

Enhancing Bioprocess Monitoring with Atlas™

Real-Time Flow Cell Analytics for Upstream and Downstream Applications

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Abstract

Nirrin Technologies is redefining bioprocess monitoring with Atlas™, an advanced flow cell-based analytical platform powered by High-Precision Tunable Laser Spectroscopy (HPTLS™).

With the sensitivity and accuracy of HPLC—but without complex assay development—Atlas™ accelerates process development, enhances process control, and supports the transition to fully automated biomanufacturing.

Introduction

Designed for perfusion cell culture, ultrafiltration/diafiltration (UFDF), buffer preparation, and chromatography, Atlas™ delivers in-line quantitation of critical process parameters (e.g., product titer, buffer composition, and excipient concentrations). This eliminates the need for offline sampling and reduces process variability.

Here we show the core technology of HPTLS and specific customer use-cases from upstream perfusion culture and downstream UFDF.

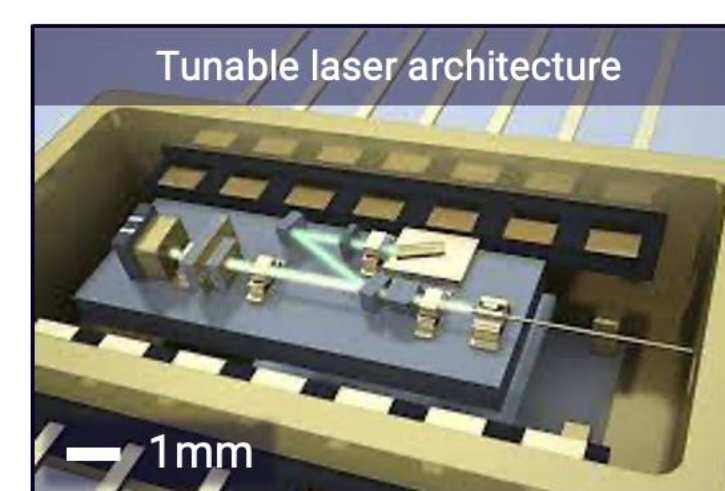
Methodology

Spectral characteristics of NIR

SECOND OVERTONE															COMBINATION BANDS				
THIRD OVERTONE						FIRST OVERTONE													
CH NH OH						OH			SH			OH			NH CH+CH		CH+CC		
CH		CH		NH CH		CH		NH		CH		C=O		NH+OH					
$\nu[\text{cm}^{-1}]$	14000		10000		8000				6000		5000		4500		4000				
$\lambda[\mu\text{m}]$	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5

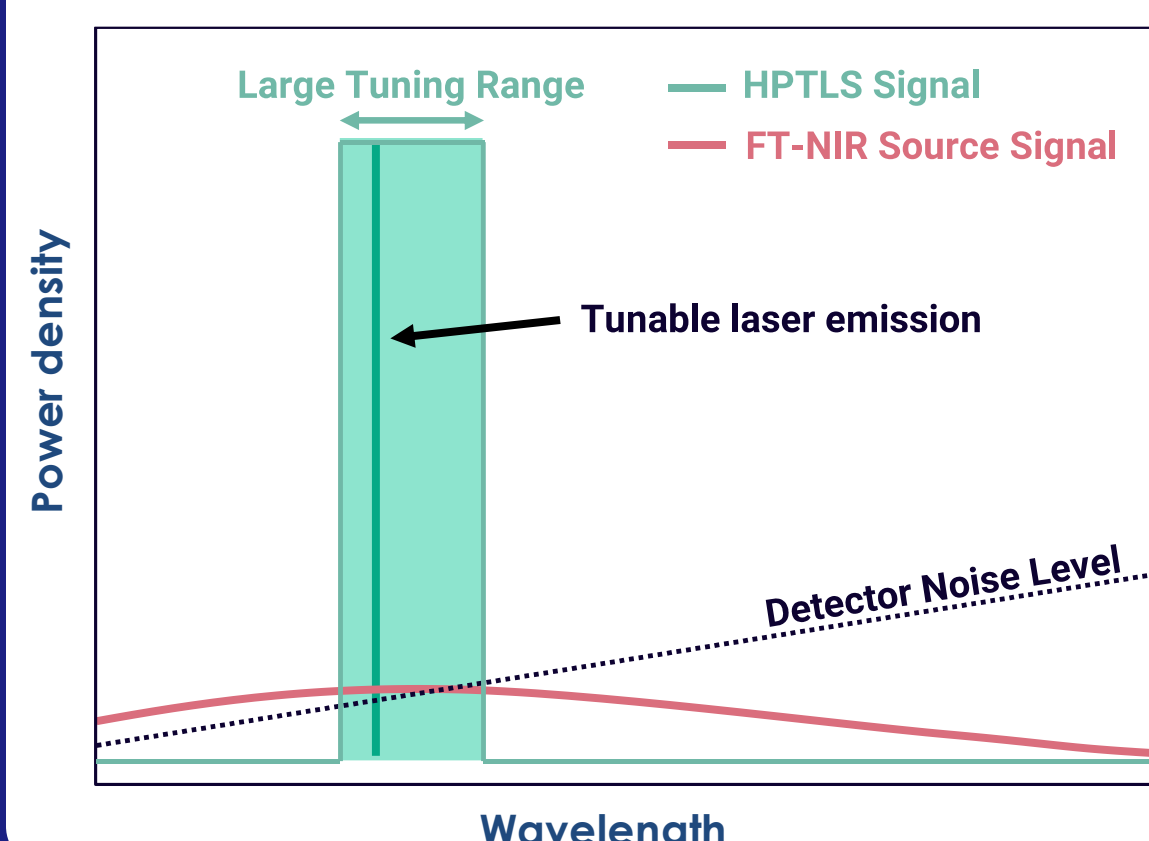
Absorbance / sensitivity	
Higher-order transitions, lower probability	Sum or difference of fundamental vibrations, leading to stronger absorption
Quantification & Linearity	
Can be nonlinear due to weak transitions	More linear absorbance behavior, improving quantitative accuracy
Selectivity	
Crowded spectral regions, causing overlap among analytes	More distinct, reducing interferences

Laser characteristics



- MEMS-based Fabry-Perot filter capable of tuning 200-300nm
- 0.1-1.0 nm spectral width FWHM across entire tuning range
- Proprietary gain chip generates light in the combination band region
- Full sweep in 100 msec

Nirrin makes the only combination band tunable laser capable of 200-300nm tuning range



- 100X higher power density than broadband light source, it yields wider dynamic range than other technologies
- Proprietary wavelength and amplitude referencing provides a calibrated spectrum with each scan: accurate library transfer across systems; best-in-class signal-to-noise (SNR) spectrometer currently available (± 10 μAU repeatability across spectrum)

High-Precision Tunable Laser Spectroscopy (HPTLS) targets the **combination band** region of NIR (2,140–2,350 nm), enabling **stronger, more linear absorbance** than higher-order overtone regions

Sugars: (glucose, sucrose, trehalose etc.). CH stretch + CH bend, OH stretch + deform

Amino acids: (histidine, arginine. etc.), NH + CH (from the amine group and side chain). OH + CH or NH + NH

Proteins: (mAbs). NH groups → NH combination bands. Side chains → CH + CH, CH + NH, etc.

Surfactants: (PS20, PS80, P188). CH + CH, CH + OH from fatty acid chains and ethoxylated regions

Applications of Atlas Flow NIR-HPTLS system

Upstream (simplified)

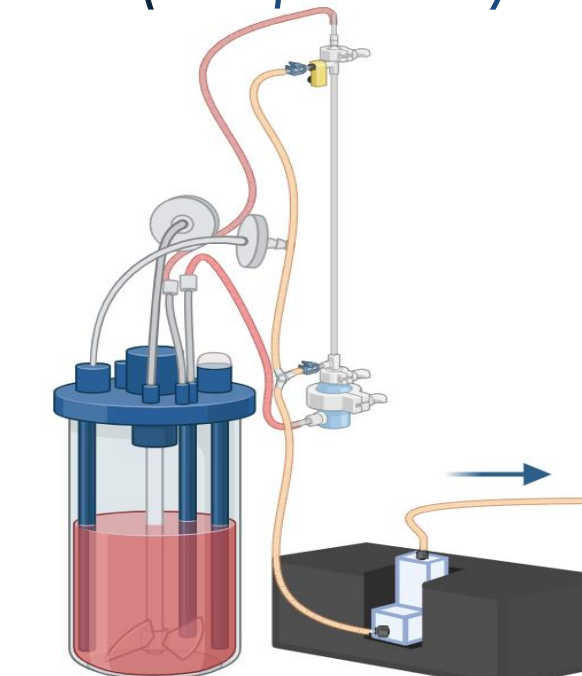


Figure 1: A perfusion bioreactor setup. The flow cell is attached to the outlet of a cell retention device, prior to the next process step.

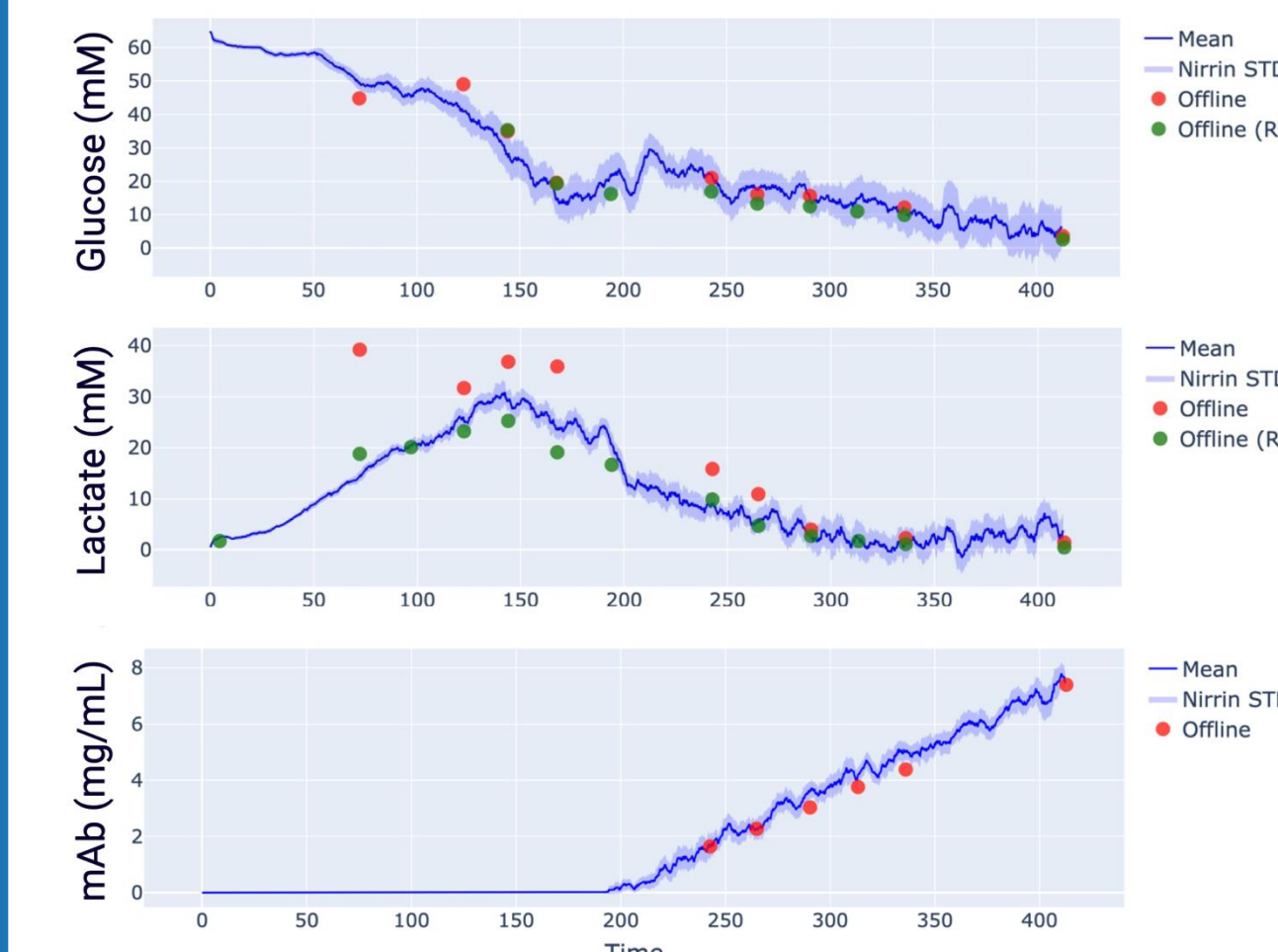
Downstream (simplified)



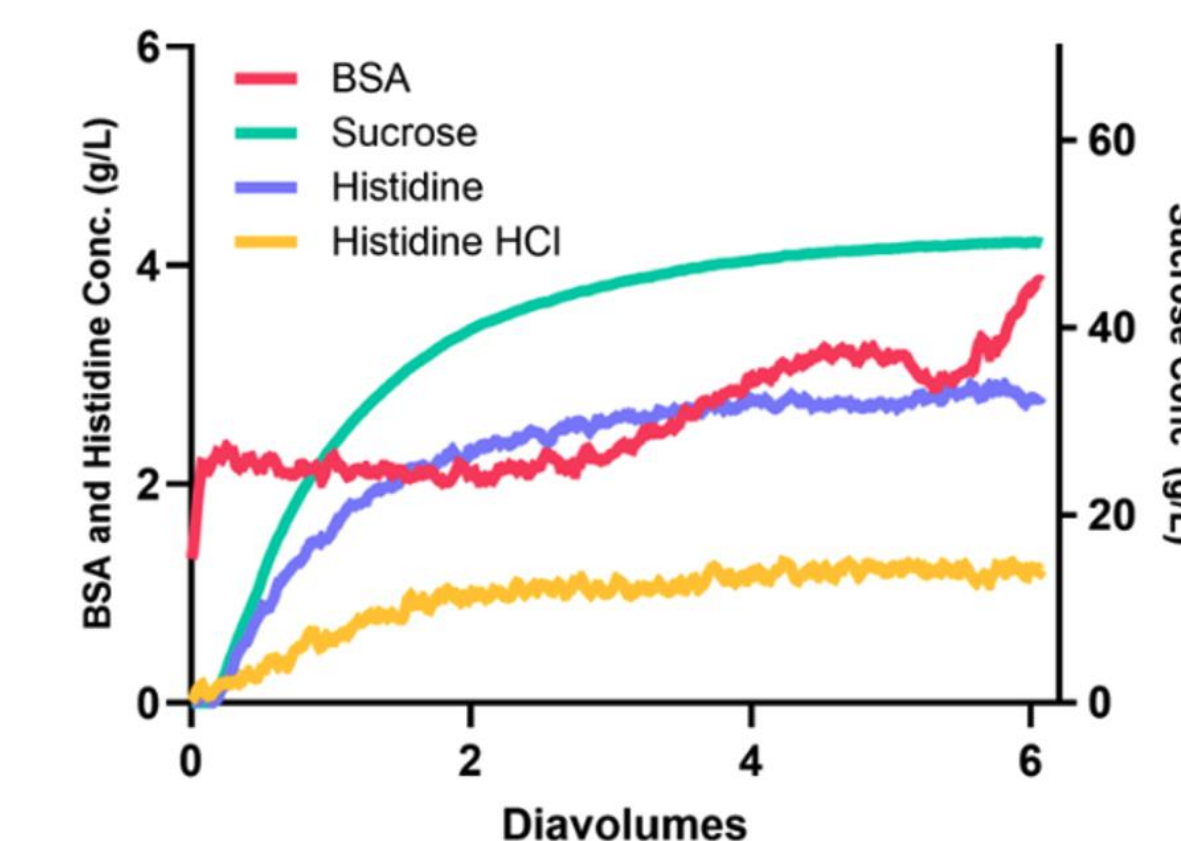
Figure 2: A TFF setup. Highlighted is the removable flow cell in the retentate line and laser path through the sample via optical windows on the flow cell

Results

Upstream perfusion



Downstream UFDF



Conclusion

Atlas Flow NIR-HPTLS system is a superior PAT tool which is a game changer for a real-time monitoring across the entire development and production process enabling traceable, automated, and repeatable workflow.