Identification of organic and pharmaceutical powders using a NIR fiber probe with a compact Fabry-Pérot spectrometer

Rapid and reliable identification of materials is essential in modern industrial settings, whether for quality control, raw material inspection, or in-line production monitoring. Near-infrared (NIR) spectroscopy is a leading solution for these tasks thanks to its speed, non-destructive nature, and suitability for analyzing bulk materials in-situ.

With the growing demand for compact and field-ready solutions, spectrometer architectures based on tunable MEMS Fabry-Pérot optical filters have emerged. These designs allow for a very compact form factor and robust performance in industrial environments.

In this application note, we demonstrate that our diffuse-reflection fiber probe is fully compatible with a spectrometer based on a tunable MEMS Fabry-Pérot optical filter. We test this setup using a variety of organic and pharmaceutical powders - including soya protein, microcrystalline cellulose, rice starch, methylcellulose, acetylsalicylic acid, lactose, and sugar - to show the versatility of the fiber-probe solution for diverse end-user applications.

The following equipment was used to perform the measurements:

- Spectrometer NIRONE S2.0 (m-u-t GmbH, Germany): This device utilizes a Fabry–Pérot MEMS Filter and a single-element extended InGaAs detector. It covers a wavelength range of 1550–1950 nm with a typical resolution of 15–21 nm. This design is optimized for a compact form factor and robust performance in industrial environments.

- NIR diffuse-reflection fiber-optic probe AP12353 (art photonics GmbH, Germany). The probe features a 12 mm Hastelloy C22 shaft with a sapphire window at the tip. It is designed with 19 illumination fibers and one detection fiber arranged with special optical design to ensure low straylight levels and high performance.

- Light source: a broadband tungsten-halogen lamp provided the necessary illumination for the spectral analysis.

Seven common organic and pharmaceutical powders were investigated: soy protein, microcrystalline cellulose, rice starch, methylcellulose, acetylsalicylic acid, lactose, icing and regular sugar. A 100% reflectance Spectralon® standard was used as a reference for all measurements.

Figure 1. Measurement setup.

The measurements on the powders were carried out exclusively in bulk mode to simulate industrial process conditions. The fiber-optic probe was immersed directly into a vessel containing the material, mimicking the analysis of bulk powders in-situ. To investigate the reproducibility of the results, measurements were repeated 5 times for each sample with slightly different position of the fibers and the probe. Between each measurement, the probe was pulled out of the vessel and re-inserted to account for variations in sample packing and probe positioning. The spectra obtained from the spectrometer underwent SNV-normalization to minimize scattering effects.

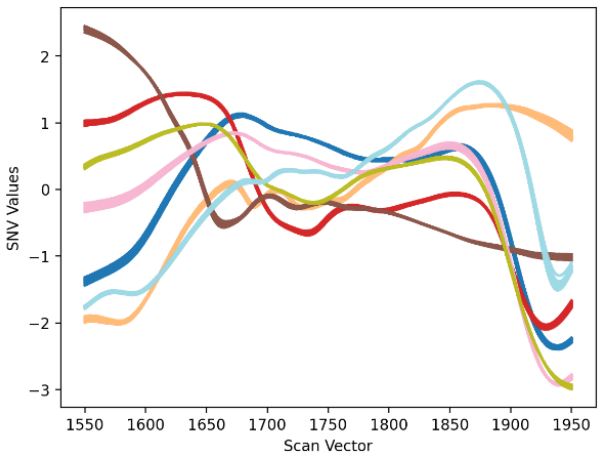

Figure 2. SNV-normalized spectra.

As an initial step, Principal Component Analysis (PCA) was performed to visualize the structure of the spectral dataset and to evaluate whether the different powders could be distinguished based on their spectral signatures. Since no single wavelength allowed unambiguous separation of all seven powder classes, PCA provided a useful multivariate approach for exploring class separability. The PCA scores plot (Figure 3) shows a clear clustering of the materials. After SNV normalization, icing sugar and regular sugar cluster into the same class, indicating highly similar spectral signatures in the investigated wavelength range.

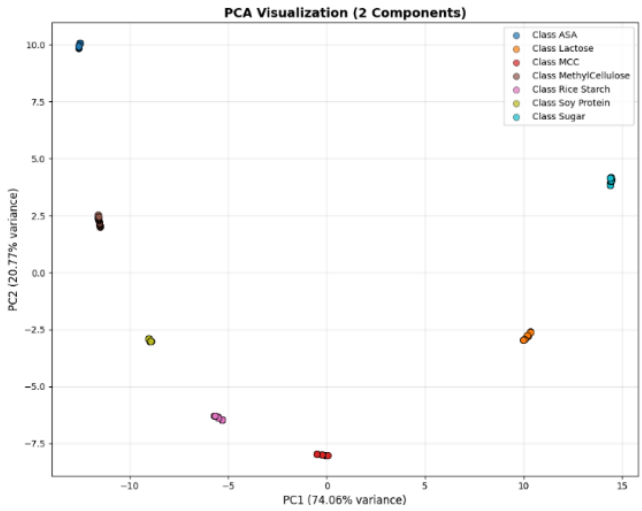

Figure 3. PCA scores plot.

The tight clustering of the measurements belonging to the same material demonstrates excellent reproducibility of the spectra despite the manual repositioning of the probe between measurements. Furthermore, the high proportion of variance explained by the first two principal components indicates that the selected spectral region 1550-1950 nm contains sufficient chemical information for reliable material discrimination.

Based on these results, a supervised classification model using logistic regression was developed using the SNV-normalized spectra. To demonstrate the practical usability of the developed classification approach, the trained logistic regression model was integrated into a mobile application connected to the spectrometer system. The application was installed on a smartphone and served as a user interface for real-time material identification.

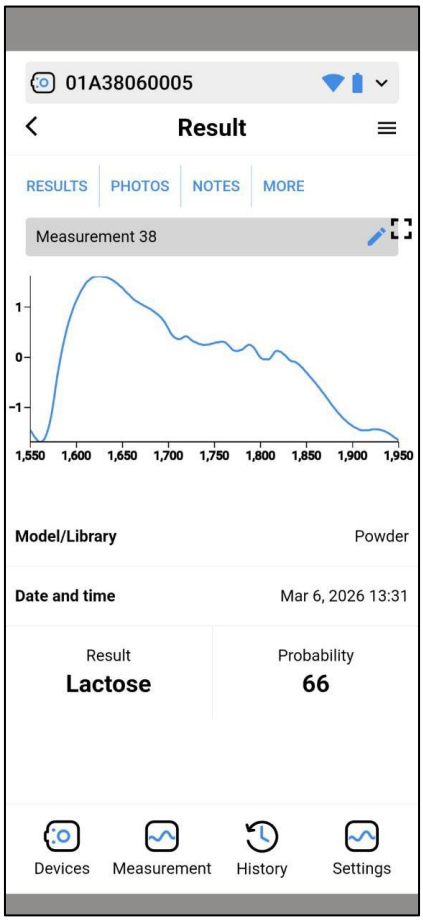

Figure 4. Mobile app with an intregrated model for classification.

The results presented in this application note prove the feasibility of using a **Fabry-Pérot based NIRONE S2.0 spectrometer by m-u-t** in combination with a **high-performance diffuse reflectance fiber probe by art photonics** to distinguish between a wide range of organic and pharmaceutical powders. By utilizing the 1550–1950 nm spectral region, we achieved successful class separation for all materials - including complex proteins, starches, and active pharmaceutical ingredients (APIs). This compact and robust setup offers an ideal solution for industries requiring portable or integrated material identification tools without compromising on analytical accuracy.