

10.5 Vapor phase combustion of ethanol

Subjects: Reactions of gases, kinetics

Description: When a spark is introduced to a container full of ethanol vapor, the vapor explodes. Because the container is closed, the rapid increase in heat and pressure blows the stopper off of the container and produces a loud bang.

Materials:

Spark chamber (plastic jug or bottle with screws drilled into it)

Stopper to fit the top of the container

2-3 mL ethanol[‡]

Tesla coil*

Watch glass

Matches

*Shared item: Located in drawer opposite the chemical storage cabinets.

‡Ethanol is located in the flammables cabinet

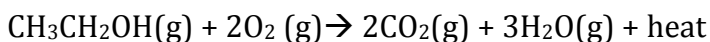
Procedure:

1. Pour 2-3 mL of ethanol into the reaction chamber.
2. Add the stopper and allow the ethanol to evaporate.
3. Turn on the Tesla coil and touch it to one of the screw head electrodes.
4. A spark will jump across to the opposite screw, detonating the mixture of ethanol vapor and air.

By comparison, pour a few milliliters of ethanol into a watch glass and light with a match.

Discussion:

The combustion reaction of ethanol with the O₂ in the air is given below:



Why does the ethanol in the bottle explode while the ethanol in the watch glass simply burns?

In the bottle the ethanol is completely vaporized creating a high surface area. The vapor is mixed with oxygen in the air to produce an explosive mixture. Furthermore, this mixture is contained in a plastic bottle. When the mixture is ignited it rapidly combusts producing a large amount of heat and pressure in a confined space. This pressure pops the stopper off of the bottle and produces a loud bang.

In the watch glass, most of the ethanol is still a liquid. Only the vapors above the liquid are reacting with the oxygen to produce a flame, thus there isn't the high surface area. Also the vapors in the watch glass are open to the air and not confined

as with the bottle demo, so that there is no rapid increase in pressure and no explosion.

Safety: Since the Tesla coil requires high voltage, care should be exercised to avoid shocks. After using the Tesla coil, turn down the power and unplug. If left on, the Tesla coil can become hot and the risk of burns exists. Ethanol is extremely flammable (as the demo proves) so keep away from ignition sources, have a fire extinguisher in the vicinity of the demo, and perform the demos away from combustible materials.

Disposal: None

References:

1. B.Z. Shakhashiri; *Chemical Demonstrations: A Handbook for Teachers of Chemistry*; Wisconsin; 1985; Volume 2; p. 216-219