect of structure properties of the compatibilization of the clay dispersion and clays amount on the microstructure of the nanocomposite were investigated. Microstructural characterization of the samples was characterized by Field Emision Scanning electron microscopy (FESEM). The results of this research were expected to produce a lightweight and strong material with homogeneized microstructure and improved mechanical properties that suitable for application of aircraft interior parts or handicap products.

Keywords: Polypropylene, Polymer Nanocomposite, Homogeneized Microstructure, Montmorillonite

INTRODUCTION

In recent years, clays containing polymer nanostructured materials have attracted great interest from researchers, both in industry and in academia, because they often have better properties than pure polymers or conventional composites[1-2]. In this research, the nanoclay used were montmorillonite (MMT). MMT is a silicate with large surface-to-volume ratio (80-300m^2/g) that exist naturally in a tactoid structure comprised of several tens of stacked layers. These layers have a typical lateral dimension of 0.1-0.5µm and layer thickness and interlayer spacing of about 1 nm. The sum of a layer and an interlayer represents the repeat unit of the stacked materials called *d*-spacing or the basal spacing (d_{001})[3]. MMT filled nanocomposite often exhibit remarkable improvement in material properties with only a low percentage of MMT fillers added. One of the major findings that have stimulated the interest in MMT filled nanocomposites is the work by Okada *et al.*,[4]. Polypropylene (PP) is one of the most widely used polyolefin polymers. It can be easily process, relatively low material cost and has good mechanical and thermal properties. This dispersion of organically modified layered silicates in PP induces enhancement in mechanical properties, flame resistance and barrier properties, compared with the pure polymer. Furthermore, these improvements are achieve for clay loading as low as 5 wt% [5-6]. However for apolar polymers such as

PP[7-9] and PE[10], the interactions between polymer chains and MMT surface are relatively weak, so it is very difficult for a polymer chains to intercalate into the MMT gallery and form fine nanocomposites. Compatibilizers such as maleic anhydride were often added to achieve a favorable polymer-surface interaction and improve the intercalation degree in the apolar polymer systems. Dispersal of the nanolayers of the MMT in the polymeric matrix produces an exfoliated polymer nanocomposite. If the polymer molecules infiltrate the interlayer spacing preserving the stacked structure, an intercalated polymer nanocomposite is obtained.

Methodology

Materials

Polymers used in this study was polypropylene (PP) injection grade. Batch number G112 supplied by Propelinas, MTBE, Petronas Malaysia, was used as the matrix for the nanocomposite. The organic MMT (o-MMT), already modified with a quaternary ammonium salt in the supplied form, was obtained from Mill Clay Inc, Rockwood Texas, USA. Maleic anhydride lot number: s46145-159 (briketts, 99%) was supplied by Sigma Aldrich was used as a compatibilizer while stearic acid lot number 05217D5-488 (reagent grade 95%) was supplied by Sigma Aldrich.

Melt processing

The composites were obtained by melt mixing the polymers with the clay using a Brabender-Lab compounder machine (model KETSE 20/40 at a nominal temperature of 180°C under nitrogen atmosphere). Before the processing process, the polymers and MMT, were dried in a vacuum oven at 80°C overnight. Polymer mix (5Kg) was prepared and mixed manually and loaded into the compounder. The concentration of the clay were in the range from 1 wt%, 3 wt%, 5 wt%, 8 wt%, and 10 wt% while maleic anhydride was added constant of 0.2 wt% for all batches. Control samples were also prepared having the same percentage concentration of the clay without compatibilizer was also prepared at the same processing condition. All batches were processed with a rotational speed of screw 300 min-1, temperature profile of a plasticizing system 185°C, 185°C, 190°C, 195°C, head temperature 200°C and the samples were all dried at room temperature using a conveyor belt and palletizing by a cutter. All samples were compounded into the brabender machine twice to make sure the homogenization of the samples obtained. Finally all the samples were injected into specimens of dumbbell shape and rectangular shape by using injection moulding machine (machine type: Haitian), 160 tonne machine. The temperature setting was 200°C, 205°C, 205°C, 190°C, 175°C, 160°C, mould temperature of 60°C with 45s cycle time.

The phase-morphology of the fractured samples were examined by field emission scanning electron microscope (FE-SEM). FE-SEM was used to obtain complementary information of the structure of the clay and the composites at microscopic and mesescopic levelsThe fractured samples imaged using an SEM (nama machine), operating at an accelerated voltage of 1kV.

RESULTS AND DISCUSSION

Phase morphology and structure of nanocomposites

The fractures samples surface of the nanocomposites were examined by FE-SEM. The surface morphology of the samples were depends on the degree of the interfacial behaviour, and the nucleation[11]. Micrograph in Fig. 1(a) to Fig. 5(b) shows typical FE-SEM images of PP/MMT nanocomposite with and without compatibilizer, maleic anhydride (MA). Fig (a) shows the micrograph of the nanocomposites with MA compatibilizer and Fig (b) shows the nanocomposites without compatibilizer. From Fig. 1 (a) to Fig. 5 (a), it can be seen that as the higher percentage of the clay loading in the PP matrix, the distribution of the clay particles can be clearly seen that the clay particles were well dispersed evenly and homogeneous of very fine particles in the PP matrix. However, it can also clearly seen that, as the higher the clay loading inside the PP matrix, there were some agglomeration of the clay particles occur. This is appear in the Fig 5 (a) While in the Fig. 1 (b) to Fig. 5 (b), the clay particles were not clearly seen except in the 10 wt% clay loading in the PP matrix, some small clay particles appear on the fractured surface. As the clay loading increases, the roughness surface of the nanocomposite were also increased.

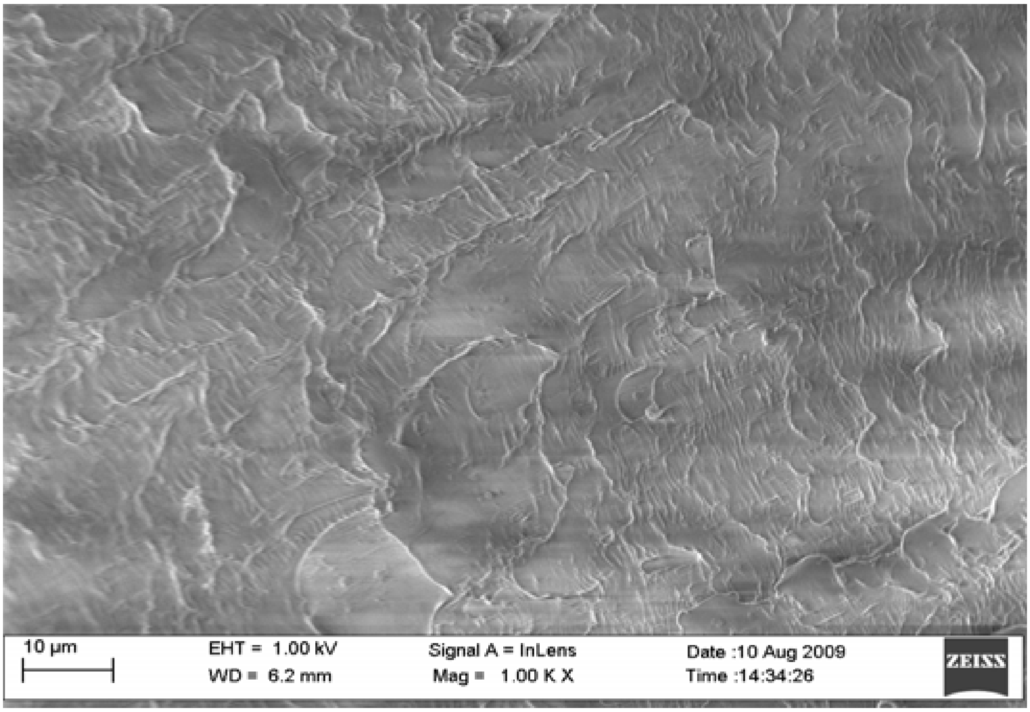

Fig. 1 (a): 1 wt% nanoclay with MA compatibilizer

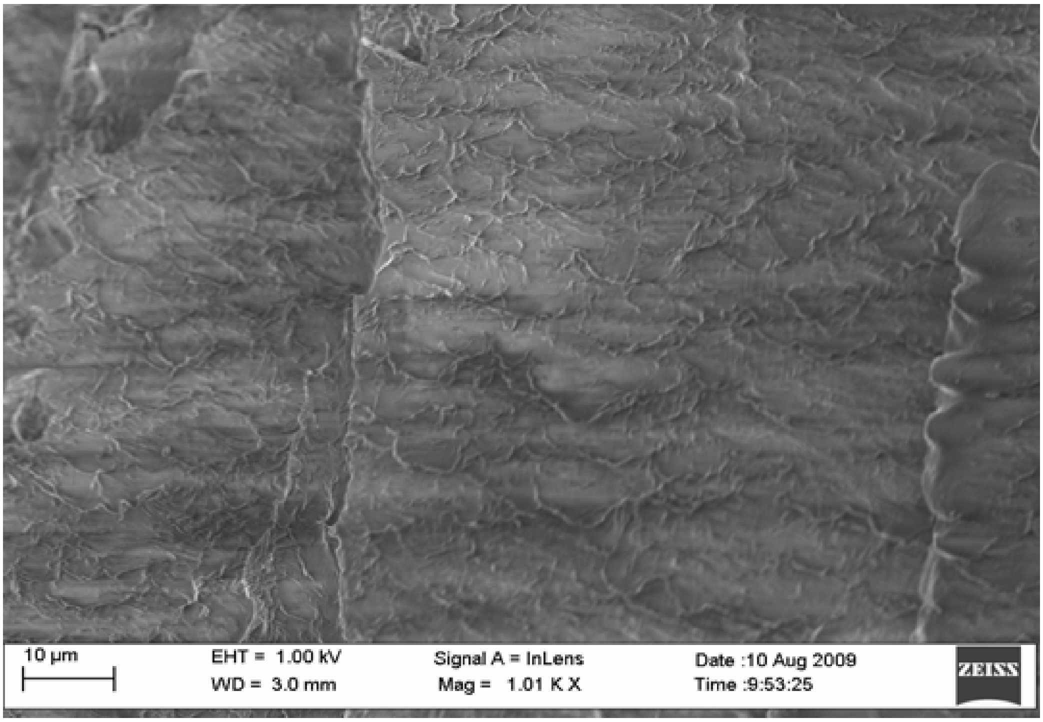

Fig. 1 (b): 1 wt% nanoclay only

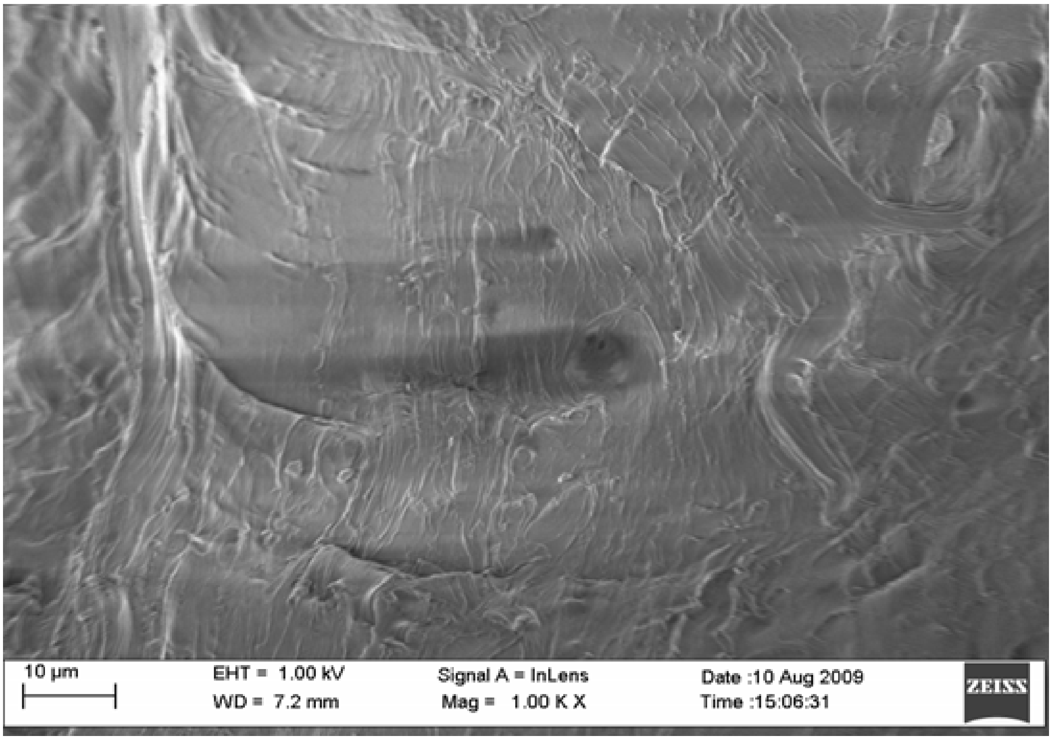

Fig. 2(a): 3 wt% nanoclay with MA compatibilizer

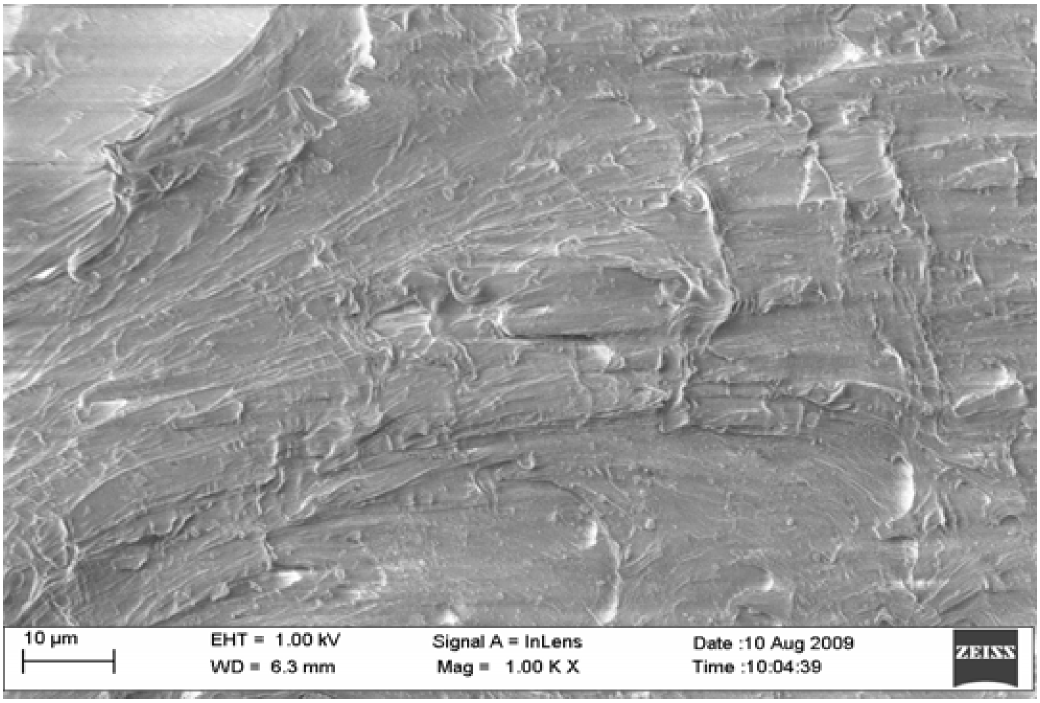

Fig. 2(b): 3 wt% nanoclay only

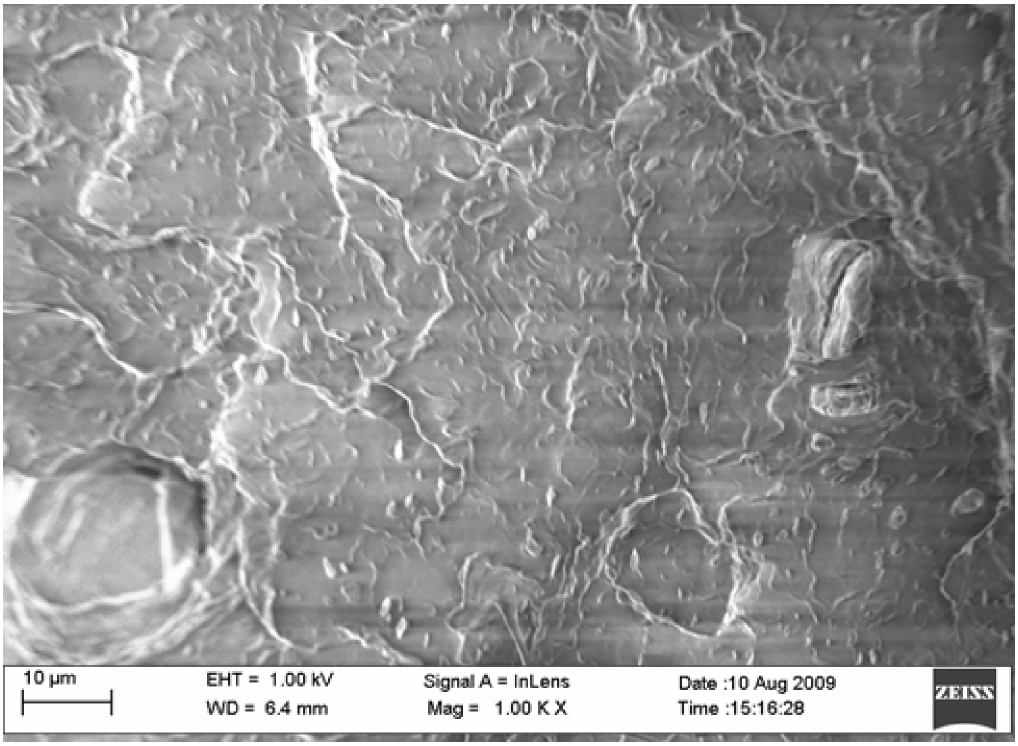

Fig. 3(a): 5 wt% nanoclay with MA compatibilizer

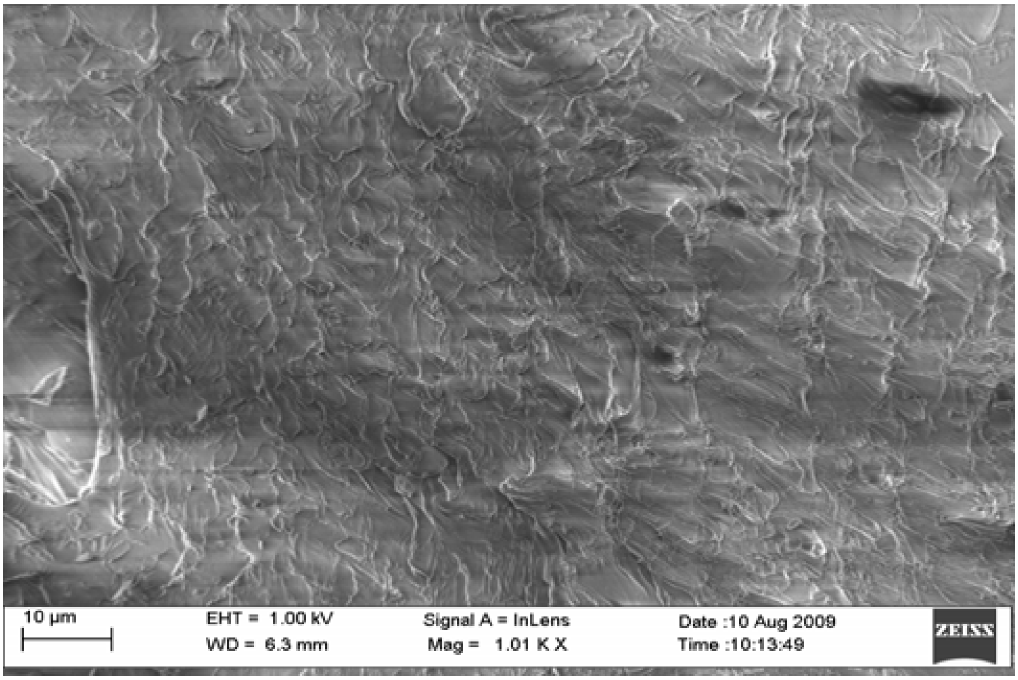

Fig. 3(b): 5 wt% nanoclay only

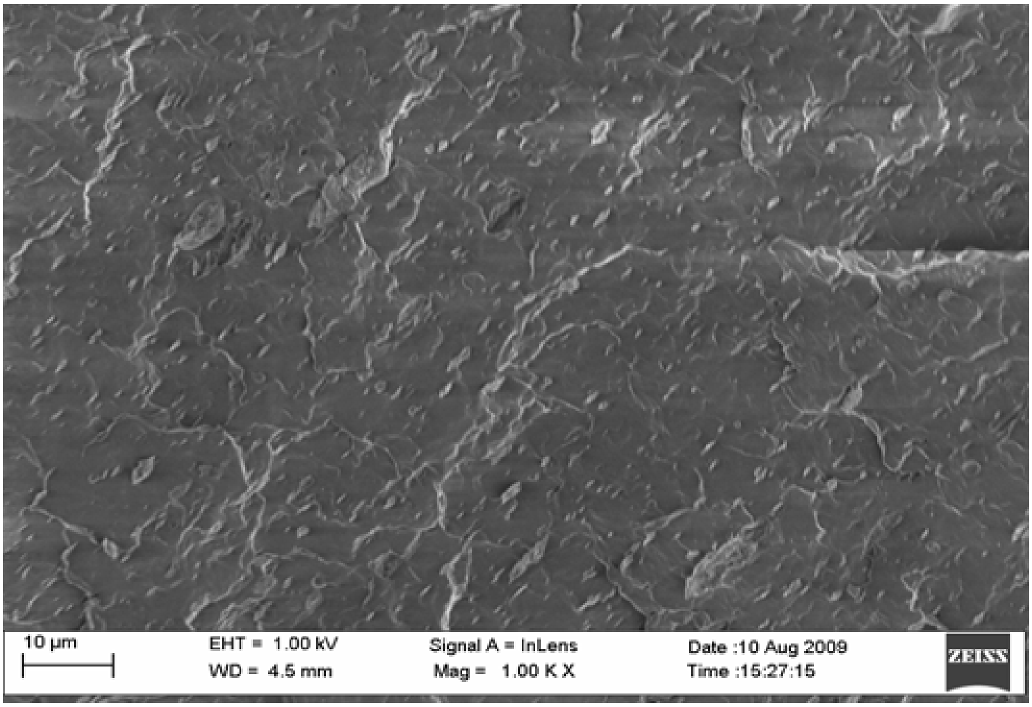

Fig. 4(a): 8 wt% nanoclay with MA compatibilizer

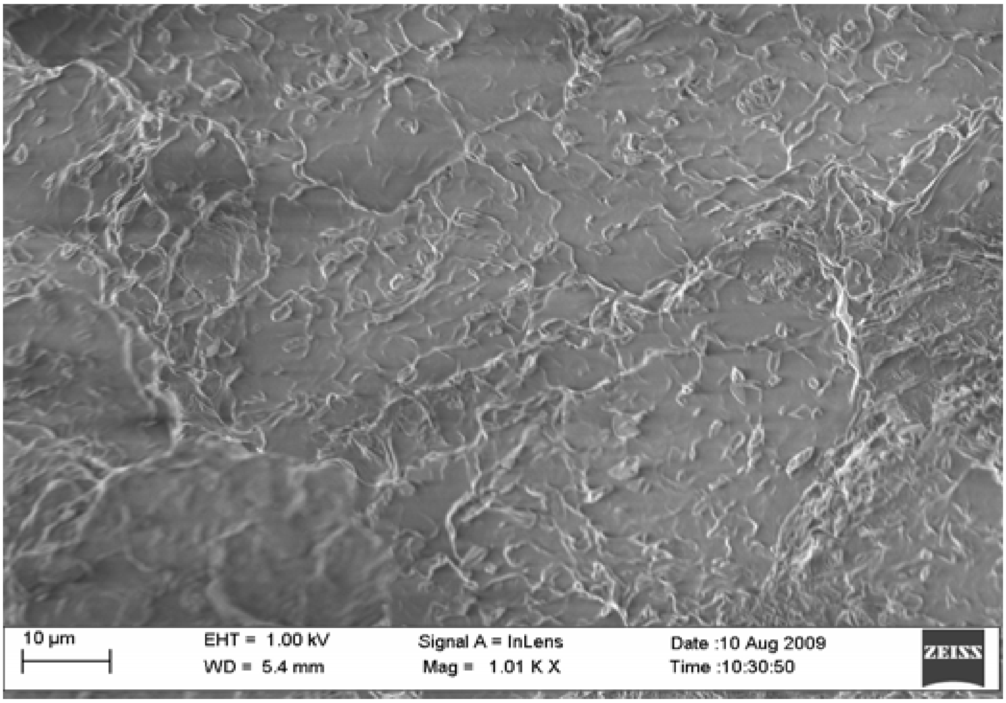

Fig. 4(b): 8 wt% nanoclay only

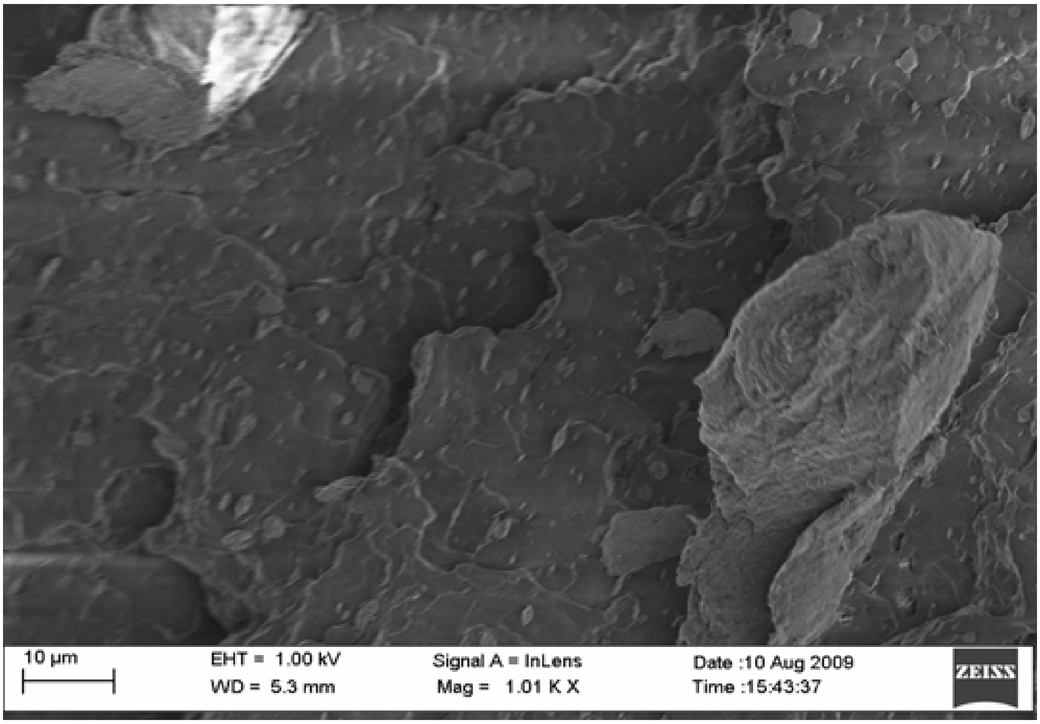

Fig. 5(a): 10 wt% nanoclay with MA Compatibilizer

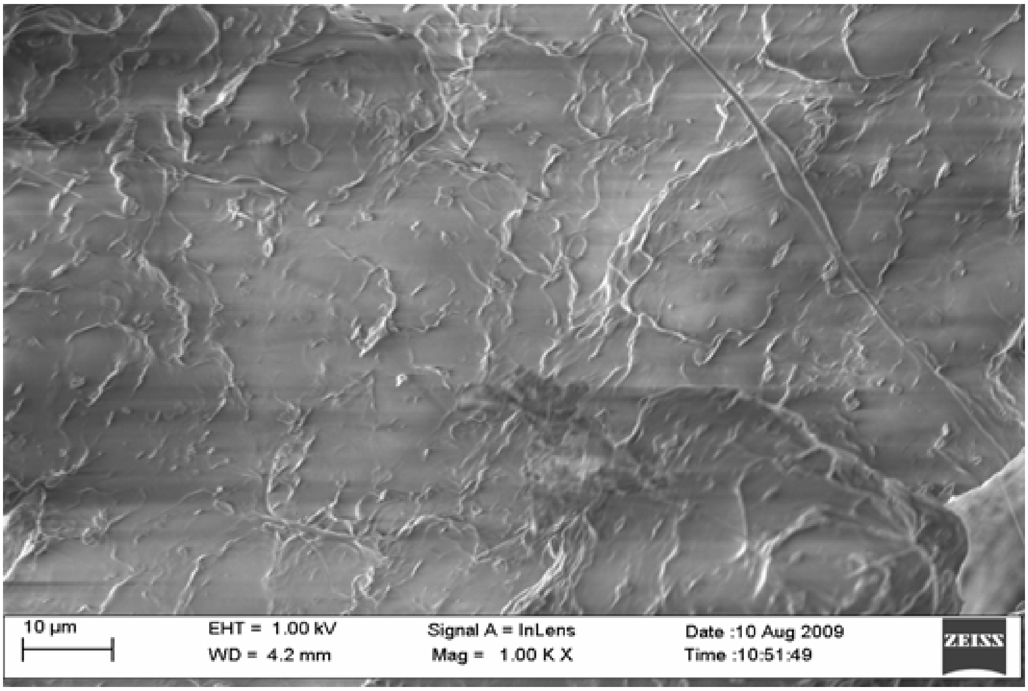

Fig. 5(b): 10 wt% nanoclay only

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