Research Paper Textiles

Shape Memory Materials: An Innovative Way to Improve Properties of Cotton

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ABSTRACT

Wrinkle resistant finish is applied on cotton fabric, which uses carcinogenic chemicals and lead to environmental and health problems. One such chemical is formaldehyde. Number of researches has been conducted for the development of new materials which can impart better properties by avoiding these problems. DMDHEU is one of the chemical being developed to impart wrinkle resistant finish on cotton. Another material which is a buzz word in 21st century is the Shape memory materials. They are biocompatible and have the potential to be incorporated in textiles. These materials include shape memory alloys and shape memory polymers. This review paper deals with the use of shape memory material in textiles to improve the wrinkle resistant property of cotton fabrics.

KEYWORDS shape memory material use, cotton, wrinkle resistance, SMA and SMPs

INTRODUCTION

Nowadays aesthetic aspects have an increasing influence on the overall quality of a garment. Fabric appearance is usually characterized by a number of factors such as strength, pilling, abrasion resistance, shrinkage, drape, color and wrinkles (Vasile et al., 2012). Cotton being most widely used fabric due to its special properties which includes hypo-allergic nature, soft hand, easy to care, can be blended with other fibers with ease, can be dyed in various colors, stains can be easily removed, comfortable to wear as it is a good conductor of heat and electricity, good moisture absorbency and many more but one of the major disadvantage is, it wrinkles very easily. The way people like to avoid wrinkles on their skin, they do not want it on their clothes either. To make cotton clothes wrinkle free it is blended with other synthetic fibres like polyester. Also wrinkle resistant property can be added to cotton fabric by durable press finishes, which use chemicals and application of heat (Anonymous, 2008). Wrinkle-free finishing also known as 'Easy Care' and 'Wrinkle – resistant' (Xiaoxia et al., 2008).

To improve end-use performance, formaldehyde based stabilizers are used to replace many of the hydrogen bonds in cellulose with permanent stronger covalent bonds called "crosslinks" that won't break when the fiber becomes wet. The original formaldehyde-containing cross-linkers from the mid 1900's suffered from poor stability, degraded strength (tear, tensile, and abrasion), and possible degradation of fabric during washing/drying. Even worse, they released airborne formaldehyde, a known human Carcinogen. Later, a more stable crosslinker called DMDHEU became the industry standard (Hauser et al., 2007). DMDHEU is the most commonly used durable press finishing agent today. These methylol amide cross-linking agents are quite effective in imparting wrinkle resistance. However DMEDU reduced many of these problems but notably did not completely eliminate the carcinogenic formaldehyde release (Data et al., 2010 & Hauser et al., 2007). Recent health risk assessment of the possible effects of continued exposure to formaldehyde vapor to humans has increased the desirability of finding material which are safe, comfortable and impart the desired properties in textiles and apparel (Welch, 1992). Some well known modalities used to improve a fabric's wrinkle resistance refer to the adequate selection of the fabric construction, raw materials and /or wrinkle resistant finishing (Vasile et al, 2012). Number of researches has been conducted for the development of new materials which can impart better properties by avoiding these problems. Studies reveal that this problem can be solved by introducing shape memory materials in textiles. These materials are new class of materials and have the potential to remember a pre-programmed shape, which can help fabrics to remove wrinkles without being ironed. (Anonymous 2008). Shape Memory Materials (e.g., polymers and alloys) have also been used lately for the same purpose.(Vasile et al, 2012)

SHAPE MEMORY MATERIALS

Shape memory materials are a family of materials that can change their shapes from temporarily deformed to their programmed original shapes. The shape recovery is usually activated by the surrounding temperature, but other stimuli such as electric field, magnetic field, pH, UV light, specific chemical, or any other stress can trigger the shape recovery force, and characteristics of recovering mechanism. Shape memory materials are either inorganic or organic materials based on their constituents. Inorganic materials include alloys and organic material includes polymers. (Cho, 2010)

SHAPE MEMORY ALLOYS

Shape memory alloys belong to the class of smart materials whose functional properties are derived from reversible solid-state thermoelastic martensitic transformation. They exhibit functional properties such as the temperature driven one- and two-way memory effect, superelastic deformation (up to 10% strain), high damping capacity and high work output upon a thermal excitation. (Janouchova et al., 2012). Although a variety of metal alloys possess this property, there is only a limited number of them that are commercially important, such as the NiTi-alloy, known as NiTinol. NiTinol exists in different forms: as a bar, rod, wire, shaped wire, sheet, ribbon wire etc. Due to their biocompatibility, NiTi-alloys are mostly developed and used for biomedications, but NiTinol in the form of fine wires is also suitable for processing on textile machines (Vasile, 2010).

APPLICABILITY OF SHAPE MEMORY ALLOYS IN TEXTILES AND APPARELS

These materials can be embedded in textile structures. One method used for embedding SMA wires into a textile structure is stitching, as used by Leenders. Another method is weaving process using a hand weaving loom. (Chan, 2007) manufactured woven samples with alternating textile and SMA wires using a Harris eight-harness table loom. Vasile S et al. 2010 conducted a study to develop fabric with SMA embedded wires in 100% natural fiber fabric. A hand weaving loom and industrial weaving loom were used to embed SMA wires in the weft direction. Body temperature SMA wires were used, which recover their straight form when subjected to human body heat or another heat source like hair dryer. Some possible applications of such fabrics include wrinkle –free clothing, bed sheeting, camping tents etc. (Vasile, 2010.)

Not only in outer apparel but these materials can also be used in intimate apparels such as bra. As mentioned by Dewsnap and Hart 2001, the problems recognized by the consumers about the intimate apparel, especially about the bra, which make them purchase a new one, include the decline of Bra's aesthetic appearance. Aesthetic appearance of intimate garments is damaged due to washing or storage and lead to wrinkle development and the deterioration behaviour, which prejudice the aesthetic aspect. To avoid the wrinkle aspect, a study is conducted by Laschuk 2009 with the main goal to develop a bra with the SMA, and take advantage of the features of this smart material adapting it to the intimate apparel. The developed SMA structure was placed internally, as a pad. If the bra is bent, it can recover the original shape upon heat treatment (Laschuk & Souto, 2009) .

SHAPE MEMORY POLYMERS

The use of shape memory materials represents one of several approaches which are being adopted in the development of smart textiles that exhibit additional functional properties and/ or outstanding structural behaviour. Within this approach, shape memory polymers (SMP) are most commonly used, as their structural and other comfort properties (hand, air permeability, surface roughness, drape, etc.) are similar to those of conventional textile materials. In contrast, the use of shape memory alloys (SMA) in smart textiles has been reported to a much smaller extent, though SMA outperform SMP in many aspects such as strength, stability of thermal and cyclic properties, thermally induced recovery stresses, etc. (Janouchova, 2012)

SMP generally characterized as a phase segregated statistically block copolymer having a hard segment and a soft segment. The hard segment acts as a frozen phase and the soft segment acts as a reversible phase. This frozen phase helps to memorize the original shape while the reversible phase acts as a switch responsible for shape recovering. Once the shape memory polymer is deformed, the original shape is recovered by heating the SMP at a switching temperature which equals to the melting temperature of soft segment (Anonymous, 2009). The shape memory polymers depend largely on the glass transition temperature for the shape memory effect.(Gopi, 2007)

Since SMPs have became the key smart material developed widely in both academia and industry (Hu 2007), several polymer systems have been developed to possess shape memory properties such as trans-polyisoprene and polymorbornene. The most readily available is segmented polyurethane (PU) which defined as functional polymers. As reported by Hu**,** segmented SMPU (shape memory polyurethane) systems have the two-phase heterogeneous structure, which consists of a rigid fixed phase and a soft reversible phase. With regard to the mechanism of shape memory effect, the reversible phase is used to hold the temporary deformation, while the fixed phase refers to the hard segments covalently coupled to the soft segments.

APPLICABILITY OF SHAPE MEMORY POLYMERS MATERIALS IN TEXTILES AND APPARELS

The use of shape memory polymers in textiles include the finishing of fabrics by shape memory polyurethane emulsion , film, powder or resin and fabrics woven or knitted by shape memory fiber or yarn (Lu & Hu 2010). Hu and her group**,** successfully developed shape memory emulsions from the polyurethane polymer family and employed them in the finishing of cotton fabrics to obtain a shape memory effect. The emulsion could be applied to woven cellulose fabrics such as cotton, ramie, linen as well as to wool fabrics by pad-dry-cure method. Their studies revealed that the shape memory functions could be effectively achieved through high wrinkle recovery crease retention and bagging recovery.(Vasile, 2012)

According to Mattila (2006) shape memory polymers have great deformation capacities, shape stability, shape fixity, shape recovery and small changes to the chemical structure and composition of them. In addition, shape memory polymers also have good performance on the biocompatibility and chemical properties. Therefore, the clothing and fabrics finished with SMPU has good shape memory effect and good wrinkle recovery angle as well as crease resistance.(Kwan, 2010) Professor Jinlian Hu of the institute of textiles and clothing became the first scholar in Asia to receive the Fiber Science Achievement Award by the US-Based Fiber society after completing her project named Development of Shape Memory Fabrics/ Garments. The research project carried out by Hu points out that having subjected to special treatments, the developed fabric possesses a shape memory function. Able to withstand high pressure, and can recover its original shape at a designated temperature. This can allow a fabric to have functions of wrinkle free, shrink resistance, easy to wash quality and good chemical resistance. (Annonymous, 2009)

One of the advantages of using SMPs is that the treated fabric does not release formaldehyde during finishing, as in the case of using DMDHEU. In addition, SMPU finishing will not significantly affect the mechanical strength of the fabric, as in the case of wrinkle-free finishing based on polycarcoxylic acids, typically BYCA,(4-butane tetra-carboxylic acid), which is also expensive (Vasile, 2012).

CONCLUSION

Shape memory materials are the new class of materials which can be successfully added to cotton textiles to improve the wrinkle resistant property. Nitinol and shape memory polyurethane can be used as wires, emulsions or knitted structure to provide the desired properties to the textile structure.

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