REUTILIZATION OF COVID-19 WASTE MASK AS AN EFFORT TO REDUCE ENVIRONMENTAL POLLUTION

Hanin Fitria, Tita Latifah Ahmad

Department of Industrial Engineering, Faculty of Science and Technology,
Universitas Muhammadiyah Kudus

ABSTRACT

Background: Masks are essential personal protective equipment used as the main barrier to protect against viruses that spread through these droplets. Wearing a mask has become daily life for many people. This has led to a significant increase in the demand for disposable face masks worldwide. Mishandling of these materials threatens the environment with new forms of plastic pollution. This study aimed to describe two options for recycling COVID-19 mask waste and explain product planning using the quality function deployment method.
Subjects and Method: This was a qualitative study. The study variables were reutilization of covid-19 waste mask and environmental pollution. The data were collected by in-depth interview and reported accordingly.
Results: Green and highly efficient pathway for the catalysis of waste mask carbonization reported into high-value carbon nanomaterials. The pyrolysis stream generated in the first stationary reactor passed through the second reactor, filled with a catalyst bed. Without a catalyst, the masked CFP did not produce aromatic compounds but branched hydrocarbons (C8eC46). QFD the product design team plays an essential role in driving sustainability by incorporating relevant requirements early in the design process.
Conclusion: Conventional QFD's limited focus on customer needs and analytical approach lacks understanding and assumes certainty in decision making. Several integrated approaches to product design have been proposed in the literature to overcome the limitations of conventional QFD in the context of creating a framework for sustainable product design.

Keywords: garbage masks, environment, QFD, COVID-19

Correspondence:
Hanin Fitria. Department of Industrial Engineering, Faculty of Science and Technology, Universitas Muhammadiyah Kudus. Jl. Ganesha Raya No. 1, Purwosari, Kudus 59316, Central Java. Email: haninfitria@umkudus.ac.id. Mobile: +62 81391190314.

BACKGROUND

In December 2019, infection with the new Corona virus (COVID-19) spread rapidly throughout the world, including Indonesia. COVID-19 is a variant of SARS or commonly called (SARS-Cov-2). Like other SARS variants, namely MERS, COVID-19 also attacks the human respiratory system (Lai et al., 2020). The virus is known to cause respiratory infections ranging from the common cold, to more severe illnesses. COVID-19 is transmitted through droplets or splashes that come out when an infected person coughs, sneezes or talks either directly from person to person or through objects that have been touched by the droplets (WHO, 2020).

On March 11, 2020, the world health organization or WHO (World

Health Organization) declared the Corona COVID-19 virus outbreak a global pandemic (WHO, 2020). Judging from the active cases and the death rate that is still growing, the COVID-19 case in Indonesia itself is quite worrying. Loaded on kompas.c-om, the total number of COVID-19 cases in Indonesia until July 14, 2021 reached 2,670,046 people since the first case was announced by President Joko Widodo on March 2, 2020. Of the total cases, 2,157,363 people were declared cured. and 69,210 people died. since the start of the pandemic. With the increasing number of COVID-19 cases, Indonesia was once the country with the highest number of COVID-19 cases in Southeast Asia.

WHO calls on countries to take immediate and aggressive action to prevent and contain the spread of this virus. The Indonesian government requires the implementation of health protocols for the entire community. The COVID-19 health protocol and maintaining endurance refers to the 5th Revision COVID-19 Prevention and Control Guidelines issued by the Indonesian Ministry of Health, namely using a mask, washing hands with water and soap or hand sanitizer, avoiding touching the face and shaking hands, avoid gathering/gathering, avoid touching objects in public places, avoid public transportation and keep a distance (WHO, 2021).

Masks are one of the most important types of personal protective equipment as the last barrier to protect against viruses that spread through these droplets. Wearing a mask has become a daily routine for many people. This has led to a significant increase in the demand for disposable face masks globally (Fadare and Okoffo, 2020). Disposable masks are basically made of poly-propylene and high-density polyethylene, and may contain other polymeric materials such as polyester, poly-urethane, poly-styrene, and polyacrylony-trile.(Prata et al., 2021).

Garbage Mask Collection During the COVID-19 Pandemic

The ongoing COVID-19 pandemic has resulted in the mass consumption of personal protective equipment (PPE) worldwide (Torres and DelaTorre, 2021). Disposable face masks are one of the most common types of PPE used to prevent viral infections. However, mismanagement of these materials threatens the environment with new forms of plastic pollution. Ignoring the seriousness of this problem could result in the release of large amounts of microplastics in landfills and the marine environment, which could have serious implications for flora and fauna (Dharmaraj et al., 2021).

The amount of medical waste generated in different hospitals is proportional to the number of infected people and the average amount of waste generated per bed. Preliminary studies show that the daily accumu-lation of medical waste in Jordan is 2.69 kg/bed/day (Minoglou et al., 2017). Meanwhile, according to estimates and analysis of medical waste in the city of Istanbul, the annual average unit of medical waste per day in hospitals was 0.43 kg/bed/day in 2000 to 1.68 kg/bed/bed in 2017. by day(Korkut, 2018). In April 2020, the maximum production level of medical waste during the COVID-19 pandemic

https://doi.org/10.26911/ICPHpromotion.FP.08.2021.08

is estimated to be around 14,500 tonnes (Sangham, 2020)

Another aspect of the COVID-19 epidemic is the improper disposal of solid waste. Improper disposal of waste can spread viruses. As a result, the number of confirmed cases has skyrocketed, and the amount of medical waste associated with COVID-19 has also increased significantly (Peng et al., 2020). In addition, the existing operational protocols for the disposal of SARSCoV2 sewage and municipal sewage (MSW)216 have special precautions, to reduce the potential risk of SARSCoV2 infection due to improper waste management processes.

Examples of Using COVID-19 Garbage Masks

As the coronavirus (COVID-19) is spreading rapidly around the world, wearing a mask has become the last barrier to protect people from the virus that spreads through droplets, and it has become a daily routine for everyone to wear a mask. However, masks that are disposed of carelessly can cause many environmental problems such as microplastics that are harmful to various ecosystems (Rai et al., 2021a, b). Therefore, it is very necessary to develop a method for handling discarded masks. This study proposes a way to produce value-added chemicals (e.g., aromatic compounds) from high amounts of masks through catalytic rapid pyrolysis (CFP). CFPs have been developed to make high-value aromatic compounds from carbonaceous substances (eg, biomass and organic waste) such as benzene, toluene, ethylbenzene and xylene (BTEX). The main body of the mask (inner, middle, outer and filter) is made of polypropylene (PP) which is pyrolyzed with various zeolite catalysts (HBeta, HY, and HZSM-5) to make BTEX. The mask was pyrolyzed in a fixed bed reactor, and the pyrolysis gas evolved in the reactor was directed to a secondary reactor where the zeolite catalyst was loaded. Without a catalyst, the masked CFP does not produce any aromatic compounds but branched hydrocarbons. The use of a catalyst generally decreases the oil yield and increases the gas yield without much change in the amount of residual solids. The catalyst also results in the production of aromatic compounds from the mask. The large pore zeolite groups HBeta and HY accounted for 134% and 67% higher BTEX concentrations than HZSM-5, likely because they had larger pores, higher surface area, and higher acid site density than HZSM-5. HZSM-5. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask.

Polypropylene (PP) is the main composition of face masks, so the recycling of mask waste is exactly the same as that of PP waste recycling. As one of the most promising recycling strategies, catalytic carbonization provides an easy, economical and efficient way to produce carbon nanomaterials from polymer waste through thermochemical conversion. It is noted that the elemental carbon content reaches 85.7% by weight in PP, which means that PP is a promising carbon raw material for producing

https://doi.org/10.26911/ICPHpromotion.FP.08.2021.08

carbon-based nanomaterials. Meanwhile, PP catalytic carbonization is also a sustainable concept and prevents PP waste from being directly dumped into landfills or incinerators. To convert PP into carbon nanomaterials, a series of combined catalysts was developed consisting of organically modified clay (OMC)/nickel (Ni-Cat) catalysts, zeolite/NiO, chlorinated compounds/Ni_2O_3, activated carbon/Ni_2O_3, carbon black/Ni_2O and C60/ $Ni(OH)_2$. Our results reveal that this catalyst can promote the decomposition of PP to selectively produce more aromatic compounds, which are then dehydrogenated and reassembled into carbon nanotubes (CNTs). Our previous work reported on the catalytic carbonization of PP waste to a magnetic carbon/Fe_3O_4 hybrid, which was used as an adsorbent to effectively remove dye pollutants from water. In particular, carbon/metal hybrids are also one of the promising types of microwave absorbent materials due to their synergistic effect between dielectric and magnetic loss. Our results show that the resulting product is a CNT/Ni hybrid, and the highest carbon yield is 64.4 g/100 g WM. Due to the synergistic effect of CNT and Ni.

SUBJECTS AND METHOD

1. Study Design
This research is a qualitative research.

2. Population and Sample
The population of this study is the worldwide contamination of COVID-19 waste masks. The sample of this study was taken from several journals discussing the contamination of COVID-19 waste masks.

3. Variable
The research variables are the reutilization of COVID-19 waste masks and environmental pollution.

4. Operational Definition of Variable
The operational definition of the variable in this study is the problem of pollution of COVID-19 mask waste in the environment.

5. Instrument
The research instrument used is a literature study by dissecting several journals regarding the contamination of COVID-19 waste masks in several journals and their handling solutions.

6. Data Analysis
Data analysis was carried out by outlining the problem of contamination of COVID-19 waste masks in several journals. The analysis is continued by reviewing several ways of reprocessing COVID-19 waste masks.

7. Research Ethics
The research ethic applied is the effort to reduce pollution to the environment on COVID-19 waste masks around the world.

DISCUSSION

The study says a green and highly efficient pathway is reported for the catalysis of the carbonization of waste masks into high-value carbon nanomaterials. The results showed that the product obtained was a CNT/Ni hybrid, and the highest carbon yield was 64.4 g/100 g WMs. Due to the synergistic effect of CNT and Ni, the resulting hybrid exhibits outstanding microwave absorption with a high reflection loss of 56.3 dB and a bandwidth of 4.3 GHz at 2.0 mm thickness, equivalent to or much better than most

https://doi.org/10.26911/ICPHpromotion.FP.08.2021.08

C hybrids. / Ni. Considering the convenience and feasibility of recycling WM from different environments, it is believed that this strategy will be extended to the actual large-scale industrial production. In addition, the recycling target is not limited to used masks, but also includes polymer waste or other biowaste, so that more valuable carbon nanomaterials will be produced and applied. It is more promising to be developed.

The second study investigated for the first time the effect of zeolite properties on BTEX production from COVID19 mask waste via CFP. The mask mainly consists of PP which has been pyrolyzed with a different zeolite catalyst (HBeta, HY or HZSM5) to produce BTEX. The pyrolysis steam generated in the first stationary reactor passes through the second reactor which is filled with a catalyst bed. Without a catalyst, the masked CFP did not produce aromatic compounds but branched hydrocarbons (C8eC46). The highest oil yield (80.7% by weight) was obtained at 550 °C, which was accounted for in all CFP experiments. The use of a catalyst usually reduces the oil yield and increases the gas yield without significantly changing the residual solids. The catalyst also leads to the production of aromatics from the mask. HBeta and HY catalysts showed significantly higher selectivity towards BTEX than HZSM5. HBeta and HY zeolite catalysts have larger pores, higher surface area and larger number of acid sites compared to HZSM5. The pore sizes of HBeta and HY are larger than the kinetic diameter of the branched hydrocarbons, allowing the thermally derived branched hydrocarbons to diffuse within the pores and thus transform into aromatic hydrocarbons above the acidic sites located mainly within the pores. HBeta has a higher acidity than HY, and this leads to more aromatic formation. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask. Higher surface area and greater number of acid sites compared to HZSM5. The pore sizes of HBeta and HY are larger than the kinetic diameter of the branched hydrocarbons, allowing the thermally derived branched hydrocarbons to diffuse within the pores and thus transform into aromatic hydrocarbons above the acidic sites located mainly within the pores. HBeta has a higher acidity than HY, and this causes more aromatic formation. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask. Higher surface area and larger number of acid sites compared to HZSM5. The pore sizes of HBeta and HY are larger than the kinetic diameter of the branched hydrocarbons, allowing the thermally derived branched hydrocarbons to diffuse within the pores and thus transform into aromatic hydrocarbons above the acidic sites located mainly within the pores. HBeta has a higher acidity than HY, and this causes more aromatic formation. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask. allows the thermally derived branched hydrocarbons to diffuse within the pores and thus transform into aromatic hydrocarbons over acidic sites located mainly within the pores. HBeta has a higher acidity than HY, and this causes more aromatic formation. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask. Allows the thermally derived branched hydrocarbons to diffuse within the pores and thus transform into aromatic hydrocarbons over the acidic sites located mainly within the pores. HBeta has a higher acidity than HY, and this causes more aromatic formation. These different factors (i.e., porosity, surface area, and acidity) synergistically contribute to the higher production of aromatic compounds from the mask.

In the two studies conducted, further research can be done by analyzing the planning and development of products that can be produced from mask waste. The method that can be used is Quality Function Deployment (QFD). Traditionally, Quality Function Deployment (QFD) has been the main framework for product design. However, due to the limited focus of conventional QFD on customer requirements and the analytical approach lacking understanding and assuming certainty in decision making, several integrated approaches to product design have been proposed in the literature to overcome the limitations of conventional QFD in the context of creating a framework. for sustainable product design (Ocampo et al., 2020). Previous models include green QFD (Zhang et al., 1999; Wong and Jupiter, 2002), QFDEnoi (Masui et al., 2003; Otani and Yamada, 2011; Younesi and Roghanian, 2015), analysis of the impact of QFD failure modes (Chen and Ko, 2009), QFD design for the environment (Rahimi and Weidner, 2002), ecological QFD (Ernzer and Birkhofer, 2003; Kuo et al., 2009; Utne, 2009), QFDLife cycle evaluation (Sakao) et al., 2005; Sakao, 2007), environmentally conscious QFD (Vinodh and Rathod, 2010), among others.

With Quality Function Deployment (QFD) as the basis, the product design team plays an important role in driving sustainability by incorporating relevant requirements early in the design process. However, the literature in this area has significant gaps, especially regarding mask waste. First, the current document does not take into account the requirements of all relevant stakeholders, which are critical for sustainability. Second, while some offer different models of QFD Fuzzy-Multiple Attribute Decision Making (QFD-MADM), they do not comprehensively address the fundamental interdependencies of the decision parameters in QFD. Moreover, most of the work on QFD-MADM is limited to product planning while losing control over the later stages of product development. Therefore, this work attempts to fill this gap by proposing an integrated multiphase fuzzy QFD-MADM framework that combines QFD, Analytical Hierarchy Process (AHP), Evaluation and Test Lab. (DEMATEL) and Analytical Network Process (ANP) with fuzzy set theory.

There are several ways to handle mask waste. The main parts of the mask (inner, middle, outer, and filter) are made of polypropylene (PP) pyrolyzed with various zeolite catalysts (HBeta, HY, and HZSM- 5) to make BTEX. The mask is pyrolyzed in a fixed bed reactor, and the pyrolysis gas developed in the reactor is directed to a secondary reactor where the zeolite catalyst is loaded. Rapid catalytic pyrolysis (CFP) has been developed to prepare high value aromatic compounds from carbonaceous substances (eg, biomass and organic waste) such as benzene, toluene, ethylbenzene and xylene (BT-EX).

Polypropylene (PP) is the main composition of face masks, so recycling mask waste is exactly the same as recycling PP waste. As one of the most promising recycling strategies, catalytic carbonization provides an easy, economical and efficient way to produce carbon nanomaterials from polymer waste through thermochemical conversion. The results showed that the resulting product was a CNT/Ni hybrid, and the highest carbon yield was 64.4 g/100 g WM. Due to the synergistic effect of CNT and Ni, the resulting hybrid exhibits an outstanding microwave absorption capacity of a strong reflection loss of -56.3 dB and a wide bandwidth of 4.3 GHz at a thickness of 2.0 mm, which is comparable or far better than most other C/Ni hybrids.

In the two studies conducted, further research can be done by analyzing the planning and development of products that can be produced from mask waste. The method that can be used is Quality Function Deployment (QFD). Traditionally, Quality Function Deployment (QFD) has been the main framework for product design. However, due to the limited focus of conventional QFD on customer requirements and the analytical approach lacking understanding and assuming certainty in decision making, several integrated approaches to product design have been proposed in the literature to overcome the limitations of conventional QFD in the context of creating a framework. for sustainable product design.

AUTHOR CONTRIBUTION

Hanin Fitria and Tita Latifah Ahmad were in charge of providing the ideas presented. Hanin Fitria develops theory and performs calculations. Tita Latifah Ahmad verified the analytical method. Hanin Fitria encouraged Tita Latifah Ahmad to investigate certain aspects and oversee the findings of this work. All authors discuss the results and contribute to the final manuscript.

ACKNOWLEDGMENT

The completion of this research has been assisted by many parties involved. Thus, the authors would like to thank the previous research cited in this study. The authors also thank the University of Muhammadiyah Kudus for supporting the completion of the research. We would also like to thank the International Conference on Public Health for organizing the event.

FUNDING AND SPONSORSHIP

Acknowledgments are given by the University of Muhammadiyah Kudus for facilitating the implementation of

this research so that it can run smoothly.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCES

Chen LH, Ko WC (2009). Fuzzy linear programming models for new product design using QFD with FMEA. Appl Math Model. 33(2), 533-647. doi: 10.1016/j.apm.-2007.11.029.

Dharmaraj S, Ashokkumar V, Hariharan S, Manibharathi A, Show PL, Chong CT, Ngamcharussrivichai, C (2021). The COVID-19 pandemic face mask waste: A blooming threat to the marine environment. Chemosphere 272: 1296-01. doi: 10.1016/j.chemosphere.-2021.129601.

Fadare OO, Okoffo ED (2020). Covid-19 face masks: A potential source of microplastic fibers in the environment. Sci Total Environ. 737: 140279. doi: 10.1016/j.scitotenv.2020.140279.

Korkut EN (2018). Estimations and analysis of medical waste amounts in the city of Istanbul and proposing a new approach for the estimation of future medical waste amounts. Waste Manag. 81: 168-176. doi: 10.10-16/j.wasman.2018.10.004.

Lai C-C, Shih T-P, Ko W-C, Tang HJ, Hsueh P-R (2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. Int. J. Antimicrob. Agents. 55(3), 105924. doi: 10.-1016/j.ijantimicag.2020.105924.

Masui K, Sakao T, Kobayashi M, Inaba A. (2003). Applying quality function deployment to environmentally conscious design. Int. J. Qual. Reliab. 20(1), 90-106. doi: 10.1108/02656710310453836.

Minoglou M, Gerassimidou S, Komilis D (2017). Healthcare waste generation worldwide and its dependence on socio-economic and environmental factors. Sustainability. 9(2): 220. doi: 10.3390/s-u9020220.

Ocampo LA, Labrador JJT, Jumaoas AMB, Rama AMO (2020). Integrated multiphase sustainable product design with a hybrid quality function deployment-multi-attribute decision-making (QFD-MADM) framework. Sustain. Prod. Consum. 24. 62-78. doi: 10.1016/j.spc.2020.06.013.

Otani S, Yamada S (2011). Application of QFDE on greenhouse gas reduction strategy. Int. J. Qual. Serv. 3(3): 285-303. doi: 10.11-08/17566691111182843.

Peng J, Wu X, Wang R, Li C, Zhang Q, Wei D (2020). Medical waste management practice during the 2019-2020 novel coronavirus pandemic: Experience in a general hospital. Am. J. Infect. Control. 48(8): 918–921. doi: 10.10-16/j.ajic.2020.05.035.

Prata JC, Silva ALP, Duarte AC, Rocha-Santos T (2021). Disposable over reusable face masks: Public safety or environmental disaster? Environments. 8(4): 1110. doi: 10.3390/environments8040031.

Sangkham S (2020). Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. Case Studies in Chemical and Environmental Engineering. 2, 100052. doi: 10.1016/j.cscee.-2020.100052

Torres FG, De-la-Torre GE (2021). Face mask waste generation and management during the COVID-19 pandemic: An overview and the Peruvian case. Sci. Total. 786, 147628. doi: 10.1016/j.scitotenv.2021.147628.

Vinodh S, Rathod G. (2010). Integration of ECQFD and LCA for sustainable product design. J. Clean. Prod. 18(8): 833-842. doi: 10.1080/19397038.2010.547624.

WHO (2020). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. https://www.who.-int/director-general/speeches/-detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

WHO (2021). Advice for the public: Coronavirus disease (COVID-19). https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public

Younesi M, Roghanian E (2015). A framework for sustainable product design: a hybrid fuzzy approach based on quality function deployment for environment. J. Clean. Prod. 108: 385–394.