



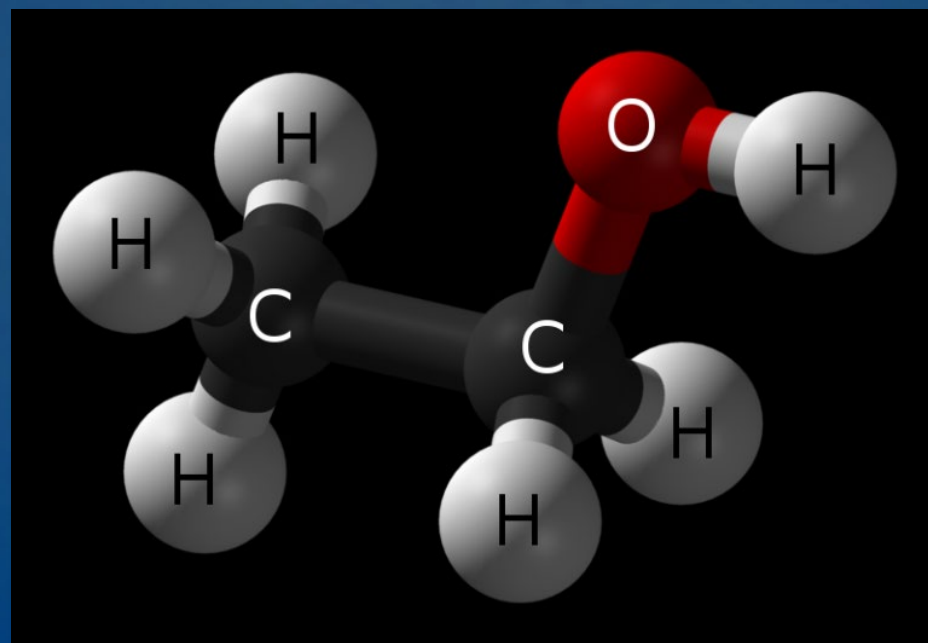
Module 3:

Chemical and Physical Characteristics of Ethanol and Hydrocarbon Fuels

Objective



Upon the completion of this module, participants should be able to describe the chemical & physical differences between gasoline, ethanol & ethanol-blended fuels.



Introduction



- Characteristics of gasoline
- Characteristics of ethanol
- Conditions under which ethanol-blended fuels will retain chemical characteristics different than an all hydrocarbon fuel

Characteristics of Gasoline



- Insoluble in water
- Produced from crude oil
- Harmful effects after long-term & high-level exposure
- Smoke from burning gasoline is black & has toxic components
- Significant hazard is flammability:
 - Fairly narrow range of flammability
 - 1.4% - 7.6% by volume in air



Gasoline Production

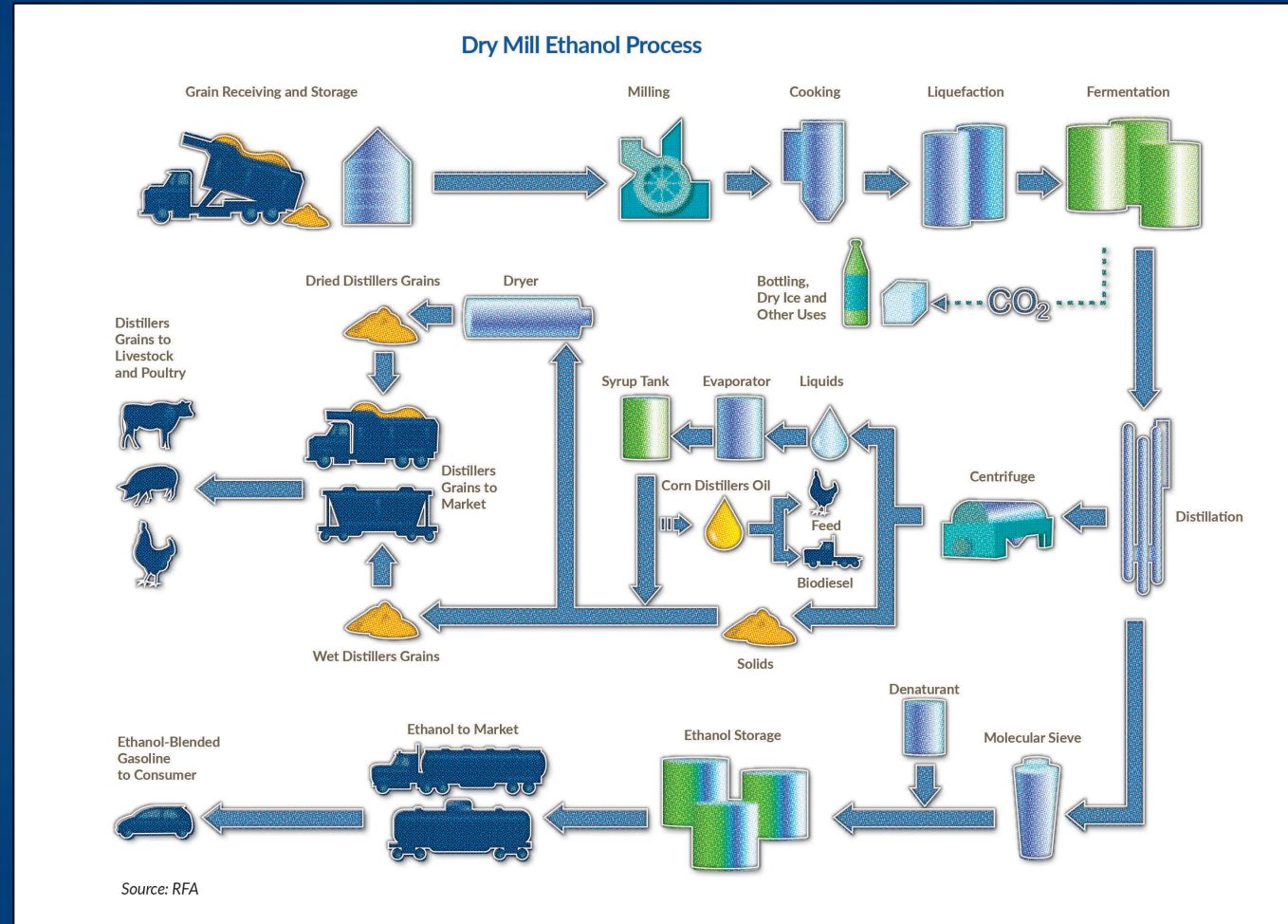


Characteristics of Ethanol



- Renewable fuel source produced by fermentation & distillation processes
- Most common feedstock in U.S. is corn
 - Other feedstock include corn cobs, corn stover, switchgrass, etc.
- Ethanol used with motor fuels must be denatured with 2% - 5% natural gasoline or similar hydrocarbon before transportation to bulk storage facilities
- Denaturant has minimal effects on characteristics except for flash point
 - The addition of denaturant further depresses the flash point

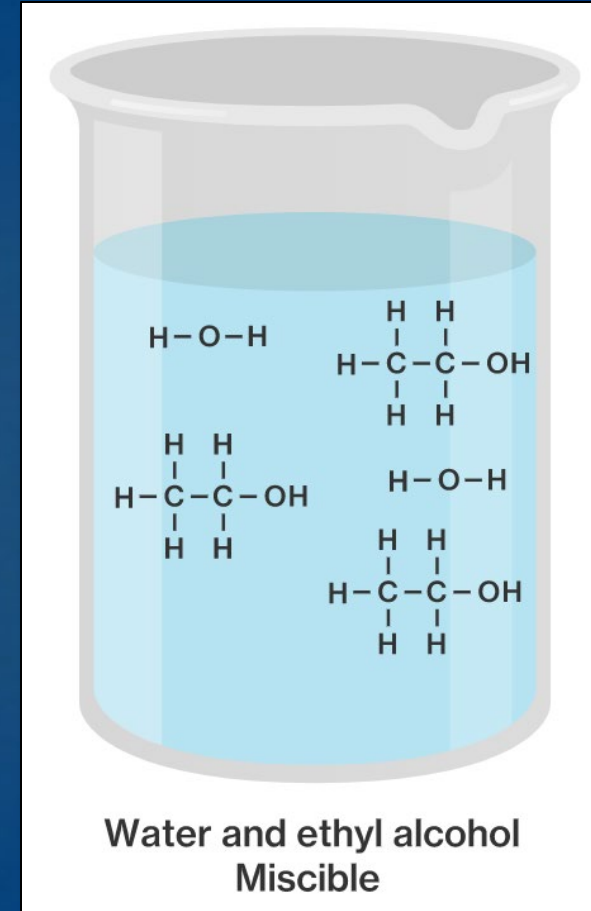
Ethanol Production



Characteristics of Denatured Fuel Ethanol



- Polar solvent
- Miscible in water
- Greatest hazard as motor fuel component is flammability
 - Wider flammable range than gasoline:
 - 3% - 19% by volume in air



Chemical Properties Comparison



Property	Gasoline	Denatured Fuel Ethanol
Flash Point	-45 ⁰ F	-5 ⁰ F
Auto Ignition Temp	530 - 853 ⁰ F	709 ⁰ F
Specific Gravity	0.72 – 0.76	0.79
Vapor Density	3 - 4	1.5
Vapor Pressure	8 - 15psi	~3psi
Boiling Point	100 - 400 ⁰ F	165 - 175 ⁰ F
Flammable Range	1.4% - 7.6%	3% - 19%
Smoke Characteristics	Black	Slight
Solubility	Trace	High

Considerations for Ethanol Fires



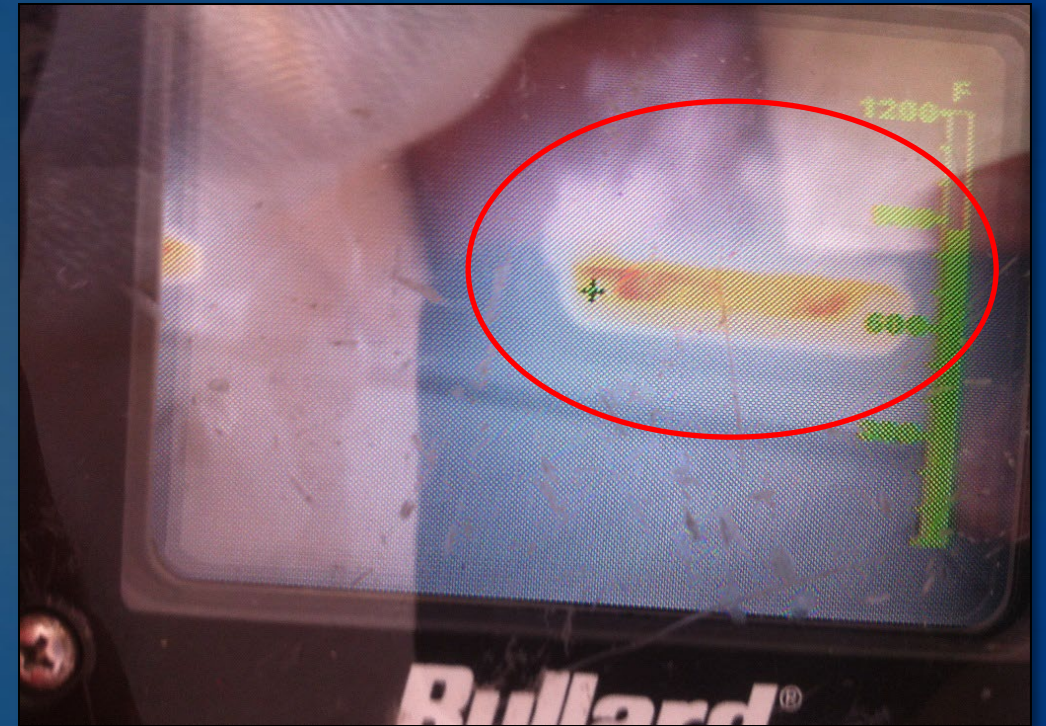
- In undenatured/ neat form, the flame & smoke are not easily visible
- In denatured form, the flame is orange and there is minimal smoke but both are visible
- Large amounts of water required to dilute ethanol to no longer support combustion
 - Will continue to burn at five parts water to one part ethanol (5:1 ratio or 500% dilution)

Invisible Flames - Ethanol



Thermal imaging

- Fires involving a high percentage of ethanol can burn with little to no smoke generation and visible flame
- The use of a thermal imaging camera is highly recommended



Characteristics of Ethanol-Blended Fuels



Blending fuels alters physical & chemical characteristics of original fuels:

- Visual difference of smoke & flame characteristics:
 - Higher content of ethanol, less visible black smoke content & orange flame production

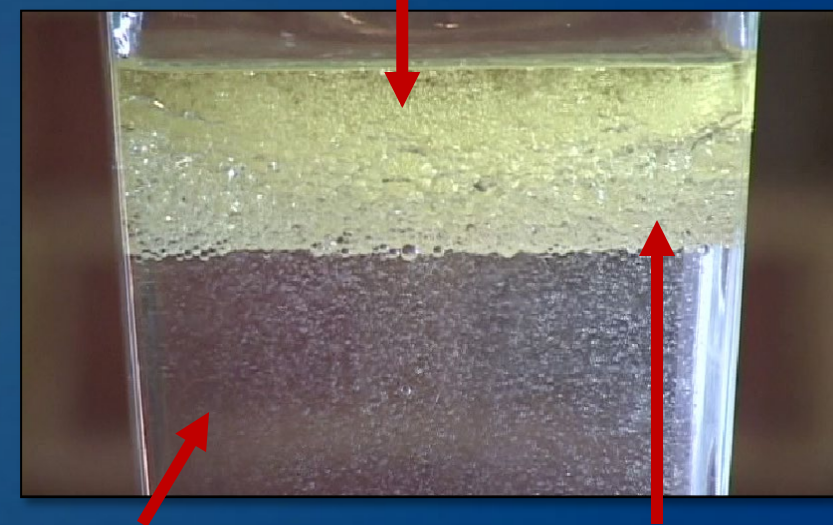


Characteristics of Ethanol-Blended Fuels



- Ethanol & gasoline are miscible, creating a homogeneous fuel blend
- Water contamination of ethanol gasoline fuel blends may cause phase separation:
 - Phase separation will introduce a water layer in the bottom that consists of water & ethanol
 - All hydrocarbon gasoline will remain in the top layer

Gasoline floating on layer of ethanol/ water solution



Ethanol/ water solution (still flammable)

Ethanol phasing away from hydrocarbon

Activity 3.1:

Comparison of Gasoline and Ethanol



Purpose:

- To allow participants to discuss the differences & similarities in the chemical & physical properties of ethanol & gasoline

Consideration for Ethanol-Blended Fuel Fires



- Best practice is the use of alcohol resistant foam, AR-AFFF
- When phase separation of ethanol & gasoline occurs:
 - Gasoline layer floating on top will burn first
 - Ethanol water layer will burn next, flames and smoke may be diminished

Activity 3.2:

Definitions



- Purpose:
 - To allow participants to identify the definitions related to ethanol & ethanol-blended fuels

Worksheet 3.2:

Definitions



- Ethanol
- Polar solvent
- Hydrocarbon
- Flash point
- Auto-ignition temperature
- Specific gravity
- Vapor pressure
- Vapor density
- Boiling point
- Flammable range
 - Upper explosive limit (UEL)
 - Lower explosive limit (LEL)
- Toxicity
- Flammable liquid

Summary



- Ethanol is a polar solvent, miscible with water, & flammable
- Higher content of ethanol means less visible black smoke, & orange flame production
- Best practice is the use of alcohol resistant foam
 - AR-AFFF