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CO_2 Cooling in Eppendorf Centrifuges

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Global warming and its consequences pose one of the greatest challenges of our time. Fluorocarbons, which, until recently, had been used in cooling systems such as air-conditioners and in laboratory centrifuges and freezers, contribute to global warming when released into the atmosphere. To protect our planet for future generations, laboratory equipment also needs to switch to using more environmentally friendly, "greener" coolants – e.g., hydrocarbons or carbon dioxide.
As one of the very first manufacturers to do so, Eppendorf now uses CO_2 cooling in our new SpinPro® 6 R centrifuge. By using CO_2, we combine the protection of your samples with the future of our planet.

Introduction

Discussions about sustainability have so far mainly focused on the energy consumption of devices. But that is only one part of the picture. The type of refrigerant a device uses is also coming under increasing scrutiny. After all, refrigerants can have a global warming potential if they are released into the atmosphere.
There are different types of cooling substances being available for compressor-driven cooling technologies.

Hydrofluorocarbons
The phase-out of ozone-depleting chlorofluorocarbon (CFC) refrigerants began over three decades ago following the international agreement on the Montreal Protocol. CFCs have been partially replaced by alternative compounds known as hydrofluorocarbons (HFCs) - in particular R508b, R404a and R134a. Although HFCs do not affect the ozone layer, they still have a high global warming potential (GWP). R134a, for example, has a GWP of 1,430. This means that 100 g of this substance has the same GWP as 143,000 g = 143.0 kg of carbon dioxide (CO_2) equivalent.

Hydrocarbons
Hydrocarbons (HC) are recognized as natural refrigerants for use in centrifuges and freezers, also known as "green gas". Their GWP is close to that of CO_2. The two most common hydrocarbons are propane and ethane - known as R290 and R170 respectively. R290 is widely used in large commercial refrigeration systems like in your kitchen refrigerator at home. Due to their superior efficiency and performance, hydrocarbon refrigerants can be used in much smaller quantities than traditional HFCs in a similar system.

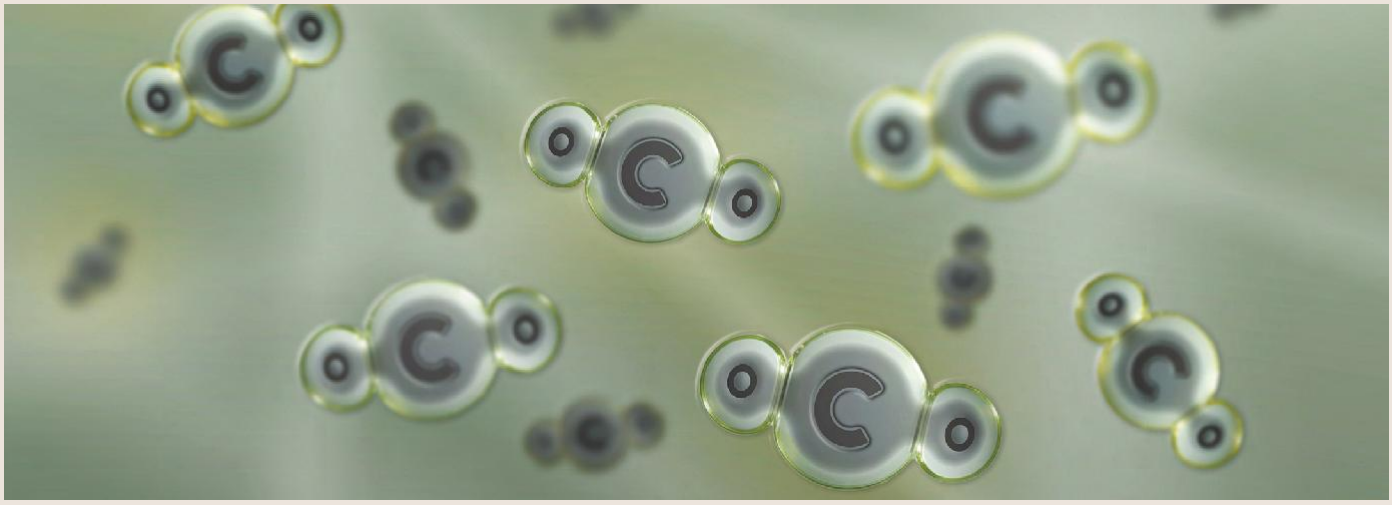

Figure 1: Molecular structure of CO_2

CO_2 cooling

CO_2, also known as R744, is well known as cooling substance for compressor systems. The first systems to create cold were developed more than 150 years ago. When synthetic refrigerants like R134a were available, they replaced CO_2. As they require lower pressures within the cooling systems, the systems could be set up more easily by e.g. thinner pipes. By checking alternatives for HFCs, CO_2 as refrigerant slips back into the focus of attention.
Both, hydrocarbons as well as CO_2, have therefore been identified as substitutes for ozone-depleting and/or global warming supporting substances under the US Environmental Protection Agency's Significant New Alternatives Policy (SNAP) program. They are approved refrigerants for refrigerated laboratory equipment such as centrifuges.

USA
In 2005, the California Global Warming Solutions Act of 2006 (AB32) required that the Air Resources Board determine the statewide greenhouse gas emissions level in 1990. Further on, the act required that the Air Resources Board approves a statewide greenhouse gas emissions limit which equals the 1990 level to be achieved by 2020.
This limit is equal to the 1990 level. This limit is an aggregated statewide limit without sector- or facility-specific focus. In 2016, the Senate Bill 32, California Global Warming Solutions Act of 2006: Emissions Limit (SB32) further intensified the limit: By 2030, California has to reduce statewide green house gas emissions by an additional 40 % below the value of 1990. This goal also includes a drastic reduction of HFC cooling liquids. The American Innovation and Manufacturing Act of 2020 (AIM Act) was enacted on **December 27th, 2020**.

The AIM Act mandates the phasedown of HFCs by 85 percent from historic baseline levels by 2036 and authorizes EPA to address HFCs in three main ways: (1) phasing down HFC production and consumption through an allowance allocation program, (2) facilitating sector-based transitions to next-generation technologies, and (3) issuing certain regulations for purposes of maximizing reclamation and minimizing releases of HFCs from equipment.
To achieve the first part, the phasedown of HFCs through an allowance program, EPA established the HFC Allocation Program in the Allocation Framework Rule. The AIM Act, which was included in the Consolidated Appropriations Act, 2021, directs EPA to phase down production and consumption of HFCs in the United States by 85 % over the next 15 years. A global HFC phasedown is expected to avoid up to 0.5 °C of global warming by 2100.

Currently, there are no requirements to stop using any specific equipment currently in use.

Europe
In April 2014, the European Union announced a midterm ban of all non-hydrocarbon-liquids for new cooling systems. This ban was implemented by gradually reducing the annual volume of newly produced or imported HFC fluids in Europe. Both producers and importing bodies of HFCs received reference quantity values based on their averaged annual quantities brought to market based on 2009 to 2012 ((EU) No 517/2014, Article 16). These allocated quotas have been reduced annually from 2015 (100 % reference value) on. The major reduction of HFCs was achieved between 2015 and 2019 by adapting newly produced cooling instruments to HCs. The Annex IV of this regulation includes centrifuges in the category of Medical and Laboratory Equipment and a ban for the use of F-Gases in centrifuges was originally planned for 2025.

Exemption for centrifuges ((EU) (2024/2729))
In October 2024, the EU Commission announced an exemption for refrigerated laboratory centrifuges due to their critical role in medical and laboratory applications. Deviating from (EU) 2024/573, there is a time limited release for this equipment with a GWP > 150. This special release framework is from January 1st 2025 to December 31st 2028.

Figure 2: Eppendorf SpinPro® 6 R centrifuge with CO_2 cooling

Safety

One concern with hydrocarbon coolants like propane and ethane is safety – they are flammable gases. So, how safe are these coolants, and how safe are the instruments that use them? We design our centrifuges with hydrocarbon cooling to be as safe as any centrifuge using traditional agents. Every instrument meets the IEC 61010-2-011 safety standard (the International Electrotechnical Commission's safety requirements for electrical equipment for measurement, control and laboratory use – particular requirements for refrigerating equipment). This includes multiple safety measures to ensure you and your lab are protected – even if a rotor were to crash.

For example, the Centrifuge 5427 R uses a special ventilation concept when switched on. We've moved all parts that could cause sparks, like the on-off switch and power cord, outside the centrifuge – away from any area where propane could build up in the unlikely event of a leak.
We also make sure every hydrocarbon centrifuge displays clear warning text and symbols. If you have questions about whether the Centrifuge 5427 R is right for your lab, we encourage you to speak with your facility's safety officer. Your safety is our priority. If you need more details, we are here to help. The Eppendorf SpinPro® 6 R centrifuge, developed as a refrigerated multipurpose
centrifuge, is using CO_2 as cooling substance.

Summary

Although the total carbon impact of a product requires a product carbon footprint analysis, the type of cooling liquids has an impact. Centrifuges like the SpinPro® 6 R that use carbon dioxide as cooling liquids are future-proof instruments which actively help you reduce your lab's greenhouse gas emissions and combat the threat of global warming.