ANALYSIS OF MATERIALS

1. MATERIALS I

1.1. Raw Materials

A raw material or feedstock is basic material used in the production of goods, finished products or intermediate materials that are themselves feedstock for finished products. As feedstock, the term connotes a bottleneck asset critical to the production of other products. For example, crude oil is a feedstock raw material providing finished products in the fuel, plastic, industrial chemical and pharmaceutical industries. The term "raw material" is used to denote material is in an unprocessed or minimally processed state; e.g., raw latex, coal, iron ore, logs, crude oil, air or seawater. The use of raw material by non-human species includes twigs and found objects as used by birds to make nests.

A material or substance used in the primary production or manufacturing of a good. Raw materials are often natural resources such as oil, iron and wood. Before being used in the manufacturing process raw materials often are altered to be used in different processes. Raw materials are often referred to as commodities, which are bought and sold on commodities exchanges around the world. Raw materials are sold in what is called the factor market. This is because raw materials are factors of production along with labor and capital. Raw materials are so important to the production process that the success of a country's economy can be determined by the amount of natural resources the country has within its own borders. A country that has abundant natural resources does not need to import as many raw materials, and has an opportunity to export the materials to other countries. Usually, raw materials are natural resources for example oil, iron and wood are all common raw materials used in the production of goods and products. Often, raw materials are altered in some way before being used in the manufacturing process.

There are two subcategories of raw materials: direct materials and indirect materials. Direct raw materials are those which will be directly incorporated into the final product, e.g. the wood used to build a table. Indirect materials on the other hand are those which are consumed during the production process, e.g. the lubricant, rags, light bulbs, etc. which are used in manufacturing facilities.

1.2. Pure Materials

In chemistry, a chemical substance is a form of matter that has constant chemical composition and characteristic properties. It cannot be separated into components by physical separation methods, i.e. without breaking chemical bonds. It can be solid, liquid, gas, or plasma.

Chemical substances are often called 'pure' to set them apart from mixtures. A common example of a chemical substance is pure water; it has the same properties and the same ratio of hydrogen to oxygen whether it is isolated from a river or made in a laboratory. Other chemical substances commonly encountered in pure form are diamond (carbon), gold, table salt (sodium chloride) and refined sugar (sucrose). However, simple or seemingly pure substances found in nature can in fact be mixtures of chemical substances. For example, tap water may contain small amounts of dissolved sodium chloride and compounds containing iron, calcium and many other chemical substances. Chemical substances exist as solids, liquids, gases or plasma, and may change between these phases of matter with changes in temperature or pressure. Chemical reactions convert one chemical substance into another.

Forms of energy, such as light and heat, are not considered to be matter, and thus they are not substances in this regard. Chemical substances (also called pure substances) may well be defined as any material with a definite chemical composition in an introductory general chemistry textbook. According to this definition a chemical substance can either be a pure chemical element or a pure chemical compound. But, there are exceptions to this definition. A pure substance can also be defined as a form of matter that has both definite composition and distinct properties. The chemical substance index published by CAS also includes several alloys of uncertain composition. Non-stoichiometric compounds are a special case (in inorganic chemistry) that violates the law of constant composition, and for them, it is sometimes difficult to draw the line between a mixture and a compound, as in the case of palladium hydride. Broader definitions of chemicals or chemical substances can be found, for example, the term chemical substance means any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature.

In geology, substances of uniform composition are called minerals, while physical mixtures (aggregates) of several minerals (different substances) are defined as rocks. Many minerals, however, mutually dissolve into solid solutions, such that a single rock is a uniform substance despite being a mixture in stoichiometric terms. Feldspars are a common example: anorthoclase is an alkali aluminium silicate, where the alkali metal is interchangeably either sodium or potassium.

1.3. Ferrous and Non-Ferrous Alloys

Ferrous (Fe^{2+}), in chemistry, indicates a divalent iron compound (+2 oxidation state), as opposed to ferric, which indicates a trivalent iron compound (+3 oxidation state). This usage has mostly been deprecated, with current IUPAC nomenclature having names containing the oxidation state in bracketed Roman numerals instead, such as iron(II) oxide for ferrous oxide (FeO), and iron(III) oxide for ferric oxide (Fe_2O_3). Outside chemistry, ferrous is an adjective used to indicate the presence of iron. The word is derived from the Latin word ferrum ("iron"). Ferrous metals include steel and pig iron (with a carbon content of a few percent) and alloys of iron with other metals (such as stainless steel). Manipulation of atom-to-atom relationships between iron, carbon, and various alloying elements establishes the specific properties of ferrous metals.

The term non-ferrous is used to indicate metals other than iron and alloys that do not contain an appreciable amount of iron. In metallurgy, a non-ferrous metal is any metal, including alloys, that does not contain iron in appreciable amounts. Generally more expensive than ferrous metals, non-ferrous metals are used because of desirable properties such as low weight (e.g., aluminium), higher conductivity (e.g., copper), non-magnetic property or resistance to corrosion (e.g., zinc). Some non-ferrous materials are also used in the iron and steel industries. For example, bauxite is used as flux for blast furnaces, while others such as wolframite, pyrolusite and chromite are used in making ferrous alloys.

Important non-ferrous metals include aluminium, copper, lead, nickel, tin, titanium and zinc, and alloys such as brass. Precious metals such as gold, silver and platinum and exotic or rare metals such as cobalt, mercury, tungsten, beryllium, bismuth, cerium, cadmium, niobium, indium, gallium, germanium, lithium, selenium, tantalum, tellurium, vanadium, and zirconium are also non-ferrous. They are usually obtained through minerals such as sulfides, carbonates, and silicates. Non-ferrous metals are usually refined through electrolysis. Non-ferrous metals were the first metals used by humans for metallurgy. Gold, silver and copper existed in their native crystalline yet metallic form. These crystals, though rare, are enough to attract the attention of humans. Less susceptible to oxygen than most other metals, they can be found even in weathered outcroppings. Copper was the first metal to be forged; it was soft enough to be fashioned into various objects by cold forging, and it could be melted in a crucible. Gold, silver and copper replaced some of the functions of other resources, such as wood and stone, owing to their ability to be shaped into various forms for different uses. Due to their rarity, these gold, silver and copper artifacts were treated as luxury items and handled with great care. The use of copper also heralded the transition from the Stone Age to the Copper Age. The Bronze Age, which succeeded the Copper Age, was again heralded by the invention of bronze, an alloy of copper with the non-ferrous metal tin.

1.4. Organic and Inorganic Materials

All materials are categorized as either organic or inorganic. Organic materials are made from (or extracted from) plants or animals. Inorganic materials are made from rocks and minerals.

An organic compound is any member of a large class of gaseous, liquid, or solid chemical compounds whose molecules contain carbon. For historical reasons discussed below, a few types of carbon-containing compounds such as carbides, carbonates, simple oxides of carbon (such as CO and CO_2), and cyanides are considered inorganic. The distinction between organic and inorganic carbon compounds, while useful in organizing the vast subject of chemistry is somewhat arbitrary. Organic chemistry is the science concerned with all aspects of organic compounds. Organic synthesis is the methodology of their preparation. Organic materials include wood, paper, textiles, and animal parts (ivory, bone, leather). They also include some natural materials that are not obviously organic (such as coal and fuel oil, which are derived from fossilized plants and animals) and some synthetic materials (such as plastics, which are made from chemicals extracted from plant and animal products). All organic materials deteriorate over time. The word organic is historical, dating to the 1st century. For many centuries, Western alchemists believed in vitalism. This is the theory that certain compounds could be synthesized only from their classical elements earth, water, air, and fire by the action of a life-force (vis vitalis) that only organisms possessed. Vitalism taught that these organic compounds were fundamentally different from the inorganic compounds that could be obtained from the elements by chemical manipulation.

Inorganic materials include stone, metal, ceramic, and glass, which are all made from rocks or minerals. Some inorganic materials are found in paper-based formats: photographs contain metallic particles; some pigments and inks contain minerals, metals, or metallic oxides; and metal particles are sometimes found in paper itself. Inorganic materials are generally stable individually, but they can react with other materials to cause deterioration. Some metals (particularly iron, copper, and platinum) react with the cellulose in paper. Like organic materials, inorganic materials can be natural or synthetic (e.g., some pigments occur naturally as minerals but can also be manufactured from other inorganic materials).

An inorganic compound is a compound that is not considered organic. Inorganic compounds are traditionally viewed as being synthesized by the agency of geological systems. In contrast, organic compounds are found in biological systems. Organic chemists traditionally refer to any molecule containing carbon as an organic compound and by default this means that inorganic chemistry deals with molecules lacking carbon. The 19th century chemist, Berzelius, described inorganic compounds as inanimate, not biological, origin, although many minerals are of biological origin. Biologists may distinguish organic from inorganic compounds in a different way that does not hinge on the presence of a carbon atom. Pools of organic matter, for example, that have been metabolically incorporated into living tissues persist in decomposing tissues, but as molecules become oxidized into the open environment, such as atmospheric CO_2, this creates a separate pool of inorganic compounds. The distinction between inorganic and organic compounds is not always clear. Some scientists, for example, view the open environment (i.e., the ecosphere) as an extension of life and from this perspective may consider atmospheric CO_2 as an organic compound. The International Union of Pure and Applied Chemistry, an agency widely recognized for defining chemical terms, does not offer definitions of inorganic or organic. Hence, the definition for an inorganic versus an organic compound in a multidisciplinary context spans the division between living (or animate) and non-living (or inanimate) matter and remains open to debate according to the way that one views the world.

1.5. Ceramic Materials

Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non-metal. Ceramic materials may be crystalline or partly crystalline. They are formed by the action of heat and subsequent cooling. Clay was one of the earliest materials used to produce ceramics, as pottery, but many different ceramic materials are now used in domestic, industrial and building products. Ceramic materials tend to be strong, stiff, brittle, chemically inert, and non-conductors of heat and electricity, but their properties vary widely. For example, porcelain is widely used to make electrical insulators, but some ceramic compounds are superconductors.

A ceramic material may be defined as any inorganic crystalline material, compounded of a metal and a non-metal. It is solid and inert. Ceramic materials are brittle, hard, strong in compression, weak in shearing and tension. They withstand chemical erosion that occurs in an acidic or caustic environment. In many cases withstanding erosion from the acid and bases applied to it. Ceramics generally can withstand very high temperatures such as temperatures that range from 1,000 °C to 1,600 °C (1,800 °F to 3,000 °F). Exceptions include inorganic materials that do not have oxygen such as silicon carbide. Glass by definition is not a ceramic because it is an amorphous solid (non-crystalline). However, glass involves several steps of the ceramic process and its mechanical properties behave similarly to ceramic materials.

Traditional ceramic raw materials include clay minerals such as kaolinite, more recent materials include aluminium oxide, more commonly known as alumina. The modern ceramic materials, which are classified as advanced ceramics, include silicon carbide and tungsten carbide. Both are valued for their abrasion resistance, and hence find use in corrosive environments such as the wear plates of crushing equipment in mining operations where other ceramic materials would not be suitable. Advanced ceramics are also used in the medicine, electrical, and aerospace industries. The physical properties of any ceramic substance are a direct result of its crystalline structure and chemical composition. Solid state chemistry reveals the fundamental connection between microstructure and properties such as localized density variations, grain size distribution, type of porosity and second-phase content, which can all be correlated with ceramic properties such as mechanical strength σ by the Hall-Petch equation, hardness, toughness, dielectric constant, and the optical properties exhibited by transparent materials. Physical properties of chemical compounds which provide evidence of chemical composition include odor, color, volume, density (mass / volume), melting point, boiling point, heat capacity, physical form at room temperature (solid, liquid or gas), hardness, porosity, and index of refraction.