IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 7, July 2015.
www.ijiset.com
ISSN 2348 – 7968

Safety Aspects of Handling Alcohols and other Alternative Fuels for use in Internal Combustion Engines

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Abstract

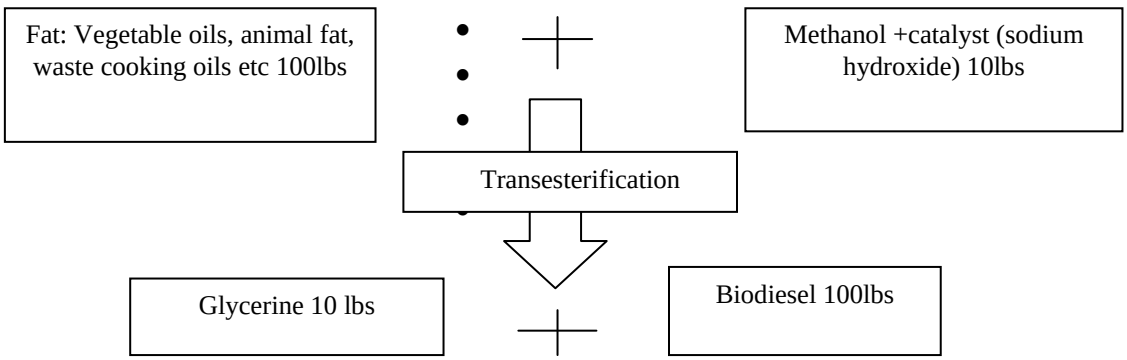
The increasing oil production cost, oil demand, and environmental concerns have facilitated extensive research development and demonstration in the past for clean or alternative fuels advanced propulsion technology. A number of alternative fuel vehicle such as methanol, ethanol, biodiesel, hydrogen, compressed natural gas, and electricity have been used extensively the world over in the transportation vehicles in place of gasoline and diesel. The numbers of transportation vehicles are also increasing enormously day by day. In addition of Air quality is an important aspect to be known every one because we cannot avoid breathing the air around us. On an average an adult breaths 20,000 litres of air per day. The transportation system is a major air pollution contributor due to the exhaust emission such as carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx), carbon dioxide (CO2), and particulate matter (PM). A general awareness on the use and handling of alternative fuels is utmost important. In this paper an attempt has been made to discuss the causes and the harmful effects of traffic vehicles released emissions to environment. The safety aspects of handlings of alcohols as alternative fuels in internal combustion engines have also been discussed.

Key words: **Safety, Pollutants, Emissions, Alcohols.**

1. Introduction

1.1 Alternative fuels and the effects of vehicle emissions

Bio-diesel: Fuels derived from renewable biological resources for use in diesel engines are known as bio diesel.bio diesel is the ester based variety oxygenated fuel derived from natural renewable biological sources such as vegetable oil. Biodiesel fuel can be made from new or used vegetable oil and animal fats. Biodiesel is high quality fuel made through a chemical process called transesterification. Needed ingredients are vegetable oil, methanol and Lye (NaoH). Figure 1 shows how to making Biodiesel.



The chemical reaction that occurs through this process breaks down the oil into a layer of biodiesel which rises to the top of the reactor, and a layer of glycerine which falls to the bottom. The glycerine is drained is drained off and used for other purposes, composed or otherwise disposed off. The biodiesel is then washed, dried and filtered to remove any extra impurities and it's ready to be used as a fuel in diesel engines without any modifications to the engine.

Biodiesel decreases the gas emissions that cause the green house effect. Biodiesel also diminishes and proliferation of deceases caused by the pollution of the environment. The majority of biodiesel is produced in the United States from soybean oil due to feed stock's abundance.

Biodiesel is a nontoxic diesel fuels substitute, which makes it easier to handle, transport and store.

This fuel is biodegradable and it dissipates quickly after a spill.

It is low volatile and does not ignite easy as gasoline increasing the margin of safety and fuel handling.

Biodiesel is a safer and produces less air pollutions than petroleum based diesel. It reduces carbon dioxide by 15%. Biodiesel from soya oil reduces green house gases an average by 57% compared to petroleum diesel and biodiesel from recycled restaurant greases results in 86% reduction.

1.2 Propane: propane is a by-product of natural gas processing and petroleum refining. In its natural state, propane is a colourless and nontoxic gas.

ISSN 2348 – 7968

- Propane gas turns into a liquid mixture under moderate pressure making it easier to transport and store in vehicle fuel tanks.
- Propane vehicle have greater engine efficiency when compared to gasoline.
  In its gaseous state, the fuel mixer readily with air in the combustion chamber to allow for nearly completes combustion. This can be minimizing problems with starting the vehicles in cold weather.
- It is environmental friendly and can lower carbon dioxide, carbon monoxide, and other toxic emissions.

Propane produces lower amount of some harmful pollutants and greenhouse gases, but it depends on the vehicle type, drive cycle and engine calibration. It has been found to emit 26% less greenhouse gases than gasoline. The alternative fuel vehicle institute compared propane to gasoline and found that the use of propane reduces particulate matter by 40%, nitrogen oxides by 50%, and total hydro carbon (THC) emissions by 87%.

1.3 *Ethanol:* Ethanol is less flammable than gasoline. Ethanol burns in air with a blue flame, forming carbon dioxide and water. Fires are less frequent and less severe when spills or releases of vapor occur. It is safer than gasoline to store, transport and refuel. Ethanol is water soluble and biodegradable hence land and water spills are usually harmless, dispersing and decomposing quickly E85 is the most popular blend for light-duty vehicles which contains 85 percent ethanol and 15 percent gasoline. Ethanol-powered vehicles produce less net CO2 than gasoline powered vehicles per mile travelled.

Alcohol fuels (unlike gasoline) easily absorb water. Extra care should be taken to prevent snow or rain from dropping into fuel tanks where water in the fuel will cause gasoline alcohol blend phase separation, leading to “water bottoms” in the tank and subsequent driveability problems. Unlike gasoline, alcohol is easily absorbed into the human body; thus ingestion, inhalation and exposure of the skin to alcohol fuels should be avoided. Neat (100%) alcohol fuel burns cooler than gasoline and with very low luminosity (difficult to see in sunlight), so a fire would be difficult to spot. But the gasoline alcohol blend, i.e. E85 & M85, makes flames more visible. Because alcohol fuels are water soluble, a small fire may be doused with water; a larger fire is extinguished with dry chemical or with foam. Chemical attack is another concern for engineers who design alcohol fuelled vehicles. Gasoline fuel system components—injectors, Orings, fuel lines, hoses and tanks—could possibly be ruined if exposed to high concentrations of alcohol.

Short-term effects of alcohol consumption include intoxication and dehydration. Long-term effects of alcohol consumption include changes in the metabolism of the liver and brain and alcoholism (alcohol dependency). Alcohol intoxication affects the brain, causing slurred speech, clumsiness, and delayed reflexes. Alcohol stimulates insulin production, which speeds up glucose metabolism and can result in low blood sugar, causing irritability and (for diabetics) possible death. Severe alcohol poisoning can be fatal.

1.4 Methanol: Methanol is also known as methyl alcohol, wood alcohol, wood naphtha or wood spirits. Methanol is the simplest alcohol, and is a light, volatile, colorless, flammable liquid with a distinctive odor very similar to that of ethanol (drinking alcohol). However, unlike ethanol, methanol is highly toxic and unfit for consumption. At room temperature, it is a polar liquid, and is used as an antifreeze, solvent, fuel, and as a denaturant for ethanol. It is also used for producing biodiesel via transesterification reaction. Methanol ingested in large quantities is metabolized to formic acid or formate salts, which is poisonous to the central nervous system, and may cause blindness, coma, and death. Methanol is very poisonous and very harmful to swallowed. Methanol must not be confused with ethanol. As with gasoline, it is also wise to avoid skin contact with methanol, as it can pass through the skin. It is not advisable to drink methanol in any quantity it is advisable not even siphon methanol or any fuel by mouth. Other than that, there's pretty much no way to accidentally ingest methanol unless you confuse it with ethanol. If you accidentally ingest even a small amount of methanol, call a poison control centre immediately, and follow their advice, which will differ depending on the expected concentration and time since ingestion.

The alcohols mix in all proportions with water due to the polar nature of OH group. Low volatility is indicated by high boiling point and high flash point. Alcohols burn with no luminous flame and produce almost no soot, especially methanol. The tendency to soot increases with molecular weight. Therefore, methanol produces less soot than ethanol. Because of the low proportion of carbon in alcohols, soot formation does not occur and therefore alcohols burn with low luminosity and therefore low radiation. In conjunction with lower flame temperature, about 10% less heat is lost to the engine coolant. The lower flame temperature of alcohols results in much lower NOx (Nitrogen Oxides) emissions. The wider flammability limits of alcohols permit smooth engine operation even at very lean mixtures. But aldehyde emissions are noticeably higher. For ethanol, emissions are acetaldehydes and for methanol, emissions are of formaldehydes. Increasing compression ratio from 9 to 14, aldehyde emissions can be reduced by 50%, to level compared to that for gasoline. An addition of 10% water reduces aldehyde emissions by 40% and NOx by 50%. Addition of 10% water in the alcohol can be tolerated without loss of thermal efficiency.

Pure methanol has been used in open wheel auto racing since the mid1960s. Unlike petroleum fires, methanol fires can be extinguished with plain water. A methanol based fire burns invisibly, unlike gasoline, which burns

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with a visible flame. If a fire occurs on the track, there is no flame or smoke to obstruct the view of fast approaching drivers, but this can also delay visual detection of the fire and the initiation of fire suppression.

Methanol has a high toxicity in humans. If as little as 10 mL of pure methanol is ingested, for example, it can break down into formic acid, which can cause permanent blindness by destruction of the optic nerve, and 30 mL is potentially fatal, although the median lethal dose is typically 100 mL (3.4 fl oz) (i.e. 1–2 mL/kg body weight of pure methanol). Reference dose for methanol is 2 mg/kg/day. Toxic effects take hours to start, and effective antidotes can often prevent permanent damage. Because of its similarities in both appearance and odor to ethanol (the alcohol in beverages), it is difficult to differentiate between the two (such is also the case with denatured alcohol). The initial symptoms of methanol intoxication include central nervous system depression, headache, dizziness, nausea, lack of coordination, and confusion. Sufficiently large doses can cause unconsciousness and death. The initial symptoms of methanol exposure are usually less severe than the symptoms resulting from the ingestion of a similar quantity of ethanol.

1.5 Electricity: Electric vehicles are more energy efficient and produce less noise than gasoline or diesel powered vehicles. Hybrid vehicles can double the gas mileage of conventional gasoline or diesel powered vehicles and can reduce emissions significantly Electric vehicles use electricity from a power source to charge EV batteries and can travel from 40 to 120 miles on a single battery charge. Auto manufacturers are now selling “hybrid” vehicles that combine an electric motor with a separate gasoline or diesel engine. Electric vehicles emit no tailpipe pollutants although the companies that produce the electricity may do. Electricity from wind-, hydro-, nuclear-, or solar- powered plants cause no air pollutants.

1.6 Hydrogen energy: Hydrogen gas is the primary fuel source for hydrogen vehicles. Hydrogen gas does not produce any harmful emissions when burned. Hydrogen-powered-cell vehicles have zero emissions. Methane, fossil fuels, and other renewable energy sources such as wind, solar, and nuclear power are major producers for hydrogen fuel. A fuel cell vehicle uses hydrogen fuel which reacts with oxygen in a fuel cell to power an electric motor. Another implementation of a hydrogen vehicle is the internal combustion engine vehicle, where a conventional combustion engine directly burns hydrogen fuel.

2. Health Related Issues Regarding Air Pollutants

Government passed the Clean Air Act in 1970 that established the National Ambient Air Quality Standards (NAAQS). These standards were set for the six common air pollutants: ozone, particulate matter, lead, carbon monoxide, nitrogen dioxide, and sulphur dioxide.

3.

2.1 Ozone

• It depends on where you find ozone as to whether it can be harmful or beneficial. In the upper atmosphere ozone is beneficial because it blocks the sun’s harmful ultraviolent radiation.The chemical reaction between oxides of nitrogen and volatile organic compounds in the sunlight forms ground-level ozone.

• Ozone is a primary component of smog and causes breathing problems, reduces lung function, irritates the eyes and throat, and can trigger asthma or emphysema.

2.2 Particulate Matter

• Particulate matter is composed of airborne dust, smoke, soot, and other microscopic pollutants.

• Combustion engines, wood burning, road dust, construction dust, and agriculture are the major contributors to particulate matter.

• It can lead to health illnesses like lung damage, long term risk of cancer, and bronchitis.

2.3 Lead

• Lead is a heavy metal found in paint, leaded gasoline, and emissions from metal smelters.

• Lead causes brain and nervous system damage, peripheral nerve paralysis, learning problems and impairs production of hemoglobin in blood.

2.4 Carbon Monoxide

• Carbon monoxide is a poisonous gas that is caused by the incomplete combustion of fuels such as gasoline, wood, or natural gas.

• It reduces the ability of the blood to carry oxygen throughout the body and can be extremely hazardous to pregnant women, foetuses, and those with cardiovascular disease.

2.5 Nitrogen Dioxide

• Nitrogen dioxide is resulted when fuels like gasoline are not completely burned in air and air contains about 70 percent nitrogen.

• Nitrogen is the key smog-forming chemical and increases respiratory problems.

2.6 Sulphur Dioxide

• The main source of sulphur dioxide is coal-burning power plants and is the main supplier to “acid rain.”

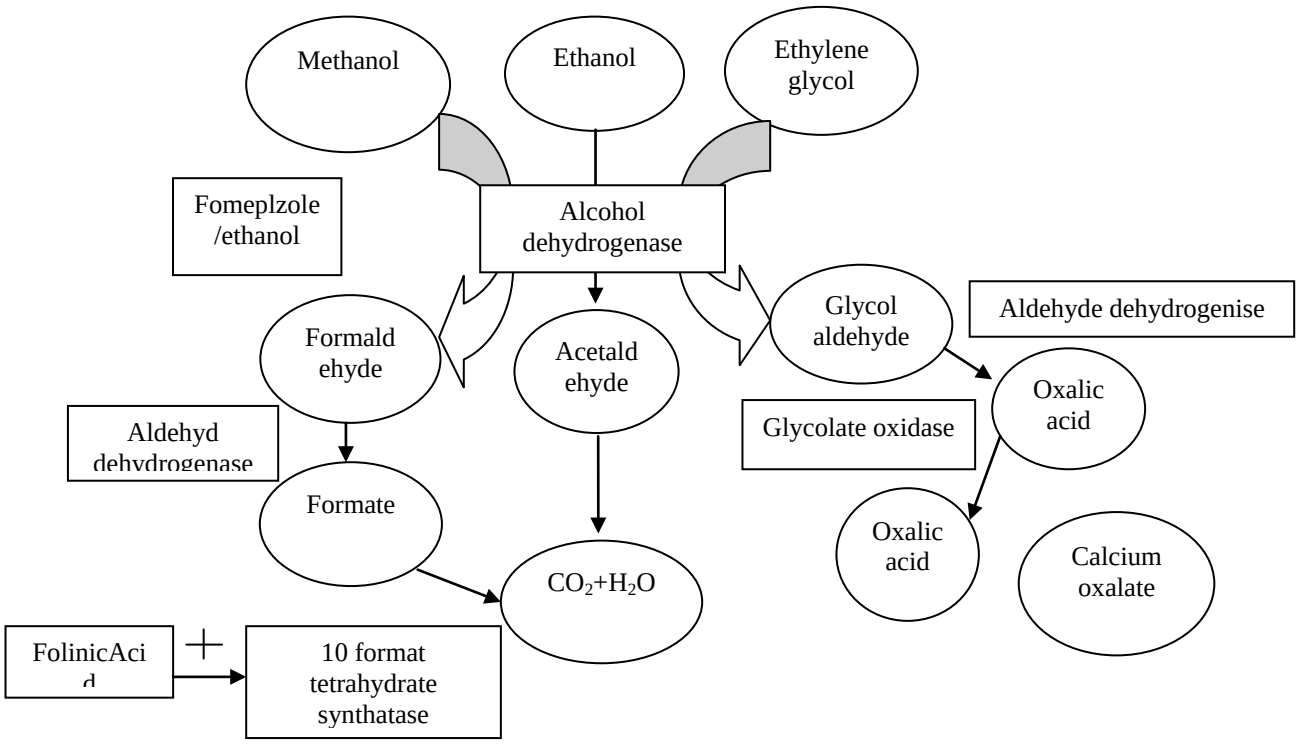
• Sulphur dioxide can cause permanent damage to the lungs if exposed to too much.

The Metabolism of Methanol

For humans, methanol is highly toxic if ingested. In contrast, other alcohols, such as ethanol or ethylene glycol, generate compounds which are part of the body’s normal metabolism. In the body, methanol is first converted to formaldehyde, which is then converted to

ISSN 2348 – 7968

formate in the liver, which can cause serious damage to the nervous system. Initial symptoms, caused by increased methanol in the blood, include headache and dizziness, lack of coordination and confusion. As the methanol is metabolized to formic acid – about 10 to 30 hours after ingestion – more serious symptoms develop, such as blurred vision or even blindness, coma and death due to respiratory failure.



Conclusions

1. Unlike gasoline, alcohol is easily observed into the human body. Thus ingestion, inhalation and exposure of the skin to alcohol fuel should be avoided. Alcohol consumption leads to dehydration. The long term effects of alcohol consumption may include changes of metabolism of the liver and alcoholism.
2. Ethanol is less flammable than gasoline. Ethanol burns in air with a blue flame, forming carbon dioxide and water. Fires are less frequent and less severe when spills or releases of vapor occur. It is safer than gasoline to store, transport and refuel.
3. Unlike ethanol, methanol is highly toxic and unfit for consumption. It is also used for producing biodiesel via transesterification reaction. Methanol ingested in large quantities is metabolized to formic acid or formate salts, which is poisonous to the central nervous system, and may cause blindness, coma, and death. it is advisable not even siphon methanol or any fuel by mouth

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