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The influence of cork on the thermal insulation properties of home textiles

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Abstract

Novel strategies and technologies to obtain home textiles with thermal insulation properties are increasingly being researched as a strategic approach in the textile industry. The fabric conductivity and heat resistance are two important parameters to take into consideration in order to obtain a structure with improved performance. It is widely accepted that thermal insulation fabrics that resist heat flow possess still air in their structure. The higher is the thickness of the fabric, the bigger is the air entrapped in the structure and thus better is their thermal insulation properties. Nevertheless, these types of textiles face a critical challenge that is obtaining a structure with decreased thickness, without losing the thermal insulation properties required to provide comfort to users. The main objective of this work was to develop different low thickness fibrous structures with improved thermal insulation properties by incorporating cork particles within nonwoven structures. The nonwoven fabrics were produced with wool and hollow polyester fibers and the cork particles were incorporated within the structure in the process of nonwoven fabrication. Nonwoven structures have been prepared in different compositions including 75 % of wool and 25 % of hollow polyester blended with cork granules with sizes ranging from 1-2 and 2-5 mm using as a control an agglomerated cork of 0.8 mm. After production, samples were tested for their thermal behaviour using Alambeta equipment. Results have shown that nonwoven composition comprising cork particles greatly influences the thermal performance, and enables for obtaining a low weight material with improved thermal insulation properties.

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1. Introduction

Human body generates a substantial amount of heat that is, since ancient times, used as a source of energy for providing comfort. Blankets and clothes able to insulate the body and prevent the rapid loss of body heat to the surrounding environment is the ever-used strategy [1]. In general, insulation products block the transfer of heat, which can be transmitted by various methods including convection, conduction and radiation. Radiation heat transfer occurs when heat is sent through space and is capable of traveling to an object where the heat can be reflected, absorbed or transmitted. Convection, i.e. flow of fluid (air) through the pack includes flow driven by external forces, such as wind, fans or blowers and natural or free flow driven by conditions within the pack, such as thermal or density gradients; similarly, conduction includes conduction by air, glass or any other compounds present within the pack [2–4].

The rate of conductive heat transfer is directly proportional to the thermal conductivity of the object through which heat is conducted. Using insulators with low conductivity can therefore slow heat transfer. Essentially, the insulation process uses a material with low overall conduction properties to reduce the energy flow across another material. It retards and/or reduces the flow of heat, thus it must have a high resistance (resistance being the inverse of conduction). In terms of bedding materials, one can use thicker blankets or blankets with lower thermal conductivity [5].

Nevertheless, other parameters such as the still air that is trapped inside the fabric structure is regarded as the most important factor to obtain thermal insulation properties in fabrics. According to Famworth [6], an effective thermal conductivity, i.e. the capacity of a fabric for transferring heat from a warmer medium to a cooler one, depends on the balance between the fiber fractions and the volume of still air in the system. Knowing that thermal resistance of air is 8 times higher than that of the fibers, i.e. the thermal conductivity of still air at 20-30ºC is 0.0245 $W.m^{-1}.K^{-1}$, the more trapped air inside the structure the better will be the thermal insulation [7].

On the other hand, engineering the fiber structure may promote the creation of more air spaces, preventing air movement, and provides a shield to heat loss, which in turn depends on the thickness, shape and structures of the textile [8,9]. In fact, the physical parameters of fabrics are very important for its thermal insulation properties, and structural parameters such as weave and drape may also play an important role [10]. The thermal efficiency depends on the level of porosity of the fabric structures, which in turn may depend on the level of yarn twist, the thickness of the fabric, among others [9]. The fiber geometry also plays an important role on the capacity of a structure to resist heat flow. Strategies such as the creation of surface irregularities, which later creates interstices in the yarn structure, the fiber crimp or the development of hollow fibers have been most commonly applied [8].

In this work, we aimed at developing a nonwoven based structure with improved thermal properties, i.e. with low thermal conductivity. Different materials with well-recognised thermal insulation properties were selected, namely wool (WO) fibers and hollow polyester (PES) fiber. Cork in the form of granules or as an agglomerated panel was further introduced in order to improve the thermal properties of WO and PES. Besides providing significant decrease in the costs of thermal insulation when compared with conventional materials, cork has a commercial appeal and it is an environmentally friendly material.

Cork is one of the oldest insulation materials used commercially. It is lightweight material, viscoelastic and impermeable to liquids or gases, it is considered a good thermal, acoustic and electrical insulator, sound and vibration insulator and exhibits a near-zero Poisson coefficient. The first application of this material was in the refrigeration industry and lately has been used in stoppers, agglomerates and aeronautics [11]. It is mainly composed by suberin (33–50%); lignin (13–29%); polysaccharides, (6–25%); and extractives (8.5–24%). The main constituent of cork, suberin, is present in plants imparting properties such as the control of water loss, insulation against climatic variability and protection against abiotic aggressions, which explains its properties as an insulating material.