



Application Note AN-NIR-023

# Quality Control of PET

Determination of diethylene glycol, isophthalic acid, intrinsic viscosity, and acid number within one minute with NIRS

Determination of the diethylene glycol content, isophthalic acid content, intrinsic viscosity (ASTM D4603), and the acid number (AN) of polyethylene terephthalate (PET) is a lengthy and challenging process due to the sample's limited solubility and the need to use different analytical methods.

This application note demonstrates that the DS2500 Solid Analyzer operating in the visible and near-

infrared spectral region (Vis-NIR) provides a **cost-efficient and fast** solution for a **simultaneous determination** of the diethylene glycol content, isophthalic acid content, intrinsic viscosity, and the acid number in PET. Vis-NIR spectroscopy allows for the analysis of PET in **less than one minute without sample preparation or using any chemical reagents**.

## EXPERIMENTAL EQUIPMENT

PET pellets were measured with a DS2500 Solid Analyzer in reflection mode over the full wavelength range (400–2500 nm). A rotating DS2500 Large Sample Cup was employed to overcome the distribution of varied particle sizes and chemical components. This allowed automated measurements at different sample locations for a reproducible spectrum acquisition. As displayed in **Figure 1**, samples were measured without any preparation step. The Metrohm software package Vision Air Complete was used for all data acquisition and prediction model development.



**Figure 1.** DS2500 Solid Analyzer with PET pellets present in the rotating DS2500 Large Sample Cup.

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

| Equipment               | Metrohm number |
|-------------------------|----------------|
| DS2500 Solid Analyzer   | 2.922.0010     |
| DS2500 Large Sample Cup | 6.7402.050     |
| Vision Air 2.0 Complete | 6.6072.208     |

## RESULTS

The obtained Vis-NIR spectra (**Figure 2**) were used to create prediction models for quantification of the diethylene glycol, isophthalic acid, intrinsic viscosity, and acid number. The quality of the prediction models was evaluated using correlation diagrams, which

display the correlation between Vis-NIR prediction and primary method values. The respective figures of merit (FOM) display the expected precision of a prediction during routine analysis.



**Figure 2.** Selection of PET Vis-NIR spectra obtained using a DS2500 Analyzer and a rotating DS2500 Large Sample Cup. For display reasons a spectra offset was applied.

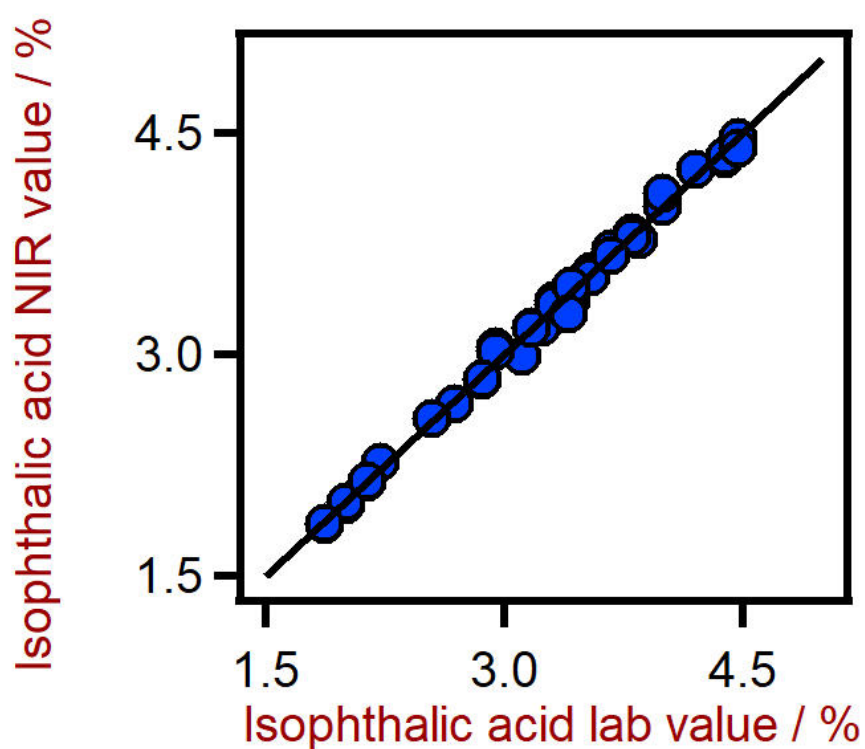


**Figure 3.** Correlation diagram for the prediction of the diethylene glycol content in PET using a DS2500 Solid Analyzer. The diethylene glycol lab value was evaluated using HPLC-MS.

**Table 2.** Figures of merit for the prediction of the diethylene glycol content in PET using a DS2500 Solid Analyzer.

| Figures of merit                   | Value  |
|------------------------------------|--------|
| $R^2$                              | 0.931  |
| Standard error of calibration      | 0.052% |
| Standard error of cross-validation | 0.066% |

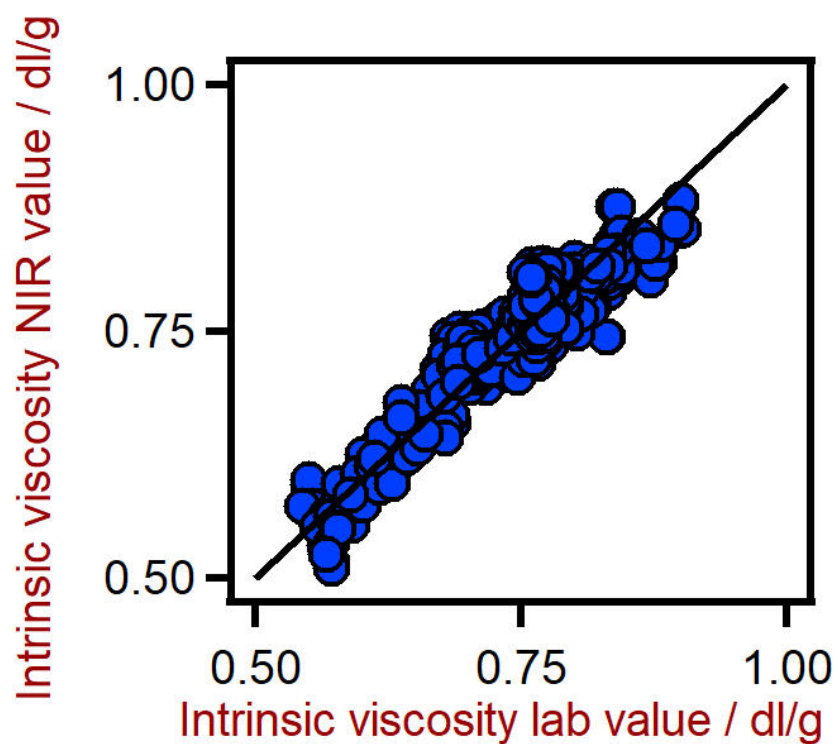
## RESULTS



**Figure 4.** Correlation diagram for the prediction of the isophthalic acid content in PET using a DS2500 Solid Analyzer. The isophthalic acid lab value was evaluated using HPLC.

**Table 3.** Figures of merit for the prediction of the isophthalic acid content in PET using a DS2500 Solid Analyzer.

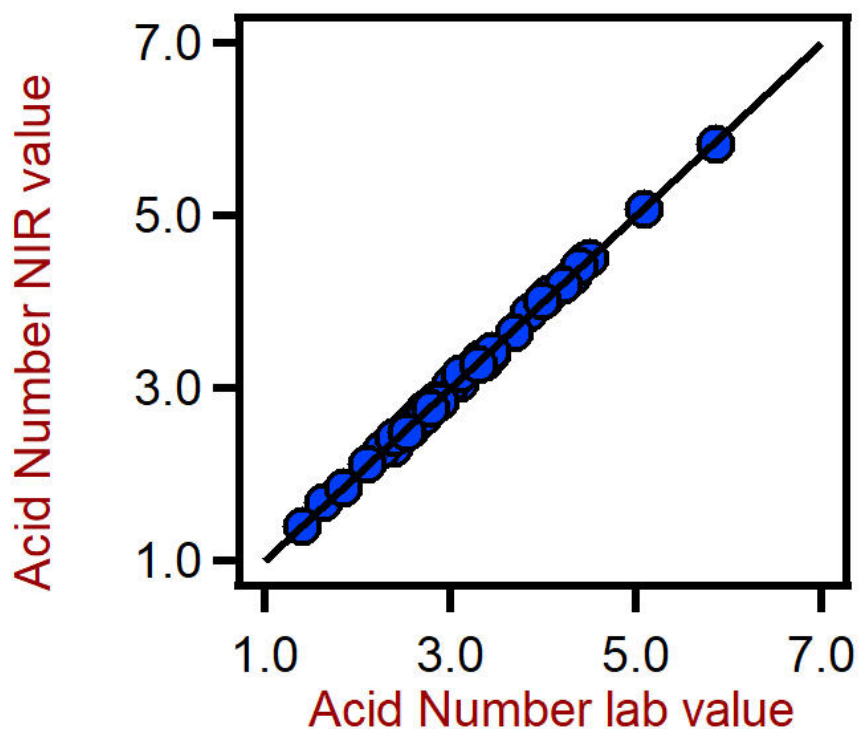
| Figures of merit                   | Value  |
|------------------------------------|--------|
| $R^2$                              | 0.995  |
| Standard error of calibration      | 0.059% |
| Standard error of cross-validation | 0.085% |



**Figure 5.** Correlation diagram for the prediction of the intrinsic viscosity of PET using a DS2500 Solid Analyzer. The intrinsic viscosity lab value was evaluated using viscometry.

**Table 4.** Figures of merit for the prediction of the intrinsic viscosity of PET using a DS2500 Solid Analyzer.

| Figures of merit                   | Value  |
|------------------------------------|--------|
| $R^2$                              | 0.873  |
| Standard error of calibration      | 0.0236 |
| Standard error of cross-validation | 0.0238 |



**Figure 6.** Correlation diagram for the prediction of the acid number in PET using a DS2500 Solid Analyzer. The Acid Number lab value was evaluated using titration.

**Table 5.** Figures of merit for the prediction of the acid number in PET using a DS2500 Solid Analyzer.

| Figures of merit                   | Value |
|------------------------------------|-------|
| $R^2$                              | 0.991 |
| Standard error of calibration      | 0.093 |
| Standard error of cross-validation | 0.143 |

## CONCLUSION

This study demonstrates the feasibility of NIR spectroscopy for the analysis of key quality parameters of PET. In comparison to wet chemical methods (Table 6), the time to result is a major

advantage of NIR spectroscopy, since all parameters are determined in a single measurement in under a minute.

**Table 6.** Time to result overview for the different parameters.

| Parameter           | Method                        | Time to result                            |
|---------------------|-------------------------------|-------------------------------------------|
| Diethylene glycol   | Extraction + analysis HPLC-MS | 45 min (preparation) + 40 min (HPLC)      |
| Isophthalic acid    | Dissolve + HPLC               | 45 min (preparation) + 40 min (HPLC)      |
| Intrinsic viscosity | Dissolve + viscometry         | 90 min (preparation) + 1 min (viscometry) |
| Acid Number         | Dissolve + titration          | 90 min (preparation) + 10 min (titration) |

## CONTACT

Metrohm France  
13, avenue du Québec - CS  
90038  
91978 VILLEBON  
COURTABOEUF CEDEX

[info@metrohm.fr](mailto:info@metrohm.fr)



### DS2500 Solid Analyzer

**Spectroscopie proche infrarouge robuste pour le contrôle de la qualité en laboratoire et en environnement de production.**

L'analyseur DS2500 Analyzer est la solution éprouvée et souple destinée aux analyses de routine de matières solides, de crèmes et, en option, de liquides, tout au long de la chaîne de fabrication. Sa conception robuste fait du DS2500 Analyzer un appareil insensible à la poussière, à l'humidité, aux vibrations ainsi qu'aux variations de température, et donc particulièrement adapté aux rudes conditions d'un environnement de production.

Le DS2500 couvre l'ensemble de la gamme spectrale de 400 à 2 500 nm et fournit des résultats exacts et reproductibles en moins d'une minute. Le DS2500 Analyzer répond aux exigences de l'industrie pharmaceutique et représente une aide précieuse pour les opérations de routine quotidiennes grâce à sa simplicité d'utilisation.

Grâce à des accessoires parfaitement adaptés à l'appareil, il atteint des performances sans précédent avec tous les types d'échantillons, quel que soit le défi qu'ils opposent (matières solides à gros grains comme les granulats ou échantillons semi-solides ou liquides telles les crèmes). La productivité lors de mesures de matières solides peut encore être augmentée par l'utilisation du MultiSample Cup, lequel permet des mesures automatisées en série jusqu'à un maximum de 9 échantillons.



### DS2500 Récipient d'échantillon, grand

Grand récipient d'échantillon pour l'enregistrement de spectre par réflexion de poudres et de granulés en différents points de l'échantillon avec le NIRS DS2500 Analyzer.



## Vision Air 2.0 Complete

Vision Air - logiciel universel de spectroscopie.

Vision Air Complete est une solution logicielle moderne et simple d'utilisation pour une application dans un environnement réglementé.

Aperçu des avantages de Vision Air :

- Des applications logicielles individuelles avec interface utilisateur adaptée sont le garant d'un maniement intuitif et simple
- Établissement et suivi simples des procédures de travail
- Base de données SQL pour une gestion sûre et simple des données

La version Vision Air Complete (66072208) comprend toutes les applications d'assurance qualité par spectroscopie Vis-NIR :

- Application de gestion des instruments et des données
- Application de développement de méthodes
- Application d'analyse de routine

Autres solutions Vision Air Complete :

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