HYPEREAL

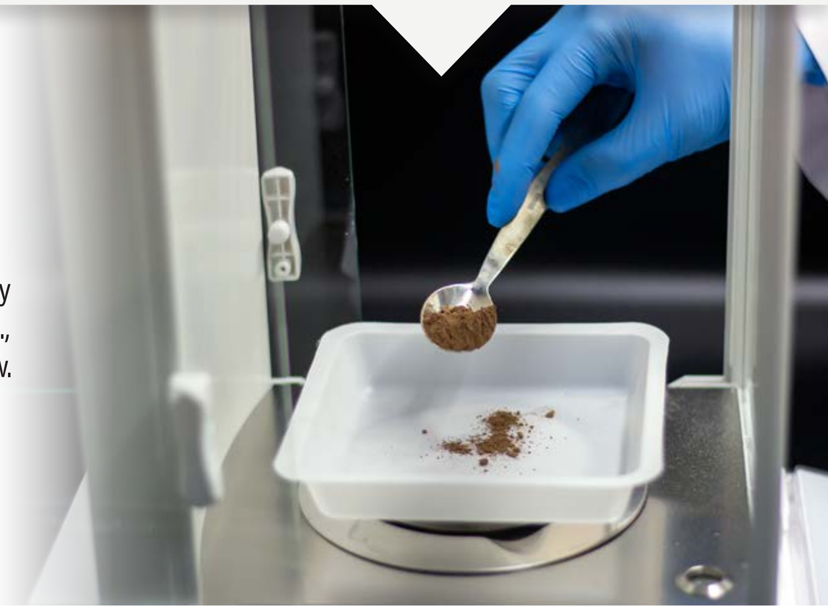
NIR HYPERSPECTRAL IMAGING

CHAUVIN ARNOUX
INDATECH

Chemicals Agri-food

Evaluation of the enzymatic reactivity of biomass using near-infrared imaging

The transformation of biomass into bioethanol by hydrolysis offers a promising solution to the growing demand for renewable energy. However, the presence of inhibitors may weaken the reactivity of the enzymes which perform the hydrolysis, thus leading to reduced yields. Consequently, to optimize this process, the enzymatic reactivity within the biomass must be evaluated. This approach allows you to select biomasses demonstrating optimum enzymatic reactivity, thus boosting the quality and efficiency of the bioethanol production process.



Objective: Classification of biomass pellets according to their enzymatic reactivity

This study is part of a collaborative project between Indatech and IFP Energies nouvelles (IFPEN, France). Its goal is to classify biomass pellets from various sources such as straw, poplar, etc., according to their hydrolytic reactivity, whether standard or low.

Indeed, the structure of certain types of biomass and the presence of inhibitors may hinder the hydrolytic process, thus limiting bioethanol production.

The use of near-infrared chemical imaging (NIR-CI) offers the advantage of several simultaneous measurements on multiple samples while allowing detailed mapping of each sample.

HypeReal: the solution for at-line analysis of your critical parameters

INDATECH proposes a unique inspection solution capable of analyzing a wide variety of solid samples by means of repeatable contactless measurements performed from beneath the sample.

Our HypeReal technology is the ideal tool for quick, non-destructive analysis of powders in the laboratory.

This spectroscopic equipment can be used to:

- Characterize powder blends
- Quantify the chemical composition of solid samples
- Qualify physical aspects such as the homogeneity and dispersion of contaminants in the sample

How to measure biomass

The analyses were performed using our HypeReal spectrometer, featuring with a spectral range extending from 935 to 1720 nm, 8 nm spectral resolution, and 300 µm/pixel spatial resolution. Each measurement line comprises 640 pixels in total.

For these analyses, the biomass pellets were measured from below using a pushbroom imaging camera with a quartz sample holder. This approach allows reproducible measurements at a fixed distance on a flat sample surface.

The acquisition parameters were adjusted to a 9 s integration time and a frequency of 25 frames per second. A 99% reflectance standard integrated in the quartz sheet was used as the I0 reference for calculating the sample holder.

Results and discussion

The data were analyzed using the HypeReal's integrated «Breeze» software and PLS_Toolbox 9.1 supplied by Eigenvector Research, Inc.

A set of 31 samples was measured using HypeReal with the aim of classifying the enzymatic reactivity of the biomass (Standard/ Low). 22 samples were used to create a PLS-DA (Partial Least Squares-Discriminant Analysis) classification model, while the 9 remaining samples were kept back to validate the robustness of the model constructed.

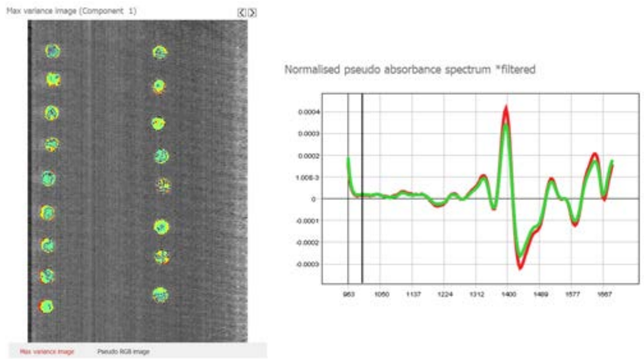
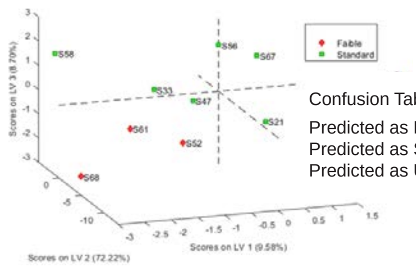


Figure 1:
Image of the calibration samples in the Breeze software, with the preprocessed mean spectra (SG derivation + SNV standardization) of just a few pixels selected (red for samples showing low enzymatic reactivity, green for standard reactivity)

The mean of pixels per sample image was calculated and used in development of the PLS-DA model.



Confusion Table:	Actual Faible	Class Standard
Predicted as Low	3	0
Predicted as Standard	0	6
Predicted as Unassigned	0	0

Figure 2 :
Results of the prediction fr the validation set by the PSL-DA model using PLS_Toolbox in MATLAB

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+33 4 80 78 01 40

The entire validation set was correctly predicted by the PLS-DA classification model. This model was then used to predict each pixel in the sample images.

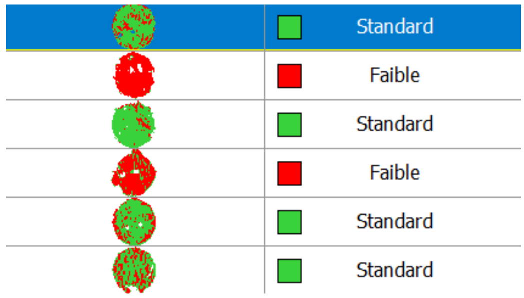

Figure 3 :
Prediction of the images of a few samples of the validation set in the Breeze software

The prediction of the whole image offers detailed information on the composition of the biomass pellets.

Hyperspectral imaging provides additional information by identifying the locations containing inhibitors in the sample, represented by red pixels. In this way, it becomes possible to use large quantities of powdered biomass, helping to speed up the process.

This approach also allows faster sorting of the raw materials containing inhibitors before their conversion into bioethanol.

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Advantages of the HypeReal spectrometer

- Fast, accurate inspections of solid blends even by non-specialized staff
- Provision of dedicated trays for the samples with integration of a reference
- Use of the ergonomic Breeze software for acquisition, analysis and report generation
- Physical and chemical characterization of solid products by means of hyperspectral imaging

FRANCE
Indatech
1900, Boulevard de la Lironde
34980 Montferrier-sur-Lez
Tél : +33 4 80 78 01 40
Fax : +33 4 80 78 01 42
sales@indatech.eu
www.indatech.eu

CHAUVIN ARNOUX
INDATECH