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TEXTILE IMPACT PLATES FOR NANOPARTICLES

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Abstract: *The paper presents textile materials with destination impact plates, having different surface architectures and active treatments for functionalization, with influence upon the aging process of nano-Ag and nano-CeO2. The woven and knitted samples from 100% cotton, cotton/PES blend and 100% PES were treated by impregnation on the laboratory padding machine, drying and condensing on the machine for drying-condensing-heat setting, with the following recipes: 50g/l RUCOSTAR EEE6+20 ml 5% nano-Ag dispersion, or 10% nano-CeO2 in ethylene glycol, respectively water and 0,5ml acetic acid 60% for products from 100% cotton and PES/cotton and 50g/l NUVA N 2114 liquid with the same percent of nanoparticles but with 1 ml/l acetic acid 60%, in case of 100% PES samples. The samples were treated in 2 steps – hydrophobic/ oleo phobic in the first stage and hydrophobic/ oleo phobic/ functionalization with nano-Ag and nano-CeO2 in the second stage.*
The complex characterization of both type of materials : hydrophobic and oleo phobic properties, color change, whitening degree, DCS, FT-IR, SEM and microbiology, evidenced through the obtained results the justness of the selection for: the raw materials (100% cotton, cotton/PES, 100% PES), the weave (plain, twill, rib, pique), the fabric tightness and fabric cover etc. These data allowed the elaboration of textile material's specifications for impact plates.

Key words: *nanoparticle, woven fabric, knitted fabric, hydrofobization, oleofobization, functionalization*

1. INTRODUCTION

The emergence of MMM (Metallic Monodisperse Nanoparticles) is getting more frequent, occurring in everyday applications with effect upon consumers and generally upon humans [1]. Nano-Ag and nano-CeO2 are the most common types of MMM, having relevance for the absorption by inhalation [2]. They are relatively cost-effective and they are produced in much larger quantities than other exotic nanomaterials such as fullerenes and quantum dots. There is an increasingly number of research studies regarding these materials (Demokritou et al. 2013, Molina et al. 2014). Inhalation is the most relevant modality for MMM absorption. During exposure, MMM get on specific chemical media. Generally speaking, the aerosolized MMM do not penetrate the organism barriers in pure state. Nevertheless, the general effects of MMM aerosols and their potential absorption are a subject of research at the moment [3-4].

2. EXPERIMENTAL WORK

2.1 Raw materials characterization

The following variants of woven and knitted fabrics were designed in order to define textile impact plates: 100% cotton, cotton / polyester and 100% polyester, with plain and twill weave for woven fabrics and rib and pique weave for knitted fabrics. The fabric cover of the warp yarns ($\mathbf{e}_u$), of the weft yarns ($\mathbf{e}_b$) and of the woven fabric ($\mathbf{e}_t$) were computed. This parameter had values in the range of 0,54-0,65 for the woven fabrics with plain weave and values in the range of 0,54-0,79 for twill weave. The tightness degree had values in the range of 54,73-70,05 for the woven fabrics with plain weave and 73,93-76,32 for twill weave.

Rib and pique weaves were used in order to design the knitted structures, by computing: the superficial fabric cover coefficient.This parameter had values in the range of 13,6-15,2 for the rib weave and in the range of 30-35 for the pique weave. The linear fabric cover coefficient δ_l, had values in the range of 0,97-1,23 for the rib weave and 1,55-5,69 for the pique weave.

2.2 Characterization of the nano-Ag and nano-CeO_2 dispersion

The UV-VIS analysis was performed on the laboratory equipment: Spectrophotometer UV-VIS-NIR Lambda 950, Perkin Elmer. The UV-VIS diagram for the nano-Ag dispersion at 800-1400 nm is presented in figure 1, while the diagram at 200-800 nm is presented in figure 2.

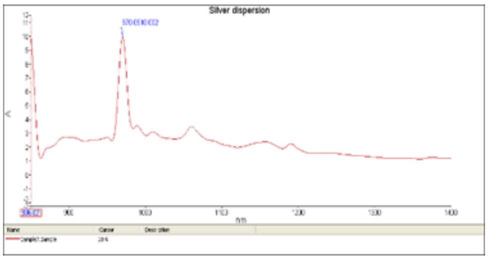

***Fig.1:** NIR spectrum nano-Ag at 800-1400 nm*

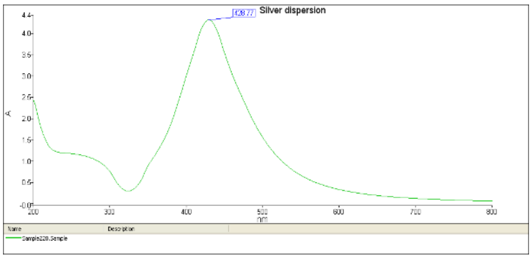

***Fig 2:** UV-VIS spectrum nano-Ag at 200 -800 nm*

The NIR absorption spectrum shows a maximum absorption at the wavelength of 970 nm, a specific value for nano-Ag and of 450 nm, a specific value for nano-CeO2. The UV-VIS absorption spectrum shows a maximum absorption at the wavelength of 470 nm for nano-Ag and 2700 nm for nano-CeO2, confirming the purity of dispersions.

The IR spectrum for the nano-Ag dispersion proves the presence of specific functional groups: alkyne, alkanes, aldehyde, cumulenes, alkene etc. at the specific wave number. FT-IR nano-CeO2 analysis proves specific functional groups for nano-CeO2 dispersion: isothiocyanates, alkyne, amide, nitro etc. (figure 3 and table 1).

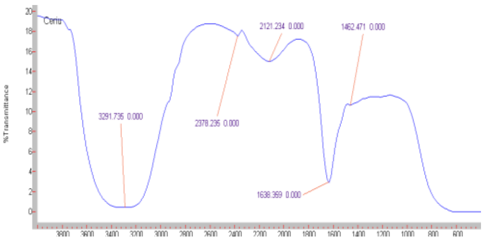

***Fig.3:** FT-IR spectrum*

Table 1: Specific functional groups

Wave number (cm^{-1})	Specific functional group
3291.7	-OH(alcohol)
2378.2	O=C=O
2121.2	N=C=S(isothiocyanates), -C≡C(alkyne)
1638.4	C=O(amide)
1462.5	N=O(nitro)

2.2 SEM and TEM analysis of nano-Ag and nano CeO_2

The electronic transmission microscope images were obtained with the electronic microscope Titan Themis 200, which performs analyses at low temperatures – in the modus (HR)TEM, STEM, EFTEM, SAED, CBED and 3D tomography in the modus TEM and STEM [5]. The SEM image of the nano-Ag sample is presented in figure 4 and the TEM image of the same sample in bright light is presented in figure 5.

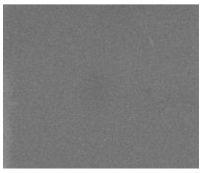

Fig.4: *SEM image*

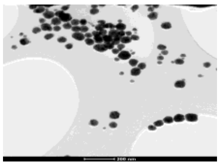

Fig.5: *TEM image-nano-Ag*

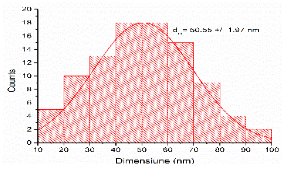

Fig.6: *Dispersion diagram nano-Ag*

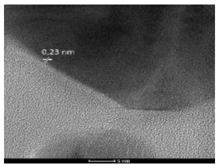

Fig.7: *.HR-TEM nano-Ag*

The images show that the sample is composed from particles of spherical and polyhedral shapes, having a mean dimension per particle of 50,55 nm ± 1,97 nm. The distribution diagram of the Ag nanoparticles dimension is presented in figure 6, proving that these are very well dispersed. The HR-TEM image on the Ag sample is presented in figure 7.

The electronic transmission microscope image of high resolution for the Ag sample showed crystalline surfaces with an inter-surface distance of 2.3 Å, corresponding to the family of crystalline surfaces (1 1 1), which are specific to silver nanoparticles. The TEM images in bright light obtained on the CeO2 sample, showed the polyhedral shape of the particles, having a mean dimension per particle of 11,86 nm ± 0,49 nm. The regular sequence of the crystalline surfaces indicated the uniformity of the nanocrystals, without amorphous structures.

2.3 The functionalization of textile materials

The woven and knitted samples from 100% cotton, cotton/PES blend and 100% PES were treated by impregnation on the laboratory padding machine, drying and condensing on the machine for drying-condensing-heat setting, with the following recipes: 50g/l RUCOSTAR EEE6+20 ml 5% nano-Ag dispersion, or 10% nano-CeO_2 in ethylene glycol, respectively water and 0,5ml acetic acid 60% for products from 100% cotton and PES/cotton and 50g/l NUVA N 2114 liquid with the same percent of nanoparticles but with 1 ml/l acetic acid 60%, in case of 100% PES samples.

3. THE CHARACTERIZATION OF THE FUNCTIONALIZED FABRICS

3.1 Physical-chemical characterization

The following aspects were evidenced when compared to the non-functionalized (hydrophobic / oleo phobic) samples:

-The oleo phobic property reached good and very good results (grades of 6 and 6-7) for the treatment with nano-Ag and with nano-CeO_2 for all variants of woven and knitted fabrics, at the same level with the non-functionalized variants;

-The hydrophobic property determined by contact angle measurement proved very good values for all variants of woven and knitted fabrics treated with nano-Ag and nano-CeO_2, at the same level with the initial variants.

3.2 DSC analysis of the fabrics functionalized with nano–Ag and nano-CeO_2

The DSC analysis [6] was performed in specific conditions (mass and temperature) for each variant of woven and knitted fabric by determining: the DSC thermogram, the processed DSC thermogram and the superposed thermogram: untreated sample (N-green), treated (T-blue) and treated /

functionalized (T/F-nano-Ag or nano -CeO_2- red) – figure 8.

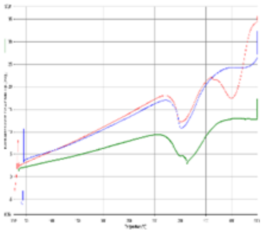

***Fig.8**: Thermogram of superposed samples*

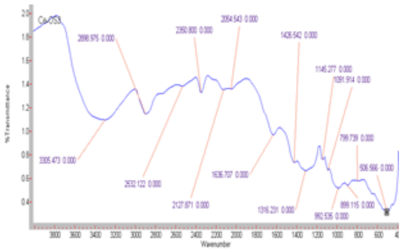

***Fig.9:** FT-IR spectru m*

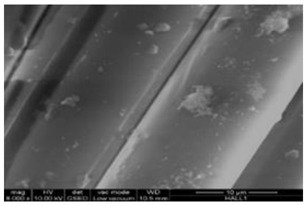

***Fig.10:** SEM images*

The DSC analysis evidenced the modification of the thermal behavior of the samples treated with nanoparticles.

3.3 Infrared spectrometry analysis with Fourier transformation (FT-IR)

This analysis was accomplished by means of spectral determination proved specific functional groups [7] in correlation with the wave number (cm^{-1}) - figure 9.

3.4 Scanning electronic microscopy analysis SEM Analysis

Figure 10 proved agglomeration of nanoparticles with various dimensions: 56-106 nm, 60-177 nm and 95-99,1 nm on the woven and knitted fabrics treated with nano-Ag and nano -CeO_2.

3.5 Anti-fungal characterization of the functionalized textile materials

The textile materials treated with nano-Ag and nano-CeO2 evidenced a weak influence upon this property for nano-Ag, well known for its anti-bacterial action, due to the influence of the oleo phobic product.

4. CONCLUSIONS

The complex characterization: hydrophobic and oleo phobic properties, color change, whitening degree, DCS, FT-IR, SEM and microbiology, evidenced through the obtained results the justness of the selection for: the raw materials (100% cotton, cotton/PES, 100% PES), the weave (plain, twill, rib, pique), the fabric tightness and fabric cover etc. These data allowed the elaboration of textile material's specifications for impact plates.

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