Ran Vijay Smarak Mahavidyalaya, Sector – 12/D, Bokaro
Semester - VI
Chemistry (DSE - IV)

INDUSTRIAL CHEMICALS & ENVIROMENT-

1. INDUSTRIAL GASES & INORGANIC CHEMICALS

ACETYLENE:-

Natural occurrence

Acetylene is a moderately common chemical in the universe, often associated with the atmospheres of gas giants. One curious discovery of acetylene is on Enceladus, a moon of Saturn. Natural acetylene is believed to form from catalytic decomposition of long-chain hydrocarbons at temperatures of 1,700 K (1,430 °C; 2,600 °F) and above. Since such temperatures are highly unlikely on such a small distant body, this discovery is potentially suggestive of catalytic reactions.

The energy richness of the C≡C triple bond and the rather high solubility of acetylene in water make it a suitable substrate for bacteria, provided an adequate source is available-. A number of bacteria living on acetylene have been identified. The enzyme acetylene hydratase catalyzes the hydration of acetylene to give acetaldehyde:

$$C_2H_2 + H_2O \rightarrow CH_3CHO$$

Preparation

Acetylene has mainly been manufactured by the partial combustion of methane.[6][14][15] It is a recovered side product in production of ethylene by cracking of hydrocarbons. Approximately 400,000 tonnes were produced by this method in 1983. Its presence in ethylene is usually undesirable because of its explosive character and its ability to poison Ziegler–Natta catalysts. It is selectively hydrogenated into ethylene, usually using Pd–Ag catalysts.

Until the 1950s, when oil supplanted coal as the chief source of reduced carbon, acetylene (and the aromatic fraction from coal tar) was the main source of organic chemicals in the chemical industry. It was prepared by the hydrolysis of calcium

carbide, a reaction discovered by Friedrich Wöhler in 1862 and still familiar to students:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

Calcium carbide production requires extremely high temperatures, ~2000 °C, necessitating the use of an electric arc furnace. In the US, this process was an important part of the late-19th century revolution in chemistry enabled by the massive hydroelectric power project at Niagara Falls.

Applications

Approximately 20% of acetylene is supplied by the industrial gases industry for oxyacetylene gas welding and cutting due to the high temperature of the flame. Combustion of acetylene with oxygen produces a flame of over 3,600 K (3,330 °C; 6,020 °F), releasing 11.8 kJ/g. Oxyacetylene is the hottest burning common fuel gas. Acetylene is the third-hottest natural chemical flame after dicyanoacetylene's 5,260 K (4,990 °C; 9,010 °F) and cyanogen at 4,798 K (4,525 °C; 8,177 °F). Oxy-acetylene welding was a popular welding process in previous decades.

Hazards

Acetylene is not especially toxic, but when generated from calcium carbide, it can contain toxic impurities such as traces of phosphine and arsine, which give it a distinct garlic-like smell. It is also highly flammable, as are most light hydrocarbons, hence its use in welding. Its most singular hazard is associated with its intrinsic instability, especially when it is pressurized: under certain conditions acetylene can react in an exothermic addition-type reaction to form a number of products, typically benzene and/or vinylacetylene, possibly in addition to carbon and hydrogen. Consequently, acetylene, if initiated by intense heat or a shockwave, can decompose explosively if the absolute pressure of the gas exceeds about 200 kilopascals (29 psi). Most regulators and pressure gauges on equipment report gauge pressure, and the safe limit for acetylene therefore is 101 kPa, or 15 psig. It is therefore supplied and stored dissolved in acetone or dimethylformamide (DMF), contained in a gas cylinder with a porous filling (Agamassan), which renders it safe to transport and use, given proper handling. Acetylene cylinders should be used in the upright position to avoid withdrawing acetone during use.

CARBON MONOXIDE :-

Carbon monoxide (**CO**) is a colorless, odorless, and tasteless flammable gas that is slightly less dense than air. It is toxic to animals that use hemoglobin as an oxygen carrier (both invertebrate and vertebrate) when encountered in concentrations above about 35 ppm, although it is also produced in normal animal metabolism in low quantities, and is thought to have some normal biological functions. In the atmosphere, it is spatially variable and short-lived, having a role in the formation of ground-level ozone.

Carbon monoxide consists of one carbon atom and one oxygen atom, connected by a triple bond that consists of a net two pi bonds and one sigma bond. It is the simplest oxocarbon and is isoelectronic with other triply-bonded diatomic species possessing 10 valence electrons, including the cyanide anion, the nitrosonium cation, boron monofluoride and molecular nitrogen. In coordination complexes the carbon monoxide ligand is called carbonyl.

Production

Industrial production

A major industrial source of CO is producer gas, a mixture containing mostly carbon monoxide and nitrogen, formed by combustion of carbon in air at high temperature when there is an excess of carbon. In an oven, air is passed through a bed of coke. The initially produced CO_2 equilibrates with the remaining hot carbon to give CO. The reaction of CO_2 with carbon to give CO is described as the Boudouard reaction. Above 800 °C, CO is the predominant product:

$$CO_2 + C \rightarrow 2\ CO\ (\Delta H = 170\ kJ/mol)$$

Another source is "water gas", a mixture of hydrogen and carbon monoxide produced via the endothermic reaction of steam and carbon:

$$H_2O + C \rightarrow H_2 + CO\ (\Delta H = +131\ kJ/mol)$$

Other similar "synthesis gases" can be obtained from natural gas and other fuels.

Carbon monoxide can also be produced by high-temperature electrolysis of carbon dioxide with solid oxide electrolyzer cells: One method, developed at DTU Energy uses a cerium oxide catalyst and does not have any issues of fouling of the catalyst

$$2\ CO_2 \rightarrow 2\ CO + O_2$$

Carbon monoxide is also a byproduct of the reduction of metal oxide ores with carbon, shown in a simplified form as follows:

$$MO + C \rightarrow M + CO$$

Carbon monoxide is also produced by the direct oxidation of carbon in a limited supply of oxygen or air.

$$2\ C(s) + O_2 \rightarrow 2\ CO(g)$$

Since CO is a gas, the reduction process can be driven by heating, exploiting the positive (favorable) entropy of reaction. The Ellingham diagram shows that CO formation is favored over CO_2 in high temperatures.

Uses

Chemical industry

Carbon monoxide is an industrial gas that has many applications in bulk chemicals manufacturing.Large quantities of aldehydes are produced by the hydroformylation reaction of alkenes, carbon monoxide, and H_2. Hydroformylation is coupled to the Shell higher olefin process to give precursors to detergents.

Phosgene, useful for preparing isocyanates, polycarbonates, and polyurethanes, is produced by passing purified carbon monoxide and chlorine gas through a bed of porous activated carbon, which serves as a catalyst. World production of this compound was estimated to be 2.74 million tonnes in 1989.

$$CO + Cl_2 \rightarrow COCl_2$$

Methanol is produced by the hydrogenation of carbon monoxide. In a related reaction, the hydrogenation of carbon monoxide is coupled to C-C bond formation, as in the Fischer-Tropsch process where carbon monoxide is hydrogenated to liquid hydrocarbon fuels. This technology allows coal or biomass to be converted to diesel.

Meat coloring

Carbon monoxide is used in modified atmosphere packaging systems in the US, mainly with fresh meat products such as beef, pork, and fish to keep them looking fresh. The carbon monoxide combines with myoglobin to form carboxymyoglobin, a bright-cherry-red pigment. Carboxymyoglobin is more stable than the oxygenated form of myoglobin, oxymyoglobin, which can become oxidized to the brown pigment metmyoglobin.

Medicine

In biology, carbon monoxide is naturally produced by the action of heme oxygenase 1 and 2 on the heme from hemoglobin breakdown. This process produces a certain amount of carboxyhemoglobin in normal persons, even if they do not breathe any carbon monoxide.

Hazards

It is the most common type of fatal air poisoning in many countries. Carbon monoxide is colorless, odorless, and tasteless, but highly toxic. It combines with hemoglobin to produce carboxyhemoglobin, by binding to the site in hemoglobin that normally carries oxygen, leaving it ineffective for delivering oxygen to bodily tissues. Concentrations as low as 667 ppm may cause up to 50% of the body's hemoglobin to convert to carboxyhemoglobin. A level of 50% carboxyhemoglobin may result in seizure, coma, and fatality.

The most common symptoms of carbon monoxide poisoning may resemble other types of poisonings and infections, including symptoms such as headache, nausea, vomiting, dizziness, fatigue, and a feeling of weakness. Affected families often believe they are victims of food poisoning. Infants may be irritable and feed poorly. Neurological signs include confusion, disorientation, visual disturbance, syncope (fainting), and seizures.