Multi-Functional Phospholipid Finishing Agents for Nylon

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Abstract: Phospholipid polymer having zwitterion polar group and cell membrane structure is known as highly biocompatible and its functionality was already verified. In this study, new biocompatible multi-functional textile finishing agents based on phospholipid 2-methacryloyloxyethyl phosphorylcholine (MPCE) which was previously synthesized were applied to nylon and their multi-functional properties were characterized.

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1. Introduction

Nylon is very old fiber historically but its usage is still growing up since outdoor activity clothing is very popular. Especially in Korea, the outdoor clothing industry is one of the most popular textile industries. Recently in this outdoor industry, environmental and biocompatible technology is required to enhance the quality and functionality of those products. Environmental technology (ET) is already one of the most important technology areas throughout the world and the demand of environmental friendly and biocompatible products are continuously increasing. Also in textile industry, lots of functional eco products such as antimicrobial, anti-skin aging, atopy prevention and moisturizing are continuously developed and introduced. Especially, biocompatible moisture finishing products for skin protection such as squalene, collagen, chitosan, and hyaluronic acid are very widespread in cosmetics or medical care area. However, in textile industry, these materials were not so popular since the performance was unsatisfactory when applied to synthetic fibers. In case of skin care products using natural materials, continuous stability was indicated with problem, and not only functionality of products but also durability were unsatisfactory. In this regards, binder treatment was attempted but it was not used widely since the performance of finishing agent itself was markedly reduced. Also the product development using microcapsules for complement of stability was progressed, but productivity decrease due to additive process and cost

performance were unsatisfactory, and materials for capsulation and binder were indicated with problem like rough touch.

The main component of phospholipid polymer known as Lipidure [1] is 2-methacryloyloxyethyl phosphorylcholine (MPC) shown in figure 1, MPC consists of hydrophilic phosphoric acid parts and hydrophobic lipid parts forming fats. It was already verified that they have functions of moisturizing, anti-skin aging, antimicrobial and excellent stability since they have similar structures to cell membrane [2-4]. Recently this phospholipid was developed extensively for textile finishing agent, but product research and application were very few [5-9].

Fig. 1 Structure of MPC polymer.

In this study, new phospholipid compound as 2-methacryloyl oxyethyl phosphoryl choline (MPCE) in which the terminal trimethyl group of MPC was substituted with triethyl group was synthesized and polymerized with biocompatible materials derivatives. Synthesized polymers were prepared as textile finishing agent with various conditions, and applied to nylon. MPCE treated textiles were investigated their functionality, such as hygroscopic property, wetting property, and anti-static property. By such study, not only functionality of phospholipid polymers was verified, but also it provided important information for preparing and application to finishing agent for nylon.

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2. Experimental

2.1 Synthesis of MPCE polymer

MPCE copolymers were prepared by the previously reported method [10]. MPCE was prepared by synthesis of 2-hydroxyethyl methacrylate (HEMA), triethyl amine (TEA) and 2-chloro-2-oxo-1,3,2-dioxaphospholane (COP), and the synthesized MPCE was polymerized with HEMA, N-isopropyl acrylamide (NIPAM) and NIPAM carboxylate. At this point, 8 types of copolymers were synthesized by varying biocompatible monomers and polymerization ratio (Table 1). The structure of MPCE and synthesized MPCE copolymers are shown on Figure 2 and 3 [10].

Fig. 2 Structure of MPCE.

Fig. 3 Structures of the synthesized MPCE polymers.

Table 1 Copolymerization of MPCE.

Polymer	Composition (g)		AIBN (mg)	Solvent (MeOH/THF)	Time (days)	Yield (%)
	MPCE	Monomer				
MPCE A	10.0	.	98	3 / 7	2	79.3
MPCE B	10.0	.	49	3 / 7	3	82.7
MPCE / HEMA (1:5)	1.7	3.2	49	3 / 7	3	72.3
MPCE / HEMA (1:1)	5	1.9	49	1 / 1	3	76.3
MPCE - NIPAM (1:5)	1.7	2.8	49	3 / 7	5	64.5
MPCE - NIPAM (1:1)	5	1.7	49	1 / 1	5	72.8
MPCE - NIPAM(-COOH)(1:5)	1.7	3.5	49	3 / 7	5	76.1
MPCE - NIPAM(-COOH)(1:1)	5	2.1	49	1 / 1	5	73.6

2.2 Finishing treatment of MPCE polymer

To apply MPCE to nylon, 8 types of finishing agent were prepared by addition of 1 wt% synthetic MPCE polymer, 0.3 wt% Tween20 as surfactant, 1 wt% Lyoprint PBA (Huntsman) as binder and 0.3 wt% Hydrophobol XAN (Huntsman) as cross-linking agent in aqueous finishing mixture at pH4. Then, nylon fabric (Nylon 20D DTY Plain Weave) was padded in this mixture, and dried at 120°C for 2 min after padding.

2.3 Property investigation of MPCE finishing

2.3.1 Wetting property evaluation

The wetting property was assessed in accordance with the AATCC Test Method 79-1992 by measurement of absorption time using drop test.

2.3.2 Moisture regain evaluation

The moisture regain was assessed according to the KS K 0220 by measurement of weight comparing sample with standard condition and dried sample.

$$\text{Moisture regain}(\%) = \frac{W_m - W_d}{W_d} \times 100$$

W_m : weight of sample in standard condition with 20°C, 65% RH

W_d : weight of sample dried with 105°C for 90 min

2.3.3 Frictional static charge evaluation

The frictional static charge was assessed in accordance with the KS K 0555 using Rotary static tester (Kanebo Engineering, EST-7).

3. Result and discussion

3.1 Synthesis of MPCE polymer

Overall, the phospholipid treatment on nylon showed satisfactory effects such as water retention, antistatic, and hygroscopic property. The MPCE was synthesized by reaction of 2-(2-oxo-1,3,2-dioxaphospholoyloxy)ethyl methacrylate (OPEMA) and triethyl amine (TEA) instead of trimethyl amine (TMA) because TMA is difficult to use since it is colorless toxic gas at room temperature having low boiling point (2.87 °C). 2-Hydroxyethyl methacrylate (HEMA) and N-isopropylacrylamide (NIPAM) were used to prepare copolymers since they are already used in medical area because of their hydrophilicity and biocompatibility. Therefore, copolymers prepared by polymerization of MPCE with HEMA and NIPAM are also expected to have biocompatibility and functionalities. In addition, it is expected to have greater hygroscopic property and water retention by substituting terminal group of NIPAM with carboxylate[11-14].

3.2 Properties of MPCE treated nylon

3.2.1 Wetting property

The prepared finishing agents for nylon are shown in table 2. As shown in figure 4(a), nylon fabrics which were treated MPCE finishing agent by above method had good wetting property within 1 second, and it was especially greater than untreated nylon or treated with MPCE polymer alone.

It was observed that overall good washing durability in figure 4(b) since wetting time was under 5 second although after washing. Also, additive agents had not durability and hydroscopic property itself because wetting time was similar to control fabric when treated additive agent alone such as binder, cross-linking agent and surfactant. At this point, in the case of nylon treated with surfactant having hydrophilicity itself, it was observed that good wetting behavior similar to MPCE finishing agent before washing, but this effect was disappeared clearly after washing. Consequently, the additive agents just help MPCE to enhance dispersibility and durability, only MPCE polymer is effective in increasing of hydrophilicity.

3.2.2 Moisture regain

Figure 5 shows the moisture regain according to sample 1~8 in table 2. It was observed that the overall moisture regain was increased 2 times in MPCE treated nylon compared with control fabric, because fabric surface was endowed hydrophilic properties. Therefore, it

Table 2 Preparation of MPCE finishing agent used in property evaluation.

No.	Polymer	Additive agent
1	MPCE contained polymer A	
2	MPCE contained polymer B	
3	MPCE:HEMA 1:5	
4	MPCE-NIPAM 1:5	Lyoprint PBA/ Hydrophobol XAN/ Tween20
5	MPCE-NIPAM(-COOH) 1:5	
6	MPCE-HEMA 1:1	
7	MPCE-NIPAM 1:1	
8	MPCE-NIPAM(-COOH) 1:1	
9	-	Lyoprint PBA
10	-	Hydrophobol XAN
11	-	PBA+XAN
12	-	Tween20

Fig. 4 Wetting property of nylon (a) treated with MPCE contained polymer/MPCE finishing agent, and (b) before/after washing.

was verified that MPCE finishing caused enhancing of hydroscopic property, and the moisture regain was increased. Although the moisture regain was reduced a little after washing, it is deduced that the MPCE finishing agent had durability since the decrease was insignificant and particularly greater than control fabric.

Fig. 5 Moisture regain of before/after washing with MPCE finishing agent treated nylon.

3.2.3 Anti-static charge property

Figure 6 shows the static charge of before and after washing with MPCE finishing agent treated nylon. The investigated MPCE finishing agents are shown in sample 1~8 in table 2. The results indicated that not only the frictional static charge was significantly decreased in MPCE treated nylon, but also less than 1000V after washing. Generally, static charge is decreased due to existence of water since dispersion of charge. Thus, it is verified that anti-static property is caused by increase of hydroscopic property according to MPCE finishing as stated above.

Fig. 6 Static charge of before/after washing with MPCE finishing agent treated nylon.

4. Conclusion

In this study, new biocompatible multi-functional textile finishing agents based on phospholipid 2-methacryloyloxyethyl phosphorylcholine (MPCE) polymer was synthesized. Synthesized MPCE polymers were prepared as textile finishing agent with additive

agents, and applied to nylon. The MPCE treated textiles were verified that biocompatible functionality, such as hygroscopic property, wetting property and anti-static property was increased clearly as compared with the untreated textile. By this study, not only synthesis process and functionality of phospholipid polymers was verified, but also it provided important information for preparing and application as textile finishing agent.

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