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Adverse environmental effects of disposable face masks due to the excess usage

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ARTICLE INFO
Keywords:
COVID-19
Face mask
Marine environment
Microfibers
Toxic metals
Volatile organic compounds

ABSTRACT
The widespread use of disposable face masks as a preventative strategy to address transmission of the SARS-CoV-2 virus has been a key environmental concern since the pandemic began. This has led to an unprecedented new form of contamination from improperly disposed masks, which liberates significant amounts of heavy metals and toxic chemicals in addition to volatile organic compounds (VOCs). Therefore, this study monitored the liberation of heavy metals, VOCs, and microfibers from submerged disposable face masks at different pH (4, 7 and 12), to simulate distinct environmental conditions. Lead (3.238% ppb), cadmium (0.672 ppb) and chromium (0.786 ppb) were found in the analyzed leachates. By pyrolysis, 2,4-dimethylhept-1-ene and 4-methylheptane were identified as the VOCs produced by the samples. The chemically degraded morphology in the FESEM images provided further evidence that toxic heavy metals and volatile organic compounds had been leached from the submerged face masks, with greater degradation observed in samples submerged at pH 7 and higher. The results are seen to communicate the comparable danger of passively degrading disposable face masks and the release of micro- or nanofibers into the marine environment. The toxicity of certain heavy metals and chemicals released from discarded face masks warrants better, more robust manufacturing protocols and increased public awareness for responsible disposal to reduce the adverse impact on ecology and human health.

1. Introduction
In December 2019, coronavirus disease (COVID-19) was declared a pandemic and attracted global attention towards reducing the infection rate (Sangkham, 2020). The World Health Organization (WHO) responded by implementing infection control practices by requiring the population to wear face masks in public, among other measures, viz. sanitization of surfaces, use of alcohol-based hand sanitizer or hand-washing with soap, and restriction of movements with lockdown measures, to reduce the COVID-19’s transmission further (Nicola et al., 2020). As a result, face masks production intensified in response to the increased demand. A disposable face mask has four filter layers, a nose wire metal frame, and an ear brace. Generally, plastics or polymers make the filter layers and ear straps, while the nose wireframes are made from metallic compounds (Lee et al., 2021; Morawska and Cao, 2020). A typical filtration layer comprises three layers: (i) a fibrous inner layer, (ii) a melt-gusted filter portion in the intermediate layer, and (iii) a nonwoven water-resistant outer layer, which is sometimes colored. The face mask’s main filtering layer is constructed by electrospinning, which utilizes traditional manufacturing fibers that can either be microfibers or nanofibers, depending on the chosen particulate matter size (Dutton, 2009; Lee et al., 2021).

Considering the chemical composition and components of the face mask, excessive use and poor disposal practices may prove detrimental to the environment. The multiple plastic fibers content, mainly polypropylene, in the face mask will persist in the environment for decades.
and possibly centuries while disintegrating into smaller micro- and nanoplastics (Saliu et al., 2021). Today, millions of passively and inappropriately disposed of face masks pose potential hazards to the general population, especially when discarded into the environment or water bodies (Saliu et al., 2021). The issue is exacerbated with the increased global demand for disposable face masks because of the COVID-19 pandemic. This unfortunate global event intensified the risk of their improper disposal that causes imminent and tangible environmental pollution. Also, the regrettable low-level awareness among societies and communities on the consequences of the irresponsible disposal of face masks in many world regions has added to the issue (Prata et al., 2020; Javid et al., 2020).

While the main advantage of wearing a face mask decreases the amount of Coronavirus (or Influenza virus) being liberated to the environment by infected individuals (Prata et al., 2020; Javid et al., 2020), the public’s awareness of the practice to discard the face masks responsibly remains low. This can be inferred from the large build-up of this waste in the environment (Saliu et al., 2021). An estimated 2.4–52 billion pieces were added into the global plastic production in 2020 (Prata et al., 2020), which is projected at 368 million tons in 2019 (Plastics – the Facts 2021). This led to ~8 million tons of plastic lost from the world’s coast annually (Jambeck et al., 2015). Augmenting the population’s attitudes and behaviors to increase the community’s awareness of the looming global environmental crises brought about by the COVID-19 pandemic through science is, therefore, necessary.

As a matter of fact, relatively little is known about the chemicals, volatile organic compounds (VOCs) microfibers and nanofibers liberated from face masks. In reality, this study sought to identify and quantify the major chemicals released from face masks before and after use, in a simulated environment. In addition, the facemasks’ fibers were also assessed for their release into the environment. As the usage of face masks increases globally, the public needs to be aware of the consequences of improper disposal of face masks. The present study provides a better understanding of the type of pollution that goes into the marine environment from degrading discarded face masks. Therefore, investigation of the toxic effects that may result from the waste of face masks is highly essential.

2. Materials and methods

2.1. Sampling

A total of 100 surgical masks from two different brands designated “A” and “B” were purchased from Econave and Watson, which produced in China and Malaysia, respectively, were submitted to the tests. These face masks were stored in a cool and dry place before the analysis.

2.2. Leaching studies

Leaching of toxic metals from face mask samples was conducted as per EPA Method 1311 (Usenpa, 1995). Briefly, a mixture comprising diluted nitric acid (HNO₃) (ratio of water: HNO₃ = 9:1 (v/v) (pH 4)), sodium hydroxide (NaOH) (pH 10), and deionized water were added to the Erlenmeyer flasks containing the face masks and made up to a final volume of 250 mL. The pH of the mixture was adjusted using a pH meter pH 700 of Eutech Instruments (United Kingdom). The samples were magnetically stirred at room temperature for one day before the leachate was collected.

Another sample was prepared by replacing the face mask with only the nose metal wire. The metal wires were extracted from the face masks using scissors and cutters. Then, a diluted HNO₃ (0.1 N) and NaOH were prepared in a 50 mL volumetric flask for the leaching solution. Then, leaching solutions at pH 4 and pH 10 were prepared by the dropwise addition of 0.1 N diluted HNO₃ and NaOH into the deionized water (DW; 450 mL), and the pH was adjusted using a pH meter. An aliquot of each leaching solution (20 mL) and the sample was transferred into 100 mL Erlenmeyer flasks containing acidic (pH 4.0), neutral (pH 7.0) and alkaline (pH 10) solutions, respectively. The samples were left to magnetically stir at room temperature for one day.

2.3. Microwave digestion

Microwave digestion was performed on the nose metal wire extracted from the face mask according to the APHA standard method of analysis 3030 K (Association et al., 1912), using Perkin Elmer Microwave Sample Preparation System Titan MPS (USA). The samples were transferred into a vessel, followed by the addition of HNO₃ (5 mL) and hydrogen peroxide (H₂O₂) (2 mL). Each vessel was transferred into the rotor for microwave digestion, and the digested samples were analyzed using graphite furnace atomic absorption spectroscopy (GFAAS) to quantify the concentrations of selected metals, namely, lead (Pb), cadmium (Cd), and chromium (Cr). Each sample was triplicated and the results were presented as mean ± standard deviation.

2.4. Toxic metal analysis

The collected leachates were then tested using ICP-OES for the detection of toxic metals. For quantification (Table 1), the GFAAS was used to quantify the Pb, Cd, and Cr ions in the leachate, previously collected into a 25 mL volumetric flask and made up to the mark using 5% nitric acid to preserve the samples.

2.5. Microfiber analysis

The face masks samples were cut into approximately 1 × 1 cm pieces. Using carbon tape, each specimen was mounted on an aluminum stub, and the treated surfaces were subjected to field-emission scanning electron microscopy-EDX (Hitachi SU8020 and Oxford Instrument Xmax-N) analysis without coating at 15 kV and magnified.

2.6. Volatile organic compounds analysis

For the detection of volatile organic compounds, gas chromatography equipped with mass spectrometry (GCMS) detector was used as a small portion of the facemasks sample was heated via pyrolysis at around 120 °C in an inert environment, broken down into smaller fragments. Thus, the separation of VOCs produced by the facemask was obtained via following conditions (Table 2). Each sample was analyzed for VOCs by a Perkin Elmer Clarus 500 Gas Chromatography-Mass Spectrometry (GC-MS). All analyses were triplicated, and the results were presented as mean ± standard deviation.

2.7. Method validation

Partial validation, including linearity, precision, accuracy, and limit of detection (LOD) and limit of quantification (LOQ) were used in validating the method employed.

2.7.1. Linearity, accuracy and precision

The plotted regression line of the standard dilution series of Pb, Cd

| Table 1 | GFAAS parameters. |
|---------|------------------|
| Parameters | GFAAS |
| GFAAS Instrument Brand | Perkin Elmer |
| Model | PinAcle 900T |
| Background corrective system | Zeeman effect using Deuterium lamp |
| Graphite tube | 28 mm length x 5 mm inner diameter |
| Carrier gas | Argon |
| Radiation source | Pb-Hollow cathode lamp Cd, Cr-Electrothermal lamp |
and Cr were prepared and was shown to provide good linearity, hence mathematical estimations of the quantities of the above-said metal ions in the samples. In this study, the equations obtained for the standard solutions of Pb, Cd, and Cr, were

$$y = 0.0018x + 0.0026$$

and

$$y = 0.0406x^2 + 0.0184$$

which corresponded to $R^2 = 0.9999, 0.9999$ and $0.9987$, respectively.

The quantification accuracy refers to the closeness of measured concentration to the actual quantity in the matrix. Calibration of the analytical method using a known standard may be required to identify the accuracy of a chemical analysis measurement. The percentage recovery in this study was conducted by spiking Pb, Cd and Cr standard solutions into sample solutions. It can be calculated using Equation (1) (Vipulanandan, 2012). The recovery should be in the range of the control limit.

$$\text{Recovery (\%)} = \left( \frac{\text{Cs} - \text{Cu}}{\text{Ca}} \right) \times 100\%$$

where $\text{Cs}$ = spiked sample’s concentration, $\text{Cu}$ = unspiked sample’s concentration and $\text{Ca}$ = concentration of analyte spiked added to the sample.

Data precision refers to the consistency of the results when measurements are repeated for the same object (Styarini et al., 2011). The closer the values of measurements, the more precise of the results. Hence, precision is closely relevant to reliability. In this study, precision was evaluated by repeatability (inter-day) and reproducibility (intra-day). The face masks samples were spiked with 5 ppb of Pb and Cr, and 2 ppb of Cd, in which the assessment produced a total of seven replicates. The precision was reported as the percentage of RSD, which can be calculated using Equation (2).

$$\text{RSD} = \left( \frac{s}{\text{average}} \right) \times 100\%$$

### 2.7.2. LOD and LOQ measurements

LOD is a significant parameter when considering method validity in analytical chemistry (Saadati et al., 2013). The LOD refers to the lowest analyte concentration possibly to be identified using several known analytical techniques. However, in this study, a modified equation previously reported by Boumans (1987) was employed, as shown in Equation (3).

$$\text{LOD} = 3s$$

LOQ is another crucial parameter adapted to evaluate the lowest analyte concentration in a sample, possibly to be identified quantitatively in an experiment with sufficient certainty (Shrivastava and Gupta, 2011). Using the signal-to-noise method, the LOQ value was determined by a signal-to-noise ratio of 10:1 and calculated based on the response and slope’s standard deviation (Armbruster et al., 1994). Equation (4) expresses the LOQ measured in this study:

$$\text{LOQ} = 10s$$

### 3. Results and discussion

#### 3.1. Toxic metals in face mask

In this study, the types of toxic metals found in face mask samples were identified (Table 3). The results revealed that the face masks liberated Cd, Cr, and Pb, probably from galvanized steel. Since zinc is reportedly used in galvanized steel, there may be trace amounts of lead contaminating it (Brandi et al., 2015; Mainier et al., 2020). In addition, the high corrosion resistance and hardness of Cr make it highly popular for robust uses. It can be concluded that the toxic metals detected in this study were from the nose wire made of stainless steel. To further confirm our suspicions, microwave digestion was performed on the samples of nose metal wires extracted from the face masks and analyzed using GFAAS.

### 3.2. VOCs in face mask

Pyr-GC-MS was used for the identification of VOCs in face masks. As can be seen, the decomposition of face masks produces different types of VOCs, as shown in Table 4. From the previous study, the composition of face mask consists of different polymers, which can be found in the filtration layer, ear-loop, and the connection between the filtration layer and the ear loop. The long-chain organic molecules which make up the polymers when combusted or undergo thermal degradation typically liberate VOCs when in use and after the masks have been discarded. VOC emissions can vary over the lifespan of the polymer because polymers deteriorate due to several factors such as thermal stress and UV exposure, even under normal circumstances. The degradation of the polymer may release several substances. These monomers and oligomers with lower molecular weight tend to produce more than those with considerably larger molecular weight, some of which are hazardous in nature (Lee et al., 2021).

Since face masks’ inner layers are mostly polypropylene and polyethylene polymers, aliphatic compounds from C5 to C17 are produced when polyethylene degrades due to oxidation reactions (Lee et al., 2021). Previous studies have shown that the degradation of polyethylene liberates the following aliphatic compounds: 4-methylheptane, octadecane, tetracosane and 2, 4-dimethylhept-1-ene (Lee et al., 2021; Liu et al., 2014; Murata et al., 2022).

### Table 3

| Samples       | Toxic Metal |
|---------------|-------------|
| Face Mask A   | Pb, Cd, Cr  |
| Face Mask B   | Pb, Cd, Cr  |
3.3. Method validation of GFAAS

3.3.1. Linearity, accuracy, and precision

The linearity can be evaluated by constructing a calibration curve. A calibration curve was plotted using absorbance against the concentration of standard solutions. 1–4 ppb of Cd and 10–100 ppb of Pb and Cr were prepared as the standard solution. The average absorbance was calculated, and the linearity was good, as seen in R² = 0.999, 0.999, and 0.998 for Cd, Cr, and Pb, respectively. Recovery tests of heavy metals in the face masks samples were carried out to ensure the method’s accuracy. The data obtained in this study were within the acceptable recommended range for the recovery percentage at 80–120% (AOAC and Latimer, 2012). The results obtained mean recoveries of 100.3% for Pb, 100.6% for Cd, and 100.6% for Cr. Thus, it can be affirmed that the leaching of face masks samples showed sufficient accuracy. The precision and day-to-day repeatability calculated from these measurements expressed as RSD were for Pb, Cd, and Cr were found to be 0.61%, 2.09%, and 1.45%, respectively. From the calculation, RSD was found to be acceptable. Therefore, the technique used in this study was proven to be reproducible for all tested concentrations.

3.3.2. LOD and LOQ

In this study, a modified equation from a previous study (Boumans, 1987) was applied, using 3σ and 10σ, respectively. The method was suitable to quantify Pb, Cd, and Cr for the face mask samples using GFAAS. Table 5 shows the LOD and LOQ value detected for the Pb, Cd, and Cr metal solutions.

3.4. Analysis of toxic metals in face mask samples

3.4.1. Microwave digestion

After identifying the presence of Pb, Cd, and Cr in the leachate of the face mask samples using ICP-OES, the nose wire from face mask samples was digested to quantify the corresponding liberated metal concentrations, and the results are depicted in Table 6. As can be seen, the nose metal wire of the face mask samples contained Pb, Cd, and Cr. Both face mask samples, A and B, had high concentrations of Cr, with 69.36 ppb and 49.64 ppb, respectively. From the samples, a maximum of 69.36 ppb of Pb, 2.80 ppb of Cd, and 84.01 ppb of Cr were detected by microwave digestion. The results showed high levels of heavy metals, primarily Pb and Cr. This suggested that a substantial amount of heavy metals were utilized during the fabrication of the face mask. During the production process, face masks may contain chemical residue, including heavy metals which, if present even in trace amounts, can cause health issues in society. Even though there were only trace amounts found and far less than the permissible limits set by authorities, it must be noted that the sample came from only one face mask. In light of the fact that almost everyone in the world uses and discards a significant number of face masks each day, the numbers are expected to be substantial (Ma et al., 2021). These accumulations are certainly not present, but they will be apparent soon, if not in the next decade, then in the next few. Therefore, the study affirmed that the nose metal wires were the source of heavy metals from the face masks. The study then proceeded with the leaching of nose wire samples to analyze the concentration of toxic metals that could possibly leach from face mask samples at different pH conditions.

3.4.2. Leaching

Before the “COVID-19” outbreak, surgical face masks were widely used by the health care sector. These face masks are classified as scheduled wastes and are disposed of in a yellow bin. However, the public is now required to wear masks as a precaution against Coronavirus infections, which contribute to an emerging environmental issue where what used to be a scheduled waste is now a common household waste item (Abdullah, 2020). The general public now discards their face masks in their trash bins at home or elsewhere irresponsibly. These disposable face masks are often disposed of at municipal landfills and inevitably contribute to environmental pollution (Hasan et al., 2021). With a population of 30 million Malaysians, and assuming they throw their face masks every day, there would be at least 1 million kilograms of used face masks generated daily (Abdullah, 2020).

In this analysis, the total metal concentration of different face mask samples by leaching with neutral (pH 7), acidic (pH 4), and alkaline (pH 10) was determined. Table 7 shows the leachable heavy metals from the disposable face masks. For all three pH 4, 7 and 10, the orders of toxic metal concentrations being leached were as follows: Pb > Cd > Cr for both face mask A and B. Pb > Cd > Cr was only observed in face mask A that was submerged in a solution at pH 7. There were trace amounts of heavy metals in the solution when leaching, regardless of the solutions’ pH. The results showed that the pH has no considerable influence on the concentration of heavy metals leached from the face mask, as can be seen in the slight concentration difference between the samples submerged in all three solutions; standard deviation for Pb (0.8 in A, 0.2 in B), Cd (0.03 in A, 0.2 in B) and Cr (0.06 in A, 0.09 in B). Generally, the concentration of leached Pb was the highest (3.24 in acidic medium) compared to Cd (0.16) and Cr (0.77). This raises concerns that Pb could leach easily from the current high quantities of discarded face masks in
the environment, which have a high potential to end up in aquatic environments.

Analysis of nose metal wires showed that the concentration of Pb ranges from 1.52 ppb to 3.24 ppb. The concentration of Cd ranges from 0.150 ppb to 0.67 ppb, while concentration of Cr ranges from 0.62 ppb to 0.79 ppb. The detection of these liberated heavy metals suggested that disposable face masks are mechanically unstable as heavy metals are easily leached out (Sullivan et al., 2021). This result shows that when these face masks are discarded and make their way to landfill, the metallic ions are leached out regardless of the pH. The toxic chemicals are further concentrated in the landfill’s leachate over time. There is a high chance that the leachate could reach groundwater or seawater and contribute to a silent environmental issue if left unchecked. According to the national standard (Department of Environment, 2021), the maximum concentration of Pb, Cr, and Cd in river water were found as 5.0 ppb, 5.0 ppb, and 1.0 ppb, respectively. Therefore, this study is concerned with the health and environmental implications of these selected toxic heavy metals (Pb, Cd, and Cr) that leach from irresponsibly disposed face masks. Toxic metals leached from the face mask samples may trigger heavy metal pollution in water ecosystems, which includes rivers, oceans, and groundwater.

The identified heavy metals (Pb, Cr, and Cd) hold high potential to harm human health and the environment (Johnson et al., 2018; Meena et al., 2018; Poonkuzhali et al., 2014). Toxicological effects of Pb on humans are well recognized as carcinogenic (Elias et al., 2021; Hamsawahini et al., 2015). Additionally, this heavy metal has a bio-accumulation potential, which can cause kidney and neurological damage in humans (Lopez-Garcia et al., 2013; Hamsawahini et al., 2015). Cd poisoning is one of the world’s health issues that affects many organs and, in certain cases, causes death (Fang et al., 2014; Oskarsson et al., 2004). Bronchial asthma, lung cancer, and nasal ulceration, as well as reproductive and developmental disorders are the major health risks associated with Cr poisoning (Sullivan et al., 2021; Johnson et al., 2018; Poonkuzhali et al., 2014). These heavy metals may be conveyed from the face masks to the respiratory system via inhalation, skin contact, or saliva droplets. In recent years, there has been increasing information showing that disposable face masks release contaminants when exposed to water. It is important to note that many of the harmful chemicals discovered in this study exhibit bio-accumulative qualities. The findings from this study suggest disposable face masks may be a major source of environmental pollution during and after the Coronavirus outbreak. This massive amount produces large quantities of the above-said heavy metals, which eventually exceed existing guideline limits. Additionally, face mask users may be at risk of heavy metal exposure because there is no time-dependent exposure data available.

3.5. Analysis of microfiber in face mask samples

The microfibers from the face masks were examined via FESEM. Fig. 1 shows the FESEM images of face masks before and after the leaching of three different conditions: acidic (pH 4) (Fig. 1b), alkaline (pH 10) (Fig. 1c), and neutral (pH 7) (Fig. 1d). Under all three pH conditions (Fig. 1b–d), the face masks showed degradation and roughness as compared to Fig. 1a. The morphology of the submerged face mask appeared courser, thus indicating a pH-related degraded material (Fig. 1). It is pertinent to indicate here that all three materials of the face mask samples displayed similar patterns of morphological degradation. After one day (24 h) of leaching, some microfiber was collected after filtration. There was no evidence of deterioration of the face mask material before leaching. The results obtained were correlated with the fiber aggregates and shreds that were noticeably floating above the leachate, as shown in Fig. 2. The outer layer’s microfibers are usually intact and have a diameter of 0.65–1 mm before the leaching process. In all three pH conditions (Fig. 1), FESEM images confirmed that the masks had deteriorated after leaching.

Meanwhile, the degradation as represented by the presence of free-floating fibers observed in different leaching solutions supported the reported tendency for materials of disposable face masks to easily degrade in solution (Saliu et al., 2021) regardless of what type of water body they are in, specifically in the oceanic habitat. Normally the marine water has a pH of approximately 8.2 while the pH of most natural freshwater ranges from 6.5 to 8.0. Due to the larger surface-to-volume ratio, microfiber degrades quicker than mesofiber and microfiber (Jedruchniewicz et al., 2021). The earliest visible symptoms of polymer breakdown on the face mask materials were noted to be color changes and surface cracking. Surface cracks lead to further deterioration of the face mask’s interior, ultimately leading to embrittlement and disintegration. Literature has shown that microfibers and nanofibers are easily leached and can have a significant polluting impact on the aquatic environment. Due to this new ‘COVID-19’ norm, disposable face masks are often termed as “COVID trash”, and were identified as possible microplastics sources (Aragaw, 2020; Ma et al., 2021).

In terrestrial and aquatic species, microplastics and nanoplastics are genotoxic and cytotoxic. Pertinently, the leaching of these substances is
conceivable and a straightforward process because the additives are not bonded covalently to the polymers. Finally, these leachable compounds may enter the environment, including soil and water. As a result, the human food chain may be polluted as they will be circulated in the ecosystem and pollute humans’ daily drinking water (Aragaw, 2020; Alberto et al., 2021).

Overall, this analysis discovered that a single face mask subjected to leaching might deteriorate significantly and produce large quantities of microfibers in the ocean that are even visible to the naked eye. This proved that these particles in disposable face masks are quickly discharged. Therefore, disposable face masks can have a significant impact on the environment by releasing contaminants merely by being exposed to liquid solutions.

4. Conclusions

Since the COVID-19 pandemic has hit the world, the one-time-use surgical masks have become the standard of protection against SARS-CoV-2 infection. This has resulted in an unprecedented level of contamination from improperly disposed masks. This study indicated that the materials in face masks contain several types of toxic metals such as Cd, Cr, and Pb, as shown by the preliminary data presented in the article, which leached from the face mask samples A and B in the following order of concentration: Pb > Cr > Cd for all three tested pH 4, 7, and 12. Besides, this study revealed that the thermal decomposition of face masks produces different types of VOCs such as 4-methylheptane and 2,4-dimethylhept-1-ene. FESEM images indicated that up to 650 nm of nanofiber and microfiber was used to manufacture disposable face masks. After 24 h of leaching, microfibers and nanofibers on the surface of the face mask material were found to degrade as seen from the coarser surface compared to the unsubmerged control. Furthermore, the validation result proved that ICP-AES is suitable for the analysis of concentration of toxic metals, showing good linearity, precision, and a good percentage recovery. The LOD and LOQ also proved that the method employed in determining the concentration of toxic metals in face mask samples poses as an added advantage in detecting trace level analysis of these pollutants. Accordingly, based on the aforementioned findings, it is imperative that immediate action be taken to reduce the amount of discarded surgical masks entering the environment, including publicizing proper disposal and improvements in waste management. Scientists, governments, and industrial players should coordinate to implement environmentally friendly alternatives based on biodegradable materials during this pandemic and in the future.

Credit author statement

Alice Sim Hui Li: Conceptualization, Investigation, Data curation, Methodology, Writing - original draft. Palanivel Sathishkumar: Conceptualization, Writing - review & editing. Mohammad Luqman Selahudddeen: Investigation, Data curation, Validation, Writing - original draft. Wan M. Asyraf Wan Mahmood: Investigation, Writing - review & editing. Mohamad Hamdi Zainal-Abidin: Data curation, Writing - review & editing. Roswanira Abdul Wahab: Investigation, Writing - review & editing. Mohamad Afiq Mohamed Huri: Writing - review & editing. Faizuan Abdullah: Conceptualization, Resources, Funding acquisition, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

The authors would like to express their gratitude to the Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, for their facilities.

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