



Application Note AN-NIR-099

# Quality Control of fermentation broths

## Multiparameter determination within one minute

Cell fermentation processes are a reliable production method for small molecules and protein-based active pharmaceutical ingredients (APIs), allowing pharmaceutical companies to optimize the production process and reduce time to market. The fermentation process requires monitoring of many different parameters to ensure optimal production. These quality parameters include (but are not limited to) pH, bacterial content, potency, glucose, and

concentration of reducing sugars. Traditional laboratory analysis takes a significant amount of time and requires different analytical techniques to monitor these quality parameters in the fermentation process.

Near-infrared spectroscopy (NIRS) offers a faster and more cost-efficient alternative to traditional methods for the determination of critical parameters in fermentation broths at any stage of the fermentation process.

## EXPERIMENTAL EQUIPMENT

Fermentation broth samples taken at different fermentation times were measured in reflection mode with the Metrohm DS2500 Solid Analyzer. Because the samples were dark in color (yellow-brown), they were measured without needing to use the gold reflector and required no sample preparation. The Metrohm software package Vision Air Complete was used for all data acquisition and prediction model development.



**Figure 1.** DS2500 Solid Analyzer.

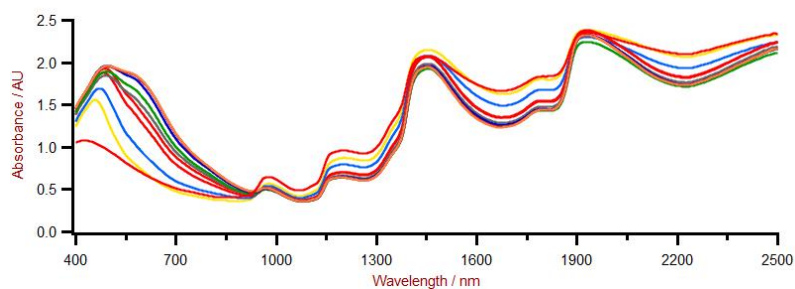
**Table 1.** Hardware and software equipment overview

Equipment	Metrohm number
DS2500 Solid Analyzer	2.922.0010
NIRS transfection vessel	6.7401.000
NIRS Mini Sample Cup Holder for DS2500	6.7430.040
Vision Air 2.0 Complete	6.6072.208

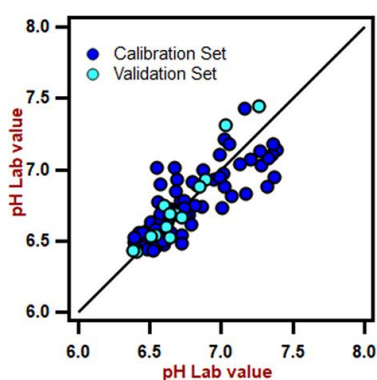
## RESULT

The obtained Vis-NIR spectra (**Figure 2**) were used to create prediction models for quantification of the bacterial, glucose, and reducing sugars concentration, as well as the pH and potency. The quality of the prediction models was evaluated using the correlation diagram, which displays a high correlation

between the Vis-NIR prediction and the reference values. The respective figures of merit (FOM) display the expected precision of a prediction during routine analysis. Potency (**Figures 7 and 8**) was measured with two different laboratory methods as described in **Table 8**.



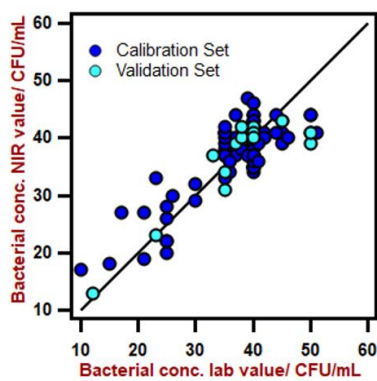
**Figure 2.** Vis-NIR spectra of fermentation broth samples taken at different fermentation times and analyzed on a DS2500 Solid Analyzer.



**Figure 3.** Correlation diagram for the prediction of pH in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using a pH meter.

**Table 2.** Figures of merit for the prediction of pH in fermentation broth using a DS2500 Solid Analyzer.

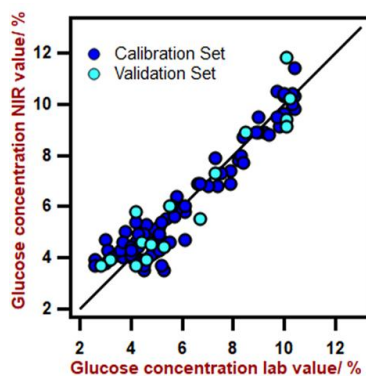
Figures of merit	Value
$R^2$	0.6461
Standard error of calibration	0.1645
Standard error of cross-validation	0.1686
Standard error of validation	0.0997



**Figure 4.** Correlation diagram for the prediction of bacterial concentration in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using UV-Vis spectrophotometry.

**Table 3.** Figures of merit for the prediction of bacterial concentration in fermentation broth using a DS2500 Solid Analyzer.

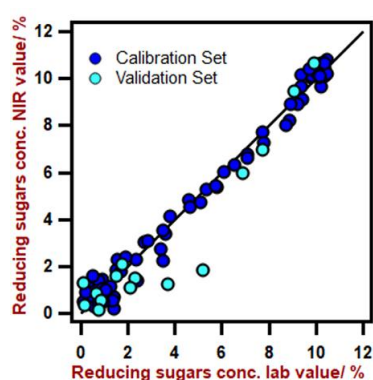
Figures of merit	Value
$R^2$	0.7086
Standard error of calibration	4.6884 CFU/mL
Standard error of cross-validation	4.7429 CFU/mL
Standard error of validation	5.0916 CFU/mL



**Figure 5.** Correlation diagram for the prediction of glucose concentration in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using HPLC.

**Table 4.** Figures of merit for the prediction of glucose content in fermentatoin broth using a DS2500 Solid Analyzer.

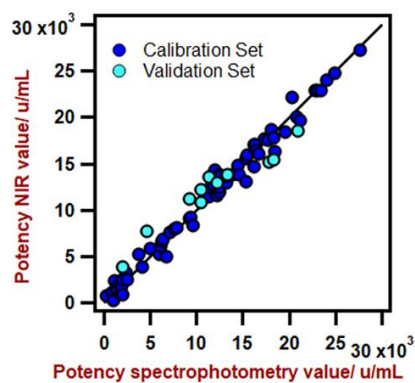
Figures of merit	Value
R <sup>2</sup>	0.9165
Standard error of calibration	0.6938%
Standard error of cross-validation	0.7896%
Standard error of validation	0.8628%



**Figure 6.** Correlation diagram for the prediction of reducing sugars in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using HPLC.

**Table 5.** Figures of merit for the prediction of sugars content in fermentation broth using a DS2500 Solid Analyzer.

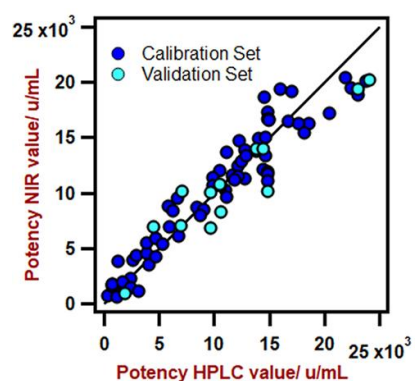
Figures of merit	Value
R <sup>2</sup>	0.9863
Standard error of calibration	0.4767%
Standard error of cross-validation	0.6821%
Standard error of validation	1.2429%



**Figure 7.** Correlation diagram for the prediction of potency in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using UV-Vis spectrophotometry.

**Table 6.** Figures of merit for the prediction of potency in fermentation broth using a DS2500 Solid Analyzer.

Figures of merit	Value
$R^2$	0.9083
Standard error of calibration	2295 u/mL
Standard error of cross-validation	2968 u/mL
Standard error of validation	2089 u/mL



**Figure 8.** Correlation diagram for the prediction of potency in fermentation broth using a DS2500 Solid Analyzer. The lab value was evaluated using HPLC + PCR.

**Table 7.** Figures of merit for the prediction of potency in fermentation broth using a DS2500 Solid Analyzer.

Figures of merit	Value
R <sup>2</sup>	0.9156
Standard error of calibration	1913 u/mL
Standard error of cross-validation	2172 u/mL
Standard error of validation	1168 u/mL

## CONCLUSION

This application note demonstrates the feasibility to determine key parameters of the quality control of the fermentation process with NIR spectroscopy. The main advantages of Vis-NIR spectroscopy over wet chemical methods

are that running costs are significantly lower and time-to-result is significantly reduced. Additionally, no chemicals are required, and the technique is non-destructive to the samples.

**Table 8.** Time to result overview for the different quality parameters

Parameter	Method	Time to result
pH	pH Meter	~ 3–5 minutes
Bacterial concentration	UV-Vis	~ 8 hours (sample preparation) + ~ 1 minute (UV-Vis)
Glucose and reducing sugars concentration	HPLC	~ 30–45 minutes
Potency	UV-Vis	~ 7 minutes (sample preparation) + ~ 1 minute (UV-Vis)
Potency	HPLC + PCR	~ 1 hour (sample preparation) + ~ 20 minutes (HPLC + PCR)

Internal reference: AW NIR CN-0017-112021

## CONTACT

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### DS2500 Solid Analyzer

固耐用的近外光,用于生境和室中的量。

DS2500 分析是的活解决方案,用于整个生程中的固体、乳膏和液体行常分析。其固耐用的使 DS2500 Analyzer 分析不受灰、湿度、振和温度波的影,因此非常用于在劣的生境中使用。

DS2500 涵盖了从 400 到 2500 nm 的整个光范,并能在不到一分内提供准和可再的果。DS2500 Analyzer 足制行的要求,并由于操作便而能助用完成其日常工作任。

由于与完美匹配,附件可以承受任何具有挑性的品型,例如:粒料之的粗粒固体或乳膏之的半固体品,可得最佳果。量固体的候,使用 MultiSample Cup 可以提高生率,可以自批测量最多 9 个品。



### NIRS

液体行光量的光学平面透射反射器皿。可与下列合使用:

- NIRS DS2500 Analyzer(号:2.922.0010)
- NIRS XDS MasterLab Analyzer(号:2.921.1310)
- NIRS XDS MultiVial Analyzer(号:2.921.1120)
- NIRS XDS RapidContent Analyzer(号:2.921.1110)
- NIRS XDS RapidContent Analyzer - Solids(号:2.921.1210)





## DS2500

本支架使用搭配:

- 小品容器 (6.7402.030)
- DS2500 Iris (6.7425.100)



## Vision Air 2.0 Complete

Vision Air – 通用的光分析件。

Vision Air Complete 是用于管范境的先易用的件解决方案。

Vision Air 点一:

- 独特的件用和配的用界面保了直的操作方式
- 操作程的建与方式
- SQL 数据,可安全且地管理数据

Vision Air Complete (66072208) 版本包含所有用于可近外光分析量保程的用:

- 器和数据管理用
- 方法用
- 常分析用

其它 Vision Air Complete 解决方案:

- 66072207 (Vision Air Network Complete)
- 66072209 (Vision Air Pharma Complete)
- 66072210 (Vision Air Pharma Network Complete)