International Journal of Nanoscience and Nanoengineering
2018; 4(5): 80-82
http://www.openscienceonline.com/journal/nano

A Study on Decomposition of Nanoparticle Finished Textiles

Liu Yu

School of Textiles & Fashion Management, Milano Fashion Institute, Politecnico di Milano, Milan, Italy

Email address

liuyu90@zoho.com

To cite this article

Liu Yu. A Study on Decomposition of Nanoparticle Finished Textiles. *International Journal of Nanoscience and Nanoengineering.* Vol. 4, No. 5, 2018, pp. 80-82.

Received: October 29, 2018; **Accepted**: November 9, 2018; **Published**: December 20, 2018

Abstract

Textiles cover a considerable share of the environmental burdens globally. They have variety of dyes and chemicals which goes with at the disposal. Decomposition or degradation rates of textile materials in soil have forensic and environmental implications, depending textile type and use. Textiles have non/and biodegradable substances also, which decompose with variant time constrains. The chemicals on them may not decompose and might be toxic to microorganisms present in the ground. At present, a lot of research is performed on the decomposition of textile materials in natural soil, converting into biomass, water and carbon dioxide, posing no harm to the environment. But very limited information is available on the decomposition of textiles with functionality attributes, like antibacterial, flame retardant and waterproofing. In this respect, this research work aimed to see the decomposition of chemicals present on textiles, in order to understand the biodegradation phenomenon of textile materials and chemicals when buried in soil. The visual observations revealed that the decomposition or degradation of cellulose textile materials proceeded earlier than the one with functionality substance present on the cellulosic textiles. For the equivalent decomposition or degradation of textiles along with attributional substance on it, it's essential to use precursors such as removal of attributional substance prior to their disposals.

Keywords

Textile, Waste, Decomposition, Silver Nano Finishes, Degradation

1. Introduction

Textiles cover a considerable share of the global environmental burdens and the production of textiles is increasing day by day [1]. Textiles take various processes to produce a single piece of textile fabric, since the value chain for production of textiles is long. In addition to that, environmental impacts occur in all stages these processes, starting from fiber production till decomposition in nature. Like, during raw material production due to agriculture, including animal husbandry, if the fiber is animal fiber, and industrial synthesis [1, 2]. A general list of processes such as spinning, weaving, sewing, and further to application of various properties such as color, antibacterial, waterproofing, flame retardants, etc. are added as per consumer or retailers demand [1]. Moreover, the textile production and consumption have high water and energy demand, it also requires to occupy land suitable for food production [1, 3]. The chemicals present on textiles during their use phase goes into drainage and into the land, with any information of their decomposition.

Some textiles are produced to have short lives, so that they can be easily degrade, such as high fashion textiles and low cost clothing. Most of these high fashion textiles and low cost clothing are cellulose based either cotton, linen or regenerated fabrics such as acetate and rayon [4, 5]. The major advantages of these biodegradable textiles are that they do not add to landfill or even they do, decompose or degrade relatively faster and most importantly they are marketed to be less environmentally harmful [4]. However, the problem recur when the functionality attributed textiles are compared with non-functional textiles and considered environmentally less harmful [6]. In reality, the chemicals present on the textiles are more persistent than the textile itself. Since the range and complexity of fibers being produced are changing, the demand of addition and modification of textiles functionality is growing exponentially. In this context antimicrobial textiles have gained a considerable popularity in recent decades and are being used in textile types [7]. The antibacterial activities in textiles with green synthesis of silver nanoparticles is one of that [7, 8]. As this functionality to everyday textiles is highly desirable for preventing odors from developing and are being used for purposes like, medical, sports, utilitarian and decorative and architectural structures and coverings. Generally, antibacterial attribution is incorporated into textiles with three different ways to achieve antimicrobial properties, that could be a controlled release mechanism, a regeneration principle, or a barrier or blocking action [9]. Similarly, all these additional and attributional components in textiles should be considered when assessing the decomposition and degradation pathways and long-term behavior of technical textiles.

Like every single natural material, textile materials will decay or decompose affected by water and microorganisms present in the ground, under practically identical natural conditions. However, the time of decomposition is predominantly depends on the raw materials utilized, some materials decompose in months, years, decades or even hundreds of years [10, 11]. Recent studies on the degradation of textile materials didn't carried out the decomposition of functional chemicals or substance on it in real soil or soil-like atmosphere. Degradation of permanent flame retardant finish from textiles [12] and its kinetics [13]. However, the assessments of decomposition depend on institutionalized soil entombment tests as indicated by International Organization of Standards (ISO), such as ISO 11721-1:2001 [14] etc., which are utilized to decide the decomposition or decay of textile materials. Resulting ecotoxicological examinations enables the researchers to make determinations of hazard assessment and environmental compatibility. Moreover, substitute disposals are suggested for textiles with functionalities, for instance gasification and oxidation processes [6, 15, 16]. In similar context, there was a need of work comparing textile materials with functional substances to non-functional textile materials in natural degradation environment in soil.

2. Experimental

100% cellulosic woven fabric having a mass of 150 g/m^2 was used in the experiments. For cellulosic textile with functionality, antimicrobial finishes based on silver (Ag) was used, the fabric was finished with silver nano powder NP-30 (Ames Goldsmith Corp., USA). Decomposition of finished and unfinished and finished cotton fabric was determined with soil microflora using soil burial test according to ISO 11721-1:2001 and ISO 11721:2003 standards. This process consists of a container filled with commercial grade compost having soil with 60 ± 5% water content for determined moisture retention capacity. pH of the soil was kept between 4 to 7.5. The textile samples were buried in the soil over a period of 3 and 12 days. To find the decomposition phenomena on textile samples, degree of polymerization was carried out. The samples were dissolved in Cuoxam, which is a solution of cupric hydroxide in ammonia (aq.) $[Cu(NH_3)_4](OH)_2$. The degree of polymerization was determined viscosimetrically with Oswald shear dilution viscometer. 5 replications of each experimental fabric were carefully carried out and excavated with lightly brushed to remove soil particles and dried to a constant weight at 55°C. The representative subsample silver finished textile samples ashed at 650°C.

3. Results and Discussion

Chemicals added to textiles for functionalization, potentially decompose later than the textiles itself, making it unsafe for to future varied vegetation. Despite the field of utilization of the textile materials, the necessities concerning textile or/and chemical decomposition in the ground can vary significantly now and then. Like, the general textile items used in daily life, like apparel or home textiles decompose faster as would be prudent and with no buildups which could be unsafe to the environment.

The results of degree of polymerization in Table 1 shows that with time interval of 3 days, the degradation or decomposition of cellulosic material started in both samples. The degree of polymerization of both samples decreased with increasing time of burial. However, the degree of polymerization of finished cellulosic material decrease slowly compare to the unfished sample. This slow drop of degree of polymerization shows an influence of functionality substance present on textile.

The decomposition or degradation of a textile begins with a fiber processing and a non-visible damage starts occurring that cannot be seen with a naked eye [17]. Some of the decomposition or degradation of textile starts from prior burial into land or soil, for instance, by abrasion and extension forces, dry-cleaning, washing and drying, ironing, then the environmental degradation which includes, temperature, light, water, weathering, soiling and burial and finally the biological attack by microbes and insects resultantly to chemical degradation such as acids, organic solvents, salts and alkalis [17-19].

Table 1. *Degree of polymerization of samples.*

Sample	Unfinished cellulose	Finished cellulose
0 day burial	1600	1620
3 days burial	1570	1600
12 days burial	1250	1440

Since all natural materials have a frame of carbon atoms, for instance materials with organic molecules (sugar, fats, proteins, nucleic acids). These carbon chains are broken during decomposition in the soil by fungi and bacteria and splitting the molecules. The time of breaking such chains is dependent to the building blocks of the atoms. The natural polymers having alcohols, acids or similar molecules are connected normally via reacting oxygen groups at their ends which sometimes contain other carbon and oxygen atoms. The cellulosic structure having the formula $(C_6H_{10}O_5)_n$, is a polysaccharide consists of a linear chain of hundred to thousands of β(1→4) linked D-glucose units. Such chains and units are readily utilized by microbes. On the other hand, the Ag finished cellulose material, makes it difficult to decompose by these same microbes. Mainly, the decomposition of such materials in the soil generate carbon dioxide as a waste product [4].

4. Conclusions and Future Perspectives

The decomposition of finish chemicals present on textiles are influence by their particle size and types and degree of cellulose biodegradation itself. From this study, it was found that, even the degree of polymerization of both samples, finished with Ag and unfished textile, started with few days of burial. However, the use of Ag for cellulosic materials functionalization, delay the decomposition in soil compared to the unfished cellulosic textile.

References

[1] Laitala K, Klepp IG, Henry B. Does Use Matter? Comparison of Environmental Impacts of Clothing Based on Fiber Type. Sustainability. 2018; 10 (7): 1–25.

[2] Smith MJ, Thompson K. Forensic Analysis of Textile Degradation and Natural Damage. In: Forensic Textile Science. Elsevier; 2017. p. 41–69.

[3] Yasin S, Behary N, Rovero G, Kumar V. Statistical analysis of use-phase energy consumption of textile products. The International Journal of Life Cycle Assessment. 2016; 21 (12): 1776–1788.

[4] Park CH, Kang YK, Im SS. Biodegradability of cellulose fabrics. Journal of Applied Polymer Science. 2004; 94 (1): 248–253.

[5] Warnock M, Davis K, Wolf D, Gbur E. Soil Burial Effects on Biodegradation and Properties of Three Cellulosic Fabrics. AATCC Review. 2011; 11 (1).

[6] Yasin S, Massimo C, Rovero G, Behary N, Perwuelz A, Giraud S, et al. An alternative for the end-of-life phase of flame retardant textile products: degradation of flame retardant and preliminary settings of energy valorization by gasification. BioResources. 2017; 12 (3): 5196–5211.

[7] Yasin S, Liu L, Yao J. Biosynthesis of silver nanoparticles by bamboo leaves extract and their antimicrobial activity. J Fiber Bioeng Inform. 2013; 6 (6): 77–84.

[8] Ullah N, Li D, Xiaodong C, Yasin S, Umair MM, Eede V, et al. Photo–irradiation based biosynthesis of silver nanoparticles by using an ever green shrub and its antibacterial study. Digest J Nanomater Biostructures. 2015; 10: 95–105.

[9] Dhende V, Hardin I, Locklin J. Durable antimicrobial textiles: types, finishes and applications. Understanding and Improving the Durability of Textiles Oxford, Cambridge, Philadelphia: Woodhead Publishing Limited. 2012; 145–173.

[10] Hawley JM. Digging for diamonds: A conceptual framework for understanding reclaimed textile products. Clothing and Textiles Research Journal. 2006; 24 (3): 262–275.

[11] Allen SJ, Auer PD, Pailthorpe MT. Microbial damage to cotton. Textile research journal. 1995; 65 (7): 379–385.

[12] Yasin S, Behary N, Giraud S, Perwuelz A. In situ degradation of organophosphorus flame retardant on cellulosic fabric using advanced oxidation process: A study on degradation and characterization. Polymer Degradation and Stability. 2016; 126: 1–8.

[13] Yasin S, Behary N, Perwuelz A, Guan JP, Chen GQ. Degradation Kinetics of Organophosphorus Flame Retardant from Cotton Fabric. In: Applied Mechanics and Materials. Trans Tech Publ; 2017. p. 54–58.

[14] ISO. ISO 11721-1:2001: Textiles - Determination of resistance of cellulose - containing textiles to microorganisms - Soil burial test - Part 1: Assessment of rot-retardant finishing. International Organization for Standardization, Geneva, Switzerland; 2016.

[15] Yasin S, Behary N, Perwuelz A, Guan J. Life cycle assessment of flame retardant cotton textiles with optimized end-of-life phase. Journal of Cleaner Production. 2018; 172: 1080–1088.

[16] Yasin S, Parag B, Nemeshwaree B, Giorgio R. Optimizing Organophosphorus Fire Resistant Finish for Cotton Fabric Using Box-Behnken Design. International Journal of Environmental Research. 2016; 10 (2): 313–320.

[17] Slater K. The progressive deterioration of textile materials part i: characteristics of degradation. Journal of the Textile Institute. 1986; 77 (2): 76–87.

[18] Gore SE, Laing RM, Wilson CA, Carr DJ, Niven BE. Standardizing a pre-treatment cleaning procedure and effects of application on apparel fabrics. Textile research journal. 2006; 76 (6): 455–464.

[19] Kemp SE, Carr DJ, Kieser J, Niven BE, Taylor MC. Forensic evidence in apparel fabrics due to stab events. Forensic science international. 2009; 191 (1–3): 86–96.