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Technical Note

Deuterium Lamp vs Xenon Lamp

The purpose of this article is to highlight the key differences between Xenon Lamp and Deuterium Lamp. We will see the operating principle of both lamps and various factors that makes Deuterium Lamp superior than Xenon Lamp for spectroscopy analysis.

For Spectroscopy, output light stability and stray light are the most important factor, thus we will highlight on the same parameters.

Xenon lamps are less stable and introduce more stray light, which is documented and validated by various organisations, as shown below

- Comparison as per Shimadzu

https://www.shimadzu.com/an/service-support/technical-support/analysis-basics/fundamentals-uv/lightsources.html

Types of Light Source

Many light sources meet some of the requirements above but no light source is able to meet them all. Many spectrophotometers switch between a halogen lamp for the visible range and a deuterium lamp for the ultraviolet range according to the wavelength setting.

This is because of the difficulty in achieving both "a high degree of brightness" and a "uniform brightness distribution" across a wide wavelength range using a single light source. Switching between light sources with different emission wavelength ranges also offers the advantages of reducing the excess incident light into the monochromator and reducing the amount of stray light (Reference 1).

Other instruments use a xenon lamp or xenon flash lamp suitable for the analysis target and aim of the analysis.

(2) Deuterium Lamps

A deuterium lamp is a discharge light source with several hundred Pa deuterium sealed in a bulb. As it uses a hot cathode to achieve stable and reliable arc discharge, approximately 10 sec for preheating is required before starting the discharge.

A deuterium lamp requires a large and complex power supply, making it more expensive than a halogen lamp. However, it is one of the few continuous spectrum light sources that is stable in the ultraviolet range.

The deuterium lamp has a short emission wavelength of 400 nm, or less. The window material limits its use at the short wavelength end.

Fig. 2 shows examples using synthetic quartz and UV glass.

The use at the long-wavelength end is limited to about 400 nm. However, the low degree of attenuation toward the longwavelength end permits use of light above 400 nm. Multiple emission spectra also exist in the range at 400 nm and above. Of these, the spectra at 486.0 nm and 656.1 nm are particularly strong (see Fig. 5) and can be used for wavelength calibration of the spectrophotometer.

Xenon Lamp (Xenon Arc Lamp)

A xenon lamp is a discharge light source with xenon gas sealed in a bulb. Xenon lamps are categorized as directcurrent or alternating-current types, according to the lighting method. If the electrodes become too hot, the tungsten electrode material can evaporate and adhere to the tube wall,

resulting in a loss in brightness. As the anode becomes particularly hot, the anode of a direct-current type xenon lamp is made larger than the cathode to increase its thermal capacity. As the electrodes of an alternating-current type electrode alternately become the cathode and anode, both electrodes are the same size. Therefore, the tungsten evaporates more easily than with the direct-current type. However, the alternating-current type permits the use of a compact, low-cost lighting device, as no current rectification is required.

The xenon lamp exhibits a similar spectral distribution to sunlight and produces a continuous spectrum from the ultraviolet to the near-infrared, as shown in Fig. 3. Overall, the xenon lamp **is inferior to the halogen lamp and deuterium lamp** in terms of cost and output fluctuations. Halogen lamps are often used in general spectrophotometers but xenon lamps are used in cases where a high light intensity is required (such as spectrofluorophotometers), due to their high brightness.

- Comparison as per Photonics.com

https://www.photonics.com/Articles/A_Guide_to_Selecting_Lamps/a44487

Deuterium lamps contain deuterium gas and emit UV light; the wavelength range depends on the lamp's glass material. The lamps emit in one direction only, unlike xenon and mercury-xenon lamps which emit in all directions. They are widely used in spectrometers, HPLC (high performance liquid chromatography), environmental analyzers, and other applications. For applications that require vacuum UV (VUV) wavelengths, deuterium lamps that emit down to 115 nm are available. For example, Hamamatsu's S2D2 VUV light source unit (L10706) can be installed and operated under depressurized conditions for VUV **spectroscopy**, photoionization, and other applications.

A key characteristic of deuterium lamps is their excellent stability compared to other lamp types (Figure 3). For example, Hamamatsu's deuterium lamps show very small output variations from lamp to lamp, and individual lamps have low fluctuation (short-term stability) and drift (long-term stability) values. Hamamatsu's S2D2 deuterium lamp module (L10671 series), for example, exhibits a typical fluctuation of 0.005% (peak to peak) and a maximum drift value of ±0.25%/hour. Such stability is due to the ceramic electrode structure, which ensures lamp stability even when the ambient temperature fluctuates. Deuterium lamps also have long life and high brightness, and they are being developed to be even brighter. For example, Hamamatsu's new X2D2 lamps have twice the brightness of conventional deuterium lamps. Using a high-brightness lamp helps an instrument have high resolution and high throughput.

Comparison of fluctuation values (a measure of short-term stability) of different lamp types from Hamamatsu. The smaller the value, the more stable the lamp

- Comparison as per Hitentechno
  https://www.hitentechno.in/deuterium-lamp-xenon-lamp

Deuterium Lamp vs Xenon Lamp [The Ultimate Comparison Guide]

June 21st, 2018

When it comes to researching materials the ultimate choice of researchers comes down to Spectrophotometers.

As there are different spectrophotometers available in market with different specs of shapes, sizes and materials. One big factor in choosing the Spectrophotometer is the light source.

In this article we analyse most often compared two Spectrophotometer Lamp Sources Deuterium Lamps (also known as D2 Lamps) and Xenon (Xe) Lamps . The basic purpose of this article is to bring out the facts concerning these two lamps and help you make informed decision on which lamp to go for.

For comparison we have considered only pure gas based Xenon Lamps and not the Xenon Mercury Lamps.

Quick Comparison

Some of the quick facts when it comes to comparing Deuterium Lamps & Xenon Lamps are as follows,

Factor	Deuterium Lamps	Xenon Lamps
Wavelength Range	180 nm to 370 nm (>370 covered by Tungsten Halogen Lamp)	185 nm to 2000 nm
Spectrum(s) Covered	UV & VIS	UV, VIS & IR
Cost Range	Affordable	High – Expensive during replacement as lamps are consumables

Deuterium Lamp & Xenon Lamp: Characteristics in brief

A Deuterium Arc Lamp as we all know is also known as D2 Lamp is an ideal source of discharge lamp in spectroscopy. In bulbs usually the filament is the source of light but in case of D2 Lamp the arc formed is the source of continuous light. D2 lamps usually comes in handy when a continuous spectrum is needed in the ultraviolet region. The filament is usually made up of Tungsten & a continuous voltage from 300 Volts to 500 Volts is needed to fire up the filament; once the arc is formed voltage levels can be brought down.

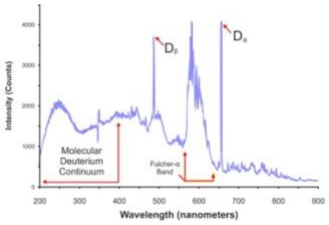
A Xenon mimics sunlight particularly because of the range of spectrum it covers (UV, VIS & IR) and also because of the white light it emits. A typical Xenon lamp consists of anode & cathode electrodes facing each other. On passing electricity in this ionized Xenon gas this lamp then discharges light.

Detailed Comparison

Wavelength

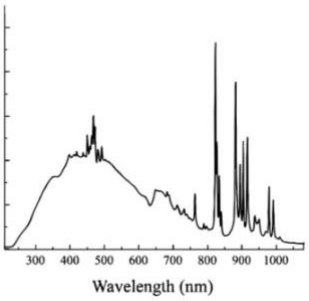
Deuterium Lamp

The stable and continuous is within 165 nm to 400 nm as shown in the diagram. Fulscher band emission is around 560 to 640 nm. Balmer lines are are also marked as Dβ and Dα. The balmer lines are 486 nm & 656 nm. As we move more towards the right we see more of the irregular spectra. Hence the old saying Deuterium Lamps are useful when you need stability in the UV region.



Xenon Lamp

Xenon Lamps show distinctive high-intensity within spectra within 850 nm to 900 nm. The broad spectrum range shown in the figure with low stability but with long-life feature adds to Xenon lamps' advantage.



Fluctuation

One thing that Deuterium Lamp score over other lamps is the low fluctuation levels in peak. This excellent characteristic of Deuterium Lamp at a level of 0.005% (peak to peak) although slight variation can be observed for different models. The stability in fluctuation levels is because of ceramic electrode structure found in Deuterium Lamps.

In case of Xenon Lamp the fluctuation level is of the value 1% and the value only increases in other types of Xenon Lamps.

Applications

Deuterium Lamps are common for testing purpose in Pharmaceutical industries and are also used for Atomic absorption spectroscopy (AAS), Thin film measurement and Thin layer chromatography (TLC)

Xenon lamps are commonly used as movie projectors and also for wafer inspection system and devices such as microscope.

Conclusion

Both lamps have there own set of benefits and limitations. When more of UV related stability is needed Deuterium Lamps are preferred. In situation when sunlight has to be reproduced then Xenon Lamps are used.

Xenon lamps although produces highly unstable output compared to other lamps. But with advances in lamp research better Xenon Lamps are manufactured.

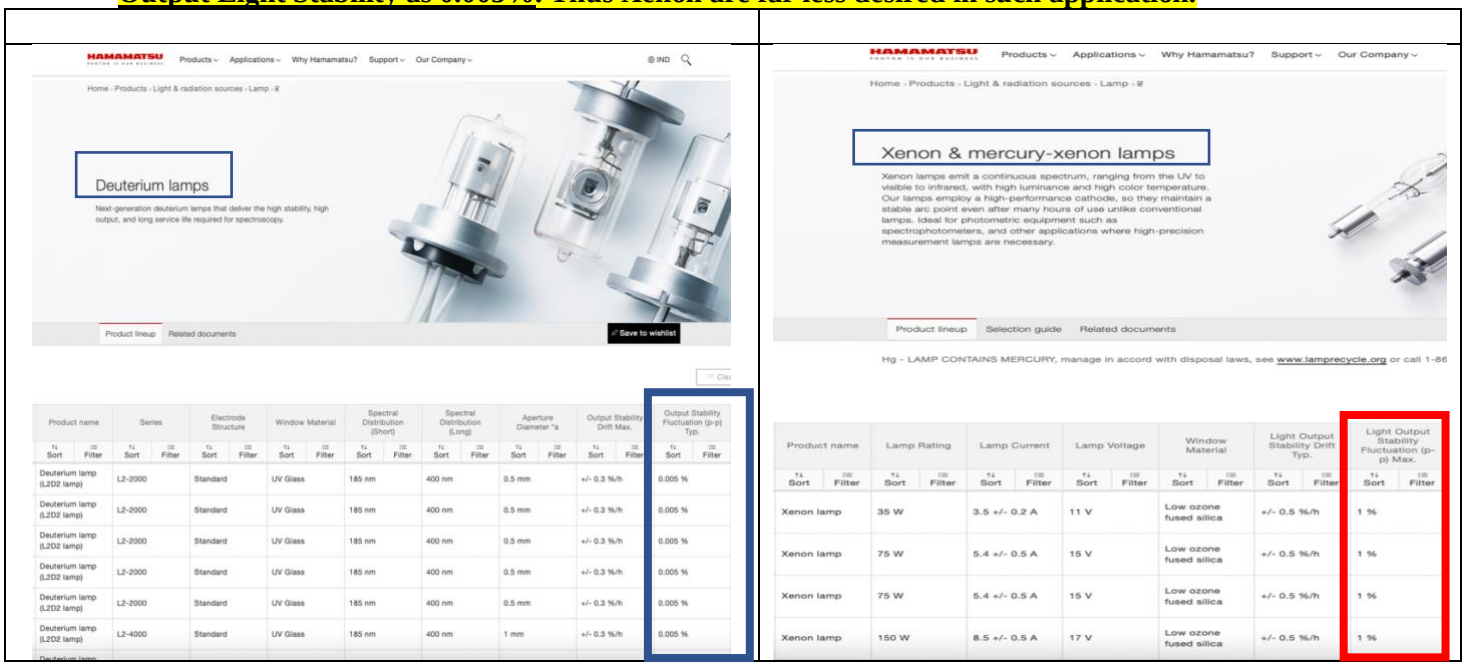
Both lamps require stable power input for the arc light to be formed. In both of the lamps safety gears are advised before using them. With better brands one can get these lamps with 2000+ hours of operation.

- Comparison as per Hamamatsu

https://www.hamamatsu.com/eu/en/product/light-and-radiation-sources/lamp/xenon-lamp_mercury-xenon-lamp/index.html

https://www.hamamatsu.com/eu/en/product/light-and-radiation-sources/lamp/deuterium-lamp/index.html

For Xenon Lamps, the best Light output stability is 1% while typical Deuterium Lamp have Output Light Stability as 0.005%. Thus Xenon are far less desired in such application.



Thus as described above, for high performance spectroscopy with ultra-stable repeatability, the Deuterium Lamps are the only choice.