



White paper

Enhancing Forensic Illicit Drug Analysis with Near-Infrared Technology

Near Infrared Spectroscopy (NIR) is a powerful tool to identify and quantify illicit drugs, cutting agents and precursors.

Abstract: NIRLAB, utilizing Near-Infrared (NIR) spectroscopy, offers a valuable addition to forensic laboratories by providing rapid, non-destructive analysis of various sample types. It enhances laboratory workflows and supports compliance with ISO 17025 standards. While not a substitute for traditional methods like GC-MS, NIRLAB complements techniques such as FTIR and Raman spectroscopy, facilitating efficient prescreening and preliminary identification. This integration makes NIRLAB an essential tool for improving forensic analysis and resource allocation.

1. Introduction

Forensic science has greatly benefited from the integration of spectroscopic techniques, crucial for identifying illicit substances. Among these techniques, Near-Infrared (NIR) spectroscopy stands out for its non-destructive nature, rapid analysis capabilities, and versatility in handling various sample types. This document explores the application of NIR technology in forensic laboratories, focusing on the NIRLAB system. It highlights how NIRLAB can enhance forensic lab workflows, increase throughput, and support compliance with ISO 17025 standards. Additionally, it discusses the complementary roles of NIR and Raman spectroscopy in targeting different substances and the routine use of Fourier-Transform Infrared (FTIR) spectroscopy in illicit drug identification, showcasing the comprehensive capabilities of these technologies in forensic investigations.

2. NIR technology in forensic Laboratories

2.1 Overview of NIR Spectroscopy

Near-Infrared (NIR) spectroscopy is an analytical technique that measures the absorbance of near-infrared light by a sample, producing a spectrum that reveals the sample's molecular composition. In forensic science, its advantages include rapid analysis, minimal sample preparation, and the ability to work with powders, pills, and plant materials. These features make NIR spectroscopy particularly useful for quickly screening and identifying substances.

2.2 Prescreening & sampling with NIRLAB

NIRLAB uses NIR spectroscopy for prescreening forensic samples. This approach is notably rapid and, with its user-friendly app interface, requires minimal workload and no sample preparation prior to analysis.



Figure 1 – Drug seizure with multiple cocaine fingers. A sampling strategy needs to be determined prior to analysis. NIRLAB can help select the relevant fingers to analyze.

One of the primary benefits of NIRLAB is its ability to quickly identify substances, allowing forensic scientists to screen large volumes of samples efficiently (Figure 1). This capability is crucial for prioritizing samples that require more detailed and time-consuming analysis. It also facilitates broader sampling strategies and helps assess homogeneity within large seizures. By quickly identifying common illicit substances, NIRLAB aids in making immediate decisions, optimizing resource allocation (More [here](#)). Additionally, the non-destructive nature of NIR spectroscopy means samples remain intact for further testing, preserving evidence integrity.

[2.3 Complementing FTIR and Raman Spectroscopy](#)

FTIR spectroscopy is a well-established tool in forensic laboratories, routinely used for identifying various drugs. Like NIR, FTIR is a vibrational spectroscopic technique that provides detailed information about the molecular composition of samples. While FTIR is highly effective for identifying functional groups and molecular structures, NIRLAB offers a complementary approach with its rapid analysis and quantitative capabilities, allowing for the estimation of substance concentrations within a sample. This quantitative data enhances the overall analytical capacity at early stages of analysis.

NIRLAB can also be used alongside Raman spectroscopy in forensic applications. While NIRLAB provides broad-spectrum analysis useful for initial screenings, Raman spectroscopy excels in identifying specific chemical bonds and structures, particularly in substances that may not be easily detected by NIR. The quantitative data from NIRLAB pairs well with the qualitative insights from Raman and FTIR spectroscopy, allowing forensic scientists to both identify and quantify substances within a sample. This integrated approach guarantees a more thorough and precise analysis, encompassing a wide range of substances essential for forensic investigations.

3. Meeting High Analytical Standards

The adoption of NIR technology, as seen with NIRLAB, can be set up to align with the requirements of ISO 17025 accreditation, which sets the international standard for laboratory competence. NIRLAB has been successfully implemented under ISO 17025 guidelines for analyzing cocaine and heroin in the Lausanne drug laboratory of the University of Lausanne, demonstrating its utility in forensic contexts (more [here](#)). By utilizing a checklist-based process with control samples and various quality criteria, it is possible to ensure the production of reliable data and valid results (Figure 2).

This example showcases how NIRLAB meets high standards by providing reliable and reproducible results.

The rapid identification and quantification capabilities of NIRLAB facilitate the optimization of forensic laboratory workflows, which is essential for sustaining rigorous operational standards and providing timely responses to law enforcement and judicial inquiries. This efficiency conserves time and resources for the analysis of complex samples, allowing for improved resource allocation and reduced consumption of reagents.

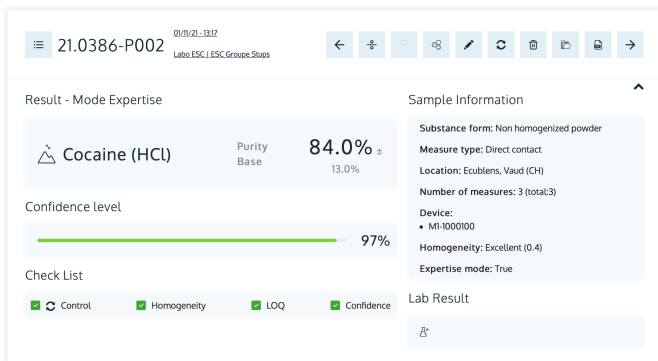


Figure 2 – Check List to ensure accuracy and performance within the ISO 17025 process. If one of the control squares is not passed, confirmatory analysis shall be performed.

NIRLAB’s web and desktop applications facilitate seamless integration with existing Integration with Lab Information Management Systems (LIMS) allowing for comprehensive data management and easy access to historical data, reports, and trends.

The data can be exported in various formats, including Excel and PDF, for further analysis and reporting.

4. NIRLAB as a complement to chromatographic methods

While NIRLAB offers significant advantages, it does have limitations, particularly in its inability to separate complex mixtures into individual components. Therefore, NIRLAB cannot replace traditional separative techniques such as gas chromatography-mass spectrometry (GC-MS) or liquid chromatography-mass spectrometry (LC-MS), essential for detailed forensic analysis and confirmation of findings. However, the rapid prescreening and preliminary identification capabilities of NIRLAB are invaluable in the initial stages of forensic investigation, helping to narrow down the focus for more detailed testing.

Looking ahead, integrating NIR technology with other advanced spectroscopic and analytical methods is expected to further improve the accuracy and efficiency of forensic investigations. This integration will optimize laboratory workflows, reduce costs, and enhance sustainability by decreasing the use of consumables.

5. Driven by data: Forensic Intelligence

NIRLAB not only adds to analytical capabilities but also serves as a valuable tool for forensic intelligence. The integrated NIRLAB dashboard provides an intuitive interface that allows users to easily manage, analyze, and visualize data. This dashboard enables forensic scientists to maintain an overview of current and past analyses, facilitating the efficient organization and retrieval of data when needed.

One of the standout features of the NIRLAB dashboard is its capacity for generating statistical insights effortlessly. By leveraging the data collected during routine analyses, forensic laboratories can quickly perform statistical evaluations, such as identifying the prevalence of certain substances, tracking the frequency of specific drug types, and monitoring overall trends in the types of samples being tested. This capability is crucial for understanding the dynamics of illicit drug markets and assessing law enforcement strategies.

6. Conclusion

NIRLAB offers rapid and efficient prescreening capabilities that enhance laboratory workflows and increase throughput. By complementing techniques like Raman and FTIR spectroscopy, NIRLAB provides broad analytical capabilities essential for the comprehensive analysis of forensic drug samples. Although it is not a replacement for traditional separative methods, NIR technology, as implemented by NIRLAB, is pivotal in modern forensic laboratories. It supports compliance with international standards such as ISO 17025 and ensures the timely and accurate processing of forensic evidence.

With analysis results available in seconds, forensic labs can significantly reduce the turnaround time for routine analyses. Furthermore, by minimizing reliance on benchtop

instruments for initial screenings, labs can lower operational costs related to sample processing and instrument use. Additionally, employing spectroscopic tools helps reduce the consumption of disposables, which lowers costs and contributes to greener lab practices.

As technological innovations advance, the role of NIR technology in forensic science is expected to expand, offering new tools and methodologies for law enforcement and forensic professionals, particularly in leveraging data to generate actionable intelligence.