Marijuana Butane Honey Oil (BHO) Extraction Fire and Explosion Investigations

Investigator Jason M. Williams

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Introduction

Fires and explosions occurring at Marijuana Butane Honey Oil Extraction (BHO) operations have increased significantly over the past several years (OFMEM, 2017). There are inherent hazards and dangers associated with the extraction process due to the volatile fuels utilized by the manufactures of the illicit marijuana concentrate product. The incidents which are occurring at the illegal drug producing facilities have caused serious injuries, property damage and even death to those involved in the manufacturing process and members of the public. Between 2012 and May of 2017, the Office of the Fire Marshal and Emergency Management (OFMEM) has investigated 30 fire/explosion incidents involving marijuana butane honey oil extraction processes in the Province of Ontario (OFMEM, 2017). This document will discuss the history, production, hazards and investigations of Butane Honey Oil Extractions and the explosion incidents directly associated with their operation.

Background

The Office of the Fire Marshal and Emergency Management (OFMEM) in the Province of Ontario is mandated to investigate all diffused fuel vapour explosions. In the recent years the OFMEM has investigated numerous explosions associated with the manufacturing of the marijuana concentrate known as Butane Honey Oil (BHO). During these incidents numerous individuals have received serious life threatening injuries, as well as causing millions of dollars' worth of property damage. These explosions can cause secondary explosion incidents and fires in neighbouring structures, which can directly affect members of the public at large.

The BHO method of producing marijuana concentrate allegedly provides a greater yield than other methods, and has become very popular. Information on how to carry out a BHO extraction can be found readily online and does not require any specialized equipment that cannot be purchased at a local hardware store.

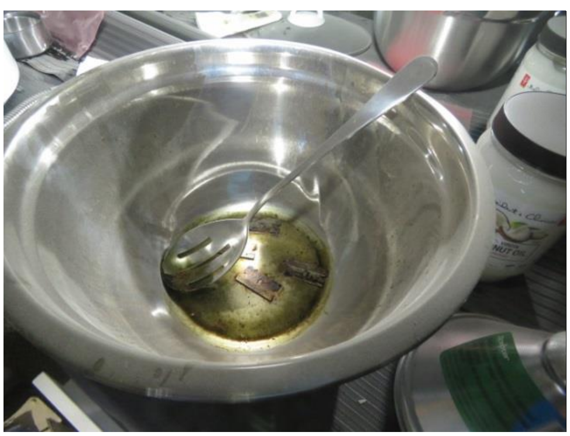
The cultivation, use and manipulation of Marijuana and its bi-products has been occurring world-wide for centuries. One of these products is Hash Oil which is an oleoresin obtained by the extraction of marijuana and/or hashish. The tetrahydrocannabinol (THC) content of hash oil from different manufactures varies as different marijuana plants and techniques are utilized in its production.

Hash oils seized in the 1970's had THC contents ranging from approximately 10-30%. Hash oils seized in the past 5 years have had THC concentrations as high as 90% as other products and techniques are being utilized by the manufacturers to obtain higher concentrations which are sought by users of the product (Wikipedia, 2017).

Marijuana Concentrate Production

Hash oil is manufactured by solvent extraction (maceration, infusion or percolation) of marijuana and/or hashish. After filtering and evaporating the solvent, a sticky resinous liquid remains. One pound of marijuana will produce between 1/5 to 1/10 of a pound of hash oil. A wide variety of solvents can and have been utilized for the extraction process including but not limited to chloroform, petroleum ether, naphtha, benzene, ethanol and butane (KLEIN, 2016). The focus of this document will focus on the utilization of butane as the solvent in the extraction process of marijuana concentrates. The preferred method to produce marijuana concentrate is to manufacture BHO, which regularly utilizes a four step process.

The manufacturers of the BHO will moderate the amount of marijuana plant material (which includes buds, stems and leaves) by grinding the material into smaller particulate utilizing a grinder or blender; the smaller particulate is commonly known as "shake". This material is then placed into an extractor tube, which can be made from PVC piping, glass mason jars, glass piping materials, stainless steel piping along with commercially available extractors. One end of the extractor is equipped with a receiver that will accommodate a butane canister dispensary nipple, and the other end will be covered with a filter (coffee filter, filter cloth or cheese cloth). A collection device (bowl or dish) is placed under the filtering device to collect the product at this stage of the process.



(Photographs: (Left) BHO collected in metal bow. (Right) BHO Extraction device. J. Williams OFMEM)

The extractors utilized by the manufacturers can vary in size and production capacity, ranging from the utilization of a single butane cylinder in a small operation to dozens of cylinders being involved in a large scale production facility.

The Butane is stored in liquid form in the commercially available cylinders sold predominantly for the purpose of refilling cigarette lighters. There are a wide variety of manufactures of Butane utilized by manufactures in the BHO process. High grade Butane is the fuel of choice of most manufactures due to the lower amount of impurities found in the Butane, which makes their product more desirable by the end user. The butane found in many of the BHO operations involved in explosion incidents does not contain pure Butane. MSDS sheets and analysis performed by exhibits collected from explosion scenes by the Centre of Forensic Science in Toronto, Ontario identified Iso-Butane, Propane and Butane.

Example of Commercially Available Butane (DEH, 2014)

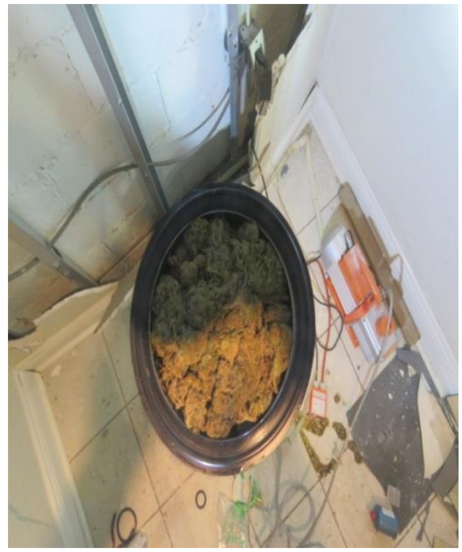
Property	MSDS	Propane	Iso-Butane	Butane
Boiling Point	11F	-42F	11.7F	31F
Auto Ignition Temp.	806F	842F	860F	550F
Odour/Colour	Gasoline/colourless	Odourless/Colourless	Natural Gas/Colourless	Natural Gas/ Colourless
Vapour Density	2	1.55	2	2.11
Flammable Range	1.4-8.4%	2.1-9.5%	1.8-8.4%	1.6-8.4%
Vapour Pressure	4.7 ATM	8.4 ATM	3.44 ATM	2.05 ATM
Flash Point	-117F	-156F		-76F

In several of the high end commercially available butane utilized in the BHO operations, Iso-Butane has been identified as being 90% of the content with Propane at 9.5% and Butane only comprising of 0.5% of the fuel contained within the cylinder.

(Photograph: Premium Butane cylinders located within BHO manufacturing operation-J. Williams OFMEM)

Butane boils at room temperature as the flash point of the liquid fuel is -60 degrees Celsius and has a boiling point of -0.6 degrees Celsius. This allows for the intentionally applied fuel to change from liquid to vapour within the compartment in which is it being dispensed. The vapour density of Butane fuel vapour is 2.0 (air being 1.0), which indicates that the fuel vapour which is being intentionally introduced into the extractor will descend within the device and subsequently within the compartment in which it is being dispensed. The process strips the cannabis marijuana of its cannabinoid rich oils and THC containing materials by using the butane to break off and dissolve the trichomes into the solvent and carry it away from the plant material which is then further refined by the manufacture of the BHO.


(Photographs: BHO Extraction Devices-J. Williams OFMEM)

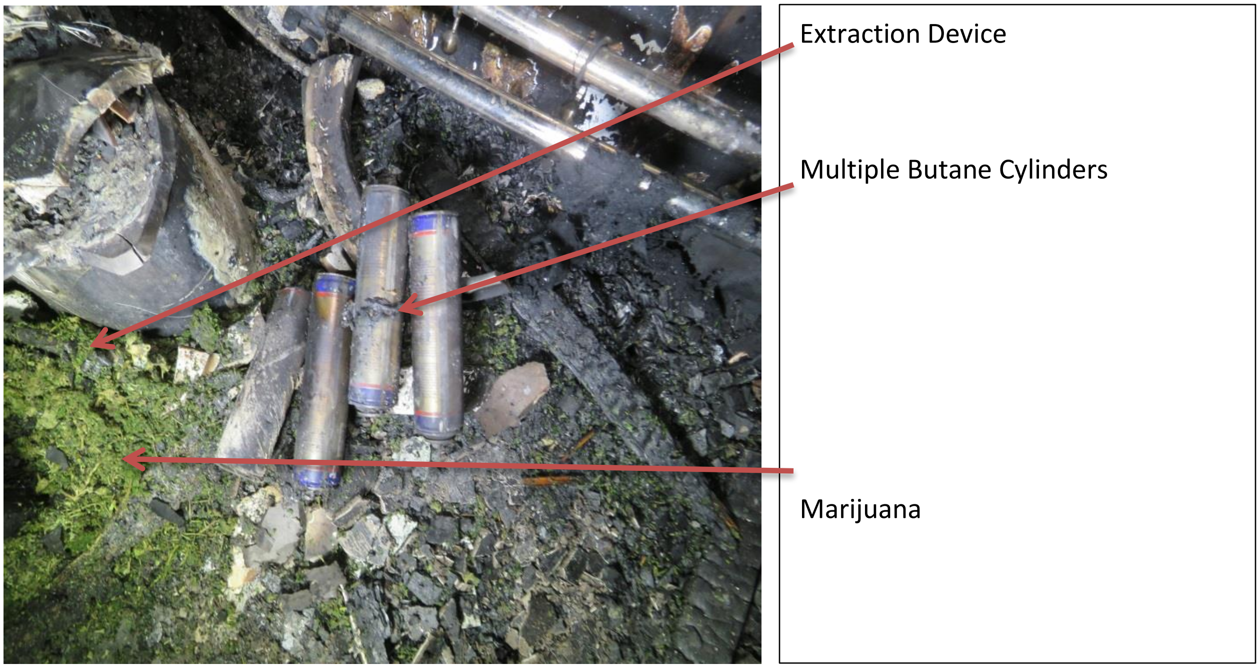
 

(Photographs: (Left) Commercially available extraction device with vacuum pump system. (Right) Marijuana located within the confines of the extraction tube- J.Williams OFMEM)

The manufactures of the BHO then attempt to refine or purge the product of any impurities or butane fuel by soaking the collection dish/bowl with a solution of warm water in a double boiler system or crock pot(s). Another common method is the use of a vacuum pump and vacuum chamber to lower the butane's boiling point, which subsequently removes the fuel from the oil product. These vacuum pump systems are commercially available at retail stores and on-line, and offer a wide variety of options and sizes of the devices.

Some of the manufactures of the marijuana concentrate will then attempt to further refine the BHO product into "shatter", which continues with the attempts to purge the product of any impurities and is known as "winterizing" or "de-waxing". These steps of the process remove the marijuana plant wax from the hash oil. The manufacturer places the BHO product into a container (example-glass canning jar) and pours acetone, toluene, 99% pure isopropyl alcohol or grain alcohol into the jar with the product which is then placed into a freezer.

BHO manufacturers believe that if they place the BHO product in the freezer the expelled Butane THC mixture will stay in liquid form due to the boiling point of butane. This practice may work for Butane, but not for Iso-Butane or Propane as their boiling points are much lower than that of butane.



(Photograph: BHO Extraction Fire Investigation- J. Williams OFMEM)

Hazards of the BHO Manufacturing Process

The properties associated with the flammable liquids used in the de-waxing process (Flash Points between -4 and 55 degrees Fahrenheit and Vapour Densities of 1.6-3.1%) (Babrauskas, 2003) result in the vapours produced during the process descending within the compartment in which they are being utilized. The accumulation of the vapours within the compartment (within the flammable range) would allow for the ignition of the diffused fuel vapours produced by the presence of a competent ignition source. The combustion of additional fuel(s) present within the compartment adds to the total heat of combustion values associated to the fire.

The butane is dispensed as a liquid but quickly boils and the vapours which are heavier than air accumulate in low lying areas. The vapours become the most easily ignitable fuels that may result in an explosion. The flammable vapour then stratifies across the surface of the floor of the compartment, creating a dangerous environment for those situated in and/or close to the operation. The flammable range of Butane is 1.8-8.4% per volume of air; and an ignition temperature of 482-538 degrees Celsius, with minimum ignition energy of 0.26mJ (DeHann, 2012)

Once the diffused butane fuel within the confines of the compartment is within its flammable range, if a competent ignition source is present an explosion and/or flash fire may occur. The resulting pressure, flame front and mechanical damage become dangerous for anyone within its proximity.

The factors affecting the dynamics of the explosion incident and pressures created by the diffused fuel vapour explosion are the fuel-air ratio, turbulence effect, volume of the confining space, location and magnitude of the ignition source, venting and strength of the structure. Mixtures near the lower explosive limit (LEL) or upper explosive limit (UEL) of a gas usually produce less violent explosions than do those near optimum concentrations. The optimum concentration is stoichiometric, which is the optimum ratio at which point the combustion will be most efficient (DeHann, 2012).

The explosion is sudden conversion of potential energy into kinetic energy with the production or release of gases under pressure, or the release of a gas under pressure. These high pressure gases then do mechanical work such as moving changing or shattering nearby materials. The blast overpressure and wave effect is a result of large quantities of gas being produced by the explosion of the material. The gases move outward at high speed from the point of origin (positive pressure phase) and then return (negative pressure phase). These blast fronts cause damage to the structure and surrounding materials, along with thermal affects and injuries to those in proximity to the point of origin (NFPA, 2017).

The damage caused is regularly classified as “low order” and the combustion reaction propagates through the air at subsonic velocities, and by definition is classified as a deflagration. Explosions occurring at BHO manufacturing facilities have completely destroyed single family dwellings, business and industrial facilities along with causing serious life threatening injuries and death to individuals in or near the incident location.

Investigations conducted by the OFMEM have shown that deflagrations producing low order damage (Example: bulging of walls, displacement of doors, fragmenting of glass windows) have occurred when as little as one half of a 330ml cylinder of intentionally introduced Butane fuel vapour was ignited within the confines of a compartment.

The Investigation of Marijuana BHO Extraction Fire and Explosion Incidents

BHO fire and explosion incidents are becoming a more regular occurrence in the Province of Ontario. These explosion investigations are being under taken by the OFMEM along with local fire and police services. Insuring the proper legal authority to conduct such an investigation is required by all of the agencies involved. Often the scene results in parallel investigations; a narcotics investigation and a fire/explosion investigation may be taking place. Under these circumstances, both a *Control Drug and Substances Act* search warrant and an s. 487 *Criminal Code* search warrant should be sought as any authority under the *Fire Protection and Prevention Act* would not be applicable in this instance.

Upon initiating the investigation into the incident the fire investigator must first credibly identify the area of fire or deflagration origin. The area of origin opinion of the investigator is supported by the physical evidence of the directional force vector analysis and displacement resulting from the deflagration at the incident location. In a fire incident the area of fire origin opinion is supported by an analysis of the physical fire pattern evidence present at the incident location as well as the dynamics of the fire.

Upon credibly identifying the area of origin the investigator must identify and isolate the fuel source of the explosion. This includes identifying all fuel sources present within the area of deflagration origin, including any and all appliances which may have attributed to the incident. Barholing and soil atmosphere testing should be completed on the exterior of the incident location to ensure that migrating fuel vapour did not enter the structure from service providing fuel to the building. (Example: Natural Gas, Propane).

In a BHO fire or explosion investigation, cylinders of Butane are commonly found in the area of fire or explosion origin, and in other location at the incident location. A sample of the fuel contained within the cylinders should be collected and analyzed to determine the exact fuel(s) present in order for the investigator to credibly provide a cause opinion. In some instances where the cylinders have been exposed to heat energy in significant enough quantities, a mechanical failure of the vessel may occur in the form of a boiling liquid expanding vapour explosion (BLEVE). This adds an additional hazard to first responders when dealing with BHO related fire and explosion scenes.

If during the investigation an extraction device (possibly containing marijuana material) or collection device is located, the investigator should collect the items and have them analyzed to determine the presence of Butane and/or any other fuels. This will provide important data to the investigator along with supporting the cause opinion.

While conducting an investigation into a possible BHO manufacturing operation these item(s) may be identified or present at the location and provide the investigator with further data and information to assist in their investigation, and support the cause opinion of the investigator:

1) Marijuana (bud, stem, shake)
2) Extraction Devices (PVC, Glass or Stainless steel tubing and commercially available extraction devices)
3) Marijuana particulate within extraction device (Test and examine for the presence of Butane)
4) Filters (Coffee filters, filter cloth or cheese cloth)
5) Vacuum pumps/heating pads
6) Collection devices (bowls, dishes, plates, crock pots or containers with BHO residue)

7) Razor blades (utilized in the finishing process of the product)
8) Instructions or print outs of information on "How to" conduct a BHO extraction
9) Clothing worn by person(s) involved in the BHO manufacturing process (Test and examine for presence of thermal damage and/or the Butane)
10) Thermal injuries sustained to individuals involved in the extraction process (Commonly seen thermal injuries are to the person(s) hands, arms and face due to their involvement in the extraction process at the time of the explosion incident)
11) Butane fuel cylinders (Example: 200-400ml metal cylinders)
12) Chemical suits / respirators

In 2014 the Department of Environmental Health (DEH), along with the San Diego Fire Department, San Diego Sheriff's Department, Drug Enforcement Administration, Narcotics Task Force and the University of California San Diego Burn Center conducted testing and experimentation in relation to explosions at BHO manufacturing facilities due to the increased number of incidents occurring within this area of California (DEH, 2014). This testing included attempting several ignition sequences involving the ignition of the diffused Butane fuel vapour (between 1-20 cans) within the confines of a 10'x10'x12' burn cell. The temperatures generated in the explosions were less than 500 degrees Fahrenheit depending on the dispersal method of the butane in the experiment.

Successful ignition sources of the diffused butane fuel vapour within the compartment were identified as static electricity, Taser (conductive energy weapon), electrical arcs and open flames. Other ignition sources which were also tested and did not ignite the diffused fuel vapour were hot plates, vacuum pumps, refrigerators, shot gun and cigarettes (DEH, 2014).

The research also showed that it was apparent that if an individual had suffered serious thermal injuries in a BHO manufacturing laboratory, they had been using four (4) or more cylinders (300ml) which would be produced by a 1 second exposure to temperatures over 160 degrees Fahrenheit according to this study. Investigations under taken by the OFMEM have found that individuals who have received thermal injuries during an explosion at a BHO laboratory have been in close proximity to the area of deflagration origin at the time of the incident. Thermal injuries to individuals hands, arms and face along with thermal affects to their clothing (melting, charring or consumption) has also occurred in many of the same incidents.

The Department of Emergency Medicine at the University of Colorado conducted research into injuries sustained during fires/explosions at BHO manufacturing facilities. The study states that nearly all thermal injuries were "flash burns" due to explosions within an enclosed space (91%), and that the median total body surface area (TBSA) burn size was 10%. A majority of the individuals had their upper extremity burns (97%) and/or burns to head or neck (66%) (Department of Emergency Medicine, 2014)

Dealing with the manufacturing of BHO

In February of 2013 the Federal Emergency Management Agency (FEMA) posted an alert in its emergency services bulletin titled *"Hash Oil Explosions Increasing across US."* The alert was in relation to an increasing number of explosion incidents occurring where "A process using butane to extract and concentrate compounds from marijuana," was being utilized. These destructive incidents that FEMA identified could even be mistaken for pipe bomb or meth lab explosions (Hallet, 2013).

In 2012, the state of Colorado de-criminalized possession of marijuana for medical purposes, regulating it like alcohol. Since the de-criminalization of marijuana there have been a reported 55 explosions which have occurred in the state which all associated with the illegal production of marijuana concentrates (KLEIN, 2016). The Drug Enforcement Administration (DEA) and local law enforcement agencies throughout the United States have implemented task forces to deal with the rising concern in relation to the illegal operation of marijuana concentrate extraction laboratories. United States law enforcement agencies have identified a rise in the number of BHO explosion incidents in states that have de-criminalized possession of marijuana for medical purposes, especially on the west coast of the country (DEA, 2014).

The Royal Canadian Mounted Police (RCMP), municipal and provincial police agencies in the Province of Ontario have all indicated that BHO operations have been identified in numerous areas within the Province of Ontario (News, 2015) In Ontario, individuals who are prosecuted in relation to an explosion at a BHO manufacturing laboratory are regularly charged under Section 436(1) of the *Criminal Code of Canada* which states *"Every person who owns, in whole or in part, or controls property is guilty of an indictable offence and liable to imprisonment for a term not exceeding five years where, as a result of a marked departure from the standard of care that a reasonably prudent person would use to prevent or control the spread of fires or to prevent explosions, that person is a cause of a fire or explosion in that property that causes bodily harm to another person or damage to property".*

Due to the high amount of BHO operations and explosion incidents occurring in California, the county of San Bernardino has implemented a regulation in relation to the sale of commercially available Butane. Within the county, if an individual purchases three or more 300ml cylinders of Butane fuel, the seller is required to obtain their contact information and confirm their age. No person(s) are allowed under the regulation to purchase more than four 300ml cylinders of Butane fuel from the same commercial establishment (Marquez, 2016). In Canada, and Ontario respectively there are no current limitation and or regulation limiting the quantity of commercially available Butane cylinders purchased by members of the public.

Conclusion

It is clear that the intentional introduction of Butane into a confining vessel or compartment for the purposes of the illicit manufacturing of BHO is an extremely hazardous and dangerous process. With the possible de-criminalization of marijuana in Canada, the likelihood of an increase in BHO laboratories and subsequent explosion incidents in Ontario can be expected as has occurred in many areas of the United States. The explosions which are occurring at these facilities are due to the improper use and handling of volatile fuels by manufactures of BHO, which puts the manufactures, members of the public and first responders at an inherent risk of an explosion and/or fire incident.

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