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# Mechanical properties of polyamide-6/montmorillonite nanocomposites — Prepared by the twin-screw extruder mixed technique ☆

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ABSTRACT

In this paper, we present the effects of incorporated montmorillonite (MMT) on a surface and the bulk mechanical properties of as-synthesized PA6/MMT composites that are prepared using the twin-screw extruder mixed technique. The as-prepared polymer–clay nanocomposite (PCN) materials in the form of a pellet subsequently characterized using the powder X-ray diffraction (XRD) and the transmission electron microscopy (TEM).

In this experiment, the surface mechanical property studies (*i.e.*, wear resistance and hardness) show that the integration of MMTs exhibited a distinct increase on shore hardness was up to 5 wt.% of MMTs loaded in composites. Moreover, the enhancement of wear resistance of as-prepared composites, compared to pure PA6, can be further identified by the Scanning Electron Microscopy (SEM) observation of the surface morphology after testing. On the other hand, for the bulk mechanical property studies (*i.e.*, tensile strength and flexural strength), we found that the composites containing 3 wt.% of MMTs in the PA6 matrix exhibited the best performance in tensile strength and flexural strength. It means that this composition of MMTs exhibits good compatibility with the PA6 matrix. Generally, PCN materials show an obvious enhancement of mechanical properties of neat polymer by an incorporated low loading of organophilic-clay platelets into a PA6 matrix used for the evaluation of the mechanical properties of the as-prepared samples. Furthermore, it was found that at higher MMT loading (*e.g.* 5 wt.%), MMTs were to be aggregated in the polymer matrix, as observed in TEM. Also, the result leads to an obvious decrease in tensile and flexural strength tests.



## 1. Introduction

Recently, layered materials such as smectite clay (*e.g.*, montmorillonite, MMT) have attracted intense research interests for the preparation of polymer–clay nanocomposite (PCN) materials. PCN materials usually demonstrate unique properties superior to traditional composites and conventional materials. In general, they combine both the characteristics of inorganic nanofillers and organic polymers at the molecular level. Currently, the PCN material is found to be a promising system due to the fact that the clay possesses a high aspect ratio and a platy morphology. It can be employed to boost the physical properties (e.g., thermal stability [1], fire retardant [2], gas barrier [3], and corrosion protection [4–15]) of bulk polymers, and mechanical properties are a particularly significant issue to study application and development for PCN materials. Kim and White [16] reported a variety of organic modified MMTs to understand the contribution of the organophilicity of organoclay on the formation of the polymer/clay nanocomposite.

Nylon 6 is a polymer developed by Paul Schlack at IG Farben to reproduce the properties of Nylon 6,6 without violating the patent of its production. Unlike most other nylons, Nylon 6 is not a condensation polymer and instead is formed by a ring-opening polymerization. Nylon 6 begins as pure caprolactam. As caprolactam has 6 carbon atoms, it got the name Nylon 6. When caprolactam is heated at about 533 K in an inert atmosphere of nitrogen for about 4–5 hours, the ring breaks and undergoes polymerization. Then the molten mass is passed through spinnerets to form fibres of Nylon 6.

Nylon 6 fibres are tough, possessing high tensile strength, as well as elasticity and lustre. They are wrinkle-proof and highly resistant to abrasion and chemicals such as acids and alkalis. The fibres can absorb up to 2.4% of water, although this lowers tensile strength. Nylon 6 is used as thread in bristles for toothbrushes, surgical sutures, and strings for acoustic and classical musical instruments, including guitars, violins, violas, and cellos. It is also used in the manufacture of a large variety of threads, ropes, filaments, nets, and tire cords, as well as hosiery and knitted garments. It can also be used in gun frames, such as those used by Glock, which are made with a composite of Nylon 6 and other polymers. It has the potential to be used as a technical nutrient [17].

Several attempts to prepare PA6–clay nanocomposites have been reported. For example, Garcia et al. [18] reported that the composites of

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