Abstract

The extreme cold weather clothing (ECWC) consists of three layers; inner, middle, and outer layers. The inner layer of the ECWC stays in contact with the skin. The function of the inner layer is to transport sweat from the skin to the next layer so that the skin remains dry. Further, it should have durable antimicrobial and quick sweat absorption properties. The function of the middle layer is to provide thermal insulation, whereas the outer layer protects from wind rain and snow.

In the present work, antimicrobial fabric was developed for potential use as an inner layer in extreme cold climates. The yarn used for skin-contacting inner layer (single jersey) was specifically designed to provide antimicrobial properties and quick liquid moisture transport by selecting an appropriate blend of antimicrobial and virgin fibres of different deniers. Fabrics made from antimicrobial fibres doped with silver nanoparticles demonstrated superior durability of antimicrobial activity even after extensive washing compared to fabrics coated with silver nanoparticles. The inner layer fabric composed of coarser fibres exhibited better moisture management properties compared to fabrics made of finer fibres. The liquid absorption and spreading capability of these fabrics, simulating the skin's sweating phenomenon, showed that fabrics with coarser fibres quickly imbibe microdroplets and spread them over a larger area.

A second garment layer was designed to absorb moisture from the skin-contacting layer and provide insulation. A fleece fabric structure was chosen to meet these functional requirements. Variations in the fleece fabrics were achieved by using filament and spun yarns in the fleece and base parts of the fabrics. The results indicated that fabric with filament yarn on the base side and spun yarn on the fleece side enhances moisture transport. The use of spun yarn made

of coarser fibres in the fleece part further promotes moisture management due to its faster wicking.

A thorough study was carried out on the outer garment (insulating cum environmental protective) consisting of a nonwoven layer sandwiched between the lining and the protective shell was designed. The effect of weave design on the fabric's mechanical properties was studied for the lining and the outer shell layer. The performance of the twill ripstop weave was found to be best due to the presence of ribs consisting of a group of parallel yarns and floats. The fabric is further laminated with different membranes (PU, mono-PTFE, and bi-component PTFE) to be used as an outer shell. The fabric laminated with bi-component PTFE membrane was found to enhance tear strength and provide good vapor transmission.

Thermal bonded nonwovens, made from different denier fibres in various proportions, were analysed to identify the one with maximum vapor transmission. Results showed that evaporative resistance increases as porosity decreases and the average specific surface area of the fibre mixture increases. Fabric thickness significantly affects evaporative resistance: thicker fabrics offer more resistance to vapor transmission.

Three ensembles (composed of single jersey, fleece and insulating jacket and trouser set) were made to investigate their performance on manikin. The variation was introduced by changing the laminated fabric layer. The ensemble with a mono PTFE laminating membrane exhibited the least evaporative resistance, followed by bi-component PTFE and PU laminated ensembles. The evaporative resistance measured on the manikin was always higher than the estimated resistance from the component fabrics measured on a sweating-guarded hot plate, due to air gaps between the fabric layers in the ensemble.