EVALUATING THE EFFECTIVENESS OF NANOTECHNOLOGY-BASED NON-WOVEN FABRICS ON CORONA PANDEMIC

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ABSTRACT

Following the global spread of the COVID-19 virus, governments have desperately resorted to various methods such as social distancing, quarantine, telecommuting, cancellation of large gatherings, stay-at-home orders, and the mandatory use of masks. Despite the successful outcomes of these policies in controlling the number of patients, social distancing and quarantine policies have damaged the economy and people's lifestyles greatly. Therefore, countries now attempt to reduce social restrictions and recommend using masks to people. Masks in public places can reduce the risk of disease through inhaling infectious droplets. In other words, masks act as a barrier and significantly reduce the possibility of viral droplets entering our respiratory system. This library study aims to evaluate the performance of nonwoven fabrics used in respiratory masks and the effect of nanotechnology in increasing their quality to better control the coronavirus.

Keywords: Nanotechnology, Coronavirus, Mask, Textiles

INTRODUCTION

Nonwoven fabrics are the product of bonding different fibres and creating a substrate or textile. In this industry, there is no warp and woof and therefore, the application areas of nonwoven fabrics can be divided into several sections, although the use of textiles is not limited to these areas. Health, wipes, clothing, medical, health care, personal care, automobile, electronics, filters production, agriculture, horticulture, furniture, construction, and packaging are among the applications of these fabrics. It is worth noting that using different technologies allows producing a single product for each field of application [1].

Generally, many nonwoven fabrics are produced for industrial applications. For example, geotextiles are utilized for road reinforcement, soil and soil stability, roofing and insulation, dust and wet wipes, household items, and filters. These fabrics are also found in clothing and other wearable cases (both disposable and durable products).

Further, nonwoven fabrics can be used in other disposable items such as wipes, feminine hygiene products, urinary incontinence pads, scrubs and surgical masks, and medical examinations. Surgical masks and other health masks are often made from non-woven melt-blown fabrics, due to their good filtration properties resulted from their very thin fibres. In this regard, the lack of biodegradability of disposable non-woven products is one of the disadvantages of these materials, resulting in accumulating in landfills. Despite the recyclability of some of these products, the recycling of many of these products creates significant problems, as expected [2, 3]. In addition, the recycling of disposable non-woven products is usually not economical, due to their limited volume.

The primary and current use of nonwovens in clothing is as interlining and intermediate fabrics. The middle fabrics are placed inside the garment to tighten areas such as collars, cuffs, coat collars, trouser straps, and parts containing buttons and buttonholes. Non-woven fabrics contribute to the stability of these areas, due to their resistance to tearing and stretching. In many cases, non-woven middle fabrics are on surfaces containing heat-activated adhesives and are thermally attached to the outer fabric through this method. Non-adhesives non-woven fabrics can provide an insulating state for clothing. Non-stretch nonwoven fabrics are produced for use in underwear and some sportswear. The nonwoven industry produces and converts versatile, engineered fibres for a variety of applications, and is constantly creating innovative products for new fields. Classifying these fabrics based on the technologies used in the process can be somewhat challenging, as multiple combinations of raw materials, network structures, network bonds, and post-processing methods lead to the production of non-woven products for use in a wide range of applications. These degrees of freedom are the key to provide non-woven fabrics with unique features tailored to numerous functional areas [4, 5].

Researchers use nanotechnology to improve or add unique features to common masks. Nanofiber-based face masks are environmentally friendly, biodegradable, and reusable materials, making them more attractive in the current 19-COVID pandemic. Clearly, the main purpose of using a mask is to prevent contaminants from entering the respiratory system. Meanwhile, the use of nanofibers in the mask layers causes the filtration of more contaminant particles. The finer fibres constituting the mask layers allow the mask layer to act as a filter with a finer mesh and will not allow smaller particles to pass [6, 7]. A simple example can be used to clarify the issue. The mask layer mesh composed of spun-bond fabric is similar to the apple filter mesh while the mask layer meshes composed of melt-blown fabric and nanofibers are similar to the rice filter mesh and salt filter mesh, respectively. It is obvious that in a volume of fluid containing pollutant particles of different dimensions, a mask made of nanofibers will prevent the passage of smaller particles. This library research seeks to evaluate non-woven fabrics produced with nanotechnology in the field of health masks to combat coronavirus, aiming to determine which face masks are suitable for controlling the virus and how masks can protect us against coronavirus.

Evaluating the function of different types of face masks and respirators

So far, previous research has emphasized the importance of thermal and ultraviolet heat treatment in disinfected masks. Despite some promising results, these methods need some devices such as UVGA and Avon, which may be available in hospitals or other places while ordinary people do not have access to them or cannot use these devices. Thus, researchers use nanotechnology to improve or add unique features to conventional masks. Zhang et al. [8] proposed an idea that self-cleaning face masks could be produced using the photo thermal mechanism and consequently, created a production line based on laser-induced forward transfer method in dual mode.

In this method, a thin layer of graphene nanoparticles is covered on the surface of the masks. The masks obtained from this method show significantly high hydrophobia that can protect the user against droplets. Furthermore, the surface temperature of the face masks under sunlight can increase rapidly up to 80 ℃. This feature allows reusing the masks after simple sterilization due to sunlight. The use of graphene in the design of COVID protective masks has been reported not only in scientific articles, but companies are also interested in using this valuable nanomaterial in designing their own mask.

Surgical masks and respirators are made from non-woven microscopic fibres and pollutants greater than the fibre pore size cannot pass, or in some cases, pollutants are absorbed into fibres due to electrostatic load. Therefore, by reducing the average diameter of the fibre, it can be concluded that increasing specific surface decreases the size of the pore. This phenomenon increases the filtration effectiveness of non-woven fibres. Currently, researchers patent nanofiber-based masks with superior properties.

Recently, Olah et al. [9] examined the ability to reuse nanofiber masks. Nanofiber and surgical masks were disinfected by spraying or immersion in 75% ethanol solution and then, allowed to be dried at ambient temperature. The results indicated a significant reduction in filtration efficiency of surgical masks, although this factor was stable for nanofiber masks. The other environmental aspect of nanofiber masks is their higher biodegradability due to the specific level. Therefore, masks produced from nanofibers can be degraded faster and generate fewer environmental issues. Liang et al. [10] designed the current nanofiber system for filtering 19-Covid particles transferred in the air and believed that a four-way nanofiber filter could filter 90% of the 19-Covid particles with dimensions of 100 nm. On the other hand, Tan et al. (11] used the solution blow spinning (SBS) method to prepare composite multi-layer filter masks. They prepared three different types of cellulose diacetate (CDA) (polyacrylonitrile) PAN, and PVDF nanofibers. The results indicated that the presence of different molecules in electrical nanofibers has a significant effect on filtration performance so that PAN nanofibers have the best filtration performance with good quality factor and air permeability (0.05pa-1) while the quality of PVDF air filtering (with the quality factor of 0.02Pa-1) was lowest among the studied nanofibers. In recent research, Lee et al. [12] produced high-performance membrane filters from poly Benz imidazole-amide (PBAs) nanofibers, which can be used for anti-dust masks or other air filters. They showed that the PBI filter nanofiber membrane reached a high filtration efficiency up to approximately 98.5% compared to the commercial face mask with the lowest pressure drop (Pa 130).

Researchers at the University of John Hopkins proposed special respirators, as well as surgical and fabric masks for creating various levels of protection against 19-Covid. In this way, N95, FFP2, and FFP3 are three specialized recommended respirators with the highest level of protection. According to CCD and FDA recommendations, the public should not use respirators. The Piece Face Filtering (FFP) score is taken from the European EN149: 2001 standard while the N sign is obtained from the American Standard National Institute for Occupational Safety and Health, as part of the CDC. These respirators can fully stick to the full face and absorb at least EFP2, EFP3, and N95 particles larger than 0.3 micrometres by 94, 99, and 95%, respectively. Waterproof surgical masks protect at the next level. These 3-layer masks are made of two layers of nonwoven fabrics and a middle layer of melt-blown material, which absorbs particles in the air. Homemade cloth fabric has the lowest level of protection and removes only 60% of particles, although they are cheaper and available. These masks are recommended to be daily used by all people in busy and crowded public places. The effect of masks in reducing corona infection rate is proven. Therefore, most people voluntarily use this personal protection equipment. A surgical mask is the most common type of face coverage used by the public. Researchers have suggested different solutions for reducing the demand for surgical masks to decrease pressure on mask manufacturing companies and control plastic waste. These solutions include heat treatment, masks disinfection, and the production of reusable cotton masks and nanofiber-based masks.

Researchers [13] provided methods for increasing the frequency of using surgical masks and believed that surgical masks and n95 respirators could be reused by applying the heat treatment or spraying disinfectant solution. The proposed heat treatment methods are listed below:

Exposed at 80°C for 24 hours

Exposed at 95 °C for 24 hours, and spraying a thin layer of the following disinfectant solutions to the surface of the masks can eliminate possible viruses.

Commercial Lysol Spray + Ethanol 58 +% Alkyl (50% C14, 40% C14, 10% C16), Dimethyl Benzyl-Ammonium Saccharin ate

70 ml isopropanol + 30 ml of deionized water + adding 3% wt. Tea tree oil

In a recent study, [14] examined the effect of steam on the removal of the virus and the efficiency of medical masks and N95 respirators. The results indicated that steaming for 120 minutes can effectively disinfect masks without reducing their efficiency. Therefore, these researchers offered steaming masks by a conventional steam machine for 20 to 120 minutes. Ultraviolet germicidal irradiation (UVGI) is another method for prolonging the use of face masks. Some Researchers reported that UVGI rays could properly disinfect the flu-infected N95 respirators for about 1 minute without reducing the filter efficiency. Further, Hamzavi et al. [15] (from the Ford Hospital) created a UVGI setup that can be used for 19-Covid disinfection. The radiant dose required for disinfection is 1 J/CM^2, which can be delivered at 40 to 60 seconds with radiation of 10 Mw/cm^2. Although these methods were somewhat successful, their performance has not been proven by international organizations such as WHO and FDA.

The micron fibres are originally produced by the electrical device. This method has been further used to produce flat nonwoven fabric and luminous membranes suitable for technical applications. Biopolymers are extracted from natural matter, including Crustacean shells, fungi, or forests. Note that intrinsic property is the main reason for using biopolymers in this review. Biopolymers are renewable resources, although they show inherently antibacterial activity, biodegradation, and biocompatibility. Therefore, these materials are ideal for use in a wide range of industries such as ophthalmology, medicine, agriculture, textiles, paper coverage, and automotive. The electrospinning non-woven made of biopolymers can provide certain applications, including air filters and protective clothing, and present an alternative to pesticides and nanocomposites.

Polyvinyl alcohol (PVA) materials are hydrophilic, non-toxic, biocompatible, biodegradable, and process able polymers with the capability of film production and suitable mechanical properties. Concerning the biodegradable polymers, polyvinyl alcohol is of great importance because of the abundant OH groups and the ability to connect the drug. In addition, these materials are uneven and non-toxic in the blood and lack harmful effects such as blood clotting, immune stimulation, inflammation, and neutrophils activation.

Non-woven membranes produced from nanofibers have very small cavities but high porosity, and thus, the filtration output is high and can be applied in the production of chemical, industrial, and hygienic masks, as well as air filters. On the other hand, recent research has shown that Nano-filter filtration yield can be increased by charged fibres with the electrostatic absorption properties of particles. In addition to the physical obstruction of air aerosol, nanofibers can be designed to absorb particles through the electrical absorption mechanism. Polyvinylidene fluoride is a non-reactive thermoplastic fluoropolymer with a significant piezoelectric property. Researchers have used this polymer for ultrafiltration, microfiltration, and membrane distillation, due to its hydrophobic, high thermal and chemical resistance, and excellent mechanical properties. Akdman [16] made cellulose acetate (CA)/polyvinylidene fluoride (PVDF) nanofibers as a potential candidate for the N95 mask filter. The results revealed that non-woven fabrics could meet all the standards of the National Institute for Occupational Safety and Health and block particles larger than 300 nm by more than 95%.

Almeida et al. [17] made biodegradable cellulose acetate (CA) / cetylpyridinium bromide (CPB) nanofibers. The results of their research show that nanofibers can block particles smaller than 300 nm with high efficiency compared to commercial face masks.

Environmental and economic aspects of nanotechnology

The unique properties of nanomaterials have been highly considered by scientists and research activists, as well as businesses and occupations, due to their great economic potential. The National Science Foundation reports that the value of Nano-related services and goods in the market increased to $1 trillion in 2015, which is larger than that of hybrid businesses such as telecommunications and the information technology industry. Nanotechnology is projected to generate several hundred billion euros over the next decade. Nanomaterial markets will expand to $4 billion in 2017. Moreover, it is estimated that 2 million new jobs will be created to meet the annual production demand of $1 billion over the next 10-15 years. Nanotechnology is also good for the environment and nanotechnology saves raw materials and improves the quality of life by using fewer resources without destructive performance [18,19].

CONCLUSION

With the spread of coronavirus in the world, a lot of contradictory information has been shared on social networks, most of which has been relying on how we can protect ourselves against COVID-19. Considering the challenging action of obtaining reliable information, this library study sought to investigate the importance of masking masks in reducing the spread of the current 19-COVID virus. Facial masks and respirators can reduce the infection rate by controlling the source in infected patients, as well as blocking and preventing infected drops from entering into healthy people's bodies. Given that most air pollutant particles have a diameter between 200 and 500 nm, the masks produced by conventional methods, which contain only spun-bond layer and melt-blown, fail to filter particles with these dimensions, as the diameter and the size of the filter layer mesh formed by them is larger than that of the pollutant particles. Nanotechnology allows producing reusable masks with superior properties. This review is an effective aid for mask manufacturers and the textile industry to produce reliable masks for protecting people against coronavirus.

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