Cyanide Sensing

Ursa BiosScience offers a patent protected unique range of free cyanide fluorescence-based molecular sensors, specifically customized for physiological measurements, making them highly suited for analytical and forensic cyanide detection as well as environmental monitoring.

Our cyanide probes readily chelate cyanide and with their relatively high binding constants (cyanide 1 - 0.12 µM$^3$) respond in a colorimetric and fluorescence excitation and emission wavelength ratiometric manner over the concentration range of free cyanide physiological importance, i.e. less than 50 µM (50 micro molar).

Advantages of Ursa’s Fluorescence-Wavelength Ratiometric Approach

It is widely accepted that fluorescence ratiometric or lifetime based methods offer intrinsic advantages for both chemical and biomedical fluorescence sensing. Fluorescence intensity measurements are typically unreliable away from the laboratory and can require frequent calibration/s due to a variety of chemical, optical or other instrumental related factors. Unfortunately, while fluorescent probes are known to be useful for many applications such as in fluorescence microscopy, fluorescence sensing and DNA technology, most sensing fluorophores only display changes in intensity in response to analytes and hence relatively few wavelength ratiometric probes are available today. Ursa’s range of cyanide sensing probes offer the significant advantages of being both excitation (colorimetric) and emission-wavelength ratiometric, with excitation and emission wavelengths over user friendly ranges.

Background on Physiological Cyanide Poisoning

Cyanide is widely considered to be one of the most lethal poisons known [1-10]. The mechanism of toxicity for cyanide is by physiological absorption. Absorption occurs through the lungs, GI track and skin. Cyanide is highly toxic because it inhibits oxygen utilization by cells, binding with ferric iron in cytochrome oxidase, blocking the oxidative process of cells. As such the tissues with the highest oxygen requirement (brain, heart and lungs) are the most affected by acute poisoning. However, cyanide poisoning is not common, but can occur from smoke inhalation from residential and industrial fires, and in people who work in the metal, mining,
Advantages of Ursa BioScience Cyanide Probes

Ursa BioScience has engineered its cyanide probes at the molecular level to function in the presence of other physiological ions and species, such as chloride, glucose and fructose, making them ideal for physiological cyanide measurements, such as in serum. For cyanide 1, the binding constant for cyanide is over 1000-times better than for Glucose and Fructose, 3.90 and 1.06 mM$^{-1}$ respectively. Ursa’s cyanide fluorescence-based probes also function very well in the presence of serum chloride, with a Stern-Volmer chloride constant, $K_{SV}$ [17], of $\approx 1.0$ M$^{-1}$.

Cyanide 1 responding to cyanide in the presence of 50, 5 and 50 mM glucose, fructose and chloride simultaneously.

Cyanide 1 C™ - Control

Ursa BioScience also offers a Control Fluorescence Compound for Cyanide 1™. Our Cyanide 1 C™ has the same chromophore fluorescent backbone, but does not chelate dissolved cyanide and is therefore not influenced by cyanide. For researcher’s and physicians alike undertaking quantitative cyanide analysis, Cyanide 1 C™ allows for any background interference of Cyanide 1™ to be corrected for, while not changing any fluorescence instrumentation or filter settings. Subsequently, Cyanide 1 C™ does not show any ratiometric response to cyanide. Cyanide 1C™ can be readily excited from 375-450 nm, with an emission centered at 560 nm. The mean and amplitude weighted lifetimes of Cyanide 1 C™ are 2.48 ns, and remain unchanged in 10 µM cyanide solutions.

Figure 5 – Cyanide 1 C™ does not chelate up to 50 µM cyanide.
Cyanide 2™ – “Turn-On” Cyanide Fluorescent Sensor

Cyanide 2™ offers a “Turn-On” response in the presence of cyanide, which is attractive to workers requiring a high signal-noise (signal to background), when working either in complex sample medias or at low cyanide concentrations. In addition, Cyanide 2™ offers a fluorescence wavelength ratiometric response to cyanide, readily allowing researchers to correct for excitation light and detector drifts / fluctuations.

Figure 6 – Fluorescence emission spectra of Cyanide 2™ with increasing concentrations of aqueous cyanide, left, and the respective ratiometric plot using the intensities at 450 and 515 nm, right.

Cyanide 3™ – “Turn-Off” Cyanide Fluorescent Sensor

Ursa BioScience offers a “Turn-Off” Cyanide Fluorescent Sensor, which is ideal for high sensitivity cyanide detection < 20 µM cyanide. Cyanide 3™ readily responds to cyanide < 100 µM. By taking the ratio of the fluorescence emission at 390 and 455 nm, one is able to analytically determine cyanide in a fluorescence ratiometric manner.

Figure 7 – Fluorescence emission spectra of Cyanide 3™ with increasing concentrations of aqueous cyanide, left, and the respective ratiometric plot using the intensities at 390 and 455 nm, right.
Cyanide Orange™

Ursa BioScience offers a “Turn-On” Cyanide Fluorescence Sensor, our longest wavelength emission Cyanide Sensor ≈ 575 nm. The probe has particular merit in the low cyanide concentration range, i.e. < 20 µM, and can be used as an intensity ratiometric probe.

**Figure 8** – Fluorescence emission spectra of Cyanide Orange™ with increasing concentrations of aqueous cyanide, left, and the respective ratiometric type plot using the initial fluorescence intensity, I’, at 570 nm in the absence of cyanide, and in the presence of increasing cyanide concentrations, I, right.

Fluorescence Intensity based Cyanide Detection

Cyanide Violet™

Ursa BioScience offers a range of Fluorescence Intensity Cyanide Detection Probes. Our Cyanide Violet™ 1-3 range chelate free cyanide and show a decrease in fluorescence intensity as a function of increasing cyanide concentration. These probes can readily be excited at 300-350 nm, with an emission ≈ 440 nm. Cyanide Violet™ 2 shows an ≈ 12-fold decrease in fluorescence intensity with 30 µM free cyanide, which is ideal for cyanide environmental or physiological safeguard monitoring. The dissociation constants for Cyanide Violet™ 1-3 are 16.7, 16.9 and 15.9 µM³ respectively. The mean fluorescence excited-state lifetime of Cyanide Violet™ 1 is 4.01 ns.

Ursa BioScience also offers a convenient Control Em...
Compound for our Cyanide Violet™ range of fluorophores, namely Cyanide Violet C™. Our Cyanide Violet C™ has the same chromophore fluorescent backbone, but has been specifically designed to not chelate dissolved cyanide and is therefore not influenced by cyanide. For researcher’s and physicians alike undertaking quantitative cyanide analysis in an intensity fashion, Cyanide Violet C™ allows for any background interference of Cyanide Violet™ to be corrected for, while conveniently not changing any fluorescence instrumentation or filter settings. Subsequently, Cyanide Violet C™ does not show any notable response to cyanide. Cyanide Violet C™ can be readily excited from 300-350 nm, with an emission centered at 440 nm. The Stern-Volmer quenching constant of Cyanide Violet C™ is a very small 0.8 nM$^{-1}$, i.e. negligible. The fluorescence excited state lifetime of Cyanide Violet C™ in water is a monoexponential 2.59 ns.

**Cyanide Blue™**

Ursa BioScience’s Cyanide Blue™ fluorophores are similar to the Cyanide Violet™ product range, except that Cyanide Blue™ can readily be excited from 300-400 nm, with a slightly red shifted emission at $\approx$ 460 nm. The dissociation constants for Cyanide Blue™ 1-3 are 52.9, 84.0 and 20.8 µM$^{-1}$ respectively. The monoexponential fluorescence excited-state lifetime of Cyanide Blue™ 1 is 26.71 ns, with a Quantum Yield $\approx$ 0.5.

Cyanide Blue C™ is a convenient Control Compound for Cyanide Blue™, which does not chelate cyanide and show a fluorescence intensity decrease. Cyanide Blue C™ can readily be excited from 300-400 nm, with emission centered around 460 nm in the Blue region of the visible spectrum. The Stern-Volmer free cyanide quenching constant of Cyanide Blue C™ is 3.0 nM$^{-1}$ with a monoexponential excited state fluorescence lifetime of 27.30 ns.

**Figure 10** – Fluorescence emission spectrum of Cyanide Blue 3™ in the presence of increasing cyanide concentrations, $\lambda_{ex} = 345$ nm.

**References Cited**


