Repeatability of Professor Robert W. Wood's 1909 experiment on the Hypothesis of the Greenhouse Effect

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**The author is grateful to the Principia Scientific International team for their kind assistance with the text; nevertheless, any errors in the text are mine alone.*

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ABSTRACT

Through a series of controlled experiments, I demonstrate that the warming effect in a real greenhouse is not due to longwave infrared radiation trapped inside the greenhouse, but to the blockage of convective heat transfer with the surroundings, as proven by Professor Wood in his 1909 experiment.

INTRODUCTION

In 1909, Professor Wood conducted an experiment consisting of testing the effect of the longwave infrared radiation trapped inside a greenhouse with respect to the elevated temperature inside a greenhouse during insolation.

His experiment was described in an article that he published in the journal Philosophical Magazine, in 1909. (See reference [1]).

From his experiment, Professor Wood found that the increase in temperature inside a greenhouse was not due to trapped radiation but to the blockage of convective heat transfer between the interior of the greenhouse and the open atmosphere.

Given that there are no other documents by other scientists who have tried to repeat the experiment of Professor Wood, except the experiment by Professor Pratt [8], which contradicted the results of Professor Wood's experiment, another science investigation by a third arbitrator is not only recommendable, but necessary. This is the reason that I decided to repeat the experiment of Professor Pratt to either falsify or verify his results and those of Professor Wood.

This document describes the experiments conducted by myself in an attempt to reproduce Prof. Wood's experiment and verify his results.

EXPERIMENT:

EQUIPMENT

2 Hanna Instruments® Digital Thermometers, Model HI98501. Range of Temperatures: -50 to 150 °C. Accuracy of ±0.3 °C (inside) and ±0.5 °C (outside). EMC deviation ±0.3 °C. [2]

3 CEM® Digital Thermometers, Model DT-131. Range of Temperatures: -40 to 250. Accuracy of 0.03 °C. EMC deviation 0.1 °C.[3]

1 Sekonic® photometer.

Praktica® MTL-5B Professional Camera. Multi layered Lens 35 mm, F-1.8.

Sony® Digital Camera α 55V. Multi-layered (ML) Zoom Lens Kit DT 18-55 mm; F 3.5-5.6 SAM.

MATERIALS

4 Lowe's® corrugated cardboard boxes, measuring 30 x 30 x 20.32 cm, thermal conductivity of 0.5 W/m K. [13]

1 impact modified acrylic plate Plaskolite®-Duraplex®, 3 mm thick. Solar near shortwave IR transmissivity index of 0.97 (0.94 in average) and Longwave transmission index of 0.12 (0.1 on average). Thermal Conductivity Coefficient of 0.18 W/m K. [4, 9]

1 silica glass panel, 3 mm thick. Solar near shortwave IR transmissivity index of 0.97 and longwave IR transmissivity coefficient of 0.1. Thermal Conductivity Coefficient of 1.2 W/m K. [4, 5, 6]

Crystal Clear Polyethylene Film, 0.051 mm thick. Solar near shortwave IR transmissivity index of 0.98 and longwave IR transmissivity coefficient of 0.87. Thermal Conductivity Coefficient from 0.42 W/m K to 0.51 W/m K. [4, 10, 11, 12, 16]

Crystal Clear Polyethylene film, 0.3 mm thick. Shortwave IR transmissivity index of 0.89 (max. = 89.93%, without coating) and longwave IR transmissivity coefficient of 0.85 (max. = 87.1%, without coating). Thermal Conductivity Coefficient 0.167 W/m K. [14]

1 tube of white acrylic latex sealant for joints. Reflectivity of 0.94. [4]

1 tube of Qualtex® Silicone, translucent multipurpose silicone. TUGT-08347. [4]

Reynolds' Wrap® aluminum foil. Reflectivity 98.4%. Thermal Conductivity Coefficient = 235 W/m K. [5, 6, 7]

White Glass Wool. Thermal Conductivity Coefficient of 0.04 W/m K. [5, 6, 7]

Quartet® Cork tiles. Thermal conductivity of 0.07 W/m K. [7]

Masking tape with similar absorptivity coefficient than that of corrugated cardboard (0.9).

Aluminum tape. Reflectivity 98.4%. Thermal Conductivity Coefficient = 235 W/m K. [4, 5, 6, 7]

Berel® Matte Black Paint. Reflectivity 0.05. [4]

Fuji® Film (ISO 400, ISO 200, and ISO 100).

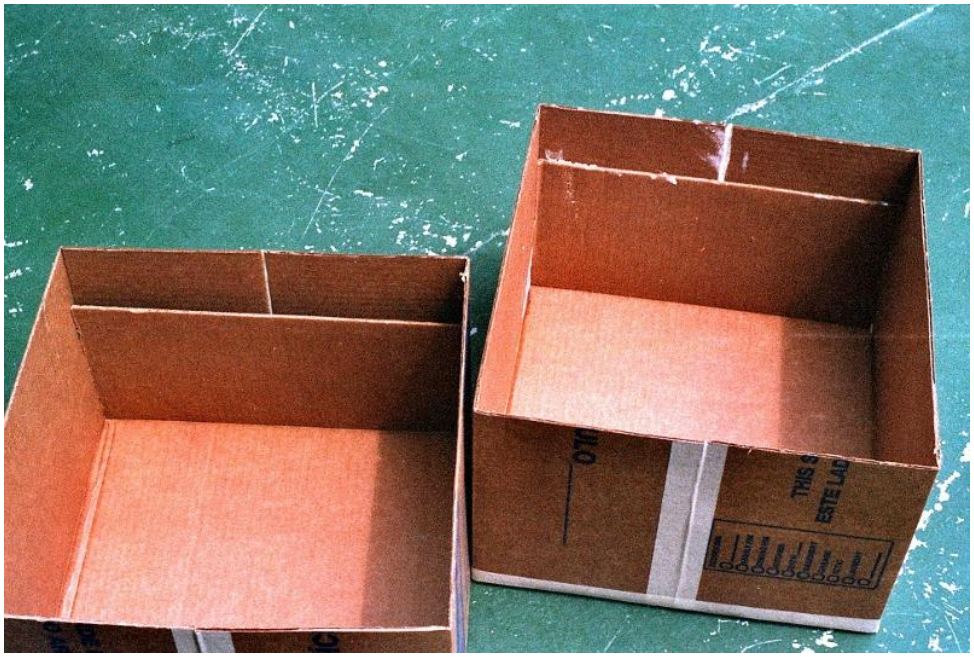
TOOLS

Bit saw, carpenter's saw, wood stripes, hammer, 2 acrylic cutters, reamer, 4 drill bits, ¼ kg nails, 8 screws, Black & Decker® screwdriver and Black & Decker® Kit.

PROCEDURE FOR THE FIRST STAGE OF THE EXPERIMENT

Four identical boxes of corrugated cardboard, by Lowe's®, were constructed by me.

The joints of the walls were sealed with white acrylic latex sealant. (Picture 01)



Picture 01: Verification of Robert Wood's Experiment - 1st Phase.
Corrugated cardboard boxes before and after sealing

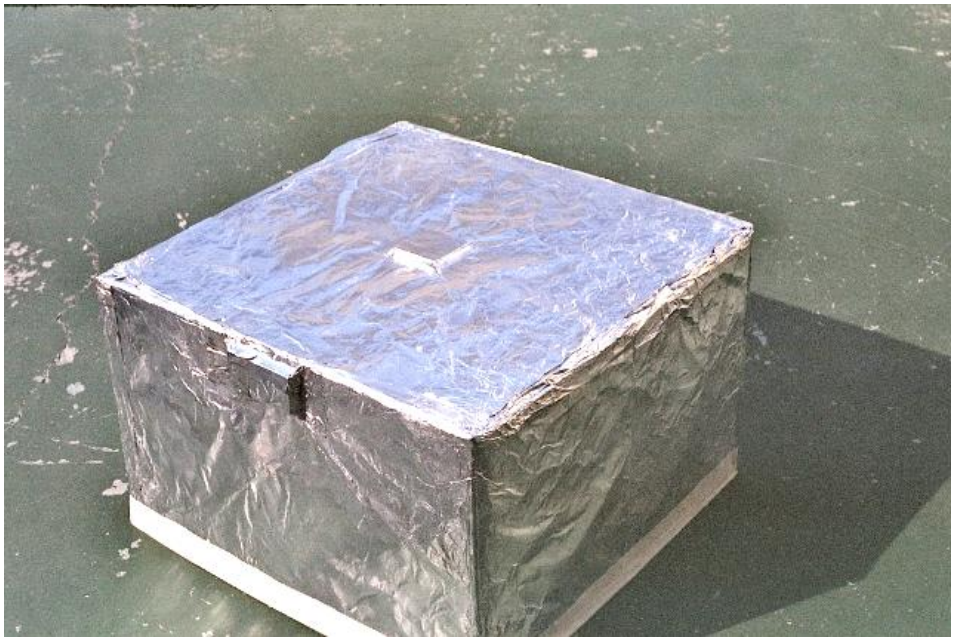
The inner walls of the boxes were painted with matt-black paint by Berel®, with a reflectivity of 0.3 and an absorbency of 0.97 (Picture 02). The reflectivity of the inner walls was confirmed with a Sekonic® photometer.

Picture 02: Verification of Robert Wood's Experiment - 1st Phase. Interior painted with Berel matt-black paint

To test the seal around the edges, I placed a box in sunshine and observed the air expanding to make the polythene sheeting bulge. (Picture 03)

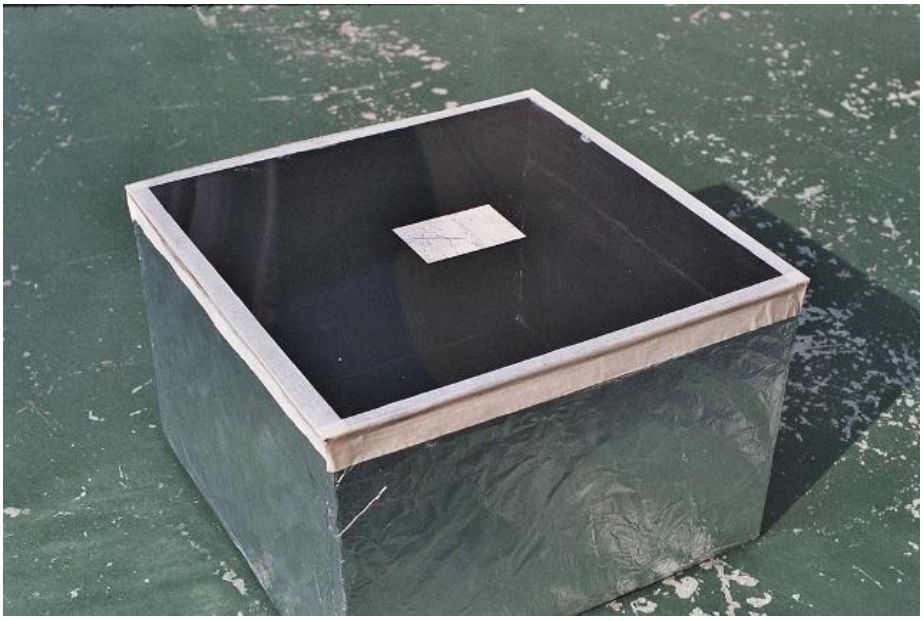
Picture 03: Verification of Robert Wood's Experiment - 1st Phase. Testing the seal around the edges

The five exterior surfaces of the boxes were covered with Reynolds' Wrap® aluminum foil. (Picture 04)



Picture 04: Verification of Robert Wood's Experiment - 1st Phase. Aluminum foil wrapped around the outside

I adhered a square of Reynolds' Wrap® aluminum foil to each of the glass and acrylic plates and the polyethylene film covering the open sides of the four boxes, exactly at the center, in order to avoid direct solar radiation having an effect on the rods of the digital thermometers so that overheating of the rods would not give false readings. (Picture 05)



Picture 05: Verification of Robert Wood's Experiment - 1st Phase. Centrally placed aluminum square

I placed a sheet of clear acrylic Duraplex® by Plaskolite® with a cut-out window of 5 x 5 cm to cover the open side of the box no. 1 (Picture 06), which was then sealed with translucent silicon glue on the free edges of the corrugated cardboard walls.

Picture 06: Verification of Robert Wood's Experiment - 1st Phase. Boxes aligned to the incoming solar irradiance. Notice the hole on the sheet of acrylic of the first box and the coating of white glass wool in the proximal box.

I placed a plate of silica glass cover on the open side of box no. 2, which was then sealed with translucent silicon glue on the free edges of the corrugated cardboard walls.

I placed a plate of clear acrylic Duraplex® by Plaskolite® to cover the open side of box no. 3, which was then sealed with translucent silicon glue on the free edges of the corrugated cardboard walls.

I placed two sheets of Crystal Clear Polyethylene Film to cover the open side of the box 4 (near side in Picture 06), which was then sealed with translucent silicon glue on the free edges of the corrugated cardboard walls. (Two sheets to reduce disproportionate conductive heat loss)

To test the reliability of the experiment the four boxes were placed under direct sunlight at 19 hr UTC (13:00 hr CST). The first segment of the experiment was then conducted the few days later at 10:40 hrs (CST), as detailed below.

The four boxes were placed on a white table at an angle of 23° 15’ so that the solar radiation would strike perpendicularly on the boxes, thus avoiding shadowing.

The four boxes were initially covered with a blanket of Aluminum Plastic with a reflectivity of 97% before they were exposed to sunlight. (Picture 07)

Figure 07: Verification of Robert Wood's Experiment - 1st Phase. Photograph of boxes protected by aluminum sheeting prior to testing

FIRST SEGMENT OF THE EXPERIMENT

The purpose of this segment is to verify the results of Prof. Wood's experiment.

I conducted the first segment of the experiment on May 25, 2011.

I started the experiment at 10:00 hr (CST).

I finished the experiment at 11:10 hr (CST).

The coordinates of the location where the experiment was carried out were:

Location: San Nicolas de los Garza, Nuevo Leon, Mexico.

Latitude: 25º 48´ North

Longitude: 100º 19' West

Altitude: 513 meters above sea level.

RESULTS

The instantaneous measurements of temperatures recorded during the first stage of the experiment were as follows:

Time Lapse	Temperature (°C)					
	Ambient	Acrylic Holed	Glass	Acrylic Uncut	Polyethylene Film	Uncovered Box
Starting	32.3	43	43.6	44.7	32.5	
5 min	32.6	57.6	57.7	59.7	59.4	
10 min	32.8	59	60.4	61.4	60.8	
15 min	33.4	60.7	61.8	62.7	61.6	
20 min	33.9	62.4	63	63.9	62.7	
25 min	34.8	65.4	66.1	66.9	66.2	
30 min	35.2	66.7	67.8	68.6	68.1	
40 min	35.5	67.1	68.8	68.8	68.4	
60 min	37.2	69.5	70.5	71.5	70.1	
70 min						45.4

OBSERVATIONS

1. The initial temperatures of the boxes in the shadow were higher than the ambient temperature.
2. After 1 minute of direct exposure to insolation (not graphed), the temperature in all boxes increased by approximately two degrees.
    a) I observed that the temperature inside the box with a holed acrylic plate remained lower than the temperature inside the boxes covered with Polyethylene and acrylic uncut plates.
    b) I observed that the temperature inside the box covered with the holed acrylic plate was the same than the temperature inside the box covered with the glass plate.
    c) I observed that the temperature inside the box covered with Polyethylene film was lower than the temperature inside the box covered with an uncut acrylic plate.
3. After 5 minutes of direct exposure to insolation, the temperature in all boxes increased around 20 degrees.
    a) I observed that the temperature inside the box with a holed acrylic plate was lower than the temperature inside the other boxes.
    b) I observed that the temperature inside the box covered with Polyethylene film was higher than the temperature inside the box covered with a glass pane and the temperature inside the box covered with a holed acrylic pane.

c) I observed that the temperature inside the box covered with glass was almost the same as the temperature inside the box covered with polyethylene film.

4. After 10 minutes of direct exposure to insolation, the temperature continued increasing inside the four boxes.

   a) I observed that the temperature inside the box covered with a glass plate was lower than the temperature inside the box covered with Polyethylene film.

   b) I observed that the temperature inside the box covered with the holed acrylic plate was lower than the temperature inside the remainder boxes.

   c) I observed that the temperature inside the box covered with the uncut acrylic plate was higher than the temperature inside the remaining boxes.

5. After 15 minutes, the temperature inside the four boxes continued increasing.

   a) I observed that the temperature inside the box covered with silica glass was almost the same as the temperature inside the box covered with Polyethylene film.

   b) I observed that the temperature inside the box covered with the holed acrylic plate was lower than the temperature inside the remaining boxes.

   c) I observed that the temperature inside the box covered with uncut acrylic plate continued being higher than in the remainder boxes.

6. After 40 minutes of direct exposure to insolation, the temperature inside the four boxes continued increasing.

   a) I observed that the trend of increase of temperature inside the four boxes continued in a quasi-stable way.

   b) I observed that the temperature inside the box covered with a glass plate was slightly higher than the temperature inside the box covered with polyethylene film.

   c) I observed that the temperature inside the box covered with the uncut acrylic plate continued being higher than the temperature of the remainder boxes.

   d) I observed that the temperature inside the box covered with a holed acrylic plate was lower than the temperature in the boxes covered with glass, acrylic, and Polyethylene film.

7. After 1 hour of direct exposure to insolation, I took off the Polyethylene sheet from the box labeled as “Polyethylene Film”, waited for 10 minutes, and inspected the temperature inside the box. I found that the temperature had decreased dramatically from 70.1 °C down to 45.4 °C.

CONCLUSIONS TO THE FIRST SEGMENT OF THE EXPERIMENT

The first phase of the experiment confirms the results of Wood's experiment, which concluded that the greenhouse effect inside a greenhouse was not due to the retention of longwave infrared radiation "trapped" by the glass windows of the walls, but instead to the blockage of convection, i.e. the free flow of currents of air between the inside of the greenhouse and its surroundings.

The cause of the higher temperatures in the boxes in the shadow is that the black walls of the boxes absorb thermal energy emitted by the surface where the boxes were placed and convection was not permitted, except for the box covered with a holed plate of acrylic, which caused a lower temperature than the boxes covered by glass and uncut acrylic because it permitted the free flow of air currents between the inside of the box and its surroundings.

The temperatures in the box covered with polyethylene film and the box covered with silica glass are similar because it is not any "trapped" radiation inside the boxes what makes them to increase, but the lack of free convective heat transfer between the inner environment of the boxes and the outer environment.

After 10 minutes of observation, the temperature in the box covered with the holed acrylic plate was lower than the temperature in the other boxes due to the free flow of air between the inside of the box covered with the holed acrylic plate and its surroundings

If the argument on the "greenhouse effect" were true, the temperature in the box covered with ordinary glass would have been by much higher than the temperature in the box covered with polyethylene film. The results of this first segment of the experiment clearly show that such "trapped" radiation does not exist and that the increase of temperature in both boxes was due to the blockage of convection.

For example, during the second stage of the experiment, after one hour of exposure to the Sun's radiation, the temperature of the box covered with the holed acrylic pane *should have been* 59.6 °C, according to the supposed longwave radiation that escaped through the hole (2.5%); nevertheless, the temperature was 57.6 °C, which is 5.2% lower than the expected temperature if the effect of warming inside the box would have been due to a blockage of the outgoing longwave radiation. This is evidence that it is convection causing the observed lower temperature in the cut acrylic box.

The final step of the first stage of the experiment -which consisted of opening the box covered with the polyethylene film, labeled with "Uncovered Box", shows that the increase of temperature inside the boxes was due to the blockage of convection heat transfer between the inner space of the box and the environment.

Once the box covered with polyethylene film was opened, the temperature dropping. The temperature of 45.4 °C was taken 30 seconds after the box was uncovered and was kept with negligible variations up to 10 minutes after the film was removed. The dramatic decrease of temperature was due to convective heat transfer with the open atmosphere.

In conclusion, Robert Wood was correct in his experimental procedure and the results of his experiment are suitable.

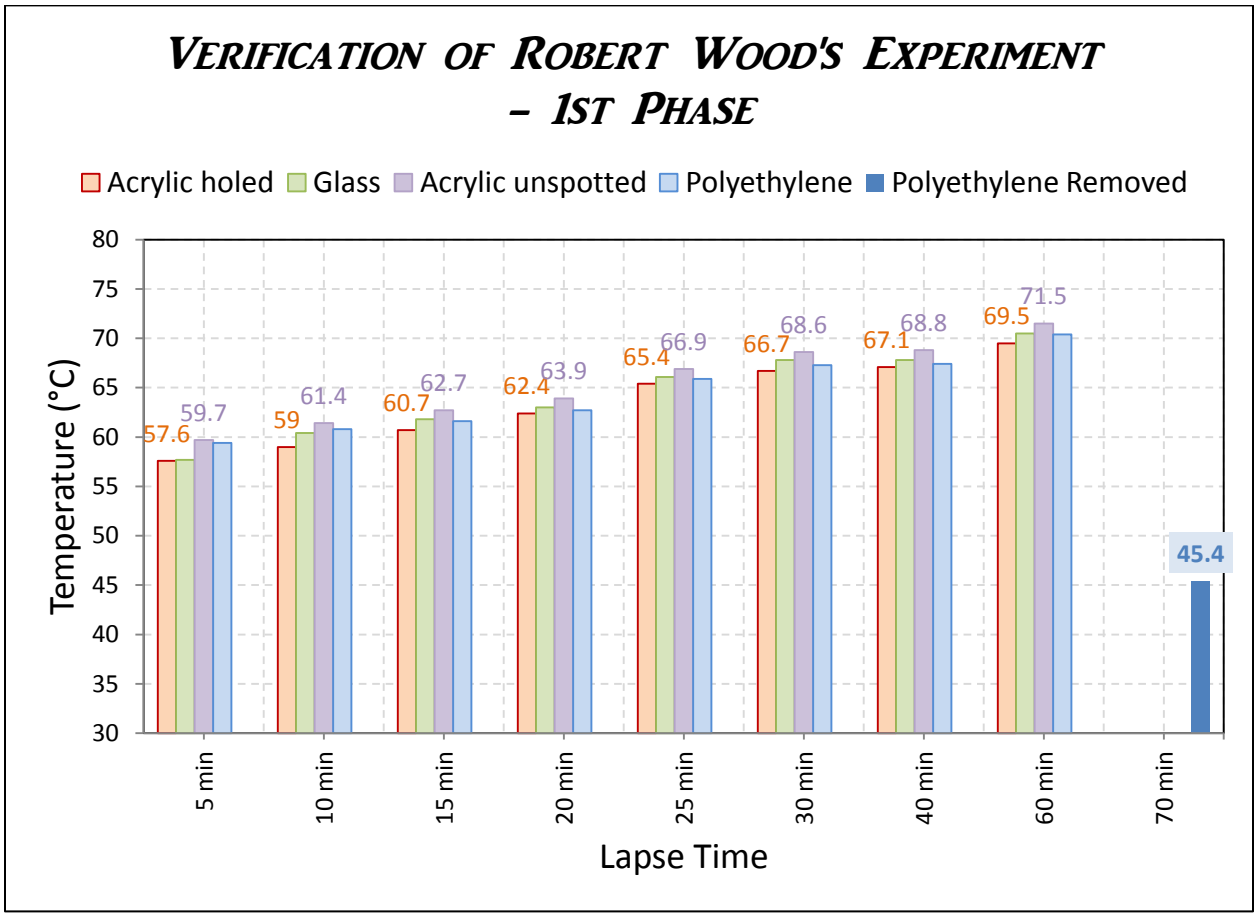
REASONING:

The box covered with silica glass, according to the hypothesis of the greenhouse effect, should have trapped inside only longwave infrared radiation, and its temperature must be higher than the temperature of the box covered with a polyethylene sheet 0.3 mm thick because the PE permits the longwave infrared radiation outgoing from inside the box. However, the difference of temperature in the box covered by a silica glass pane was almost the same temperature of the box covered with polyethylene, which demonstrates that longwave infrared radiation is not trapped by atmospheric greenhouse gases.

Evidently, the increase of temperature is not due to radiation "trapped" inside the greenhouses, but to the blockage of convective heat transfer.

Actually, this experiment demonstrates that the warming of the atmosphere by "trapped" longwave radiation does not exist physically. Consequently, the hypothesis of the greenhouse effect by longwave infrared radiation trapped by greenhouse gases is false.

I plotted the results on the following graph, except for the ambient temperature:



SECOND SEGMENT OF THE EXPERIMENT

The objective of this segment is to verify if the white glass wool could be the cause of the homogeneity of temperatures between the box covered with polyethylene and the box covered with glass. Additionally, this would be a second test to verify the experiment of Prof. Wood.

May 26, 2011; 10:40 hrs (CST).

The materials used for this stage of the experiment are the same materials used in the first experiment, except for the double sheet of polyethylene film, which was substituted with a single sheet of polyethylene film, 0.051 mm thick. A single sheet of polyethylene was used in the remaining segments of this experiment. Additionally, I used an anemometer to record wind speed.

I removed the White Glass Wool from the walls of the fourth box and covered it with Reynolds' Wrap aluminum foil.

I replaced the Crystal Clear Polyethylene Film to cover the open side of the fourth box because I had destroyed it to investigate the effect in a completely open box.

I integrated four rotary frameworks as supports of the boxes, one framework to each box, with the purpose of changing the plane of the angle of the boxes so they were always oriented perpendicularly with respect to the solar radiation stream.

RESULTS OF THE SECOND SEGMENT OF THE EXPERIMENT

I conducted the experiment on May 26, 2011.

I started the experiment at 10:40 hr (CST).

I and finished the experiment at 11:40 hr (CST).

The coordinates of the location where the experiment was carried out are:

Location: San Nicolas de los Garza, Nuevo Leon, Mexico.

Latitude: 25º 48´ North

Longitude: 100º 19' West

Altitude: 513 meters above sea level.

I have recorded the results of the second experiment on the following table:

Time Lapse	Wind Speed (Km/h)	Temperature (°C)				
		Ambient	Acrylic Holed	Glass	Acrylic Uncut	Polyethylene Film
Starting	0.4	34.2	34.8	35.1	35.1	36
5 min	0.2		52.6	55.3	53.1	56.4
10 min	0.1		56	57.9	59.1	59
15 min	0.1		57.4	59.1	60.6	59.9
20 min	0.2		58.5	60.1	61.8	60.9
25 min	0.1		59	60.7	62.3	60.9
30 min	4.2		58.4	60.3	62.1	60.6
45 min	6.8		58.1	59.8	61	60.2
1 hour	7.2	32.4	57.9	59.5	61.1	60.2

Observations:

1. The temperature inside the box covered with a holed Acrylic pane was always 3 °C lower than the temperature of the box covered with an uncut Acrylic pane.
2. The temperature of the box covered with a polyethylene film was almost the same than the temperature inside the box covered with a silica glass pane.
3. The temperature inside the boxes diminished as the wind started to speed up above 1 km/hr.
4. The temperature inside the box covered with a holed panel of Acrylic was always lower than the temperature inside the remainder boxes.
5. The temperature inside the box covered with the uncut acrylic plate is higher than the temperature inside the boxes covered by silica glass and inside the box covered by polyethylene film.
6. The increase of the wind flow outside the boxes resulted in a decrease of their temperature in the boxes. Light wind conditions caused slight drop in expected temperatures at 30 min, 45 min, and 60 min readings.

CONCLUSIONS TO THE SECOND SEGMENT OF THE EXPERIMENT

The second segment of the experiment confirms the results of Wood's experiment. Additionally, this segment confirms that the absence of white glass wool to wrap the box covered with a polyethylene film does not interfere with the results.

The increase of the wind flow outside the boxes worked like a coolant of the walls of the boxes resulting in a decrease of the temperature inside the boxes.

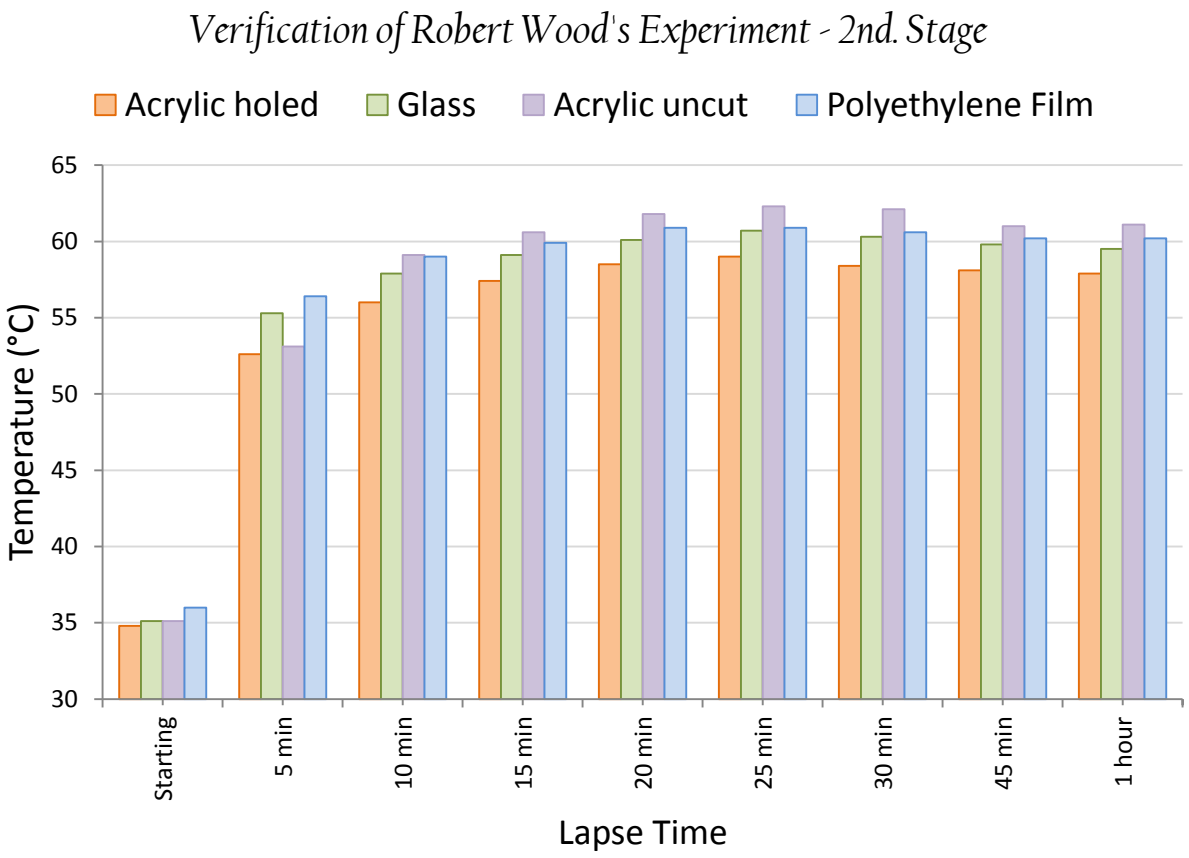
The results by using a single sheet of polyethylene film were the same as the results by using a double sheet of polyethylene film during the first segment of the experiment (see picture 03).

I found that the acrylic panels transmit the solar longwave radiation though to very low extent, inwards and outwards of the box; however, it works more like the silica glass than like the rock salt.

I found also that the polyethylene film, used by Prof. Pratt in his experiment[8] to simulate the action of the rock salt panels, is excellent for this kind of experiment because it permits the transmission of solar shortwave IR into the box, and allows the longwave radiation flows freely into and out of the box.

The results of this stage of the experiment show that the greenhouse effect by longwave infrared radiation trapped by the atmosphere, inside or outside the boxes, is inexistent. Such phenomenon is not physical and, consequently, the hypothesis of the greenhouse effect caused by longwave infrared radiation trapped in the atmosphere is false.

I plotted the results on the following graph. I did not include the ambient temperature:



THIRD SEGMENT OF THE EXPERIMENT

The purpose of this segment is to verify if the solar longwave radiation is transmitted by the sheeting of polyethylene, as it is specified by the manufacturer and other authors.

I conducted the experiment on May 28, 2011.

I started the experiment at 16:00 hr (CST).

I and finished the experiment at 17:30 hr (CST).

The coordinates of the location where the experiment was carried out are:

Location: San Nicolas de los Garza, Nuevo Leon, Mexico.

Latitude: 25º 48´ North

Longitude: 100º 19' West

Altitude: 513 meters above sea level.

METHODOLOGY:

I constructed a wood structure with a frame covered by a silica glass panel with a total height of 50 cm so that it covered the whole acrylic pane of the first box. This was made to reproduce the experiment of Prof. Robert W. Wood[1], who placed a silica glass pane above the boxes with the purpose of blocking the solar longwave radiation and to keep this solar longwave radiation from penetrating into the box. This would resemble the experiment of Prof. Wood, who used a rock salt panel and a screen of silica glass.

I placed three boxes on a white table made of a poor absorbent material; one box covered by the uncut acrylic pane, one box covered with a polyethylene film and one box covered with a holed acrylic pane to allow convection between the inner space of the box and its surroundings.

I placed the wooden structure with the silica glass above the box covered with the intact panel of acrylic in parallel to the acrylic panel of the box, so that it kept the solar longwave infrared radiation from reaching the box; silica glass is opaque to longwave IR.

I observed the change of temperature inside each box each five minutes, except at 10:35 hr. I have summarized the results of the second experiment in the following table:

Hour (CST)	Temperature Inside the Box Covered with an Acrylic Panel Protected by a silica glass Panel (°C)	Temperature Inside the Box Covered with a Polyethylene Panel (°C)	Temperature Inside the Box Covered with a Holed Acrylic Panel (°C)	Ambient Temperature (°C)
16.00	44.5	44.5	40.0	38.9
16:05	55.2	57.8	48.5	39.1
16:10	57.2	60.2	55.9	39.3
16:15	57.7	61.2	59.4	39.3
16:20	58.5	61.8	60.1	39.4
16:25	57.1	60.8	58.4	39.6
16:30	57.5	61	58.9	39.2
16:40	56.8	60.6	58.7	39.2
16:45	56.6	60.2	58.1	39.2
16:50	56.4	60.0	57.3	39.2
16:55	56.5	59.9	58.0	39.3
17:00	56.6	59.8	58.3	39.2

Observations:

1. I observed that, unlike the results obtained during experimental series 1 and 2, the protection of the silica glass placed to avoid the passage of the solar longwave infrared radiation, the temperature of the box covered with the intact acrylic cover still remained below the temperature of the box with the acrylic cover with a hole and below the temperature of the box covered with a polyethylene film.

2. I observed that the temperature inside the box covered with a polyethylene film remained higher than the temperature of the acrylic holed panel. Also, the box covered with the holed pane of acrylic remained lower than that of the box covered by a polyethylene film.

   This fact is verified through the second segment of this experiment. The temperature of the box covered with a polyethylene film and the temperature of the box covered with a silica glass pane remained higher than the temperature of the box covered by the holed acrylic panel.

After removing the silica glass screen that protected the box with an acrylic panel, the results were as follows:

Hour of the Day (CST)	Temperature Inside The Box Covered with an Acrylic Panel After the Silica glass Panel was Removed (°C)	Temperature Inside The Box Covered with a Polyethylene Panel (°C)	Temperature Inside The Box Covered with a Holed Acrylic Panel (°C)	Ambient Temperature (°C)
17:10	58.6	59.1	57.4	39.2
17:15	58.5	58.5	56.8	39.2
17:20	58.4	58.3	56.7	39.2
17:30	58.3	58.2	56.8	39.0

3. I observed that, after the protection provided by the silica glass to avoid the solar longwave infrared radiation from reaching the box covered with the acrylic panel, the temperature inside the acrylic paneled box increased until reaching a temperature higher than the temperature inside the box covered with a polyethylene film and the box covered with an acrylic holed panel.

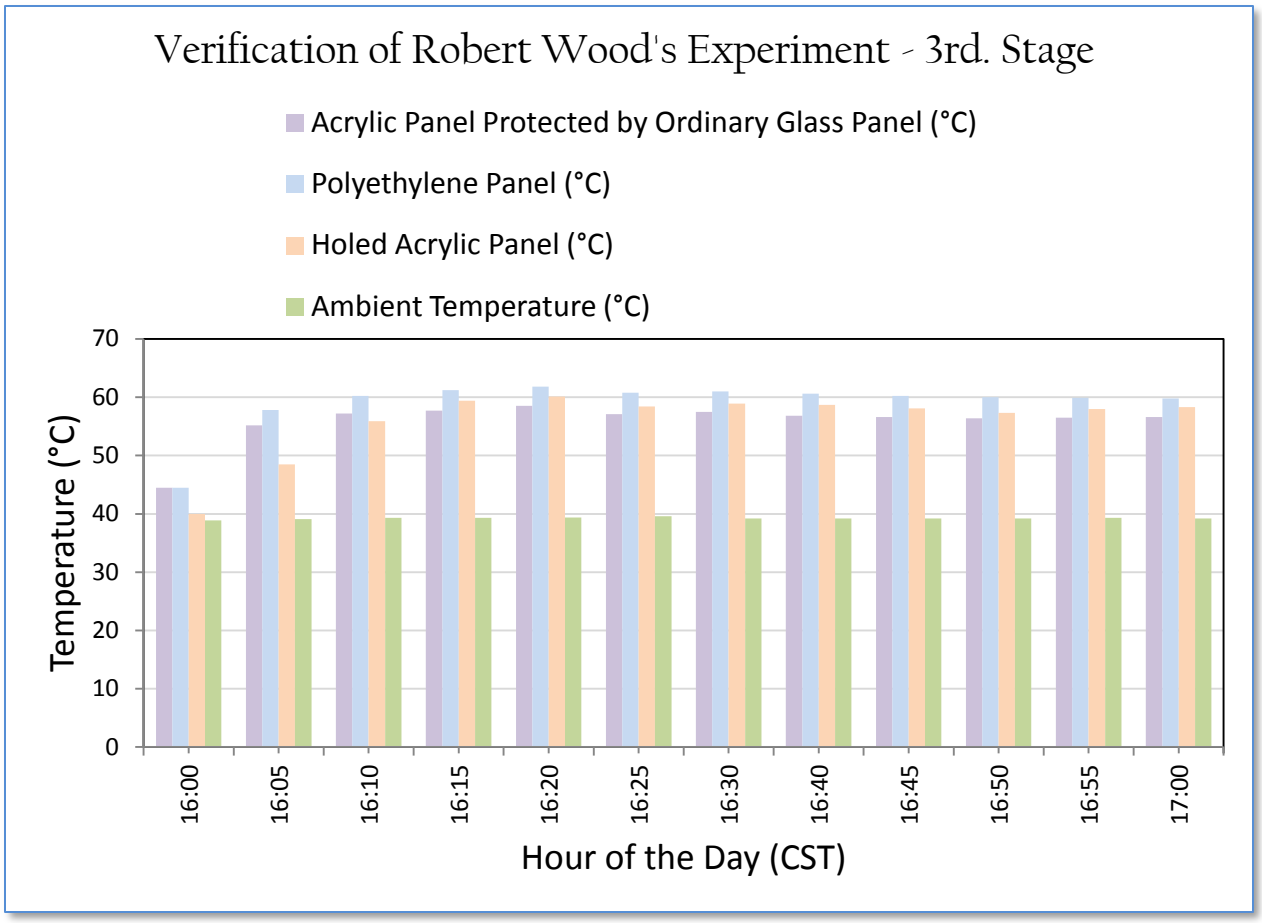
CONCLUSIONS TO THE THIRD STAGE OF THE EXPERIMENT

The third segment of the experiment confirms the results of Wood's experiment[1].

The addition of a glass screen to protect the box covered with the uncut acrylic pane eliminated the absorption of longwave solar infrared radiation by the acrylic pane.

The polyethylene sheeting works like the rock salt window used by Prof. Robert W. Wood[1]. The temperature in the box covered with the polyethylene sheeting was higher than the temperature in the other boxes. This means that the polyethylene transmits inwards and outwards the longwave solar radiation, but blocks the free convection with the open environment. Therefore, the so called greenhouse effect is not due to any trapping of longwave radiation inside the house, but to the blockage of free convective heat transfer, which was allowed in the box covered by an acrylic holed panel. For this reason, the temperature of the box covered with the holed acrylic pane was lower than the temperature of the other boxes.

I have plotted the results of the third stage of the experiment in the following graph:


Verification of Robert Wood's Experiment - 3rd. Stage
Acrylic Panel Protected by Ordinary Glass Panel (°C)
Polyethylene Panel (°C)
Holed Acrylic Panel (°C)
Ambient Temperature (°C)
Temperature (°C)
70
60
50
40
30
20
10
0
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:40
16:45
16:50
16:55
17:00
Hour of the Day (CST)

FOURTH STAGE OF THE EXPERIMENT

The purpose of this experiment is to reproduce Prof. Wood's use of a glass panel in front of a salt panel (using poly in lieu of salt) and see if I can recreate his conclusions, as well as to investigate if the polyethylene film allows the passage of solar longwave IR and solar shortwave IR, similar to rock salt panels.

PROCEDURE

For this experiment, I constructed a cardboard box and covered its open side with a polyethylene film. I wrapped the remaining walls with Reynolds' Wrap aluminum foil.

I constructed also a box covered with a silica glass panel and wrapped the remaining walls with Reynolds' aluminum foil.

I placed the two boxes on a table made of poor absorbent material.

I took off the protective aluminum plastic sheet to expose the two boxes to direct insolation.

I observed the change of temperature every five minutes during one hour.

At 75 minutes mark, I placed a protective silica glass screen above the box covered with polyethylene film for the purpose of keeping the longwave solar IR from entering into the box, and recorded the temperature of the box.

The results of the fourth experiment are recorded in the following table:

Time Lapse	Wind Speed (Km/h)	Temperature (°C)			
		Ambient	Glass	Polyethylene Film	Screened Polyethylene film
Starting	1.6	29.8	34.2	32.1	
5 min	5.2	30.1	45.3	40.7	
10 min	2.8	30.9	58.8	57.5	
15 min	4.2	32.1	60	62	
20 min	6.6	32.8	61.8	64.2	
25 min	8.2	33.2	61.2	62.9	
30 min	4.2	33.4	61.7	63.1	
35 min	5.2	33.6	61.5	63.1	
45 min	6.8	33.7	61.6	63	
50 min	0.5	33.8	62.5	64	
55 min	0.8	33.9	62.2	63.5	
60 min	1.2	33.8	62.5	64	
75 min			63.7		59.2

Observations:

1. At the start of the experiment, I observed that the temperature in the box covered by a silica glass panel was higher than the temperature in the box covered with polyethylene film.

2. The temperature of the box covered with the silica glass panel and the box covered with polyethylene film was higher than the ambient temperature.

3. After five minutes of direct exposure to sunlight, the temperature of both boxes increased sharply.

4. After ten minutes of direct exposure to sunlight, the temperature in the box covered with polyethylene film was higher than the temperature in the box covered with a silica glass panel.

5. I observed that the temperature in the box covered with polyethylene film remained higher than the temperature in the box covered with a silica glass panel up to one hour of direct exposure to sunlight.

6. I observed that 25 minutes after the exposure to sunlight, the wind speeded up. I observed that the temperature of both boxes decreased. The same phenomenon happened 35 minutes and 45 minutes of exposure.

7. I observed that the temperature of the box covered with polyethylene film, and protected with the silica glass screen, decreased dramatically after 15 minutes of exposure to insolation.

CONCLUSIONS TO THE FOURTH SEGMENT OF THE EXPERIMENT

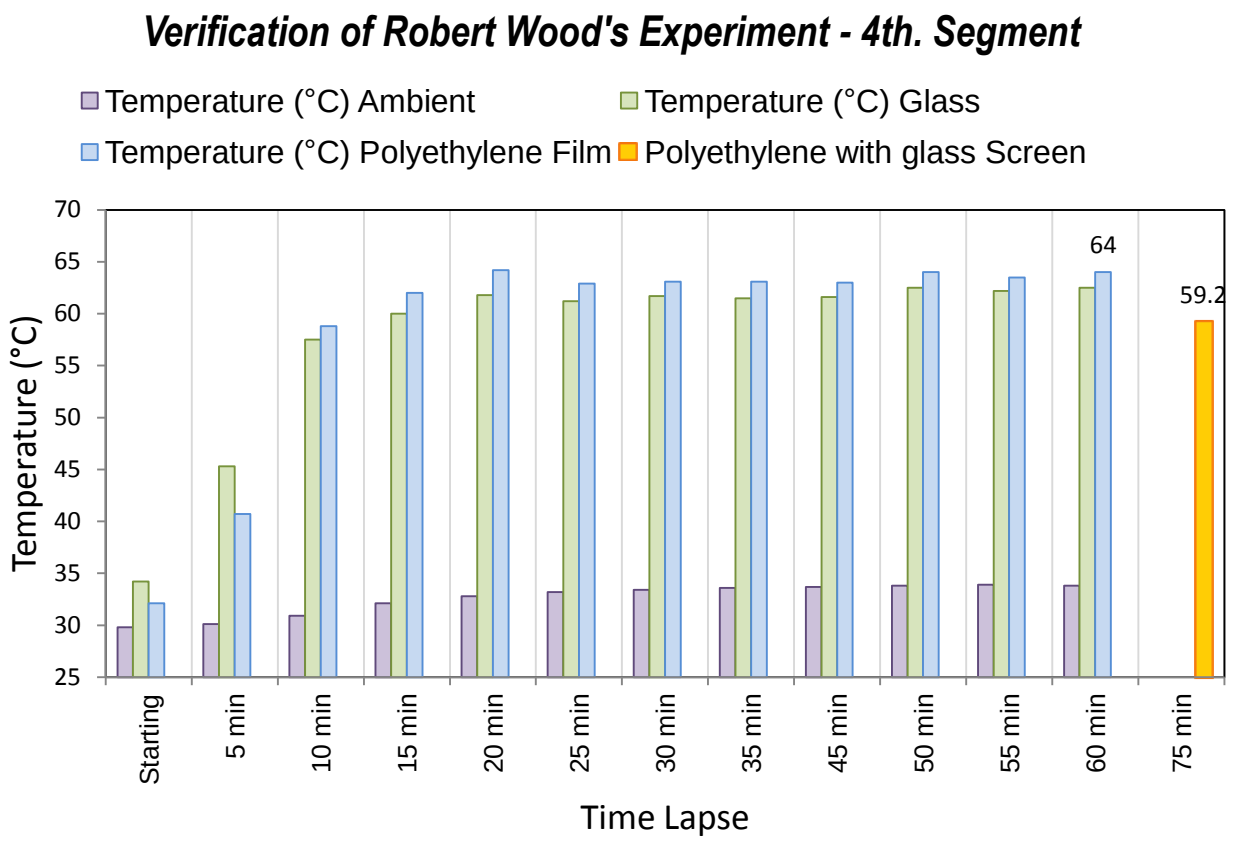
Given that the polyethylene permits the passage of solar longwave and shortwave IR, the temperature inside the box covered with polyethylene film was always higher than the temperature of the box covered with the silica glass panel. This means that more radiation penetrated into the box covered with polyethylene film than into the box covered with silica glass because the latter blocks the passage of solar longwave radiation.

As I placed the silica glass screen before the box covered with the panel of polyethylene film, the temperature in this box decreased dramatically by 4.8 °C in 15 minutes. This means that the polyethylene film is a good substitute of the rock salt glass because it permits the passage of shortwave and longwave IR into and out the box.

As the polyethylene film has a higher transparency index to IR, the only possible cause of the increased temperature inside the box is due to the blockage of convective heat transfer. Otherwise, the radiation of longwave IR outwards the box would have maintained its inner temperature very close to the ambient temperature.

The experiment of Prof. Robert W. Wood is validated through the four stages of this experiment.

I have plotted the results of the fourth segment of the experiment in the following graph:



Explanation to the graph above these lines: The glass panel permits the solar shortwave infrared radiation to penetrate into the box but blocks most of the solar longwave infrared radiation; therefore, only solar shortwave IR passes through the glass into the box covered with this panel.

On the other hand, the polyethylene film allows the solar shortwave and longwave infrared radiation go into and out the box. Therefore, the temperature of the inner surface of the box covered with polyethylene (PE) film is higher than the temperature inside the box covered with glass (more IR radiation enters to the box covered with PE than to the box covered with glass, and it is absorbed by the black walls of the box).

As I placed the glass screen over the box covered with PE, most of the solar longwave IR was blocked by the glass screen and mainly the solar shortwave IR penetrated to the box covered with PE film; consequently, the temperature inside this box decreased. I left a free space between the silica glass screen and the polyethylene film pane, so that the heat transfer by convection could take place extensively through this space.

Also, given that the polyethylene film permits the longwave radiation emitted by the walls to go in the box covered with PE film, the temperature in the box, as I screened it with the glass panel, dropped down to a lower value than the temperature inside the box covered only by glass because the silica glass panel placed above the polyethylene film avoids the solar longwave radiation to reach the LDPE film below, so there was not solar longwave radiation going in the box; consequently, the walls of the box would not have been warmed up by absorbing additional solar longwave thermal radiation as it could have happened

if the solar longwave radiation had been allowed to go in the box; as a result, the temperature of the air inside the box covered with LDPE film and screened with a silica glass panel, which does not permit the passage of longwave thermal radiation, dropped down.

FIFTH EXPERIMENT

The purpose of this experiment is compare the temperature changes of a box wrapped in white glass wool, resembling the experiment of Prof. Wood, and a box wrapped with Reynolds' Wrap Aluminum Foil.

In the final part of this experiment, I cut the polyethylene film from the two boxes so the effect of convection was evident.

PROCEDURE

I constructed two boxes covered with polyethylene film. The first box was wrapped with white glass wool and the second box was wrapped with aluminum foil.

I placed both boxes under direct sunlight during one hour and recorded the temperatures inside each one of the boxes.

The results of the fifth experiment are recorded in the following table:

Time Lapse	Temperature (°C)				
	Ambient	Polyethylene Film Box wrapped with white glass wool	Polyethylene Film Box wrapped with Aluminum foil	Partially open box wrapped with white glass wool	Partially open box wrapped with aluminum foil
Starting	30.1	32.4	31.8		
5 min	31.6	45.6	40.8		
10 min	32	57.7	57.6		
15 min	32.1	61.8	60.1		
20 min	32.3	66.0	61.6		
25 min	32.4	68.2	61.9		
30 min	32.6	70.6	63.7		
35 min	32.7	72.5	64.9		
40 min	32.8	73.3	64.5		
45 min	32.6	70.3	60.1		
50 min	32.7	71.4	61.2		
55 min	32.7	72.1	62.0		
60 min	33.1	73.8	64		
70 min	33.3			69.9	59.5
75 min	33.3			67.6	59.2
80 min	33.4			68.2	60.0
85 min	33.4			66.8	58.5
90 min	33.5			67.2	59.1

Observations:

1. I observed that he temperature in the box wrapped with white wool glass was always higher than the temperature in the box wrapped with Reynolds' Wrap Aluminum Foil.

2. I observed that the temperature decreased sharply as the polyethylene film was cut in both boxes.

3. I observed that the difference of temperatures between the box wrapped with white glass wool and the box wrapped with aluminum foil stabilized after their respective polyethylene films were cut.

CONCLUSIONS TO THE FIFTH SEGMENT OF THE EXPERIMENT

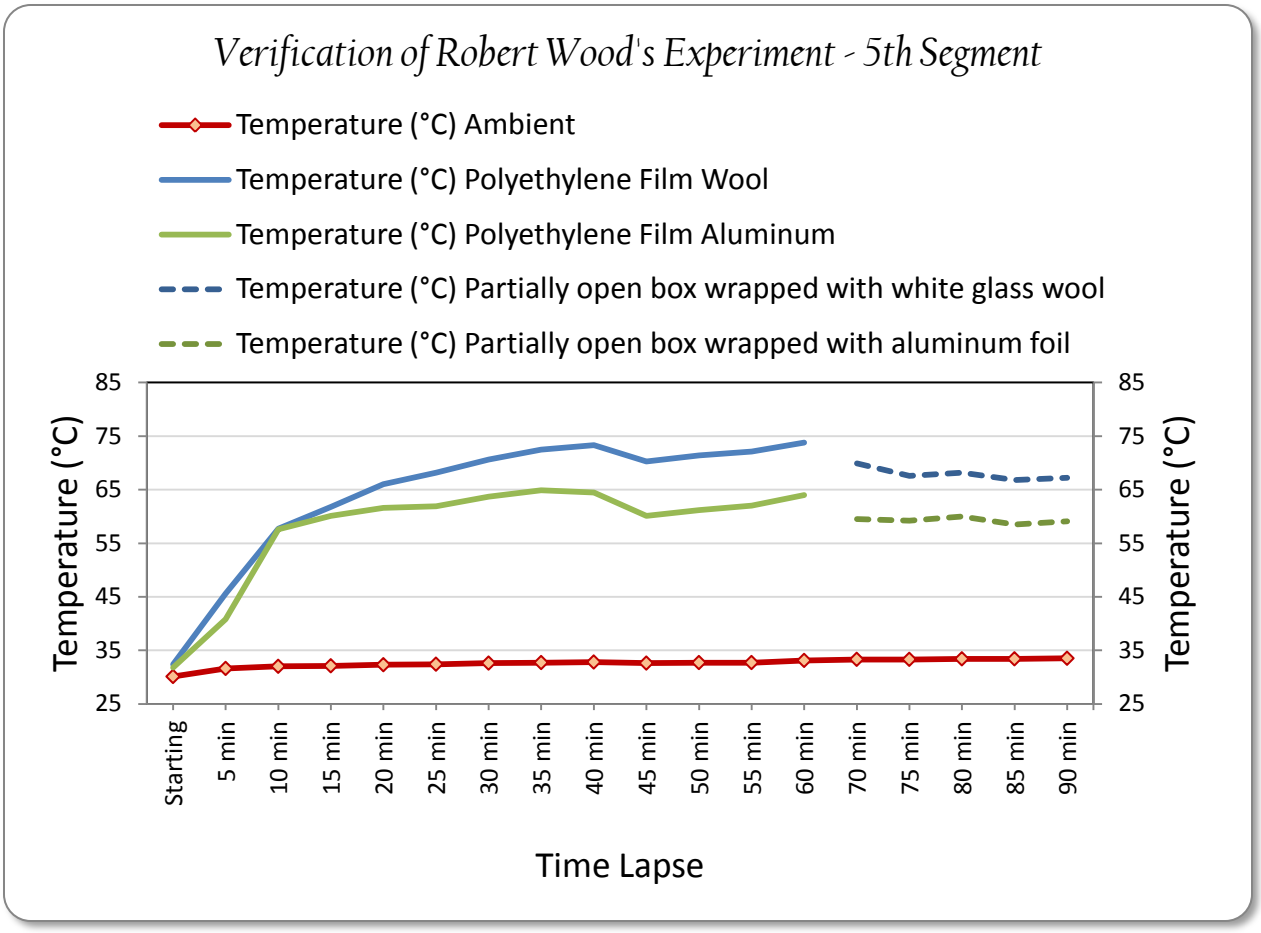
Prof. Robert W. Wood may have observed very high temperatures similar to the temperatures that I observed from the box wrapped with white glass wool. My results confirm that the white glass wool is a good insulator against losses of thermal energy by conduction.

From the results obtained by cutting the polyethylene film of both boxes, it is also evident that the heating of the air inside the boxes sealed with polyethylene film was due to the blockage of free convection between the inside of the box and the open environment and not to any longwave IR "trapped" inside the boxes because the polyethylene film permits the free flow of longwave IR, into and out of the boxes.

The temperatures inside the boxes were higher than the temperature of the environment because the matte black paint is a good absorber and emitter of infrared radiation in the main wavelengths.

According to Kirchhoff's Law, the volume of air in the boundary layer between the walls of the boxes and the atmosphere is heated up by conduction and convection, especially in the first 10 centimeters of air inside the boxes.

I have plotted the results in the following graph:


Verification of Robert Wood's Experiment - 5th Segment
Temperature (°C) Ambient
Temperature (°C) Polyethylene Film Wool
Temperature (°C) Polyethylene Film Aluminum
Temperature (°C) Partially open box wrapped with white glass wool
Temperature (°C) Partially open box wrapped with aluminum foil
Temperature (°C)
85
75
65
55
45
35
25
Starting
5 min
10 min
15 min
20 min
25 min
30 min
35 min
40 min
45 min
50 min
55 min
60 min
70 min
75 min
80 min
85 min
90 min
Time Lapse

SIXTH EXPERIMENT

The Greenhouse Effect hypothesis is founded in the argument that the atmosphere inhibits the flow of longwave infrared radiation from the surface to the outer space.

The hypothesis is based in a speculation made by Svante Arrhenius in 1885 [15] in the sense that the carbon dioxide would act as a storage space of heat in the atmosphere.

The hypothesis says that a great part of the solar shortwave radiation incoming from the Sun penetrates the Earth's atmosphere and strikes on the surface -land and oceans- heating it up. As the solar shortwave and longwave infrared radiation is absorbed by the surface, the surface radiates longwave infrared radiation that is effectively absorbed by the greenhouse gases in the atmosphere, stored by them and reradiated towards the surface heating it up more and more.

The principle adduced by the greenhouse effect hypothesis is based on the idea that, in a real greenhouse, the glass panels permit the solar shortwave radiation to penetrate into the enclosure but does not permit the longwave emitted by the inner surfaces of the enclosed space to escape.

To verify this hypothesis, I carried out an experiment using two boxes constructed with five sides made of cardboard and one open side which I covered with polyethylene film. The polyethylene film permits the passage of both shortwave and longwave infrared radiation.

One of the boxes was completely covered and sealed with the polyethylene film, while only a 53% of the open side of the other box was covered with the polyethylene film

I placed one thermometer into each one of the boxes to monitor the temperature during one hour, recording the observed temperatures every five minutes.

I placed the boxes on a high density polyethylene table, 2.54 cm thick, for being exposed to direct solar radiation during one hour and I recorded the temperatures of each box.

If the greenhouse effect hypothesis were true, the temperatures in both boxes would be the same because the outward radiative heat transfer would be the same from both boxes.

On the other hand, if the greenhouse effect hypothesis were false, a difference of temperature would be present due to convective heat transfer allowed by in the partially covered box.

To confirm the results, I placed a silica glass screen before the box partially covered with polyethylene film.

In case of the greenhouse effect hypothesis were true, the temperature in the box partially covered with polyethylene would not decrease by the effect of convective heat transfer, but it would be stable or increasing by the effect of the longwave infrared radiation emitted by the inner surfaces of the box and the solar shortwave infrared radiation that the silica glass panel permits to move across the glass.

However, if the hypothesis of the greenhouse effect were true, the temperature in the box partially covered would be higher by the effect of the longwave infrared radiation emitted by the inner surfaces of

the box and the solar shortwave infrared radiation that the silica glass panel permits to move across the glass.

Procedure:

I placed two boxes on a high density polyethylene table, 2.54 cm thick, and 80 cm above the floor.

I covered the two boxes with an aluminum plastic sheet to keep the solar radiation from entering the boxes before the experiment started.

At 16:00 hrs (CST), I removed the aluminum plastic sheet to expose the boxes, at the same time, to the solar irradiance.

I recorded the temperatures of each box every 5 minutes up to one hour.

After 1 hour of observation, I stopped recording the temperature of the box completely covered with a polyethylene film.

I placed a silica glass screen 50 cm before the box partially covered with polyethylene film so the solar longwave infrared radiation did not strike onto the inner surfaces of the box.

I proceeded to record the temperatures every five minutes in the box partially covered by polyethylene film up to one half hour.

I recorded the results of the two phases of the experiment on the following table:

Time Lapse	Temperature (°C)			
	Ambient	47% Cut Polyethylene Film	Polyethylene Film	LDPE film screened with a Glass pane
Starting	34.4	36.5	37.7	
5 min	34.8	41.4	52	
10 min	35.1	48.6	60	
15 min	35.1	49	60.8	
20 min	35.2	47.5	60.5	
25 min	35.2	48.2	60.1	
30 min	35.3	47	60	
35 min	35.3	47	59.5	
40 min	35.3	47.2	59.4	
45 min	35.3	46.8	58.9	
50 min	35.5	46.5	58.8	
55 min	35.7	47.4	59	
60 min	35.6	46.3	58.1	
5 min	35.6			45.2
10 min	35.6			45
15 min	35.7			44.1
20 min	35.5			43.5
25 min	35.5			43.8
30 min	35.4			43.4

Observations:

1. I observed that the temperature in the box covered with a partially cut polyethylene film was lower than the temperature in the box covered with a complete polyethylene sheeting.

2. I observed that the temperature in the box partially covered with the complete polyethylene sheeting decreased after it was protected with a screen of glass.

Conclusions to the Sixth Segment of the Experiment:

The excess of temperature in the box partially covered with polyethylene film with respect to the same box after it was screened with silica glass decreased because the silica glass blocked the solar longwave infrared radiation and did not allow it to hit on the inner surfaces of the box heating them up.

The convective heat transfer was not impeded in both phases of the experiment; consequently, the lower temperature in the box completely open was due to a larger area of convective heat transfer with the environment.

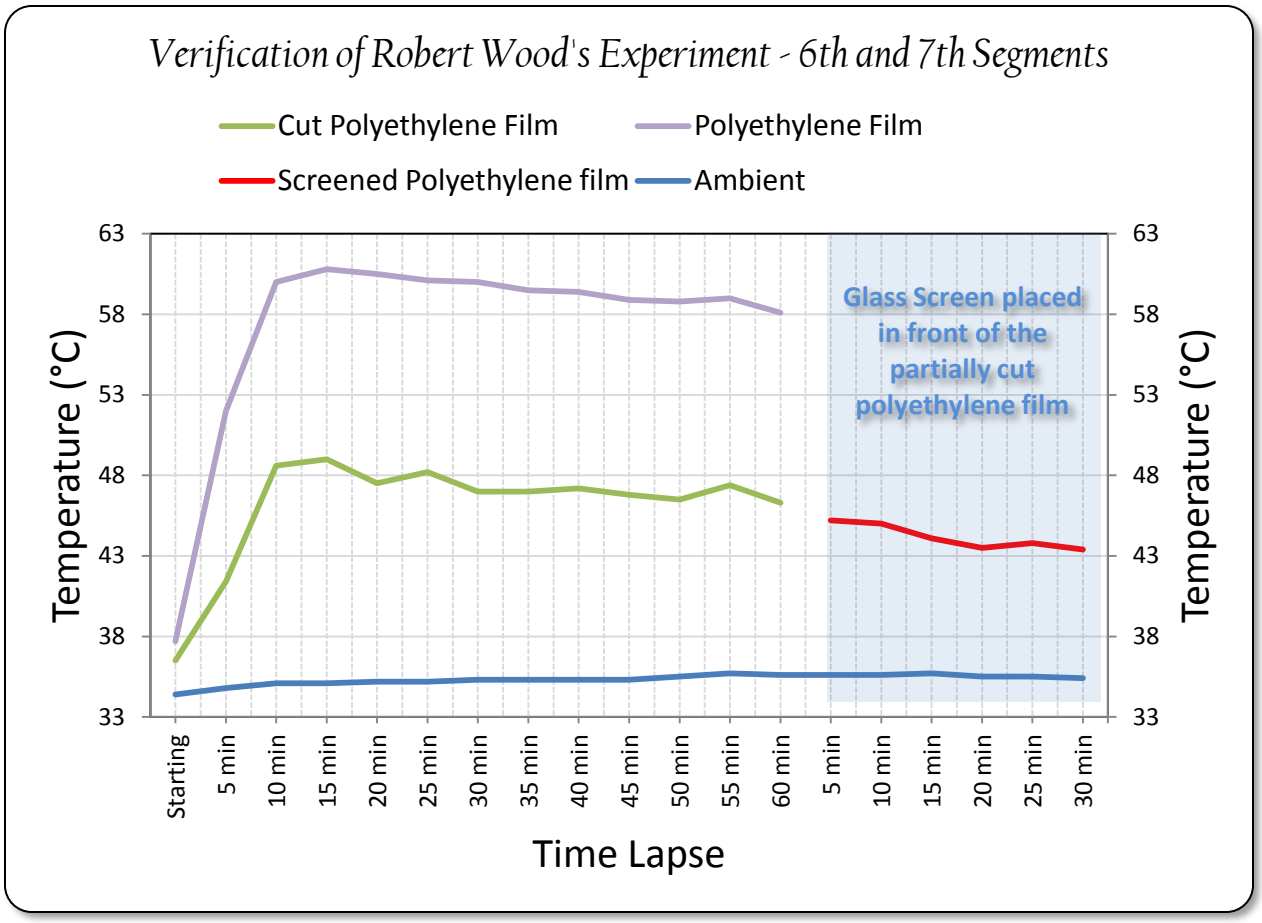
Silica Glass inhibited the longwave radiation to penetrate into the box partially covered with polyethylene film; consequently, after I screened with a glass pane the box covered with the cut polyethylene film, the temperature decreased. The latter is due to a lower load of thermal radiation penetrating into the box as the glass pane allowed only the passage of shortwave infrared radiation.

The temperature in the box covered by a partially cut polyethylene film remained lower than the temperature in the box covered by the complete sheet of polyethylene because I permitted the convective heat transfer from the inside of the box with the environment.

Given that the shortwave and longwave radiation incoming from the Sun was permitted to freely go in and out both boxes, the solitary explanation to the low temperature in the box partially opened with respect to the box completely sealed is the free convective heat transfer with the environment.

The results of this segment of the experiment, in particular the fact that the temperature in the box covered with a partially cut polyethylene film was lower than the temperature of the box covered with an intact polyethylene film, demonstrate that the hypothesis of the “greenhouse effect” due to longwave radiation trapped by the atmosphere is false.

I have plotted the results in the following graph:


Verification of Robert Wood's Experiment - 6th and 7th Segments
Cut Polyethylene Film
Polyethylene Film
Screened Polyethylene film
Ambient
Glass Screen placed in front of the partially cut polyethylene film
Temperature (°C)
63
58
53
48
43
38
33
Starting
5 min
10 min
15 min
20 min
25 min
30 min
35 min
40 min
45 min
50 min
55 min
60 min
Time Lapse

TESTING EXPERIMENT

As a required review to verify the conclusions of the previous experiments, I decided to conduct an experiment using an open box (with a white matte interior) and a polyethylene screened box with a black matte interior and compare the temperatures of each.

With this purpose in mind, I constructed a new box, wrapped it with Reynolds' Aluminum Foil, and painted its inner surfaces with matte white paint.

I suspended a rectangle of aluminum tape, which was kept up by three fishing threads crisscrossed on the place that would correspond to a panel of other materials, so as to cast a shadow on the thermometer's rod beneath and, therefore, to protect it from direct insolation.

I used the box covered with polyethylene film that I had used in the fourth segment of the experiment for comparison.

I conducted the experiment on June 11, 2011.

I started the experiment at 16:00 hr (CST).

I and finished the experiment at 17:00 hr (CST).

The coordinates of the location where the experiment was carried out are:

Location: San Nicolas de los Garza, Nuevo Leon, Mexico.

Latitude: 25º 48´ North

Longitude: 100º 19' West

Altitude: 513 meters above sea level.

Summary of Records of Temperature:

I placed the two boxes on a table made of white High Density Polyethylene (HDPE) with low absorptance.

The experiment started at 16:00 hrs (CST) and concluded at 17:00 hrs (CST).

I have recorded the results of the experiment in the following table:

Time Lapse	Temperature (°C)		
	Polyethylene	Control Box	Difference
Starting	35.4	35.4	0
5 min	47.6	43.2	4.4
10 min	52.8	41.9	10.9
15 min	54	43	11
20 min	55.7	43.6	12.1
25 min	56.8	44.1	12.7
30 min	55	42.6	12.4
35 min	54.8	43.4	11.4
40 min	54.5	43	11.5
45 min	54.4	43.1	11.3
50 min	55	43.6	11.4
55 min	53.1	42.8	10.3
60 min	53.9	42.9	11

Observations:

1. I observed that the initial temperatures in both boxes were exactly the same.

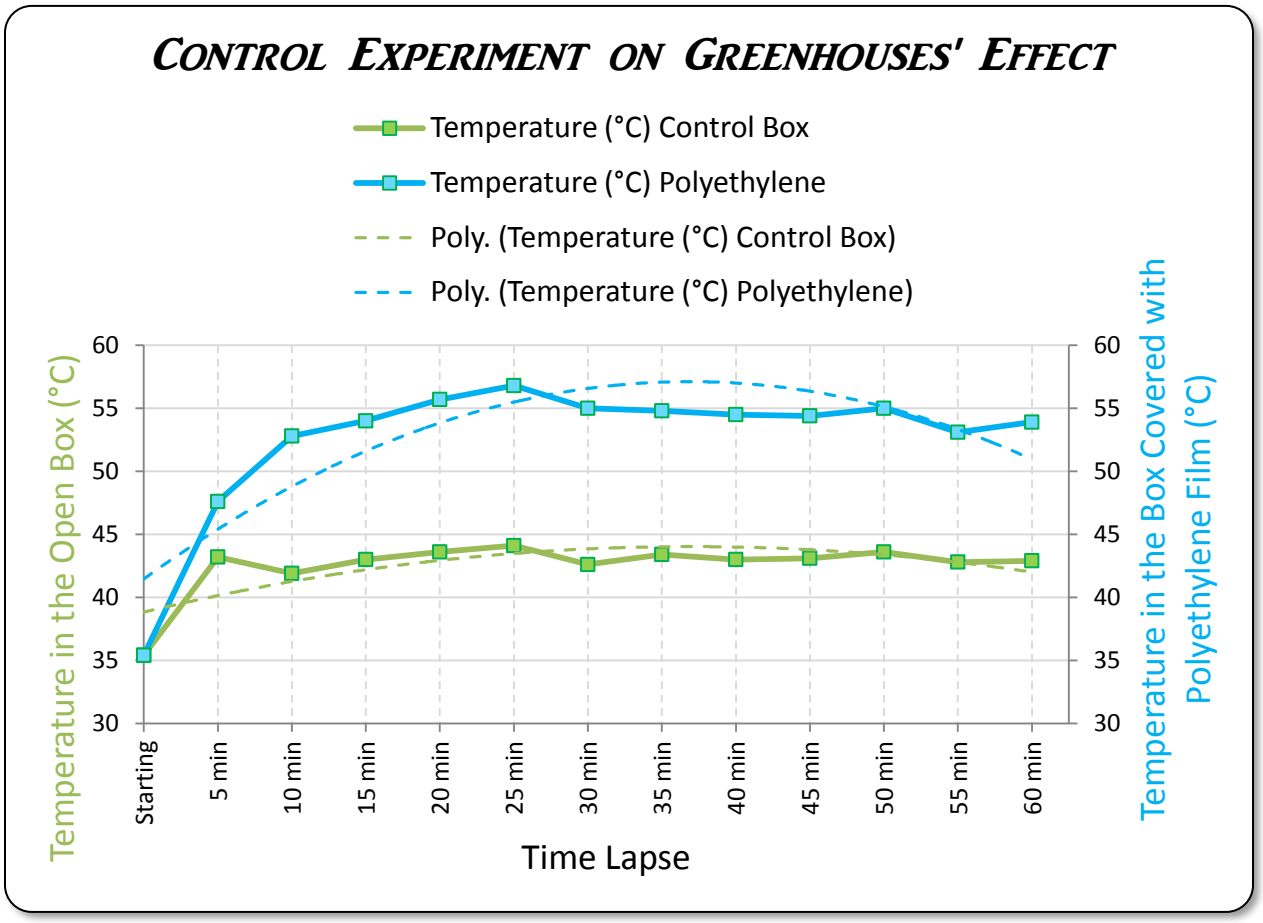
2. Five minutes after I started the experiment, the temperature of both boxes increased; however, the temperature in the box covered by polyethylene film was higher than the temperature in the control box.

3. Ten minutes after I started the experiment, the temperature in the box covered with polyethylene film increased considerably higher than the temperature in the control box. The difference of temperature between both boxes was 10.9 °C.

4. 25 minutes after I started the experiment, the difference of temperatures between the box covered with polyethylene film and the control box was 12.7 °C.

5. I observed that the difference of temperature between the box covered with polyethylene film and the control box remained more or less stable until concluding the experiment.

I plotted the results in the following graph:



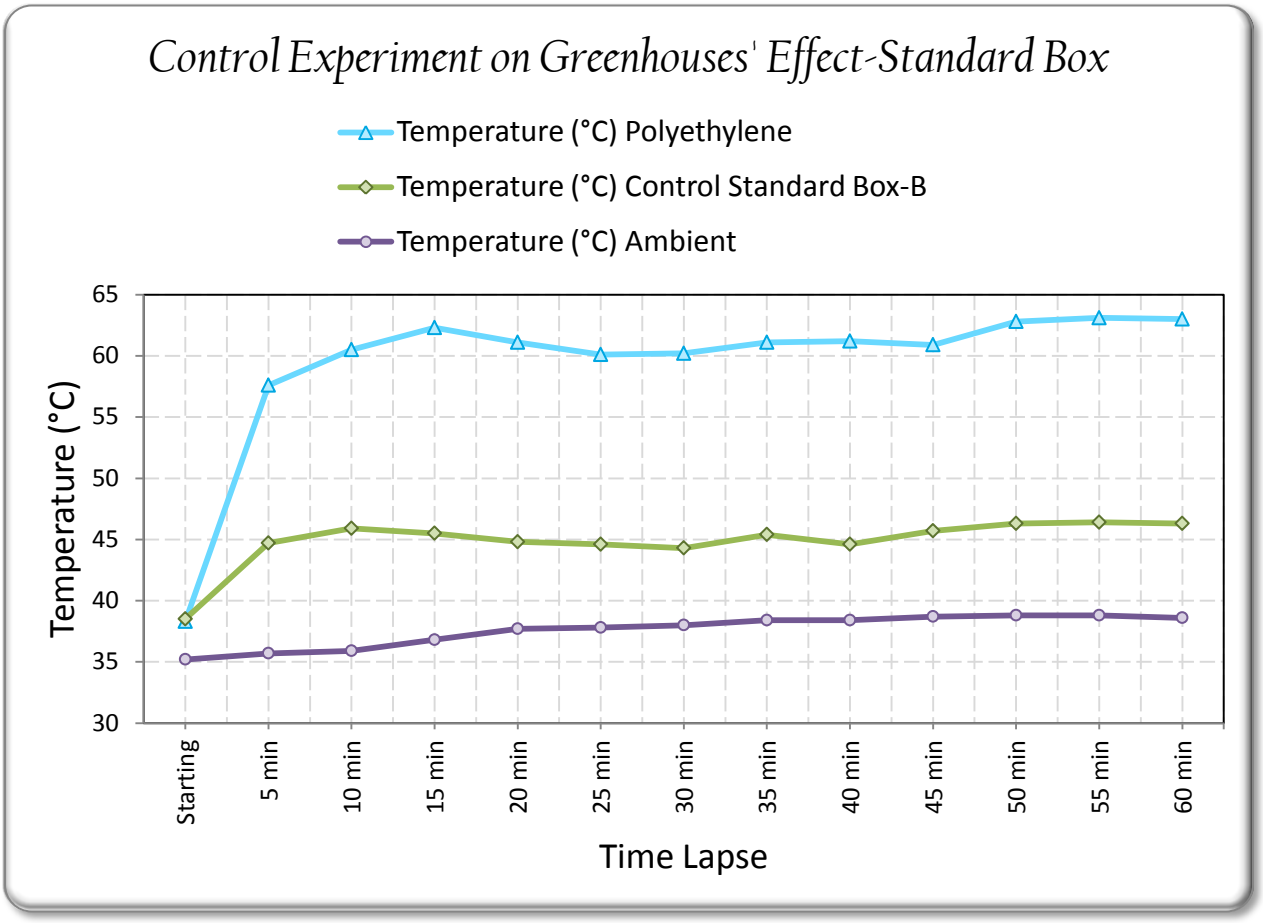
After this testing experiment finished, I compared the increase of temperature between a box covered with polyethylene film, wrapped with aluminum foil, and an standard box, completely open on one side, with no painted surfaces neither wrapped with aluminum foil (a standard box as it is received, except for the square of cork to hold the thermometer's rod, and the two small wood squares to fasten it to the support structure).

I exposed both boxes to the solar irradiance, starting the experiment at 15:30 hrs (CST) and finishing it at 16:30 hrs (CST).

The temperature was recorded every five minutes. I have recorded temperatures in the following table:

Time Lapse	Temperature (°C)				
	Polyethylene	Control Standard Box-B	Ambient	Wind Speed (Km/h)	Diff. T (Stage B) (°C)
Starting	38.3	38.5	35.2	2	-0.2
5 min	57.6	44.7	35.7	2.2	12.9
10 min	60.5	45.9	35.9	1.8	14.6
15 min	62.3	45.5	36.8	2.6	16.8
20 min	61.1	44.8	37.7	3.6	16.3
25 min	60.1	44.6	37.8	3.8	15.5
30 min	60.2	44.3	38	2.6	15.9
35 min	61.1	45.4	38.4	0.6	15.7
40 min	61.2	44.6	38.4	1.3	16.6
45 min	60.9	45.7	38.7	0.2	15.2
50 min	62.8	46.3	38.8	0.4	16.5
55 min	63.1	46.4	38.8	0.4	16.7
60 min	63	46.3	38.6	0.2	16.7

I have plotted a comparison concerning to the difference of temperature when using a control box wrapped with aluminum foil and painted with matte white paint, and when using a control standard box, i.e. a box that was not painted neither wrapped with any kind of material.



GENERAL CONCLUSIONS:

The greenhouse effect inside greenhouses is due to the blockage of convective heat transfer with the environment and it is not related, neither obeys, to any kind of "trapped" radiation. Therefore, the greenhouse effect does not exist as it is described in many didactic books and articles.

The experiment performed by Prof. Robert W. Wood in 1909 is absolutely valid and systematically repeatable.

In average, the blockage of convective heat transfer with the surroundings causes an increase of temperature inside the greenhouses of 10.03 °C with respect to the surroundings temperature.

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