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A Study on the Properties of Carbon and Its Usage

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Abstract – Carbon is a naturally abundant non-metallic element that occurs in many inorganic and in all organic compounds, exists freely as graphite and diamond. One of the hardest substances known to man (diamonds). The Physical and Chemical Properties are the characteristics of a substance, like Carbon, which distinguishes it from any other substance. Most common substances, like Carbon, exist as States of Matter as solids, liquids, gases and plasma.

Physical properties of Carbon are the characteristics that can be observed without changing the substance into another substance. Physical properties are usually those that can be observed using our senses such as color, luster, freezing point, boiling point, melting point, density, hardness and odor.

Keywords: Properties, Carbon, Industries

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INTRODUCTION

Since prehistoric days, humans have been aware of the presence of carbon. When the cave people made a fire, they saw the formation of smoke. The black smoke color is indicatives of carbon particles from unburned materials.

Later, oil was used as a fuel for lamps. The burning of oil resulted in the release of carbon, which formed a sooty covering on the lamp interior. This sooty covering came to be known as lampblack. Lampblack was mixed with balsam gum or olive oil to make ink.

Charcoal is the most common form of carbon. Wood when heated in the absence of air, in particular oxygen, results in the formation of charcoal. The French Physicist René Antoine Ferchault Reaumur, realized that carbon may be an element and published work to this effect in 1722. The official classification of carbon happened during the end of the 18th century. It was initially named Carbone based on the previous Latin term for charcoal, charbon.

Carbon is unique in its chemical properties because it forms a number of components superior than the total addition of all the other elements in combination with each other.

The biggest group of all these components is the one formed by carbon and hydrogen. We know a minimum of about 1 million organic components and this number increases rapidly every year. Although the classification is not strict, carbon forms another series of compounds considered as inorganic, in a much lower number than that of the organic compounds.

Elemental carbon exists in two well-defined allotropic crystalline forms: diamond and graphite. Other forms with little crystallinity are vegetal carbon and black fume. Chemically pure carbon can be prepared by termic decomposition of sugar (sucrose) in absence of air. The physical and chemical properties of carbon depend on the crystalline structure of the element.

Its density fluctuates from 2.25 g/cm³ (1.30 ounces/in³) for graphite and 3.51 g/cm³ (2.03 ounces/in³) for diamond. The melting point of graphite is 3500ºC (6332ºF) and the extrapolated boiling point is 4830ºC (8726ºF). Elemental carbon is an inert substance, insoluble in water, diluted acids and bases, as well as organic solvents. At high temperatures it binds with oxygen to form carbon monoxide or dioxide. With hot oxidizing agents, like nitric acid and potassium nitrate, metilic acid $C_6(CO_2H)_6$ is obtained. Among the halogens only fluorine reacts with elemental carbon. A high number of metals combine with the element at high temperatures to form carbides.

It forms three gaseous components with the oxygen: carbon monoxide, CO, carbon dioxide, CO2, and carbon suboxide, C3O2. The two first ones are the most important from the industrial

point of view. Carbon forms compounds with the halogens with CX4 as general formula, where X is fluorine, chlorine, bromine or iodine. At ambient temperature carbon tetrafluoride is gas, tetrachloride is liquid and the other two compounds are solids. We also know mixed carbon tetrahalides. The most important of all may be the dichlorodifluoromethane, CCl2F2, called freon.

PROPERTIES OF CARBON AND ITS USAGE

Carbon and its components are widely distributed in nature. The estimation is that carbon forms 0,032% of The Earth's crust. Free carbon is found in big reservoirs like hard coal, amorphous form of the element with other complex compounds of carbon-hydrogen-nitrogen. Pure crystalline carbon is found in the form of graphite and diamond.

The Earth's atmosphere contains an ever-increasing concentration of carbon dioxide and carbon monoxide, form fossil fuel burning, and of methane (CH4), form paddy fields and cows.

No element is more essential to life than carbon, because only carbon forms strong single bonds to itself that are stable enough to resist chemical attack under ambient conditions. This give carbon the ability to form long chains and rings of atoms, which are the structural basis for many compounds that comprise the living cell, of which the most important is DNA.

Big quantities of carbon are found in the form of compounds. Carbon is present in the atmosphere as carbon dioxide in 0,03% in volume. Several minerals, like limestone, dolomite, gypsum and marble, contain carbonates. All the plants and live animals are formed by complex organic compounds where carbon is combined with hydrogen, oxygen, nitrogen and other elements. The remains of live plants and animals form deposits: of petroleum, asphalt and bitumen. The natural gas deposits contain compounds formed by carbon and hydrogen.

The free element has a lot of uses, including decoration purposes of diamonds in jewelry or black fume pigment in automobile's rims and printer's ink. Another carbon form, the graphite, is used for high temperature crucibles, dry cell and light arch electrodes, for pencil tips and as a lubricant. Vegetal carbon, an amorphous form of carbon, is used as gas absorbent and bleaching agent.

Carbon compounds have plenty of uses. Carbon dioxide is used in drinks carbonatation, in fire extinguishers and, in solid state, as a cooler (dry ice). Carbon monoxide is used as reduction agent in many metallurgic processes. Carbon tetrachloride and carbon disulphide are important industrial solvents. Freon is used in cooling systems. Calcium carbide is used to prepare acetylene; it's used for welding and cutting metals, as well as for preparation of other organic compounds. Other metallic carbides have important uses as heat-resistants and metal cutters.

Elemental carbon is of very low toxicity. Health hazard data presented here is based on exposures to carbon black, not elemental carbon. Chronic inhalation exposure to carbon black may result in temporary or permanent damage to lungs and heart.

Pneumoconiosis has been found in workers engaged in the production of carbon black. Skin conditions such as inflammation of the hair follicles, and oral mucosal lesions have also been reported from skin exposure.

Carcinogenicity- Carbon black has been listed by the International Agency for Research on Cancer (IARC) within Group 3 (The agent is not classifiable as to its carcinogenicity to humans).

Some simple carbon compound can be very toxic, such as carbon monoxide (CO) or cyanide (CN-).

Carbon 14 is one of the radionuclides involved in atmospheric testing of nuclear weapons, which began in 1945, with a US test, and ended in 1980 with a Chinese test. It is among the long-lived radionuclides that have produced and will continue to produce increased cancers risk for decades and centuries to come. It also can cross the placenta, become organically bound in developing cells and hence endanger fetuses.

Most we eat is made up of compounds of carbon, giving a total carbon intake og 300 g/day. Digestion consist of breaking these compounds down into molecules than can be adsorbed to the wall of the stomach or intestine. There they are trasported by the blood to sites where they are utilized or oxidized to release the energy they contain.

Carbon has several allotropes, or different forms in which it exists. Interestingly, carbon allotropes span a wide range of physical properties: diamond is the hardest naturally occurring substance, and graphite is one of the softest known substances. Diamond is transparent, the ultimate abrasive, and can be an electrical insulator and thermal conductor. Conversely, graphite is opaque, a very good lubricant, a good conductor of electricity, and a thermal insulator. Allotropes of carbon are not limited to diamond and graphite, but also include buckyballs (fullerenes), amorphous carbon, glassy carbon, carbon nanofoam, nanotubes and others.

DISCUSSION

Carbon compounds form the basis of all known life on Earth, and the carbon-nitrogen cycle provides some energy produced by the sun and other stars. Carbon has an affinity for bonding with other small atoms, including other carbon atoms, via the

formation of stable, covalent bonds. Despite the fact that it is present in a vast number of compounds, carbon is weakly reactive compared to other elements under normal conditions. At standard temperature and pressure, it resists oxidation; it does not react with sulfuric acid, hydrochloric acid, chlorine, or any alkali metals. At higher temperatures, carbon will react with oxygen to give carbon oxides, and metals to give metal carbides.

Carbon has the ability to form very long chains of strong and stable interconnecting C-C bonds. This property allows carbon to form an almost infinite number of compounds; in fact, there are more known carbon-containing compounds than all the compounds of the other chemical elements combined, except those of hydrogen (because almost all organic compounds contain hydrogen as well).

Carbon has two stable, naturally occurring isotopes: carbon-12 and carbon-13. Carbon-12 makes 98.93% and carbon-13 forms the remaining 1.07%. The concentration of ^{12}C is further increased in biological materials because biochemical reactions discriminate against ^{13}C. Identification of carbon in NMR experiments is done with the isotope ^{13}C. ^{14}C is a radioactive isotope of carbon with a half-life of 5730 years. It has a very low natural abundance (0.0000000001%), and decays to ^{14}N through beta decay. It is used in radiometric dating to determine the age of carbonaceous samples (of physical or biological origin) up to about 60,000 years old.

In total, there are 15 known isotopes of carbon and the shortest-lived of these is ^{8}C, which decays through proton emission and alpha decay, and has a half-life of 1.98739×10^{-21} seconds. The exotic ^{19}C exhibits a nuclear halo, which means its radius is appreciably larger than would be expected if the nucleus were a sphere of constant density.

Carbon represents one of the most abundant chemical elements on Earth and by its mass, falls second only to oxygen. Life on Earth owes is existence to carbon, as it is the chemical basis for all living things on this planet. Because of its four valence electrons, carbon molecules bond with oxygen, hydrogen and nitrogen. Carbon also bonds with phosphorus and sulfur to form the biochemical building blocks that include fats, proteins and carbohydrates. Without carbon, humans would not exist in the form they do today.

As an allotropic biochemical element, carbon exists in multiple physical forms, even though they are chemically similar. Carbon exists as graphite, diamond or carbon residue left behind when carbon-based compounds experienced heat and pressure. Graphite, which exists in a sheet-like structure, is soft and conducts electricity. By contrast, diamond is extremely hard, does not conduct electricity and is inert. Carbon residue includes coal, charcoal and other substances that humans use for energy.

A stable carbon atom possesses six protons, six neutrons and six electrons, resulting in an atomic mass of 12.011 and sits in the sixth position on the Periodic Table of Elements. Four of its electrons are found in the outer shell of the atom, while the other two exist in the inner shell. Solid-state molecules consisting of only bonded carbon atoms form tetrahedral or hexagonal shapes, depending on the physical status of the substance.

Carbon burns in oxygen to create carbon dioxide and carbon monoxide. Carbon can also form carbides when heated with oxides. For example, calcium oxide heated with carbon forms calcium carbide and carbon monoxide. In addition, carbon compounds such as carbon monoxide act as a reducing agent to metallic oxides. For example, applying extreme heat from a source such as a furnace to ferric oxide in a carbon monoxide environment reduces the ferric oxide to iron.

Almost 18% of an individual's body weight is due to carbon. Carbon is the second most common element in the human body, the fourth most common element in the solar system, the sixth most common element in the universe and the 17th most common element in the Earth's crust. Carbon occurs in minerals such as magnesium ($MgCO_3$) and calcium carbonate ($CaCO_3$) and rarely occurs as graphite and diamond. Carbon also occurs in the form of carbon dioxide (CO_2) present in the atmosphere. Though carbon dioxide makes up only a small part of the atmosphere, it is a very crucial gas as it is used for photosynthesis. A few varieties of coal are almost pure carbon. Natural gas, coal and oil have carbon in them. Natural gas and oil are all hydrocarbons that are compounds made from hydrogen and carbon.

While allotropes of carbon such as graphite and diamond have been known for centuries other allotropes such as carbon nanotubes, graphene and buckminsterfullerene have been discovered more recently. These have played significant roles in the development of the field of nanotechnology.

In basic terms they can be described as:

- Graphene – A single sheet of carbon atoms arranged in a hexagon pattern, such that all carbon atoms are bonded to 3 other carbon atoms
- Carbon Nanotubes– A tube made from a graphene sheet (single-walled carbon nanotubes). Variations include tubes closed at one or both ends, and tubes made by rolling graphene sheets such that

they are several layers thick (multi-walled carbon nanotubes).

- Buckminsterfullerene– Sometimes called buckyballs, they normally consist of 60 carbon atoms bonded together to form a spherical structure with 20 hexagonal faces and 12 pentagonal faces.

CONCLUSION

Carbon can form chains of carbon in single, double and triple bonds with other carbon atoms. Called catenation, this process is the basis for the creation of organic compounds and the study of organic chemistry. Although other elements such as silicon or germanium are capable of limited catenation, carbon can also form chains of unlimited size. In addition, only carbon can catenate double and triple bonds whereas other elements can only form single bonds.

Carbon is absolutely essential for life and almost every molecule in a living organism contains carbon. Carbon also has a few ill effects on living organisms. Black lung, for instance is a disease developed in coal miners. The miner's lung develops a black color that is caused when coal dust is inhaled by the miner. This coal dust blocks the small holes through which oxygen enters the lungs resulting in breathing difficulty that can in the worst instance result in death.

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