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# Nano Coating Of Cu-O Particles On Single Slope Solar Distillation Absorber Plates

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*ABSTRACT*

Clean water is one of the basic needs for living creatures, especially humans, such as for drinking, cooking, washing, and so on. Natural sources of clean water have become increasingly rare in recent years, while the water that is available is increasingly polluted and contaminated by human and industrial activities. For this reason, various efforts are needed to process the available water into potable water that is suitable for drinking. One easy and cheap way to treat clean water is by distillation which utilizes solar radiation heat, known as solar distillation. The use of solar distillation technology generally has very low productivity, so it is necessary to develop technology so that productivity can be increased. This paper shows the effect of adding Cu-O nanoparticles to the absorber plate coating paint located at the bottom of the basin of a solar-powered distillation device to increase the productivity of clean water resulting from distillation. Variations in the concentration of Cu-O nanoparticles coated on the absorber plate are: 10%, 15% and 20% by weight of the black paint used. Experimental results show that there is an increase in efficiency of 6.66%, 16.91% and 27.93% for Cu-O concentrations in black paint of 10%, 15 % and 20% by weight respectively.

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**Keywords:** Solar distillation, Cu_O nanoparticles, *absorber plate coating paint.*

## 1. INTRODUCTION

### 1.1 Background

Water is one of the basic needs that must be met by living creatures, especially humans, starting from daily activities such as cooking, washing, and so on. Currently, Indonesia is the country with the fourth largest population after China, India and the United States. The high growth of Indonesia's population means that the need for basic commodities, especially water, continues to increase, and not all components of society feel that clean water is available. Lower class (poor) people often have difficulty accessing clean water, as a result many of them use groundwater and river water as an alternative to meet their household drinking water needs, even though this water is not necessarily safe for consumption.

In general, water sources obtained from river water and ground water do not rule out the possibility of being contaminated with soil, dangerous metals, bacteria and other substances that can endanger health. For this reason, contaminated water must be purified before drinking to avoid health hazards. Apart from the difficulty of getting clean water, Indonesia is a country where part of its territory is ocean, apart from that, Indonesia is also in the Tropics which has very high rainfall intensity compared to other countries, so there are many springs that can be processed into clean water and potable water.

There are various ways that can be used to obtain suitable water, including using a solar powered distillation device. Using this tool has several advantages, especially in terms of low cost, relatively easy use and maintenance. The working principle of a solar powered distillation device is the process of evaporating raw water followed by the process of condensing the water vapour into liquid water which has high purity. In general, a solar distillation device has 2 (two) main parts, namely a basin as a reservoir for raw water and a transparent cover such as glass to transmit solar radiation heat and a place for condensation of water vapor to become liquid water. The absorber plate installed at the bottom of the basin functions as a heat catcher for solar radiation so that it can heat the water in the basin. [1]

Conventional solar power distillation equipment generally has low productivity (less than 10 liters/m2/day), therefore many researchers are trying to develop it so that this limitation can be overcome [2]. Several efforts to increase the productivity of this distillation system include: regulating the amount of raw water in the basin, selecting the cover glass material, selecting the thickness of the cover glass, placing the equipment and the intensity of solar radiation [3]. Apart from this method, an additional energy storage system (TES) was also developed where the heat obtained when the intensity of solar radiation is high (during the day) is stored and will be left over when the intensity of the sun is low (at night). Due to the stored heat, the temperature difference inside and outside the distillation apparatus is high enough to speed up the process of condensing water vapor on the cover glass so that the productivity of clean water becomes higher. The TES method can be carried out by adding nanoparticles as a coating on the absorber plate [4].

In this research, Cu-O nanoparticles were added to the absorber plate coating material (black paint).

The aim of the water purification process is to separate water from contaminants, so that water can be used for daily purposes. This requires more attention, because humans are very dependent on clean water sources. Several conditions to determine if the water is suitable for use are to pay attention to the color, smell and taste. One way to separate water from contaminants is by distillation, where the raw water is heated until it evaporates, then the steam is condensed again until water with high purity is obtained.

Water Distillation has been carried out for many years. This technology is used to obtain fresh water from water that is not suitable for drinking, such as : sea water, river water, brackish water or polluted industrial waste water. The heat source used for heating and evaporating raw water can come from a fuel combustion system, an electric heating system, and for areas with high intensity of solar radiation, solar energy can be used as a heating source. [5]

Solar power distillation systems have two main classifications, namely, active and passive solar power distillation. In the process, a passive solar power distillation system uses direct sunlight to evaporate dirty water in a storage tank, while an active solar power distillation system has several additional requirements that are used to increase heat transfer thereby speeding up evaporation. This can be done through some design modifications, integration of additional devices or a combination of both [6].

The type of solar power distillation carried out in the basin still type passive solar distillation system research, this type is the simplest or conventional, the working mechanism is that solar radiation is transmitted through a cover glass which is received by water and a black paint absorber plate placed at the bottom of the basin. The heat energy stored in the absorber plate is used to heat the water above it. Thus, the water in the basin obtains heat through two main methods, by convection from the absorber plate and by radiation from sunlight entering through the cover glass. The entire walls and bottom of the basin are insulated so that heat is trapped in the distillation system until the temperature inside the system is higher than the outside air temperature. Under these conditions, water vapor can easily condense on the surface of the cover glass until pure water can be obtained. The Single Slope Solar Distillation system is shown in Figure 1.

1.2 Single Slope Solar Distillation

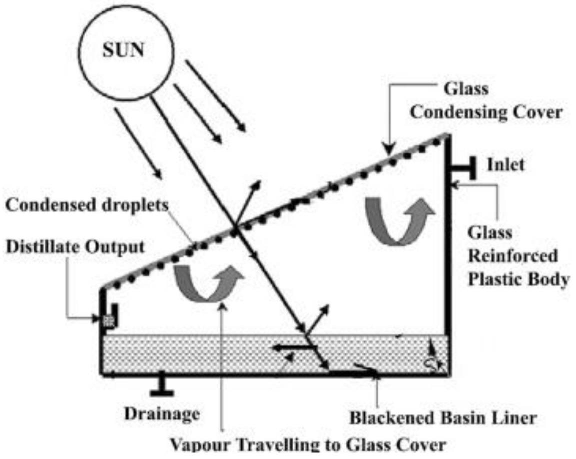


Figure 1. Single Slope Solar Distillator [6]

1.3 Cu-O nanoparticles

Copper oxide (Cu-O) material is a metal oxide compound which has the characteristics of a p-type semiconductor. The physical properties of Cu-O include:

Density : 6315 $\left({}^{kg}/_{m^3}\right)$
Melting point : 1326 °C
Solubility : Insoluble in water
Specific heat of copper : 0.385 kJ/(kg.K)

The Cu-O compound known as Cupric Oxide is an inorganic compound that is commonly used as:

- Pigment component in colouring enamel materials, artificial gems, ceramics and others.
- Mixed ingredients for making insecticides and fumigants.
- Wood preservative.
- Fireworks material.
- Anti-fouling paint on the bottom of the boat to prevent rust.

For use in solar power distillation systems, Cu-O has attracted a lot of attention, because its price is relatively cheap, high light absorbance, low thermal emissions, non-toxic, and the manufacturing process is also relatively simple.

Several previous studies have shown that the use of Cu-O can increase distillate production and also the efficiency of the distillation equipment itself.[7]

1.4 Efficiency of Solar Distillation Equipment

The efficiency of a solar powered distillation device is determined based on the heat of evaporation required to produce condensate water against the solar radiation heat received by the device during a certain time. [5]. The following is the formula for calculating the efficiency of a solar powered distillation device:

$$\eta_d = \frac{m_c . h_{fg}}{A_c x\, I_r x t} \quad (1)$$

Where :
$m_c$ = mass of condensate water per day (kg)
$h_{fg}$ = latent heat of vaporizationwater (kJ/kg)
$A_c$ = area of absorber plate (m2)
$I_r$ = solar radiation intensity (W/m2)
t =solar radiation exposure time(s)

## 2. METHODOLOGY

The research was carried out experimentally using 4 similar solar distillation tools, including:

Type : Single Slope Solar Distillator (SSD)
Dimensions
Length : 66 cm
Wide : 49 cm
Height : 15 cm
Cover glass tilt angle : 30 °
Orientation Placement : tilt the cover glass facing north.
Location : Rooftop of the Center of Excellence (COE) Building at Sultan Ageng Tirtayasa University - Cilegon.

Variations in the solar power distillation system are carried out on the coating material used on the absorber plate, ie :

- System A: the absorber plate is only coated with black paint.
- System B: the absorber plate is coated with black paint with the addition of 10% weight Cu-O.
- System C: the absorber plate is coated with black paint with the addition of 15% weight Cu-O.
- System D: the absorber plate is coated with black paint with the addition of 20% weight Cu-O.

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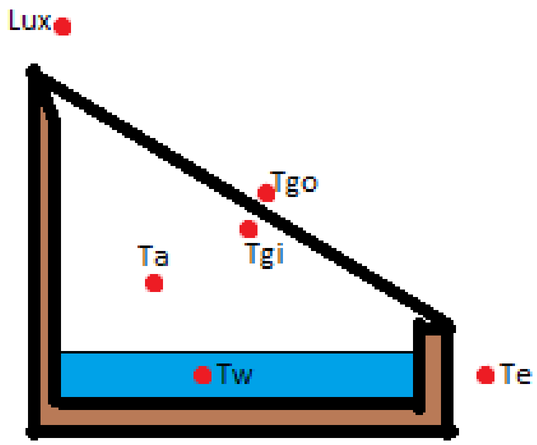


Figure 2. Location of the measurement sensors

Experimental testing.

Data was collected using Arduino Uno with a recording interval of 5 minutes, starting from 9 am to 5 pm. Figure 2. Show the location of the measurement sensors

$T_{g,i}$ = Inside glass surface temperature (°C)
$T_{g,o}$ = Outer glass surface temperature (°C)
$T_W$ = Water in the basin temperature (°C)
Ta = inside - air temperature (°C)
$I_r$ = Intensity of solar radiation (lux)
Te = Ambient air temperature (°C)
mc = Condensate produced an a day (ml)

Testing and calibration are carried out first before data collection is carried out. The raw water level in the basin at the start of the experiment testing was made in 5 cm.

## 3. RESULTS AND DISCUSSION

Tests were carried out for 5 consecutive days at the same time for the 4 variations of absorber plates used.

The test results for 5 days were averaged to obtain the following data:

*Raw water temperature in the basin*

The raw water temperature in the basin at the observation time from 9 am until 5 pm is shown in Figure 3 accompanied by data on the average intensity of solar radiation.

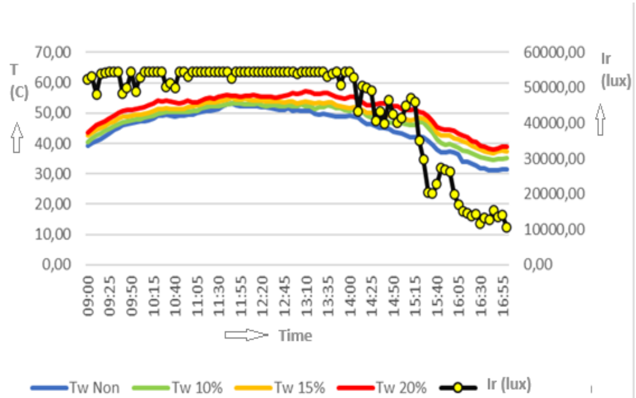


Figure 3. Temperature water in the Basin and Radiation Intensity vs time.

Figure 3 shows that the addition of Cu-O nanoparticles increases the basin water temperature. This can happen because the copper material used is a conductor so that the heat absorbed by the absorber immediately increases the temperature of the absorber plate which then makes it easier to transfer heat to the raw water above it. The basin water temperature for the absorber plate with a Cu-O nanoparticle content of 20% has the highest value followed respectively for a Cu-O nanoparticle content of 15%, 10% and 0%.

*Inside and outside cover glass temperature*

Figure 4 and figure 5 show temperature average for inside and outside cover glass surface during the day.

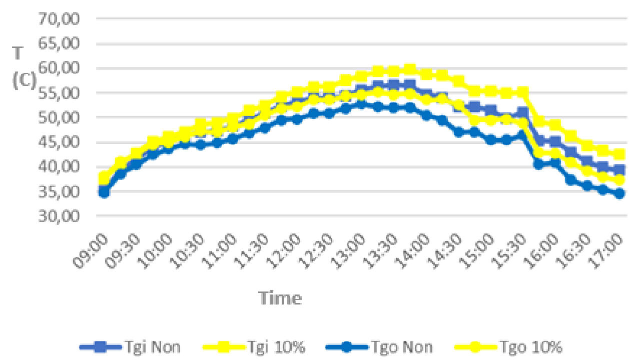


Figure 4. Average Temperature of Inner and Outer Glass Without Cu-O and 10% Cu-O

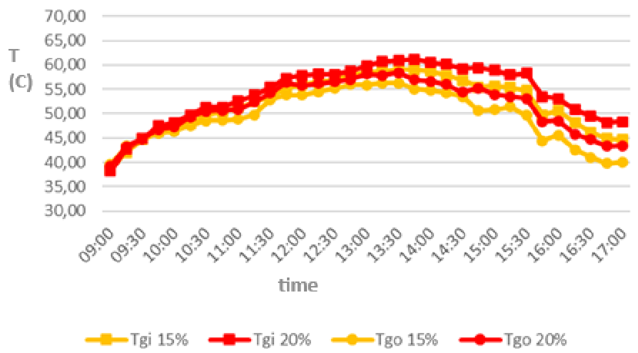


Figure 5. Average Temperature Inner and Outer Glass for 15% Cu-O and 20% Cu-O

Based on the graph in the image above, it can be seen that the increase and decrease in the temperature of the inner and outer glass move simultaneously, the temperature of the inner glass appears to be greater than the temperature of the outer glass, this is because the temperature of the inner glass is isolated in the basin, causing this event to occur. In conventional distillation equipment, the glass temperature is relatively lower than the temperature of the glass to which CuO nanoparticles are added to the base plate. This event proves that the addition of CuO nanoparticles can increase the temperature of the inside and outside of the glass.

*Solar Radiation Intensity and ambient Temperature*

The intensity of solar radiation has an effect on environmental temperature. The increase in the intensity of solar radiation is directly proportional to environmental temperature, and vice versa. In this case, it was found that the average intensity of solar radiation reached 44867 lux and the environmental temperature reached 37.97 ℃, with the environmental temperature reaching the highest heat peak at 13.55 WIB, where the temperature reached 42.06 ℃. Figure 6 present relation of solar radiation intensity and ambient temperature average in the day.

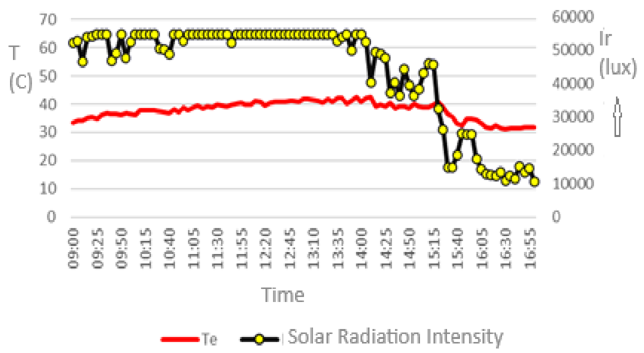


Figure 6. Comparison of Solar Radiation Intensity with Environmental Temperature.

*Distillate Productivity*

The total daily distillate yield from a conventional painting distillation tool with painting added with Cu-O nanoparticles using variations of 10%, 15% and 20% for 24 hours, starting from 9 am to 9 am the following day is showed in Figure 7.

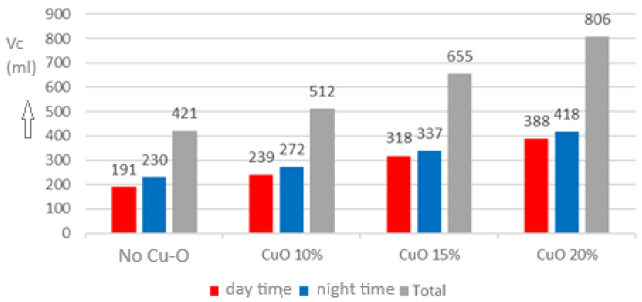


Figure 7.Comparison of Average Condensate production for a day.

Figure 7 shows condensate production from solar distillation device with a comparison between conventional distillation equipment and distillation with added Cu-O nanoparticles. Testing was carried out for 8 hours, starting from 9 am to 5 pm. Meanwhile, the water distillation results are taken for 24 hours, based on the total distillation from 9 am to 9 am in the next day. Based on this data, it can be seen that the greater the percentage of Cu-O used, the greater the mass of condensate produced, this is caused by Cu-O nanoparticles which function well as heat absorbers from sunlight so they can increasethe temperature of raw water. In this research, the addition of 20% CuO nanoparticles produced the highest average mass of condensate, as much 806 ml/day.

*Distillation Equipment Efficiency*

Based on efficiency calculations using equation (1), it can be seen the average increase in efficiency of conventional distillation equipment for each variation where Cu-O nanoparticles are added. Figure 8 present increase in efficiency value the result of increased efficiency towards no Cu-O nanoparticles in coated absorber plate (conventional systems).

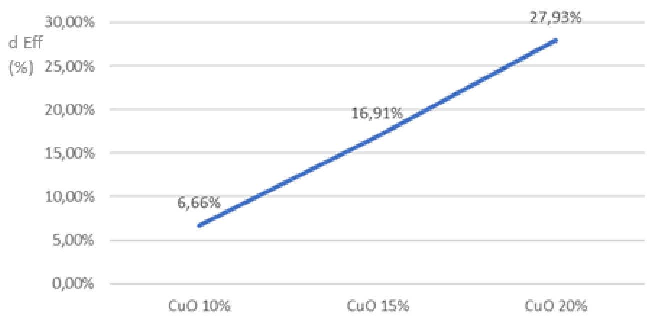


Figure 8. Increasing Efficiency of Cu-O used from Conventional Distillation Equipment

Based on the graph in Figure 8, there was an increase in the efficiency of the distillation system between the conventional system and the modified system by adding base plate paint using Cu-O nanoparticles. The increase in efficiency of adding Cu-O nanoparticles by 10%, 15% and 20% was 6.66%, 16.91% and 27.93% respectively. This, proves that the addition of Cu-O nanoparticles can affect the efficiency value, the larger the Cu-O nanoparticles used, be greater the efficiency obtained. This is because Cu-O nanoparticles can help accelerate heat absorption so that the water temperature (Tw) in the distillation apparatus with the addition of Cu-O nanoparticles is higher than without the addition of Cu-O nanoparticles.

## 4. CONCLUSION

Based on the results of experiments, analysis and calculations that have been carried out, it is concluded that:

Based on the test results, painting with added Cu-O nanoparticles has an impact on heat absorption which has the effect of increasing water temperature and also has an effect on increasing condensate mass productivity,

Based on the analysis results, the condensate mass results for each variation show different results on each day, this depends on the intensity of solar radiation on that day. The highest average condensate mass was obtained from variations in the addition of 20% Cu-O nanoparticles, with an average of 806 ml/day, while variations in the addition of 10% and 15% Cu-O nanoparticles obtained an average condensate production of 512 ml/day and 655 ml/day. while conventional distillation equipment only obtains a condensate mass of 421 ml/day,

Based on the analysis results, it was found that the efficiency of the distillation apparatus with variations in the addition of 10%, 15%, and 20% Cu-O nanoparticles increased respectively by 6.66%, 16.91%, and 27.93% compared to the efficiency of the distillation apparatus without addition of CuO nanoparticles (conventional).

There are some concerns about the potential environmental and health impacts of nanoparticles, especially during synthesis and application, so its need Proper handling and disposal protocols to minimize exposure risks

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