

Optofluidic fiber platform for molecule sensing

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Considerable advances have been achieved with optical sensors throughout the years, which today find real world applications in diverse areas. For chemical and biosensing, a number of methods based on, e.g., photoluminescence and Raman scattering, allow for obtaining chemical composition information of analytes. In particular, surface enhanced Raman scattering (SERS) can achieve detection at single molecule concentrations. Optofluidic sensors, which combine the compactness and practicality of microfluidics with the high sensitivity of optical sensing, present a high potential for practical, reliable and low sample volume testing. Even though most optofluidic sensors rely on integrated optics on chips and planar structures, structures that are based on optical fibers containing micron-scale fluidic channels can take advantage of the well-established optical fiber industry, with cost effective optical sources, detectors and components widely available. In addition, with channels of few to tens of microns in diameter, as little as nanoliter sample volumes are required. Our group has a long-term experience with optofluidic fiber structures, with a fluidic fiber dye laser, e.g., demonstrated [1]. This expertise has now been used in combination with the functionalization with graphene oxide of the internal walls of microstructured fibers [2], for the preparation of a sensitive and ultralow volume SERS sensor [3]. A fiber with an 80-μm-diameter central capillary was functionalized in a 2-step process, first with graphene oxide, and subsequently with gold nanorods with a ~15-nm diameter and a ~50-nm length (Figure 1A). Graphene oxide plays a triple role, mediating the attachment of the nanorods in the fiber, suppressing photoluminescence from the analyte and stabilizing the SERS signal [4]. Centimeter long sections of the fiber were tested as optofluidic SERS platforms, placed under a WITec Alpha 300R confocal Raman microscope, with an excitation wavelength of 633 nm. Rhodamine 640 and Rhodamine 6G were used as analytes and were inserted into the fibers in aqueous solutions. We highlight that volumes as low as a few hundreds of nanoliters were sufficient for the measurements. Figure 1B shows the obtained SERS spectra for Rhodamine 640, in which case concentrations as low as 10^{-9} M still presented the analyte's characteristic modes. Figure 1C shows that sub-second integration times were sufficient to obtain low noise and temporally stable spectra, allowing for fast analysis. The developed sensing platform can be adapted to be selectively sensitive to specific biomolecules, such as viral proteins, potentially providing highly sensitive and precise tests with ultralow-volume requirements.

REFERENCES

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FIGURES

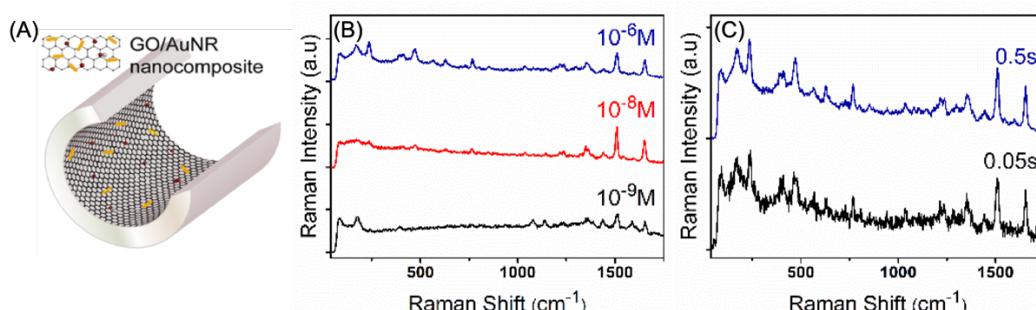


Figure 1: (A) Schematic representation of the capillary fiber internally coated with GO/AuNRs. SERS spectra of Rhodamine 640 solutions for various concentrations (B) and for different integration times at 10⁻⁶ M (C).