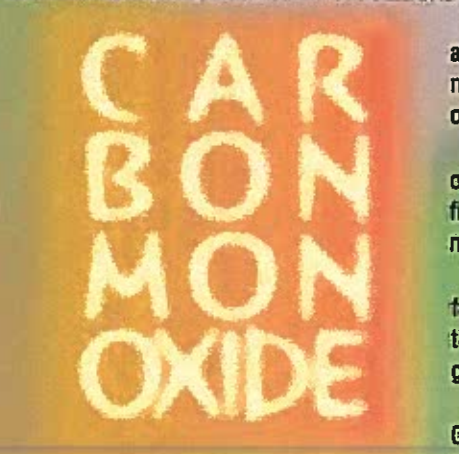
CO CONTROL

On the Street, In the House, Where You Live



Early each morning, when his mother went to work, young Anthony Mojica went to his sitter's home in Chicago. He stayed with sitter Ruth Munoz until his school started at 8:30 a.m. But when Anthony arrived on the morning of November 16, 1993, he immediately knew that something was very wrong. The entire Munoz family—four adults and three children—were lapsing into unconsciousness, stirring just long enough to vomit.

Anthony ran to a friend's house and told them to call 911. Within minutes, ambulances jammed the street as the paramedics took everyone in the apartment to the hospital, including the children ranging from 1 to 12 years of age.

Fortunately, everyone in the Munoz household survived. Anthony's quick thinking saved them from the silent, invisible killer—carbon monoxide. In too many other cases, the gas leaves no survivors.

Incomplete oxidation

Carbon monoxide, CO, is a product of the combustion of carbon-based fuels, such as natural gas, heating oil, and gasoline. Natural gas, for example, is composed mostly of methane, CH_4, which usually burns to give the relatively harmless gases, water vapor and carbon dioxide *(see Reaction a on opposite page)*. However, if the combustion takes place with a shortage of air (due, for example, to the accidental blocking of the air intake vent of a furnace), carbon monoxide may be produced *(see Reaction b on opposite page)*.

According to the U.S. Consumer Product Safety Commission, 250 to 300 people in the United States are killed every year by carbon monoxide from space heaters, furnaces, or other household devices. Another 5,000 to 10,000 victims do not die yet suffer acute carbon monoxide poisoning.

Carbon monoxide is invisible and has no flavor or smell. It is an equal opportunity poison, killing the rich and famous along with the rest of us. Carbon monoxide often poisons several people at once, sometimes whole families:

- Three children were killed and four others poisoned when carbon monoxide fumes from a furnace filled a Suffield, Connecticut, home on November 11, 1993.
- In 1994, carbon monoxide from a faulty swimming-pool heater killed flamboyant tennis star Vitas Gerulaitis in a Long Island guesthouse.
- Twenty-three worshipers at the Hill of Calvary Missionary Baptist Church in Detroit, Michigan, were overcome by carbon monoxide fumes that spewed from a boiler during Sunday services on December 10, 1995.
- On December 26, 1996, carbon monoxide leaking from a furnace poisoned four adults and 11 children who were gathered for the Christmas holiday in a Maywood, Illinois, apartment.
- Sixteen residents of a Queens, New York, house were taken to the hospital when a partially clogged chimney forced carbon monoxide into their residence on January 19, 1997.

Hemoglobin in a death grip

Carbon monoxide is poisonous because hemoglobin has a ravenous chemical appetite for the gas. Hemoglobin is the remarkable protein in red blood cells that binds with oxygen in the lungs and transports the oxygen to all the tissues of the body. But, in

By Bruce Goldfarb

addition to binding with oxygen, hemoglobin can also carry carbon monoxide, forming the molecule carboxyhemoglobin. In fact, hemoglobin has a preference for carbon monoxide that is about 250 times stronger than its affinity for oxygen.

Each hemoglobin molecule that binds to carbon monoxide means that there is one less available to carry oxygen. It doesn't take much carbon monoxide to make a person seriously ill. Fresh air contains 20% oxygen by volume. If you breathe air that contains the usual amount of oxygen but is contaminated with just 0.1% carbon monoxide, within 1 hour the carbon monoxide will bind to 50% of your hemoglobin molecules. The result will be death, just as surely as if you had suddenly lost half your blood. Although hemoglobin will eventually give up the bound carbon monoxide, it does so very slowly. At atmospheric pressure, the half-life of carboxyhemoglobin is 4–6 hours. One way of speeding up recovery from carbon monoxide poisoning is to give the victim supplemental oxygen via an oxygen mask. This increases the concentration of inspired oxygen from 20 to 100% and reduces the half-life of carboxyhemoglobin to 90 minutes.

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$$

Reaction a

$$2CH_4 + 3O_2 \rightarrow 4H_2O + 2CO$$

Reaction b

For a victim of acute carbon monoxide poisoning, in which a large portion of hemoglobin is bound to carbon monoxide, breathing 100% oxygen may not be enough; the patient may be treated in a hyperbaric chamber, a device that creates the equivalent of 3 atm (atmospheres of pressure). This treatment has two effects. Because the atmosphere is compressed, each lungful contains three times as many oxygen molecules, which helps reduce the half-life of carboxyhemoglobin to about 30 minutes. But a critically poisoned person could easily die in 30 minutes. So more importantly, at 3 atm, the portion of oxygen that dissolves in the liquid blood serum increases from 1.5% to about 5%—enough to support life. This means that the victim's brain can survive while waiting for the hemoglobin to recover. If proper treatment is initiated quickly, victims usually recover from carbon monoxide poisoning with no long-term effects.

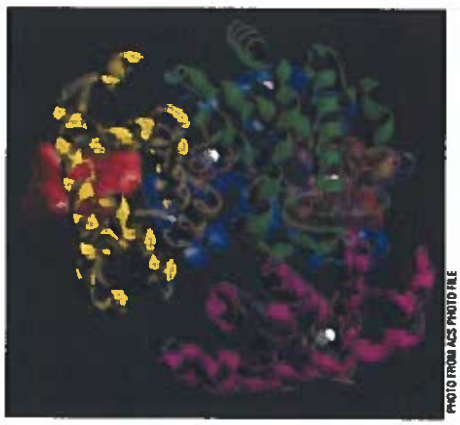


PHOTO FROM ACS PHOTO FILE

A ribbon structure of the carboxyhemoglobin molecule.

Slow poison

Most instances of carbon monoxide poisoning are not life-or-death cases, and victims may never realize that they have been poisoned. Typically, a low concentration of carbon monoxide in the air goes unnoticed as the amount in the blood gradually builds to toxic levels. The poisoning can develop over a period of weeks, causing the victim to become tired and irritable and complain of headache and nausea.

This nonlethal carbon monoxide poisoning may not be unusual. One recent study found that almost 25% of patients who were treated at a hospital emergency room for "flu-like" symptoms had carboxyhemoglobin levels greater than 10%—evidence of carbon monoxide poisoning.

Safe at home

To be safe at home, you should install a carbon monoxide detector, a device that looks like a smoke detector. A modern detector sounds an alarm when there is a sudden increase of carbon monoxide or when a low concentration is present over a period of time.

A typical CO detector

The heart of a carbon monoxide detector is a sensor that aims a beam of infrared light at a chromophor. A chromophor is a substance that changes optical properties depending on the levels of carbon monoxide, explains Mark Goldstein, a chemist who is president of Quantum Group, a company that makes gas-sensing electrodes for First Alert and other manufacturers.

Sensor Disk
Contains chromophor, that darkens when exposed to carbon monoxide, blocking the light. This module fits inside the CO detector unit.

Although carbon monoxide alarms are lifesavers in the event of a large leak of poisonous gas, they are less sensitive to chronic, low-level exposure. This is because carbon monoxide alarms are set at a relatively high level to prevent false alarms, says Goldstein.

When carbon monoxide alarms first came on the market, they were set to go off when gas levels reached 9–15 parts per million (ppm). But some U.S. cities are so polluted that the alarms often malfunctioned. "A lot of people were throwing their alarms out because they kept going off," Goldstein says. The solution was to raise the settings in the detector. Modern detectors sound the alarm when carbon monoxide reaches 70 ppm or stays above 30 ppm for 30 days. The higher settings reduce false alarms but can allow a family to be exposed to potentially serious levels of carbon monoxide.

CO control

David Schreyer, research chemist at NASA's Langley Research Center, has developed a device that may be better than an alarm—a carbon monoxide eradicator. Schreyer was working on a project to put a CO_2-filled laser in a satellite that would orbit the earth. When energized, carbon dioxide would give off laser light that would be used to measure high-altitude winds above the earth. But, over time, a portion of the carbon dioxide converted to carbon monoxide. In ground-based lasers, carbon dioxide is periodically replenished—not an option for a laser in space. Schreyer developed a room-temperature catalyst that oxidizes the carbon monoxide. The catalyst contains tin hydroxide doped with palladium. (Doping is the careful addition of small amounts of a known substance to an otherwise pure solid.) As gas passes through the catalyst, carbon monoxide is converted back into carbon dioxide.

With funding from the Rochester Gas and Electric Company, Schreyer and his colleagues have adapted the catalyst to a home ventilating system, where it should eliminate even low levels of carbon monoxide. The device is just now entering the in-home testing phase and should be commercially available in 1999.

Poisoning symptoms

Common indications of carbon monoxide poisoning are...

- **Headache**
- **Ringing or buzzing in ear**
- **Nausea**
- **Dizziness**
- **Weakness**
- **Confusion or drowsiness**
- **Heart symptoms: chest pain, rapid or irregular pulse, cardiac arrest**

Clearly, there is no single solution to the carbon monoxide problem. We will be healthier and safer when automobiles and furnaces are not only clean burning, but stay that way. Catalytic devices can sweep any remaining carbon monoxide from the air, and detectors can sound the alarm if the other measures fail. When people wake up to the risks of carbon monoxide, perhaps we can stop this killer's terrible toll.

HOME SAFETY

To keep your home safe from carbon monoxide...

- **Buy carbon monoxide detectors and place them near potential sources of toxic fumes, such as the hot water heater or furnace.**
- **Check carbon monoxide alarms and smoke alarms regularly, making sure that the battery is still good and the devices are working properly.**
- **Keep stove burners clean. Burners covered with soot can produce carbon monoxide.**
- **Consider replacing your carbon monoxide alarms and smoke alarms if they are more than 10 years old.**
- **Never use a space heater fueled by kerosene or propane indoors. These open-flame space heaters are so dangerous they are outlawed in many states.**
- **Never leave a car running in an enclosed garage, even for a few minutes.**
- **Never use a charcoal grill indoors.**
- **Make sure fireplaces are checked regularly by a qualified professional.**

Bruce Goldfarb is a science and medical writer in Baltimore, MD. His article "Laundry Disks: Miracle or Money Down the Drain" appeared in the April 1997 issue of *ChemMatters*.

FOR FURTHER INFORMATION

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