INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 8, Issue 3, July-September 2017: 401-410 www.ijcs.uaic.ro

# THE EFFECTIVENESS OF *SANSEVIERIA TRIFASCIATA* CUTICLE ISOLATION TO PROTECT THE MATERIALS OF CULTURAL HERITAGE OBJECT AGAINST WEATHERING CAUSED BY RAINWATER

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***Abstract***

*This research discusses the use of Sansevieria trifasciata as a natural water repellent for andesite and brick materials. Most of the outdoor cultural heritage objects are made of andesite and brick materials and are subject to disaggregation caused by rainwater. The decision to choose to isolate the cuticle of Sansevieria trifasciata based on knowledge that cuticle on plant can become water repellent on the plant and its availability is abundant in Indonesia. The authors isolated the cuticle of Sansevieria trifasciata for coating surface of andesite and brick materials and created an alternative solution by using natural substance against weathering of cultural heritage objects. The result shows that the cuticle isolation can effectively prevent the absorption of water on andesite but it cannot prevent absorption of the brick material. Although it's effective to reduce water absorption for andesite, cuticle isolation has changed the surface colour of andesite and brick materials. Referring to the principles of cultural heritage management, cuticle isolation has changed the authenticity of the material. Therefore, in the future, more research is needed to achieve the transparent color of cuticle isolation before being applied to cultural heritage objects.*

***Keywords:*** *Andesite; Brick; Coated; Cuticle; Rainwater; Sansevieria trifasciata, Weathering*

## Introduction

Indonesia is a country with abundant cultural heritage. It also has a high rainfall level [1]. Indonesia needs to preserve and prevent damage of the cultural heritage due to the effect of nature, especially weathering caused by rainwater. The effects of rain and sun made outdoor cultural heritage materials susceptible to corrosion [2]. Corrosion has led to the appearance of microorganisms and has brought the cultural heritage to critical condition [3].

In 2013, the Directorate of Cultural Heritage Preservation and Museums showed that the number of cultural heritage units in Indonesia reached 66.513, of which 54.398 are moveable and 12.115 immovable. From that database, 1.895 units of cultural heritage have been preserved. A number of 643 units of cultural heritage have been restored, and 146 units conserved [4]. However, the data show that a small persentage of cultural heritage units have been preserved. Therefore, a more serious safeguard is needed for cultural heritage, especially for the cultural heritage in outdoor areas, since this category is more susceptible to weathering.

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Nowadays, the use of water repellents to protect the Indonesian cultural heritage from weathering caused by rainwater relies on synthetic chemicals [5]. The synthetic chemicals turned out to have had a negative impact on the cultural heritage, such as in the case of monuments made of stone which became drier, or those made of brick, which witnessed peeling of the outer surfaces [5]. Therefore, a breakthrough is needed in the protection of the cultural heritage from weathering caused by rainwater, that consider both the secure for the building materials and the environment [6-8].

The 2007 UNESCO Convention endorsed reducing the use of synthetic chemicals, in order to limit the damaging impact on cultural heritage. UNESCO also recommended the use of natural substances that have no negative effect [9]. Based on suggestion, the authors make an experiment to create a natural water repellent substance that prevents water absorption and capillarity into cultural heritage objects. The natural substance is the cuticle of *Sansevieria trifasciata* plant.

The cuticle is a layer of cells that are in the top layer of epidermis that is a smooth surface, rough, wavy or grooved. Cuticle has four kinds of layers, namely wax, cutin, pectin, and mixtures cutin-cellulose-pectin. The wax coating that surrounds the skin is a mixture of long-chain hydrocarbons, ketones, fatty acids, and esters. Cuticle also contains cutan, which is a compound of hydrocarbon nonpolimer. Cuticle membrane impregnated with a waxy cuticle and covered with epicuticular wax is a mixture of aliphatic hydrophobic compound that is hydrocarbon long chain in the range $C_{16}$ to $C_{36}$ [10]. The composition of cuticle compounds can reduce evaporation, provide a water permeability barrier on plant surfaces, protecting agains dirt, microorganisms and contamination of plant tissue [10]. The characteristics of the cuticle vary across the plant species. The cuticle with a high ability to reduce evaporation, water permeability barrier and inhibit the growth of bacteria is the cuticle of xerophyte plants [11].

For this research, the authors has chosen *Sansevieria trifasciata*, since this species is abundant in Indonesia and has a very good ability to hold the rate of water. It was the function of the cuticle which inspired the authors to isolate it and make an experiment in the form of testing it on andesite and brick or terracota. The andesite and brick materials were selected for the experiment because these materials were commonly used as material for artefacts such as statues and buildings located in outdoor areas and still lacking an effective protection. Based on these problems, the authors examine how effective is the isolation of *Sansevieria trifasciata* cuticle for the protection of the cultural heritage against weathering caused by rainwater.

## Experimental Part

Three phases were set for coating cultural heritage objects with natural coating from cuticle isolate:

1. *Phase of Isolation of Cuticle Compounds.*

   In this research, the isolation method used soxhletation. In soxletation, the cuticle's compound will be separated from the Sansevieria trifasciata at quite high temperatures, in order to evaporate and dissolve the cuticle's compound from solid form into powder [12], and then coat it at the andesite and brick surface. In this research, Petroleum Ether was used as a solvent cuticle with a ratio of 2:1 [13]. Petroleum Ether solvent was chosen because a comparison with other solvents by maceration methods — including Hexane, Toluene, Thinner, Ethyl Acetate, Chloroform and Petroleum Ether — was done previously. Of the six solvents, Petroleum Ether is the most soluble one for cuticle by maceration methods. Experiment of cuticle isolation with soxhletation method, provided 4,000 grams of *Sansevieria trifasciata* then isolated by soxhletation method using Petroleum Ether at 80° C for 30 cycles to get optimal results [12]. After isolation, the next process is distillation to purify cuticle.

2. *Phase of Testing on Andesite and Brick Materials.*
   This phase carried out physical test using the Aging Test method. Aging Test is a method to accelerate the aging process of objects so that the extent of materials on which can be used can be predicted [3]. These method is commonly used to know the effect of substance on the cultural heritage so it can predicted whether the materials have a positive or negative effect to cultural heritage in long term. Aging test method in this research consisted of physical object test with parameters of density granules, saturated water content, porosity, and hygroscopic content [14]. The steps of method are:
   - Make 6 pieces of andesite and brick cubes each measuring 5×5×5cm [15]. Both of samples have similar physical and chemical characters with cultural heritage [16]. Andesite and brick from experiment was selected from the property of Borobudur Conservation Laboratory that has been identified the resemblance of physical and chemical characters with andesite in Borobudur Temple and named 1st andesite to 6th andesite and so brick also named 1st brick to 6th brick.
   - Classified andesite and brick materials into 4 parts.
   - The first part is andesite 1st and brick 1st as a control sample or uncoat by cuticle but carried out to Aging Test treatment. The purpose is to find differences materials which cuticle coated and cuticle uncoated.
   - The second part is 2nd andesite and 2nd brick carried out to physical test. The purpose is to know the difference between physical influence on andesite and brick materials before and after Aging Test treatment.
   - The third part is 3rd, 4th, 5th andesite and 3rd, 4th, 5th brick coated by cuticle isolation that blend with Petroleum Ether.
   - The fourth part is 6th andesite and 6th brick oiled by Petroleum Ether. The aim is to examine differences of water capillarity and compared with other stone material.
   - Furthermore, dry the andesites and bricks for 24 hours to know the weight dry of materials in indoor area.
   - After drying, the next is Aging Test of materials for 10 cycles which include:
     a. Dried (put in the oven at 100° C) for 24 hours and be pondered.
     b. Saturated for 24 hours and be pondered.
     c. Put in outdoor for 24 hours and be pondered.
   - When reaching 10 cycles, the tables and charts data for interpretation will be obtained.

   Experiment by method of Aging Test in laboratory that use repeatedly test until 10 cycles aims to shorten the time of the research but it is representative to condition in outdoor area in a long time. One cycle of Aging Test is similar to material in outdoor about more than 1 year [17].
3. *Phase of Analysis Surface of andesite and Brick Material.*
   In order to know the different surface section of brick and andesite before and after coated by cuticle, Scanning Electron Microscop (SEM) and Stereoscope display were used. The use of SEM in this research is to know the surface section of the cuticle [5] whereas the use of Stereoscope is to observe the surface of brick and andesite materials [9] and compare the pore differences in andesites and bricks which were coated and uncoated with cuticle isolate.

## Result and Discussion

*Analysis of Sansevieria Trifasciata Cuticle Isolate*

4,000 grams of Sansevieria trifasciata have been provided, that after isolated become 4 grams of powder. It means, to get the cuticle isolation to be applied in this experiment is 1:1.000 or 0.1% of total number of *Sansevieria trifasciata*.

*Analysis of Aging Test*

After the cuticle isolation coated to bricks and andesites, the andesite material changed from black to grey. The color brick materials have changed. From red into inclined to white after coated with cuticle isolation.

Cuticle isolation that was tested by Aging Test and physical tests to materials of andesite and brick have different data. Data of Aging Test shows that the percentage of water that permeated into the pores of andesite material are significantly different. The average of water that permeated into the pores of cuticle-coated andesite was from 5% to 6.5%, and the data of water percentage cycle on Aging Test incline to decrease in each cycle, whereas amount of water which permeated the pores of andesite cuticle uncoated is 7.9% to 11.1% and the percentage of water cycle data incline to fluctuate (Fig. 1).

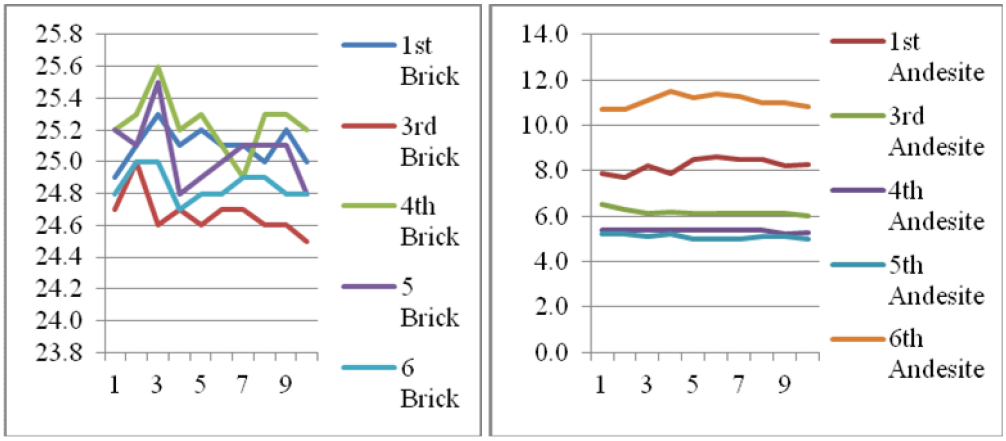


**Fig. 1.** Percentage of water permeate into bricks and andesites

The average percentage of water that permeated into the pores of andesite with cuticle-isolate coating is 5.75%. The percentage of water that permeate into the pores of the uncoated andesite is 9.55%. The difference of average percentage of water that permeated into coated and uncoated andesite is 39.79%. These data show that the percentage of water that permeated into the pores of the uncoated andesite is much higher, and accordingly, that cuticle isolate coating can play a role in reducing water capillarity on andesite materials.

On the brick material, the data of Aging Test shows that the percentage of water that permeated into the pores did not show a significant difference. The average water permeating to the brick coated with cuticle isolate is 24.5–25.6%, and the percentage of water on the Aging Test tends to fluctuate in each cycle. The percentage of water that permeated the pores of the uncoated bricks is 25.3–24.7%, and the percentage of water tends to fluctuate in each cycle. These data indicate that coating with cuticle isolate does not reduce water capillarity in brick materials.

The tests show that water more permeate into brick pores than andesite pores. This is due to the higher hygroscopy of brick compared to andesite. The cuticle isolate performed differently according to the material it coated. In andesite, the cuticle isolate can diminish water absorption, whereas in the case of brick it is ineffective.

The differences of water percentages which absorb into the pores of andesite also affects to the data of physical test. Variable data of physical test used in this research include density, saturated water content, content of hygroscopic and porosity. Based on the data from the calculation, density of andesite which coated by cuticle isolation is more dense than the density of uncoated andesite.

*Differences with brick material data.*

On the brick material, the density of each brick is the same between coated or uncoated by cuticle isolation. Density of andesite before coating ( brick 2$^{nd}$ ) was 2.1 g / cm$^3$. After coating (3rd, 4th, 5th stone) and performing Aging Test for 10 cycles it showed a change in density from 2.1 g / cm$^3$ to 2.2 g / cm$^3$ and 2.3 g / cm , becoming denser and the ratio was 4.8% until 9.5%.

In addition, percentage and ratio density of brick has no difference. Brick material before coated by cuticle isolation (brick 2nd) is 1.5 g / cm$^3$. After coated by cuticle isolation and performing Aging Test, brick material has not changed the value of 1.5 g / cm$^3$. Similarly, the value of density is 2.3 and the percentage ratio of density is 0%. It means that the value of density does not change. The data shows that the cuticle isolation can affect the density of andesite whereas the brick material is not affected (Fig. 2.).

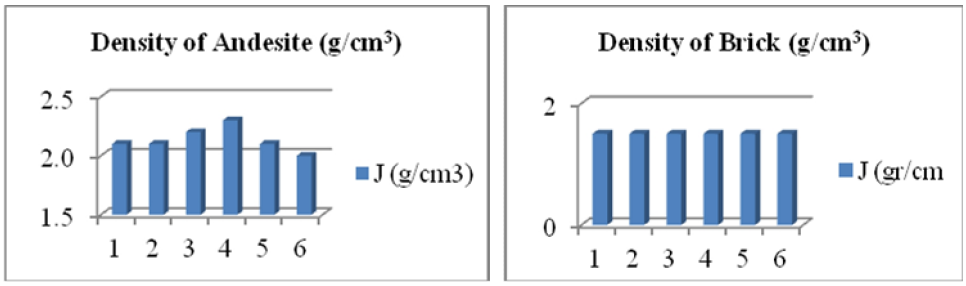


**Fig. 2.** Comparison of density of andesites and bricks

Saturated water content on andesite material which is coated by cuticle isolation is lower than the saturated water content on andesite uncoated cuticle isolation. These case shows that cuticle isolation have an effect to reduce water content on andesite. Otherwise, on brick materials have no effect to reduce saturated water content. The highest saturated water content is brick material which is coated by cuticle isolation (4th and 5th bricks) although only little difference with uncoated brick material (Fig. 3).

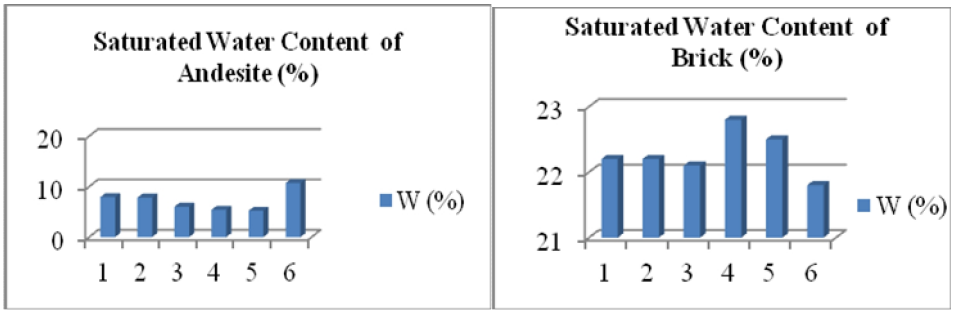


**Fig. 3.** Comparison of Saturated Water Conten on Andesites and Bricks

Based on respect to porosity, that of the coated andesite material is lower than uncoated andesite. These case shows that andesite coated by cuticle isolation is denser and stronger than the material of uncoated andesite. Otherwise, the brick material which is coated by cuticle isolation is higher than uncoated brick although there is no significant difference. From the data it can conclude that the cuticle isolate has no effect to reduce the porosity of bricks (Fig. 4).

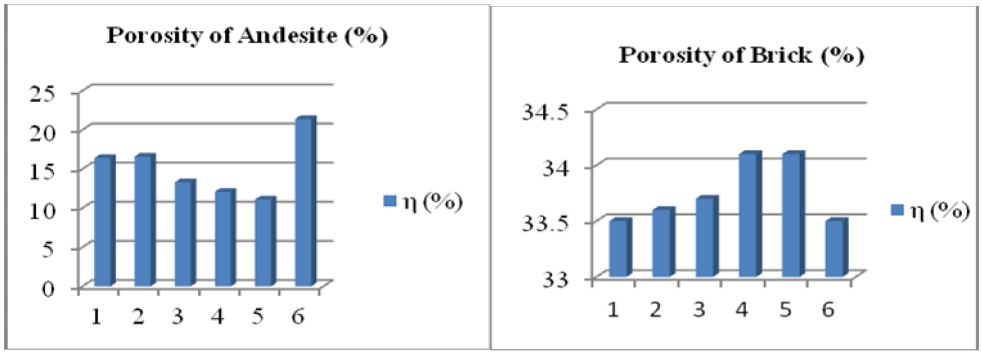


**Fig. 4.** Comparison of Porosity of Andesites and Bricks

The content of hygroscopy on coated andesite is lower value than uncoated andesite. The data show that the cuticle isolate can reduce the absorption of water in the material andesite. Differences with data on the brick. On the brick materials, the percentage of hygroscopic only have a little difference around 19.4% to 20.1%. The data shows that the cuticle isolation can not reduce absorption of water on the brick material (Fig. 5).

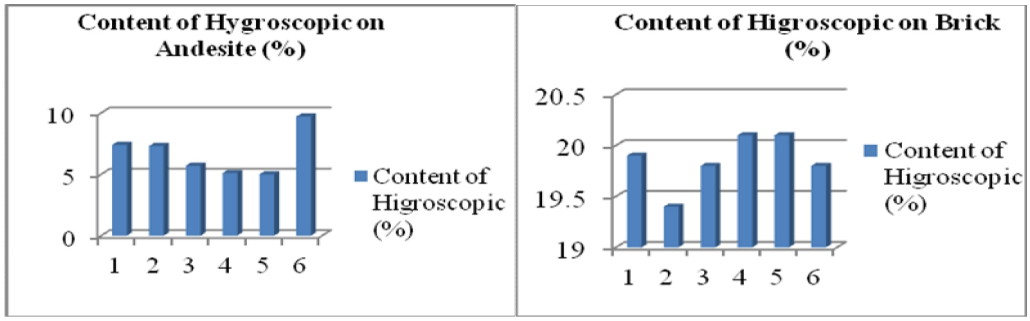


**Fig. 5.** Comparison of Content of Hygroscopic on Andesites and Bricks

Therefore, it can be concluded that the cuticle isolation have effect to reduce the water content wich permeate to the pores of andesite material whereas the brick materials have no effect to reduce the water content. Table 1 presents a comparison regarding the physical tests between andesite and brick.

**Table 1.** Comparison of Physical Test on Andesite and Brick

| | Andesit Sample | | Brick Sample | |
|---|---|---|---|---|
| | Coated | Uncoated | Coated | Uncoated |
| *Aging Test* | • Infiltration of water is lower<br>• Inclined to decrease | • Infiltration of water is higher<br>• Fluctuation | • Almost same<br>• Fluctuation | • Almost same<br>• Fluctuation |
| Density | • Density has changed | | • Density is permanent | |
| Saturated Water Content | • Lower | • Higher | • Higher with litte differences | Lower with little difference |
| Content of Hygroscopic | • Lower | • Higher | • Higher with litte differences | Lower with little difference |
| Porosity | • Lower | • Higher | • Almost same | Almost same |
| Conclution | Influential | | Not Influential | |

*SEM and Stereoscope analysis*

Data of SEM show that the cuticle has a such as dragnet measuring in diameter between 2.1 microns to 19.8 microns. The function of dragnet is to restrain the rate of water. After cuticle has isolated, the cuticle has changed into a powder. These cuticle powder that coating to material of andesite and brick.

The display of binocular microscope shows that andesite and brick pores after Aging Test and coated by cuticle isolation have different surface of pores which uncoated. Display of uncoated andesite and brick surfaces by cuticle isolation show many pores whereas the display of coated andesite and brick surface by cuticle isolation show that most of surface has been covered by cuticle isolation and there are still some pores that have not been covered (Fig. 6-9).

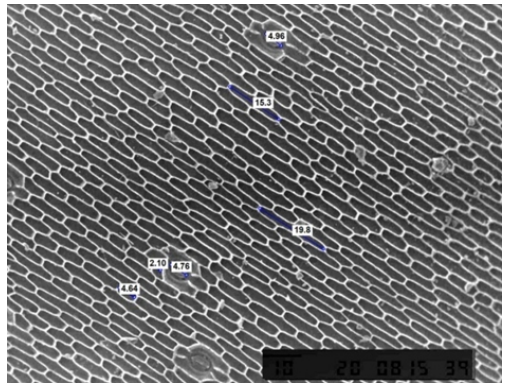


**Fig. 6.** Structure of Cuticle Surface


**Fig. 7**. Comparison of Coated and Uncoated Brick

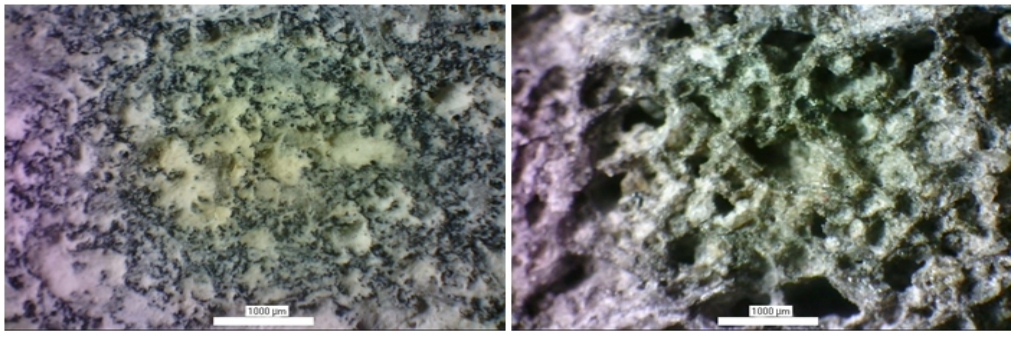


**Fig. 8.** Comparison of Coated and Uncoated Andesit

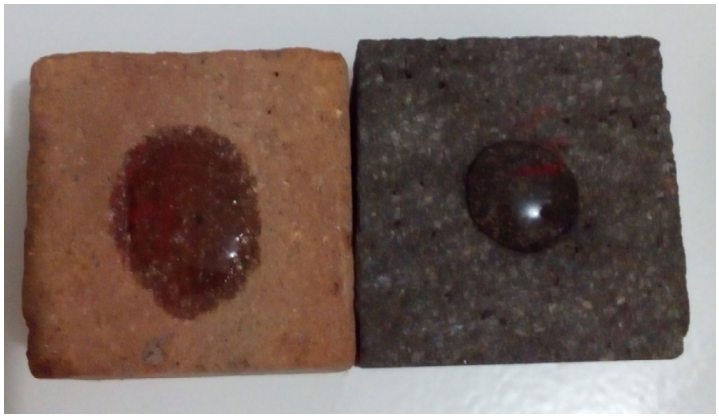

**Fig. 9.** Comparison cuticle isolation on andesite and brick

## Conclusion

The result of research show that the cuticle isolate has the ability to reduce water infiltration on andesite, while in the case of brick material there is no such effect. Nevertheless, there are still some shortcomings in this research, including:

- A quantity of 4000 grams of Sansevieria trifasciatais necessary to produce 4 grams of isolate, meaning that to get the cuticle isolate to be applied in this experiment is 1: 1,000 or 0.1% from total number of *Sansevieria trifasciata*. This indicates that the cuticle isolation obtained is very little. Therefore, further research about the method of isolation which can produce more of cuticle isolation is needed.
- From the Stereoscope display can be seen that on the material andesite and brick that coated by cuticle isolation there are some pores that have not been covered by cuticle powder. This case shows that the method of coating is less precise, requiring a careful coating method.
- Only andesites and bricks have done an experiment about water repellent from cuticle isolation whereas other material have not done an experiment. Therefore, trying experiment to the other materials is important.
- Solvent of cuticle isolation use the Petroleum Ether that is a petroleum distillate [18]. Further research is needed to know the safety of Petroleum Ether solvent for cultural heritage and environment in a long term.
- Cuticle isolation which tested on andesite and brick material have an impact to change the color of surface material. Referring to the principles of conservation with attention on archaeological value, the use of extract of cuticle would change authenticity of material [19]. Therefore, further research is needed to produce transparent cuticle isolate applying on cultural heritage objects.
- Isolation of cuticle does not have knowledge about reversible, effective, efficient and safe for cultural heritage [16]. More research is needed to examine the suitability about using the isolation of cuticle and technical principles regarding the preservation of cultural heritage.

**Acknowledgements**

This research is part of author's thesis. Authors gratefully to Department of Archaeology, University of Gadjah Mada. I am Thankful to my Thesis Supervisor and Staff of Borobudur Conservation Office especially Mr. Marsis Sutopo, Mr. Iskandar Mulia Siregar, Mr. Nahar Cahyandaru, Ms. Ary Swastikawati, Mr. Widyo, Mr. Yudhi, Ms. Yuyun, Mr. Liliek, Mr. Gugun, Mr. Rony, Mr. Toso, and Mr. Ahmad who have helped in this research.

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*Received: October 31, 2016*
*Accepted: August 20, 2017*