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NANOCLAY INCORPORATED POLYPROPYLENE MELTBLOWN WEBS

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Abstract

Influence of natural nanoclay reinforcement on morphology, thermal response, and mechanical properties of polypropylene meltblown microfiber webs were investigated. Combination of WAXD, DSC and TEM were used to determine nature of clay dispersion and resultant morphology. Effect of nanoclay additive on the structure and properties of webs were analyzed. Clay additive does not seem to offer any property benefit in case of melt blown webs. Melt blown web samples with additives show higher variability in web structure, higher air permeability, higher stiffness and lower mechanical properties.

Background

Melt blowing (MB) is a one-step process in which high-velocity hot air blows a molten thermoplastic resin from an extruder die tip onto a conveyor or take-up screen to form a fine fibrous and self-bonding web [1]. Schematic of a melt blown process is shown in Figure 1. MB webs have fiber diameters generally in the range of 2 to 4 µm. MB webs produced from different polymer systems are extensively used in a wide range of applications such as filtration media, medical fabrics, adsorbent media and sanitary products, to name only a few [2,3]. One of the disadvantages of MB web is its lack of mechanical strength. For most of the applications, it is used along with a supporting material in the composite form.

To date, influence of nano additives on the structure, and properties of melt blown webs is not reported. In our previous studies of nanoclay on spunbond nonwovens, nucleating ability and role of clay in crystallization and spun fiber morphology was studied[4,5]. In this research, we produced melt blown webs with very low wt % of clay additive. Influence of nanoclay, different wt % of compatibilizer and difference in air pressure on resultant structure and properties of web is studied. Influence of nanoclay additive on polymer morphology and structure and properties of resultant MB webs are discussed here.

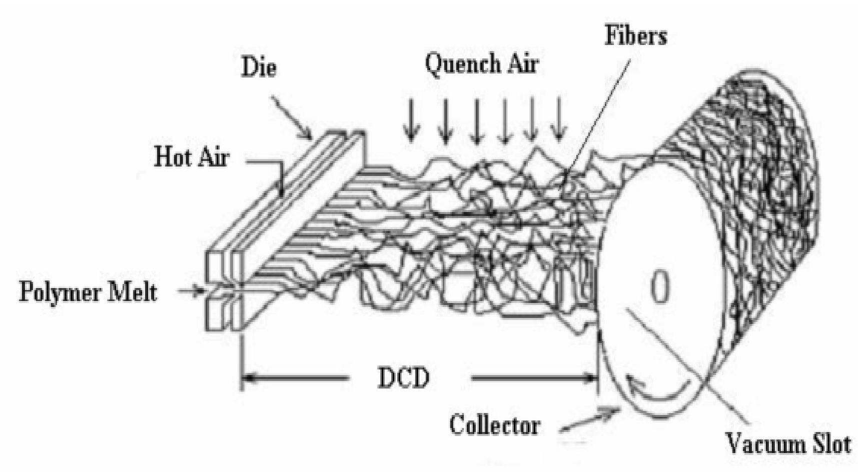

Figure (1) : Schematic of a meltblown process [1].

Materials and Method :

MB fabrics were produced from 1500 MFR Polypropylene with 0.5 wt. % Closite Na+ with 1.25 wt % and 2.5 wt % maleated polypropylene (mPP) compatibilizer. The 1500 MFR PP was provided by ExxonMobil Chemical Company, Baytown, TX. Natural nanoclay Closite Na+ was obtained from Southern clay and then compounded with PP at Techmer PM, Clinton, TN. Different samples produced and their respective compositions are included in Table 1. The samples were characterized for nanocomposite morphology and properties. Wide angle X-Ray Diffraction (XRD) of samples was carried out using a Phillips X Pert Pro x-ray diffraction system in continuous scan mode. TEM image of thin section of the samples was obtained using Hitachi H-800 electron microscope operated at 200 kV. Scanning Electron Microscopy images of the meltblown web surface were taken using the Leo 1215 Field emission gun. The samples were coated for 10 seconds using the SPI sputter coater. Physical properties of the webs were determined according ASTM standards [6].

Table (1) : Details of sample composition and hot air pressure.

Sample	Composition	Air Pressure
Control MB	1500 MFR PP	21 kN/m^2
1LP	0.5 % Closite Na+ and 1.25 % mPP	21 kN/m^2
1HP	0.5 % Closite Na+ and 1.25 % mPP	41 kN/m^2
2LP	0.5 % Closite Na+ and 2.5 % mPP	21 kN/m^2
2HP	0.5 % Closite Na+ and 2.5 % mPP	41 kN/m^2

Results and Discussion :

The WAXD scans of different melt blown web samples are shown in Figure 2. The scans for web samples do not show any peaks corresponding to natural nanoclay which occurs around 2θ of 6.07° which reconfirms good dispersion or delamination of the clay platelets beyond 100 A°. The delaminated structure or loss of ordered structure is due to higher level of shear involved in the extruder.

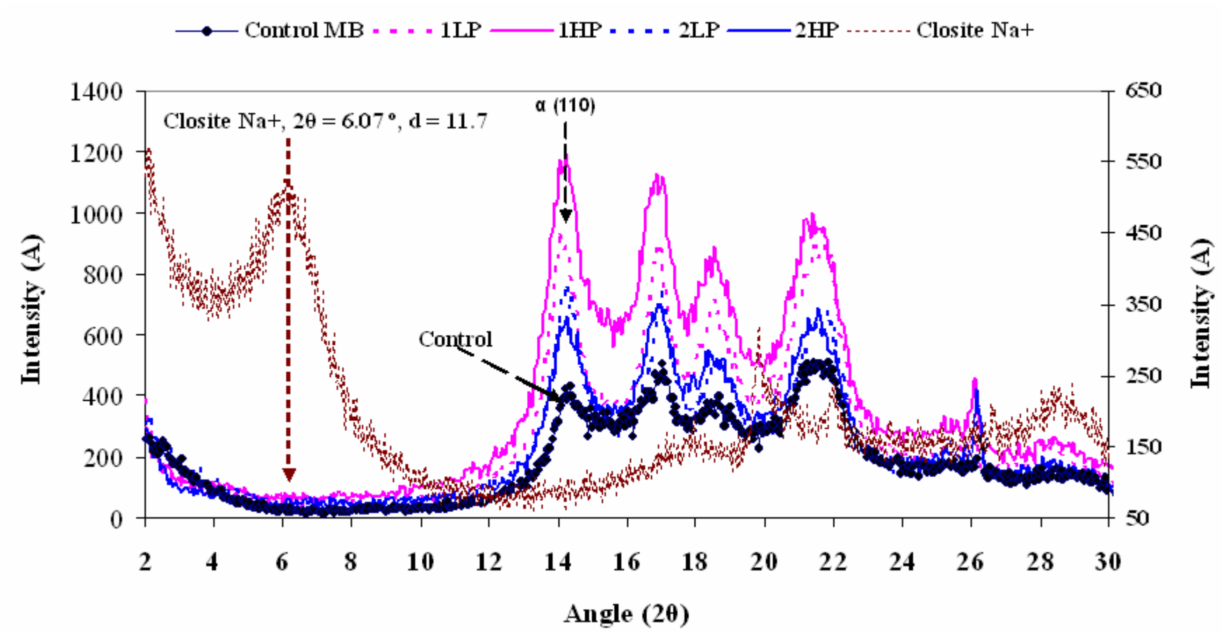

Figure (2) : WAXD scans of melt blown web samples.

TEM studies also revealed significant dispersion of clay platelets, which is due to high melt flow rate (MFR) of polypropylene resin and also higher shear rate experienced by concentrates in extruder. Clay platelets in the case of sample 1LP show complete dispersion of clay additives through fiber section. Small delaminated stacks of clay platelets were observed in 1LP sample sections.

SEM micrographs of control and 1LP surface (Figure 3 (a) and (b)) clearly show increase in fiber diameter variation and shot formation for samples with clay. Fiber diameter shows much higher variability for webs with additives. Increased melt viscosity increases the fiber diameter and causes web variation. In the presence of the clay additive, mechanism of heat transfer, cooling rate and rate of crystallization are different. Also, having additives facilitate the web to cool at a faster rate compared to control polypropylene web. These differences contribute to the difference in the observed web structure.

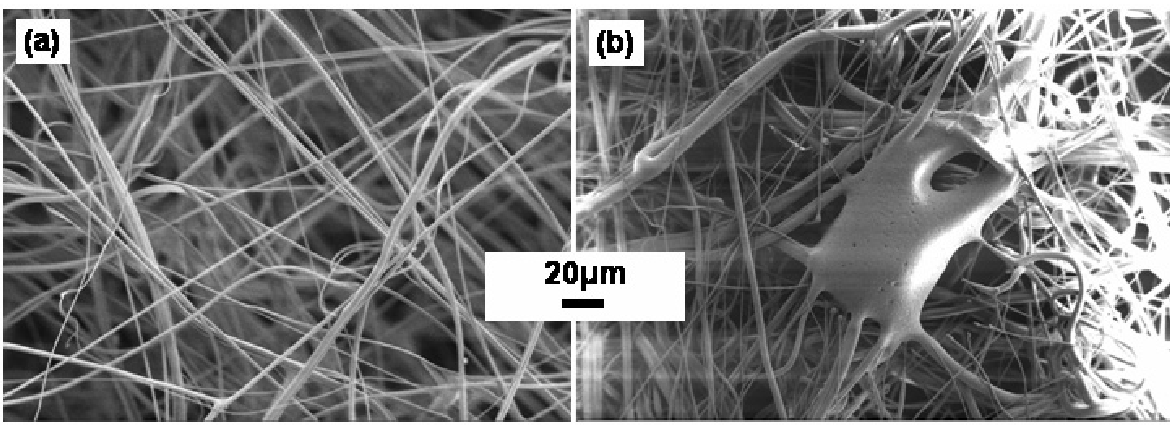

Figure (3) : SEM micrograph of (a) control MB web, (b) 1LP web with shots.

Conclusion :

WAXD and TEM micrographs revealed significant dispersion of clay platelets through the samples. Clay additive did not give any property benefit in case of melt blown web. Compared to control meltblown webs, stiff, open, weak structure was obtained for samples with clay additive. The property differences are the result of higher crystallization kinetics and resultant change in polymer microstructure in the presence of nanoclay. Stiffer webs with variations are due to larger fiber diameters. This study has shown that by using a suitable compounding method, nanoparticle reinforced fibers and fibrous products can be produced using conventional production machinery.

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