Evolution of Waterproof and Water Resistant Fabrics for Garments

Conference Paper · March 2023

Abhishek Kumar
University of Petroleum & Energy Studies

ISBN: 978-81-953853-8-6

Evolution of Waterproof and Water Resistant Fabrics for Garments

Abhishek Kumar[1], Dr. Manpreet Manshahia[2]
[1]Ph.D. Scholar, ASFT, Amity University, Noida, [2]Assistant Professor, ASFT, Amity University, Noida
abhishek.kumar3@s.amity.edu

ABSTRACT

Waterproof and water resistant garments are protective garments that keeps the wearer dry in wet weather by stopping the water molecules to penetrate inside the garment. The fabric for these garments can be prepared in a variety of ways to meet the waterproof/water resistance criteria. Since the first known attempt, the fabric used for this purpose has changed considerably. In the past sailors utilised linseed oil, animal fat, or wax to make waterproof garments for their voyages. Materials manufactured using previous techniques were unbreathable and hence uncomfortable to wear for long periods of time, necessitating the development of breathable waterproof fabrics. This paper reviews the advancements in the field of waterproof and water resistant fabrics used in garments over time, as well as the obstacles that remain.

Keywords: Coating, Membranes, Protective Clothing, Waterproof Breathable Fabric, Water resistant

1. INTRODUCTION

The basic purpose of a waterproof or water resistant garment is to prevent its wearer from getting wet. Water cannot permeate a waterproof garment, but it can penetrate a water-resistant garment to some level if it is exposed to water for an extended period of time (Porav, 2011). The waterproof characteristics of a fabric can be measured by either simulating rain or by testing hydrostatic pressure at which water penetrate through the fabric surface. If the hydrostatic pressure rating of a fabric is greater than 5000 mm, it means that it can withstand light rain and is resistant to water under low pressure. If the water column rating is between 10, 000 and 15, 000 mm, it can withstand moderate rain under light pressure, and a rating of more than 15, 000 mm indicates that the fabric is completely waterproof and can withstand heavy rain (Williams, 2018).

Waterproof characteristics of fabric can be examined by mimicking rain using a variety of methods, such as a spray test or a rain test. Spray tests can be carried out on fabrics that are permeable to air. In a spray test, the specimen is positioned at a 45o angle and water is sprayed from above using a spray nozzle, after which the wet specimen is evaluated by comparing it to a reference sample. Standard spray test ratings are used to interpret the results (AATCC-22). In rain test the specimen is exposed to the shower for 10 minutes and the wet condition of specimen is assessed by comparing with the reference sample. Equation (1) and (2) are used to calculate the amount of water absorption and rate of water absorption respectively (AATCC-35).

$$g = M - M_o \quad (1)$$

$$\% = \frac{M - M_o}{M_o} \times 100 \quad (2)$$

Where, g = amount of water absorption; % = rate of water absorption; M_o = mass of specimen before the test; M = mass of specimen after the test.

2. HISTORY

The 15th century saw the first recorded effort to develop water-repellent protective garments. Sailors attempted to infuse their garments with linseed oil, animal fat, or wax during the time (Camotrek, 2020). The South American tribes used rubber in their crude clothes long before it was known in civilised countries. The King of Portugal was given with a waterproof garment in 1759, which was manufactured by pouring rubber over the cloth and leaving it to dry. The first solid rubber pieces were apparently introduced to this nation by South American Indians, and the substance was sold in London in 1770 for erasing pencil markings. Rubber was used to "proof" clothes for the first time between 1790 and 1830; the term "to render cotton, linen, and woollen cloths, etc., waterproof" appears in multiple patents by Peal, Macintosh, Hancock, and others. In the early 1820s, Charles Macintosh established a rubber factory and named a fabric after himself, which is still used in the word "mackintosh, " a waterproofed fabric in which rubber creates an air and water-impermeable flexible coating on a fabric (Blow, 1939). Between two layers of cloth to make it waterproof, Macintosh layered rubber dissolved in naphtha, a material derived from coal tar, which is obtained from the 'cooking' of coal to make coke. Unfortunately, rubber handled in this way retains many of the same characteristics as rubber in its original state: it stiffens when cold and becomes sticky when heated, neither of which are desirable characteristics for a wearable item. It also smelled awful, and the manufacturing process was quite hazardous. It wasn't until around 1843, when Thomas Hancock developed the vulcanisation method in which natural rubber is heated and combined with sulphur under controlled conditions that it became truly practicable to use (Newton, 2015).

3. WATERPROOF BREATHABLE FABRICS

In order to eliminate interstices between fibre and yarn, a closed structure with high density and yarn twist are used to create waterproof fabric structures. Lineseed oil, rubber or silicone emulsions coatings are used to prepare waterproof fabrics. These coatings completely block the pores in the fabric, making it unbreathable and difficult to wear. This results in development of waterproof and breathable coatings. Breathability is an important aspect of comfort for the users as good breathable garment transports the sweat away from the body. Water-resistant fabrics, in compared to waterproof fabrics, provide better breathability to users since they are laminated with membranes, which are ultra-thin films with a strong resistance to liquid water penetration while remaining permeable to water vapour (Porav, 2011). During World War II, England manufactured the first true water-resistant or waterproof breathable fabric. In 1943, mass production began (Camotrek, 2020). Breathable waterproof fabrics can be achieved by three methods, using high density fabrics, film – laminated materials and resin – coated materials. Cotton or synthetic microfilament yarns with a compacted weave structure make up the tightly woven waterproof breathable fabrics (Kanjana and Nalankilli, 2018). In 1879 Thomas Burberry invented that waterproofing and water resistance can also be achieved by employing tightly woven materials like gabardine (Newton, 2015). Ventile is one of the most well-known waterproof breathable textiles, and it's made from long staple cotton with few intervals between the threads. Combed yarns are usually woven parallel to each other, with no pores through which water can pass. When water is sprayed on a fabric's surface, the cotton fibre swells transversely, reducing the size of the fabric's pores and necessitating extremely high pressure to penetrate. Micro-denier synthetic filament yarns can also be used to create densely woven fabrics. Individual filaments in these yarns are fewer than 10 microns in diameter, allowing for the creation of textiles with incredibly small pores (Kanjana and Nalankilli, 2018).

Membranes are applied to textile products to create laminated waterproof breathable fabrics. These are polymeric membranes that are very thin. They have a strong barrier to water penetration while also allowing water vapour to pass through. The membrane's maximum thickness is 10 microns. They are of two types, microporous membranes and hydrophilic membranes. The microporous membrane has microscopic holes on its surface that are smaller than raindrops but bigger than water vapour molecules. In 1969, W. Gore brought a revolutionary change in the field of waterproofing material by developing Gore-tex membrane which is a film of polytetrafluoroethylene (PTFE) also known as Teflon. It provides a breathable waterproof material. PTFE membrane is hydrophobic in nature and has pores 20, 000 times smaller than size of water drop, thus it doesn't allow the water droplets to penetrate inside the fabric but it is 700 times larger than water molecule allowing the water vapour to get out and making it comfortable for the user. It also provides protection from wind penetration and are resistant to extreme temperatures (Porav, 2011). Thin films of chemically treated polyester or polyurethane serve as hydrophilic membranes. The addition of poly to these polymers changes their properties. By producing an amorphous region in the main polymer system, the poly forms the hydrophilic section of the membrane. Due to the obvious solid nature of the membrane, this amorphous region works as intermolecular gaps, allowing water vapour molecules to pass through but preventing liquid water from penetrating (Kanjana and Nalankilli, 2018).

Polymeric material is put to one surface of the cloth to make it waterproof and breathable. The coating is made out of polyurethane. Microporous and hydrophilic coatings are the two types of coatings available. Microporous coatings have very narrow interconnecting channels that are significantly smaller than the molecules of water vapour. Water vapour travels via the permanent air-permeable structure of the microporous coating, whereas the hydrophilic coating transmits vapour through an adsorption-diffusion and desorption mechanism (Kanjana and Nalankilli, 2018).

4. SUMMARY

Waterproof breathable fabrics contain membranes and/or durable water repellent finishes made using chemistries based on polyfluorinated and perfluorinated compounds, which are known to be detrimental to human health and the environment. As a result, manufacturers have been under a lot of pressure to produce safer alternatives without sacrificing performance (Businesswire, 2020). It is important to build environmentally sustainable durable water repellent coatings using bio-based ingredients and designing ecologically sustainable technologies (Businesswire, 2020).

REFERENCES

[1.] AATCC-22 (2005), “Water Repellency: Spray Test”

[2.] AATCC-35 (1980), “Water Resistance: Rain Test”

[3.] Blow, CM (1939), “Recent Developments in the Deposition of Rubber on to Textile Fibres”, The Journal of the Society of Dyers and Colourists, Vol. 55 – No. 7

[4.] Businesswire.com (2020), “Waterproof Breathable Fabrics Report 2020: Balancing Performance and Environmental Sustainability – Research And Markets.com”, https://www.businesswire.com/news/home/20200305005722/en/Waterproof-Breathable-Fabrics-Report-2020-Balancing-Performance-and-Environmental-Sustainability---ResearchAndMarkets.com, Accessed in Sep 2021

[5.] Camotrek.com (2020), “Water-Repellent vs Water-Resistant vs Waterproof Fabrics: The Differences Explained”, https://camotrek.com/blogs/news/waterproof-and-water-repellent-fabrics/, Accessed in Sep 2021

[6.] Kanjana, S; Nalankilli, G (2018), “Smart, Waterproof Breathable Sportswear – A Review”, Journal of Textile and Apparel Technology and Management, 10, 3, 1-13

[7.] Newton, W (2015), ” A very brief history of staying dry”, V&A Blog, https://www.vam.ac.uk/blog/textiles-and-fashion/a-very-brief-history-of-staying-dry, Accessed in Sep 2021

[8.] Porav, AV (2011), “Gore-Tex and Sympatex Textile Waterproofing”, Annals of the University of Oradea Fascicle of Textiles-Leatherwork, XII (1), 160-165

[9.] Williams, JT (2018), “Waterproof and Water Repellent Textiles and Clothing”, Woodhead Publication