



Application Note AN-PAN-1065

拉曼光谱在线监测细胞培养物

Cell culture is a key part of the biopharmaceutical industry to monitor the health of cells. Tight control of this process is necessary to overcome unwanted side reactions or poor yields.

Glucose is essential for cell energy, but its conversion to energy through glycolysis produces lactate. Lactate accumulation induces acidity, causing cellular stress and reduced cell growth rates.

Manual laboratory methods can be quite cumbersome and can introduce bias depending on the analyst, resulting in inaccurate results and

sample contamination. To address these issues, inline Raman spectroscopy is a very well-suited analysis technique for this industry as it does not require any reagents and the sample remains unaltered.

This Process Application Note presents a method to accurately monitor cell growth inside a bioreactor in «real-time» with the 2060 Raman Analyzer from Metrohm Process Analytics. In this case, an inline process analyzer is the preferred solution to guarantee high product quality and avoid contamination from measurement.

INTRODUCTION

Cell culture is an essential step in the production of a wide range of biopharmaceuticals, including complex therapeutic proteins, monoclonal antibodies, and vaccines [1]. This process involves growing cells in a controlled environment, typically in a bioreactor, to produce the desired product.

Glucose is an important component of cell culture, as it provides cells with the energy they need to grow, divide, and form the final product [2]. **Figure 1** illustrates the fundamental process of converting glucose into energy within a cell.

The conversion of glucose to energy (i.e., glycolysis) results in the production of lactate, the ionized form of lactic acid. Accumulation of lactate in cell culture media can adversely impact cell growth and productivity. As lactate functions as an acid, its buildup in the culture medium can lower the pH, inducing cellular stress and diminishing growth rates [4].

To prevent lactate accumulation, manufacturers must monitor and adjust cell culture conditions to maintain lactate levels within an acceptable range. This may involve continuously measuring the glucose concentration in the culture medium, ensuring precise adjustments to prevent over- or underdosing.

Typically, analysts perform such measurements manually (offline). However, contamination is common in this setup, and the data fails to reflect the true state of the cell culture process.

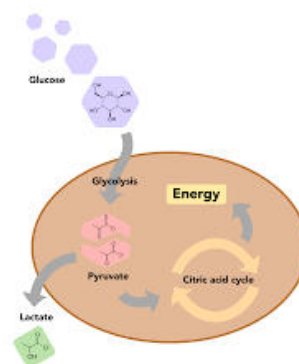


Figure 1. Overview of glucose mechanism in human cells. Extracted from [3].

INTRODUCTION

A safer, more efficient, and faster way to monitor multiple parameters simultaneously in bioreactors is via inline analysis with reagent-free Raman spectroscopy (**Figure 2**). This is a

nondestructive and non-contact technique – thus it is ideal for inline analysis directly at the bioreactor (**Figure 2**, left side).

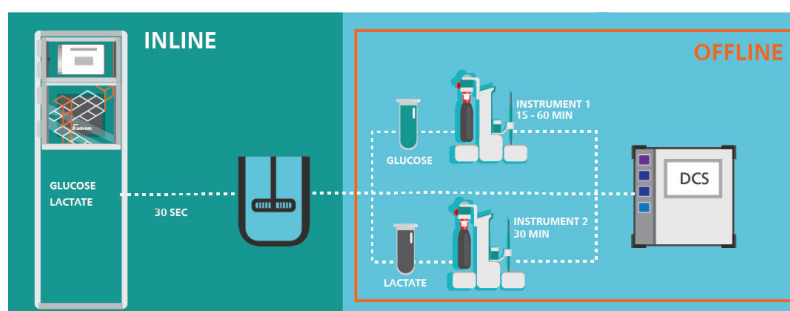


Figure 2. Steps to measure glucose and lactate in a bioreactor by implementing inline (left) or offline (right) analysis.

The 2060 Raman Analyzer by Metrohm Process Analytics enables the comparison of «real-time» spectral data from the process to a reference method (e.g., titration, ion chromatography, HPLC) to create a simple, yet indispensable calibration model for monitoring glucose and lactate in the cell culture bioreactor.

«Real-time» analysis of the state of the culture keeps the glycolysis reaction within control. Additionally, inline analysis can provide information about the current state of different processes (e.g., substrate consumption and kinetics).

APPLICATION

Laser used: 785 nm. Inline analysis is possible using an autoclavable immersion probe designed by Metrohm Process Analytics. Spectral data was collected with a 2060 Raman

Analyzer (**Figure 3**) by using both IMPACT and Vision software from Metrohm. Measurements were collected every minute.

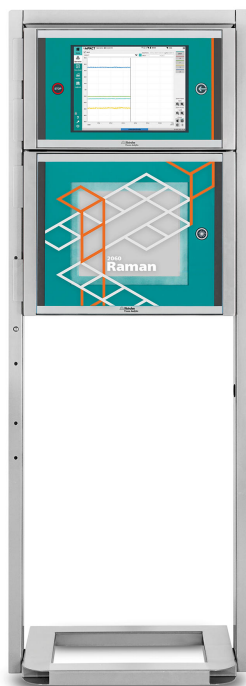


Figure 3. 2060 Raman Analyzer for quantitative analysis of lactate and glucose in a cell culture bioreactor.

Table 1. Prediction accuracy of the two measured parameters in a cell culture bioreactor as analyzed by the 2060 Raman Analyzer (Figure 3).

	Glucose	Lactate
Minimum concentration	0.1 g/L	0.0 g/L
Maximum concentration	40 g/L	5.0 g/L
Bias	-0.1349	-0.0849
SEP	0.2009	0.1166

CONCLUSION

Raman spectroscopy is used for many different applications and industries where high-quality data is essential. The 2060 Raman Analyzer is a high-performance Raman system designed for operations like cell culture monitoring, which

require non-contact analysis. Together with Metrohm's Vision and IMPACT software, the 2060 Raman Analyzer can be used to acquire near real-time results, supporting time-critical processes such as pharmaceutical development.

BENEFITS FOR RAMAN IN PROCESS

- Early detection of batch failures during cell culture.
- Multiple parameters from a single measurement.
- Minimize risks of sample contamination by being a non-contact technique.
- Unique Raman spectra that serve as specific fingerprints for **material identification**.
- **Low signals from water** or moisture which complements other spectroscopy techniques.
- **Nondestructive** technique, thus ideal for inline analysis.



REFERENCES

1. *Cell Culture for Manufacturing*.
https://www.sigmaaldrich.com/NL/en/applications/cell-culture-and-cell-culture-analysis/cell-culture-for-manufacturing?gclid=Cj0KCQiA35urBhDCARIsAOU7QwnVfiHJBACARsDiW_HbgHGXW3Fs-69CzCg6ottMMj-nmakHFZ5QTrUaAt10EALw_wcB
(accessed 2023-11-29).
2. *Glucose in Cell Culture*.
<https://www.sigmaaldrich.com/NL/en/technical-documents/technical-article/cell-culture-and-cell-culture-analysis/mammalian-cell-culture/glucose>
(accessed 2023-11-29).
3. admin. The Circle of Lactate: How Cancer Cells Can Reuse Their Own Waste. *Science in the News*, 2018.
4. Li, Z.-M.; Fan, Z.-L.; Wang, X.-Y.; et al. Factors Affecting the Expression of Recombinant Protein and Improvement Strategies in Chinese Hamster Ovary Cells. *Front Bioeng Biotechnol* **2022**, *10*, 880155. <https://doi.org/10.3389/fbioe.2022.880155>.

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CONFIGURATION



2060 Raman

2060 Raman Analyzer 是一款非破坏性的在线过程分析仪,采用 Raman 光谱技术,可提供准确和实时的过程监控。凭借其自我监控功能、高通过量光谱仪和实用的激光稳定性,它可以立即了解化学成分,并能及时调整以实现非常好的过程控制,确保一致的产品质量,并提高整体工作效率。

可在分析仪上连接多达 5 个探头和/或流通池。所有 5 个通道均可在嵌入式专有软件中相互独立地配置。