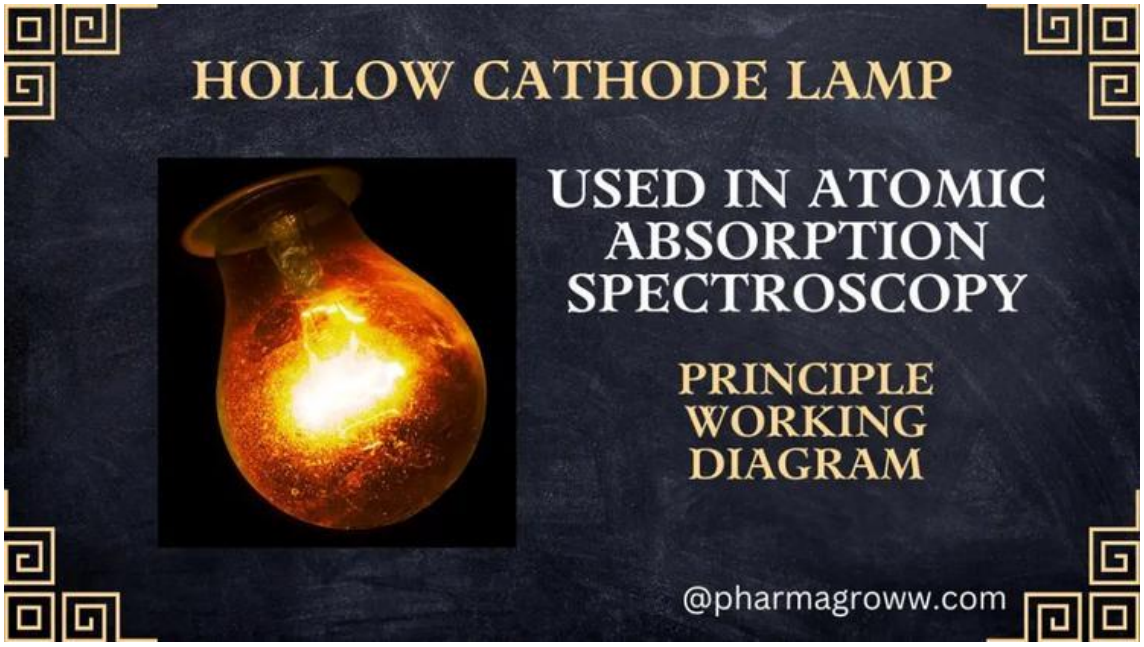

A hollow cathode lamp is used in atomic absorption spectroscopy. Atomic absorption spectroscopy is based on the principle that a ground-state atom is capable of absorbing light of a characteristic wavelength in a gaseous state. To provide an element its characteristic wavelength of absorption, we use a source that will only provide the wavelength emitted by that particular element. This is achieved using a hollow cathode lamp. This lamp is specific for each element. There are some reasons why we do not use a traditional UV/Vis continuous light source in atomic absorption spectroscopy. Let's see those reasons.

Problems with typical UV/Vis light source for AAS

- It provides the right intensity but a lot of other interferences are present (non-monochromatic light).
- Sensitivity is less due to which when atoms absorb less, we cannot see the decrease in signal.
- It is hard to match the absorption wavelength of a specific element and provide it as a light source. But this can be easily achieved with the help of a hollow cathode lamp.

Hollow cathode lamp principle

A hollow cathode lamp works on the principle that the energy required by an atom to get excited (absorption wavelength) is equal to the energy released by the atom when it goes back to the ground state (emission wavelength).

The potential difference applied across the cathode and anode causes inert gas to bombard the cathode containing the element to be determined. Metal atoms get sputtered and get excited by hitting with inert gas. When metal atoms get back to the ground state, they emit a characteristic wavelength of that element.

Working of Hollow cathode lamp

- The lamp consists of a cylindrical hollow cathode made of the element to be determined and a Tungsten anode. It is filled with an inert gas like Neon.
- When we apply the potential difference, the inert gas gets excited and drives toward the cathode.
- This causes metal atoms to sputter off from the cathode surface. The ejection of metal atoms from the cathode is known as sputtering.
- The sputtered metal atoms constantly get hit by the excited inert gas atoms which cause metal atoms to get excited.
- And when these metal atoms go back to their ground state, they emit a characteristic wavelength that is specific to that element. This emitted wavelength passes through the Quartz window and reaches the sample.
- If the sample contains the element, it will absorb the wavelength emitted by the lamp source and the transmitted light will therefore be of a lesser intensity which will be detected by the detector.

Reactions in Hollow cathode lamp

The following reactions happen in the lamp when we apply a potential difference across the anode and the cathode:

1) Ionization of filler gas: Filler gas is the inert gas that we fill in the lamp such as Neon (Ne).

$$Ne + e^- = Ne^+ + 2e^-$$

2) Sputtering of the cathode element (M): When the ionized neon atoms hit the hollow cathode lamp, the metal atoms get sputtered from the surface.

$$M_{(s)} + Ne^+ = M_{(g)} + Ne$$

3) Excitation of cathode element: The ionized neon atoms constantly hit the sputtered metal atoms which cause metal atoms to get excited.

$$M_{(g)} + Ne^+ = M^*_{(g)} + Ne$$

4) Emission of radiation: When the excited metal atoms go back to the ground state, they emit radiation that is equal to the absorption wavelength of the element of interest.

$$M^*_{(g)} \rightarrow M_{(g)} + h\nu$$

Link: https://pharmagroww.com/hollow-cathode-lamp/

https://www.youtube.com/watch?v=G5UdTGqnX4I

https://www.agilent.com/en/product/atomic-spectroscopy/atomic-absorption/atomic-absorption-hollow-cathode-lamps