



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 4, April 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

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A Study Investigation of Fire Retardant Cloth with Coating

Dr M Ravi, Dinesh Kumar B

Professor, Department of Mechatronics Engineering, K S Rangasamy College of Technology, Tiruchengode, India

P.G Scholar, Department of Mechatronics Engineering, K S Rangasamy College of Technology, Tiruchengode, India

ABSTRACT: This study and analysis focus on the effect that ceramic coating has on the qualities of fire retardant wearable fabrics used in the chemical industry and other industries that are connected. Ansys software is used to do research on a variety of ceramic powders, such as zirconia and alumina. In the beginning, the prototype model needs to be designed and imported into the Ansys software so that the thermal behavior of the coated sample can be investigated and compared to the behavior of the uncoated sample. The effect of ceramic on a variety of parameters, including Density, porosity, interlaminar shear strength, tensile strength, bond strength, bending modulus, transition temperature, and interlaminar shear strength, was investigated. In order to determine the optimum quantity of ceramic that should be present in the matrix, a method of decision-making that is systemic is utilized. According to the findings, the presence of ceramic powders may serve as a thermal barrier while also increasing the thermal resistance of the material. Therefore, the heat does not conduct to the human as quickly, and as a result, the level of safety may have risen.

I.INTRODUCTION

Because of its low thermal conductivity and high mechanical performance, rigid polyurethane foam (RPUF) is a great polymeric material for thermal insulation. However, it is also highly combustible, and the combustion process generates a great deal of heat and toxic fumes that can cause serious injury and extensive property damage. Polyurethane foam, or RPUF, is a type of rigid polyurethane. If RPUF is to find widespread use, flame retardant and smoke suppressant treatments are essential. [1] Na₃Zr₂Si₂PO₁₂ (NZSP) ceramic, a sodium superionic conductor, has the potential to address the safety and energy density issues that have plagued several sodium-based batteries. In particular, SEs can mitigate polysulfide shuttle effects in room temperature sodium-sulfur (RT Na/S) batteries. Producing the ceramic in a thin and flexible form is a major hurdle in the commercialization of NZSP. Here, we detail a technique for making a thin and bendable "polymer ink" (250 m thick). ceramic" type sodium ion conductor film from the previously brittle ceramic film, and show its use in RT Na/S batteries. [2] The Montreal Protocols of 1987 phased out the manufacturing and use of ozone-depleting substances (Halons). Many studies have now been conducted all around the world on condensed aerosol-based fire extinguishing technology as a replacement for Halons. When compared to other alternatives including water mist, dry powders, inert gases, hydrofluorocarbons, and carbon dioxide, it has emerged as the most effective halon replacement technology. On a weight-to-volume ratio, it is three times more effective than Halon 1301. It offers several benefits over Halon alternatives, including no ozone depletion potential, no atmospheric lifetime, no global warming potential, low space requirements, easy & cost-effective installation & maintenance, no need for pipe & pressurised cylinders, no oxygen depression, etc. Around the globe, power plants, transportation hubs, warehouses, public buildings, and even some of the most industrial of sectors have found uses for condensed aerosol fire extinguishing systems (CAFES). Energy storage, military use, etc. Class A fires in libraries, archives, storage rooms, etc. are the primary focus of this overview, while class B fires in machinery spaces, gas turbine enclosures, combat vehicles, chemical storage rooms, and electrical fires in control rooms, UPS rooms, electrical/power substations & panels are also discussed. Its testing and implementation procedures, as well as examples from a variety of reports and case studies, have also been discussed. The possibility for further study and uses of aerosol technology are also highlighted. [3] Protection gear made specifically for firefighting is crucial since it helps keep firefighters safe from burns while they're on the job. However, when firefighters are exposed to temperatures that are exceptionally high in the course of battling fires, it is still impossible to identify the amount of damage to protective clothing at an early stage. In order to achieve ultrasensitive temperature monitoring and energy harvesting in firefighting clothing, a conductive aerogel fibre made of calcium alginate (CA), Fe₃O₄ nanoparticles (Fe₃O₄ NPs), and silver nanowires was used to create an ultralight self-powered fire alarm electronic textile (SFA e-textile) (Ag NWs). As a result, the SFA e-textile was developed and integrated with firefighter protective apparel to achieve wide-range temperature sensing at 100-400 °C and reliable fire warning capacity. This allowed the firefighter's protective

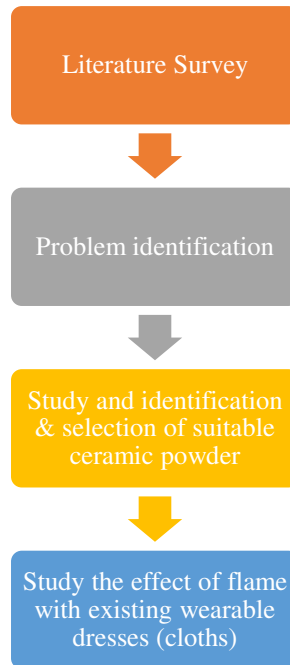
equipment to send an alert signal to the wearer before the clothing completely failed in high-heat situations. Further development of the SFA e-textile led to the creation of a self-powered fire self-rescue locating system. The use of this method could facilitate the search for and rescue of firefighters who have become trapped in blazes. The self-powered fire finding device was powered by a triboelectric nanogenerator based on an SFA e-textile (TENG). This work contributed to the presentation of a useful design strategy for the creation of a lightweight wearable SFA e-textile for temperature monitoring, which can be used as part of firefighter protection gear. [4] Clothing designed for use in a fire is a crucial piece of gear that can protect firefighters from burns and other ailments caused by exposure to heat. High-fire-safety firefighting gear with an early fire alarm reaction to prevent protective clothes malfunctioning in extreme fire situations is still a work in progress. Here, using a wet spinning process, we created a wearable self-powered early fire warning e-textile (MAA e-textile) enabled by Ti₃C₂T_x MXene/silver nanowires (Ag NWs)/aramid nanofibers (ANFs) aerogel fibre. Since there is a linear relationship between thermoelectric voltage and temperature thanks to the thermoelectric characteristic of MXene, the resulting self-powered fire warning MAA e-textile can be integrated into firefighting clothing to achieve wide-range temperature sensing at 100-400 °C, allowing firefighters to evacuate in a timely manner before their protective clothing is damaged. Because to the interconnectivity between the Ag NWs and MXene nanosheets, an e-textile containing 30 wt% MAA can emit a fire warning signal every 1.6 seconds when burned. Meanwhile, the synergistic carbonization of MXene and ANFs led to outstanding flame retardancy in a 30 wt% MAA e-textile, with an 80% reduction in peak heat release compared to ANFs aerogel fibre. To further aid in the rescue of trapped firefighters, a self-powered rescue location system is created using an MAA e-textile-based triboelectric nanogenerator. This work presented a simple method for creating and implementing self-powered early fire warning e-textile in firefighting clothing, which may be used to protect firefighters while they are on the job. [5] There have been many recent breakthroughs in the design and performance optimisation of smart mechanisms related to both natural and man-made risks. The development of sophisticated sensing systems, as well as related communication and data technologies, is largely responsible for this. In-depth, current advancements in smart danger monitoring equipment and materials applied to textile sensing systems are surveyed here. This research focuses on firefighter protection apparel since fire is one of the most common natural disasters worldwide, including in Australia, and because so many firemen are injured or killed in the line of duty each year. More efficient methods of training and improved safety protocols for fire fighters may be gleaned from this review's examination of smart sensing systems in coating technologies. The purpose of this article is to review the progress made in the field of smart coating and fire-resistant clothing, as well as to discuss the most current difficulties encountered and promising avenues for advancement. The purpose of this analysis is to shed light on the topic of smart coating in firefighter gear. Clothes fabricated with phase change and shape memory substances are an appealing option for modifying certain characteristics of industrial textiles because of their ability to manage thermal stresses, respond to humid environments, monitor certain critical parameters, and adapt to the size of the wearers. The definitions of phase change materials and shape memory materials, as well as their incorporation into fabric structures, are described. This paper also offers a comprehensive analysis of fire fighters' exposure to heat and an evaluation of the capabilities of shape memory materials (SMM) and phase change materials (PCM) to stall the spread of heat through protective gear. Previous studies have revealed that consuming these substances can cause a number of problems. For instance, there is a significant amount of room for development in terms of evaluation strategies and testing criteria for the combination of phase change and shape memory materials. Modifying mechanical properties, functionality, and durability under diverse situations are just some of the recent advancements in the field of PCM and SMM that have been informed by these developments. It has been hypothesised that the most difficult aspect of creating fabric-based Phase Change Material (PCM) and Shape Memory Material (SMM) systems is figuring out how to put them to use. Finally, cutting-edge innovations in wearable monitoring devices have found their way into firefighting gear. Firefighters' safety data is typically monitored by sensors worn on the body or attached to other devices. [6] Here, we detail the production of a very effective flame retardant consisting of a phosphorus-grafted chitosan-functionalized graphene oxide (GO) based nanocomposite (PCG) (FR). Whereas the chitosan coated cloth (CC) and graphene oxide coated cloth (GC) samples totally burned within 20 seconds of being exposed to flame, the PCG-coated cloth (PCGC) sample maintained its original size and form and burned to generate just a negligible quantity of smoke for 23 minutes. A 5-second flame would completely consume an untreated cotton cloth, leaving only a tiny bit of black ash behind. Other flame criteria, such as the limiting oxygen index test (LOI), the vertical flammability test (VFT), and stability at elevated temperatures (e.g., 1500 °C), were used to evaluate the PCG-coated cloth sample's (PCGC) flame-retardant (FR) efficacy. Results from a vertical flammability test (VFT) showed that the PCGC was safe to use, with a residual char length of 1 cm and a limiting oxygen index value of 51.2%, compared to 17.6% for uncoated cloth. Tensile strength for the PCGC went up to 42.15 MPa from 27.52 MPa, and elongation at break went up from 25.7% to 45.4%. The PCGC maintained its flame resistance even after being washed five times. The flame retardancy of the synthesised nanocomposite was tested on

both cotton cloth and wood, with encouraging results. With its potential use as a flame-retardant material for fire prevention, this work describes the first attempt to create a phosphorus-modified GO chitosan nanocomposite (PCG) via a straightforward, low-cost synthetic method in comparison to the prior work. [7] Using components that are not susceptible to combustion at high temperatures eliminates a major safety concern in energy storage systems. Unfortunately, the high-temperature breakdown still destroys these devices, making them unreliable. Here, we show that a supercapacitor containing a "solute-in-air" electrolyte may recover from fire damage. CaCl₂ in air ("CaCl₂-in-air") is a self-healing electrolyte that loses its water solvent at high temperatures but spontaneously absorbs water from the air to recover on its own at low temperatures; this is accomplished by using fire-tolerant electrodes and a separator in a semiopen device configuration. Around 500 degrees Celsius, the supercapacitor shuts down, yet it recharges when exposed to air. Not only that, but it actually gets better after being burned at 647 degrees Fahrenheit. Inspiring a potentially fruitful approach to dealing with general fire-related dangers, the work provides a self-healing strategy to develop high-safety, high-reliability, and fire-tolerant supercapacitors. [8] Residents in nursing homes sometimes have decreased abilities, reducing their ability to respond appropriately to emergency situations requiring evacuation. Accidental fires, in particular, can endanger both people and property. In this research, we developed a water film cooling system to increase the fire retardant curtain's resilience to heat and smoke. The smoke control performance of the suggested curtain was able to meet the ISO 5925-1 criterion, and experimental findings on a full-scale door/wall refractory furnace and smoke-barrier system confirmed its heat resistant properties at 1.5 h. Lastly, we simulated a nursing home using Fire Dynamics Simulator (FDS) 6.0 with this fireproof curtain configuration for a horizontal evacuation waiting area. Our findings demonstrate that the smoke dispersion can be efficiently stifled in the early stages of a fire using our suggested water film cooling technology, providing a secure waiting area for those who are less fortunate to escape. [9] Nylon/cotton blends are especially dangerous because of their high flammability. In this study, a bio-based boron-contained flame retardant (PBN) was developed and applied to nylon/cotton blend fabrics with the help of phytic acids by a simple dipping and nipping procedure. Reduced phosphorus concentration in the presence of PBN greatly enhanced the fabric's flame retardancy. In the cone calorimeter test, the LOI of the PBN-treated blend fabric was 30.1%, and the pHRR and TSP were reduced by 46.0% and 71.8%, respectively, as compared to the control blend fabric. According to an examination of the char residue, the polyphosphoric acids in the flame retardant sped up the production of the char while the ceramic boron structure remained in the char to maintain the char layer's stability. Furthermore, it was hypothesised that the combustion volatiles in the gas phase were diluted due to the production of inert gases including NH₃ and H₂O. This study suggests a route towards manufacturing flame-resistant nylon/cotton blends made from bio-based materials. [10] Hydrogels made from polyvinyl alcohol (PVA), xanthan gum (XG), and lignin nanoparticles were used to create a green fire retardant, which was reported here (LNP, synthesised using nanoprecipitation). Crosslinking with borax and NaOH created the hydrogel network. The chemical state of lignin was not altered after the creation of nanoparticles, as shown by XPS analysis of LNPs. Hydrogels were defined in detail. Thermogravimetric, FTIR, and FE-SEM analysis. Hydrogels' rheological characteristics were evaluated. Hydrogel PX3B0.4N2L20 has an excellent balance of characteristics, including a mesh size of 5.60 nm, a crosslinking density of 870,350.12 kmol m³, and an elastic modulus (G') of 23,428.57 Pa (showing a strong elastic network). The fire resistance of PX3B0.4N2L20 hydrogel was improved by its high char formation (34.61 wt%). The limiting oxygen index (LOI) of cotton fabric increased from 20% to 39% after being coated with PX3B0.4N2L20 hydrogel. Hydrogel's activation energy of 493.8 kJ mol⁻¹ from kinetic analysis of TGA data is consistent with the results of the LOI test. PX3B0.4N2L20 hydrogel had the lowest peak heat release rate (90.3 10 kW/m²) and lowest overall heat release rate (1.56 4 MJ/m²) in cone calorimeter tests. In conclusion, the PVA-based hydrogels synthesised in this study show great promise as eco-friendly and effective fire barriers.

Aim & Objectives

- To study the importance of flame and fire retardant
- To investigate the, problem faced by working peoples with existing wearable dresses
- To study and identification of suitable ceramic powder's for wearable clothes

II. METHODOLOGY



1.2 Fire retardant

As a consequence of more rigorous rules on fire safety and a greater awareness among the general public, fire-resistant textiles are becoming increasingly widespread. This is one of the many benefits that the general population is experiencing. Demand for materials with fire-retardant capabilities that are created from jute and other natural fibres is increasing as there is a rising concern about the environment in the market, which is pushing up the demand for these materials. Other than clothing for children, important applications for fire protective technical textiles materials include drapery, upholstery, vehicle upholstery, floor coverings, tents, kitchen aprons, and gloves are just a few of the many uses for ornamental fabrics. Other examples include jute brattice cloth in mines and pandal fabrics in temporary structures, and other similar items, all of which should preferably be fire retardant. Jute is also used to make brattice cloth for use in mines, pandal textiles for use in temporary structures, and house upholstery, among other essential purposes. A material that is used to slow down or halt the spread of fire, or to lessen the intensity of the flames, is referred to as a fire retardant. There are many different types of fire retardants available. A common strategy for accomplishing this objective is to make use of chemical processes that either reduce the flammability of fuels or slow down the combustion process. It is possible for fire retardants to put out a fire in one of two distinct ways: either by physical action or through endothermic chemical reactions. There are many various kinds of fire retardants, such as a powder that, when mixed with water, produces a foam that may be used to put out fires, as well as gels and other types of fire retardant. In addition, there are fire retardants that may be applied to an object in the form of a coating or a spray. These fire retardants are available in a variety of forms.

3.3 Surface coating

It's possible for things to have fire retardant coatings applied to them. For instance, flame retardants are sprayed on Christmas trees; yet, once a tree dries out, it becomes very flammable and poses a risk of starting a fire. In order to protect structural elements from becoming compromised in the case of a fire, steel buildings often have a fire-retardant coating applied around their columns and beams. The use of these items is also being considered for dorms in the United States. According to the online journal Campus Firewatch, there have been 109 deaths across the country as a result of fires that broke out in student dormitories or off-campus housing since the year 2000. Ed Comeau, the publisher of Campus Firewatch, mentioned that a fire that occurred at Seton Hall University in New Jersey in January of 2000 brought attention to the dangers of fire on campus. Two students in a residence hall at Seton Hall started a fire

in the common area of the dorm by lighting a flag that was hanging from a bulletin board. The fire swiftly spread to the furniture, and as a result, three students were killed and 58 others were injured.

III. CERAMIC POWDER'S

Advantages

- Protection from oxidation at high temperatures for carbon- and metal-based components
- As low as 10% of the coating's melting point can be used for deposition.
- No porosity (fully dense)
- Carbides, oxides, nitrides, and borides of several metals are readily available.
- High emissivity
- Thermal protection
- Applicability to intricate shapes and textured surfaces

Studies on technological advancement and the reduction of expenses associated with internal combustion engines continue. Efforts to increase engine efficiency through structural changes have expanded in recent years. One example is the rapid expansion in the use of ceramic coatings in internal combustion engines, which has occurred in tandem with the advancement of advanced technology ceramics. Maximum conversion of fuel energy to mechanical energy is essential for optimal engine performance. Internal combustion engine cylinders see an increase in temperature and pressure after being coated with low heat transmitting ceramic materials. As a result, we should see improved fuel economy from our engines.

The goal of applying ceramic coatings to the combustion chambers of diesel engines is to lower the amount of heat transferred from the cylinders to the cooling system. The elimination of engine cooling systems in internal combustion engines is a goal of research into high technology ceramics. Removing cooling system components is likely to boost engine power while decreasing engine weight and expense (coolant pump, ventilator, water jackets and radiators etc.)

Increased temperature following compression due to minimal heat rejection might facilitate simpler engine initiation, such as a shorter ignition delay, in ceramic coated diesel engines. As a result of reduced detonation and noise from uncontrolled combustion, quieter engine operation is possible. Lower compression ratios are possible because the engine's ignition delay is reduced. As a result, mechanical efficiency and fuel economy are both enhanced. Exhaust emissions are another major consideration for internal combustion engines. With ceramic-coated internal combustion engines, an increase in combustion chamber temperature reduces emissions of soot and carbon monoxide, and when the higher temperatures of the exhaust gases are also taken into account, turbocharging and the engine's overall thermal efficiency are improved.

3.1 Advanced technology ceramics

Ceramics have been utilised in low heat rejection engines practically since their inception. These components are lighter and have a lower heat conduction coefficient than their counterparts in traditional engines. The production and quality of ceramics have made great strides in recent years. The latter quarter of the 20th century also saw the development of new materials known as "advanced technology ceramics."

Advantages of advanced technology ceramics can be listed as below Resistant to high temperatures

- High chemical stability
- High hardness values
- Low densities
- Can be found as raw material form in environment
- Resistant to wear
- Low heat conduction coefficient
- High compression strength

Pure oxides like alumina (Al_2O_3), zirconia (ZrO_2), magnesium (MgO), berillya (BeO), and others are the building blocks of high-tech ceramics. Ceramic coatings used to lessen heat transmission can be broken down into two categories. Coatings with a thickness of up to 0.6 mm are considered thin, while those of up to 5.6 mm are considered

thick. In Otto and diesel engines, thin ceramic coatings are utilised in gas turbines, on piston tops, cylinder heads and on valves. In the early days of applying ceramic coatings on low heat rejection engines, the coatings were thick and monolithic. The inadequacy of these coatings for diesel engine running conditions was later realised. As a result, work began on a fresh strategy. Ceramic and other material coatings come in a wide variety of kinds and systems. Among the most crucial are;

Thermal spray coating: Plasma spray, wire flame spray and powder flame spray,

- electrical arc spray, detonation gun technique and high speed oxy fuel system
- Chemical ceramic coating: Sole-gel, slurry, chemical vapour sedimentation, physical vapour sedimentation, hard coating
- Laser coating
- Arc spark alloying
- Ion enrichment method

IV. CONCLUSION

Flame retardants pose a risk to human health as well as to the natural environment. It is able to store, bioaccumulate, and biomagnify in living organisms, including humans, animals, and the environment. Ingestion, inhalation, dermal contact, and direct entry into the systemic circulation are the primary routes of FR entry into the human body. Because FRAs have the potential to be released into the environment throughout the production process, the environment is more vulnerable to the pollution caused by FRs. The usage of FRs by manufacturers should be kept to a minimum if they want to prevent significant quantities of these compounds from entering the environment as well as human bodies. Therefore, all currently available wearable clothing should be coated with a high-level thermal barrier coating material such as alumina or zirconia. In addition, the literature review that was conducted revealed that ceramic powder may be able to endure more heat due to its low thermal conductivity and high thermal barrier properties. Consequently, the ceramic powders are used for applications requiring flame retardancy, such as power plants and other sectors that produce combustible chemicals.

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Impact Factor: 8.423



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