ANALYSIS OF THE THERMAL COMFORT PROPERTIES AND FIR INFRARED EMISSION CHARACTERISTICS OF CERAMIC NANOFILLERS IMBEDDED FABRICS

Ashik Md Faisal[1,2,3,4], **Fabien Salaün**[1,2], **Stéphane Giraud**[1,2], **Ada Ferri**[3], **Yan Chen**[4], **Lichuan Wang**[4]

[1]*University of Lille Nord de France, F-5900 Lille, France*
[2]*ENSAIT, GMTEX, F-59100, Roubaix, France*
[3]*Politecnico di Torino, DISAT, Corso Duca degli Abruzzi 24, 10129, Turin, Italy*
[4]*Soochow University, College of Textile and Clothing Engineering, Suzhou, Jiangsu, 215123, China*
ashik-md.faisal@ensait.fr

EXTENDED ABSTRACT

Far-infrared (FIR) ray emitting textiles are claimed to be functional textiles that improve the health as well as well-being. FIR ray emitting fabrics are derived from traditional fibers by incorporation of ceramic nanofillers with appropriate electromagnetic absorption and emission properties. This study examined the far-infrared emission characteristics and thermal comfort properties of ceramic-imbedded cotton knitted fabrics. For this purpose, a combination of Aluminum Oxide, Silicon Dioxide and, Titanium Dioxide were dissolved in water-based polyurethane binder by sonication technique and then applied to the cotton fabric samples by padding. Reflection and transmission of the samples were measured with an integrating sphere by Fourier-transform infrared spectrometer. The result shows a significant change in terms of emissivity between the treated and the untreated samples. Thermal properties of fabric samples were investigated by thermogravimetric analysis (TGA) and by differential scanning calorimetry (DSC). The results showed that the thermophysical properties of the fabrics are strongly dependent on the nature of nanofillers present on the coating. In addition, properties like tensile strength, moisture absorbency, and antimicrobial properties were also measured to evaluate the feasibility of the ceramic nanofiller coated fabric towards thermal comfort.

Key words: FIR, knitted fabric, ceramic nanoparticle, thermal comfort, functional textiles.

1. INTRODUCTION

Human thermal comfort depends on four basic environmental variables i.e. air temperature, air movement, humidity, and radiant temperature[1]. Radiative thermal management has been shown to be an effective way of balancing the human thermal environment (by heating or cooling)[2]. Thermal transfer in fibrous material depends on thermal conduction, moisture evaporation, and air convection[3]. Adjusting the thermal conductivity of conventional textile fibers by changing the porosity, aerial density, thickness, and structure seem to be not enough to gain the perfect microclimate for human skin. Therefore, changing the thermal conductivity by applying a multifunctional coating on the fibrous structure may offer various advantages without changing the fiber structure, porosity, even the moisture evaporation.

2. MATERIALS AND METHODS

A 100% cotton single jersey knitted fabric (162 gsm) was used in this study. Aluminum Oxide (80~120nm), Silicon Dioxide (5~50nm), Titanium Dioxide (70~100nm) were obtained from Sigma-Aldrich and a water-based polyurethane binder was supplied by Archroma. The fabric was bleached with standard bleaching recipe and parameters. A uniform mixture of coating solution containing 3% of ceramic nanoparticle (on the basis of the solid content of the end product) was prepared by sonication and then applied to the fabric by dip-coating technique. A 100% wet pickup was set by adjusting the pressure on the padders Then the fabric was dried and cured at 130ºC for 7 minutes. Finally, the fabric was washed with both hot and cold water for the removal of the unfixed chemical.

3. RESULTS AND DISCUSSION

The effect of ceramic coating on the radiative properties has been shown in Figure 1. Competitively lower emissivity was found at human skin resonance wavelength (6~14µm)

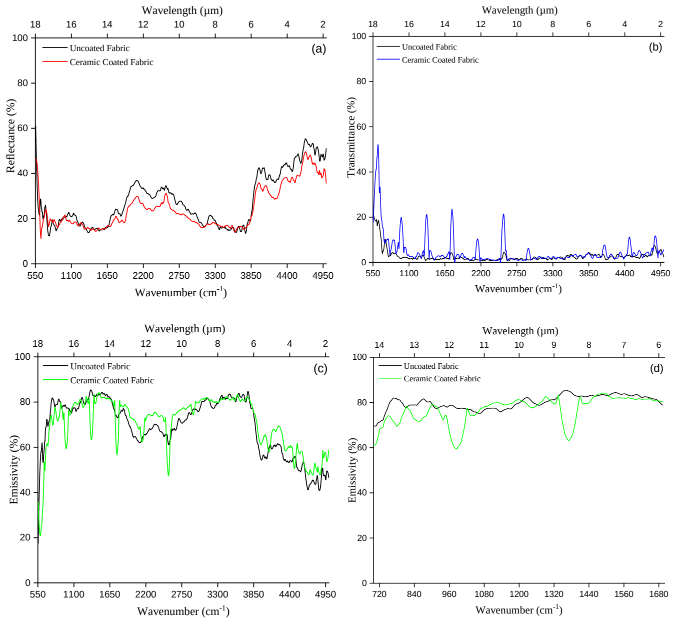

Figure 1. Infrared property characterizations of different fabrics. Measured total FTIR (a) reflectance, (b) transmittance, (c) emissivity, and (d) emissivity at the resonance wavelength

Thermal behavior of both uncoated and ceramic coated fabric displayed a single step degradation (Figure 2). The char residue remaining at 600ºC was reported 0.99% (uncoated fabric) and 9.95% (coated fabric) and the main decomposition (T_{max}) took place at 426 ºC (uncoated fabric) and 423 ºC (coated fabric).

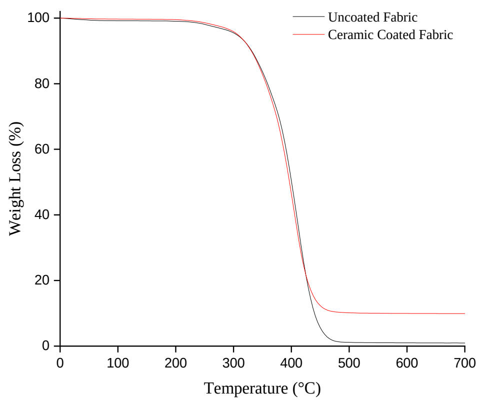

Figure 2. TG curves of different fabrics

The antimicrobial effects (for bacteria E.coli and S.aureus) of both uncoated and coated fabric have been shown in Figure 3. Good resistance for both bacteria (E.coli and S.aureus) have been found for the ceramic coated fabric during the test.

Figure 3. Zone of inhibition of uncoated and ceramic coated fabric against E.coli and S.aureus

The tensile strength properties of uncoated and coated fabric have been shown in Table 1. The addition of ceramic coating has shown an increment of tensile strength.

Table 1. Tensile Properties of different fabric

Tensile Properties	Uncoated Fabric	Ceramic Coated Fabric
Tensile strength (MPa)	10±0.2	11±0.8
Elongation at break (%)	16±1.0	18±0.4

4. CONCLUSION

In this paper, it has been demonstrated that a polyurethane based coating containing multifunctional ceramic nanofiller can improve the fabric thermal radiative property as well as other chemical and physical properties. Good bacterial resistance has been found. The decrease in air permeability and fabric softness was also observed.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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