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A Study of the Different Properties and Characterization of Selenium for Photo-Voltaic Application with Variable

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Abstract – Nikola Tesla said, "If you want to know the secrets of the universe, then think in terms of frequency and vibration." When we talk about the photo-illumination of selenium element, the aforementioned principle greatly expounds the high electrical conductivity of the element, thus making it useful in photo-voltaic applications such as solar cars.

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PHYSICAL CHARACTERISTICS OF SELENIUM ELEMENT

The red, crystalline solid form of the element selenium was discovered by Jöns Jacob Berzelius, a Swedish chemist, in 1817 from the mines of Falun, Sweden.

Selenium is a naturally occurring mineral element that is distributed widely in nature in most rocks and soils. In its pure form, it exists as metallic gray to black hexagonal crystals when extracted, however, in nature, it occurs usually in combination with sulfide, silver, copper, lead or nickel minerals. Selenium is a rare mineral, composing approximately 90 parts per billion of the crust of the earth.

The name selenium is derived from 'selene' who means 'the moon' in Greek. 'Se' is its chemical symbol.

She is the isotropic form of selenium which is solid, crystalline and silvery white in colour at 25° Celsius.

Red selenium, gray selenium and black selenium are the allotropic forms of selenium.

Following are the fundamental physical characteristics of selenium isotope.

Melting point of ^{80}Se: 220.8°C
Boiling point of ^{80}Se: 685°C
Mass density of ^{80}Se: 4.809 gms/cm^3
Relative atomic mass of ^{80}Se: 78.97

USES OF SELENIUM

Most processed selenium is used in the electronics industry in the manufacture of electronic equipment.

Not only that, but also selenium is used as a nutritional supplement; in the glass industry in the making of glass; as a component of pigments in plastics, paints, enamels, inks and rubber; in the preparation of pharmaceuticals; as a nutritional feed additive for poultry livestock; in pesticide formulations; in rubber production; as an ingredient in anti-dandruff shampoos; and as a constituent of fungicides.

Radioactive selenium is used for medical diagnostics.

CHEMICAL PROPERTIES OF SELENIUM MINERAL

Selenium ('Se') is a chemical element in the Group 16 [VI a] of the periodic table, closely allied in chemical and physical properties with the elements sulphur and tellurium.'Se' is a metalloid, that is, it is an element intermediate in properties between metals and non-metals.

The gray, metallic form of 'Se' element is the most stable under ordinary conditions. This form of 'Se' has the unusual property of greatly increasing in electrical conductivity when exposed to light.

'Se' compounds are toxic to animals; plants grown in splendiferous soils may become poisonous when they concentrate the 'Se' element.

Following are the chemical properties of Selenium mineral.

Symbol: 'Se'
Atomic number: 34
Atomic weight: 80
Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^4$
Crystal structure: Hexagonal
Acid-base properties of higher valence oxides: Strongly acidic
Physical state at 20°C: Solid
Oxidation states: -2, +4, +6

OCCURRENCE OF SELENIUM

The proportion of selenium in the earth's crust is about 10^{-6} to 10^{-5} percent. It is obtained mainly from the anode slimes deposited in the electrolytic refining of copper and nickel. About 1.5 kilograms of selenium can be obtained from a tonne of smelted copper. Other sources of selenium are the flue dusts in copper and lead production and the gases formed in roasting pyrites.

ELECTRICAL CONDUCTIVITY OF SELENIUM

Principle:

Crystalline selenium is a photo-electrical conductor. On illumination by solar light, the electrical conductivity of selenium increases many-fold. This phenomenon results from the promotion of loosely held electrons by light to higher energy states, thus permitting electron migration.

Application:

Illumination of crystalline selenium for 0.001 seconds increases its conductivity by a factor of 10 to 15 times. This property of photo-sensitivity and resultant electrical conductivity of selenium is harnessed in a variety of devices that can transform variations in light intensity into electric current. Rectification of alternating electrical current (AC) by conversion into direct electrical current (DC) also is accomplished through selenium-based devices.

Photocell Application of Selenium

Principle:

A photo-voltaic cell ('PV cell' or 'photocell') uses two types of electrical contacts, namely, a positive electrical semi-conductor contact (p-type material contact) and a negative electrical semi-conductor contact (n-type material contact) within which electrical energy flows from the n-type contact plate to the p-type contact plate upon photo-illumination, through the medium of a conducting material (p-n junction). This type of arrangement produces an electrical energy field causing negatively charged particles to move in one direction and positively charged particles in the other direction. When light of a certain wavelength is incident on the n-type contact plate of the photocell, energy from an illuminated photon is transferred to an electron of the semi-conducting material, causing it to jump to a higher energy state known as the conduction band. In their excited state in the conduction band, these electrons are free to move through the material which creates an electric current in the photocell which is used in the functioning of the device harboring the photocell.

Application:

A photo-voltaic cell ('photocell') can be constructed using selenium metalloid as follows. A steel plate can be used as p-type material contact and a cathodic plate can be used as the n-type material contact of the photocell, with selenium metalloid as the p-n material for conduction of electrical energy. The following diagrammatic representation provides a detailed method of construction of the selenium photocell with variable p-type contact plating.

DIAGRAMMATIC REPRESENTATION OF SELENIUM PHOTOCELL

Figure 1.1 below represents the diagrammatic construction of the selenium photocell shown in cross-section.

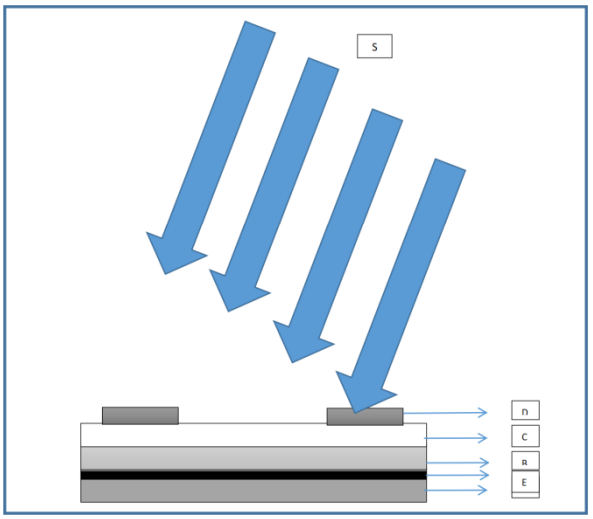

FIGURE 1.1

CROSS-SECTIONAL REPRESENTATION OF SELENIUM PHOTOCELL

A: p-type semi-conductor

B: p-n conducting junction

C: n-type semi-conductor

D: Contact ring

E: Metallic spray coating

S: Solar energy rays

Figure 1.1 above shows a cross-sectional representation of a selenium photocell, that is, it shows a photocell comprising selenium in section.

The steel plating 'A' is the positive contact (p-type material contact) of the photocell shown in Figure 1.1. Plate 'A' carries a layer of metallic selenium 'B' (p-n type material of the photocell) as shown in the Figure 1.1. Above the selenium plating 'B' is a thin, transparent electrically-conductive cathodic plating 'C' (n-type material contact) or the negative contact of the photocell shown in Figure 1.1.

The cathodic plating 'C' is reinforced along the edge of 'B' by a negative contact ring 'D', thus protecting 'C' from damage by lacquering. The steel plate 'A' of the photocell is protected from corrosion by a metallic spray coating 'E', which also improves the electrical contact of 'A'.

TECHNOLOGY USING SELENIUM PHOTOCELL

Another type of photocell which uses selenium is the zinc oxide photocell which contains zinc oxide base and only 9% selenium. Even this relatively small amount of selenium boosts the photocell's efficiency in absorbing light to a great extent.

Photo-electrochemical splitting of water uses energy from the sun to split water into hydrogen and oxygen gases. This could potentially be the most exciting application of the selenium photocell. This in turn could lead to the production of hydrogen-powered vehicles which would hypothetically run only on water and sunlight.

CONCLUDING REMARKS

We might not see many hydrogen-run cars on the roads in any great numbers on the roads any sooner. However, the photo-electrochemical splitting of water itself is a futuristic photo-voltaic application which can be used for various scientific purposes.

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