

THERMAL INSULATION FOR APPAREL

FIELD OF THE INVENTION

The invention relates to thermal insulation for apparel, and in particular, to thermal insulation applied to fabric of garments.

BACKGROUND OF THE INVENTION

Insulating materials in textile areas mainly refer to the fillings or paddings for apparel and other protective objects against the external environment, such as winter jackets, gloves, footwear, tents, sleeping bags, blankets etc. The conventional insulating materials for these applications are natural fibers like cotton, wool, down, long filament synthetic fibers or staple fibers.

When the protective object is designed for extreme conditions such as wintry areas with temperature of less than 30 degrees Celsius or in the polar regions, the dependency on the thermal comfort of the apparel is even pronounced.

Technologies which are currently applied in order to improve the thermal insulating property of the lining fabric are mainly directed towards retention/accumulation of heat or reflection of rays in the infrared spectrum. In particular, non-woven materials, down and polymeric foams are used as an inner layer of clothing for thermal insulation. However, this results in bulky and heavy apparel, and there is a demand for lightweight thermal insulated apparel of low bulk.

SUMMARY OF INVENTION

The thermal insulation for apparel increases thermal insulation properties of lining material of apparel, making winter apparel warmer. Reducing the thickness of thermal insulation achieves winter apparel that is more flexible and therefore more functional and better able to cater to different types of winter sports and even for casual wear. Reducing bulkiness of winter apparel makes it more attractive and shapely. This will also make winter apparel cheaper, because as the thermal insulation layer cost typically forms 20-30% of the price for winter apparel.

A thermal insulating composite is applied in a pattern to lining material of apparel. The thermal insulating composite includes a polymer which plays a role of a matrix in which

particles of aerogel or another additive with improved thermal insulating properties are distributed.

Thus, the present invention allows application of heat insulating material on the lining fabric of apparel. Aerogel or another thermal insulating additive is mixed with liquid monomer, thus achieving its ideal homogeneous distribution in the material. As a result of polymerization, particles of aerogel or other thermal insulating additive remain within the polymer and the phenomena of migrating outward, dusting, etc. are completely excluded. Elastic polyurethane used as a matrix to create thermal insulation composite penetrates deeply into the fabric that provides a tight grip between polymer prints and fabric. The elasticity of the polymer preserves flexibility of the lining fabric.

According to a first aspect, there may be provided a thermal insulation for apparel comprising: a polymeric composite pattern applied onto a fabric, the polymeric composite comprising a polymer and a thermal insulating additive configured to improve thermal insulation.

The thermal insulating additive may comprise an aerogel.

The aerogel may comprise particles from 100 nm to 5000 μm in size.

The thermal insulating additive may comprise expanded graphite.

The polymer may comprise polyurethane.

The polymer may comprise polyethylene.

The polymer may comprise polyacrylates.

The polymer may comprise polysiloxanes.

The polymer may comprise polyepoxides.

The polymeric composite further may comprise at least one of: a gold dye and a silver dye.

The polymer may be formed from a monomer and a ratio of the thermal insulating additive to the monomer may range from 1:4 to 3:1.

The polymeric composite pattern may cover an area ranging from 5% to 50% of a total area of the fabric.

The polymeric composite pattern may have a width of less than or equal to 5mm.

The polymeric composite pattern may have a height ranging from 0.5 mm to 2.5 mm.

The polymeric composite pattern may comprise a number of elements, each element ranging from 0.5 mm to 5 mm in width.

According to a second aspect, there is provided a method of forming a thermal insulation for apparel, the method comprising the steps of: a) providing a fabric; and b) applying a polymeric composite pattern onto the fabric, the polymeric composite comprising a polymer and a thermal insulating additive configured to improve thermal insulation.

Step b) may comprise: mechanically mixing a monomer with the thermal insulating additive in powder state to form a first mixture; adding a polyester diol to the first mixture to form a second mixture; pouring the second mixture into a pre-heated mold having a pattern formed thereon; placing the fabric onto the mold containing the second mixture therein; and applying pressure to the fabric and the mold for a period of time at a specific temperature. The polymer may comprise polyurethane.

Alternatively, step b) may comprise: mixing the thermal insulating additive in powder state with the polymer when the polymer may be in a liquid state to form the polymeric composite; pouring the polymeric composite into a pre-heated mold having a pattern formed thereon; placing the fabric onto the mold containing the polymeric composite therein; and applying pressure to the fabric and the mold for a period of time at a specific temperature. The polymer may comprise polyethylene.

Alternatively, step b) may comprise: mechanically mixing a monomer with the thermal insulating additive to form a mixture; pouring the mixture onto a roller having a pattern formed thereon; supplying the fabric continuously and pressing the fabric against the roller at

an area that may be illuminated by UV light. The polymer may comprise polyacrylates.

The polymer may comprise polysiloxanes.

5 The polymer may comprise polyepoxides.

The thermal insulating additive may comprise an aerogel.

The thermal insulating additive may comprise expanded graphite.

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BRIEF DESCRIPTION OF FIGURES

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative

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drawings.
FIG. 1 shows examples of molds having a desired pattern engraved for applying the thermal insulation to fabric.

FIG. 2 shows examples of the printed pattern.

FIG. 3 shows an exemplary apparatus for using UV light polymerization to form a thermal

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DETAILED DESCRIPTION

Exemplary embodiments of a thermal insulation for apparel will be described with reference to FIGS. 1 and 2 below, in which the same reference numerals are used to denote the same or similar parts.

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In general, to form the thermal insulation, a monomer is mixed with a thermal insulating additive in a particular ratio together with an initiator, a catalyst, and a dye until a homogenous distribution of all components in the liquid phase is reached. In case of a bi- or more component monomeric composition, the mixture of the first monomer and thermal insulating additive is mixed with another monomer(s). After reaching the homogenous distribution, the mixture is poured onto a preheated mold as shown in FIG. 1. Excess of liquid is eliminated from the top of the mold using a special knife or another appropriate device. A fabric is placed on the mold and a pressure and temperature is applied for a certain time which is enough for polymerization of monomer(s) in the mixture. Subsequently,

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the mold is cooled down and the fabric provided with a thermal insulating pattern is separated from the mold surface, as can be seen in FIG. 2. In the last stage, the fabric may be kept at a certain temperature for a defined period of time for polymerization to be completed.

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An exemplary embodiment of fabricating the thermal insulation is as follows:

1) Diisocyanate monomer (monomer A) for example, toluene diisocyanate, is mixed with a particles of a thermal insulating additive, for example aerogel, by means of mechanical mixer. Aerogel powder components A is mixed with component B (diisocyanate and polyalcohol monomers for polyurethane synthesis) using a paddle mixer. Volume ratio between aerogel powder and monomers can vary from 1 to 1 up to 3:1 with optimum value 2:1. Below 1:1 ratio, the thermoinsulating properties of composite material become worse comparing with the fabric itself due to of good thermoconductivity of the polymer itself (at least better than fabric). A ratio of aerogel : monomer that higher than 3:1 is impossible to mix and impossible to get polymer due to of high amount of inorganic aerogel powder. The value of 2:1 is optimum from thermal insulation and polymerization sides. Lower amount of aerogel in the material provides worse thermoinsulating property: higher amount of aerogel leads to the crumbly mechanically instable structure of polymer.

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Thus, volume ratio between aerogel powder and monomers from 1 to 1 up to 3:1 with optimum value 2:1 allows good performance of thermal insulation, while providing acceptable mechanical properties of the lining fabric.

25 2) Aerogel, a market available product, for example from Aspen Aerogel Co, Lumira® aerogel or another suppliers, should be in powder or particles states with the particles size ranging from 100nm to 5000 µm. Particles of aerogel should have a hydrophobic surface, for example after treatment by chlorotrimethyl silane.

30 3) Dye can be added if necessary to provide a certain color for the polymer composite. Dye should not contain water.

4) After reaching homogeneous mixture, a second component polyester diol (B) with specific molecular weight is added to the mixture. A necessary amount of initiator and hardener can be added to the polyester diol in advance. Final mixture is stirred within 1-3

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min using mechanical mixer. After that, the mixture is poured into a mold (examples shown in FIG. 1) where a desired pattern has been engraved. The mold can be made of aluminum or stainless steel.

Summarily, the thermal insulation for apparel consists of a polymer composite. Material for the printed pattern includes monomers, aerogel or another thermal insulating additive with good thermal insulating properties, initiator, hardener and dye. Monomers in liquid form are convenient for mixing with other components. Composition can be made based on polyurethanes, polyacrylates, polyepoxides, polysiloxanes. Monomers form polymer after hardening under the impact of high temperature or UV light. Composition itself may include only monomers, hardener and initiator. Dye may be included if a specific color of composite is needed. Polymer can be applied without aerogel. It also may give an increase in thermal insulation but less promising comparing if the aerogel was added to the composite.

5) The pattern may cover from 5 to 60 percent of the lining surface. The optimum value is located between 10 and 20% of the fabric surface. Lower area of coverage does not provide significant difference in thermal insulation. Bigger covered area reduces flexibility of lining material and makes fabric heavier due to of high amount of polymer. It was discovered that coverage of the surface more than 20% by polymer pattern does not provide significant increase in thermal insulation property.

The height of the pattern can vary from 0.5 to 2.5 mm, with the optimum range 1-1.5 mm. The width of the polymeric pattern which is placed on the fabric should be less than 5 mm. All elements of polymeric structure/pattern on the fabric should be larger than 0.8 mm width and minimum 0.7 mm height. Lowest values do not provide visible increase in thermal insulation and in addition it is difficult to perform technically. From the maximum side, there are also limitations. The height of the polymer pattern should be not higher than 1.5 mm from aesthetical point of view. The width of the fragments of polymeric pattern should not exceed 5 mm. Larger value dramatically reduces flexibility of lining fabric.

The above pattern parameters improve heat insulation and saves exploitation and aesthetic quality of the products. Exemplary patterns are shown in FIG. 2.

6) Excess liquid is removed from the mold by special knife. Mold is preheated at the temperature 90-120°C within 1-5 min to provide prepolymerization and certain level of

viscosity. After that the fabric is placed onto the mold and pressure is applied. Plates of hotpress are preheated up to 90-120°C. Level of pressure is from 10 to 50 kg/cm², but the optimum value is 20 kg/cm². The fabric is kept under the pressure and temperature for the time which is enough for polymerization. For example, optimum condition for polymerization of polyurethane is 90°C and 5 min.

7) Finally, the pressure is removed and the fabric with polymer print is cooled down. Printed fabric may be kept in the oven/room at 80°C within 8 hours for finishing or for termination of the polymerization.

Material of fabric can be polyester, cotton, silk and their combination as well as other fabrics which can save their structure at 90-120°C.

In alternative embodiments, the following variations may be applied:

1) Not only polyurethane but other polymers can be mixed with aerogel to form the thermal insulation pattern on fabric. For example, monomers for making polysiloxanes, polyacrylates, polyepoxides can be used. Initiation for these polymers can be done by thermal impact, ultraviolet (UV) irradiation or can be done just at room conditions. The amount of aerogel mixed with the above mentioned monomers can vary from 1:4 to 3:1 in a volume ratio.

2) The thermal insulating mixture can be formed by melting polyethylene and mixing in the aerogel or another thermal insulating additive (such as expanded graphite) into the liquid polyethylene. After that, the mixture is poured into the preheated mold. The fabric is placed on the mold and pressure of hotpress can be applied for a certain time. The mold is then cooled down and the fabric with thermal insulating pattern can be removed.

3) The thermal insulating mixture can comprise a polymer in the state of foam with closed pores. In this case, a necessary amount of foam generator, for example, azoisobutyronitrile (AIBN) can be added into the monomer mixture with the thermal insulating additive. During the stage of heating the fabric in the mold under pressure, the foam generator will degrade, giving off a gas which forms pores in the polymer composite.

4) If photoinitiation is used for polymerization, for example, for acrylic polymers, the steps of mixing monomers with aerogel and other components are the same as previously described.

However, for the polymerization stage, rollers and a UV light source are required. In this

case, as shown in FIG. 3, the final mixture of monomer(s) with all additives is spread onto a first roller having an engraved pattern. Excess of monomer(s) is removed by means of knife. The fabric is supplied continuously and pressed onto the first roller by means of two additional rollers at an area of the first roller surface that is illuminated by UV light from the UV light source to polymerize the final mixture on the fabric at the area where polymerization occurs.

5) Gold or silver dye can be added to the polyurethane to increase heat reflection capability of lining material.

The thermal insulation 10 for apparel thus provides a new way of improving warming property of lining fabric in winter clothing by applying a decorative pattern made of polymer composite. As a result, the lining possesses higher thermal insulation properties.

Table 1 below presents the increase in CLO (thermal insulation) for fabric printed with a pattern comprising a polymer composite with different amounts of aerogel. The printed pattern covered 10% of the fabric surface.

Sample and type of polymer	Amount of aerogel (aerogel: polymer) vol % (mass %)	CLO value, m ² K/W	CLO increment due to polymer printing, %
Initial fabric	0	0.749±0.002	
Fabric with PU	0	0.796±0.002	+6,0
Fabric with PU	1:2 (2.2% wt)	0.806±0.002	+7,1
Fabric with PU	1:1 (4.4% wt)	0.813±0.004	+7,9
Fabric with PU	2:1 (8.8% wt)	<u>0.832±0.004</u>	+10,0
Fabric with silicon	1:4 (1.1% wt)	0.823±0.005	+9.0

Table 1. (PU =polyurethane)

Advantages of the thermal insulation for apparel include:

- Improved heat retention of the apparel
- Decrease in thickness of winter apparel that provide more flexibility and functionality of the apparel, particularly important for winter sports

Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations in details of design, construction and/or operation may be made without departing from the present invention.

CLAIMS

1. A thermal insulation for apparel comprising:
a polymeric composite pattern applied onto a fabric, the polymeric composite
5 comprising a polymer and a thermal insulating additive configured to improve thermal insulation.
2. The thermal insulation for apparel of claim 1, wherein the thermal insulating additive comprises an aerogel.
- 10 3. The thermal insulation for apparel of claim 1, wherein the aerogel comprises particles from 100 nm to 5000 μ m in size.
4. The thermal insulation for apparel of claim 1, wherein the thermal insulating additive
15 comprises expanded graphite.
5. The thermal insulation for apparel of any preceding claim, wherein the polymer comprises polyurethane.
- 20 6. The thermal insulation for apparel of any one of claims 1 to 4, wherein the polymer comprises polyethylene.
7. The thermal insulation for apparel of any one of claims 1 to 4, wherein the polymer comprises polyacrylates.
- 25 8. The thermal insulation for apparel of any one of claims 1 to 4, wherein the polymer comprises polysiloxanes.
9. The thermal insulation for apparel of any one of claims 1 to 4, wherein the polymer
30 comprises polyepoxides.
10. The thermal insulation for apparel of any one of the preceding claims, wherein the polymeric composite further comprises at least one of: a gold dye and a silver dye.
- 35 11. The thermal insulation for apparel of any one of the preceding claims, wherein the

polymer is formed from a monomer and wherein a ratio of the thermal insulating additive to the monomer ranges from 1:4 to 3:1.

12. The thermal insulation for apparel of any one of the preceding claims, wherein the polymeric composite pattern covers an area ranging from 5% to 50% of a total area of the fabric.

13. The thermal insulation for apparel of any one of the preceding claims, wherein the polymeric composite pattern has a width of less than or equal to 5mm.

14. The thermal insulation for apparel of claim 8, wherein the polymeric composite pattern has a height ranging from 0.5 mm to 2.5 mm.

15. The thermal insulation for apparel of any one of the preceding claims, wherein the polymeric composite pattern comprises a number of elements, each element ranging from 0.5 mm to 5 mm in width.

16. A method of forming a thermal insulation for apparel, the method comprising the steps of:

a) providing a fabric; and

b) applying a polymeric composite pattern onto the fabric, the polymeric composite comprising a polymer and a thermal insulating additive configured to improve thermal insulation.

17. The method of claim 16, wherein step b) comprises:

i. mechanically mixing a monomer with the thermal insulating additive in powder state to form a first mixture;

ii. adding a polyester diol to the first mixture to form a second mixture;

iii. pouring the second mixture into a pre-heated mold having a pattern formed thereon;

iv. placing the fabric onto the mold containing the second mixture therein; and

v. applying pressure to the fabric and the mold for a period of time at a specific temperature.

18. The method of claim 17, wherein the polymer comprises polyurethane.

19. The method of claim 16, wherein step b) comprises:

- i. mixing the thermal insulating additive in powder state with the polymer when the polymer is in a liquid state to form the polymeric composite;
- ii. pouring the polymeric composite into a pre-heated mold having a pattern formed thereon;
- iii. placing the fabric onto the mold containing the polymeric composite therein; and
- iv. applying pressure to the fabric and the mold for a period of time at a specific temperature.

20. The method of claim 19, wherein the polymer comprise polyethylene.

21. The method of claim 16, wherein step b) comprises:

- i. mechanically mixing a monomer with the thermal insulating additive to form a mixture;
- ii. pouring the mixture onto a roller having a pattern formed thereon;
- iii. supplying the fabric continuously and pressing the fabric against the roller at an area that is illuminated by UV light.

22. The method of claim 21, wherein the polymer comprise polyacrylates.

23. The method of claim 16, wherein the polymer comprise polysiloxanes.

24. The method of claim 16, wherein the polymer comprise polyepoxides.

25. The method of any one of claims 16 to 24, wherein the thermal insulating additive comprises an aerogel.

26. The method of any one of claims 16 to 24, wherein the thermal insulating additive comprises expanded graphite.