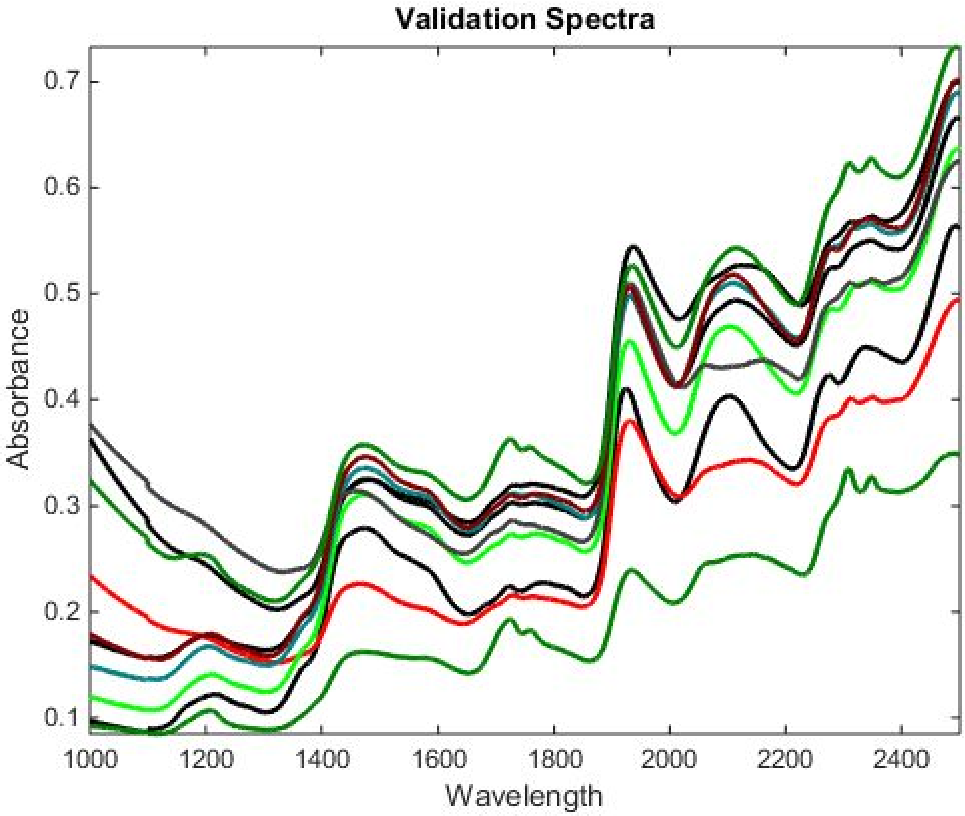
NIR Application Note NIR-038

Fast measurement of biochemical methane potential (BMP) by NIRS



This Application Note shows that the NIR solution based on the combination of Metrohm NIRS DS2500 analyzer and Ondalys Flash BMP® calibration model offers time-saving and an increased efficiency of BMP evaluation of different kinds of substrates that are used in anaerobic digestion during the biogas production. In contrast to the standard method, the results can be obtained within a few minutes. Therefore, this solution offers an alternative way to optimize digestion process and to obtain higher methane yields.

Metrohm NIRSystems

Method description

Introduction

Methane is the main component of a biogas which is produced by anaerobic digestion of wastes (one of the most established technologies). In order to manage and increase the methane yield, the Biochemical Methane Potential (BMP) is a commonly used parameter to determine the volume of methane that is produced by the biodegradability of wastes. The conventional BMP test method is based on a fermentation process that directly correlates to the composition of organic matter, such as carbohydrates, proteins, lipids, and fibers. However, this method is very time consuming, takes up to 30 to 40 days and therefore it is not suitable as a management tool for anaerobic digestion optimization. In contrast, Near-infrared Spectroscopy (NIRS) can be used for fast analysis of the substrate, used in biogas production. In combination with the Flash BMP® calibration model provided by Ondalys, the BMP value of organic substrates can be determined within one minute without any additional chemicals.

Configuration

Table 1: Used equipment.

Equipment	Metrohm code
NIRS DS2500 Analyzer	2.922.0010
NIRS DS2500 sample cup	6.7425.100
Vision Air software	6.6072.111
Flash BMP calibration model	(by Ondalys)

Fig. 1: A NIRS DS2500 Analyzer was used to analyze samples.

Experimental

The Flash BMP® calibration model was created in a collaboration between Ondalys, Veolia and the laboratoire de Biotechnologie de l'Environnement (INRA-LBE); it involved the collection of approximately 500 samples and their respective NIR spectra. The sample set includes the following types of materials: agro-industrial waste, biowaste, energy crops, agricultural residues, fatty waste, plants and vegetables, agro-industrial sludge, sewage sludge and digestate. The conventional method to assess the BMP value which was used to provide the reference values for the NIR calibration development was described in detail by Angelidaki et al., (2009). The correlation plot and the calibration details are shown in Fig. 2 and Tab. 2 (respectively).

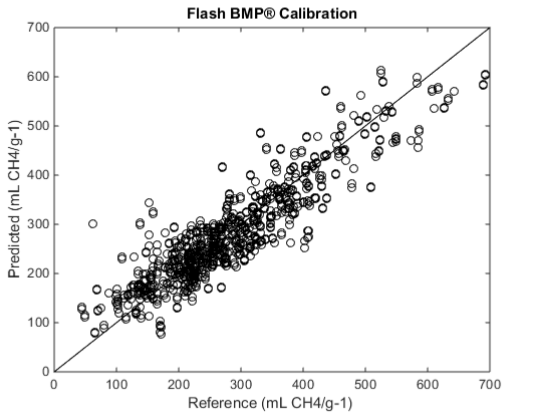


Fig. 2: The correlation plot of the PLS regression of the samples from the Flash BMP® calibration model.

Tab. 2: Details of the Flash BMP® calibration model

No. of samples	Approx. 500
Calibration Range	20-700 mL $CH_4 \cdot g^{-1}$ VS
Model accuracy	15-20 (% deviation)
Model validity	• Green waste • Agricultural waste • Energy crops • Agro-industrial waste • Municipal solid waste • Sludge

Method description

In this application note, ten different substrates with BMP values from 209 to 443 milliliter of methane per gram of volatile solids (mL $CH_4 \cdot g^{-1}$ VS) were used to validate the accuracy and the robustness of the Flash BMP® calibration model (Tab. 3). The samples were frozen and dried to allow easy grinding, which improved the homogeneity of the final samples for more accurate results. For the NIR measurement, Metrohm NIRS DS2500 Analyzer was used. The Flash BMP® calibration model from Ondalys was imported to the Vision Air software to predict the BMP values.

Tab. 3: Substrates used for validation.

Sample name	Substrate type
S0370	Manure
S0380	Flower
S0388	Manure
S0390	Sorghum
S0391	Energy crop
S0393	Wheat
S0394	Manure
S0401	Wheat, Sorghum, Millet
S0413	Sunflower
S0419	Fat

Results

The spectra of the validation samples are shown in Fig. 3. The spectral data of the samples were acquired using Vision Air and the constituent values were evaluated with the Flash BMP® calibration model.

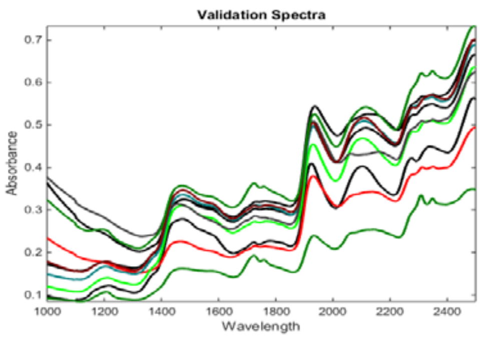


Fig. 3: NIR spectra of the validation samples.

The predicted BMP values compared to the reference values are shown in Tab. 4. The results of the validation were comparable to the accuracy of the reference method. The Standard Error of Prediction (SEP) was 14.3 mL CH4·g-1 VS and the Root Mean Square of Standard Deviation (RMSD) was 14.8 mL CH4·g-1 VS. Ten analyzed samples showed a standard deviation between 0.5 and 8.8%. The results of the validation were thus acceptable.

Tab. 4: comparison between BMP values (in mL $CH_4 \cdot g^{-1}$ VS) from the reference method and the NIR prediction.

Sample	Reference value	NIR predicted	% Deviation
S0370	228	229	0.5
S0380	303	306	1.0
S0388	216	197	8.8
S0390	291	283	2.8
S0391	296	283	4.4
S0393	334	309	7.5
S0394	209	196	6.3
S0401	259	274	5.8
S0413	304	288	5.3
S0419	443	460	3.9

Method description

Conclusion

This application note demonstrates the benefits of using NIR spectroscopy for the determination of BMP values in different substrates used for the methane production in biogas plants. The combination of the Metrohm NIRS DS2500 Analyzer with the ready-to-use Flash BMP® calibration model provided by Ondalys enable a fast analysis of BMP without the use of any additional chemicals. The results can be achieved with Vision Air easy-to-use software within few minutes, which is much faster than the conventional method.

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