International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 12, December-2016

Study of Heat Resistant material, their classification, properties and performance standards

Jyoti Kaushik[1], Anju Bhardwaj[2], Dr. Lalit Jajpura[3]

[1,2]M.Tech Dept. of Fashion Technology, School of Engg. & Science, BPSMV Khanpur Kalan, Haryana
[3]HOD, Dept. of Fashion Technology, School of Engg. & Science, BPSMV Khanpur Kalan, Haryana

ABSTRACT

A technical protective textile is a product of textile manufactured for non-aesthetic purposes. Fabrics have become a field for competition basically for scientists all over the world. The race is to develop the new fabrics that will not only keep warm but also dry, cool and moisturized, also odor and stains while measuring the heart rate or beat. Also technical protective textiles are divided into different categories depending on their end use. The main aim of the technical protective fabrics is to improve safety of people in their workplaces. A technical protective fabric may saves a worker's life, so most of them are used to manufacture PPE (Personal Protective Equipment). The demand of these fabrics is growing faster all around the world. There are some organizations from around the world (like ASTM and ISO) which basically describes the requirements and regulations to fulfill by a fabric and has to be considered as a technical protective fabric. The main aim of a technical protective fabric is not only fashion but they are also designed to have extra values in protection, against any or some hazards.

Keywords: Textile, fabrics, heat resistant, heat retards, technical cloth

INTRODUCTION

Protective textiles are a part of technical textiles that do not have only aesthetic and decorative properties but also having some technical performance. Protective textiles provide solutions for the technical challenges like environmental protection, personal safety, general safety, health etc. These textiles protect the wearer from harsh climate that may results in injury or death. These are basically developed for civilian and military occupations. Protective garments that provides protection from various hazards may be mechanical, environmental pressure, thermal, fire, chemical, biological, electrical and radiations.[1-2]

Fig.-1 Flame retardant [16]

Heat Resistant clothes:

The flame and heat resistance of textiles : Heat resistant is based on the flammability of such materials, i.e. flammable or non-flammable, and the ability of these materials is to reduce the heat transfer from a high temperature source, either by direct contact (conduction /convection) or via radiation. The flame and heat resistance of a textile product as required will depends on its end-uses in exceptional applications. The various terms which are used for the reaction of a fabric when it in direct contact with the heat or flame are as follows –

1. If insignificantly affected, then it is said to be flame-proof or fire-proof.
2. If it ignites due to flame but if it self-extinguishes after removal from the flame, then it is said to be fire resistant.
3. If it can melt and/or decompose at high temperature, then it is said to be incombustible or flame retardant.
4. In special case, it is thermally stable or not easily shrink or burn, when it is exposed to an intense heat or flame (i.e. heat resistant or heat proof).

High-performance fibres (HPFs) are the type of fibre that are considered as non-combustible or heat resistant. This is also said as inorganic fibres such as glass/ ceramic fibres or fibres spun from thermally resistant synthetic polymers such as Kevlar and Nomex that are made of aramid polymers. The above properties can be determined for a particular type of fibre using ISO or ASTM standard test methods –

- Ignition temperature :- It is the minimum temperature at which the fibre will burn -
  i) If in contact with a spark or a flame (forced ignition),
  ii) if there is no spark or flame (i.e. auto-ignition/ self-ignition/ spontaneous ignition).
- Melt Temperature/ Melting point :– It is the temperature at which the polymers that melt are likely to drip in the molten state and could originate burning of some other material.

  - Heat Release or Heat of Combustion: - Heat is generated during burning.
  - Limiting Oxygen Index (LOI) :- For combustion, the minimum amount of oxygen is required.[3]

Classification :-
Flame resistant fibres can be divided into two main groups :-

1) Inherently flame resistant fibres:
E.g. : Aramid fibres, Modacrylic fibres, Polybenzimidazoles fibres (PBI), Semi-carbon fibres and phenolic fibres.

2) Chemically modified fibres:
E.g. : Flame resistant cotton, wool and synthetic fibres.[4]

Uses of Heat Resistant Fabrics :-

Nomex is an inherently flame and high temperature fibers that will not burn and drip**.** It is best known as a obstacle to fire and heat and apart from racing car drivers but is worn by fire fighters, astronauts and military personnel. It is also widely used in more mundane ways, such as in household oven gloves. The heat proof Nomex (in sheet form) also used in automobiles, including high-temperature hoses and insulation for spark plugs.

But Nomex is not only useful for protective clothing but has the molecular structure that stops heat passing through as well as stops electricity flowing through it. Also it is an extremely poor conductor and almost a perfect insulator of heat. Nomex which is made into the form of a board or a paper sheet is a great insulating material for all kinds of electrical equipment.

Like Kevlar, Nomex is very strong and light so that it is often used in Nomex sheet and is widely used to make the honeycomb reinforcement inside helicopter blades and fins in airplane tail.

In Industry, it is also used in cutting flames, hot metals, welding, manufacturing, die casting. Also used in Petrochemical, steel, food and bakery.[5-6]

Kevlar is extremely strong, lightweight, corrosion and heat resistant. Kevlar, because of its high tensile strength-to-weight ratio, has many applications, ranging from bicycle tires and racing sails to body armor. Also it is 5 times stronger than steel.[7-8]

Fig.2- Heat resistant fabric [17]

Properties of fire resistant clothes:- The properties are as follows :-

- **Protection**: Protective performance ratings like NFPA 2112 or flash fire rating, ATPV or Arc Rating are based on the FR fabric.
- **Durability**: They do not have long term durability of flame resistance.
- **Shrinkage**: The fabric should not shrink when exposed to heat.
- **Cost**: The cost should be within reach as like as commercial product.
- **Comfort**: Comfort is an inherently subjective property.[9]

Table 1: – Chemical Properties of heat resistant fibres.[10]

Fibres	Tenacity (g/de)	Elongation (%)	Limiting Oxygen Index	Chemical resistance	Operating temperature
M-aramid (Nomex)	3.8-7.2	25-40	30	Mild-Good	400^0 F
Para-aramids (Kevlar)	22 - 26	2.4 – 4.4	25 – 28	Mild - Good	375^0 F
Fluorocarbon (Teflon)	2	25	95	Excellent	500^0 F
Polyphenylene Sulfide (PPS)	3.5 – 4.5	32 – 49	34	Very Good	500^0 F
Melamine (BASF)	2.0	18	32	Mild - Good	400^0 F
Zylon (Toyobo)	42	3.5	68	Mild-Good	$550\text{-}600^0$ F
PBI (Celanese)	2.7	29	41	Good - Excellent	482^0 F

*

Performance Specification :- The specifications for flame-resistant garments for industrial personnel which are as follows -

1. ASTM's F1506-98 – It stands for the standard performance specification for clothing worn by the electric workers that resists the fabric from the flame, which also means that it won't continue to burn after exposure to the source of ignition.

2. ASTM's F1891-98 – It stands for the standard for arc and flame-resistant rainwear applies for waterproofing the materials used in rain and also can be made from coated or laminated fabrics. The stated standard is now to test the fabric flammability to make it more suitable for coated fabrics.

3. NFPA's 2112-XX - It stands for the standard for flame-resistant garments to protect the industrial personnel against flash fire and is currently under development. It will be the first U.S. standard that addresses the need of flame-resistant uniforms for industries.

4. NFPA's 2113-XX – It stands for the standard that regarding the selection, care and maintenance of flame-resistant clothing and is also under development. It will serves as a user guide for industrial FR (Flame-Resistant) clothing. It addresses topics such as storage, purchasing, repairs, cleaning, decontamination and retiring garments. This standard will requires the garments that certified to NFPA 2112.[11]

METHODS OF FIRE / HEAT RETARDATION

Layer-by-layer PIN (Phosphorus Inorganic and Nitrogen) flame retardancy for cotton fibres –

Fig.3-Layer-by –layer PIN flame retardancy for cotton fibres

According to recent papers which shows innovative solutions for PIN (Phosphorus Inorganic and Nitrogen) fire safety treatment of cotton fibres by using layer-by-layer deposition of PIN flame retardant combinations including Phosphorylated Poly-Vinyl Alcohol (PVA), chitosan, PHMGM (Poly Hexa-Methylene Guanidine Phosphate) and Melamine Poly-Phosphate (MPP) and Ammonium Phosphate (APP). Chitosan is a natural nitrogen occurring widely and containing polysaccharide (e.g. occurring in shellfish and crab wastes). PVA is basically a water soluble polymer that easily biodegrades. These two chemicals i.e. Chitosan and PVC were deposited using a water-based process onto cotton fabrics. PHMGP and APP were deposited using an aqueous process onto cotton fibres in multi-layers, such as 1 minute dipping, 30 seconds rinsing and drying for each layer. 20 bi-layers significantly reduces the cotton flammability and also offered anti-microbial properties while 30 bi-layers significantly improves the fire performance The multilayer Chitosan and Melamine Poly-Phosphate on polyester-cotton fabric was achieved in a water-based process by applying the MPP (water-insoluble) on the fibre surface and then reacting the aqueous solution of Sodium Hexa meta phosphate and Melamine onto it.12

Metal oxide surfacing to reduce fire propagation -

Based on metal oxides, the EU project SESBE is developing an inorganic Transparent Conductive Oxide (TCO) coatings to reduce the risk of fire propagation. When the coated materials are exposed to thermal radiation (i.e. at 25 kW/m2), then only a thin layer of indium tin oxide or zinc oxide have been shown to delay ignition times of PMMA (Poly-Methyl Methyl Acrylate or Plexiglass). The thin inorganic layers are transparent to visible light but reflect long wave radiation or heat, whereas the standard paints absorb up to 90% of the heat radiation.[13]

Brominated flame retardants –

The Brominated Flame Retardant's (BFR's) are made from a list of man-made chemicals and are added to a huge variety of products to make them less flammable. They are commonly used in plastics, textiles and electrical equipment. There are five main types of BFRs which are as follows:

- Polybrominated Diphenyl Ethers (PBDE's) –textiles, electronic castings, circuitry, plastics.
- Hexa Bromo Cyclodo-Decanes (HBCDD's) – basically for thermal insulation in the industry.
- Tetra Bromo-Bisphenol A (TBBPA) and other phenols – thermoplastics (in TV's), printed circuit boards.
- Poly-Brominated Biphenyls (PBB's) –textiles, plastic foams.
- Other BFR's (Brominated Flame Retardants).[14]

Nano particles –

By adding nano-concentrates with Nanometer Layer Double Hydroxides (Nano-LDH's) and Nanometer Titanium Dioxide (Nano-TiO_2) to ammonium polyphosphate–pentaerythritol–melamine (APP–PER–MEL) coating resulting the Flame-retardant nano-coatings. The dispersion and the stability principle of nanoparticles have been analyzed by using Transmission Electron Microscopy (TEM) and Fourier Transform Infrared Spectroscopy (FT-IR). [15]

CONCLUSION

Many factors contribute to fabric selection in commercial upholstery applications like heat resistance, durability, dimensional stability, stain resistance, and fire retardance. In order to provide enhanced performance characteristics and textile applications of nanotechnology have focused on generating nanostructures and nano-sized chemicals. These characteristics include holdback performance to water, chemicals, electrical conductivity and reduction of static electricity; ultra-violet (UV) absorption and antimicrobial; self–decontamination and heat resistance. The performance fabrics representing a new specimen for the textile industry and also represents one of the fastest growing sector.

REFERENCES

[1] www.tpot.eu/docs/Workshops/STFi_01_Nau_TechTextiles_Intro.pdf Romy Naumann, An Introduction in technical textiles ,T-pot Workshop Technical Textile and Textile recycling 30 Nov-04 Dec 2009,Chemnitz(DE)
[2] www.slideshare.net/mahundhanmurugasen/protective-textiles M. Muhundhan & M. Kavitha, PSG College of Technology, Coimbatore
[3] www.tikp.co.uk/knowledge/material/-functionality/flame-and-heat-resistance/
[4] textilelearner.blogspot.in/2012/03/textiles-for-safety-flame-resistant.html Yugansh Sethi, A paper on Safety Textile, Mn-made Textile Technology Branch, D.K.T.E Society's Textile& Engineering Institute, Ichalkaranji, India
[5] www.dupont.com/products-and-services/fabrics-fibers-nonwovens/fibers/products/nomex-fibers.html
[6] www.explainthatstuff.com/nomex.html
[7] http://en.wikipedia.org/wiki/Kevlar
[8] www.technologystudent.com/joints/kevlar1.html
[9] ehstoday.com/emergency-mamagement/fabric-matters-flame-resistant-specification-considerations
[10] www.interxa.com/downloads/hightemp.pdf
[11] www.ishn.com/articles/83052-what-you-need-to-know-about-flame-resistant-clothing
[12] pinfa.org/index.php/media-events/pinfa-old-newsletters-archieve/299-newsletter-issue-n-56-10
[13] pinfa.org/index.php/media-events/pinfa-old-newsletters-archieve/299-newsletter-issue-n-56-11
[14] www.efsa.europa.eu/en/topics/topic/bfr
[15] www.sciencedirect.com/science/article/pii/S0257897205009230 Zhenyu Wang, Enhou Han, Wei Ke, Effect of nanoparticles on the improvement in fire-resistant and anti-ageing properties of Flame retardant clothing, Surface and Coatin Technology, Volume 200 Issues 20-21 22 May 2006,Pages-5706-5716
[16] http://news.softpedia.com/news/Toxic-Flame-Retardants-Found-in-the-Bodies-of-People-in-California-US-464853.shtml
[17] https://www.alibaba.com/product-detail/flame-retardant-for-cotton-nylon-T_755727432.html