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Blended Film from PVA and *Sansevieria trifasciata* Dichloromethane Fraction for Reducing Heat Radiation from Smartphones

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Abstract

It has been reported that the lidah mertua plant (*Sansevieria trifasciata*) can absorb electromagnetic radiation from various electronic equipment. The current study aimed to make a film layer from polyvinyl alcohol (PVA) and a dichloromethane (DCM) fraction of *S. trifasciata* to reduce heat radiation from smartphones. *S. trifasciata* leaves were macerated using ethanol and partitioned with ethyl acetate, DCM, and *n*-butanol. The DCM fraction was chosen to create the film, for which PVA was also used. The blended film made from PVA and 0.02% DCM reduced heat radiation from smartphones by up to 4.4 °C starting from the first minute of use; its heat reduction remained stable until the 20^{th} minute. Based on these results, it was determined that the active compounds in the DCM fraction are closely related to saponin-type steroids.

Keywords: radiation, sansevieria trifasciata, smartphone

Introduction

Nowadays, smartphones have become essential for almost people in every type of community. According to the Kominfo report (2015) [1], more and more Indonesian households have access to cellphones, a trend which is increasing every year. In 2013, 83.5% of Indonesian households had cellphones; this number increased to 84.3% in 2015. Cellphone usage in 2015 was greater in urban areas, where 90.9% of households use cellphones; in rural regions, only 78.8% of households do.

Smartphones can install various social media applications that enable users to carry out daily activities. Popular applications include Line, WhatsApp, Facebook, Twitter, and Instagram. The convenience of smartphones lead many people to rely on them heavily, even though smartphones are associated with various types of risks from the electromagnetic radiation (EMR) they emit [2]. Smartphones can also heat up more easily than ordinary cellphones and are more vulnerable to damage. Smartphones can even overheat if used frequently. A smartphone that is too hot will adversely affect the user's health, especially that of their skin. Heat from smartphones can cause skin irritation and can even cause black spots and hyperpigmentation [3].

One way to protect smartphones from damage is to use an external protector or case. A common type of case is a sparkly liquid case equipped with some type of liquid. However, such cases only protect the smartphone from damage; they cannot reduce the heat radiated by the smartphone. According to the United State Consumer Product Safety Commission (USCPSC) 2017) [4], liquids in smartphone cases can cause burns and skin irritation. Therefore, casing materials that are safe for smartphones and users are needed; one alternative involves materials obtained from natural products, especially from plants. Plants are widely found in nature, and some plant compounds are bioactive in a variety of ways, so it is expected that casing materials from plants will be safer and more economical than synthetic polymer. One plant with potential to reduce heat radiation is the lidah mertua plant (*S. trifasciata*).

Sansevieria is a species of flowering plant in the family Asparagaceae. That plant now used predominantly as an ornamental plant. This plant gained popularity when NASA, in collaboration with Associated Landscape Contractors of America (ALCA) conducted research on it in 1989 [5]. This study reported that *Sansevieria* effectively absorbs pollutants such as formaldehyde, benzene, and trichloroethylene, so it is very suitable for indoor decoration. In addition, other reports have found that *Sansevieria* can absorb electromagnetic radiation from some electronic equipment. The juice of 15% *S. trifasciata* lorentii reduced exposure to electromagnetic radiation from a television for one hour [6]. Another study found that an anti-radiation bioscreen made from *S. trifasciata* lorentii reduced radiation from laptops by 24.45% [7]. *S. trifasciata* can also adsorb heavy metals such as Ag [8] and Pb [9]. However, no published studies have investigated the effectiveness of *Sansevieria* in reducing heat radiation from smartphones. Therefore, the current study is the first to examine the effect of *S. trifasciata* on smartphone heat radiation. The first step in making a casing involves mixing *Sansevieria* extract with polyvinyl alcohol (PVA) to create a film that can attach to the back of the smartphone.

Methods and Materials

General. *S. trifasciata* leaves were obtained from the Rangkasbitung area, Lebak-Banten, Indonesia and identified at the Biology Research Center of the Indonesian Institute of Sciences (LIPI), Cibinong, Indonesia. The scientific names of the plants were identified. The leaves were dried and mashed to 80 mesh. Ethanol, ethyl acetate, dichloromethane, and *n*-butanol were used as solvents. Thin layer chromatography (TLC) analysis was conducted using a TLC plate Kieselgel 60 GF254 0.25 mm (Merck). Film layers were formed from a glycerol plasticizer and polyvinyl alcohol (PVA) with a molecular weight of 3000 g/mol. The molecular structure was predicted via liquid chromatography-mass spectrometry (LC-MS) analysis using Acquity ultra performance liquid chromatography (UPLC) and a Xevo G2-S Q-TOF mass spectrophotometer C-18 column. A Thermophile Array 81 (TPA81) equipped with the PLX-DAQ program was used to measure the temperature sensors.

Extraction and fractionation. Dried, powdered *S. trifasciata* (600 g) leaves were macerated with 96% (4.8 L) ethanol for 24 h at room temperature, and the ethanol extract was evaporated under reduced pressure to create a semisolid residue (105 g). The residue was dissolved in 500 mL of distilled water and stirred until homogenous. This mixture was partitioned into ethyl acetate, dichloromethane, and *n*-butanol fractions at a 1:1 ratio. The DCM fraction (13.46 g) was chosen for the film layers because it had more mass and a simpler spot than other fractions. The molecular weight and fragments of the DCM fraction were determined using LC-MS.

Preparation of blended film and application on smartphone. PVA 5% was prepared under a controlled temperature of 90 °C. The DCM fraction was made in three concentrations: 0.01%, 0.02%, and 0.03%. All solutions were left to cool at room temperature. The PVA and DCM fraction were blended at a 1:1 ratio using hot magnetic stirrers for 10 minutes [10]. After the solution was homogenous, it was poured onto a glass plate and dried in the oven for 15 h at 60 °C, then left under ambient temperature. The dried films were slowly peeled off the glass [11].

The measurement process was conducted in a closed box when the outside ambient temperature was 27 °C. Increasing the temperature of the smartphone increases the temperature of the surrounding environment in the box. The smartphone's heat was measured by Thermophile Array 81 (TPA81) temperature sensors equipped with the PLX-DAQ program. Four different treatments were used on the smartphones: no film layer, a PVA film, a commercial case, and a blended PVA/DCM film with various concentrations. The heat of all smartphones was measured at the same time, in the same room, and at the same humidity level. The temperature of all treated smartphones was measured while the phone was used to browse the internet for 20 minutes. Heat was measured every minute from one to 20 minutes.

Results and Discussion

Absorption of heat radiation on smartphones was measured using a TPA81 temperature sensor equipped with the PLX-DAQ program. TPA81 can detect heat radiation emitted by infrared light without touching the heat source; it can measure heat radiation at a distance of two meters and is not affected by light in the room [12]. TPA81 can detect heat radiation at eight points (Figure 1) simultaneously since there are 8 pieces thermopile sensors in TPA8, each of which has measurement angle of 5.12^0 toward horizontal axis and 6^0 towards the vertical axis [13].

The temperatures on the treated smartphones were measured at eight points, but T1 showed more significant differences than the other points. The temperature measurements at T1 are shown in Figure 2. The PVA film had no effect on smartphone temperature, as the temperature continued to increase until the end of the measurement period. The other treatments provided a quite sharp early decrease in temperature up to the fifth minute. The PVA/0.02% DCM fraction blended film reduced heat radiation the most in the first two minutes, reducing the temperature by 4.4 °C. The PVA/0.03% DCM fraction and PVA/0.01% DCM fraction blended films also decreased the temperature significantly in the first two minutes, by 3.8 °C and 1.5 °C, respectively. Overall, the blended PVA/DCM fraction films decreased the temperature of the smartphones during the 20-minute measurement period, while the untreated smartphone and the smartphone with a commercial silicon casing only exhibited meaningful decreases in temperature until the 10^{th} min, after which they began to heat up.

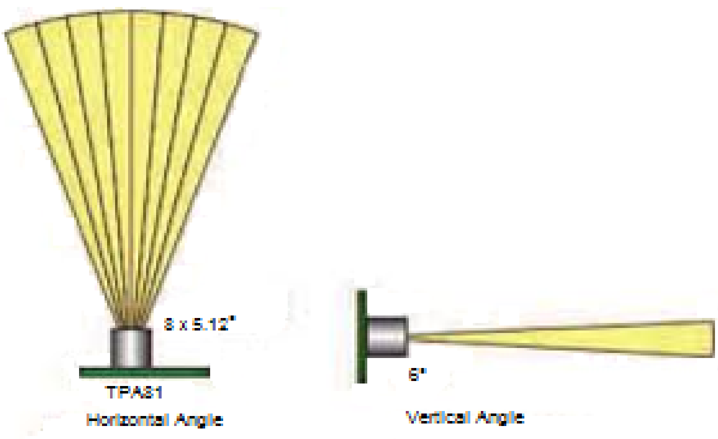


Figure 1. The Viewpoints for Measuring Heat Radiation by TPA81

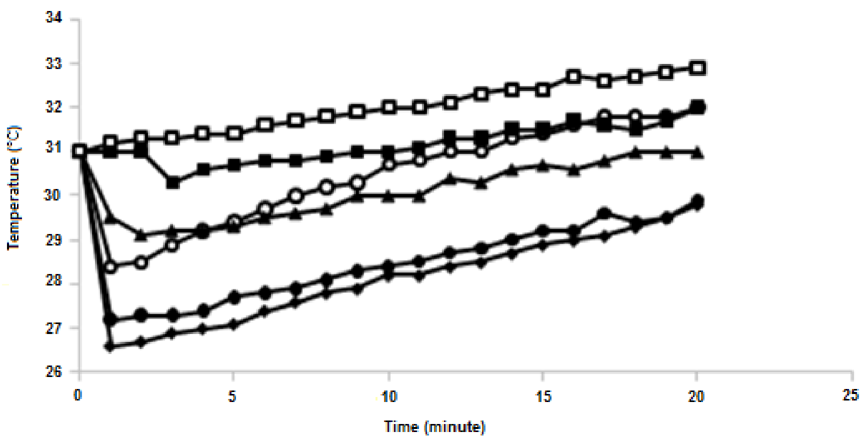


Figure 2. Smartphone Heat Measurement Results: Smartphone without Film Layer (-○-), Smartphone with PVA 5% Film (-□-), Smartphone with Commercial Casing (-■-), Smartphone with Blended Film PVA/0.01% DCM Fraction (-▲-), Smartphone with Blended Film PVA/0.02% DCM Fraction (-♦-), and Smartphone with Blended Film PVA/0.03% DCM Fraction (-●-)

Therefore, it can be assumed that the compounds contained in the DCM fraction of *S. trifasciata* leaves reduced the heat radiation released by the smartphones. The DCM fraction used here still contains several compounds; further purification is needed to identify the exact structure of the compound responsible for this heat reduction. A preliminary determination based on the LC-MS chromatogram of the fraction (Figure 3) shows four dominant peaks at 17.91, 16.37, 15.79, and 6.68 minutes, hereinafter referred to as peaks **1**, **2**, **3**, and **4.** The mass spectrum analysis of peak **1** shows high similarity (99.83%) to the molecular formula $C_{28}H_{47}O_3$ and *m/z* $[M–H]^-$ 431.3530. Based on a literature review, the suspected compound is 24-*epi*-cathasterone or (3β, 5α, 22*S*)-3,22-dihydroxyergostan-6-one (Figure 4). Peak **1** is a saponin group compound; based on its aglycone group, the compound includes a saponin-type steroid.

The peak mass spectra **2**, **3**, and **4** show absorption at the base peak *m/z* $[M–H]^-$ 435.2188, 419.3174, and 391.2836, respectively. These compounds are also members of the saponin steroid group with the proposed molecular formulas of $C_{27}H_{31}O_5$, $C_{26}H_{44}O_4$, and $C_{24}H_{39}O_4$. The differences lie in the functional groups at C-3 and C-4 and in the substituents in R1, R2, R3, and R4, as shown in Table 1. Therefore, based on the LC-MS analysis, the saponin steroid group in the DCM fraction of *S. trifasciata* leaves are expected to be responsible for absorbing heat from the smartphones. No previous study has reported on the activity of steroids as absorbers of heat radiation. Steroidal saponin compounds have generally been reported for their bioactivity, which include antifungal [14], antitumor [15], immunotropic [16], and anticancer [17] activities. Therefore, this is the first study that has reported that steroidal saponins can reduce heat radiation.

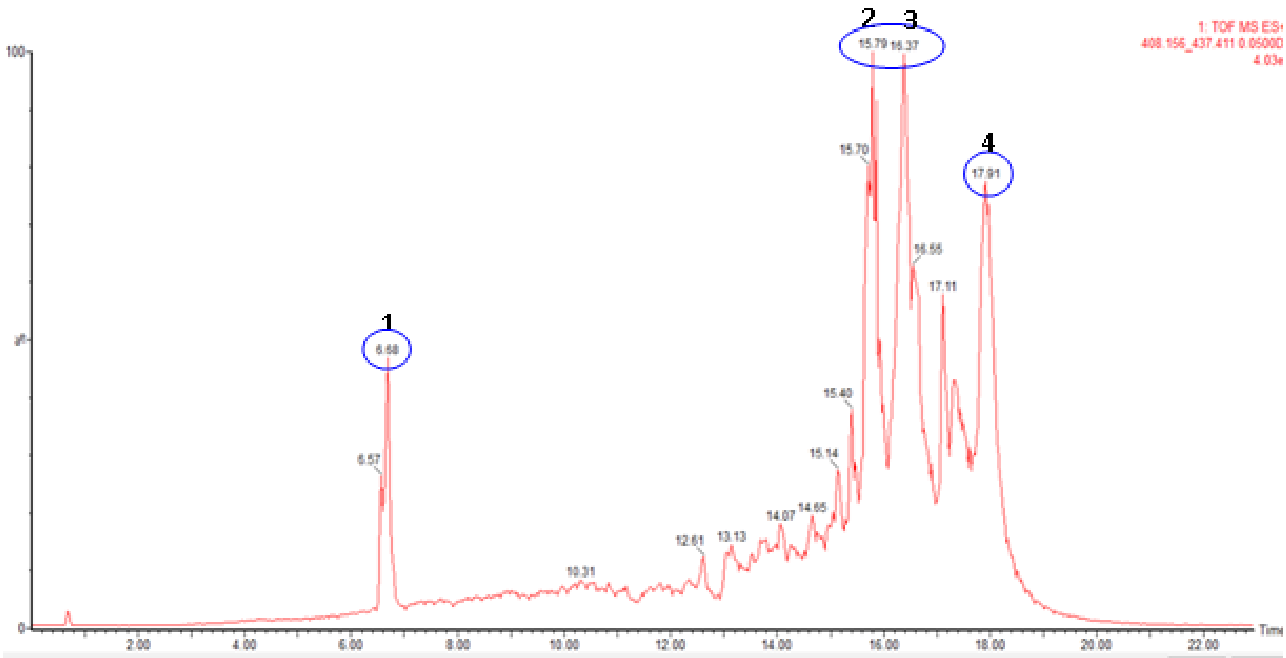


Figure 3. LC-MS Chromatogram of DCM Fraction

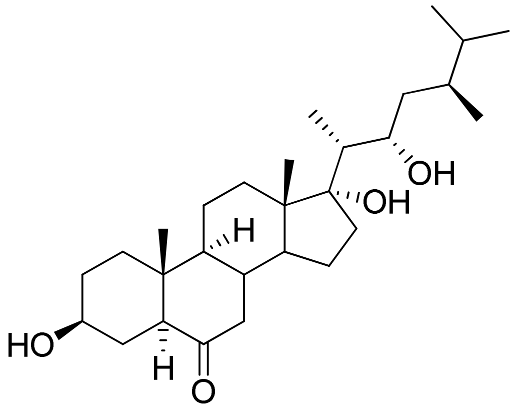
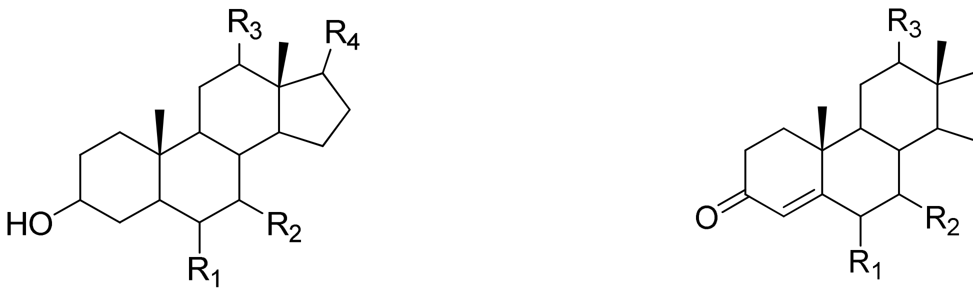


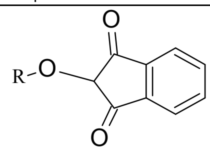
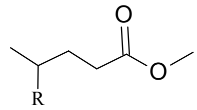
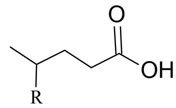
Figure 4. Approximate Structure of Peak 1



(a) (b)

Figure 5. The Basic Structure of the Compound at Peak 2 (a); 3 and 4 (b)

Table 1. Differences in the Structure of Peaks 2, 3, and 4

Peak	Suspected compound	R_2	R_3	R_4
2	2-hydroxy-2-{[8α,10α,13α,14β,17α]-3-oxoestr-4-en-17-il]oxi}-1H-indene-1,3(2H)-dion	-H	-H	
3	methyl (3α-5β-12α)-3-hydroxy-12-methoxykolan-24-oate	-H	-OCH_3	
4	(3α-5β-7β)-3,7-dihydroxykolan-24-oic acid	-OH	-H	

Conclusion

In this study, the blended film PVA/DCM fraction of *S. trifasciata* reduced the heat radiation emitted by smartphones for 20 minutes. The best result occurred with the blended film made from PVA and a 0.02% DCM fraction, which decreased heat radiation by 4.4 °C in the first minute and 4.3 °C in the second. This film reduced heat more effectively than the commercial case used in the study. The compound suspected to be involved in decreasing heat radiation is the steroidal saponin group. Further research is needed to identify the pure compounds involved in this activity and the heat reduction measurements of those pure compounds in order to determine which compound is responsible for the decrease in heat radiation.

Acknowledgments

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