

Suicidal Carbon Monoxide Poisoning by Formic and Sulfuric Acids

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ABSTRACT

In 1987, a case report was published in the German journal *Archiv für Kriminologie* describing an apparently novel method of suicide in which the decedent produced a lethal amount of carbon monoxide by mixing formic acid and sulfuric acid. This method of chemical suicide remained obscure until 2003, when Dr. Philip Nitschke, a vocal supporter of assisted suicide, began promoting a homemade carbon monoxide generator which utilized this same chemical reaction. In 2006, he coauthored *The Peaceful Pill Handbook*, which provided further details about how the device worked. Pro-voluntary euthanasia organizations and online forums continue to provide information about this method, promoting it as painless and efficient. There have been nine case reports of suicides and attempted suicides using this chemical reaction, with five reported in Europe, three in the United States, and one in Taiwan. Two additional cases were reported in news articles that did not correspond to known case reports, indicating that this method of suicide is more common than the scientific literature would suggest. We present the case of a 44-year-old male who learned about this method of chemical suicide online and filmed the suicidal act while verbally recording carbon monoxide levels prior to losing consciousness. *Acad Forensic Pathol.* 2019 9(3-4): 217-224

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INTRODUCTION

Although inhalation of gas emissions from automobiles remains the most common form of intentional carbon monoxide (CO) poisoning in the United States, the use and mortality of this method has steadily declined since the 1980s, likely due to the implementation of the Clean Air Act in 1970 and the subsequent introduction of the catalytic converter in 1975. Catalytic converters reduce the toxicity of vehicle exhaust by transforming CO into carbon dioxide and water, making this method less attractive to those looking for a reliable and efficient means of suicide (1,2). Carbon monoxide poisoning continues to be promoted by pro-voluntary euthanasia organizations as an efficient and painless method of suicide, but the use of car exhaust is discouraged as modern vehicles are no longer considered reliable sources of this toxic gas. During the 1990s, Dr. Jack Kevorkian used cylinders of compressed CO for physician-assisted suicides, but as compressed CO cannot readily be purchased by the public, pro-assisted suicide organizations began promoting the use of a simple chemical reaction in which sulfuric acid acts as a catalyst to convert formic acid into CO and water:



Carbon monoxide binds hemoglobin with affinity over 200 times greater than that of oxygen and then prevents bound oxygen from dissociating in peripheral tissues. When hemoglobin is bound to CO, it forms the complex structure carboxyhemoglobin (COHb), which can be measured as a percentage of an individual's total hemoglobin and correlated with the severity of hypoxia (7). Most CO-related fatalities are associated with COHb levels above 40%. Initial symptoms of CO poisoning include headache, dizziness, dyspnea, and nausea. Increasing exposure levels may result in hypotension, confusion, seizures, cardiac arrhythmias, coma, and death (8).

CASE REPORT

The decedent was a 44-year-old Caucasian male found in a seated position inside his vehicle which was

parked in a secluded gravel pit. A chemical suicide kit was assembled on the passenger's side floorboard. The kit consisted of a 500 mL separatory funnel secured to a ring stand and positioned over a large bowl containing a cloudy clear liquid. Beside the bowl were two empty bottles of commercially available sulfuric acid-based drain cleaner, one nearly empty bottle of 95% concentrated formic acid, rubber gloves, one unopened box of baking soda (sodium bicarbonate), and a 32 ounce measuring cup (**Image 1**).

One hour prior to the discovery of the body, the decedent's probation officer received a suicide note in the form of a delayed email which had been timed by the decedent to arrive a few hours after death. Although the vehicle was parked in a remote location, police were able to quickly locate the decedent after receipt of the email by tracing his electronic ankle monitor. The email warned first responders of the danger of CO gas and also contained instructions on how to safely neutralize the acid using gloves and baking soda located within the vehicle. Upon arrival at the scene, precautions were taken to limit chemical exposure, and no symptoms of CO poisoning were reported by responders. While the vehicle was being aired out, police noticed an "ammonia bleach" odor emanating from the vehicle. The police report also noted a foamy substance emanating from the decedent's mouth and patchy red lividity of the hands. An industrial CO monitor was visible on the dashboard alongside an open laptop computer which was facing the decedent (**Image 2**). It was later discovered that the man had filmed the incident using this laptop computer and periodically reported CO levels in the vehicle prior to becoming unconscious.

In the video file recovered on the decedent's laptop, the man explains each of the components of his "exit kit," noting that he was able to acquire both the drain cleaner and CO monitor on a popular auction website. Although he does not indicate where he first learned about combining formic acid and sulfuric acid to generate CO, he describes frequent use of r/sanctionedsuicide, a now-banned Reddit forum in which anonymous commenters discussed the ethics of suicide, offered emotional support to one another, and

occasionally exchanged advice about different suicide methods despite moderators' explicit prohibition against these types of comments. Two months prior to the decedent's suicide, an archived page of this online forum recorded 9359 subscribers (9). Prior to mixing the chemicals, the decedent claims that death by CO should be "relatively painless...like falling asleep." However, he also acknowledges that CO poisoning causes headaches and ingests four ibuprofen pills prophylactically. The man states that exposure to 10 000 parts per million (ppm) of CO will cause death in as little as 2 to 3 minutes, but after testing his suicide kit in the days prior, he was unable to generate levels above 7700 ppm inside his vehicle. Based on the disappointing results of his earlier test, he estimates that

death should occur approximately 15 minutes after mixing the two acids.

Approximately 80 minutes into filming, the man turns off the air conditioning in the vehicle and rolls up all of the windows. He opens the stopcock on the separatory funnel to release formic acid into the bowl of sulfuric acid. He then begins verbally recording readings from the CO meter which is positioned just left of the steering wheel. Approximately 3½ minutes after the acids are combined, the CO concentration inside the vehicle reaches 7000 ppm. No further readings are recorded after this point as the man begins to cough and complain of an unspecified burning sensation. At 5 minutes, the man is observed profusely sweating,



Image 1: "Exit kit" assembled on the passenger side floorboard.



Image 2: Laptop and carbon monoxide monitor used by decedent to record carbon monoxide levels inside the vehicle.

possibly due at least in part to increasing temperatures inside the vehicle, and his face begins to turn bright pink. At 7 minutes, pronounced epiphora, rhinorrhea, and labored breathing are observed. Violent coughing and tachypnea continue until the man appears to lose consciousness 11 minutes after the acids were mixed. Brief seizure-like activity is observed as the man raises his arms with fingers clasped tightly together, explaining the patchy appearance of lividity later observed and documented in crime scene photos. For several minutes, accessory muscle use and respiratory distress are accompanied by a buildup of foam which accumulates around the man's mouth. Agonal breathing continues for approximately 12 minutes, gradually decreasing in frequency until reaching a nadir of one breath per minute before ceasing entirely. Agonal breathing ceases 21 minutes and 27 seconds after the

formic and sulfuric acids were combined. Based on details provided in the video and the police report, it can be deduced that the decedent's body was discovered approximately 3 hours after the time of death.

At autopsy the following day, the body displayed partially blanching, cherry red lividity over the head, upper chest, back, and legs. There was mild cardiomegaly (420 g), and sectioning of the organs revealed dark red parenchyma of the lungs, liver, and spleen. The lungs were moderately congested and edematous. The postmortem blood toxicology revealed a COHb level of 83%, and the remaining toxicology tests were negative.

DISCUSSION

Dehydration of formic acid by sulfuric acid is a well-known method of generating CO in laboratory settings (10,11), but it was not until 1987 that the first scientific case report appeared where this chemical reaction was used for the purpose of suicide. Published in the German criminology journal *Archiv für Kriminologie*, the case report describes a 35-year-old student who enclosed himself in a large plastic bag and then combined the two acids in smaller plastic bags, filling the small space with CO (12). No additional reports appeared in the literature until 2005, when Prahlow and Doyle reported the case of a 21-year-old male from Indiana who carried out a similar method of chemical suicide using a homemade CO generator the previous year. The generator was constructed out of a series of buckets and plastic tubing, significantly more sophisticated than the method used in the 1987 case. Although the chemical ingredients had been purchased online, the police investigation did not reveal a clear source of information used by the decedent to design the CO generator. According to the case report, only a single pro-suicide website could be found that briefly described the mixing of formic and sulfuric acids as a means of intentional CO poisoning, but this single source appears to have been a record of a much earlier comment made to the Usenet newsgroup alt.suicide.holiday in 1998 (7,13). Usenet predates the World Wide Web as a means of electronically exchanging ideas in a public format, similar to today's online forums. Many Usenet newsgroups such as alt.suicide.holiday are anonymous and unmoderated (14). It is likely that the first pro-suicide reference to this method of intentional CO poisoning appeared on the Usenet newsgroup alt.suicide.holiday sometime during the 1990s, but no case reports or news sources have been found to suggest that the method was used during this period. It is not known whether the decedent in the Indiana case report was a user of alt.suicide.holiday or if he had access to some other unknown resource. As an alternative explanation for how the decedent may have become aware of this unusual method, the authors noted that several news articles had recently appeared online describing a newly invented "death machine," referring to an invention by Dr. Philip Nitschke, Aus-

tralian founder of the international pro-voluntary euthanasia organization Exit International (7). In 2003, Dr. Nitschke formally presented his CO generator at assisted suicide conferences in Australia and the United States, eliciting ample media coverage and controversy (4,5). To Dr. Nitschke's apparent dismay, rudimentary instructions appeared online shortly after the device was publicly announced. In addition to promoting the device at international meetings and euthanasia workshops, Dr. Nitschke coauthored *The Peaceful Pill Handbook* in 2006, a guidebook which describes several methods of suicide and stratifies them according to their "reliability and peacefulness." The book specifically details the use of sulfuric acid-based drain cleaner and formic acid purchased online for the generation of CO (3).

Since Dr. Nitschke's CO generator first gained media attention in 2003, eight cases of suicides and attempted suicides have been described in the literature; all carried out by males between the ages of 21 and 31 (7,15-21). Our case is an outlier in this respect as the decedent was 44 years old. Two additional suicides were uncovered from English-language online news articles, the first case from Pennsylvania in 2012 and the second from California in 2016, each describing similar incidents which did not correspond to cases in the scientific literature (22,23). In addition to the 2017 case described in this report, our facility investigated a similar case in 2018. The decedent was a 51-year-old male whose body was discovered in the bathroom of his residence. The bathroom doors were sealed with duct tape and towels from the inside. A large condiment jar was situated on the floor in front of the decedent in which formic acid had been mixed with soap detergent. Blood analysis revealed a COHb level of 75%. It is unknown how this individual first learned about chemical suicide methods, but he had previously been hospitalized for suicidal ideation. The actual number of suicides involving the use of formic acid and sulfuric acid remains unknown even within the United States because the disease classification system used by government organizations such as the Centers for Disease Control and Prevention does not adequately distinguish between different CO generation methods to identify additional cases (2,24).

In total, five incidents have been reported in Europe (three in Germany, one in Slovakia, and one in Croatia), one in Taiwan, and seven in the United States. The seven cases in the United States include previous case reports, our present case, a second case investigated by our facility the following year, and two fatal incidents described in public news sources (22,23), one of which has been corroborated by autopsy report (Humboldt County Sheriff's Office, personal communication, July 30, 2018). Of these 13 cases, two individuals attempting suicide survived with COHb levels recorded at 20.8% (16) and 36.8% (21) upon arrival at the hospital. The CO generators used in each case varied greatly in design and complexity, with one even incorporating a timer so that the formic and sulfuric acids would mix while the subject was asleep (19). In contrast to the more popular "detergent suicides" which produce highly toxic hydrogen sulfide gas and a distinct rotten egg odor (24), suicides by CO are less likely to result in the hospitalization of family members or first responders who are exposed at the scene, and a vaguely described chemical odor has been noted in half of the incidents (**Table 1**). In the 2005 Taiwan case, however, the decedent's parents attempted to revive their son and were subsequently hospitalized for symptoms of CO exposure. The father was found to have a COHb level of 45.8% and later developed hemoptysis and acute respiratory distress syndrome (ARDS). The father ultimately survived, as did the mother who suffered milder symptoms including pharyngitis, and her COHb level was measured at 23.0% (15).

As CO is an odorless, nonirritating gas, the development of pharyngitis, hemoptysis, or ARDS is an unexpected presentation of CO exposure. In five of the case reports, first responders arriving at the scene described a chemical odor which is likely attributable to formic acid vapor (7,15,18,20,21). An often overlooked complication of this method of generating CO is that while CO itself is an odorless, nonirritating gas, liquid formic acid produces noxious fumes upon exposure to air which cause irritation of the mucous membranes and damage to the respiratory tract (15,18,21). This is consistent with the coughing and epiphoria

observed in the video recovered from our case. In *The Peaceful Pill Handbook*, the authors briefly note some "unresolved issues" with the CO generator and subsequent prototypes, noting, "Although the cooling and washing process is designed to remove [acid vapor] contaminants, any failure to do so will result in the production of contaminated monoxide that will not be odourless" (3). The homemade CO generator used in our case, like many of the devices described in previous reports, did not closely resemble the designs promoted by pro-euthanasia groups like Exit International and did not incorporate any form of a washing chamber to minimize exposure to formic acid vapor. The video recovered in our case provided a rare but sobering opportunity to observe the symptoms of combined exposure to CO and formic acid vapor. The decedent complained of a burning sensation as he became progressively dyspneic and distressed, manifesting symptoms of respiratory failure before losing consciousness. Foam emanating from the mouth was suggestive of pulmonary edema which was confirmed by gross examination of the lungs at autopsy. Although the decedent's chosen method of suicide did indeed prove fatal, the acute signs and symptoms observed upon exposure to CO in the presence of a noxious vaporized chemical irritant differ greatly from the purported peacefulness and painlessness of this method as it is commonly promoted in pro-voluntary euthanasia publications and websites (3,26).

The Internet has no doubt played a key role in promoting this method of suicide, from providing instructions on how to construct a homemade CO generator, to enabling individuals with little to no chemistry background to select and purchase industrial-grade ingredients which would otherwise be unavailable to the average consumer. Suicidal individuals interested in comparing suicide methods have an abundance of resources available in the form of books, websites, and anonymous online community forums (27). It is hoped that this case will provide forensic investigators with a greater understanding of the reasoning and epidemiology behind this unusual, but increasingly utilized, method of intentional CO poisoning.

Table 1: Intentional Carbon Monoxide Poisonings Involving the Combination of Formic and Sulfuric Acids

Year	Location	Demographic	Outcome	Carboxy-hemoglobin (COHb)	Site	Additional details recorded at the scene	Reference
1987	Germany	35-year-old male	Deceased	80.3-93.4%	Enclosed in a large plastic bag	None	Wehr & Schafer, 1987.
2004*	Indiana	21-year old male	Deceased	64%	Closet	Chemical odor	Prahlow & Doyle, 2005.
2007*	Taiwan	26-year old male	Deceased	No autopsy performed	Bedroom	Father and mother were hospitalized due to gas exposure, but both survived. Father described a pungent odor in the room.	Yang et al., 2008.
2012	Pennsylvania	28-year old male	Deceased	Unspecified	Tent	Mother and state trooper exposed to gas at the scene, both required medical treatment.	Logue, 2012. [News article]
2012*	New York	26-year old male	Deceased	85%	Car	Strong chemical odor	Lin & Dunn, 2014.
2013*	Germany	26-year old male	Survived, GCS 3	20.8% at hospital	Car	Mild nosebleed noted.	Santamaria et al., 2013.
2013	Germany	27-year old male	Deceased	Unspecified	Bedroom	Detailed chemical equations found in home; breathing mask was used to inhale carbon monoxide gas.	Hecht et al., 2014.
2015*	Slovakia	29-year old male	Deceased	76.5%	Bedroom	Double container system was attached to a timer.	Zeleny et al., 2015.
2015*	Croatia	22-year old male	Deceased	30% with possible chemical ingestion	Bathroom	Penetrating chemical smell	Bakovic et al., 2015.
2015*	California	31-year old male	Survived, GCS 7	36.8% at hospital	Motel room	Foamy secretions around mouth; faint odor of a chemical.	Schneir & Rentmeester, 2016.
2016	California	28-year old male	Deceased	61%	Car	None	Kemp, 2016. [News article]; Autopsy report, Humboldt County Office of the Coroner [personal communication].
2017	Texas	44-year old male	Deceased	83%	Car	Foamy secretions around mouth; ammonia-bleach smell.	Autopsy report, Southwestern Institute of Forensic Sciences at Dallas (present case).
2018	Texas	51-year old male	Deceased	75%	Bathroom	None	Autopsy report, Southwestern Institute of Forensic Sciences at Dallas.

* For cases in which the precise year of the incident was not indicated in the case report, the year was approximated based on the date that the original manuscript was received for publication.

GCS: Glasgow coma scale

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