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Research Paper

Study of mosquito attractants for photo catalytic mosquito trap

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Abstract

Photo catalytic mosquito trap is made of TiO_2-Activated Carbon (AC) with a certain composition of AC. Research concerns on the heat spectrum which is produced by combination process of existing CO_2 and humid air. The purpose of performance testing is to observe capability of this device in trapping mosquitoes related to the air temperature profile for heat spectrum is play important role for attracting mosquitoes. Result shows photo catalytic mosquito trap is more effective than devices which only consist of UV light or stream of CO_2 and the humid air. A number of mosquitoes trapped by the photo catalyst coated panel configuration and UV lamps were lit proved far more effective because the heat production from recombination process. A little difference in temperature can be detected by mosquito.

Keywords: *Photo Catalytic, Mosquito, Recombination*.

1. Introduction

In a tropical country like Indonesia, the growth of mosquitoes is extremely rapid. Mosquitoes can transmit in various types of diseases to human. Global warming increases surrounding air temperature which is also suitable for mosquitoes' propagation. Currently, the number of mosquitoes has reached 5 times the human population [1].
Anti-mosquito products are available in the market. Although proven effective to kill and drive out mosquitoes, it is dangerous for human health. Mosquito spray, gas, and electric have active ingredients such as organophospate group banned that are carcinogenic.
A new environmentally friendly solution can be used as mosquito trap is a photo catalytic process, utilizes energy photons and TiO_2 as potentially catalyst. Photo catalytic process is able to degrade various pollutants of air space and produce CO_2 and water vapor from the process and heat spectrum from recombination process. UV light (as source of photon energy) also attracts mosquitoes. These reaction scan be used as attractant for mosquito come into this mosquito trap. In this trap, deceived mosquitoes will be attracted to become closer, trapped, and death of dehydration.
The photo catalytic device based mosquito traps that have been certified international patent no. Domestic PCT/KR/01-00427 and Korean Patent No. 43,847 in 2001. Although the devices available mosquito traps have been proved effective to trap and kill mosquitoes, these devices have various shortcomings such as relatively expensive price, availability must be imported from abroad, and especially the claim that these mosquito trap devices can degrade the air pollutants that need to be questioned again because form design device that made it less effective. One technique that allows the increase rate of indoor air pollutants degradation in order to get CO_2 and water vapor as mosquito attractants is to use adsorbent (activated carbon) as a buffer photo catalyst TiO_2[2]. Addition of activated carbon (15% composition weight) is the most optimum result and effective in catching mosquitoes. It is close with 13% composition weight of activated carbon using for pollutant reduction. [3]
Comparison study for commercial mosquito trap shows that Mosquito Magnet Pro and Mosquito Magnet Liberty mosquito trap and Bug Eater are better. It was assumed that CO_2 from those devices more attractive to mosquitoes [4].
Heat spectrum is also play important role for attracting mosquitoes. Temperature will significantly affect the activity of mosquitoes. Higher temperature showed that mosquitoes are more active and more attractive for mosquitoes to come closer. [5].

In this study, the mechanism of mosquitoes attracting is based on the hypothesis that there are various mosquito attractant such as CO_2, water vapor and heat of the spectrum will be studied. By knowing the most dominant mosquito attractor factor then the effectiveness of the tool in attracting mosquitoes can be improved.

2. Experimental

2.1. Device design

Figure 1 shows the construction of mosquito trap device for a configuration based on the various considerations mentioned previously. It can be seen there are 2 lamps UV-A arranged on the upper side.

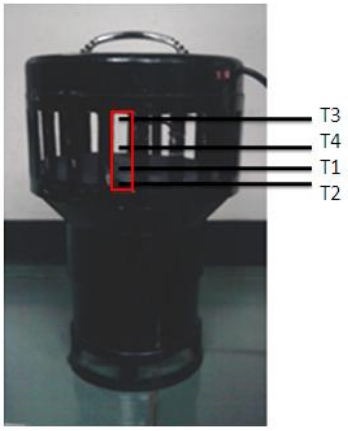

Fig. 1: Photo catalytic mosquito trap

In addition, the placement of the fan blade is in the middle of the tube for focus on trapping mosquitoes. Around the fan blade, installed a buffer that can serve as a panel of TiO_2. At the bottom of the screen there is a device that serves as a place for air discharge and mosquito net barrier to exit. Thermometers are placed on four positions so it can be . T1 is temperature in panel aluminum, T_2 is temperature in the upper side of air lattice, T3 is temperature in the lower side of air lattice and T4 is temperature outside mosquito trap which 3 cm in front of air lattice.

2.2. Photo catalyst adsorbent coating

There are two considerations for selection of coating methods, (1) method of making an attached film to the substrate without any transparency effect, (2) type of buffer panels made of aluminum. In this study, we choose the film preparation using direct TiO_2 powder spray coating methods. Steps for composite coating are as follows:
First, treatment of activated carbon (AC) by washing and then drying it in furnace at a temperature of 250°C for 1 hour and followed by grinding them into a fine powder of AC. The AC powder then sized for 0.125mm sieve
Second, the suspension formation of TiO_2-AC by dissolving TiO_2 powder mixture into 100 mL of demineralized water and sonicating for 10 minutes. AC added to 1 mL of TEOS (tetraethyl orthosilicate) solution into the former solution then sonicating for 20 minutes more. The clean panel covered with aceton and TiO_2 suspension sprayed into the aluminium area panels using a spray gun and dried panel with a hair dryer first. Repeating the two later steps 5 times until a uniform layer of aluminum on panel formed. The last, drying the coated panel by using a programmable oven at a temperature of 150°C for 1 hour.

2.3. Device performance test

To know the performance for each trap used in experiment, blank test is done. For first day, trap A tested by using panel with composite and after that following by CO_2 and water vapor and trap B only tested by using panel with composite. The next day, trap A is tested by using panel with composite and trap B by using panel with composite and flowed by CO_2 and water vapor.

2.3.1. Role of CO_2 and water vapor as mosquito's attractant

To test the role CO_2 and water vapor, CO_2 and water vapor is flowed into mosquito trap with aluminum panel which is non-coating and without using UV lamp.
This test is conducted for 12 hours (7 pm until 7 am). Testing is done using variation of CO_2 flow (400 cc/minutes, 450 cc/minutes and 500 cc/minutes). One device uses the flow of CO_2 and water vapor and another without them.

2.3.2. Role of heat spectrum as mosquito's attractant

To test the role of heat spectrum, thermocouple K that is connected to data acquisition Adamtech is used for detecting temperature at four positions around the mosquito trap.
The test is conducted for 4 hours (240 minutes) where UV and fan are turned on. Variable in this test is the treatment for the aluminum panel. There are two panels, panel with composite and panel without composite. In result, the profile of temperature for each treatment can be performed.

2.3.3. Role of photo catalyst

Testing the role of photo catalyst is intended to test the capabilities of photo catalyst to attract mosquitoes. This test is conducted for 12 hours (7 pm until 7 am). Testing is done to compare the photo catalytic trap with mosquito trap with CO_2 flowed at rate 450 cc/minutes and water vapor and also with mosquito trap with only UV as its attractant.

3. Results and discussion

Two devices are used in this experiment. In order to know the ability of each trap, the blank test was done with the results as shown in Figure 2.

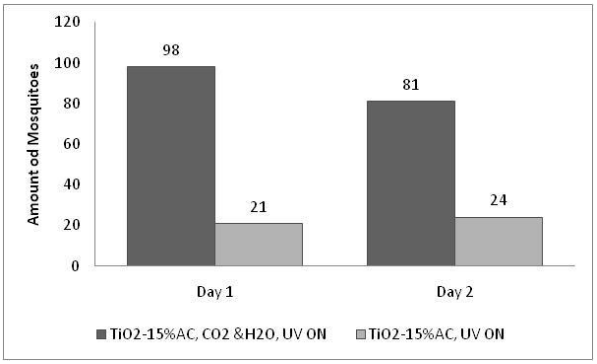

Fig. 2: The result of blank test

It can be seen from Figure 2, the performance for those devices in trapping mosquito are similar for day 1 and day 2. This blank test is to ensure there is no intrusion or problems with part of each trap. From this blank test, CO_2, water vapor and photocatalyst gives positive impact in attracting mosquito rather than photocatalyst alone.

3.1. Role of CO_2 and water vapor as mosquito attractant

Tests are conducted to see the role of CO_2 in attract mosquitoes to come and become trapped in the device and die because of dehydration from a straw stuck in a constant fan. A test conducted by state UV lamp off and the fan is on. Testing was done in laboratory warehouse with bright weather and rainy weather.
The test results are shown in Figure 3 and Figure 4, are the mosquito trap with CO_2 and water vapor will attract and trap more mosquito than the mosquito trap without CO_2 and water vapor. It is because CO_2 can be detected by mosquitoes from 18-36 meter and humidity from water vapor will also attract mosquitoes [6].

3.2. Role of heat spectrum as mosquito's attractant

This test is intended to see the role heat spectrum as mosquito attractant. Testing is done with state of UV light and fan on. The treatment of panel were varied A with and without composite. Testing is done in 2 days which is cloudy at the same place. Because the temperature from each day is not same, we use T/T0 for analysis to compare data from one day to another day.

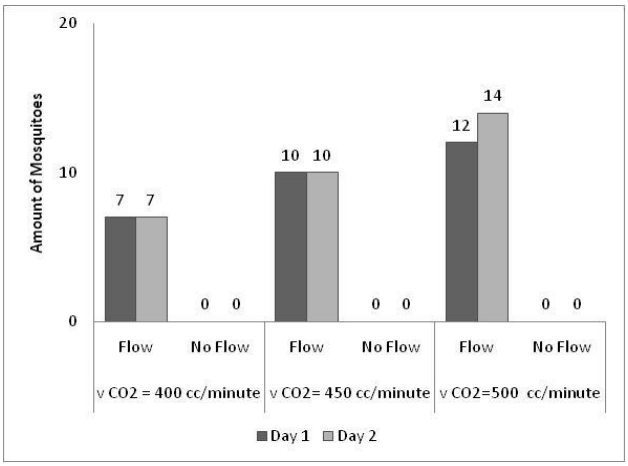

Fig. 3: The results of bright weather

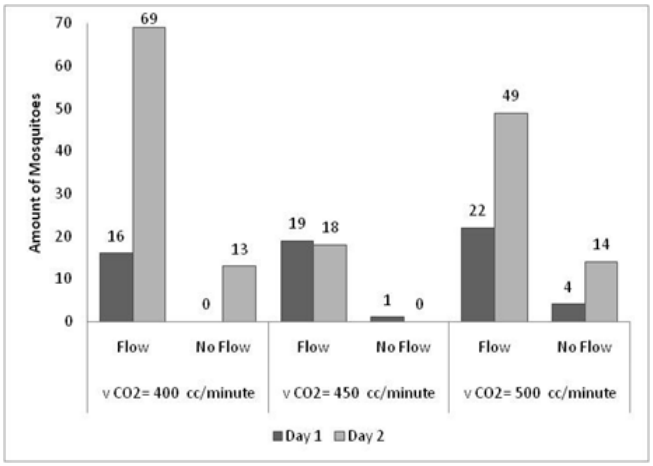

Fig. 4: The results of rainy weather

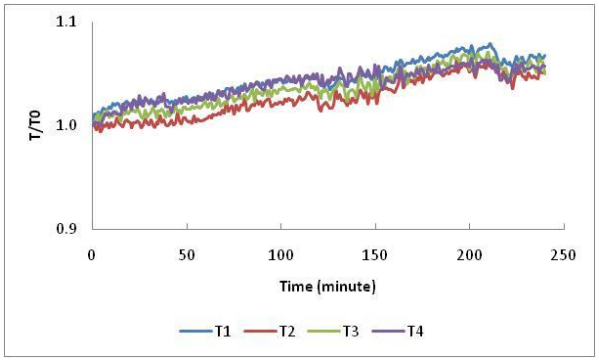

Fig. 5: Temperature profile for panel without composite

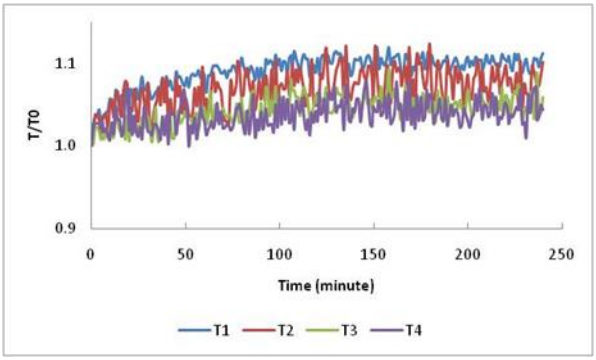

Fig. 6: Temperature profile for panel with composite

Tests are shown in Figure 5 and Figure 6, weather really influence the recorded temperature. As seen in those figures, the temperature can be higher or lower minute by minute. In overall, the temperature for will be increase because the UV lamp will become hotter after a period time of testing. On the other hand, panel with composite will become hotter also because of heat that probably comes from the recombination process [7].
The role of photo catalyst-adsorbent at panel can be seen by comparing the profile of T1 which is temperature at panel.

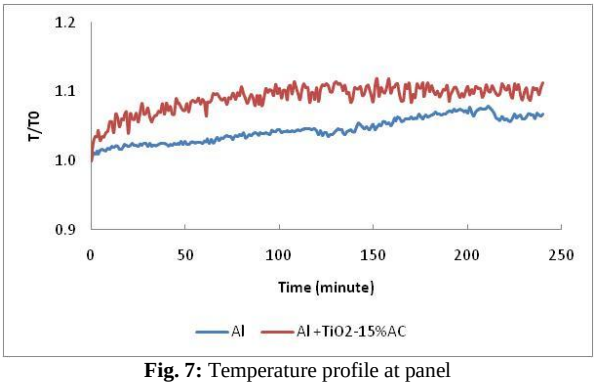

Fig. 7: Temperature profile at panel

Based on Figure 7, the increasing temperature on panel with composite is relatively faster than increasing temperature on panel without it. This clearly shows that photocatalyst activated by photon energy of UV light will produce heat through recombination process which is dominating in photocatalytic process [7].

3.3. Role of photo catalyst

This test is intended to see the role of photocatalyst on this device.
Based on Figure 8, the photocatalyt process will attract mosquitoes because of the heat spectrum as the result of recombination process. Mosquitoes will be attracted to testing location because it was detected at their receptor. For closer attractants, mosquito will be attracted more with certain wavelength of heat spectrum and UV light [8]. The

photocatalytic process will clearly more effective in catching mosquitoes which can be analyzed through photocatalytic mechanism.

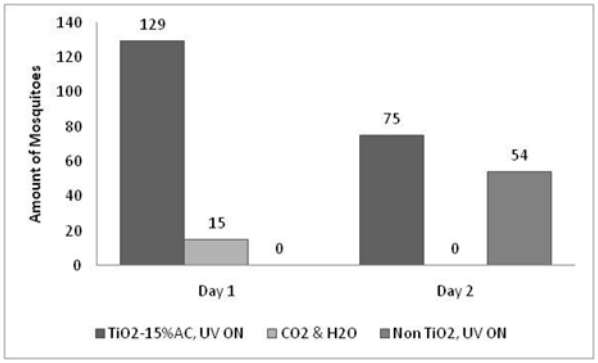

Fig. 8: Effect of photo catalyst

The light of UV-A (with a wavelength of 365 nm) will enable providing the energy required for exciting electrons from the valence band into the conduction band of TiO_2. Electrons (e-) in the valence band will move into the conduction band, leaving positive holes (abbreviated as h+) in the valence band. This event is called excitation. However, most couples of e- and h+ will recombine again, either on the surface of the particle or in the bulk phase, while producing heat energy equivalent to human body heat radiation. The recombination events dominate in the photo-catalytic mechanism [7]. Mosquitoes are coming into this device can be caused by heat energy generated by the recombination process. Electrons in the valence band that managed to move to the conduction band will leave a hole in the conduction band. Part of the hole formed will react with water vapor in the air to form hydroxyl radical (•OH), while the electrons will react with oxygen molecules to form radical anion superoxide ($•O_2$-) [9]. If there is an organic species in a room where the instrument is placed radicals are highly reactive forms will cooperate in a completely oxidize the organic species [9]. The photo-catalytic radicals are able to degrade various air pollutants in the living room into carbon dioxide and water vapor [10]. Product carbon dioxide produced from the photo-catalytic process will be an attraction for mosquitoes to get closer to the device [12]. Both heat generated by recombination events as well as carbon dioxide are produced if there is an organic compound will be degraded mosquito attractants to approach this device.

Testing result for air around photo catalytic mosquito trap indicates that there is no CO_2 and water vapor detected. It is likely that the indoor air pollutant is in very small concentration or even there is not any indoor air pollution thus there is no CO_2 and water vapor produced.

At times during the 12-hour test also attracted mosquitoes into a prototype device that is not coated photocatalyst and its UV lamp still on. Attraction of mosquitoes to the prototype device caused by the heat generated by UV lamps was lit so long after mosquitoes taken, and fall into the trap. UV light can also attract mosquito especially Anopheles stephensi. [12]. A number of mosquitoes trapped by the photo catalyst coated panel configuration and UV lamps were lit proved far more effective because the heat production from recombination process. A little difference in temperature can be detected by mosquito. Thermo receptor sensitivity in the mosquito can detect in accurateness of 0.2^oC, thus the difference of $1\text{-}2^oC$ can give significant impact in attracting mosquitoes [13], [14].

4. Conclusion

Based on the results of research and discussions that have been described previously, obtained some conclusions, namely:

- CO_2 and water vapor give positive impact as mosquito attractant.
- UV light also can attract mosquito into the device.
- Heat spectrum which is produce by recombination process plays significant role than CO_2 and water vapor or UV light in attracting mosquitoes.
- If the device put in room contain with indoor air pollutant, the effectivity for this device will increase by the production of CO_2 and water vapor.

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