

COVID-19 Disposable Face Masks: a Precursor for Synthesis of Valuable Bioproducts

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Research Article

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Abstract

Disposable face mask has become a mandatory personal protective equipment in order to prevent contracting COVID-19. With the significant surge in its usage, its adverse environmental impact is becoming a source of concern. Disposable face masks are made from thermoplastic polymers and therefore they can be safely converted into valuable bioproducts. This paper discussed the possibility of converting waste/contaminated face masks into valuable bioproducts, which will essentially eliminate secondary transmission of the coronavirus and the concerns of environmental pollution.

Introduction

According to the U.S. Center for Disease Control and Prevention Data Tracker, the total confirmed COVID-19 cases in the U.S. stands at 27.1 million with total death of 465,281 (Prevention 2021) while the total cases worldwide stands at 107,376,504 and a total death toll of 2,348,684, as of February 09, 2021 (Worldometer 2021). While the roll out of vaccines are underway to help combat this pandemic, both the World Health Organization (WHO) and the U.S. Center for Disease Control and Prevention have recommended preventive measures such as social distancing, hand sanitizers, frequent handwashing, and the use of face masks.

The recent surge in the total COVID-19 cases and spread of the coronavirus outbreaks in new parts of the United States has led to a significant increase in the use of face masks. For example, between June and August 2020, the result of a survey conducted by Pew Research Center showed that there was a 23%, 27%, 28%, and 33% increase in the use of face masks by U.S. adults in the West North Central, West South Central, East South Central, and Mountain regions, respectively (Kramer 2020). This is an indication that more U.S adults regardless of their political affiliations and perspectives, are now considering face masks to be an effective personal protective equipment. Public health and medical officials have described face mask to be a simple barrier which prevent respiratory droplets from reaching others, thereby substantially slowing down the transmission of the coronavirus (Prevention 2021).

With the significant increase in the use of face masks, there is a concern about the safe disposal of these waste materials (Nzediegwu & Chang 2020). Specifically, handling of waste disposable face masks will compound the current environmental problems constituted by the large volume of various plastics that are disposed in water bodies. This is because disposable face masks are made from polymers such as polypropylene, polyurethane, polyacrylonitrile, polystyrene, polycarbonate, polyethylene, or polyester (Fadare & Okoffo 2020, Potluri & Needham 2005) and they are not biodegradable. Fadare and Okoffo (Fadare & Okoffo 2020) stated that the high rate of single use of disposable face masks will emerge as a new source of microplastic fibers in the environment. Nzediewu and Chang (Nzediegwu & Chang 2020) stated that improper handling of waste COVID-19 preventive gears can increase the spread of COVID-19 in developing countries. The United Nations Environment Program (News 2020) estimates that about 75% of used face masks and other pandemic-related wastes will end up in landfills or waterbodies. If the disposal of these waste materials are not properly managed, it can ultimately result in

public health risks such as secondary transmission from contaminated used face masks. This is supported by a study conducted by Kampf et al. (Kampf et al. 2020), investigating the persistence of coronavirus on inanimate surfaces and reported that the human coronavirus can remain infectious on inanimate surfaces at room temperature for up to 9 days and an increase in temperature above 30 °C, will result in shorter persistence duration of the coronavirus.

While the disposal and management of used face masks and other pandemic-related materials may present an environmental challenge, these waste resources can be converted to valuable bioproducts. Fadare and Okorro (Fadare & Okoffo 2020) conducted an FTIR analysis of disposable face masks and reported that the inner and outer layers of the disposable face masks presented a characteristic peak of polypropylene and high-density polyethylene, respectively. Polypropylene and high-density polyethylene are thermoplastic hydrocarbon polymers produced from propylene and ethylene monomers, respectively. Due to their hydrocarbon nature, they can be converted to valuable bioproducts such as syngas, bio-oil, and biochars. This implies that the vast quantity of used disposable face masks can serve as reliable feedstock for bioproducts synthesis.

In comparison to lignocellulosic feedstocks, polymeric materials such disposable face masks have been shown to have impeccable characteristics such as low moisture content (0.00 – 0.80%), low ash content (0.00 – 1.40%), and high volatile content (86.83 – 99.63%) (Jouhara et al. 2018). Bioproducts obtained from the thermochemical conversion of disposable face masks will therefore not have physicochemical characteristics inhibiting the direct utilization of lignocellulosic feedstock derived bioproducts.

Pyrolysis is a thermochemical conversion technology which involves the thermal decomposition of a material at a temperature above 400 °C in the absence of oxygen to produce bio-oil, biochar, and non-condensable gas (Oginni & Singh 2019, Oginni et al. 2017). This conversion technology has been reported in various literatures to convert lignocellulosic and non-lignocellulosic feedstocks to bio-oil and biochar. For example, Ahmad et al. (Ahmad et al. 2014) investigated the pyrolysis of polypropylene (PP) and high density polyethylene (HDPE) at temperature range of 250 – 400 °C. Optimum bio-oil yields of 69.82% and 80.88% were obtained at pyrolysis temperature of 300 °C and 350 °C for PP and HDPE, respectively. Jung et al. (Jung et al. 2010) also investigated the pyrolysis of waste polypropylene and polyethylene in a fluidized bed reactor at a temperature range of 650 – 750 °C and reported a bio-oil yield of 43% and 53% for polypropylene and polyethylene, respectively.

The bio-oil obtained from pyrolysis of polypropylene and polyethylene, have been reported to have a very high calorific value, which is almost equivalent to the calorific value of conventional liquid fuel. For example, Lopez et al. (López et al. 2011) reported calorific values of 40.8 – 43.5 MJ/kg for bio-oils produced from pyrolysis of plastic mixtures at temperature range of 460 – 600 °C. Paradela et al. (Paradela et al. 2009) also reported a calorific value of 44.7 MJ/kg for bio-oil obtained from pyrolysis of plastic wastes at temperature of 450 °C.

Biochar is a solid porous carbonaceous product obtained from pyrolysis (Oginni & Singh 2020). Due to its tunable physicochemical characteristics, it has been explored extensively for soil amendment, carbon

sequestration, water treatment, residential heating, catalyst, and energy storage. The use of disposable face masks for producing biochar is significantly dependent on the carbonization temperature. Due to the high temperature required to thermally decompose thermoplastics and the low fixed carbon content of these materials, biochar yield is generally very low. Papuga et al. (Papuga et al. 2015) reported a decrease in biochar yield from 25.46 to 1.23% during pyrolysis of waste plastics mixture, (45% polypropylene, 35% low density polyethylene, and 25% high density polyethylene) as pyrolysis temperature increased from 450 to 525 °C. Lopez et al. (López et al. 2011) reported a very low biochar yield of 0.8 – 1.1% during pyrolysis of plastic mixture (40 wt% polyethylene, 35wt% polypropylene, 18 wt% polystyrene, 4 wt% PET, and 3% PVC) at temperature range of 460 – 600 °C. This implies that biochar production from waste face masks may not be as high as bio-oil production.

Since the persistent duration of coronavirus decreases as temperature increases, the use of waste/contaminated disposable face masks as precursor for bio-oil and biochar production will not present any danger of secondary transmission as the virus will not be able to survive the temperature at which this thermochemical conversion process is taking place. However, in the consideration of pyrolysis technology to safely handle waste/contaminated disposable face masks, it will be recommended that these masks are collected separately just as plastic bottles and other recyclable waste materials are collected. This will eliminate the need for sorting the masks from other waste materials.

World Health Organization estimated a monthly global consumption and waste of 129 billion face masks and the weight of a face mask is 3.5 g. Therefore, a total of 451.5 billion grams of waste face masks will be generated monthly worldwide. Based on the bio-oil yield range (43 – 80%) that has been reported in literatures during pyrolysis of plastics, it can be estimated that a total of 194.2 – 361.2 grams of bio-oil can be generated monthly from these waste face masks worldwide. This is an indication that while the disposal of used face masks seemed to present itself as an environmental pollutant, it can be safely converted into a useful valuable bioproducts.

Conclusion

Disposable face masks are personal protective equipment recommended to prevent COVID-19 transmission. In this study, pyrolysis has been identified as a tested conversion technology which can be utilized to convert contaminated face masks into high valued bioproducts such as bio-oil and biochar while also eliminating any possibility of COVID-19 transmission as the virus cannot survive the operational temperature of this conversion technology.

Declarations

Conflict of interest

The author declare no conflict of interest including financial, personal or other relationships with anybody or organizations.

Ethics approval and consent to participate : Not applicable

Consent for publication: Not applicable

Availability of data and materials: Not applicable

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