Effects of Bentonite and Sodium Chloride on Flame Retardant and Antidripping of Polyester Fabric

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1. INTRODUCTION

Poly(ethylene terephthalate) (PET) fiber has an excellent characteristics of high tenacity, quick drying, high resistance to biological damage and minimal shrinkage and stretch as well as chemical stability in comparison with other industrial fibers. It has found wide applications not only in industrial but also in daily life and engineering plastics for automobile. However, its high combustibility and serious flaming drips which can lead to burns or secondary ignition of underlying surfaces such as carpet or human skin are still disadvantage for some applications. Therefore, it is a great concern to impart both flame retardancy and antidripping to polyester fiber [1].

Halogen-based compounds are generally recognized as effective flame retardants for polymeric materials due to their excellent flame retardancy [2]

.However, because of their risks by inhalation of toxic gases, HBr and HCl etc., during combustion, risks by emission of dioxins and furans (carcinogens) during incineration and their corrosivity [3], some halogen-based flame retardants such as penta BDE and octa BDE were banned of use in all applications in EU market by the EU regulations [4]. As a consequence, halogen-free flame retardants or green materials have been much increasing due to public interests concerning health, safety and environmental aspects.

Recently, several papers have reported about the improvement of flame retardancy and antidripping of polymer using montmorillonite [5-9]. It is believed that the presence of montmorillonite or nanoclays in PP or other polymers slow down burning and provide evidence of char-enhancement.

In this study, the awareness of fire safety, human health and environment as mentioned above drive us to utilize green product which was bentonite or sodium montmorillonite clay as flame retardants and antidripping agents for PET fabric. The fabric was treated with bentonite in various amounts by pad-dry technique. At high amount of bentonite (10% over), sodium chloride was added to bentonite to reduce viscosity of the suspension [10]. The effect of the mentioned compositions on burning behavior was investigated.

2. EXPERIMENTAL

Materials

A bleached twill woven polyester fabric (PET fabric) with the density of 140 g/m^2 was kindly provided by Thainamsiri Intertek Co., Ltd. Bentonite (sodium montmorillonite) was also kindly supplied by Thai Nippon Chemical Industry Co., Ltd. Sodium chloride (NaCl) was supplied by Asia Pacific Specialty Chemicals Co., Ltd.

Suspension preparation

Two types of bentonite suspension were prepared. First type of suspensions without NaCl was 0, 3, 5, 7 and 10% (w/w) bentonite alone. Second type of bentonite suspensions with NaCl was 0, 10, 15, 20 and 25% (w/w) bentonite and 4% (w/w) NaCl. The 2nd type of slurry was prepared by adding bentonite into 4% (w/w) NaCl aqueous solution and continuous mixing at 100 rpm.

Flame retardant treatment

PET fabric was treated with bentonite and NaCl suspensions using a pad mangle set to a pressure nip at 80-90 percent wet pick up. The treated fabric was then dried at 60 °C for 10 min.

Flaming drip and burning behavior test

Flaming drip and burning behavior of untreated and treated PET fabric were investigated under standard test method of ASTM D1230 using the Atlas 45° Automatic Flammability Tester. In this study, the flame application time was set at 5 sec and a piece of cotton pad (weight: 700 mg, size: 64 cm^2 and thickness: 0.5 cm) was placed under the sample to observe whether flaming drips could ignite and burn the cotton pad or not. Experiments were conducted under condition of an ambient temperature of 30±2°C and 60±2% RH. The burning behavior was recorded by a digital video camera.

3. RESULTS AND DISCUSSION

Flaming drip and burning behavior

Flaming drip and burning behavior of untreated and treated PET fabrics is shown in Table 1.

Table 1 Flaming drip and burning behavior of untreated and treated PET fabrics

Fabric	Add-on (%)	Afterflame ti	Flame spread rate (cm/s)	Char	Flaming drip	Cotton pad burning status
Untreated	-	7	1.15	×	✓	Heavy
B3	1.79	31	15.81	✓	✓	Heavy
B5	3.05	32	0.51	✓	✓	Heavy
B7	4.35	28	0.58	✓	✓	Heavy
B10	5.42	26	0.62	✓	×	None
B10Na	8.60	24	0.49	✓	✓	Moderate
B15Na	12.01	25	0.50	✓	✓	Moderate
B20Na	15.50	20	0.59	✓	✓	Moderate
B25Na	17.56	22	0.60	✓	✓	Heavy
Na	2.54	16	0.37	✓	✓	Heavy

B; Bentonite Na; Sodium chloride
×; char or flaming drip ✓; no char or no flaming drip

After removing the ignition source, untreated PET fabric was molten and its flaming drip leading to severe burns of underlying cotton pad while char was not observed. Similarly, the treated PET fabric with bentonite alone up to 7%, the fabric was also molten and its flaming drip caused severe burns of underlying cotton pad. However, when 10% bentonite was applied, the fabric burned without melting but leaving some amounts of char. Furthermore, there is no any flaming drip. This indicated that incorporation of bentonite consisting layered silicate provide evidence of char formation but they do not reduce ignition tendency or reduce after flaming. The higher amount of bentonite could increase the viscosity of the burning fabric resulting in decreasing tendency of drip with fire. The carbonaceous-silicate chars build up on the surface during burning, and insulate the underlying material, slowing the mass loss rate of decomposition products [8-9]. Since the suspension of bentonite over 10% was too viscous to treat the fabric uniformly, adding sodium chloride was found to solve this problem. The PET fabric could treat with bentonite over 10%. However, the treated fabrics turn to drip but its flaming drip caused only moderate burns of underlying cotton pad. Moreover, it was noticeable that the dripping occurred behind the treated one with bentonite alone and more area of fabric was left behind.

4. CONCLUSIONS

Bentonite alone with lower concentration could not promote the flame retardancy and antidripping of PET fabric, whereas, 10% bentonite could enhance antidripping of PET fabric. Sodium chloride addition could facilitate the application of bentonite suspension onto PET fabric. Although the treated fabrics with bentonite and NaCl turn to drip, its flaming drip caused only moderate burns of underlying cotton pad which is better than that of the untreated one.

5. ACKNOWLEDGEMENTS

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