Total consumption burner and premix chamber burner comparison biology essay

Atomic emission is a process that occurs when electromagnetic radiation is emitted by excited atoms or ions. In atomic emission spectrometry the sample is subjected to temperatures high enough to cause not only dissociation into atoms, but also to cause significant amounts of collisional excitation and ionisation of the sample atoms to take place. Once the atoms and ions are in the excited states, they can decay to lower states through thermal or radiative (emission) energy transitions and electromagnetic radiation is emitted. An emission spectrum of an element contains several more lines than the corresponding absorption spectrum.

FES (formerly called flame photometry) is in principle similar to emission spectroscopy, with flame as the source of excitation energy (flame atomiser). A flame provides a high-temperature source for desolvating and vaporizing a sample to obtain free atoms for spectroscopic analysis. In atomic absorption spectroscopy ground state atoms are desired. For atomic emission spectroscopy the flame must also excite the atoms to higher energy levels. The table lists temperatures that can be achieved in some commonly used flames.

In atomic spectroscopy, atomization is the conversion of a vaporized sample into atomic components or the process of obtaining atomic vapor.

Liquid samples are first nebulized (convert a liquid into a mist or fine spray), the fine mist is transported into the atomization source (flame or plasma), where the solvent evaporates and the analyte is vaporized, then atomized.

A flame atomiser is composed of a nebulisation system with a pneumatic aerosol production accessory, a gas-flow regulation and a burner. Flame are produced by means of a burner to which fuel and oxidant are supplied in the form of gases. There are two types of aspirator-burner used, total-consumption burner and premix chamber burner.

Nebulisation is a process to convert (a liquid) to a fine spray

Total Consumption Burner

In total-consumption burner, the fuel and oxidant (support) gases are mixed and combust at the tip of the burner. The fuel (usually acetylene), oxidant (usually air) and sample all meet at the base of flame. The sample is drawn up into the flame by the ‘ Venturi Effect’, by the support gas. The gas creates a partial vacuum above the capillary barrel, causing the sample to be forced up the capillary. It is broken into a fine spray at the tip where the gases are turbulently mixed and burned. This is the usual process of ‘ nebulisation’.

The burner is called total consumption because the entire aspirated sample enters the flame or in other words the sample solution is directly aspirated into the flame. All desolvation, atomization, and excitation occurs in the flame.

However, the total consumption burner can be used to aspirate viscous and ‘ high solids’ samples with more ease, such as undiluted serum and urine. Also, this burner can be used for most types of flames, both low- and high-burning velocity flames.

Surface mixing

Total Consumption Burner

The Venturi Effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe

Premix Chamber Burner

The second type of burner, most commonly used now, is the premix chamber burner, sometimes called laminar-flow chamber. Premix burners were the first purpose-designed burners, and they can be traced back more than 100 years to the Bunsen and similar laboratory burners. A premix burner system really consists of two key components, the burner head or nozzle, and the gas-air mixing device that feeds it. The fuel and support gases are mixed in a chamber before they enter the burner head (through a slot) where they combust. The sample solution is again aspirated through a capillary by the ‘ Venturi effect’ using the support gas for the aspiration. Large droplets of the sample condense and drain out of the chamber. The remaining fine droplets mix with the gases and enter the flame. As much as 90% of the droplets condense out, leaving only 10% to enter the flame. The 90% of the sample that does not reach the flame will travels back through the mixing chamber and out as waste drain.

The premix burners are generally limited to relatively low-burning velocity flames. The most outstanding disadvantage of the premix burner is that only low burning-velocity flames can be used. A burning velocity which is higher than the rate of flow gases leaving the burner will cause the flame to travel down into the burner resulting in an explosion commonly known as flashback. Because of this limitation it is somewhat difficult to use high burning-velocity gases, which includes oxygen-based flames.

Most commercial instrument use premix burners with the option of using total-consumption burner. Premix burners are distinguished as Bunsen-, Meker-, or slot-burners according to whether they have one large hole, a number of small holes, or a slot as outlet for the gas mixture, respectively. When several parallel slots are present, they are identified as multislot burners (e. g., a three-slot burner). A popular version of premix burner is the ‘ Boling’ burner. This is a three slot burner head that results in a broader flame and less distortion of radiation passing through at the edges of the flame. This burner warps more easily than others, though, and care must be taken not to overheat it when using organic solvents.

The difference between total-consumption burner and premix chamber burner

a) Nebulisation process

In total-consumption burner, the fuel (usually acetylene), oxidant (usually air) and sample all meet at the base of flame. The sample is drawn up into the flame by the ‘ Venturi Effect’, by the support gas. The gas creates a partial vacuum above the capillary barrel, causing the sample to be forced up the capillary. It is broken into a fine spray at the tip where the gases are turbulently mixed and burned. This is the usual process of ‘ nebulisation’.

While in premix burners, the fuel and support gases are mixed in a chamber before they enters the burner head (through a slot) where they combust. The sample solution is again aspirated through a capillary by the ‘ Venturi effect’ using the support gas for the aspiration. Large droplets of the sample condense and drain out of the chamber.

b) Size of sample droplet that enters the flame (atomization efficiency) and absorption pathlength

The total consumption burner obviously uses the entire aspirated sample, but it has a shorter path length and many larger droplets are not vaporized in the sample. The path length is extremely short, since combustion occurs only at a point above the capillary tube. Although in the total-consumption burners the entire sample is aspirated, the vaporization and atomization is poor.

Although a large portion of the aspirated sample is lost in the premix burner, the ‘ atomization efficiency’ (efficiency of producing atomic vapour) of that portion of the sample that enters the flame is greater, because the droplets are finer. Also, the path length is longer. The sample which does reach the flame is efficiently atomized. So sensitivities are comparable with either burner in most cases.

c) Interference to flame

In total consumption burner, the larger droplets may vaporize partially, leaving solid particles in the light path. This may result in light scattering, which is registered as an absorbance. The absorbance by the sample, that is, the atomic vapour population, is generally more dependent on the gas flow rates and the height of observation in the flame than with the premix burners. The viscosity of the sample will more greatly affect the atomization efficiency (production of atomic vapour) in the total consumption burner. The resulting drops are relatively large which will cause the flame temperature to fluctuate and will scatter the source radiation. This may cause false measurements to be detected. This interference will not happen in premix burner since fine droplets of sample is produced.

d) Flame homogeneity

Total consumption burner is used in flame photometry and is not useful for atomic absorption. The reason for this is that the resulting flame is turbulent and non-homogenous because it combines the function of nebulizer and burner. Here oxidant and fuel emerge from separate ports and are mixed above the burner orifices to produce a turbulent flame. Non-homogenous flame is a property that negates its usefulness in atomic absorption, since the flame must be homogeneous, for the same reason that different sample cuvettes in molecular spectrophotometry must be closely matched. One would not want the absorption properties to change from one moment to the next because of the lack of homogeneity in the flame.

In premix burner, the fuel and oxidant are thoroughly mixed inside the burner housing before they leave the burner ports and enter the primary combustion or inner zone of the flame. This type of burner usually produces an approximately laminar (streamline) flame, and is commonly combined with a separate unit for nebulizing the sample.

e) Noise

Combustion with the premix burners is very quiet, while with the total-consumption burner it is noisy to the detector as well as to the ear, possibly on a level similar to that of a jet engine.

Summary of the difference between the total-consumption burner and premix burner:

No

Characteristics

Total Consumption Burner

Premix Chamber Burner

Nebulisation process

The fuel and oxidant (support) gases are mixed and combust at the tip of the burner.

The sample is drawn up into the flame by the ‘ Venturi Effect’, by the support gas. The gas creates a partial vacuum above the capillary barrel, causing the sample to be forced up the capillary. It is broken into a fine spray at the tip where the gases are turbulently mixed and burned.

The fuel and support gases are mixed in a chamberbefore they enter the burner head (through a slot) where they combust.

The sample solution is again aspirated through a capillary by the ‘ Venturi effect’using the support gas for the aspiration.

Size of sample droplet that enters the flame (atomization efficiency)

Larger droplets

¯atomization efficiency

Many larger droplets are not vaporized in the sample. The larger droplets may vaporize partially, leaving solid particles in the light path (result in light scattering and registered as an absorbance). The viscosity of the sample will more greatly affect the atomization efficiency (production of atomic vapour) in the total consumption burner.

Small droplets

atomization efficiency

Although a large portion of the aspirated sample is lost in the premix burner, the ‘ atomization efficiency’of that portion of the sample that enters the flame is greater, because the droplets are finer.

Absorption path length

Shorter path length

¯atomization efficiency

Longer path length

atomization efficiency

Interference to flame

The resulting drops are relatively large which will vaporize partially, leaving solid particles in the light path. This may result fluctuation of flame temperature and light scattering, which is registered as an absorbance may cause false measurements to be detected.

None (fine drops)

Flame homogeneity

The resulting flame is turbulent and non-homogenous

Usually produces an approximately laminar (streamline) flame

Noise

Combustion with the total-consumption burner is noisy

Combustion with the premix burners is very quiet