Broadband near-infrared spectroscopy of organic molecules on compact photonic devices

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Abstract: We demonstrate a nanophotonic approach for broadband near-infrared spectroscopy of organic molecules. Waveguides, tapered microfibers and gold nanoparticles enable ultra-sensitive miniature spectrometers for highly sensitive detection in ultra-low sample volumes.

The ability to detect evanescently high-vibrational frequencies (overtones) of molecules in the near-infrared (NIR) using two different optical platforms with broadband illumination is demonstrated. Here we show how surface preparation using gold nanoparticles of 250nm diameter (Au250nmNPs) in conjunction with tapered microfibers or oxygen plasma treatment of an optical waveguide surface results in ultra-sensitive miniature spectroscopic elements for highly sensitive detection in ultra-small volumes.

Photonic waveguides were realised by potassium ion-exchange in borosilicate glass and microfibers were realised by conventional tapering technology. The waveguides were end polished to allow butt-coupling from a monomode optical fibre. Light was launched from a broadband source into the pre-treated waveguide or microtapered fiber to evanescently analyse tear-sized samples. Figure 1 illustrates the performance of such devices.

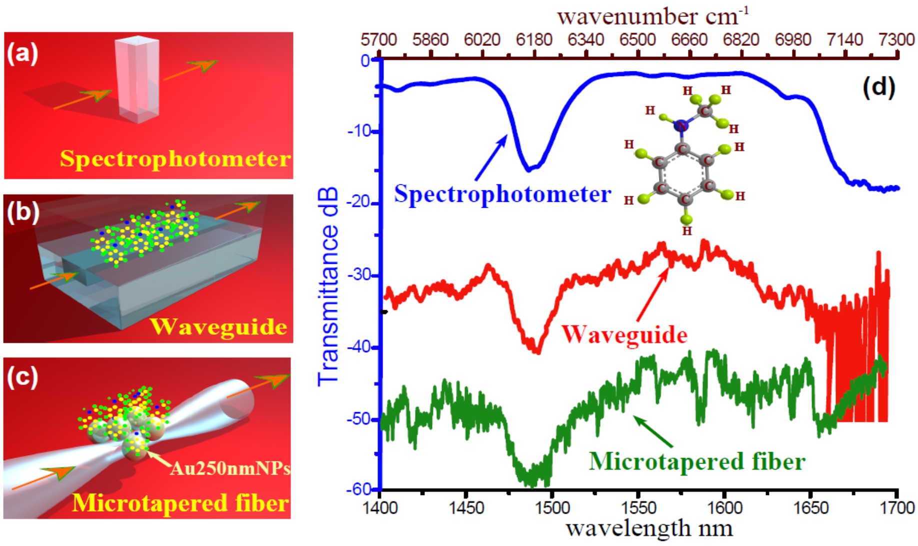

Fig. 1: Performance of evanescent NIR spectroscopic elements. (a) Conventional spectrophotometer measurements using a cuvette. Evanescent spectroscopy using **(b)** channel waveguides and **(c)** microtapered fibers with Au250nmNPs. **(d)** Measured transmittance spectra of N-Methylaniline on fabricated photonic devices: tapered fiber (green) and waveguide (red), compared with a measurement using a commercial spectrophotometer (blue).

The measurements are conducted by placing gold nanoparticles on our evanescent spectrophotometers tapered fiber and treating the waveguide surface while utilizing donor-acceptor property of N-Methylaniline. As a result of increased affinity of organic molecule to surface of our devices and strong overlap between evanescent field and liquid we detect its molecular signature in NIR with a high signal to noise ratio. Our experimental results indicate that evanescent vibrational spectroscopy has the potential to achieve groundbreaking sensitivity and specificity in chemical sensing compared to conventional spectroscopy, promising breakthroughs in chemical monitoring, healthcare and security applications.