

Supporting Information:

Photochemical device for selective detection of phenol in aqueous solutions

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Section S1: Measurement principle of temperature independence of the device

We know that LPFG is sensitive to temperature and RI, thus, the EYST-coated LEPFG (PLPFG) is also sensitive to temperature and RI. According to the literature [1], a central wavelength of rejection band λ_{LP} of a PLPFG (LPFG) with grating period Λ can be expressed by the phase-matching condition:

$$\lambda_{LP} = (n_{co}^{eff} - n_{cl,m}^{eff})\Lambda_{LP} \quad (1)$$

where n_{co}^{eff} and $n_{cl,m}^{eff}$ are the effective RIs of the fundamental core mode and the m th cladding mode, respectively. Changes in the temperature and RI of the external medium (analyte) surrounding the PLPFG (LPFG) can alter the Λ and the differential refractive index of the core and cladding modes. Using eq. 1, the effects of the temperature (T) and analyte RI (n_a) on the λ_{LP} can be expressed as:

$$\begin{aligned} \frac{\Delta\lambda_{LP}}{\lambda_{LP}} &= \left[\frac{1}{n_{co}^{eff} - n_{cl,m}^{eff}} \frac{\partial(n_{co}^{eff} - n_{cl,m}^{eff})}{\partial T} + \frac{1}{\Lambda_{LP}} \frac{\partial\lambda_{LP}}{\partial T} \right] \Delta T + \\ &\left[\frac{1}{n_{co}^{eff} - n_{cl,m}^{eff}} \frac{\partial(n_{co}^{eff} - n_{cl,m}^{eff})}{\partial n_a} + \frac{1}{\Lambda_{LP}} \frac{\partial\lambda_{LP}}{\partial n_a} \right] \Delta n_a \\ &= k_{T,0} \Delta T + k_{n,0} \Delta n_a \end{aligned} \quad (2)$$

where $k_{T,0}$ and $k_{n,0}$ denote the temperature sensitivity coefficient and RI sensitivity coefficient, and, respectively, of the PLPFG (LPFG) sensor. Furthermore, the relationship between the RI and the concentrations of an analyte in the mixture solution is assumed to satisfy the function equation:

$$n_a = Ac + B \quad (3)$$

where A and B are constant parameters, and c is the phenol concentration of aqueous solutions. Thus, by using eqns. 2 and 3, the change in the wavelength with changes in the temperature and phenol concentration can be expressed as:

$$\Delta\lambda_{LP} = \lambda_{LP} k_{T,0} \Delta T + \lambda_{LP} A k_{n,0} \Delta c = k_{T,1} \Delta T + k_{n,1} \Delta c \quad (4)$$

where $k_{T,1} = \lambda_{LP} k_{T,0}$, $k_{n,1} = A \lambda_{LP} k_{n,0}$, and $k_{T,1}$ and $k_{n,1}$ represent the change in wavelength with changes in the temperature and phenol concentration, respectively.

In this work, to accurately monitor the phenol in aqueous solutions, the FBG was employed to monitor the temperature and compensate the effect of the temperature on the rate of change of the wavelength. In particular, the Bragg wavelength (λ_B) for the unperturbed FBG is sensitive only to surrounding temperature changes and can be expressed as follows.

$$\Delta\lambda_B = \alpha \lambda_B \Delta T = k_B \Delta T \quad (5)$$

Thus, by using eqns. 4 and 5, the matrix can be expressed as:

$$\begin{bmatrix} \Delta\lambda_{LP} \\ \Delta\lambda_B \end{bmatrix} = \begin{bmatrix} k_{T,1} & k_{n,1} \\ k_B & 0 \end{bmatrix} \begin{bmatrix} \Delta T \\ \Delta c \end{bmatrix} \quad (6)$$

Reference:

- [1] N. D. Rees, S. W. James, R. P. Tatam and G. J. Ashwell, Optical fiber long-period gratings with Langmuir–Blodgett thin-film overlays. *Opt. Lett.* 2002, **27**, 686–688.

Section S2: Figs. S1–S5

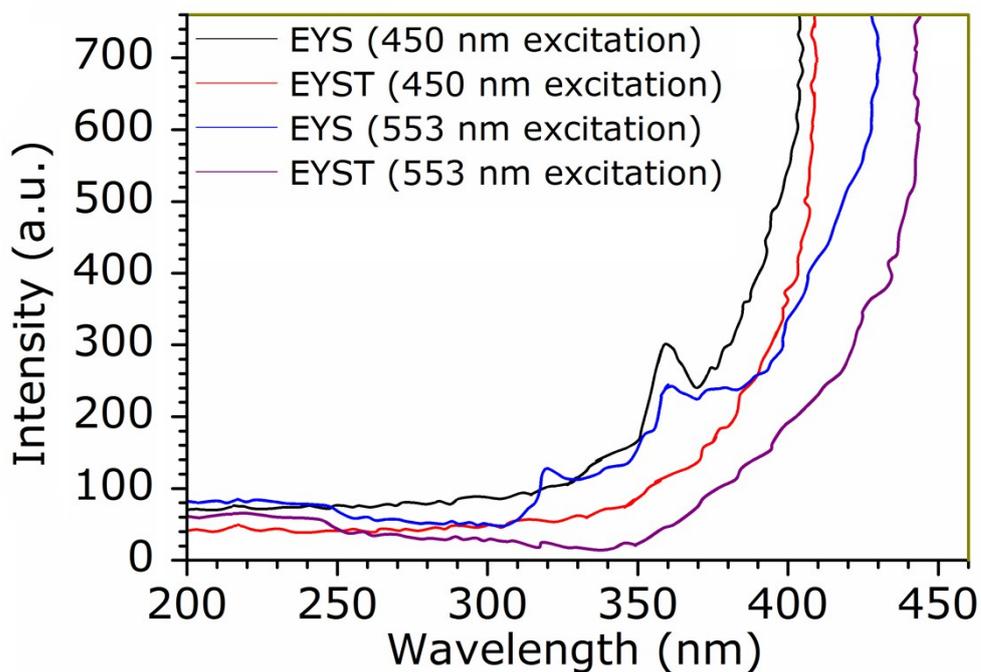


Fig. S1. Representative fluorescence spectra of EYS ($\text{Er}^{3+}:\text{YAlO}_3/\text{SiO}_2$) and EYST ($\text{Er}^{3+}:\text{YAlO}_3/\text{SiO}_2/\text{TiO}_2$) under 455 and 553 nm excitation; the fluorescence spectra of EYS and EYST were recorded on a Horiba FluoroLog-3 spectrofluorometer equipped (HORIBA Scientific, Edison, NJ, USA).

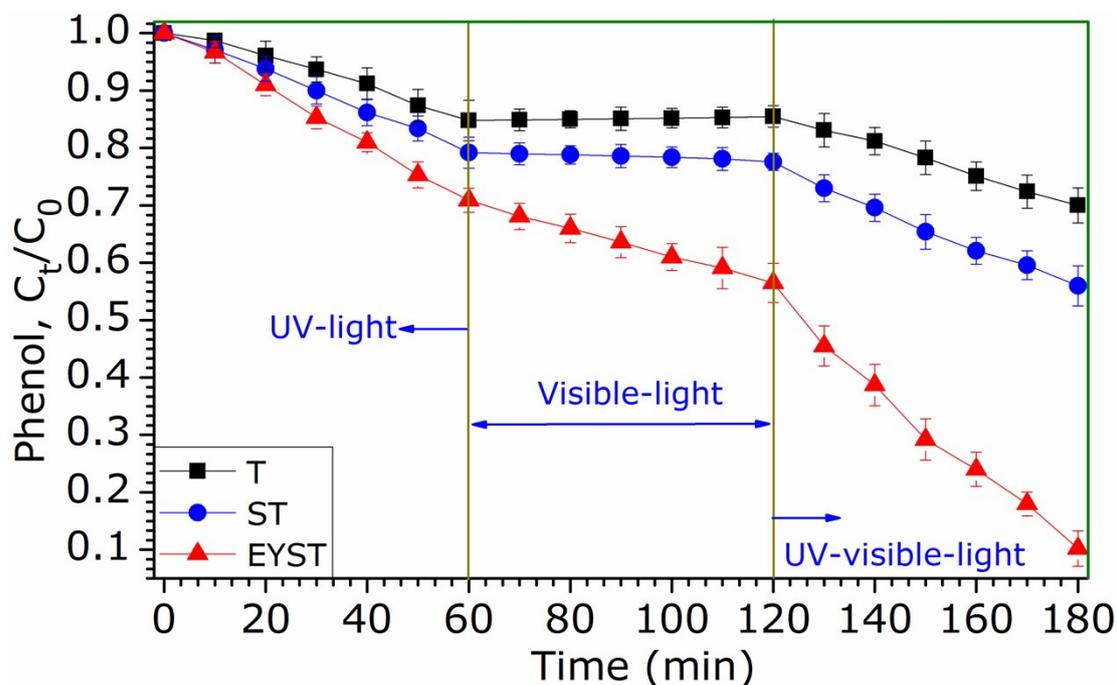


Fig. S2. Photocatalytic activity of T (TiO_2), ($\text{SiO}_2/\text{TiO}_2$), EYST ($\text{Er}^{3+}:\text{YAlO}_3/\text{SiO}_2/\text{TiO}_2$) nanoparticles under UV light (wavelength: 290–370 nm), visible light (wavelength: 400–800 nm), and UV-visible light irradiations (wavelength: 260–800 nm); operation conditions: pH

6.25, 30 °C, 0.02 g catalysts, 10 ml deionized water, 100 ml beaker, and without any agitation.

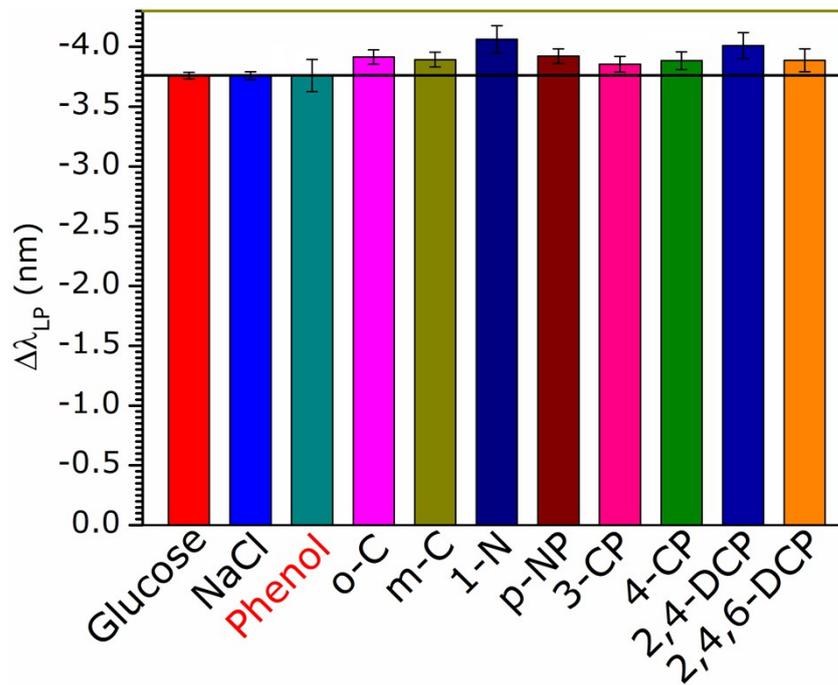


Fig. S3. The selectivity of the device to analytes (the analytes were injected into the Z-shaped micro-channel of the device, respectively; the nitric acid solution with pH 6.25 was injected into the sensing chamber of the device).

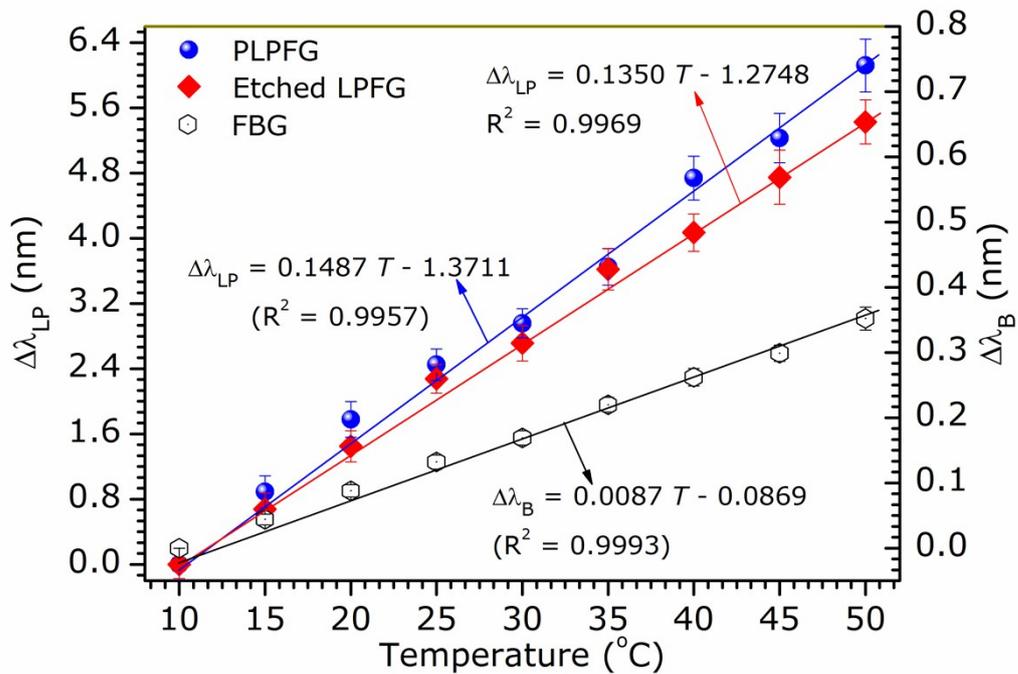


Fig. S4. Wavelength shifts of PLPFG, etched LPFG and FBG sensors as a function of temperature in nitric acid aqueous solution under UV-visible light irradiation (pH 6.25).

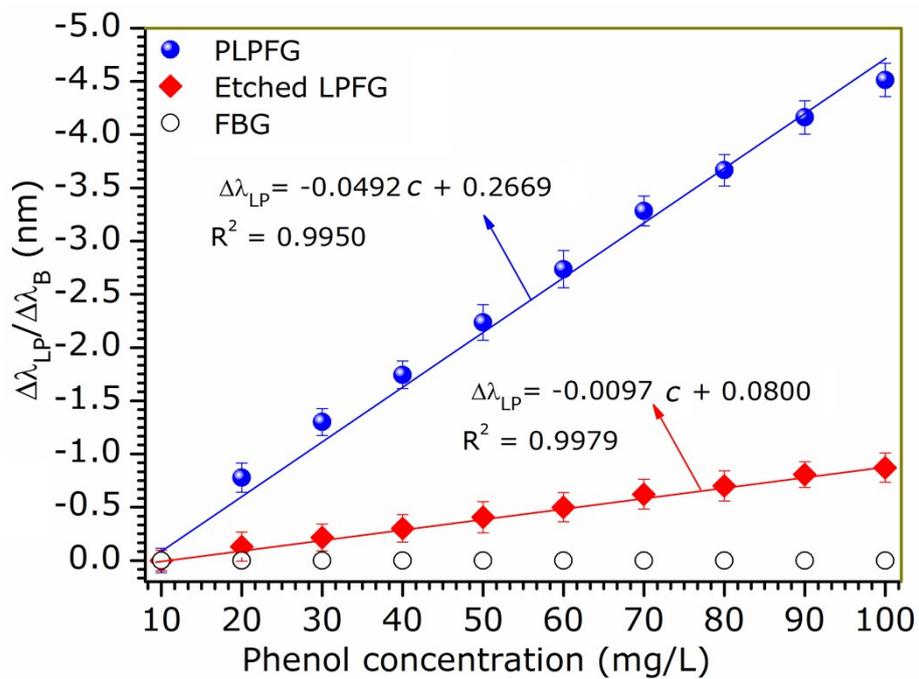


Fig. S5. Wavelength shifts of PLPFG, etched LPFG and FBG sensors as a function of phenol concentration under UV-visible light irradiation (pH 6.25, 30 °C).