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Nanotechnologies — Evaluation de la performance antimicrobienne des textiles contenant des nanomatériaux manufacturés

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Foreword

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This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

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Introduction

The utilization of nanotechnology in textile industry has presented novel functions such as antimicrobial activity, stain resistance, flame retardancy, mechanical strength enhancement, UV resistance, and wrinkle resistance into the conventional textiles without significant loss or change of the original properties. According to the nanodatabase website[17] there are already over 400 textiles containing manufactured nanomaterials (TCMNMs), making them the second largest market among other nanoproducts.

The rapid and continued growth of TCMNMs is increasing the need to develop international standards specific for manufactured nanomaterials (MNMs) in textiles and testing processes guidelines. It is a dual need of industry and consumer.

TCMNMs can be classified into three groups based on how nanomaterials are integrated into the textiles including nanofinished, nanocomposite, and nanofibrous textiles[1]:

a) Nanofinished textiles: The textiles that the applied nanoscale property is added after the textile fabrication through post-manufacture treatments and coatings to create nanostructured surfaces on fibre media. Most nanotextiles on the consumer market belong to this category.

b) Nanocomposite textiles: The textiles composed of fibres containing one or more nanostructured or nanoscale components produced by pre-manufacture integration of nanoscale properties into fibrous components.

c) Nanofibrous textiles: The textiles made of nanofibres which have a nanoscale cross-sectional area and may or may not have a nanoscale length.

Natural and manufactured textile fibres can be treated with different nanomaterials and chemicals to provide enhanced antimicrobial properties. The antimicrobial activities of TCMNMs include activities against bacteria, fungal, viruses, and other microorganisms. Also, the antimicrobial activities can help to impart anti-odour property as the consequence of the reduced microbial activity. For antimicrobial TCMNMs, various metals, mainly silver and copper, and metal oxides such as copper oxide (CuO), titanium dioxide (TiO_2) and zinc oxide (ZnO) are normally used.

Several characteristics of MNMs have great impacts on their antimicrobial performance including size, shape, surface area, chemical composition, surface chemistry and surface charge. The size and shape of MNMs have important impacts on their antimicrobial property due to their association to their surface area. Generally, the antibacterial properties of nanoparticles are size-dependent. Smaller particles with higher surface area to volume ratio have more contact with either bacteria or fungi cells, or both, leading to improve either the bactericidal or fungicidal effectiveness, or both[2]. Therefore, when they incorporate in textiles even at low concentrations they show noticeable antimicrobial activity compared to their micro-and macro scale counterparts.[3]-[5] The shape of MNMs remarkably influences the rate of interaction and uptake by microbial cells. For instance, spherical-shaped of gold nanoparticles demonstrated higher cellular uptake than nanorod shaped particles[7]. Surface charge of MNMs is another important characteristic that can be measured by Zeta potential method. The antimicrobial effect of MNMs is triggered by the electrostatic interaction between the positively charged MNMs and the negatively charged microbial cell membranes ultimately leading to cell damage and inhibition of their growth and reproduction. Surface chemistry of MNMs has an important effect on their antimicrobial activity. The presence of functional groups, capping agents or biomolecules on the surface of nanomaterials has also potential influence in their antibacterial activities. Surface functionalization of antimicrobial nanoparticles such as silver nanoparticles with bioactive molecules exhibited enhanced antibacterial activity compared to the bare ones[8]. The above-mentioned inter-relationship highlights the important effect of physiochemical characteristics on antimicrobial performance of TCMNMs.

Currently, there are various antimicrobial TCMNMs products in the market such as underwear, shirts, socks, and bed sheets/covers. The antimicrobial mechanism of action of nanomaterials can generally be described as one of three models: oxidative stress induction, metal ion release, or non-oxidative mechanisms, which can occur simultaneously as well[1]. The antimicrobial activity of

TCMNMs can decline significantly after several washing cycles and exposure to body sweat due to the possible release of incorporated nanomaterials and also the chemical action of sweat and laundering solution on the nanocompounds. Currently, there is no ISO document specific to TCMNM products. Therefore, the development of a standard to determine antimicrobial performance of TCMNMs subjected to washing process and body sweating can facilitate the trade and growth of market. It is worth mentioning that already published ISO standards are related to the assessment of antimicrobial properties of conventional textiles. Moreover, there is an ASTM standard document for detection and characterization of silver nanomaterials in textiles[9]. However, these documents do not address the potential release of nanomaterials/nanostructure from TCMNNs following washing or sweating and their possible consequence on the antimicrobial activity of these textiles.

This document does not address nano-safety and environmental impact of the release of nanomaterials from TCMNMs into the air, water and to landfill. Data related to the release of nanomaterials from the fabrics under different conditions such as sweating, mechanical stresses (repetitive abrasion) during washing process in a laundry machine, are considered as essential information for understanding the potential releases to the environment.

Artificial sweat solution is an appropriate candidate to use as a material to resemble the human skin sweat to determine the amount of release of nanomaterials from TCMNMs to human body. For many TCMNMs applications, such as human clothes, there is a high possibility of skin contact and interaction with incorporated nanomaterials[10]. In such condition, the involved interaction and release of the nanomaterial can also affect the antibacterial performance of TCMNMs.

Considering the effect of the release of nanomaterials from TCMNMs by washing process and human sweat, this document specifies the measurement methods of the released nanomaterials, the antimicrobial performance and the assessment method of TCMNMs. Further, from TCMNMs subjected to washing process and exposed to artificial human body sweat solution are specified.

