



Environmental and Safety Concerns

Definitions:

Autoignition temperature (AIT): The autoignition temperature of a substance is the temperature at or above which a material will spontaneously ignite without an external spark or flame [12].

Lower flammability limit (LFL): This is the mixture of substance and air that lack sufficient fuel(substance) to burn [13]. This value is also known as lower explosive limit (LEL).

Upper flammability limit (UFL): This is the mixture of substance and air that is too rich in fuel to burn [13]. This value is also known as upper explosive limit (UEL).

Methanol CH₃OH:

Methanol gas is used as the feed for the olefin reaction and is a product from the splitter. Methanol is highly flammable as a liquid and vapor. It is toxic if swallowed, get into contact with skin. Methanol is also toxic if inhaled and can cause damage to organs. The gas waste produced in this olefin plant includes the methanol that is not able to be separated from the water and carbon dioxide. Methanol is considered to be extremely toxic if released to the environment. The unused methanol mixture needs to be prevented from reaching any drains, sewers, or waterways. The unreacted methanol mixture can form explosive mixtures with air where the vapor could travel to a source of ignition and flash back. The containers used to store the methanol may explode if it is heated. To avoid explosion, remove all sources of ignition. For safe storage, make sure to store the methanol mixture in a cool location and provide ventilation for the containers [1]. The AIT for methanol is 470 degrees celsius. The LFL is 6.7% and UFL is 36% by volume of air [10].

Water H₂O: Water is not classified as a hazardous chemical. However, there is a mixture stream of unreacted methanol and water that is sent for quenching. This is for the purpose of treating the water to purify it before recycling.

Ethane C₂H₆: Ethane is a part of the methanol mixture used in the feed for the reactor. The ethane mixture is sent to a distillation tower where the ethane is separated from the desired light olefin product ethylene. Ethane is an extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. For preventative measures, containers that are used to hold the ethane by-product will be equipped with pressure relief devices. Eye and skin contact with rapidly expanding gas may cause burns or frostbite. All of the piped systems and associated equipment must be grounded. Use a back flow preventative device in the piping to avoid unwanted reactions with other olefin by-products. To prevent explosion, remove all sources of ignition. If released to the environment, vapours may travel and accumulate in low-lying areas. For precaution, dispose the contents of ethane according to OSHA regulations. For transportation purposes make sure there is adequate ventilation and everything is sealed properly. The AIT for ethane is 515 degrees celsius.

The LFL is 3% and UFL is 12.4% by volume of air [10].

Propane C₃H₈: Propane is a part of the methanol mixture used in the feed for the reactor. The propane mixture is sent to a distillation tower where the propane is separated from the desired light olefin product propylene. Propane gas is extremely flammable. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. Propane should be stored in a segregated and approved area, away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials. For precaution, do not open any valves until it is connected to the equipment prepared for use, use a back flow preventative device in the piping, and always keep container in upright position. Propane does not pose any major effect to the environment. However, precautions are still taken to avoid accidental gas releases and dispersal of spilled material and contact with soil, waterways, drains, and sewers. For storage and transportation purposes, keep propane cylinders stored upright with valve protection cap in place and firmly secured. Cylinder temperatures should not exceed 52 degrees Celsius. [2] Use process enclosures, local exhaust ventilation or other engineering controls to keep gas, vapor, or dust concentrations below the statutory limits. The engineering controls also need to keep the gas vapor or dust concentrations below lower explosive limits. The AIT of propane is 455 degrees Celsius [8]. The LFL is 2.1% and UFL is 10.1% by volume of air [10].

Ethylene C₂H₄: Ethylene is a part of the methanol mixture used in the feed for the reactor. The ethylene mixture is sent to a distillation tower where the ethane is separated from the desired light olefin product ethylene. Ethylene gas is highly flammable and explosive. Exposure to the gas can cause you to feel dizzy, lightheaded, and to pass out. Contact with liquid Ethylene could cause frostbite. Ethylene may cause suffocation. Excessive amounts in the air in an enclosed space will decrease the amount of oxygen. The health effects caused by exposure to Ethylene are much less serious than its fire and explosion risk. Use a back flow preventative device in the piping. For storage and transportation purposes, always keep ethylene containers in the upright position. Cylinders containing ethylene should not exceed 52 degrees Celsius. Accidental release of ethylene to the environment can pose serious fires or explosion hazards. In some cases, fume scrubbers, filters or engineering modifications to the process equipment is necessary to reduce emissions to acceptable levels. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below the statutory limits. [3] The AIT of ethylene is 450 degrees Celsius [8]. The LFL is 2.75% and UFL is 28.6% by volume of air [10].

Propylene C₃H₆: Propylene is a part of the methanol mixture used in the feed for the reactor. The propylene mixture is sent to a distillation tower where the propane is separated from the desired light olefin product propylene. This material is considered hazardous by the OSHA Hazard Communication standard. Propylene gas is highly flammable and explosive severe fire hazard. Vapor/air mixtures are explosive above flash point. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Electrostatic discharges may be generated by flow or agitation resulting in ignition or explosion. For precaution, keep away from

heat, open flames and other ignition sources. Accidental releases of propylene may pose serious fires or explosion hazards. For safe handling, contain the gas under pressure and use only with adequate ventilation. Within the process, close each valve after use and also when it is empty. Use a suitable hand truck for cylinder movement. Emissions from the ventilation or work process equipment should be checked to make sure they follow the requirements of environmental protection legislation. Propylene cylinders should be stored upright with the valve protection cap in place. The AIT of propylene is 458 degrees Celsius. The LFL is 2.0% and UFL is 11.1% by volume of air [10].

Butene C₄H₈: Butene is a part of the methanol mixture used in the feed for the reactor. The butene mixture is sent to a distillation tower where the heavier hydrocarbons including butene, C₄, and C₅ are separated from the desired light olefin products propylene and ethylene. Butene is an extremely flammable gas. If it is heated it may explode as well as cause drowsiness or dizziness. Butene may also displace oxygen, cause rapid suffocation, and form explosive mixtures with air. For precaution, eliminate all sources of ignition, use a device that prevents back flow from occurring inside the piping, and protect this chemical from sunlight when ambient temperatures exceed 52 degrees Celsius. Use an explosive-proof local exhaust system. Local exhaust and general ventilation must be adequate to meet exposure standards. Prevent the waste from contaminating the surrounding environment, and contributing to soil and water pollution. Dispose the contents of the butene mixture in accordance with the regional regulations. [4]. The AIT of butene is 465 degrees Celsius [8]. The LFL is 1.8% and UFL is 9.0% by volume of air [10].

Dimethyl ether CH₃OCH₃: Dimethyl ether is generally a by-product of the MTO process. However, due to the reactions found in the literature, this by-product will not be considered within this reaction. Dimethyl ether is an extremely flammable gas. Since it contains gas under pressure, it may explode if it is heated. It can also cause drowsiness, dizziness, and harmful if swallowed. Dimethyl ether may displace oxygen and cause rapid suffocation. It may form explosive mixtures with air as well as cause frostbite. The thermal decomposition can lead to the release of irritating gases and vapors. This in turn can cause the formation of vapors in an explosive mixture with air causing the vapors to flash back. For precaution, store dimethyl ether in a cool location away from hot surfaces and sources of ignition. Provide exhaust ventilation to keep the airborne concentrations of vapor and mists below the applicable workplace exposure limits. Dimethyl ether should not be released into the environment. It must be prevented from reaching drains, sewer, or waterways. After removal of the dimethyl ether, the containers used to store it must have adequate ventilation and must be tightly sealed. [5] The AIT of dimethyl ether is 350 degrees Celsius [9]. The LFL is 2% and UFL is 50% by volume of air [11].

Methane CH₄: The primary methane mixture is sent to a heat reactor for the formation of olefins. This mixture is then sent a series of a distillation columns to remove the unreacted

methane from the desired light olefins ethylene and propylene. Methane is highly flammable and explosive. When involved in a fire, this gas will ignite and produce toxic gases including carbon monoxide and carbon dioxide. Extinguish fires of this gas by shutting off the source of the gas. Vapors may travel to a source of ignition and flash back. Contact with cryogenic liquid or rapidly expanding gases (which are released under high pressure) may cause frostbite. Very high levels of methane can decrease the amount of oxygen in the air and cause suffocation with symptoms of headaches, dizziness, and weakness. For precaution, metal containers involving the transfer of methane should be grounded and bonded. There must be maintained amount of 19.5% oxygen content. The methane containers must be stored in a well-ventilated place away from sunlight. The generation of methane waste must be avoided or minimized as much as possible. Methane waste should not be disposed of or untreated to the sewer unless it fully complies with the requirements of all authorities with jurisdiction as well as the emissions from ventilation or work process equipment. [6] The AIT for methane is 580 degrees Celsius [8]. The LFL is 4.4% and UFL is 16.4% by volume of air [10].

Butane C₄H₁₀: Butane is a part of the methanol mixture used in the feed for the reactor. The butane mixture is sent to a distillation tower where butane is separated from the desired light olefin products propylene and ethylene. Butane is an extremely flammable gas. It can explode if it is heated because it contains gas under pressure. It can also displace oxygen and cause rapid suffocation. Butane may also form explosive mixtures with air and may cause frostbite. Butane should not be released into the environment. Accidental releases pose a serious fire or explosion hazard. For preventative measures, contain gas under pressure and use only with adequate ventilation. Close the valve after each use and also when empty. Eliminate all ignition sources and cylinder temperatures should not exceed 52 degrees Celsius. The engineering controls also need to keep the gas, vapor, or dust concentrations below lower explosive limits. Emissions from ventilation or work process equipment should be checked to make sure they follow the requirements of the environmental protection legislation. [7] The AIT for butane is 405 degrees Celsius [8]. The LFL is 1.86% and UFL is 8.41% by volume of air [10].

Pentane C₅H₁₂: Pentane is a part of the methanol mixture used in the feed for the reactor. The pentane mixture is sent to a distillation tower it is separated from the desired light olefin products propylene and ethylene. Pentane is a highly flammable liquid and vapor. It may be fatal if it enters airways or swallows. It can also cause drowsiness or dizziness. Pentane is toxic to aquatic life with long lasting effects so it must be disposed of in an approved waste disposal plant. It is environmentally damaging particularly to the aquatic environment with long lasting effects. For preventative measures, ground and bond the container as well as the receiving equipment. Keep the pentane away from heat and ignition sources. Store in a well-ventilated place and keep cool. With its toxic effects towards the aquatic environment, effort must be taken towards containing any accidental releases from reaching drains, sewers, or waterways. Provide exhaust ventilation to keep airborne concentration of the pentane vapor and mists below the applicable workplace exposure limits. The AIT for pentane is 260 degrees Celsius [8]. The LFL is 1.4% and UFL is 7.8% by volume of air [10].

Hydrogen H₂: Within this MTO process, some traces of hydrogen gas are released. For simplification purposes, an assumption has been made to disregard the small traces of hydrogen gas. Hydrogen is an odorless, colorless, flammable gas. The primary concern for this main health hazard is asphyxiation as a result of a release of hydrogen gas. The liquified gas of hydrogen can also cause frostbite to contaminated issues. Hydrogen can also pose a serious fire hazard if released. Storage for hydrogen must be handled in a temperature controlled environment. Failure of temperature control and adequate ventilation can cause the storage tank to rupture without activating the cylinder's relief devices. For emergency response situations, adequate fire protection must be provided [10].

Carbon Dioxide: Carbon dioxide is a part of greenhouse gas and can cause global warming. OSHA has the limitation of 5000 ppm per 8 hours. there are two places in our plant from where CO₂ emission takes place. One from the overhead of demethanizer and other from the regeneration chamber. The emission of CO₂ from demethanizer is negligible since these are present in traces and also because they will be sent to hydro processing industry for fueling use after processing. The emission of CO₂ from regeneration chamber is about 206 mt/day which is within the OSHA limits and hence making our plant environmentally feasible.