Title: Reduction of greenhouse gas, CO_2, through active control of molecular motions with a special laser

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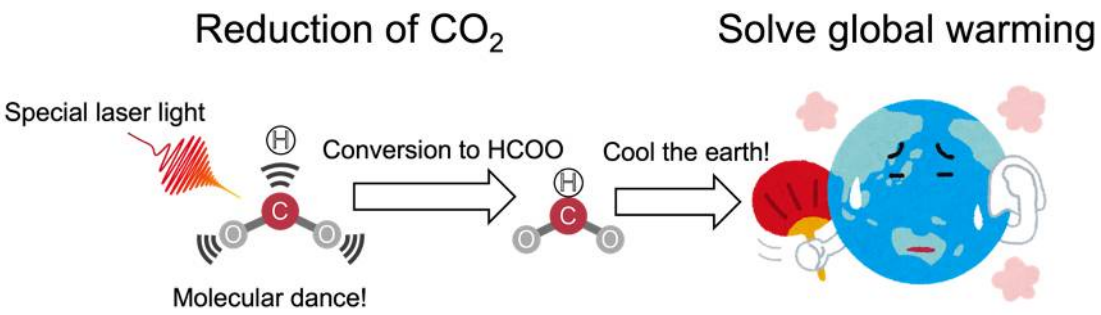

(1) Research description

Do you know what a laser is? If you're not quite sure, think of a laser pointer. I'm sure you've seen one before. A laser is a type of light source that emits a bright, focused beam of light. Unlike sunlight or a light bulb, lasers have some remarkable features: (1) they can travel long distances without spreading out, (2) they maintain their waveform over time, and (3) they can be focused into extremely small spots. Thanks to these properties, lasers have made it possible to actively control materials using light. With lasers, we can cool atoms, trap cells, and more[1][2].

Now, imagine a special kind of laser—one that emits ultra-short pulses of invisible infrared light, which is the kind of light we feel as heat. Recently, scientists have discovered how to use these pulses to make molecules "dance" by exciting them in very specific ways [3]. Unlike traditional heating, this method can deliver energy precisely to certain parts of a molecule, eventually breaking or forming chemical bonds, and

thereby opening new paths for chemical reactions. Its image is shown on top of this essay.

In my research, I aim to apply this reaction control method to the conversion of gas-phase CO_2 into HCOO. This research is significant because it (1) could lead to a novel way to reduce greenhouse gases, (2) helps reveal the dynamics of chemical reactions, and (3) may have ripple effects in other fields such as pharmaceuticals—where the ability to control reactions precisely could enable the synthesis of drugs and molecules with high purity.

To achieve this CO_2-to-HCOO conversion, I aim to control not only the "dance" of the molecules—that is, their vibration—but also their rotation. In gas-phase chemical reactions, the orientation of reactant molecules plays a crucial role in determining reaction efficiency. In my experiment, I want the carbon atom in the CO_2 molecule to point directly toward a hydrogen atom so that the hydrogen can bond with the carbon and form HCOO. To achieve this ideal orientation, I need to carefully control the rotational state of the CO_2 molecule.

(2) Why I find it interesting

Reason 1: Controlling molecules with light is super cool!

Do you know how small a molecule is? It's about 10^{-10} meters—that's so small that you can neither see nor touch it. Controlling the vibration and rotation of something that tiny is already a huge challenge. But what makes it even more amazing is that we do it using light. You can't touch light, can you? Your intuition probably tells you that light can't interact with physical matter. And yet, we use it to control the motion of

molecules. So essentially, molecular control with light means manipulating something you can't see using something you can't touch. Isn't that incredible?

Reason 2: It has great potential for real-world impact

Global warming caused by the increase of greenhouse gases is one of the most urgent problems facing society. If the method proposed in my research succeeds, it could contribute to solving this problem—and that would benefit everyone. Moreover, the impact of this research isn't limited to CO_2 conversion. Once vibrational control of molecules is proven to promote desirable reactions, chemists and pharmacists could apply this approach to develop new reactions, leading to highly pure molecule synthesis and more efficient drug development.

(3) Advice to your 12-year-old self

Advice 1: Always question what you hear and think for yourself

Science is about challenging existing knowledge. Throughout history, many scientists have questioned commonly accepted ideas — such as the Ptolemaic model — and ultimately made discoveries that transformed the way people see the world. To make such breakthroughs, you need to develop the habit of questioning what you are told. By doing so, one day you may find flaws in what people believe to be "common sense," and that could lead to a major discovery!

Advice 2: Be communicative and friendly

To become a good scientist, it's extremely important to be communicative and friendly. That's because science often involves collaboration. In my case, I have to write code to run experiments and discuss project directions with my lab members. Being

communicative and friendly helps you build good relationships with other scientists and makes it easier to carry out tasks that require teamwork. Also, it helps you enjoy research more. At academic conferences, there are many chances to meet and talk with other researchers. If you're open and friendly, you can make connections—and even friends—within the scientific community. This makes it much more enjoyable to be part of that world.

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reference

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