الدكتور المهندس أحمد علي نور الدين

Copper, Our Eternal Metal Friend

Copper has been one of the most influential metal ever since its discovery few thousand years ago. It was a star item for making cookware, weaponry, ornaments, and coins. Later, the invention of electricity saw a big demand for copper due to its super conducting capabilities. The current transition into renewable energy gave copper another boost due to increased reliance on this metal. The discussion here briefly discusses the history of copper, its use, its physical, natural, and chemical characteristics and the future outlook due to new evolving technologies.

Historical Background

The name Copper comes from the old Latin word 'Cyprium aes' or metal from Cyprus since Cyprus was famous for its copper mines during the Roman Empire. Copper is however much older than the Roman Empire. The Egyptians used copper plumbing in pyramids with remnants still existing today. The Sumerians and Chaldeans of Mesopotamia extensively made use of copper [1]. Figure 1 shows the famous "Imdugud" relief located at the British museum. This type of relief was common for that period that was normally hung at house entrances and dates back to around 3000BC or 5000 years ago.

Figure 1. The Imdugud copper relief found at Al'Ubaid, near Ur in modern day southern Iraq.

Some scholars believe copper was discovered as early as 10 thousand years ago in the east Mediterranean area and specifically in modern day Turkey, Syria, Lebanon, and Palestine. The copper age marked the end of the Stone Age and the end of what scientists call Pre History and the beginning of Ancient History. When civilizations started to use metals, they developed methods for searching, mining, and working these metals to the desired shape. Perhaps the human brain was set on a track of identifying needs and developing tools and methods to achieve their goals.

Since bronze is merely copper with a small amount of tin we can safely claim the Bronze Age is a continuation of the copper age with an added technology of alloying the material. At the time iron was discovered around 1200 BC it was worth much more than copper [2]. Steel tools and weapons were much harder than copper and iron was a rare commodity and believed to be a heavenly material. Today copper is about 10 times more expensive than iron and is considered a strategic commodity worldwide [3].

Copper in Nature

Most metals have a silvery grey appearance in their pure and natural form. Copper is one of few exceptions. Copper has naturally a distinctive reddish orangey color that turn to mahogany as it ages and when exposed to nature's elements it is oxidized but develops a patina of a green tinge and keeping the original material intact. Copper is mined from earth as copper sulfides (Figures 2 and 3) and goes through various processes that must include smelting to become purified [4].

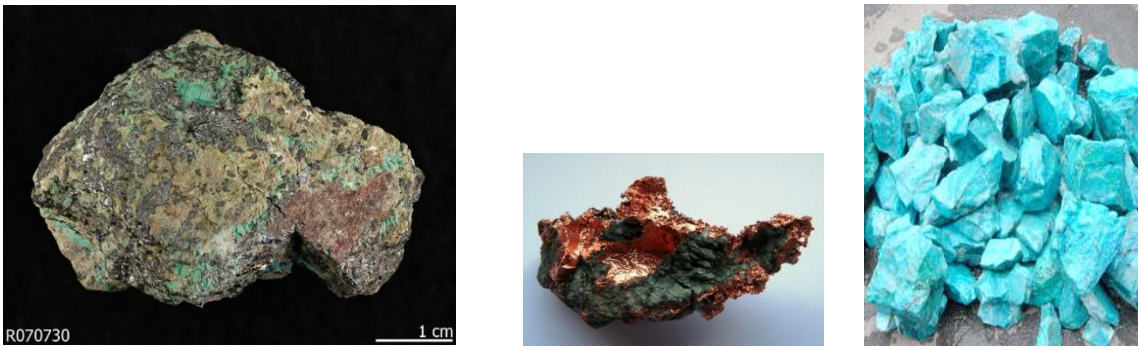

Figure 2. Copper ores containing various concentrations of copper

Figure 3. Copper-rich mountain in Cyprus

Bronze and Brass are alloys of copper. Historically they were considered natural but a slightly different metal. When science advanced, it became known that Bronze is copper with a small portion of Tin while Brass is obtained by adding a small amount of Zinc. With modern industry, different grades for each are obtained and marketed for different application.

Copper In The Periodic Table

The periodic table, originally the idea of a Russian scientist called Dmitri Mendeleev (1834 1907), is a place where all known elements are grouped together in a systematic and meaningful way (Figure 4). All known 118 Elements are listed in a table format with increased atomic numbers. Elements in the **same row or period** have the same number of electron shells but different number of electrons on the outer or valence shell [5].

The next row contains elements with an added outer shell keeping elements with same number of valence electrons below each other. For example, Figure 5 shows the electron valence configuration of copper and its neighbors Nickle and Silver. Copper has 4 shells and one valence electron. Nickle, to the left also has 4 shells but 3 valence electrons while silver below copper has 5 shells but still 1 valence electron.

The row containing copper also contains iron, Nickle, and Zinc while below Copper sits Silver then Gold. These metals along with Lead and Tin were historically known for thousands of years without knowing the chemical physical connection relating them as represented by the periodic table.

The symbol for Copper in Chemistry is **Cu**. It has an atomic number of 29. In the periodic table, copper is located in column or group number 11 just above silver and gold and on row or period 4 adjacent to zinc, Nickle, cobalt, and iron.

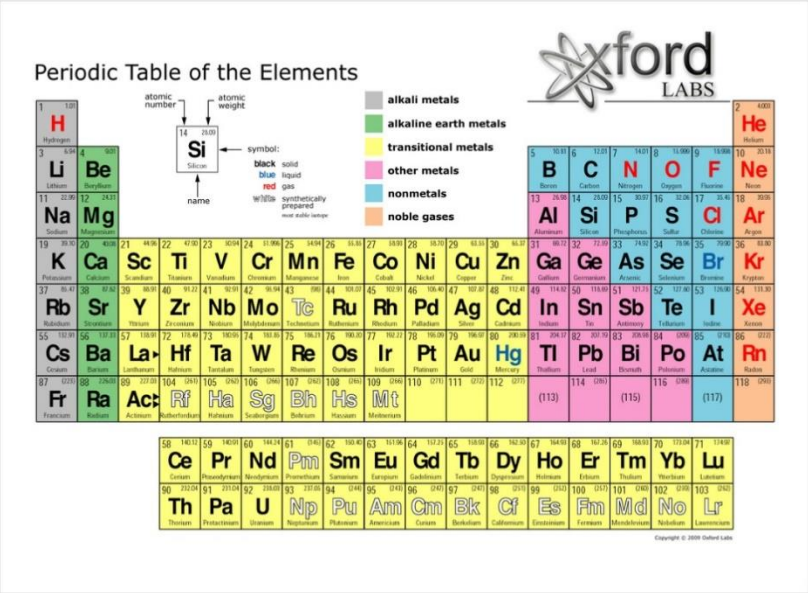

Figure 4. The periodic table of elements in 2024

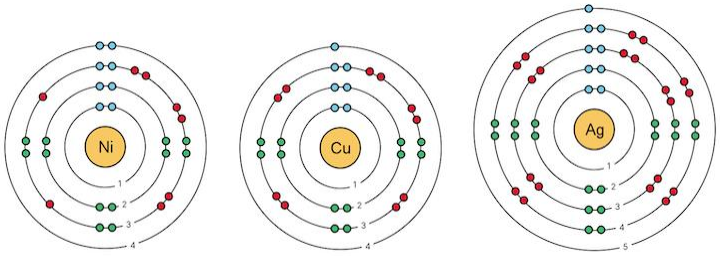

Figure 5. Electron valence configuration of copper, Nickle, and Silver atoms

Copper Production

Chile is by far the largest copper producer in the world. This South American country produces about quarter of the world output and with neighboring Peru more than the third (Table 1). Traditionally these

countries were famous for mining copper and silver for hundreds of years. It is to be noted that Copper mines take almost 20 years to become operational and in many countries mining is nationalized. The good news is that copper costs less to recycle than to produce new while keeping exactly the same original properties.

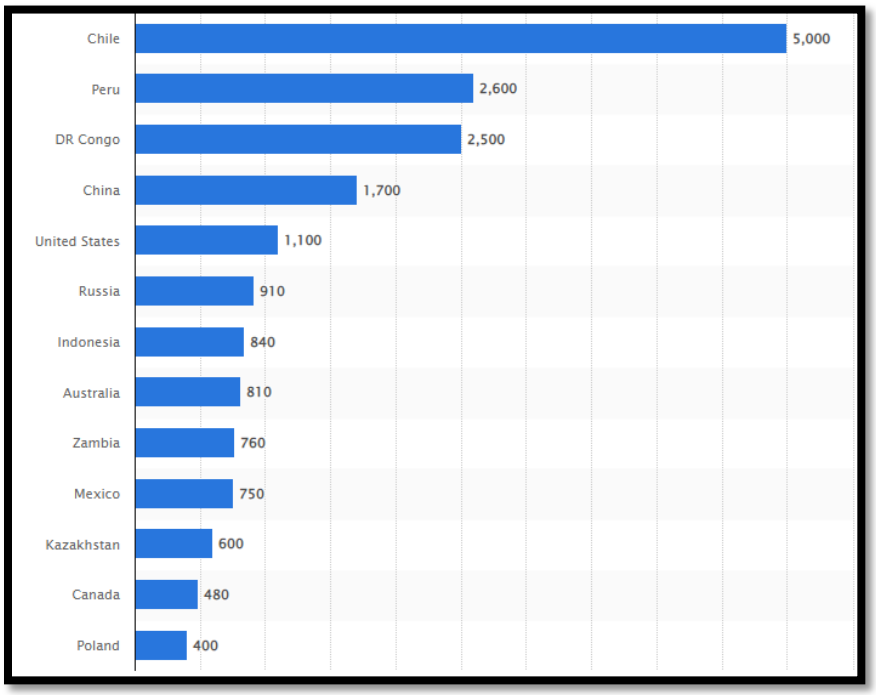

Table 1. 2023 Copper production by country in thousand metric tons [6].

Organic Characteristics of copper

Antibacterial characteristics

An interesting property of copper is that it is naturally antibacterial. Only Silver and to a lesser degree Nickle and Silver possess this property. It is believed that ions released from these metal surfaces cause membrane disruption or deterioration of many types of germs. An

example of direct application of this antibacterial property is its use as door handles and hand rails in public places

Copper and the Human Body

Copper is both essential and toxic to living systems. It is required to maintain good health and development. It is needed for cardiovascular integrity, metabolism, lung elasticity, new blood vessel formation, and other complex inner body functioning [7]. This mineral is consumed into the body with our food intake. Nuts and seeds, organ meats, lobster, mushrooms, leafy greens, and dark chocolate are examples of foods that are naturally high in copper.

Copper Uses

Copper is deeply embedded in our life applications that it is difficult to imagine the world without it. Products that are made with copper are normally associated with quality, they are long lasting and of course more expensive.

Almost every house and building in the world uses electric copper wiring (Figure 6) and some even use copper plumbing. It is estimated that the average home uses about 100 kg of copper. Most appliances, computers, phones, tablets must have copper in them.

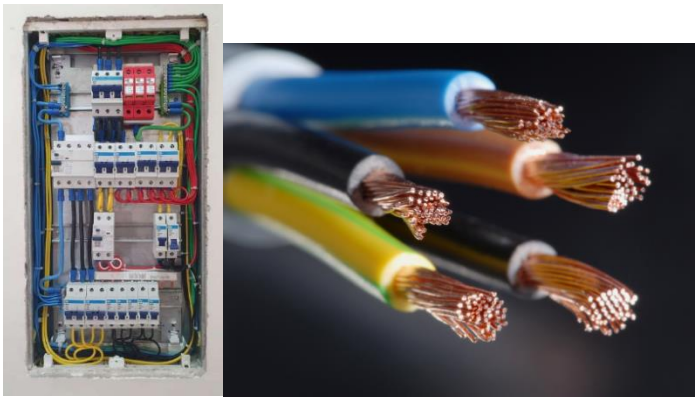

Figure 6. Typical electric wiring and wiring panels for homes and buildings

For transportation, every conventional car uses about 20 kg of copper and every electric car uses about 80 kg [8]. Copper is also essential in marine transportation. Ships are clad with copper sheets to protect against the elements (Figure 7).

Figure 7. Cladding of ship structures with copper sheets to prevent rust and barnacles.

The use of copper in electric generation and power transmission is also crucial. More so with renewable energy technology where solar

panels, wind turbines, inverters, and all necessary accessories rely heavily on copper.

What makes this metal so versatil and essential across many areas of applications is its preferred characteristics. Top quality is its super electric conducting capability. For example It is about 20 times more conductive than iron. Only Silver is slightly more conductive but it is 100 times more expensive. The other preferred quality of Copper is that it is rust proof and protects itself when oxidized instead of rusting. Copper also has a lower melting temperature than Steel at 1084 C vs 1540 C which makes it easier to manufacture. The only disadvantage of Copper in some applications is that it has half the strength of iron.

Future Outlook for Copper

The world is quickly transitioning into green energy. The main drivers for the new technology are electric vehicles (EV), batteries, solar panels, and wind turbines. These technologies require much more copper than conventional energy that depends on fossil fuels. A 1 megawatt (MW) solar plant requires an average of 5 tons of copper while a 1 MW wind turbine require about 600 Kg of copper [9]. Electric vehicles with their batteries and charging stations use about 4 times the amount of copper in conventional cars (Figure 8). Generally, renewable energy systems require 4 to 12 times more copper than those of traditional energy (Figure 9).

Finally, the best thing about copper is that it is100% recyclable while having the ability to keep its original properties. In fact, it is cheaper to recycle copper than to mine. Most copper products we use today have been recycled and maybe many times. This makes copper one of the most sustainable and essential material today and in the foreseeable future.

Figure 8. Charging electric vehicles

Figure 9. One of the largest solar farm in the world in Bhadla, India

REFERENCES

[1] Smithonian Enterprises “HISTORY THE DEFINITIVE VISUAL GUIDE” DK Publishing, New York, USA 2007

[2] Smithonian Enterprises “TIMELIBE SCIENCE” DK Publishing, New York, USA 2013

[3] lme.com (June 20,2024). London Metal Exchange

[4] The University of Arizona (Feb 10, 2015) “Copper Mining and Processing: Processing Copper Ores” http//www.Arizona.edu.

[5] National Geographic *The Sciencebook* “everything you need to know about the world and how it works”. The National Geographic, Washington DC USA. 2008

[6] statista.com (January 29, 2024) “Major countries in copper mine production worldwide in 2023”

[7] Magdalena Araya, Manuel Olivares, and Fernando Pizarro, “Copper in human health” International Journal of Environment and Health, Vol. 1, No. 4, 2007

[8] metelec.com (Feb 16, 2024). “The power of copper in electric vehicles.”

[9] International Copper Association (August 27, 2018). “Renewable Energy : A sustainable Driver of the Copper Industry” Retrieved from http://www.Internationalcopper.org