Detecting whatâ??s Inside without Opening the Bottle

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Raman spectroscopy offers a new way to detect substances such as methanol inside sealed, coloured bottles without opening or damaging the container. By combining laser beam shaping with wavelength modulation, researchers have developed a technique that can overcome weak Raman signals and interference from packaging and fluorescence, enabling rapid, non-destructive screening.

The technology could have significant implications for food and beverage safety, counterfeit detection and product authentication, particularly for applications where large numbers of samples need to be screened across the supply chain. Beyond detecting methanol in alcoholic beverages, the approach could potentially be used to authenticate wines, identify pesticide and herbicide residues in products such as olive oil, and tackle counterfeiting in sectors including perfumes.

In this interview with NUFFOODS Spectrum Asia, Dr Ralf Mouthaan, ARC Grant-Funded Research Fellow, School of Biological Sciences, College of Science, discusses how the Raman spectroscopy technique works, the challenges of analysing substances through coloured packaging, its potential applications in food and beverage quality control, and the team's efforts to develop a hand-held prototype for real-world deployment.

What were the key challenges in detecting substances inside sealed, colored bottles, and how does the new Raman spectroscopy technique address them?

While Raman spectroscopy is a powerful technique that allows us to obtain a unique molecular fingerprint, Raman signals are often weak and drowned out by other signals such as fluorescence from the sample. This problem is compounded when the sample of interest is in a container: the signal from the sample is attenuated and is hidden by the signal from the container. This work combines several techniques we have developed to enhance the Raman signal from the sample and suppress the signal from the container.

How do laser beam shaping and wavelength modulation improve sensitivity and distinguish the chemical fingerprint of methanol from packaging interference?

We carefully shape our beam into a hollow cone such that it is a ring when it passes through the container and collapses to a high-intensity point in the liquid where it excites the desired Raman signal. We then collect this Raman signal through the dark middle of the ring, avoiding the container's signal. We also modulate the laser wavelength as we take a measurement. We find that the Raman peaks move with the wavelength modulation, whereas the fluorescence signals mostly stay put, allowing us to distinguish between the two.

Since the technology detects methanol well below safety limits, what are the implications for regulators, customs, and manufacturers seeking non-destructive screening methods?

We envisage that this technology can be used at any stage in the supply chain: from factory floors to shop floors. It will allow manufacturers, sellers and regulators to rapidly and non-destructively screen large numbers of samples, in contrast to current slower gold standard methods, where individual samples need to be sent to a specialised laboratory for testing.

Beyond counterfeit detection, how can this technology support wine authentication and help address global wine fraud?

Each wine has a unique molecular fingerprint and we can use similar approaches to identify fraudulent wines and combat wine fraud. Fraud is a major challenge for the wine industry, costing Australia hundreds of millions of dollars each year.

What other applications do you foresee for this technology in food and beverage quality control, such as detecting contaminants or verifying authenticity?

We are currently interested in identifying herbicide and pesticide contamination in olive oil through the bottle. One of our students is currently considering the identification of hazardous materials through the container with applications in law enforcement. We are also keen to explore applications in the perfume industry, where counterfeiting is a massive problem. The strengths of this technology is its versatility and we are open to exploring a wide range of opportunities.

What are the next steps for moving this technology from the lab to commercial deployment, and how do you see non-destructive testing evolving?

We are currently developing a hand-held prototype that will allow this technology to be used in realistic settings outside of the lab. We are looking for key partners to explore real-world applications, with a view to ultimately commercialising this technology.