



The Combustion of Denatured Alcohol and Its Role in a Legal Case

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Abstract: On a warm spring day in Howell, MI, April 30, 2010, the Victim pulled into her driveway and was accosted by the Defendant. He sprayed the cologne *Charlie* onto the Victim, depressing the plunger three or four times. The vapor ignited resulting in a flame that surprised both the Victim and the Defendant. The Defendant was taken into custody and charged with Assault with Intent to Murder. The physical properties of the cologne in combination with weather conditions that day increased the likelihood that, in the presence of an ignition source, flaming combustion of the atomized vapor of the cologne could occur. The Defendant, to a reasonable degree of scientific certainty, could not have anticipated that the flammable *Charlie* product could produce visible flame under these conditions. While spraying a flammable substance upon another person is an apparent assault, the facts of this case and the application of the fundamental science do not, to a reasonable degree of scientific certainty, support the charge of Assault with Intent to Commit Murder.

Key Words: Aerosol, flash point, lower and upper explosive/flammability limits and denatured alcohol.

INTRODUCTION

On a warm spring day in Howell, MI, April 30, 2010, the Victim was driving a Volkswagen convertible with the top down when she pulled into her driveway at ca. 6:00 PM EDT. The Defendant (the Victim's ex-boyfriend) approached the vehicle and sprayed the atomized mist of cologne into the Victim's cleavage. The vapor was ignited by a spark, resulting in a flame that left both the Victim and the Defendant shaken.

Three felony counts were subsequently brought against the Defendant (Victim), including Assault with Intent to Murder. Documents provided by the Public Defender and the discussion with the Defendant indicated that he had used the commercial product *Charlie* in this incident. A typical sample of *Charlie* contains about 3.5 o.z. of spray cologne. *Charlie* is dispensed as an atomized mist when the plunger is pressed down. The dispensing of *Charlie* follows the same basic principle in dispensing the desired product contained in an aerosol can [1].

DEFINITIONS & SCIENTIFIC TERMS

An **aerosol** has two primary components: a **Product** (the desired chemical) and a **Propellant** (the agent that enables the propellant to be dispensed) [1,2].

Flash Point - The minimum temperature of a gaseous fuel in the presence of an ignition source and oxygen that produces a visible flame [3].

Lower and Upper Explosive/Flammability Limits - A mixture of gaseous fuel in air (under standard conditions of atmospheric pressure and temperature) is explosive/flammable when the percentage of the gaseous fuel in air is in the range between the lower and upper limits [4].

Concentration - The amount of a given chemical divided by the total volume.

DISCUSSION OF FINDINGS & RESEARCH

The ingredients in *Charlie* are: **SD Alcohol 40-B, Fragrance, Water, BHA or butylated hydroxyl anisole** (a preservative), **Benzophenone-2, D&C Orange No. 4, and FD&C Blue No. 1** [5].

When listing the ingredients in many commercial products, the order is on the basis of decreasing concentration. The SD Alcohol 40-B is present in the largest amount; the two dyes (D&C Orange No. 4 and FD&C Blue No. 1) are present in the least amount. This rationale supports the warning that *Charlie* is flammable.

The alcohol present in *Charlie* is not intended for drinking. Alcohol products of this type are designated as **denatured alcohol**. The alcohol product intended for drinking is ethyl alcohol or ethanol (C₂H₅OH). The designation SD in the list of ingredients in *Charlie* means that the alcohol has been specially denatured. The US Bureau of Alcohol, Tobacco, and Firearms designation 40-B indicates that the compound denatonium benzoate was used to denature the alcohol [6].

The compound denatonium benzoate is considered to be the bitterest compound known. Other applications for this denaturing compound include: deer repellent, nail polish (to discourage nail-biting), paints, antifreeze and windshield washing fluid (to prevent accidental ingestions), and to coat electrical cables to prevent rats from eating the insulation [7].

Benzophenone-2 is used as an ingredient (used) since it is an absorber of ultraviolet light. This energy is dissipated as heat [8].

The primary ingredient in *Charlie* is 70% ethanol. The flash point for this concentration is 61.9°F (16.6°C). Ethanol, in the presence of an ignition source and sufficient oxygen, is flammable at a temperature less than ambient or 72°F (22°C). The respective lower and upper explosive/flammability limits are cited as 3.3% and 19.0% by volume [9].

The flash point for denatured alcohol is 55°F (13°C) [10]. This means that ethyl alcohol not intended for drinking can have its vapor produce a visible flame, in the presence of an ignition source and oxygen, at a considerably lower temperature than ethyl alcohol intended for drinking. Per the warning on *Charlie*, we must reiterate the flammable nature of this product.

Under Handling and Storage of the MSDS for 70% ethanol, explicit comments emphasize avoiding static sparks and static electricity, plus other ignition sources.

The Weather Underground website maintains historical meteorological data. The weather data for Howell, MI at 5:55 PM EDT on April 30, 2010 is given in Table 1 [11]. The weather conditions identified at the approximate time of the incident are a typical breezy spring day. (This set of weather conditions is also consistent with the conditions reported at the National Weather Service station in Flint, MI.)

Table 1. Weather Data at Howell, MI for 5:55 PM EDT on April 30, 2010 [11]

Temperature = 77.0°F
Dew Point = 53.6°F
Relative Humidity = 44%
Barometric (Sea Level) Pressure = 29.60 inches (Hg)
Visibility = 7.0 miles
Wind Direction = South-South-West (SSW)
Wind Speed = 17.3 miles per hour
Wind Gust Speed = 24.2 miles per hour
Conditions = Clear

The Victim was driving a Volkswagen convertible with the top down when she pulled into her driveway at ca. 6:00 PM EDT. In (By) his own words (testimony), the Defendant pushed down on the *Charlie* product plunger three (3) or four (4) times. The atomized cologne mist was directed toward the Victim's cleavage when a visible flame was observed.

The ignition source, to a reasonable degree of scientific certainty, was static electricity. Contact of the Victim's clothing with the upholstered seat and her shoes with the carpet in the car was sufficient to produce flaming combustion on this warm, dry day. Typical ignition sources, such as lighters and matches, were not found.

The Defendant had been driving a black truck during the day on April 30, 2010; the *Charlie* was in the truck most of the day. It is clear from this information and the supporting weather data that the ambient temperature conditions exceeded that of the flash point for denatured alcohol (55°F = 13°C). All that was needed for the observation of flaming combustion was an ignition source.

OPINIONS

The Defendant acknowledges that he did spray the atomized mist of the commercial product *Charlie* cologne

into the Victim's cleavage on April 30, 2010 at ca. 6:00 PM EDT. The resulting flame left the Victim shaken. This event most definitely scared the Defendant.

The Defendant is neither trained in chemistry nor does he have experience in understanding the relevant key terms Flash Point and Lower and Upper Explosive/Flammability Limits.

The presence of denatured alcohol in *Charlie* demonstrates why this commercial product is flammable. The Defendant indicated that he was not aware that *Charlie* is flammable and that there are conditions that need to be avoided.

Material Safety Data Sheets (MSDS) for 70% ethanol (intended for drinking) and denatured alcohol indicate low flash point temperatures for these chemicals. The Defendant indicated that had he known the flash point for denatured alcohol is about 55°F, he would not have kept the *Charlie* in his black truck during most of this warm spring day.

The MSDS also indicate that the static sparks and static electricity are prospective ignition sources that need to be kept away from 70% ethanol (intended for drinking) and denatured alcohol. The lower flash point for denatured alcohol indicates that in the presence of an ignition source and oxygen, its vapor can produce visible flame at a lower temperature than ethanol intended for drinking.

The lower explosive/flammability limit for both 70% ethanol (intended for drinking) and denatured alcohol is 3.3% by volume in air. When *Charlie* was sprayed on the Victim and visible flame was observed, the percent of denatured alcohol had to be between 3.3% and 19.0% by volume in air in the presence of an ignition source.

The combustion leading to the visible flame was not sustained when the Defendant was no longer pushing down on the plunger. Based on the volume increase, due to the expansion of the denatured alcohol vapor around the Victim's Volkswagen convertible, the concentration of denatured alcohol vapor in air decreased to less than 3.3% and the temperature decreased to less than 55°F (13°C). As a result, the visible flame went out.

The Defendant, to a reasonable degree of scientific certainty, could not have anticipated that the flammable *Charlie* product could produce visible flame under the conditions noted here. (It is fortunate that by no longer pushing down on the plunger, the total amount of fuel was limited.)

The expansion of the denatured alcohol vapor results in increased volume (and the lower temperature). To a reasonable degree of scientific certainty, this increase in

volume is sufficiently large to cause the concentration of the fuel to decrease to less than the 3.3% lower explosive/flammability limit by volume in air in the presence of an ignition source [plus the reduced temperature to less than the flash point (55°F = 13°C)] necessary for combustion.

Static electricity was, to a reasonable degree of scientific certainty, the ignition source. Neither a lighter nor matches were found. On a warm, dry day static electricity is a plausible ignition source.

Based on the information contained in the collection of documents received from the Public Defender, the Victim neither sought medical attention nor did she keep the clothes that she was wearing in this incident. As a result, these items weren't available for examination.

While spraying a flammable substance upon another person is an apparent assault, the facts of this case and the application of the fundamental science do not, to a reasonable degree of scientific certainty, support the charge of Assault with Intent to Commit Murder.

The Intent to Commit Murder specification on (portion) of the Assault charge was not included in the jury verdict.

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