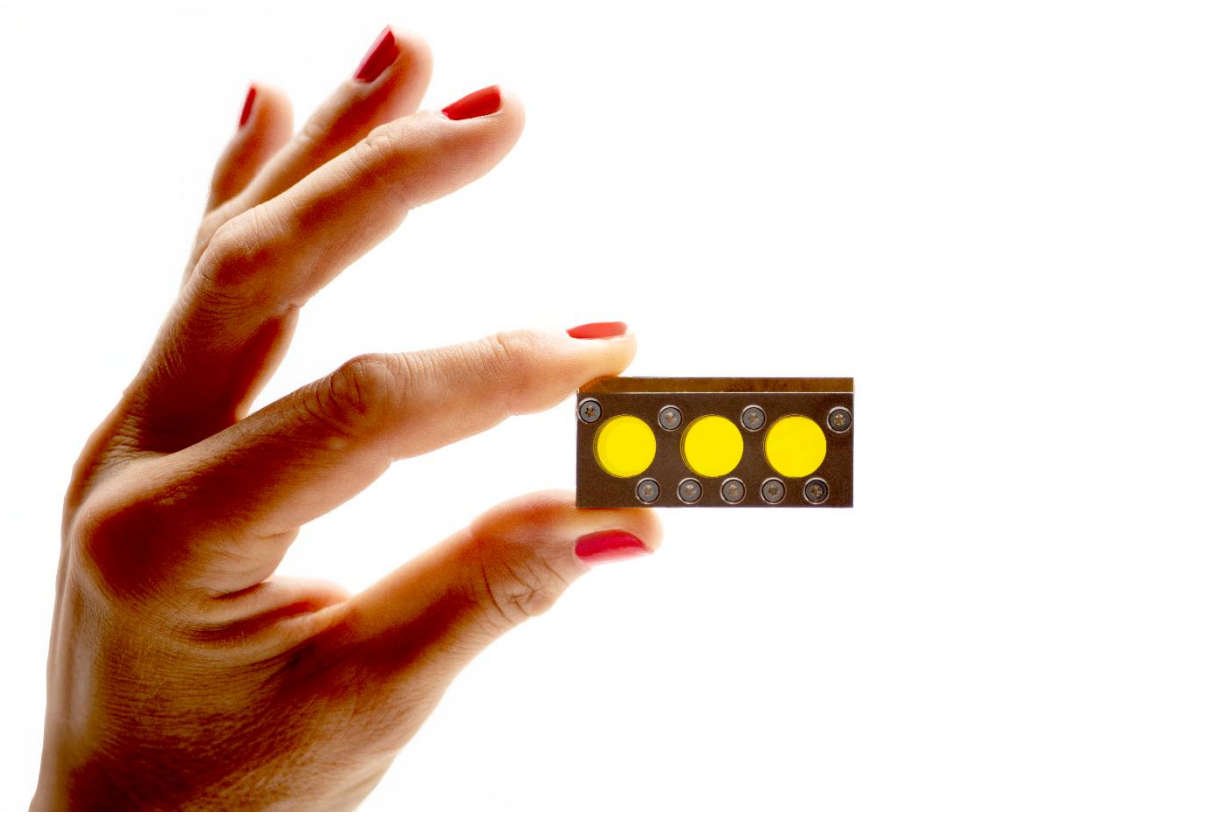
New Ways to Gain Insights into Lubricants and Base Oils using eraspec oil FTIR Analysis

Unlike traditional stationary lab FTIRs, the era**spec oil** is a professional, rugged, and highly portable stand-alone analyzer that allows users to perform laboratory-grade lubricant condition monitoring directly on-site. It significantly simplifies the testing process by using a fully automated workflow that features an integrated pump for sample introduction, pre-programmed standard test methods, and an automatic reference measurement that eliminates the need for solvents. Furthermore, it requires no complex sample preparation or programming to deliver precise, instantaneous evaluations of degradation products, contaminants, and chemometrically predicted parameters like TAN and TBN. These features already make era**spec oil** the market leader in terms of functionality, but eralytics, the Austrian innovation powerhouse, has now taken further steps, by adding:

1. A unique triple-cell geometry to boost the limit of detection
2. The next generation of water content quantification with chemometrics
3. Spot-on fingerprinting for rapid product verification



The unique triple-cell geometry

Equipping the era**spec oil** with an additional 500 µm measurement cell alongside the standard 100 µm cell provides significant analytical benefits, particularly when measuring trace amounts of substances. The built-in reference cell completes the unique triple-cell geometry.

The main advantages of this technology include:

- Improved Limits of Detection (LOD): Using a cell with a higher pathlength of 500 µm compared to the mandatory 100 µm cell leads to enhanced detection limits for specific trace substances, such as antioxidant additives (e.g., AO Phenol) and contaminants like water or ester.
- Automatic "Smart" Evaluation: The instrument's software can handle both cells seamlessly to provide the most accurate reading. If the result measured by the standard 100 µm cell falls below a certain threshold, the analyzer will automatically calculate and report the result using the 500 µm cell instead, ensuring higher precision at very low concentrations.
- Fully Automated Workflow: The instrument automatically performs the additional scan through the second cell. The evaluation of the extra spectra is done automatically by the software without requiring extra manual steps from the operator.

In short, the addition of a 500 µm measurement cell allows the era**spec oil** analyzer to dynamically adapt to the sample's concentration level, combining the broad measurement range of the 100 µm cell with the improved sensitivity of the 500 µm cell for demanding low-level detections.

Water content quantification with chemometrics

The traditional direct approach for determining water concentration in lubricants via FTIR spectroscopy (e.g. ASTM E2412) often suffers from spectral overlaps in the O-H stretching region caused by the accumulation of oil oxidation products and additives. On the other hand, the actual water content is often determined using the chemical reference method, Karl Fischer (KF) titration with oven accessory (ASTM D6304-B). This approach takes a lot of measuring time (up to an hour) and often yields overestimated values in degraded oils, since volatile oxidation byproducts are co-distilled and anti-wear additives such as ZDDP undergo thermal decomposition.

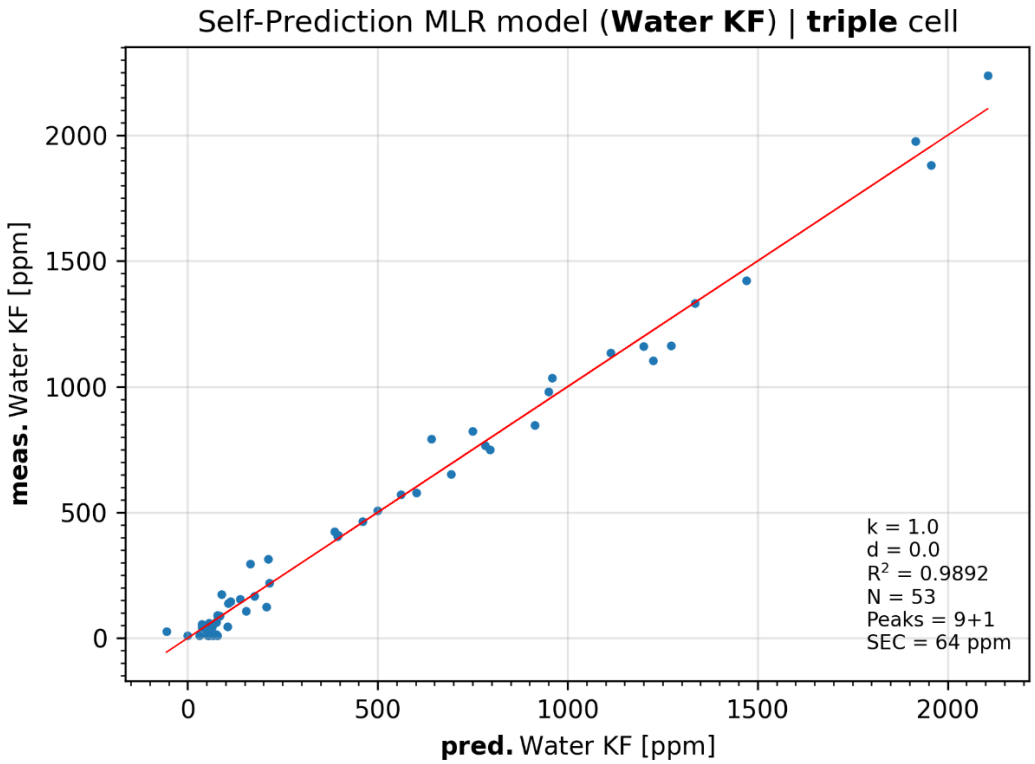
To resolve these intersecting methodological limitations, the era**spec oil** analyzer implements a novel approach combining its highly sensitive hardware architecture with a rigorous chemometric model. The hardware utilizes the triple-cell design for enhanced trace-level detection limits. The instrument's algorithm dynamically evaluates spectral saturation; if the primary water regions in the 500 µm spectrum are oversaturated, it seamlessly calculates results using the 100 µm cell to maintain a broad measurement range.

Simultaneously, the chemometric model actively calibrates against the true KF reference baseline by utilizing a strategically selected vector of nine significant mid-infrared spectral regions. This multivariate architecture treats spectroscopic and chemical interferences as quantifiable independent variables, mathematically isolating the water absorption bands from overlapping degradation phenomena like carbonyls, amines, and sulfate by-products. By algorithmically correcting the information inherent in FTIR spectroscopy, the combined chemometric model provides a robust correlation that is consistent with the reference.

Ultimately, for critical water concentrations of 100 ppm or higher, this combined approach improves analytical detection performance by up to twice that of the direct method, while delivering laboratory-grade precision within two minutes.

To evaluate the accuracy of FTIR-based water quantification, a dedicated study analyzed various lubricating oils that were gravimetrically spiked with water to create a precise validation dataset spanning from trace levels below 100 ppm up to 2000 ppm. The research compared traditional FTIR measurements against the Karl Fischer (KF) titration reference method according to ASTM D6304-B, demonstrating that a standard direct approach fails for degraded oils due to severe chemical and spectroscopic interferences. Ultimately, the study concluded that utilizing the era**spec oil**'s triple-cell design alongside a chemometric model successfully mitigates these interferences, yielding an excellent correlation with the KF method and effectively doubling the analytical performance for trace water detection.

The graph below shows the correlation between the reference titration method and the chemometric prediction using FTIR spectroscopy. The results obtained are well within the reproducibility of the reference method, which is e.g. 390 ppm @ 1000 ppm.

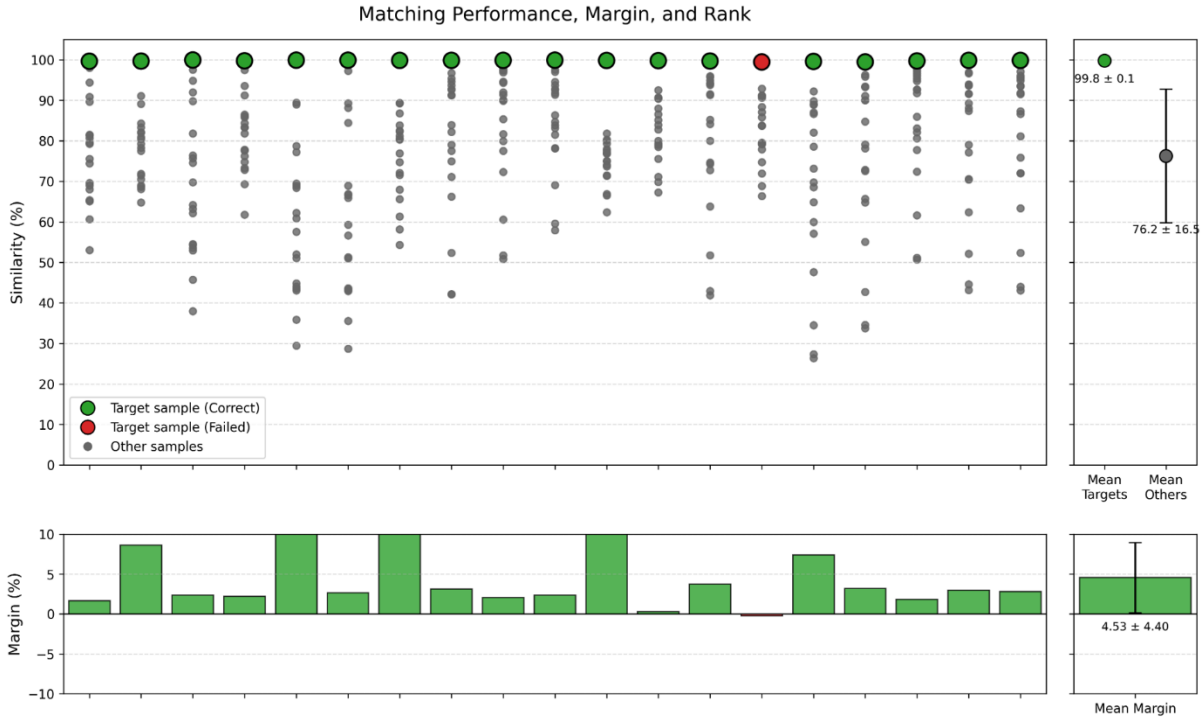


Fingerprinting for rapid product verification

Automated FTIR spectral matching using the era**spec oil** analyzers provides an objective method for the positive product identification of fresh lubricating oils. This capability verifies an unknown lubricant's unique molecular fingerprint by cross-referencing its spectrum against a comprehensive on-board reference database. The analytical process relies on a matching algorithm that calculates a Pearson correlation coefficient to determine the optimal product match. Before this comparison, the raw spectral data undergoes mathematical preprocessing to normalize baseline variances and isolate the most significant spectral regions. Consequently, the system evaluates the target against the database to generate a cross-validation similarity which is then presented in the displayed data.

The verification study utilizing 19 distinct fresh oil formulations demonstrated the high accuracy of the spectral matching algorithm, successfully matching 18 of the 19 samples to their correct reference profiles. The system exhibited excellent analytical robustness against batch-to-batch variations and instrumental noise, achieving an overall measurement repeatability of roughly 0.5%. Furthermore, the algorithm generated an average discrimination safety margin of approximately 5%, which sufficiently exceeds the baseline measurement noise by far to effectively minimize the risk of false-positive identifications. The single mismatch in the validation study occurred between closely related "sister products" that possessed nearly identical chemical matrices and differed only slightly in additive concentrations.

The following illustration demonstrates an excellent correlation during this study:



This feature is a very helpful tool for supporting incoming goods inspections, helping to prevent problems and associated costs, as well as disruptions in downstream processes.

Conclusion

era**spec oil**, the professional FTIR system for lubricant analysis, is now equipped with a triple cell. This allows detection limits to be significantly lowered without compromising the measurement of higher concentrations. In addition to the detection of additives, this technology is already being used in the new chemometric method for determining water content. Automatic fingerprinting for product control complements this new suite of features.

era**spec oil:** always the best. Now, unmatched.