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Laboratory Experiments Do Not Support the Greenhouse Effect as Applicable to CO_2

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Abstract

The analysis of Greenhouse Effect experiments in the public domain indicated that the lab tests were primarily centered around illustrating the mechanics of conventional greenhouses. They used high-energy visible light (such as sunlight), rather than addressing the Greenhouse Effect, which involves low-energy infrared radiation emitted by the Earth's surface. Studies with argon, a non-greenhouse gas with similar density to CO_2, showed thermal heat transfer as the dominant factor in the temperature profiles, with radiation absorption being undetected. The same conclusion was drawn by another study, which measured infrared back radiation. Experiments using exaggerated CO_2 concentrations inadvertently illustrated the principle of the Popper Falsification Test by disproving the Greenhouse Effect applicable to CO_2 within the troposphere. A straightforward kitchen test showed that a microwave oven cannot be used as a model for the Greenhouse Effect.

Keywords

Laboratory Experiment, Climate Change, Greenhouse Effect, CO_2

1. Introduction

The aim of this study is to determine if there are publicly available lab experiments that confirm or refute the Greenhouse Effect. The literature search proved to be more complex than anticipated due to the dual usage of the term "greenhouse" for both atmospheric effect and commercial greenhouses. Both operate through entirely different processes. Scientists agree that the Greenhouse Effect is just an analogy to the way real greenhouses work. In order to understand these systems and the resulting confusion, it is necessary to have knowledge of the meanings of those expressions.

1.1. What Is a Conventional Greenhouse?

A greenhouse is constructed with transparent materials, typically glass and plastic, which allows sunlight to enter. This sunlight gets absorbed by the ground, plants, and other objects within the structure. The heated objects warm the air inside through convection. The objective of the greenhouse is to maintain a closed system and retain heat inside. Greenhouses were created during the Roman Empire in 30 A.D. to provide the emperor Tiberius with his cucumbers and have been used in the United States since the 1700s [1]. Because the greenhouses are in a closed system, it keeps the insects away and eliminates the need for chemical pesticides. Commercial greenhouses often add CO_2 to boost plant growth [2].

1.2. What Is the Greenhouse Effect?

The Sun emits high-energy sunlight during the day, which heats up the Earth's oceans and land. To cool down, the Earth releases infrared radiation. However, certain gases in the atmosphere, known as Greenhouse Gases, absorb some of this low energy infrared radiation. According to the theory, this process of absorption warms the atmosphere and hinders the escape of heat into space [3].

1.3. What Is an Analogy?

The use of analogies makes complex concepts easier to grasp by comparing them to simpler ones. As an illustration, one can liken the complexities of electricity flow to the flow of water. The purpose is to aid comprehension. It should not be utilized as evidence to prove the concept itself. Employing an analogy as proof of its validity is improper. Attempts to do so are commonly known as the "Myth of Metaphor" and "Ingrained Analogy" and have the effect of degrading or biasing the research results [4].

2. Differences between the Greenhouse Effect and a Regular Greenhouse

It would be impossible to list all the differences between the two. While physical traits are easily observed, non-experts find it difficult to comprehend the more complex technical aspects, such as quantum mechanics.

2.1. Technically Complex Differences

The high-energy photons used in greenhouses are absorbed by the electrons in the atoms and molecules at the surface of solid or liquid objects inside the enclosure. Absorption of these photons prompts electrons to move to a higher energy level, aligning with the photon's energy. This process results in an increase in the kinetic energy of atoms or molecules, also known as temperature.

The mechanism in the Greenhouse Effect, on the other hand, is that certain gas molecules have covalent chemical bonds between the atoms that allow them to vibrate (stretch, compress, or bend) when they absorb infrared radiation. About 80% - 90% of the vibrational energy is then re-emitted as infrared radiation of the

same wavelength. The theory provides that a portion of the energy is used to raise the molecules' kinetic energy (temperature).

2.2. Physically Obvious Differences

Four observable differences are identified in Table 1 below: These observable differences make distinguishing between them obvious. But as discussed in Section **2.1**, radiation and radiation absorption is a complex concept. The main source of confusion comes from the word "greenhouse" being included in the name. To be more specific, we can refer to it as Infrared Absorption through Molecular Vibration (IAMV) rather than the Greenhouse Effect.

If a more descriptive name had been used, there would have been less confusion with a regular greenhouse. Labeling the gases that vibrate as Greenhouse Gases compounds the problem. TV shows and social media introduced most people to Greenhouse Effect experiments, which were later replicated in K-12 schools.

Table 1. Observable differences between two systems.

Conventional Greenhouse	Greenhouse Effect
Absorbs High Energy Visible Sunlight	Absorbs Low Energy Invisible Infrared
Heats Solid & Liquid Objects	Heats Greenhouse Gases
Man Made Closed System	Open System
Dark colors increase absorption	Gases are colorless

Some of these entities lacked the necessary technical knowledge to understand the differences.

2.3. High Energy Sunlight versus Low Energy Infrared Radiation

Understanding the importance of radiation wavelength and gas absorption is key to differentiating between high energy sunlight and low energy infrared radiation. The visualization of the wavelength and absorption profiles can be observed in Figure 1.

The graph displays the wavelength of light and the corresponding radiation absorption. It ranges from high energy ultraviolet light (0.2 - 0.4 μm) and high energy visible light (0.4 - 0.7 μm). This is shown as the red region in the upper left portion of the figure. A decrease in wavelength corresponds to a higher temperature of the emitting source. For example, high energy visible light has a wavelength emitted by a source having a temperature ranging from 7,000˚F to 12,000˚F.

As the temperature drops, the type of radiation emitted by objects changes to infrared. This type of radiation, called infrared, cannot be seen and has significantly less energy. The blue area in the upper right corner of Figure 1 represents this region. The lower section labeled "Major Components," depicts five Greenhouse Gases found in the atmosphere. The gray areas represent the absorption profiles for those gases. The white portion signifies that the radiation is able to

move through this zone without any hindrance. Water vapor, with its multiple gray peaks, is the dominant absorber across a wide range of wavelengths, surpassing all other greenhouse gases combined by a factor of about 50.

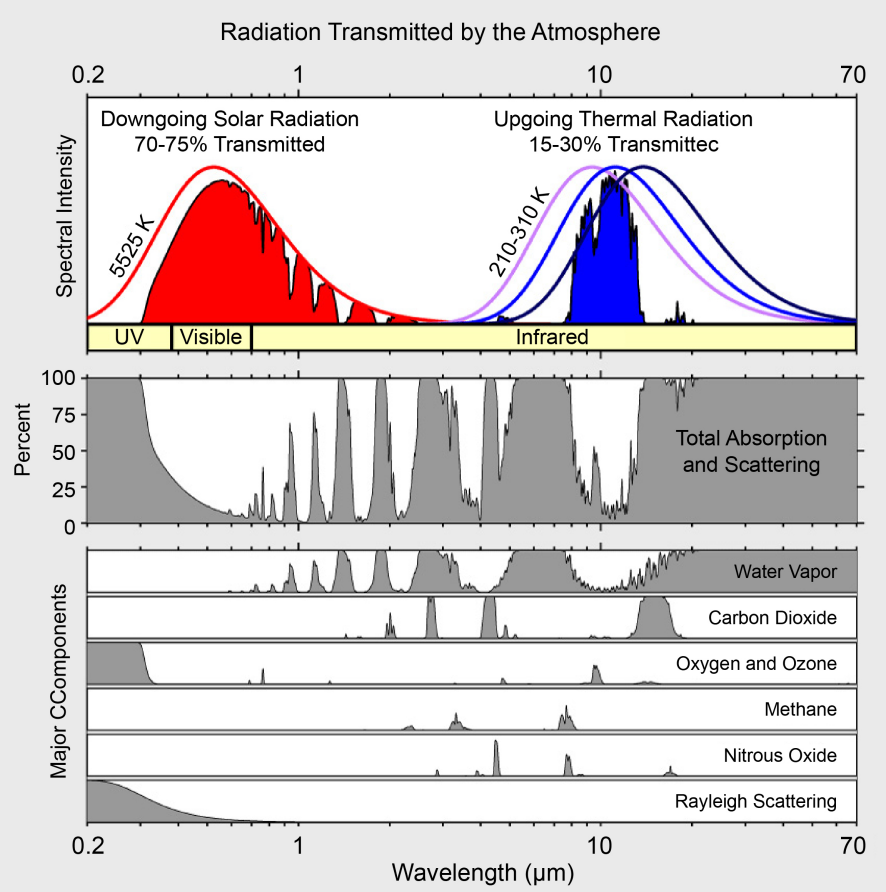

Figure 1. A graph prepared by Robert A Rohde, Global Warming Art and uploaded from https://www.wikimedia.org/ [5] under the terms of GNU Free Documentation License.

2.4. Infrared Radiation Emitted from Earth's Surface

Wilhelm Wien developed the Wien's Displacement Law, which allows us to translate the peak wavelength of Earth's infrared radiation into temperature. Wojciech Sas developed an online calculator [6] that offers a convenient method to calculate temperature using peak wavelength. According to Wien's law, the temperature indicates the highest point of the emissions curve rather than a specific wavelength. That is because there are diminishing amounts of wavelengths on both sides of the peak. Nearly all natural observations display diminishing values that revolve around a peak. Some examples are temperature, concentration, pressure, hardness, force, inertia, magnetism, electric fields, voltage, and more. This is a recurrent aspect of nature.

The next step is to determine the normal temperature range of the Earth. The average temperature is 59˚F (15˚C) but a single temperature would only cover a segment of the surface. The Earth's normal surface temperature varies from −13˚F

(−25˚C) to 113˚F (45˚C) [7]. A range of −20˚F to 125˚F would constitute more than 99 percent of the Earth's surface temperatures. This broader range translates into an infrared wavelength between 8.9 to 11.8 μm. The majority of the blue-colored block in the top right part of Figure 1 (between 8.9 - 11.8 μm) is the normal Earth temperature.

2.5. Photon Energy and Wavelength

A single photon emitted by the sun with a wavelength of 0.4 μm (visible light) has an energy of 4.97×10^{-19} J. A photon of infrared emitted by the Earth at its average temperature of 59˚F (15˚C) has an energy of 0.197×10^{-19} J. Therefore, each photon emitted from a visible light source will have an energy level about 25 times higher than a photon emitted from the Earth.

Why is this important? If CO_2 caused a 1˚C temperature increase in an experiment using high energy visible light, then if infrared radiation were used as the heat source, then the temperature rise would only be 0.04˚C. The majority of scientific thermometers cannot measure temperature changes below 0.1˚C.

Exaggerated findings occur as a consequence of using a high energy light source. The Greenhouse Effect principle is based on absorbing low energy infrared radiation from the Earth. Conventional greenhouses only use high energy visible light.

2.6. Open SYSTEM versus a Closed System

An open system permits the unrestricted movement and dispersion of energy and mass within the system. The atmosphere is an example. Air molecules and heat can freely circulate throughout the entire system.

Mass and, to a lesser extent, energy are confined in a closed system. Usually, it's confined by physical barriers like walls. An example of a closed system would be an oven. It only works as long as the mass and heat are trapped inside by a barrier. It would be a poor oven experiment if the doors and walls were removed. A refrigerator does the same thing, except the barriers keep the higher outside heat from getting inside. Conversely, tests on an open system, but with walls and barriers added to trap the mass and heat, would be a poor experiment for that system.

The Greenhouse Effect only operates in an open system. A real greenhouse is an example of a closed system. For the Greenhouse Effect to be demonstrated, the laboratory test should ideally simulate atmospheric conditions as accurately as possible.

2.7. Gases More Restrictive than Solids and Liquids

Kirchoff's laws state that solids and liquids absorb radiation across all wavelengths, while gases only absorb radiation at specific spectral wavelengths (see Figure 1). Hence, in a conventional greenhouse, the sunlight is absorbed by the solid surfaces inside, *i.e.* ground, plants, framing, etc. The surfaces warm up due to this absorption and the heat is distributed to the air by convection. Conventional

greenhouses have limited thermal warming by radiation absorption because of restrictions imposed by Kirchoff's laws.

2.8. Concentration of the Greenhouse Gases in the Atmosphere

The gases present in the troposphere are set forth in Table 2. The troposphere is the lowest layer and contains 75% to 80% of the total mass of the atmosphere [8]. Since the Greenhouse Gases are indicated as parts per million (ppm) the composition is also shown in ppm as well as percentage. The Greenhouse Gases are highlighted in green. The concentration of the Greenhouse Gases is important because those gases absorb infrared radiation based on the number of molecules (concentration) and the molecules' specific spectral absorption profile (the ability to absorb a particular wavelength of radiation).

Table 2. Concentration of gases in the troposphere.

Atmospheric Gas	Percentage of Total	Parts per Million (ppm)
Nitrogen	76%	76,0000
Oxygen	20%	200,000
Water Vapor	3%	30,000
Argon	0.93%	9,300
Carbon Dioxide	0.0421%	421
Neon	0.0018%	18
Helium	0.00052%	5.22
Methane	0.00019%	1.9
Nitrous Oxide	0.000033	0.33
Ozone	0.000001%	0.01

The range of water vapor concentration is commonly stated as 0 to 4%. However, the average above the ocean is approximately 3% [9], while in jungles it increases to around 4.2%.

3. Are There Any Laboratory Tests That Support the Greenhouse Effect?

The answer is a simple no, but there are others who disagree.

The IPCC (Intergovernmental Panel on Climate Change) [3] listed three reasons why the Greenhouse Effect was true. Absent from the list is a single laboratory test. The organization at the forefront of the Greenhouse Effect would definitely mention a laboratory experiment if it existed.

The IPCC 1990 on page xiv states, "*How do we know that the natural greenhouse effect is real*".

It lists three things:

- Firstly, the earth is warmer by 33 degrees from what calculations show it

should be;

- Secondly, the compositions of Venus and Mars support the Greenhouse Effect Theory;
- Thirdly, Ice core measurements going back 160,000 years show greenhouse gas concentrations match global temperatures.

The ice core data referenced by the IPCC, which includes CO_2 concentration and temperature measurements, do not meet the criteria of a lab experiment proving the Greenhouse Effect. Furthermore, the information's accuracy is diminished by selectively choosing the data and using anomalies instead of actual concentrations and actual temperatures. For instance, up to 40% of the data exhibit opposite trends in temperatures and concentrations (e.g. rising temperature with dropping CO_2, or rising CO_2 with dropping temperature), while up to 70% show no correlation between stimulus and response [7].

4. Laboratory Tests Covered in Television and Social Media Platforms

TV shows and social media have tried to demonstrate the Greenhouse effect using DIY experiments. The more popular ones are discussed in more detail hereinafter.

4.1. Bill Nye Experiment [10]

Bill Nye is known as The Science Guy and had a television show funded by the National Science Foundation and the Corporation for Public Broadcasting. His television program aired from 1993 to 1998. He made appearances on almost all the main street media as an expert and consulted with various Hollywood productions.

With respect to the Greenhouse Effect, Mr. Nye stated that most of the radiation reaching the Earth is absorbed by the surface and atmosphere, which in turn radiates **infrared energy** into space. To support his hypothesis, he suggested placing two glass jars side by side. Each jar contained a small earth globe, and a thermometer perched on top. One jar had air from the room, while the other was filled with 100% carbon dioxide. Two high energy heat lamps were placed above the jars. However, the brightness and distances of the lamps were not identified. The heat lamps emitted a visible reddish glow.

The temperature of each thermometer started at 96.2˚F and a video clip showed them increasing with time. The reported time was missing. In a close-up video, the thermometer in the left jar (air) rose to 97.9˚F, and the temperature in the right jar, (CO_2) rose to 100.2˚F. This meant CO_2 containing jar rose 2.3˚F higher than the air jar. Mr. Nye concluded from this experiment that the bottles were like the atmosphere absorbing the infrared radiation being emitted by the earth and increasing the temperature of the atmosphere.

Potential Deficiencies with the Bill Nye Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased

concentrations of CO_2.

1) High Energy Source Used

The energy source used in the test was a high energy visible light. The Greenhouse Effect involves absorption of **low energy infrared** radiation. Infrared photons emitted by the Earth's surface are invisible to the human eye. A single photon of visible light carries approximately 25 times more energy than a photon from an infrared source at Earth's average temperature. Tests that use high energy sunlight or heating lamps generating visible light suggest confusion with real greenhouses (see Sections **1-1.3**). CO_2 also has some absorption peaks in the high energy light wavelengths that do not exist within the wavelengths that are normally emitted by the Earth (11.8 μm to 8.9 μm).

Others could argue that because a control chamber containing air was used and subjected to the same conditions, then any differences between them must be attributed to CO_2 acting as a Greenhouse Gas. Although the statement seems logical, it is flat-out incorrect. There were no measurements made distinguishing between high energy visible radiation absorbed by the objects as compared to radiation absorbed by the gases. There were no measurements of re-emissions, nor were there any measurements of the amount of infrared radiation generated by the objects. In addition, a comparison with a jar containing air **assumes:** (1) the quantum mechanisms going on inside the jars were the same (they were not—see Section **2.1**), (2) there were no absorption profiles in the visible light spectrum (but that was not true either since there were absorption peaks see **Figure 1**) and (3) all test conditions in each of the chambers were equal (they were not the same as discussed hereinafter).

2) Open and Closed System

They sealed one jar, which showed a closed system. In the other jar, they cracked open the lid, which allowed some of the gas and heat inside to escape. That would be a hybrid system because they used a glass bottom and sides. Hence, they were making comparisons between a closed system and a partially open system with no comments, observations, or measurements of the effects of that difference.

3) Differences in Lamp Intensities

The data did not include any details about the intensity or energy level (wavelength) of the lamps used. During the initial stage of the test, the light source above the air jar displayed a solid red *instrument* light on the housing, while the light source above the CO_2 jar exhibited an *instrument* light showing 2/3 white light and 1/3 red light combined (at timeframe 1:07). Later in the test (timeframe 1:17), the lamp above the air jar displayed a complete red *instrument* light, while the lamp above the CO_2 jar showed a white *instrument* light. It suggests the two light sources had different light intensities. Light intensity and light wavelengths play crucial roles in determining the heat absorbed by the glass, globes, thermometers, or the gases inside. Lamps with different intensities in the two jars also raise questions about violations of the scientific method and the accuracy of the reported data.

4) Use of Glass Bottles

Low energy infrared is absorbed by glass while high energy visible light easily passes through. The Greenhouse Effect only involves invisible infrared radiation emitted by the Earth's surface.

5) Using Different Thermometers

The thermometers used and placed inside the jar on top of the globe (timeframe 1:01-1:09) were not the same thermometers that were shown in the close-up video clip (timeframe 1:10-1:16). In the close-up video, the thermometers were in front of a uniform greenish yellow background. However, the thermometers in the jars were balanced on orange sections of the globes. The thermometer inside the jar had different temperature scales from the ones used in the close-up video. (compare timeframe 1:02 with timeframe 1:14). In addition, the jar had a reddish reflection from the heat lights (timeframe 1:07) but no such reflection appeared in the closeup of the two thermometers (timeframe 1:10-1:16). Therefore, the author used different thermometers than those shown in the jars. This raises serious concerns about the validity of the test. It suggests that the test equipment may have been used as props in a movie set.

6) Exposed Thermometer Bulb

The thermometer bulb was not protected from the radiation from the lamp. One thermometer was more or less horizontal, while the other thermometer was tilted. The thermometer bulb, being a solid, has a high absorptivity of radiation at all wavelengths.

7) Used 100% CO_2

There was no specific information about the amount of CO_2 added. However, CO_2 from pressurized canisters is typically 100%. Plus, CO_2 has a density higher than air and it would be expected to replace the air in the jar. Depressurizing the CO_2 from the canister would cool the contents of the jar in accordance with Boyles and Charles Gas laws.

Tests are often done with exaggerated conditions to determine the durability or weakness of the system. But in these types of accelerated or exaggerated tests, **there must be a correlation back to real-world conditions**. In the scenario where the CO_2 concentration is doubled (842 ppmv) from the current level (421 ppm), a researcher may seek to determine the resulting temperature. The IPCC has indicated that there would be dire consequences if this were to occur. Comparing a 2.3˚F temperature difference associated with doubling of the CO_2 concentration would only show a change of 0.00193˚F. This is far below the accuracy of modern thermometers.

8) Exposure to an Outside Light Source

The experiment in timeframe 1:06 showed that the jar containing the CO_2 was receiving more sunlight from the window behind it than the jar containing air. Therefore, the CO_2 jar received radiation from two sources.

9) Moving Test Jars and Lamps during Test

In the video (timeframe 1:17), it appears the jars and lamps were moved (see

timeframe 1:06). This is shown by a change in the location of the window and hanging office light behind them in the timeframes.

4.2. MythBusters Test [11] [12]

There were two videos covering the experiment. The first video is referenced as V1, while the second video is referenced as V2.

In the **MythBusters test,** four chambers were used, each about 3-feet tall and 3-feet long. The width of the chamber was not specified but appeared to be about two feet. Made from 2 × 2 inch wood framing, each chamber was enclosed with a mylar plastic sheet on the top and three sides. The back wall was made of plywood and painted black. The mylar sheet was stapled to the framing and sealed with silicone caulking. It was laid down on a plywood table, but it did not appear to be sealed. A thermometer was inserted through a hole in the framing in the front, with the probe extending about six inches into the chamber. (timeframe V2, 7:15-7:19). A two-foot ice sculpture was placed inside each chamber next to the black wall. It appeared that the two end chambers were the test chambers filled with air. One inner chamber was filled with CO_2, and one was filled with CH_4 (methane). However, the amounts of CO_2 and CH_4 were not explicitly stated in the video. They appeared to increase CO_2 to 7.35%, which is about 175 times more than normal (0.0421%). The CH_4 increase was not specified and may have been increased to 100% to avoid making an explosive mixture.

The light source was not identified by the model or manufacturer. They were commercial lights with short flaps to guide the light toward the chamber. They emitted white light so that the emitted radiation was in the high energy visible range. There was no specific mention of the distance between the chamber and the light source, but it was roughly 2 feet (see timeframe V2, 7:07). They measured the light intensity with a light meter placed against the front of the chambers. Each chamber received 1570 foot-candles (timeframe V2, 7:13) which is about 24.74 watts/m^2.

During the assembly (timeframeV2, 7:20), it showed that one thermometer registered 20.4˚C (68.72˚F) before the installation of the ice sculptures. The temperature at the commencement of the test was not reported. The test went on for four hours, at which time the two control chambers (air only) had a temperature of 23.9˚C (75˚F). The chamber with CO_2 had a temperature of 24.8˚C (76.6˚F) and the chamber containing the CH_4 was 24.9˚C (76.8˚F). The conclusion by the MythBusters was that CO_2 and CH_4 increased the temperature inside the greenhouses by about 1˚C, thereby proving the Greenhouse Effect.

Potential Deficiencies with the MythBusters Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased concentrations of CO_2.

1) Using High Energy Visible Light

High energy visible light source is at least twenty-five times higher than the low

energy infrared emitted by the Earth's surface. This is a major violation of the conditions of the Greenhouse Effect. The MythBusters painted the back of the test chamber black. Their position was that the high energy light would be absorbed by the black paint, and the black paint would then generate infrared radiation to raise the temperature. The amount of energy produced by high energy visible light was more than 25 times greater than that of infrared radiation, leading to a temperature rise. No effort was made to differentiate or quantify the disparities between the high-energy light and infrared light produced by the backdrop. If the visible light was being used as an exaggerated test, they should have correlated it back to real-world conditions. That was not done.

MythBusters believed that the temperature in the control chambers would reflect the increase in the temperature attributed to the absorption by the black background. Since the temperature in the chambers containing the CO_2 and CH_4 rose more than in the controls, then it must be attributed to the presence of the CO_2 and CH_4 and not from the absorption by the black background. This argument **assumes** (1) the quantum mechanisms were the same in the chambers (they were not—see Section **2.1**), (2) there were no absorption profiles in the visible light spectrum (but there were—see Figure 1) and (3) all test conditions in each of the chambers were equal (but they were not, and this is discussed below).

2) Light Placement

This involves the placement of the lights in front of the four test chambers. Two control chambers were used and placed on each end. The chamber receiving the CO_2 was at the right center (timeframe V1, 2:31-2:35) and the chamber receiving the CH_4 was at the left center (timeframe V2, 7:47-7:48).

Figure 2 shows how the two interior chambers each received about 40% more light than the two controls. This means the inner chambers would have been receiving more radiative flux, *i.e.* about 600 foot candles (9.4 watts/m^2) more than the end chambers. The greater the amount of light received by the back, bottom, plastic sides, and top of the chamber, the greater the temperature will rise. This is a cogent explanation for the observations.

The MythBusters also had a light meter and could have measured the light hitting the back of each chamber.

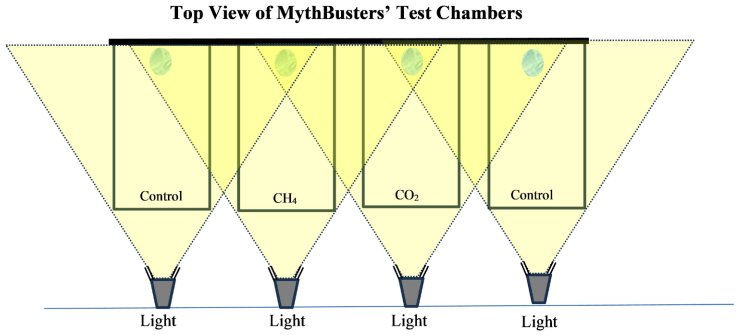

Figure 2. A recreation of the MythBusters Greenhouse Effect experiment, as shown in the YouTube videos [10] [11].

This would have revealed an increase in the light intensity for the two interior chambers. They also could have repeated the experiment with the two control chambers in the center to eliminate the light placement issue. However, they decided against doing either option.

3) Using a Higher CO_2 Concentration

The experiment involved using a higher concentration of CO_2 (7.35%) than exists in nature. The normal CO_2 concentration is 0.041%. Both pure CO_2 and CH_4 (methane) were injected into the two chambers to increase their concentrations. The results with exaggerated conditions must be converted to the real-world conditions to have any meaningful value. That was not done in this test, nor was the need to do so even mentioned.

4) Using a Closed System

The four chambers containing the different gases represented a closed system. It prevented heat and mass from escaping. This is consistent with real greenhouses, but inconsistent with the Greenhouse Effect (see discussion in Section **2.4**).

5) Initial Temperatures Not Identified

The specific temperatures of all four chambers were not specifically disclosed at the commencement of the test. It is assumed that they were all at the same temperature.

6) The Use of Ice Sculptures

The MythBusters inserted an ice sculpture into each chamber of the experiment. The presence of ice has no purpose in proving that CO_2 or CH_4 absorbs infrared radiation. In addition, it created major problems in radiative and thermal heat transfer. Ice melts at 0˚C. The melting process consumes 334 watts per gram of water without changing the temperature, *i.e.* it cools the surrounding gas. Under their experiment design, there was no reasonable way of determining if the temperature increase is coming from thermal heating or radiative heating, since the latent heat absorbs much of the energy flux. Also, ice is highly reflective. There was no measurement about light reflection from the ice. The two interior chambers would receive twice as much reflected light from the ice as the two end chambers acting as controls.

Water vapor produced by the ice sculptures was not monitored or measured. It has many absorption bands, and many are as high as 100%. The melting ice in all four chambers would create water vapor, which in turn would likely absorb more of the high energy radiation than CO_2 and CH_4 combined. Hence, using ice sculptures would seriously complicate any of the results of this test. The absence of a scientific justification for ice sculptures suggests the experiment prioritized entertainment over science.

7) Different Temperatures between CH_4 and CO_2

Another problem relates to the temperature difference between CO_2 and CH_4. If radiative heating is the mechanism being studied, then the CO_2 should have been higher than CH_4 because of the absorption spectra for these two gases. CH_4

has only two extremely small absorption bands in the high energy wavelengths emitted by the heat lamps. CO_2 has three significant absorption bands in this area. Hence, there should have been more absorption by CO_2 over CH_4. That means radiation was probably not the scientific principle governing temperatures in this experiment.

4.3. Keep Scotland Beautiful—Greenhouse Effect Experiment [13] [14]

In this experiment, two large 2-liter plastic soda bottles were used. Each bottle was filled with 400 ml of vinegar. A thermometer was glued to the top of each bottle. The test showed regular glass thermometers were used with no shield against direct sunlight. A blue balloon was attached to the top of one bottle to keep it sealed from the outside air. A yellow balloon was attached to the other one, which contained a pinch (1/16th of a teaspoon) of bicarbonate of soda.

The test started when the bicarbonate was dropped from the yellow balloon into the vinegar. This caused an immediate reaction, and the balloon became inflated with CO_2 and air. The two bottles were placed on the windowsill in the sunlight. The temperature of each bottle was taken in the morning at the same time over the next five days. The data showed the temperature of each bottle had a one degree difference over the first four days. On the fifth day, the temperature difference between the two dropped by 0.5˚C. The author observed the balloon had partially deflated and believed that was the cause of the 0.5˚C temperature drop.

Potential Deficiencies with the Scotland Beautiful Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased concentrations of CO_2.

1) High Energy Sunlight

Using high energy sunlight as the heat source violated the infrared conditions of the Greenhouse Effect. The Greenhouse Effect is based on the absorption of low energy infrared radiation emitted by the Earth's surface by the Greenhouse Gases. The photon energy of sunlight is at least 25 times higher than the infrared photon energy. In order to prove the Greenhouse Effect, one must use low energy infrared radiation as the heating source.

The plastic bottles absorb the sunlight and could be the reason for the increase in temperatures of the contents inside. One argument is since the sunlight was the same for both bottles, any differences in the temperatures must be because of the presence of CO_2 in one bottle. This argument **assumes** (1) the quantum mechanisms were the same (they were not—see Section **2.1**), (2) there were no absorption profiles in the visible light spectrum (there were some, see **Figure 1**) and (3) all test conditions in each of the chambers were equal (they were not equal as discussed below. The three disparities between the bottles are enough to cause significant doubts about the data.

2) Pressure in One Bottle

One bottle had an inflated balloon. Under the standard gas laws (Gay-Lussac Law) an increase in pressure causes a reciprocal increase in temperature. In this experiment, the reaction with the carbonate caused the yellow balloon to be inflated with CO_2. This means that this bottle was pressurized. And a higher pressure causes a direct increase in temperature. Since the blue balloon did not inflate, that bottle was not pressurized. The yellow balloon partially deflated on day five, coupled with a 0.5˚C temperature drop, strongly points to pressure as a contributing cause of the temperature changes.

3) Used a Closed System

The two bottles containing the different gases constituted a closed system. It inhibits heat and mass from escaping. This is consistent with real greenhouses, but inconsistent with the Greenhouse Effect.

4) Difference in Density

The pressurized CO_2 increases the density of the gas in that bottle. An increase in density increases the ability of the gas to conduct heat from the outside. It also changes the convection inside the bottle to disperse that heat. This point is discussed in more detail in the Argon experiments addressed in Section **5.1**.

5) Increased Surface Area

The yellow balloon has a significant surface area as compared to the deflated blue balloon. Based on the video, the yellow balloon appeared to be 4 to 5 inches in diameter. Both radiation and thermal absorption are directly related to the surface area. The greater the surface area, the greater the heat transfer. A 4 inch diameter party balloon will create 50 in^2 in surface area while a 5 inch diameter balloon will create 78.5 in^2. This surface area is in direct contact with the sunlight during the day and the ambient conditions on the windowsill. This increases the changes of the inflated balloon to be a cause for the increased temperature difference.

6) Darker Colors Absorb More Radiation

The yellow balloon is opaque and dark. It has a high absorption of the sunlight, *i.e.* between 60 to 80%. A transparent plastic bottle made of polyethylene terephthalate (PET) will have an absorption of 5 percent or less. Hence, it would be expected that the bottle with the inflated balloon will absorb more heat than the one without an inflated balloon.

7) Difference in Ambient Conditions Not Stated

The experiment lasted over five days on the building's windowsill. The temperature was measured each morning. The ambient temperatures, both daytime and nighttime, were not provided. Likewise, the physical condition of how much light was hitting each bottle was not specified. The closeness of each bottle to warmer or cooler objects was not disclosed. Since the density of the gas in each bottle was different, that factor directly affects the heat transfer that would occur during the preceding night.

8) Water Vapor

The reaction of a mole of sodium bicarbonate with vinegar produces a mole of sodium acetate, which stays in the liquid vinegar, plus a mole of CO_2 and a mole of water vapor. Water vapor (H_2O) has a far higher absorption profile in high energy sunlight than CO_2 (estimated about 50 times greater). Hence, if there were any gas absorption effect from the sunlight, it would be attributed to water vapor over CO_2 by a factor of 50.

4.4. Eric Christensen Lab Experiment [15]

This is a greenhouse gas experiment presented by **Erik Christensen,** and he stated he fashioned the experiment after a JetStream Online School Training program sponsored by NOAA. The link in the NOAA training program was broken. We could not find a JetStream Online Training experiment similar to the one Mr. Christensen used.

In the experiment, two plastic soda bottles were half filled with water. A rubber stopper with a digital thermometer was inserted in a hole and connected to a computer. The end of the thermometer terminated several inches above the water and appeared to be in the same general location. The thermometers were not shielded from the heat light. An Alka-Selzer™ tablet, broken into several pieces, was dropped into Bottle 2 as a supply for CO_2 and promptly sealed the top with the stopper. A single high energy heat lamp was placed about 40 centimeters (1.3 feet) in front of the bottles. The reflection appeared to show that the light was directed more to the bottle with the Alka-Selzer tablet.

After an hour, the temperature in the CO_2 bottle was about 9 degrees warmer than the bottle containing air. The temperature chart showed a rapid climb in temperature in both bottles in the first 7.5 minutes. Bottle 1 (air) appeared to reach equilibrium after about 10 minutes. Bottle 2 (CO_2) reached equilibrium around 25 minutes. There was an abrupt jog in the temperature around 20 minutes in Bottle 2. That could have been from the bottle being bumped. Based on the results, the author concluded that CO_2 absorption caused the temperature difference, and it represented how the Greenhouse Effect works in the atmosphere.

This type of study was similar to an experiment done at The Dawood Foundation Science Center [16] except vinegar was used to react with the bicarbonate to produce the CO_2 and two lamps were used rather than one.

Potential Deficiencies with the Christensen Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased concentrations of CO_2.

1) Using High Energy Visible Light

Using high energy visible light source is a major violation of the conditions of the Greenhouse Effect, which is specifically based on absorbing low energy infrared radiation emitted by the Earth. High-energy photons from visible light are at

least 25 times higher in energy than the infrared radiation emitted by the Earth's surface. This may be from confusing natural greenhouses with the Greenhouse Effect (see discussion in Sections **1-1.3**).

Mr. Christensen might argue that the temperature in the air control bottles would offset any of these issues and the difference between the bottles would reflect the increase due to CO_2. This argument **assumes** (1) the quantum mechanisms were the same (they were not—see Section **2.1**), (2) there were no absorption profiles in the visible light spectrum (but there were some see **Figure 1**) and (3) all test conditions in each of the chambers were equal (they were not equal as discussed below.

2) Uneven Light

Based on the video, the reflection inside Bottle 2 (CO_2) appeared to be higher. This suggests that the bottles were not placed in a manner where the light was evenly distributed. In video timeframe 1:53 and again at 2:01, it showed that the light was more concentrated inside Bottle 2. Having a higher concentration of light in the bottle containing the gas will be expected to show an increase in the temperature inside that bottle.

3) One Bottle Pressurized

There was an increase in pressure in Bottle 2 because of the generation of CO_2 by the reaction of the Alka-Seltzer tablet with water. Since the bottle was capped with a rubber stopper while the tablets were active, the CO_2 added would cause a pressure build-up. The operator did not measure or report the pressure increase. One Alka-Seltzer is about 1.91 grams of sodium bicarbonate, which will generate about 1 gram of CO_2. One gram of CO_2 at standard conditions will generate 0.508 liters. The volume of an empty soda bottle is about 2 liters, and it was half filled with water. The CO_2 from one Alka-Seltzer tablet (0.5 liter) would make up 33% of the bottle's contents. Therefore, the pressure increase from the Alka-Seltzer would more than likely be a significant factor for the temperature increase in Bottle 2.

4) Using a Closed System

The two bottles containing the different gases constituted a closed system. It prevents heat and mass from escaping. This is consistent with real greenhouses, but inconsistent with the Greenhouse Effect.

5) Using a Higher CO_2 Concentration

The experiment involved using a higher concentration of CO_2 than exists in nature. The normal CO_2 concentration is 0.041%, but the experiment involved using about 33% CO_2 generated in one bottle over the air bottle. The results with exaggerated conditions must be converted to the real-world conditions to have any meaningful value. That was not done in this test.

6) Density Difference Due to CO_2

The density of air is about 1.2 kg/m^3 and the density of CO_2 is about 1.98 kg/m^3. In the argon experiments, it showed that CO_2 and argon, despite their similar densities, each had comparable temperature responses. But since CO_2 is a Greenhouse

Gas and argon is not, the test negated the infrared absorption by the CO_2 gas as a factor in the temperature signature. The temperature differences from the air were CO_2 due to thermal heat convection transfers. The argon test is discussed in more detail in Section **5.1.**

The pressurized CO_2 also increases the density of the gas. An increase in density increases the ability of the gas to conduct heat from the radiation absorbed by the plastic bottle.

4.5. Action Lab [17]

This video was made by the Wren Company, which is a non-profit organization in the UK. A division of that company called the Action Lab performed three tests relating to the Greenhouse Effect.

In the first test, they put two glass jars in front of a plate that was heated to a temperature of 419˚F. One jar was filled with air and the other was filled with CO_2. The results were that the temperature in both jars went up the same. He explained it was because glass absorbed the infrared radiation, and it had nothing to do with CO_2.

In the second test, he repeated test one, except that he used a high energy visible light lamp. The test showed the jar with CO_2 had a temperature of 85.1˚F and the temperature of air was 84.9˚F. This was a difference of 0.2˚F. The author concluded the slightly higher temperature was because CO_2 was a heavier molecule and had a higher density. The temperature was higher because of the thermal convection and not absorption of radiation.

The Action Lab performed a third test. In that test, they used a hot plate set at 419˚F as the infrared source. An infrared thermometer was set up about 2 feet away. The infrared thermometer does not measure temperature directly. It measures the intensity of the infrared radiation (energy of the photons) and converts the information into temperature using an electric signal. That is because any object at the same temperature will produce the same photon intensity. This type of detector has the advantage of measuring the energy absorbed based on an object's presence in front of the heat source.

The Action Lab filled a plastic zip-lock bag with air and another bag with CO_2. Then they sequentially moved the bags across the path of the heater. The temperature registered by the infrared detector showed the bag containing air went down to 315˚F and the bag containing the CO_2 went down to 305˚F. The detector was measuring the photon intensity emitted by the heater **as reduced by the bags**. Based on the 10˚F reduction in photon intensity between the bags, the author concluded that CO_2 was absorbing more photons than the bag containing air. This conclusion assumes that all the conditions associated with the bags and their contents remain constant.

Potential Deficiencies with the Action Lab Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased

concentrations of CO_2.

1) Reducing the Pressure reduces the Temperature

In the experiment, it showed that the author injected CO_2 into the bag from a high pressure canister. Whenever someone reduces a pressurized gas, there is a direct reduction in the temperature of the gas. The freezing temperatures caused by high pressure canisters are so intense that foam insulation is typically included to protect the operator's hand. The temperature in the CO_2 was significantly reduced, which also reduced the bag temperature. It was the reduced bag temperature that reduced the amount of photon density reaching the detector and not because of infrared photon absorption by the CO_2.

This test was duplicated by us except we used a hotplate temperature of 257˚F (125˚C). We also allowed the CO_2 bag to reach the ambient room temperature. The results showed no difference in temperature between the CO_2 bag and the air bag. It is believed The Action Lab study demonstrated a discrepancy because they didn't allow the CO_2 bag to reach the same temperature as the air bag.

2) The 419˚F Hotplate Temperature Is Too High

The object of the Greenhouse Effect is to use a normal temperature that actually exists on Earth. That temperature should have been closer to 125˚F (wavelength of 8.9 μm) (see Section **2.2**). The wavelength determines the spectral absorption of gases in the atmosphere. In this test., the absorption profile at 419˚F (5.9 μm) of CO_2 remained low at about 2%. On the other hand, the spectral absorption of water vapor increases from about 3% to about 90%. The Action Lab did not specify the relative humidity of the air used in the bag. If it was the normal 30% to 40%, then it would have been expected to absorb a portion of the 419˚F (5.9 μm) infrared radiation. Hence, the special absorption criteria would suggest that the bag containing the water vapor would be expected to show a slightly higher temperature than a bag containing CO_2. But this was not observed, suggesting some other mechanism was present. It is also possible that some of the assumptions were wrong.

4.6. Summary of Popular Experiments

When discussing the Greenhouse Effect, TV and social media focus on using high-energy visible light as the heat source. This contradicts the fundamental concept of Greenhouse Gases absorbing low-energy infrared radiation emitted by the Earth.

It demonstrates confusion with real commercial greenhouses that rely on sunlight for energy. These tests are conducted in closed laboratory systems, which is also a fundamental violation since The Greenhouse Effect operates in an open system environment. Combining closed system experiments with open system environments is unsuitable because of the impact of varying laboratory conditions.

Table 3 is a list of different conditions between the test chambers. Section **4.0** discusses each of them in more detail. Column one is the name of the author/sponsor of the experiment**.** The second column indicates discrepancies with

Table 3. List of differences between test conditions.

Test Name	Light Placement	Pressure	Density	Other Issues
Bill Nye	Yes. Moved lights and bottles during the test.	No	Yes. CO_2 denser	Yes. Switched thermometers. Air bottle sealed & CO_2 bottle unsealed. Different light source intensities.
MythBusters	Yes. Air received 40% less light.	No	Yes. CO_2 denser	Used ice sculptures causing water vapor interference.
Scotland	Unknown. No data provided.	Yes. Only CO_2 bottle pressurized	Yes. CO_2 denser	Increased surface area in CO_2 balloon. Water vapor added.
Christensen	Yes. Uneven light	Yes. Only CO_2 bottle pressurized	Yes. CO_2 denser	
Dawood	Yes. Possible Misalignment	Yes. Only CO_2 bottle pressurized	Yes. CO_2 denser	Water vapor added in CO_2 bottle
Action Labs	None identified	No	Yes. CO_2 denser	They concluded the temperature observations were because of the higher CO_2 density and not from the Greenhouse Effect.

the light source placement. Column three displays whether the CO_2 container was pressurized while the air was not. Column four covers whether there were differences in the gas density. The fifth column relates to differences with other conditions.

Most people familiar with basic laboratory quality control standards can easily spot them. However, apart from the Action Lab, none of them choose to mention or discuss any of them.

These experiments illustrate factors normally linked to regular greenhouses. As such, they do not prove or support the Greenhouse Effect.

5. Laboratory Tests in Scientific Publications

The following is a review of some of the scientific publications on the Greenhouse Effect. These articles provide far more details about the test conditions. The laboratory tests were limited to those directed to Greenhouse Effect. They did not include tests applicable to individual components of it. Examples of components include spectroscopic analysis of specific Greenhouse Gases, such as water vapor, CO_2, CH_4, etc. or their specific chemical or thermodynamic properties.

5.1. Paul Wagoner, Chunhua Liu & R. G. Tobin Experiment [18]

In this experiment, two identical trapezoidal containers were constructed. They had a base that was shorter, featuring a black surface and a wider opening at the top that faced the room. Heat lamps that put out high energy visible light representing the sun were installed directly above each container. An electronic temperature probe was installed 2.5 cm above the bottom of each of the containers, which were shielded by an infrared reflector. The lamps were turned on until they reached a steady state at 27.5˚C. After 500 seconds, CO_2 was slowly poured into

container 1. After that was concluded, Argon was then poured into container 2.

Both Argon and CO_2 were heavier than air and settled to the bottom of the open containers. They used a candle to show that the oxygen inside the chambers had been displaced by the new gases.

They plotted the temperatures in both containers for about 23 minutes. This is shown in **Figure 3**. It showed that the temperature plots between CO_2 and argon were essentially equal. Since argon is not a Greenhouse Gas and Carbon Dioxide is, the same temperature profile proves that the temperature increase was from thermal convection and conduction. It was not from the absorption of radiation from either the high energy light or from the infrared heat generated by the black surface on the bottom.

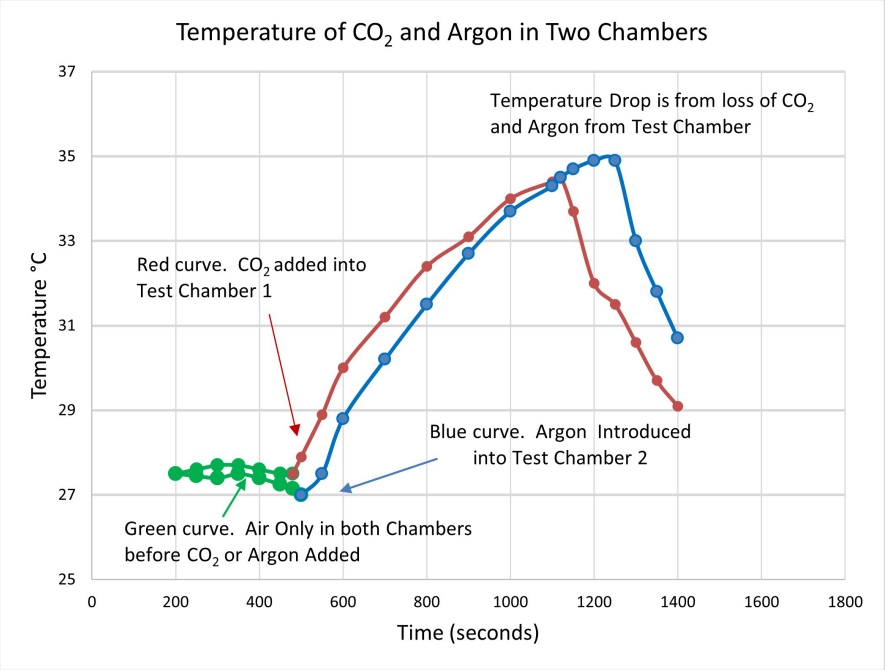

Figure 3. Extrapolated from Wagoner P, Liu, C & Tobin, R.G. [17]. The comments and description of the curves were added.

The Wagoner *et al.* experiment comparing CO_2 and Argon was confirmed in subsequent investigations from scientists from the University of Wisconsin, Department of Chemistry (Bell) [19] and from scientists from the University of Toronto, Department of Chemistry (D'eon *et al.*) [20].

Comments

The test performed by Wagoner *et al.*, and later supported by Bell and D'eon *et al.*, had a profound impact on the approach by university scientists towards laboratory experiments on the Greenhouse Effect. Wagoner *et al.* summarized their position on page 539.

"*the temperature rise observed in a popular classroom demonstration arises not from the radiative greenhouse effect responsible for global warming but primarily*

from the suppression of convective heat transport."

A computer search of the IPCC reports (thousands of cited references) failed to reveal that any of those studies were cited.

5.2. Seim-Olsen Lab Experiment [21]

The laboratory experiment utilized a one-meter long horizontal box, divided into two chambers. The walls of the chamber were covered with Styrofoam® and a thin aluminum foil to reflect the IR radiation. Air was added to the smaller rear Chamber 2 (30 cm - 45 liters), while the larger front chamber 1 (70 cm - 105 liters) was filled with the test gas.

In the rear chamber, a metal plate with an area of 360 cm^2 generated low energy infrared radiation at 100˚C (wavelength of 9.32 μm). An infrared detector (IR1) was placed outside a hole in the front Chamber 1 to receive the direct infrared radiation from the plate. A second infrared detector (IR2) was placed outside a hole of Chamber 2 and used to measure the back scattered radiation given off by the test gases. Thermocouples were installed to monitor the temperatures in each chamber. Small fans were installed in each chamber to avoid a temperature gradient.

They measured the amount of back scattered infrared radiation reaching the rear Chamber 2. They correlated this measurement to the amount of radiation being absorbed. The experiments ran for about 33 minutes. The testing included air containing 400 ppmv CO_2, 100% CO_2, and argon mixed with 200 ppmv CO_2. Three tests with each gas were recorded, and the data plotted on graphs. The room temperature was measured and varied about 0.9˚C during the tests.

By applying the IPCC formula, they predicted that using 100% CO_2 would cause a temperature rise of 33˚C. According to the Stefan-Boltzman law, the predicted temperature increase should be approximately 4˚C. However, the actual measured temperature difference was zero. This is shown in **Table 4**.

Table 4. Predicted and measured temperature increase.

Temperature Increase Predicted by	IPCC	Stefan-Bolzman Law	Actually Measured
Using 100% CO_2 Compared to Air	33˚C	2.4 to 4˚C	0˚C

Comments

This study confirmed what the Wagoner *et al.* experiments [18] showed. But they used an entirely different methodology. The Seim *et al.* experiment [21] used radiation backscattering to measure absorption. In addition, they used low energy infrared radiation and not the high energy visible light heat source used in actual greenhouses. The data based on the absorption of low energy infrared radiation showed **there was no measurable effect on the temperature.** A computer search of the IPCC reports (thousands of cited references) failed to reveal a reference to this article.

5.3. Levendis *et al*. Balloon Cooling Experiment [22]

This is an experiment where the authors measured the time it took for a heater to cool down inside three different diameter exercise balls. The balls were 65 cm (25 in), 75 cm (30 in) and 85 cm (33 in) in dimeter. Half the balls were filled with air and the other half were filled with CO_2. They measured the heater cool down rate at three different pressures.

The heater was 0.635 cm (1/4 inch) in diameter and 2.54 cm (1 inch) long. It provided heat at a temperature of 323 K (50˚C or 121˚F). An attached thermocouple measured the heater's cool down rate. The temperature of the heating element was measured over 1200 seconds (20 minutes) and then stopped. The ambient temperature outside the ball was measured at 296˚C (22.85˚C) and used to adjust the temperature measurements. This suggested that the gas temperature inside the balls had equalized thereby requiring an ambient temperature adjustment.

A theoretical calculation was made based on two sources of heat loss. One was thermal losses by conduction and convection by the gases. The other was based on radiation being emitted by the heater into the ball. They plotted the temperature of the heater during each test. It ended in 20 minutes with a heater temperature of about 293˚ (19.8˚C) for the ball with air at a pressure of 104 kPa. The ball with CO_2 ended with a temperature of 294.5˚K (21.3˚C) at that same pressure. This is a difference of about 1.5˚C. Because the heater temperature was higher for the CO_2 containing balls compared to air, the authors concluded that it was because of the Greenhouse Effect.

Potential Deficiencies with the Levendis *et al*. Balloon Experiment

The following is a list of reasons why there were differences in the temperature observations between chambers containing air and those containing increased concentrations of CO_2.

1) Data Proved Convection and Conduction Heat Transfer

The slightly slower cooling shown in the test data was most likely due to the differences in convection and conduction by air and CO_2. This is shown by their own data set forth in their article. The thermal conductivity of air was reported as 0.0295 W/m K and that of CO_2 was 0.0166 W/m K. Hence air was 56% more effective in **conducting** heat away from the heater than CO_2. With respect to **convection**, the heat transfer coefficient of air was 46.6 $W/m^2 \cdot K$ and for CO_2 it was 32.8 $W/m^2 \cdot K$. That means air was 70% better is transferring heat away by convection than CO_2. This means the balloon cooling test proved that thermal transfer mechanisms were at play over radiation. It showed the higher CO_2 temperature versus air **would be expected based on thermal heat transfer mechanisms.**

2) Infrared Absorption Negated

At the infrared wavelength emitted by the heater (wavelength 8.9 μm), the infrared spectroscopy data applicable to CO_2 data shows a very low absorption profile, *i.e.* less than 3%. That is because that particular wavelength is in the middle of the infrared radiation window (see Figure 1 set forth earlier). It's called a

window because infrared radiation freely passes through it unabsorbed.

No measurements were made of the infrared radiation inside or outside the balls. Infrared detectors are widely available at low costs. There were no temperature measurements of the gas in the balls or the surface of the balls. They performed no comparison tests with argon. Those tests showed that argon acted like the CO_2 because it had a similar density as compared to the lighter air. Argon is not a Greenhouse Gas and therefore cannot absorb infrared radiation.

The balloon test only proved that thermal convection/conduction processes were at play. Published spectroscopy data negated any significant infrared absorption within the infrared window wavelengths [7].

3) Enthalpy of Heater Too Small

The enthalpy of the small heater is too small to have a measurable temperature effect on the ball and its contents. Enthalpy is a thermodynamic measure of the total heat content. There is no statement how long the heater was turned on. The statement that it was "expediently" brought to a higher temperature and then turned off, suggests that it could have been "on" less than a few seconds.

The tiny heater would provide a total heat content of 83.74 J for each degree. On the other hand, the heat content for air inside the ball at a pressure of 104 kPa is 389 J/˚C and 492 J/˚C for CO_2. The PVC exercise balloon adds another 1620 J/˚C in enthalpy. That means for the balloon and its contents to change by one degree it takes 2,006 J/˚C for air and 2,604 J/˚C for CO_2. There is only 83.7 J/˚C available from the heater. If all the heater's energy is used, it would only be able to change the temperature of the ball and its contents by a maximum of 0.04˚C for air and 0.03˚C for CO_2. The heater is simply too small to have any measurable impact.

4) Other Sources of Heat Loss

The room temperature was measured to be 296˚K (22.8˚C). This is higher than the ending temperature of the heat source. The test ended with a heater temperature of 293˚ (19.8˚C) for air and 294.5 ˚K (21.3˚C) for CO_2. They were 1 - 2 degrees lower than the ambient temperature. Something was cooling the heater below the temperature of the balls.

The diagram in their balloon test showed that the balls were receiving air and CO_2 from compressed sources, *i.e.* CO2 from a cylinder and air from a compressor. According to the standard gas laws, whenever a gas is decompressed, it cools the gas in direct relation to the reduction in pressure. The study provided no apparent offset or discussion as to resolving this temperature cooling source.

5) Closed System

All the balloons constituted a closed system. It prevents heat and mass from escaping. This is consistent with real greenhouses, but inconsistent with the Greenhouse Effect.

5.4. Summary of the Scientific Studies

The results of the three argon experiments [18]-[20] indicated that temperature

differences were caused by thermal heat transports and not from the absorption of infrared radiation. This explains the temperature differences identified in the five experiments discussed in section **4.0** and Table 3. The Seim & Olsen backscatter experiment [21] used a low energy infrared radiation source and further negated any measurable temperature variation based on radiation absorption. These scientific studies constitute a significant challenge to the validity of the Greenhouse Effect experiments.

The Levendis *et al.* experiment [22] proved that conduction and convection were the reasons for the cooling time for the heater inside the different balls containing air versus 100% CO_2. This was proven by their own data. Without measuring infrared radiation, it was impossible to correlate the temperature difference as being associated with radiation absorption.

6. Accelerated or Exaggerated Test Conditions

Performance or quality control is often measured using exaggerated test conditions. They perform a valuable service. The majority of these tests simulate challenging real-world conditions. Examples include endurance tests (product failure), safety tests (pharmaceutical dosage,), detection tests (leakage), reliability (precision), etc.

When exaggerated conditions are used, the researcher must convert the results to performance data under normal conditions. This reversion process is challenging and necessitates verified modeling. Examples of models include the Henry's Law model or Peck's model. The Henry's Law Model is based on a direct relationship between pressure and concentration. The Pecks model is a more complicated analysis with an exponential decay. If there are multiple exaggerated conditions, the model needs to consider the impact of each one individually and in combination with others. This is because two conditions may combine and have synergistic effects. The evaluation of these reversion procedures is frequently a challenge. That's why scientists usually steer clear of them, choosing real-life scenarios instead. The use of extreme conditions in modeling can lead to significant harm [23].

On the other hand, exaggerated test conditions may have an alternative objective. Scientists occasionally utilize extreme conditions to refute a hypothesis. Karl Popper (1902-1994) a philosopher of Science from Vienna called this type of proof a Falsification Test. An experiment using 100% CO_2 can be conducted to challenge the validity of the Greenhouse Effect hypothesis. If there is no detectable response when a high CO_2 concentration is used, then logic would support the premise that no concentration below that value would have a response.

6.1. Using Higher CO_2 Concentration versus a Normal Concentration

In those instances where there is a response, the temperatures must be adjusted to reflect the real-world conditions. Regarding radiation, under the Beer-Lambert

Law [24] the amount of radiation energy absorbed is directly related to its concentration and its molar absorptivity. If the concentration is doubled, then the amount of radiation absorbed is doubled.

The concentration of CO_2 in the atmosphere is only 0.041% and has never been higher than 0.78% for the last 600 million years [7]. A 100% CO_2 atmospheric concentration does not currently exist, nor has it ever existed. It must be back correlated to real-world conditions. Assume one wants to know what would happen if the CO_2 concentration were doubled, *i.e.* increased to 0.0824%. This would yield a reduction factor of 1187 (100% divided by 0.0824%).

The observed temperature difference would need to be divided by 1187. Or if 50% CO_2 was used, it would change the reduction factor to 607 (50% divided by 0.0824%) etc. Or if 33% CO_2 was used, it would change the factor to 400. Or if 7.35% CO_2 was used, it would change the factor to 89. The last column in **Table 5** shows the temperatures which would be observed if the current CO_2 concentration were doubled.

Table 5. CO_2 concentration temperature reduction.

Test Name	CO_2 Percent	Observed Temp Diff	Temp Diff Reduction
Bill Nye	100%	2.3˚F	0.00193˚F
MythBusters	7.35%	1.6˚F	0.0179˚F
Keep Scotland	50%	1.8˚F	0.0029˚F
Eric Christensen	33%	9˚F	0.0225˚F
Levendis *et al.*	100%	2.7˚F	0.0022˚F
Wagoner *et al.*	100% CO_2	0 from absorption	None measured
Jerry Bell	100% CO_2	0 from absorption	None measured
D'eon *et al.*	100% CO_2	0 from absorption	None measured

This table shows a temperature modification that must be made because of the exaggerated concentration used in the experiment. The first column is the name of the author/sponsor of the experiment. Column two is the percent of CO_2 used in the test. Column three is the reported temperature difference between air and CO_2. In the first five tests, there was a measurable temperature difference reported. The reduced values set forth in the last column are too low to be detected. A regular scientific thermometer has a detection limit of about 0.1˚F. Therefore, any value in the last column less than 0.1˚F would be considered a null value. A null value is anything below what can be detected and therefore is zero.

In the last three experiments (Wagoner *et al.*, Bell, & D'eon *et al.*) showed there were no observed temperature differences related to gas absorption by the radiation. Argon was utilized in the three experiments to demonstrate that temperature variances were caused by thermal mechanisms, not by gas absorption of radiation. Since CO_2 was denser than air, argon was chosen due to its similar density to CO_2. They discovered that argon and CO_2 had essentially the same temperature

response curves. Since argon is **not** a Greenhouse Gas and cannot absorb infrared radiation, it proved that absorption of infrared radiation **was not a factor** in those observed temperature changes.

6.2. Using High Energy Light versus Earth's Infrared

Almost all of the tests involved using high energy white light as the heating source. The Greenhouse Effect theory is based on absorbing low energy infrared radiation that is released by the Earth's surface. There are multiple reasons why high energy visible light should not be used. First is the fact that photons of visible light carry about 25 times more energy than the infrared radiation emitted by the Earth. Second, there are wavelengths that have absorption peaks in the higher energy spectra that would not apply to the Earth's infrared range.

The observed temperature difference between using the high energy visible light and the infrared radiation emitted by the Earth must be corrected to reflect those values assuming a low energy infrared radiation were used. The adjusted values are shown in Table 6.

Table 6. High energy visible light temperature reduction.

Test Name	Light Source	Observed Temp Diff	Temp Diff Reduction
Bill Nye	Visible light	2.3˚F	0.092˚F
MythBusters	Visible light	1.6˚F	0.064˚F
Keep Scotland	Visible light	1.8˚F	0.072˚F
Eric Christensen	Visible light	9˚F	0.36˚F
Wagoner *et al.*	Visible Light	0 from absorption	Does not apply
Jerry Bell	Visible Light	0 from absorption	Does not apply
D'eon *et al.*	Visible Light	0 from absorption	Does not apply

The column descriptions are the same as shown in Table 5 except, related to an exaggerated light source. The observed temperature difference (column 3) is divided by 25 to yield the temperature difference reduction (column 4). As before, temperatures below 0.1 ˚F in column 4 will be considered null values. The reduced temperature by Eric Christesen is within the detection abilities and therefore does not have a null value. However, that test violated several standards of the scientific method. This included pressurizing the CO_2 bottle and not the air bottle (see Table 3 for a listing of some of these differences).

Compression directly causes the temperature to increase in gas systems. There were also differences in the light intensities between the bottles, etc. (see discussion in Section **4.4.1**).

6.3. Using Closed System versus Open System

The vast majority of the tests relating to the Greenhouse Effect were done in a closed system even though the Greenhouse Effect is based on an open system.

Closed systems allow heat and mass to be trapped. This can seriously affect the system's enthalpy (internal and external heat). The open and closed systems differ in many aspects, including shape, volume, boundary conditions, pressure, mass flow, heat flow dynamics, and more.

There are many tests that are routinely done in open systems. A few of them include the following. Spectral radiation detectors used in satellites to measure photons, pilot tubes measure speed in every commercial jetliner, altimeters routinely measure pressure, thermometers measure outdoor temperatures, sound meters measure sound wave intensity, and many more. Therefore, designing a test for an open system is easy and is done routinely.

The study of an open system requires using open system laboratory conditions, and a closed system should use closed system laboratory conditions. If different systems are mixed, the scientific method requires that each difference be adequately explained, quantified, tested, and measured. A table converting the reduction attributed to using a closed system experiment for an open system environment requires an empirical model, *i.e.* a model based on repeated testing of each of the various differences. The lack of empirical models made it impossible to create a table using the open system-closed system adjustment.

6.4. Allocating Effect of Water Vapor and CO_2 Contained in the Air

Air contains CO_2 at a present concentration of 421 ppm and water vapor at the humidity in the vicinity. Since water vapor is 84 times more effective than CO_2 in absorbing the infrared radiation emitted from the Earth [7], there must be an allocation of what part of the temperature increase is due to CO_2 and what part is applicable to water vapor. This was not done in any of the experiments listed in **Table 3**. None of those experiments included humidity data, so it couldn't be accurately analyzed here.

7. Does the Microwave Oven Prove the Greenhouse Effect?

The operation of a microwave oven has been proposed as evidence for the Greenhouse Effect. This can be debunked by a simple experiment that can be done in almost every kitchen. The photo in **Figure 4** shows a bag of 100% CO_2 with a temperature of 75.8˚F. The photo in **Figure 5** is of the same bag immediately after being inserted into the microwave oven for 30 seconds on the highest power setting. The two photos show that the temperature remained constant. Hence, a microwave oven does not support the position that CO_2 can heat the atmosphere under the Greenhouse Effect. Microwave ovens operate on a mechanism unrelated to the Greenhouse Effect.

These ovens work by utilizing polar molecules and oscillating electromagnetic fields. A polar molecule is created when one portion of the molecule carries a slight positive charge while another portion carries a slight negative charge. Water (H_2O) is a perfect illustration. Each hydrogen atom in the water shares an electron with the oxygen atom, resulting in a slight positive charge from the isolated

protons. Simultaneously the additional electrons make the oxygen atom slightly negative.

Figure 4. The temperature of the bag containing CO_2 taken before being exposed to the microwave oven.

Figure 5. The temperature of the CO_2 bag taken after being exposed to the microwave oven.

The polar molecule rotates and twists as a result of the attraction and repulsion from alternating electric and magnetic fields. By repeating this process millions of times, heat is generated in the molecules due to friction, not absorption. In a microwave oven, a magnetron generates microwaves at a frequency of 2.45 gigahertz. Frequency is the number of times the wave repeats itself per second. A gigahertz is a billion times per second. Hence, the amount of friction that is generated with the polar molecules rotating and flipping back and forth a billion times per second causes the temperature to rise.

Carbon Dioxide (CO_2) is not a polar molecule, so it is unaffected by the oscillating electric and magnetic fields. That is why the bag shown in Figure 4 and Figure 5 did not increase in temperature inside the microwave oven. Cardboard, oils and fats, plastics, glass, paper, methane, etc. do not contain polar molecules and remain unaffected by the microwave oven.

The photon energy in the microwave oven is 1.62×10^{-24} J. This is 120,000 times less than the photon energy of infrared emitted by the Earth at its average temperature of 59˚F (15˚C). Therefore, the heating of polar molecules does not occur through absorption of microwave radiation. But rather, it is the presence of the oscillating magnetic and electric fields acting upon the polar molecules thereby creating friction.

8. Conclusions

Virtually all scientists agree that the Greenhouse Effect and regular greenhouses involve two entirely different processes. It was only being used as an analogy. Unfortunately, non-scientists used greenhouses as proof of the Greenhouse Effect concept itself. The public's exposure to laboratory experiments on the Greenhouse Effect came from TV shows and social media. These simplistic experiments were quickly duplicated in K-12 schools around the country. Many of these entities lacked the technical knowledge to understand the differences, or they prioritized entertainment over scientific value.

There are three fundamental differences between the regular greenhouse and the Greenhouse Effect. The conventional greenhouses use high-energy visible light as the heat source. The solid or liquid objects inside the structure absorb the light, and the heat and mass are trapped inside a closed system. The Greenhouse Effect occurs when specific gases in an open system (atmosphere) absorb the Earth's low energy invisible infrared radiation. Even the quantum mechanics are different. In greenhouses, the high energy light is absorbed by the electrons which increase the temperature of the molecules. Whereas in the Greenhouse Effect, the low energy infrared radiation is absorbed by certain covalent bonds in the gas molecules which cause them to vibrate. About 80 to 90% of this absorbed radiation is then re-emitted as photons with the same wavelength. Only a small portion of the absorbed infrared radiation goes to increase the temperature of the molecules.

The tests conducted by TV shows, social media, and schools draw incorrect conclusions due to the fundamental differences between the two systems mentioned above. Besides these core distinctions, there were other significant disparities. These include misplacement of the heat lamps, failure to consider the differences in density, pressurizing the CO_2 bottles and not the bottles containing air, etc. There are many other differences, as shown in Table 3.

Laboratory tests done and published in the scientific literature show an entirely different picture. The results of the three argon experiments [18]-[20] showed the temperature differences between CO_2 and air were caused by thermal heat transports and **not** from the absorption of infrared radiation. The Seim & Olsen

radiation backscattering experiment [21] substantiated the argon tests. These studies constitute a significant challenge to the validity of the Greenhouse Effect experiments at the locations where they were performed, *i.e.* troposphere.

When compared to air, laboratory tests with elevated CO_2 levels showed no measurable change in the **adjusted** temperature. This applied to 8 out of 8 tests (see Table 5**)**. The outcome was consistent for the 6 out of 7 tests performed using an exaggerated high energy visible light as the heating source. This is shown in Table 6. These exaggerated conditions (concentration & light source) may support the Popper Falsification Test, *i.e.* disputing the validity of the Greenhouse Effect at the location of the test.

A simple test with a kitchen microwave oven shows that it does not demonstrate the Greenhouse Effect.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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