Clay Coating for UV Resistant Nylon Fiber

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Abstract

Thin coating layer of clay minerals was fabricated on nylon fiber and uv-light resistivity of the clay-coated nylons, schematically shown in Figure 1, were investigated. Clay minerals with higher absorbance protect the nylon fibers more effectively from uv light. The coating process is expected as safe and stable procedure because clay and aqueous dispersion of the clay used for the process is innocuous.

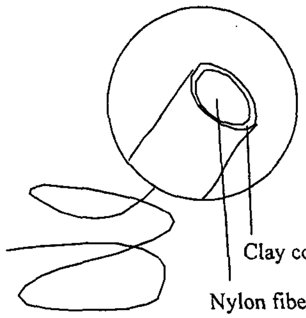

Figure 1 Model structure of clay coated nylon

Introduction

Nylon is a polymer material with high bending tenacity and abrasion proof used for commodities and industrial parts. However, light fastness of nylon is not sufficient for tougher application. Some methods have been developed to improve the light fastness by kneading sacrificial light absorber in spinning process or coating light absorbing reagents. The latter process is widely applicable to finishing and dyeing of fiber and textile.

Spray coating or dip coating with light absorbing materials are concise surface modification applicable to textile and some clothes. Here, we report an effective and cost-competitive process for UV protective coating on nylon fiber using aqueous clay solution under ordinary atmosphere at ambient temperature. Clay minerals are also safe components for the coating because they are already important ingredients for food additives, drugs and cosmetics.

Experimental

Montmorillonite clays were purchased from the Clay Science Society of Japan and kindly supplied by Nissho-Iwai Bentonite. The clays were dispersed in deionized and distilled water by sonication and stirrng. Nylon-6 fiber (TORAY) was immersed in the aqueous clay solution, washed with water and dried in the air overnight.

Surface morphology was observed by Hitachi S-5000 FE-SEM. Tensile strength was measured by Shimadzu AGS-5kND autograph. UV irradiation was carried out using Ushio UL0-6DQ 6w low pressure mercury lamp with line spectrum at 254 nm. UV-visible absorption spectra of clay minerals were measured in diffuse reflection mode on Shimadzu UV-2400PC spectrophotometer with integrating sphere attachment.

Results and Discusion

UV-visible spectrum of montmorillonite powder (Mont-1) was observed in diffuse refrection mode (Figure 2a). It absorbs most of the uv-light in the wavelength shorter than 300 nm. The absorption spectra for the series of clays were also observed by the same procedure and the absorbance at 254, 303 and 366 nm, corresponding to the line spectrum of mercury arc lamp, are plotted for the series of clay mineral (Figure 2b). It is expected that clay minerals with lower tranmittance are effective to uv-resistive cooating. According to the bar graph, three clay minerals were selected for the typical coating

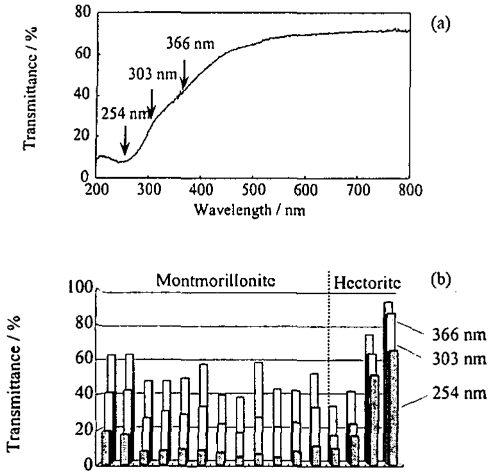

Figure 2 UV-visible spectra of clays
(a) Uv-vis spectrum of Mont-1 clay; (b) Transmittance of a series of powdered clay minerals at 254, 303 and 366 nm.

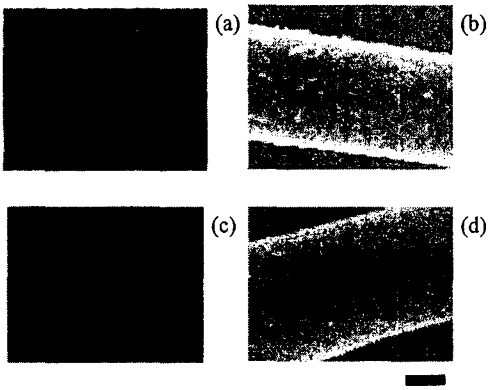

Figure 3. SEM photograph of clay-coated nylon fiber. (a) untreated; (b) montmorillonite-coated; (c) saponite-coated; (d) hectorite-coated nylon fibers. Scale bar represents 10 μm.

materials (Figure 2b); montmorillonite-1, Na-montmorillonite and hectorite-1. Iron content of the clay tends to correlate with uv-light absorptivity for the series of montmorillonite clays.

The clay minerals were dispersed in water by stirring and sonication. After stirring overnight, slightly turbid dispersions were obtained. When some perticles were left undispersed, the supernatant solutions were used for the following coating process. Nylon fiber were immersed in those solutions and washed with water at least 3 times to remove excess clays.

Surface morphology of the clay-coated fiber was observed by scanning electron microscopy (Figure 3). The clay-coated nylons have scale-like layer on the surface, in contrast to a smooth surface of the untreated nylon fiber. Synthetic hentorite with fine perticles and excellent dispersibility makes smooth furface as the untreated fiber. However, all the clay-coated fiber had different touch from that of the untreated one. The results strongly suggest the coating model as shown in Figure 1.

Uv-light resistivity of the clay-coated nylons was estimated by measuring their tensile strength after uv-light irradiation (Table 1). The clay-coated fiber shows almost the same strength as the untreated fiber, which reveals the coating is a mild process for nylon. After uv-light irradiation, the untreated fiber was damaged and the tensile strength was deacreased to less than 80% of the unirradiated fiber. In contrast, the clay-coated fiber, especially Mont-1, showed almost the same strength as unirradiated fiber. The uv-resistivity tends to correlate with the uv-absorbance of the clay.

Table 1 Tensile strength of clay coated nylon fiber

	Tensile strength / GPa		
coating clay	before irrad.	after irrad.	I_{rel}*
Untreated	1.07	.82	.77
Na-mont	1.04	.96	.92
Mont-1	1.05	1.00	.95
Hectrite-1	1.07	.92	.86

* Basis: untreated and unirradiated nylon

Conclusions

An effective and convenient process for UV-resistive coating for nylon fiber was developed using aqueous clay solution under ordinary atmosphere. The products and process of the clay coating are compatible to the sustainable system because clay minerals are mild and safer materials than ordinary synthetic chemicals.

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