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Pharmaceutical Cleaning Verification using Deep UV Resonance Raman Spectroscopy (DUVRRS)

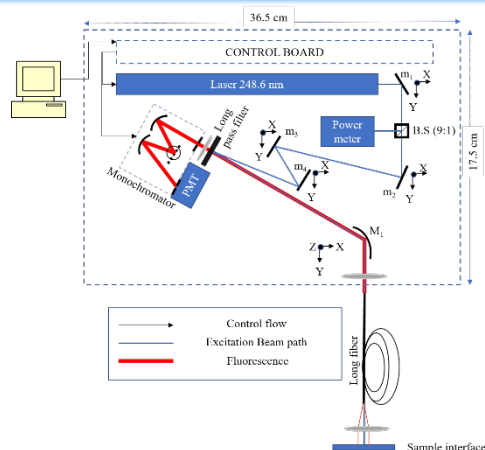
Cleaning verification is a quality control process for determining the effectiveness of a cleaning event, and forms an important component of **Process Analytical Technology (PAT)**. It is used to establish that product cross contamination is controlled, ensuring patient safety and product quality. Current verification is made using visual inspection and/or analytical verification (e.g. Total Organic Carbon (TOC), HPLC/UPLC, UV or conductivity). This project aims to develop a preferred direct surface measurement using **Deep UV Resonance Raman Spectroscopy**.

Proposed Solution – DUVRRS

Deep UV Resonance Raman Spectroscopy provides a combined Raman and fluorescence spectra measurement with improved detection limits vs Surface-enhanced Raman spectroscopy (SERS) and a considerable level of chemical specificity. Rapid analysis & feedback on contaminant levels and identity can be achieved with minimal sample preparation. Specific improvements on existing technologies like HPLC are contained within an easy-to-use analysis protocol. This project will:

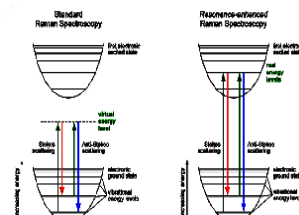
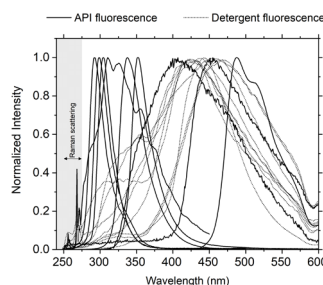
Build a bench top prototype to determine the detection/sensitivity of DUVRRS for use with pharmaceutical excipients, APIs and cleaning agents

Investigate the applicability of using an optical fibre to develop a contact probe for hard to reach areas



Raman Spectroscopy

Raman spectroscopy is a non-contact, non-destructive, method of elucidating the composition and structure of unknown materials without sample handling, processing, or use of reagents. Visible and near-IR lasers have photon energies below the first electronic transitions of most molecules, but when the photon energy of the laser lies within the electronic spectrum of a molecule, as is the case for UV lasers and most molecules, the intensity of Raman-active vibrations can increase by many orders of magnitude. This effect is called "resonance-enhanced" Raman scattering.



Advantages of DUV Resonance Raman

- **Rayleigh Advantage:** Scattering of photons is $\sim 1/\lambda^4$, so higher in the UV.
- **Resonance Enhancement:** Factors of $\sim 10^5$ compared to normal Raman scattering.
- **Fluorescence Avoidance:** Excitation in the UV allows easy filtering out of fluorescence, since Raman fingerprints are far away.
- **Ambient Background Elimination:** Essentially no background irradiation from solar or artificial lighting.
- **Chemical Specificity:** Only those Raman bands associated with electronic transitions are enhanced, enabling easier interpretation.

Industry Impact

- Help identify difficult to clean areas
- Simultaneous multi-component detection
- Reduced production downtime from days to hours
- Improved sample response times prevent a measurement backlog
- Identification of molecular functional groups allows end users to apply targeted cleaning procedures



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