Ultrasensitive detection of endocrine disruptors via superfine plasmonic spectral combs

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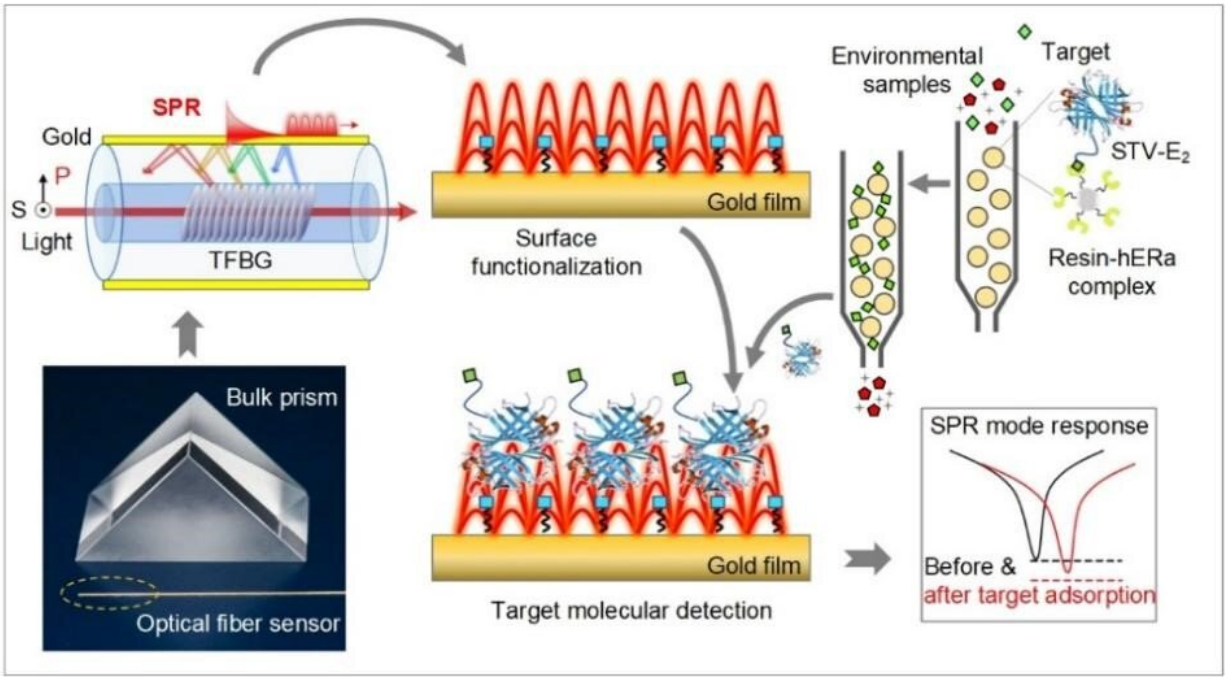

Sensing mechanism for detection of broad ranges of EEs by using human estrogen receptor α (hERα) as the biological recognition element. In brief, a gold-coated tilted fiber Bragg grating excites surface plasmon resonance (SPR) that enables the ultrasensitive monitoring of refractive index changes at the fiber surface. Environmental estrogens in the samples compete the hERα with the E_2–STV conjugates. The fiber senor is tethered with the desthiobiotin (DTB) molecules and the unbound E_2–STV conjugates are captured via the STV–DTB affinity interaction, which induces the wavelength shift of the SPR spectrum (from black to red). This method offers in situ detection of environmental

estrogens with high sensitivity and specificity. Credit: Lanhua Liu, Xuejun Zhang, Qian Zhu, Kaiwei Li, Yun Lu, Xiaohong Zhou and Tuan Guo

The apparent increase in hormone-induced cancers and disorders of the reproductive tract has led to a growing demand for new technologies capable of detecting nanogram per liter level endocrine disruptors. Scientists in China invented an ultracompact optical fiber biosensor displaying superfine plasmonic spectral combs and enhanced by conjugate-induced bio-amplification, which showed the limit of detection down to 1.5 ng l^{-1} estradiol equivalent concentration. The technique has the potential to revolutionize environmental and health monitoring.

Developing the advanced and powerful detection techniques to characterize as many endocrine disruptors as possible with ultra-sensitivity in the environment is still challenging, however highly demanded. Environmental estrogens (EEs), as typical endocrine disruptors, have been listed as one of the global environmental issues to be addressed through international collaboration by the United Nations. They are structurally diverse compounds that can interact with nuclear estrogen receptors and pose significant risks to ecological and human health.

In a new paper published in *Light Science & Application*, a team of photonics and environmental scientists, led by Prof. Tuan Guo from Jinan University and Dr. Xiaohong Zhou from Tsinghua University, developed a simple-to-implement plasmonic optical fiber biosensing platform for ultrasensitive detection of estrogenic endocrine disruptors. The platform is based on a gold-coated highly tilted fiber Bragg grating, which excites high-density narrow cladding mode spectral combs overlapping with the broader absorption of the surface plasmon for high

accuracy interrogation, hence enabling the ultrasensitive monitoring of refractive index changes at the fiber surface. Through the use of estrogen receptors as the model, they design an estradiol-streptavidin conjugate with the assistance of molecular dynamics, converting the specific recognition of environmental estrogens by estrogen receptor into surface-based affinity bioassay for protein. The ultrasensitive platform with conjugate-induced amplification biosensing approach enables the subsequent detection for EEs down to 1.5 ng l^{-1} estradiol equivalent concentration. It is the lowest limit of detection for any estrogen receptors-based detection reported to date.

Moreover, the compact size, flexible shape, and remote operation capability of in-fiber plasmonic biosensor open the way for detecting other endocrine disruptors with ultrahigh sensitivity and in various hard-to-reach spaces, thereby having the potential to revolutionize environment and health monitoring. For example, the biosensor is able to perform for the in-field continuous detection of endocrine disruptors, meeting the highly desired demand for the timely monitoring of environmental status. By integrating such fiber biosensor with a hypodermic needle on the other hand would allow similar measurements, as portable on-site and in-field analysis in health monitoring, even in vivo.

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