

## Postmortem Alcohol Formation in a Severely Burned Victim

*In this case study, a passenger severely injured in a motor vehicle fire filed a lawsuit against the vehicle manufacturer. The case partially rested on whether or not the driver and his passenger could be shown to have been intoxicated. The surprising outcome was based on a little known but well-documented fact concerning "endogenous alcohol" which can be created following destruction of the protective integument layers of a charred body.*

### Vehicle Fire Results in Massive Injuries and Death

Female plaintiff was involved in a collision while riding as a passenger in a pickup truck driven by her boyfriend. Although the woman initially sustained only minor injuries, the truck's gas tank was ripped open as the truck ran over a stop sign post, cutting through the plastic safety shield covering the plastic fuel tank. The ensuing gasoline spill caused a massive fire with flames shooting more than 20 feet into the air.

The fire breached the passenger compartment of the truck killing the boyfriend and causing catastrophic injuries to the plaintiff, including third degree burns on both legs and face and loss of portions of her hands. The woman filed a lawsuit against the vehicle manufacturer, alleging that the fuel system was defective. Defendant claimed that plaintiff and her boyfriend were both intoxicated as, prior to the accident, they had been at a bar.



The truck's gas tank was ripped open as it ran over a stop sign.<sup>[a]</sup>

### Postmortem Alcohol Formation

Upon review of the matter, Dr. Sawyer noted that the quantity of alcoholic beverage consumed at the bar was discrepant with the postmortem blood alcohol concentration (BAC) of 0.11% noted for the driver. It was also discrepant with the postmortem urine and vitreous alcohol concentrations when applying generally-accepted conversion equations. Such data immediately raised a "red flag."

Review of the autopsy report and photos of the driver revealed that approximately 95% of his body was burned so severely that striated muscle and bones were visibly evident. Although not well known to most professionals, it is generally accepted and documented within the toxicological literature that severely burned postmortem bodies frequently produce endogenous alcohol. This postmortem alcohol formation stems from microflora deposits on the open tissues causing rapid alcoholic fermentation to occur.

This rapid-fermentation phenomenon has been studied and published in articles by the Federal Aviation Administration (FAA) following the autopsies of hundreds of plane crash victims known not to have consumed alcohol. It was also observed in victims of the USS Iowa turret gunnery disaster in 1989 and in other severe burn cases.

### Summary

Following multiple depositions and a hearing before the judge, Dr. Sawyer was permitted to present evidence without any limitations regarding postmortem alcohol formation. After a lengthy three week trial, the jury found that the fuel system was defective and, therefore, partially responsible for the catastrophic injuries to the plaintiff, resulting in an apportioned 4.3 million dollar verdict against the vehicle manufacturer.

*(Disclaimer: Toxicology case studies are impartial and objective summaries of toxicological matters in which TCAS was retained for the purpose of assessing health-based factors which, in some cases, led to a determination of causation. No names or identifying information have been provided due to privacy and legal considerations. In the above matter, Dr. Sawyer was retained by plaintiff.)*

### Images

a. Photo adapted from National Park Service, [Firefighter Training Class](#), "Structural Fire Management Program"

## Postmortem Ethanol Formation Studies

Although a complex subject, the possibility of the body producing alcohol after death via microbial contamination and fermentation is a recurring issue in toxicology. The following useful reference identifies nine (9) peer-reviewed studies addressing this phenomenon accompanied by general study notes.

1. Bowers, RM, "Sources of bacteria in outdoor air across cities in US," September 2011, Applied and Environmental Microbiology, Vol. 77(18), pgs. 6350-6356.
  - o "Scientists have long known that bacteria are ubiquitous in the atmosphere. Bacterial concentrations typically range from 10<sup>4</sup> to 10<sup>6</sup> colony forming units (CFUs) per cubic meter though concentrations may be far higher in proximity to point sources such as compost facilities. Recent evidence suggests that, even in some relatively unpolluted locations, bacteria or portions of bacteria may represent a major component of the organic aerosols residing in the atmosphere."
  - o Levels are higher in the summer months.
2. Canfield, DV, et al., "Postmortem ethanol testing procedures available to accident investigators," August 2007, FAA, DOT/FAA/AM-07/22.
  - o "Postmortem ethanol production in human bodies has been well documented by many forensic scientists over the past 70 years. The FAA laboratory found that postmortem ethanol occurred in 27% of all ethanol-positive aviation accidents."
  - o "Postmortem ethanol formation is far more likely to occur in cases involving severe trauma from high speed crashes. If there is a fire that damages the protective dermal layer of the body, there is an increased opportunity for ethanol-producing micro-organisms to invade the body and produce postmortem ethanol."
  - o In one aviation fatality occurring at an airport, postmortem specimens were collected two hours after the accident. "An ethanol concentration of 0.055% was found in the pilot's blood, but no ethanol was found in vitreous fluid, brain or muscle."
  - o "Postmortem ethanol concentrations above 0.350% have been found in postmortem specimens taken from aviation accidents."
3. Canfield, DV, et al., "Postmortem alcohol production in fatal aircraft accidents," July 1993, Journal of Forensic Sciences, Vol. 38(4), pages 914-917.
  - o Review of 975 victims of fatal aircraft accidents revealed that in 21 of the positive cases for ethanol, 27% were from postmortem alcohol production. In two cases, postmortem alcohol production exceeded 0.15%.
  - o Previous authors have pointed out the dangers of interpreting ethanol in postmortem samples. Corry (1) warns the forensic scientist to "...bear in mind that specimens of human tissue containing micro-organisms, particularly specimens taken from corpses, may contain ethanol produced by microbial fermentation. Extreme caution should be exercised when assessing the significance of postmortem ethanol."
  - o "Severe damage to the body often exposes specimens to micro-organisms that can produce ethanol under the proper circumstances (temperature, time and nutrients.)"
4. Galtelli, M, "An assessment of the prevalence of pathogenic microorganisms in the rotor wing air ambulance," Air Medical Journal, March-April 2006, Vol. 25(2), pages 81-84.
  - o Study on the potential role that out-of-hospital transport vehicles and medical crew may play in the spread of microbial transmission.
  - o "The results showed that large numbers of microbes remained on the surfaces of the transport vehicle even after initial cleaning."
  - o "Potential for pathogen transmission clearly exists."
5. Kuhlman, JJ, et al., "Toxicological findings in federal aviation administration general aviation accidents," July 1991, Journal of Forensic Sciences, Vol. 36(4), pgs. 1121-1128.
  - o Review of 377 FAA aviation fatalities during 1989 revealed that "14.8% of these cases were positive for ethanol. Of the 14.8% ethanol positive cases, 4.5% of cases (30% of ethanol positives) were determined to be due to ethanol ingestion, 8.5% of cases (57% of ethanol positives) were determined to be due to postmortem ethanol formation."
6. Lewis, RJ, et al., "Ethanol formation in unadulterated postmortem tissues," 2004, Forensic Science International, Vol. 146, pgs. 17-24.
  - o "Many species of bacteria, yeast and fungi have the ability to produce ethanol and other volatile organic compounds in postmortem specimens."
  - o The postmortem tissue specimens have generally been subjected to severe trauma and may have been exposed to numerous microbial species capable of ethanol production.
  - o "Candida albicans has been the microbe most often ascribed to be responsible for postmortem production of ethanol in humans. This species of yeast is commonly found in humans in vivo. Located ubiquitously throughout the body, the highest concentrations are typically found in the mouth and on the skin."
  - o "After death, endogenous and/or exogenous microbes begin rapidly consuming the glucose and other nutrients present in the body and produce ethanol and/or other organic volatiles as metabolic byproducts. Under optimal conditions, substantial concentrations of ethanol may be formed within hours of death. The relatively short time required for microbes to begin producing ethanol complicates the interpretation of a positive ethanol result in postmortem specimens."
7. Mayes, R, et al., "Toxicologic findings in the USS Iowa disaster," September 1992, Journal of Forensic Sciences, Vol 37(5), pgs. 1252-1357.
  - o Autopsies were performed within 48 hours of death with thermal injuries in 23 cases determined to be the cause of death (47 victims in total).
  - o "No evidence to suggest that any of the victims had been drinking alcoholic beverages prior to the accident."
  - o "Multi-fluid analysis enabled the presence of ethanol to be attributed most likely to postmortem formation. For example, victim 2 had a blood ethanol concentration of 0.19 g/dL; however, the bile ethanol and urine ethanol concentrations were less than 0.01 g/dL."

8. O'Neal, C, et al., "Postmortem production of ethanol and factors that influence interpretation: A critical review," March 1996, American Journal of Forensic Medicine & Pathology, Vol. 17(1), pgs. 8-20.
- o "Many substances of bacteria, yeast and molds are capable of producing ethanol from a variety of substrates. The probability of postmortem ethanol synthesis increases as storage temperature and the interval between death and autopsy increases. It is often difficult to distinguish between postmortem ethanol production and antemortem alcohol ingestion."
  - o "There are at least 58 species of bacteria, 17 species of yeast and 24 species of molds that can produce ethanol under a variety of conditions. Microbial contamination can occur after death through breaks in the skin, but the source can also be endogenous. Intestinal bacteria can penetrate the intestinal walls after death and be distributed through the bloodstream via the hepatic portal vein and the intestinal lymph system as long as the body temperature exceeds 5 degrees C (41 degrees F). Synthesis by microbial contamination can be prevented by proper preservation of specimens. Refrigeration of the body within four hours of death and preserving the specimens with 1% sodium fluoride after autopsy inhibits ethanol production by most microbes, except for *C. albicans*."
  - o Several authors report that urine is a poor medium for microbial ethanol synthesis.
  - o "In most of the studies reviewed by Corry, several days elapsed before significant concentrations of ethanol were produced, but conditions can exist that allow for synthesis to occur in only hours."
  - o "A review of the literature revealed a total of 7 criteria that has been applied to make the determination of postmortem synthesis or antemortem ingestion: a) case history of decedent, b) the condition of the specimen, c) types of microorganisms present, d) atypical distribution of ethanol in multiple specimens, e) presence of ethanol in one specimen and absent in other specimens, f) presence of other alcohols or volatiles, and g) the concentration of ethanol. These criteria are useful generalizations; however, there is no correlation between the degree of decomposition and the amount of ethanol produced because all bodies and conditions are different."
  - o "In the ideal case, at least three specimens should be collected for analysis - blood, urine and vitreous humor."
9. Ziarrou, K, et al., "Insights into the origin of postmortem ethanol," 2005, International Journal of Toxicology, Vol. 24, pgs. 69-77.
- o "It has been commonly accepted that ETOH could originate postmortem only from microbial activity."
  - o "The greatest increases in ETOH levels have been usually attributed to enterococci or enteric bacilli."

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**A Message from Dr. William R. Sawyer**  
Chief Toxicologist, TCAS, LLC



*"A forensic toxicologist is part scientist and part detective. The outcome of an accident case can sometimes hinge on the smallest details. Proper application of peer-reviewed scientific knowledge plays an essential role in an impartial toxicological assessment."*

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**Toxicology Consultants & Assessment Specialists, LLC**  
**(800) 308-0080** or send a message

6450 Pine Avenue, Sanibel, FL 33957 **(239) 472-2436**  
29 Fennell Street, Skaneateles, NY 13152 **(315) 685-2345**  
View Dr. Sawyer's profiles on [LinkedIn.com](#), [AlmExperts.com](#) and [Jurispro.com](#)

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