01. Polymer Technology Outlook Study: Face Shields for Responding SARS-CoV2 Pandemic

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Submission date: 09-Nov-2021 10:58AM (UTC+0700)
Submission ID: 1697406920
File name: 01._38-Research_Instrument-133-4-10-20210707.pdf (448.85K)
Word count: 2596
Character count: 14577

International Journal of Eco-Innovation in Science and Engineering Vol. 2 No. 01, 2021 (20-24)
E-ISSN: 2721-8775 /https://ijeise.upnjatim. ac.id/

Article

Polymer Technology Outlook Study: Face Shields for Responding SARS-CoV2 Pandemic

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Received: 20th April 2021; Revised: 25th April 2021; Accepted: 29th April 2021;
Available online: May 2021; Published regularly: May and November 2021.

Abstract

The coronavirus disease 2019 (SARS-CoV2) has attracted most interest in current years due to the worst impact for the global public health. In this situation, the whole world requires wearing face shield and mask as the personal protective equipment, especially for medical personnel. Polymer technology have been introduced as a helping tool against SARS-CoV2 by producing healthcare product such as face shield as the first line of resistance due to it was cost effectiveness, sterile nature, versatility and easy to modify. This article clarifies the discussion about face shields in the polymer technology as the point of view and aims at providing a deeper understanding about polymer, polymeric material, synthesis methodology and its application for responding SARS-CoV2 pandemic in a form of face shields. The study of the synthesis route and methodology, chemical and physical properties of the polymer for face shields have also been described.

Keywords: polymer technology, face shield, SARS-CoV2, polymerization

1. Introduction

Since December 2019, Wuhan City, Hubei, China gave notice of the severe pneumonic disease, namely Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). It has been killed peoples in the worldwide, more than 279,286 deaths with infected people of 4,080,426. The virus transmission was going rapidly infected from people to people via physical contact, airbone transmission to a smaller extent, respiratory droplets such as resulting from coughing and sneezing [1]. Therefore, the World Health Organization (WHO) declared a Public Health Emergency of International Concern in January 2020. Considering to use personal protective equipment (PPE), especially for medical personnel by wearing surgical mask, medical face masks and face shield to prevent the spread of the virus [2]. Furthermore, the use of face masks is essential for medical and healthcare personal during clinical practice or care of patients suffering from COVID-19 with the effectiveness around 68-96% to against the pathogen [3].

In early 2021, the use of face shield and other PPE initiates researchers to start the innovation and solving this kind problem. Compared to conventional technologies, the use of additive manufacturing in the medical field has several benefits, such as inner specific design, personalized layout, sustainability, and time reduction, in addition to minimalized transportation costs [4,5].

Polymer technology gave a major useful outlook, for instance cleaner, safer, easy to be recycled to reuse [6]. However, there are not many studies on this approach to polymer technology which correlated with PPE such as field shield. The basics of polymers study was very important to know to improve and develop the quality and innovation related to their effectiveness in overcoming this pandemic.

Therefore, this mini review provides the information of the polymer and polymeric

material to fabricate face shield, including general discussion about PPE, polymer type and its molecular weight determination, face shield design and structure, and the polymer production.

2. Discussions

2.1 Application of Polymers on Personal Protective Equipment (PPE) in SARS-CoV2 Prevention

Personal protective equipment (PPE) is commonly focus on minimalization the toxic and hazardous substance which possibility injures the human and environment. The PPE product include items such as goggle, gloves, safety glasses, safety gown, earplugs, shoes, safety hat, respirators etc [4,7]. These products are commonly produced from polymer and polymeric materials and designed to be fit comfortability, encouraging worker use.

The lack of the PPE usage may cause dangerously exposure, especially in SARS-CoV2 problem. Each PPE product was recognized to have standard material criteria to optimize the characteristic and usage, such as thickness, flexibility, fog scratch resistant and clearness. The methods used to develop the following technical specifications involved review of the infection prevention and control (IPC) COVID-19 guidelines, review of PPE products available in the market, and PPE products approved by stringent regulatory agencies, and analysis of international, regional and country standards on PPE [8,9].

World Health Organization (WHO) had published the technical specification for procurement for items in medical field which mostly fabricated from polymers [10]. In this focus, face shield required clear plastic, reusable, disposable and providing good visibility for wearer and patient. The band of the face shield need to be adjustable, fit snuggle and fog resistant. The performance standards were considered based on ED 166, ANSI/ISEA Z87.1 or alternative equivalent set of standards.

2.2 Polymer Type of Face Shield and Its Molecular Weight

Face shield is commonly fabricated from polymer and polymeric materials which consists of visor as the lens or window and frame (Figure 1). The visor for covering face were produced from polycarbonates (PCs), polyvinyl chloride (PVC), while the frame from polyvinyl chloride (PVC) polymer [3].

Fig. 1 Decoration of Face Shield [3].

2.2.1 Polycarbonates (PCs)

Polycarbonates (PCs) is an organic functional groups linked together by carbonate groups (–O–(C=O)–O–) which firstly prepared in 1898 by Einhorn from the reaction between polyhydroxy compound and some carbonic acid, namely hydroquinone (1,4-dihydroxybenzene) and resorcinol (1,3-dihydroxybenzene) in pyridine with a phosgene solution as the solvent [11–13]. PCs also known to have superior properties on the chemical and physical properties due to show high resistance polymer at high temperature, excellent toughness and the optical clarity. The superior characteristics have been owned by aromatic polycarbonates such as bisphenol A (BPA) polycarbonates. Other than that, an aliphatic PCs with a lower characteristic such as low melting point can be also synthesized using different raw material as shown in Figure 2. It showed a pre-synthesis reaction to produce a commercially available PCs before polymerization occurs [14].

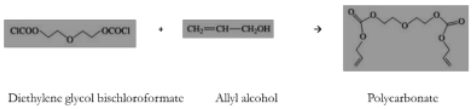

Fig 2. The Polymerization Reaction to Produce the Aliphatic Polycarbonates [14].

The molecular weight in mL.g^{-1} of the BPA PCs contribute to determine the melting point value and solution viscosity which can be evaluated using correlation of inherent viscosity (η) with weight-averaged molecular weight (Mw) as shown in Eq. 1.

$$[\eta] = (41.2\ x10^{-3}).(M_w^{0.69}) \quad (1)$$

The Mw determination can also be evaluated through a chemical analysis using chromatography, melt flow and solution

viscosities. The relationship between viscosity of a polymer solution and molecular weight is given by Mark-Houwink equation the relationship among the molecular weight and viscosity are given below

$$[\eta] = (K.M^{\alpha}) \qquad (2)$$

Where [η] is the intrinsic viscosity, M is Molecular weight, K and α are constants for a particular polymer solvent system. If we know the K and α values for a given polymer solution the intrinsic viscosity and molecular weight can be calculate using the above equation [15].

2.2.2 Polyvinyl chloride (PVC)

Polyvinyl chloride (PVC) is the second most popular polymer after polyethylene (PE), which is widely used worldwide to produce plastic-based products from monomers of vinyl chloride as illustrated in Figure 3.. The medical field uses PVC as surgical items, especially PPE, up to 28% of plastic use [16]. PVC is mostly composed by C-C, C-H, C-Cl which contributes the hydrophobic properties. However, PVC could provide a defect side due to the oxidation, occurring unsaturation and branching.

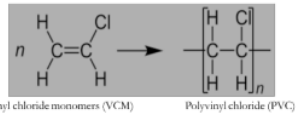

Fig. 3 The Illustration of Polyvinyl chloride (PVC) manufacturing from Vynil chloride monomers (VCM).

These fundamental properties can be clarified by the molecular weight measurement. Pepperl determine the molecular weight of PVC using size exclusion chromatography using Mark-Houwink coefficient as aforementioned. The result showed that the polydispersity of PVC increases with increasing K value. This may be caused by a reduced terminating reaction and long- chain branching of molecules [17]

Based on the previous literature, a commercially available PVC was mainly manufactured using suspension polymerization process (S-PVC). The other alternative method possibly to be applied for PVC manufacturing, namely bulk and emulsion process (E-PVC) [18]. The stage of S-PVC was firstly prepared Vinyl chloride monomer (VCM) as a raw material which commonly in a form of gas with molecular weight of 62.5. VCM was then liquefied and fed with water and suspending agent into reactor to be polymerized. Subsequently, the polymerization initiator was added then PVC slurry obtained under condition of few bar pressure at 40-60 ℃. Next, the slurry was dehydrated and dried until it becomes white powder. The advantage of this method, the unreacted monomer of vynil chloride could be recycled and reused as the next PVC production.

The E-PVC method cam be applied to manufacture a finer resin grades with more smooth and smaller particle size 40-50 μm with a range of 0.1-100 μm that can be applied in a certain application. It stimulated using surfactant compounds to break down the bonding of monomers (vinyl chloride) in water.

2.2 Face Shield Design and Structure

The design, structure, characterization, performance test and manufacturing of the face shield which currently be used by people in this pandemic has been regulated according to the American National Standards Institute (ANSI)/International Safety Equipment Association (ISEA) Z.87.1–2010 standard. It is due to keep a good quality and effective to be used especially for medical personnel [10]. The major structural components of a face shield include the following: visors and frame.

Visors referred to as protection lenses, has been successfully manufactured from any of several types of polymer and polymeric materials such as polycarbonate, acetate, propionate, polyethylene terephthalate glycol, and polyvinyl chloride. Polyethylene glycol showed the most economical and provides the best clarity. However, polycarbonate and propionate offer better quality thus it has been widely used as raw material of the visors. In addition, optical quality tends to crucial to be had that automatically reduce eye strain associated with face shield.

Other than that, some modification has been improved to develop the quality of visors to against droplet and other superior characteristics, namely anti-fogging, anti-static, anti-glare, ultraviolet light (UV) protection which good for eyes, and scratch resistance features to extend the durability of the visor.

The frame of face shield used in healthcare item are generally manufactured from lightweight polymer or plastic. The frame needs to have a variety characteristic, such as easily to be adjusted and high durability for nonadjustable frames such as equipped with eyeglass. It can be fully or

partially encircling the circumference of the skull hat are worn like standard eyewear.

3. Conclusions

In this mini review, the polymer study outlook according to the face shield has been declared. It has been established that the face shield commonly manufactured using polymer namely polycarbonate as the most common used and polyvinyl chloride. The classification and characteristics of the polymer can be determined by conventional method, namely molecular weight measurement. It can be calculated using a formula from Mark-Houwink equation. The value of molecular weight can also clarify the quality of the polymer.

Acknowledgement

There is no funding source as per stated in the acknowledgement.

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