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Analytical Approach To Devise The Role Of Nanotechnology In Enhancing The Effectiveness Of Face Masks

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Abstract. *The outbreak of COVID-19 has altered lives completely all over the globe. The governments have undertaken all the necessary measures to ensure social distancing and ensuring that face masks are worn at all times. In this regard it is quite pertinent to ensure that the face-masks on sale for the public at large should be meticulously examined in terms of its impact on the wearer's lungs, skin and the ecology. The objective of this paper is to provide an overview on the role of nanotechnology in enhancing the effectiveness of face-masks and on the possible repercussions of improper use of nanotechnology in textile production.*

Keywords. *Nanotechnology, COVID-19, Social Distancing, Face-Masks, Textiles.*

INTRODUCTION

On account of the global spread and subsequent impact of the COVID-19 pandemic, wearing of face-masks is consider[1]ed as a significant preventive measure (Eikenberry et al., 2020). As concerns, the filtering capacity of face-masks it can be segregated into three distinct categories (Otto & De, 2020). a) "Single-Use" face masks b) "Respirator" face masks and c) "Surgical" face-masks. Made out of a single thin layer of cloth, single-use masks have lower filtering capacity for small particles and droplets. Popularly known as N-95 masks, respirator masks comprise multiple layers and are high on the filtering aspect. Considered to be the most commonly used forms of facial protection, surgical face-masks which are made of non-woven fabric can also be further classified into various levels based on their filtering efficacy (Cheng, et al. 2020).

The recent developments in textile and clothing technology are aptly represented and embodied in nano engineered functional textiles (Zhao et al 2020). To ensure comfort and improved functionality, nanomaterials are implanted into textiles. As opposed to larger-sized materials, nanomaterials have diverse biological and chemical properties which change according to the particle mass (Gandhi, et al. 2020). This facilitates limited contact with bacteria and viruses. Due to the "mask-wearing" protocols the nanoresearch community has contributed immensely and continuing to further its applications. In their quest for novel solutions and responses to the pandemic, textile manufacturers are increasingly engaging with nanotechnology based solutions (Huang et al, 2020). Specific importance is being placed on the role of nanomaterials and nanofibers in the context of facial protection. In the subsequent sections, we provide an overview of the primary research findings centered on application of nanotechnology in facial protection (Palestino et al. 2020).

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Table 1: “Formulated Disinfectants for Antimicrobial Activity of Surgical Mask Fibers”

	Formulation			
	a	**b**	**c**	**d**
“Benzalconium Chloride”	**0%**	**0.05%**	**0.1%**	**0.2%**
“Ethanol-water 45% V/V”	**85%**	**85%**	**85%**	**85%**
“Triclosan”	**0.03%**	**0.03%**	**0.03%**	**0.03%**
“Silver Nanoparticles”	**10%**	**10%**	**10%**	**10%**
“Lauryl Alcohol Ethoxylate”	**0.3%**	**0.3%**	**0.3%**	**0.3%**
“Triton X-100”	**0.2%**	**0.2%**	**0.2%**	**0.2%**
“Citric acid”	**2%**	**2%**	**2%**	**2%**
“Microdacyn 60”	**To complete 100%**			

Source: Huang et al, 2020

The formulation and results of numerous compounds evaluated for increasing AgNPs incorporation and promoting antibacterial activity into surgical masks are presented in Table 1 illustrated above.

Behaviour and Interventions in Use of Facial Protection Based on Nanomaterials

A detailed overview of the process, guidelines, interventions and sensitization is provided in the figure 1 provided below. As seen in the illustration, we have included the three critical stakeholders i.e. suppliers, consumers and the government (Li et al., 2020). The schematic flowchart provides the flow of activities as adopted by the suppliers and government agencies in the awareness, usage and disposal of nanomaterial based facial protection (Tcharkhtchi et al. 2020). As far as the government is concerned the regulatory issues range from establishing nanosafety guidelines and applications for citizens, improving waste management facilities with nanoparticle removal strategies, encouraging nanowaste recycling system by creating dedicated collection points for disposal of facial masks and informing citizens about the environmental and health risks of nanomaterials (Weiss et al. 2020) . From the suppliers forefront it is quintessential to study nanomaterial release during usage, conduct toxicological assessments & dermatological testing, subsequently submit a nanosafety report, explore nanomaterial release during washing and also provide instructions to consumers regarding washing/disposal. From the standpoint of the consumer, it is important that they only use products having a safety report, understand the ecological aspects of usage and follow the disposal instructions (Konda et al 2020).

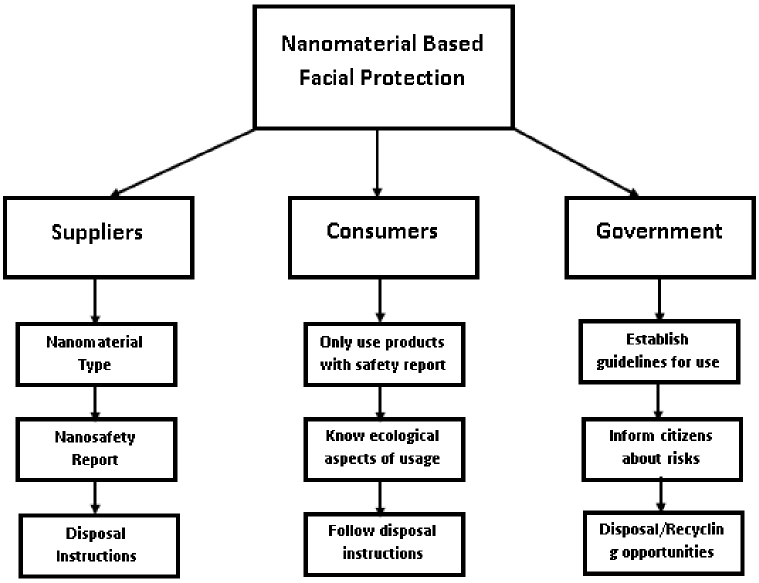

Fig.1 Overview of interventions and nanomaterial usage. Source: Authors own depiction

Nanotechnology and Enhanced Mask Performance

The efficacy of facial-masks is an outcome of both material properties and various external factors. Developed with the objective of filtering bio-aerosols and ensuring comfort, an ideal face-mask possesses multiple attributes (Valdiglesias, &Laffon, 2020). Out of them, particle flow rate, size and charge are considered to be of utmost importance. In conditions of low flow-rate, electrostatic mechanisms and diffusion rate dominate for small particles such as viruses. Interception of viral particles in mask fibers occurs along with an increase in flow-rate (Nasrollahzadeh et al, 2020). Retailed face-masks already comprise nanomaterials such as carbon, copper dioxide, graphene, titanium dioxide, nanosilver, nanodiamonds embedded in them. Face-masks also comprise of polymers such as polyethylene, polyesters, polyamides and polycarbonates which are moisture resistant and easy to charge (Campos et al, 2020). A comprehensive list of Campos and colleagues' patented antiviral technologies is shown in table 2illustrated below.

Table 2: “Patents using nanomaterials for production of commercial masks”

Name of Product	**Application**	**Name of Company**
“Surgical Masks - Espin Technologies”	“Remove Nano-fibre particle”	“Espin Technologies Inc. , USA”
“Defenser Series - Respirator Masks”	“ Copper and silver nanoparticles acting as a blend with antimicrobial activity”	“Nexera Medical, Canada”
“The Guardian (valve) – Reusable”	“ Copper and silver nanoparticles acting as a blend with antimicrobial activity”	“Nexera Medical, Canada”
“The Guardian Masks – Reusable”	“ Copper and silver nanoparticles acting as a blend with antimicrobial activity”	“Nexera Medical, Canada”
“MVX Nano Mask”	“Surgical self-cleaning mask with titanium and silver zeolite nanoparticles”	“MVX Prime Ltd.”

Source: Campos, et al. (2020)

Environmental safety, Nano safety and skin damages

In the context of safety aspects concerning nanoparticles, it is quite important that its coating should be durable, non-toxic and not prone to damage caused due to washing/rubbing (Chan, 2020). Addressing such safety concerns are quite pertinent especially in case the nanoparticles embedded in facial masks are washed away, the nanowaste arising out of the same would lead to serious environmental hazards. Due to a high surface to volume ratio of nanomaterials, the toxicology levels of the same escalates to a different level altogether (Mujawar et al, 2020). This can pose serious health and environmental risks. Hence, the components, composition and their stability is an aspect demanding utmost attention (Feng et al, 2020).

CONCLUSION

In the process of imbibing nanotech applications in addressing the impact of the pandemic, it is crucial for the nanotech research community to take the nanosafety and ethical aspects into due consideration. Mass usage and inappropriate disposal of face-masks can ultimately lead to aquatic pollution. Directionally, it is the need of the hour to continuously innovate and come-up with novel and improved products which address the needs of environmental protection. Considering the huge investments being made to boost nanotechnical research, effective measures need to be taken by the government agencies to enhance sensitization, issue guidelines for disposal to ensure nanosafety and develop mechanisms for recycling.

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