SPES CLASSIFICATION OF MAYONNAISE

INTRODUCTION

Mayonnaise is a thick, cold, and creamy sauce that is commonly used on sandwiches, hamburgers, composed salads, and fries. It also serves as the foundation for a variety of other sauces and food preparations. Mayonnaise is an emulsion of oil, egg yolk, and either vinegar or lemon juice as an acid. Additional flavourings are used to create and market mayonnaise variants, such as olive oil. The colour ranges from nearly white to pale yellow, and the texture ranges from light cream to thick gel. Commercial eggless imitations are produced for those who avoid chicken eggs due to egg allergies, dietary cholesterol restrictions, or veganism.

The classification and analysis of real, flavoured, and vegan mayonnaises via EOS Classizer™ ONE and liquid sample manager EOS LMS01™ is presented in this app note.

PARTICLE ANALYSIS METHOD

Traditional light scattering methods are widely used in scientific and industrial applications. However, the number of parameters affecting the scattering properties of a given particle is such that the basic measure of the scattering power (or even the extinction) is far from being enough to recover something more than a rough estimate of its size. Traditional approaches become even less reliable when mixtures of particles with different properties are analysed.

EOS Classizer™ ONE is based on patented Single Particle Extinction and Scattering (SPES) method. It introduces a step forward in the way the light scattering is exploited for the characterization of particle mixtures in liquids through the classification of single particle optical properties.

EOS Classizer™ ONE particle analyzer + LMS01™ - front view

EOS Classizer™ ONE retrieves the particle size distribution, numerical concentration, oversize, optical structure, other insights for each particle population detected. Classizer™ ONE works offline and online/real-time, enabling to verify the consistency of the intermediate and final formulations with target QbD, SbD expectations.

For a general introduction to SPES and EOS Classizer™ ONE, please refer to the Application Note AN001/2021, available online along with other application notes and examples at: www.eosinstruments.com/publications/

APPLICATION EXAMPLES

EOS Classizer™ ONE is exploited to characterise four types of commercial mayonnaises, as reported below:

1. Analysis of three real mayonnaises
2. Analysis of olive oil-modified mayonnaise
3. Analysis of yoghurt-modified mayonnaise
4. Analysis of vegan mayonnaise

EOS Classizer™ ONE retrieves key indicator of mayonnaise quality and its emulsion stability as particle size distribution and oversize of PSD tails.

EOS Classizer™ ONE Operative Procedure is:

Refractive Index (RI) – **Automatic SPES classification of effective RI for each single population detected in each sample** – Accurate Particle Size Distributions and other information retrieved accordingly to measured RI.
A small aliquot of sauce dispersed in 10mL milliQ H_2O
Sample flow: measured at 4ccm / Stirrer speed: 10%
Sample run time: 10min (internal checks comprised)
Background concentration: <10^4 ptc/mL
Target sample concentration: 10^6 ptc/mL
During each run, thousands of particles are measured, yielding an appropriate statistic for the data interpretations discussed below. Each sample was analysed in triplicate.

1) Analysis of three real mayonnaises

Commercial mayonnaises are emulsions with an expected refractive index of about 1.46-1.49 depending on the formulation. In Figure 1 an EOS CLOUDS dataset obtained with a commercial mayonnaise is presented. EOS Classizer™ software automatically estimates a RI of 1.48 in agreement with the expected value (red line).

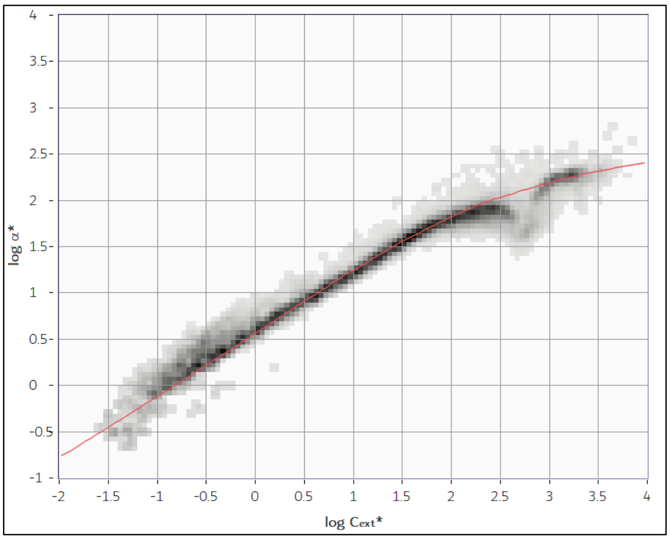

Figure 1 EOS CLOUDS of a commercial mayonnaise emulsion dispersed in milliQ water. Red line corresponds to n=1.48.

Three different brands of mayonnaise are measured and compared in Figure 2 and in Figure 3. EOS Classizer™

software automatically estimates a RI for each sample in agreement with expected values. The automatic identification of this parameter allows a better evaluation of the numerical particle size distribution of the emulsions.

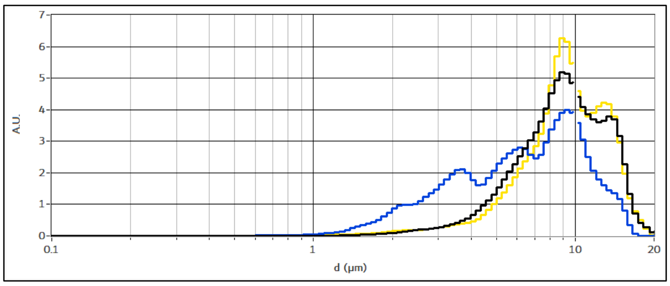

Figure 2 Volumetric particle size distributions of three different commercial mayonnaises. Note. the volumetric particle size distributions are calculated from the numerical particle size distributions which are retrieved by Classizer™ ONE.

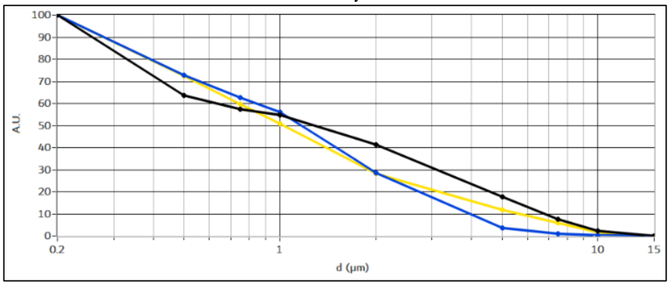

Figure 3 Numerical oversizes of three different commercial mayonnaises. Note. oversizes are calculated from the numerical particle size distributions retrieved by Classizer™ ONE.

Results show a peak in the volumetric particle size distributions around 10 μm in agreement with expectations for these samples. Effective refractive indexes are about 1.48±0.01 for all the samples revealing similar optical properties. Minor differences between the samples are related to a broadening of the volumetric size distribution of one sample, indicating increased polydispersity.

2) Analysis of popular olive oil-modified mayonnaise

An interesting result is obtained with commercial oil-modified mayonnaise. Two distinct populations are observed with different optical properties (Figure 4).

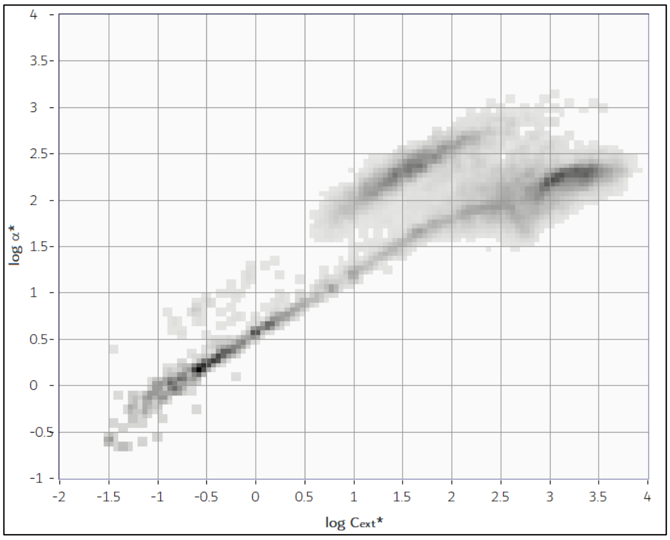

Figure 4 EOS CLOUDS of a commercial olive oil-modified mayonnaise. Two distinct populations are observed.

Analysis of TOP population (Figure 5) shows a population of particles having an effective refractive index close to that of the medium. Numeric and calculated volumetric particle size distribution of this population are plotted in Figure 6.

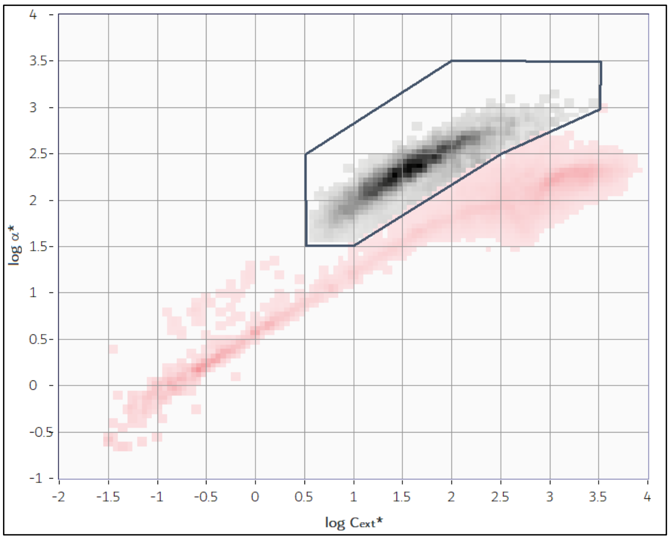

Figure 5 TOP population – selection.

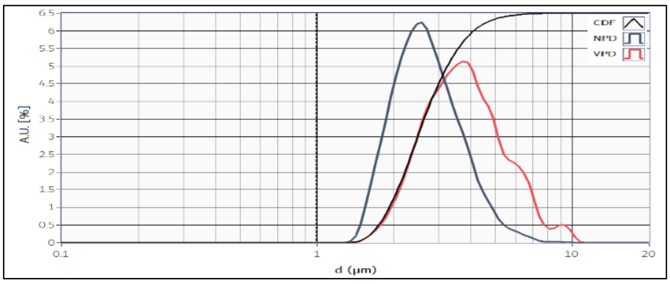

Figure 6 Numeric (blue) and Volumetric (red) particle size distribution of the TOP population. Black line is the cumulant of the numeric particle size distribution.

Analysis of BOTTOM population (Figure 7) shows a population of particles having an effective refractive index close to n=1.49. Numeric and calculated volumetric particle size distribution of are plotted in Figure 8.

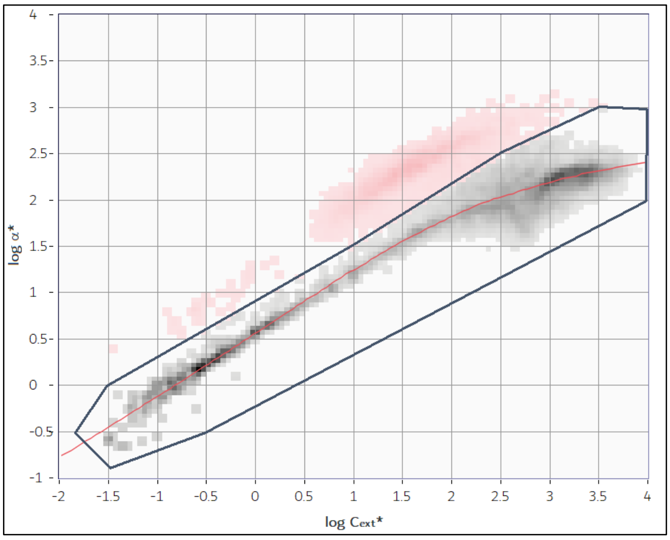

Figure 7 BOTTOM population – selection

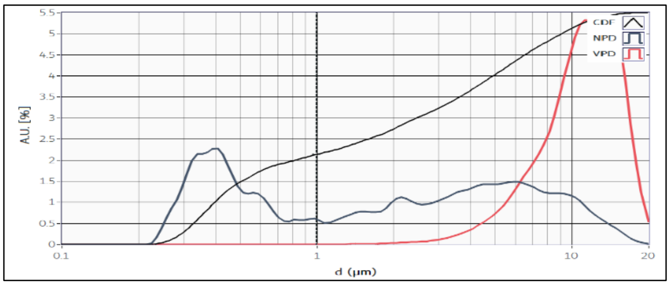

Figure 8 Numeric (blue) and Volumetric (red) particle size distribution of the TOP population. Black line is the cumulant of the numeric particle size distribution.

3) Analysis of a yoghurt-modified mayonnaise

In Figure 9 an EOS CLOUDS dataset obtained with a commercial yoghurt-modified mayonnaise is presented. EOS Classizer™ software estimates a RI of 1.45 (red line).

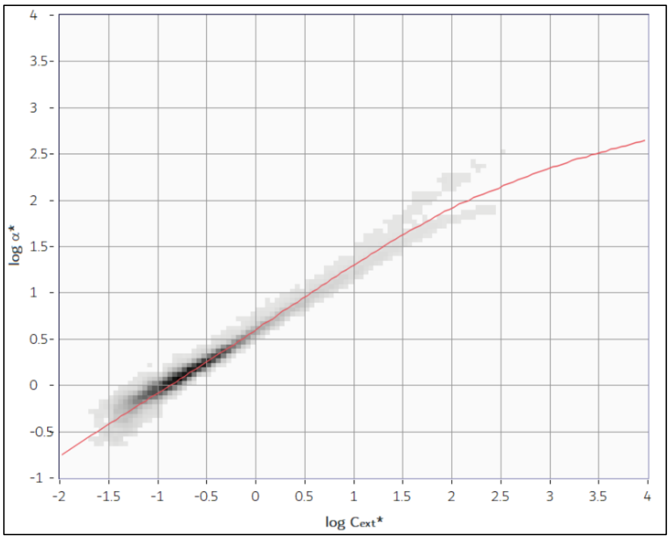

Figure 9 EOS CLOUDS of a yoghurt-modified mayonnaises dispersed in milliQ water. Red line corresponds to n=1.45.

Numerical and volumetric particle size distributions are presented in Figure 10. It is observed that although the volumetric dimensional distribution is somehow comparable to the previous cases, the different shape of the EOS CLOUDS, the different effective refractive index, and the different numerical particle size distribution allow us to conclude that the different formulation produces completely different droplets of the emulsion in suspension. This is a case in which the differences are mainly due to the small particles compared to the few large ones, which dominate the volumetric distribution.

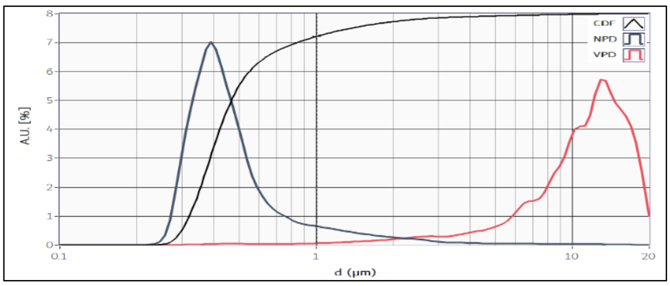

Figure 10 Numeric (blue) and Volumetric (red) particle size distribution of the yoghurt-modified mayonnaise. Black line is the cumulant of the numeric particle size distribution.

A secondary population related to the yoghurt is observed, as represented in Figure 11. The population is enhanced by contrasting the grey tones. These data are compatible with components observed in yoghurt as the lactic ferments.

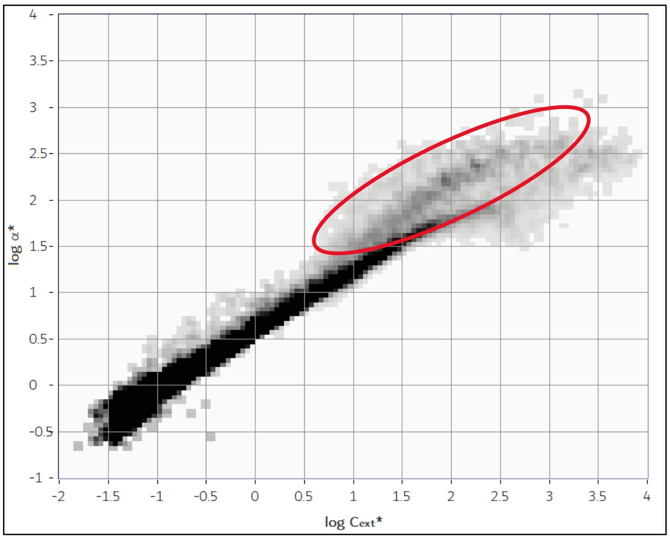

Figure 11 Secondary population present data represented in Figure 9 and related to the corpuscles of the yoghurt (red ellipse)

4) Analysis of vegan mayonnaise

In Figure 12 data of vegan mayonnaise is presented.

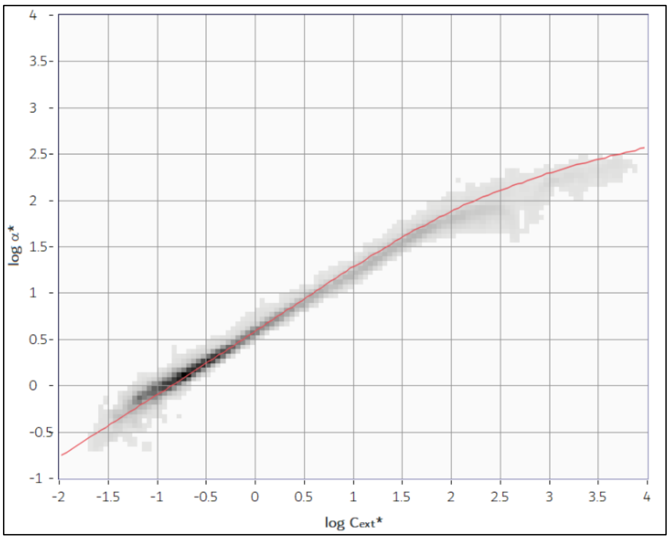

Figure 12 EOS CLOUDS of a vegan mayonnaises dispersed in milliQ water. Red line corresponds to n=1.46.

EOS Classizer™ software estimates a RI of about 1.46 for this vegan product, lower than the pure mayonnaise reflecting the different composition of the droplets.

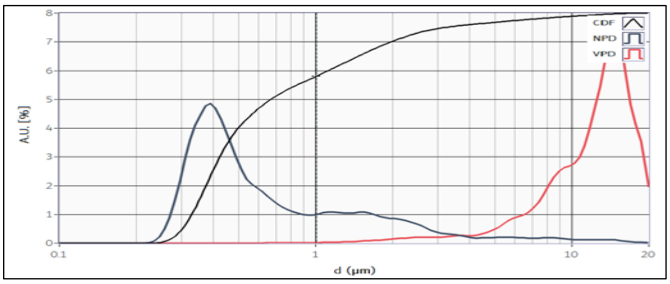

Figure 13 Numeric (blue) and Volumetric (red) particle size distribution of the vegan mayonnaise. Black line is the cumulant of the numeric particle size distribution.

The peak of the volumetric particle size distribution is around 15 µm, larger than the pure mayonnaise corresponding one.

Multiparametric PCA classification of mayonnaises

Modern industry in the food market relies on quality control to guarantee the robustness of its productive process. EOS software provides a useful add-on to automate the analysis of a large ensemble of data. Each measure is a batch control, which is confronted with a starting dataset. Combining PCA (Principal Component Analysis) for data reduction with a supervised-learning algorithm does it possible to make a very fast batch-to-batch control. For a complete introduction to PCA analysis with SPES data refer to the Application Note AN005/2022. For this study, the dataset is made up of the analyses of the commercial real, vegan, and modified mayonnaises studied. Results of the EOS PCA algorithms are shown in Figure 14.

Effective classification of the samples without any special selection is done thanks to the different optical properties of the samples, which produce different EOS CLOUDS histograms. Note. for batch-to-batch QC purposes, SPES-PCA allows a further classification of unknown batches of mayonnaise by running supervised learning and K-nearest neighbor algorithms using existing databases as a training dataset.

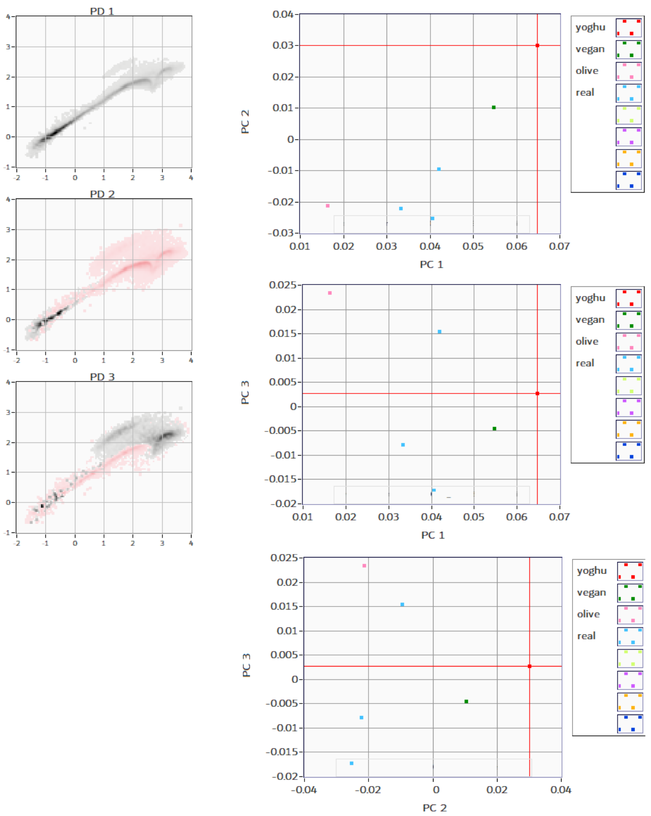

Figure 14 PCA analysis of all the samples measured. Principal Components allow a classification and recognition of samples benefiting from the different shape of EOS CLOUDS of the samples. This is a case where a multiparametric approach allows a classification of complex data with reduced set of number.

CONCLUSIONS

The capability of EOS Classizer™ ONE and SPES patented method fits the need of a value-added application in the characterization of food products such as mayonnaise. The dynamic range of EOS Classizer™ ONE is adequate to fully characterize all samples in terms of numerical particle size distributions and volumetric particle size distributions. The LMS01™ sample manager made sample analysis quick and easy, with total analysis time plus flushing taking around ten minutes per sample. The high classification and added value results, concentration data, and calculations for the particle populations detected provide significantly enhanced results compared to other traditional particle sizing techniques.

RELEVANT PUBLICATIONS AND REFERENCES

Presentation of Single Particle Extinction and Scattering (SPES) method for particle analysis
AN001-2021 Analysis of Polymeric Particle Mixes via SPES Technology – an introduction to SPES method

AN006-2021 Multiparametric Classification of Particles as a Pathway to Oversize Analysis in Complex Fluids via SPES Technology

Potenza MAC *et al.*, «Measuring the complex field scattered by single submicron particles », AIP Advances 5 (2015)

Example of CFA application of SPES technology
AN002-2021 Continuous SPES Flow Analysis CFA-SPES

Example of PCA application of SPES technology
AN005-2022 Batch-To-Batch Consistency Via Multiparametric SPES Principal Component Analysis PCA

Classizer™ ONE + Sample Managers & Autosampler
AN008-2022 Automatic Liquid Sample Management and System Cleaning with EOS LMS01™ and LMA01™

AN009-2022 Standardize SPES Operative Procedure and improve throughput of Liquid Samples via EOS LAS01™

Example of SPES application to aggregates
AN003-2021 Addressing the Issue of Wetting and Clustering by Means of SPES Technology

Potenza MAC *et al.*, «Single-Particle Extinction and Scattering Method …», ACS Earth Space Chem 15 (2017)

SPES application to non-spherical particles
AN004-2021 Addressing the Classification of Non Spherical Particles by Mean of the SPES Technology

Simonsen MF *et al.*, «Particle shape accounts for instrumental discrepancy in ice …», Clim. Past 14 (2018)

Example of SPES application to emulsions w/o payload in food and environmental waters
AN012-2021 Monitoring the Fate of a Lipid/ZnO Emulsion in Environmental Waters

AN015-2022 Classification of Oil and Oil Mixes Emulsions via SPES Technology

AN021-2023 SPES Classification of Mayonnaise

Examples of SPES application to particle analysis and behavior characterization in biotech applications
AN011-2021 Quantitative Classification of Particles in Biological Liquids via SPES Technology

AN016-2021 Multiparametric Determination of Yeast Cell Viability via SPES Technology

Sanvito T et al., Nanomedicine 13, Issue 8, 2597-2603 (2017)

Examples of SPES application to inks and pigments
AN018-2022 Classification of Inks and Pigments via SPES

Example of SPES application to oxide particles, abrasives, and industrial slurries w/o impurities
Potenza MAC *et al.*, «Optical characterization of particles for industries», KONA Powder and Particle 33 (2016)

AN013-2022 Analysis of Abrasives via SPES Technology

Example of SPES application to ecotoxicity analysis
Maiorana S *et al.*, «Phytotoxicity of wear debris from traditional and innovative brake pads», Env Int., 123 (2019)

Example of SPES application to aerosol analysis
Cremonesi L *et al.*, «Multiparametric optical characterization of airborne dust …. », Env Int 123 (2019)

AN010-2023 Multiparametric Optical Characterization of Airborne Particles via Patented SPES/SPES² Technologies

Visit EOS website for further applications
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