Supporting Information

$NaBiF_4$ Upconversion Nanoparticle-based Electrochemiluminescent Biosensor for *E. coli* O157:H7 Detection

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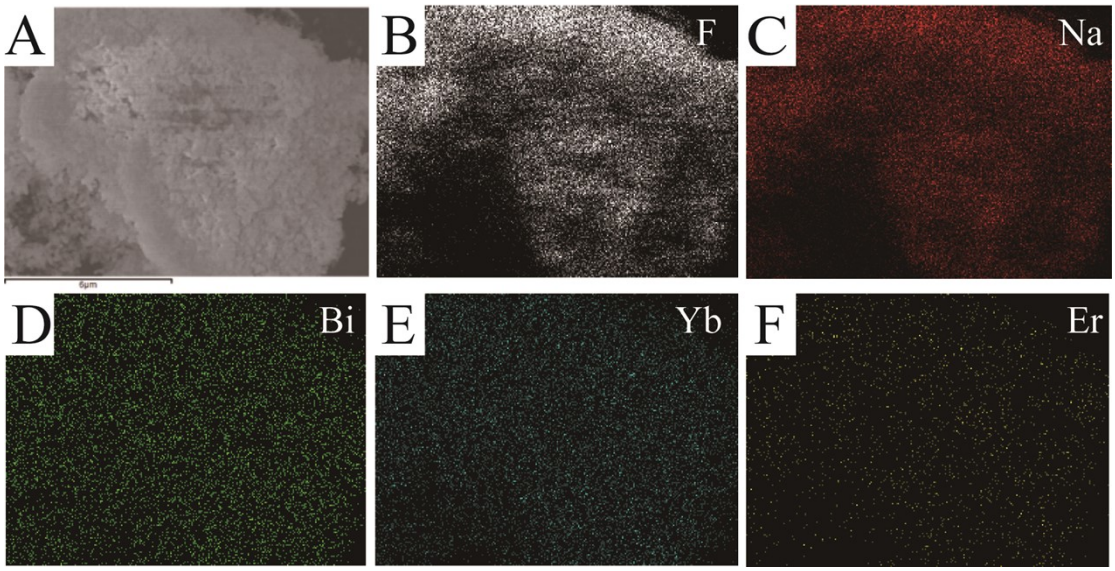

Figure S1. SEM elemental mapping of (B) F, (C) Na, (D) Bi, (E) Yb and (F) Er according to (A) the original SEM image of $NaBiF_4$:Yb^{3+}/Er^{3+} UCNPs.

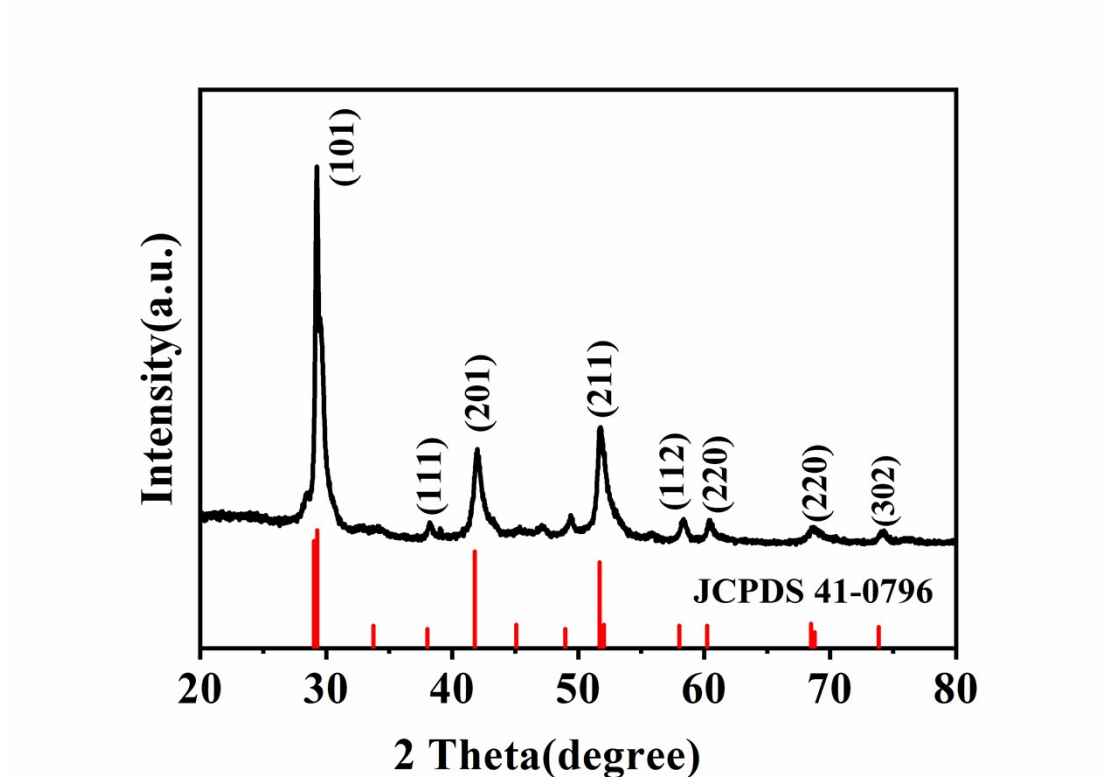

Figure S2. XRD pattern of $NaBiF_4:Yb^{3+}/Er^{3+}$ UCNPs in comparison with the standard peaks of hexagonal phase $NaBiF_4$。

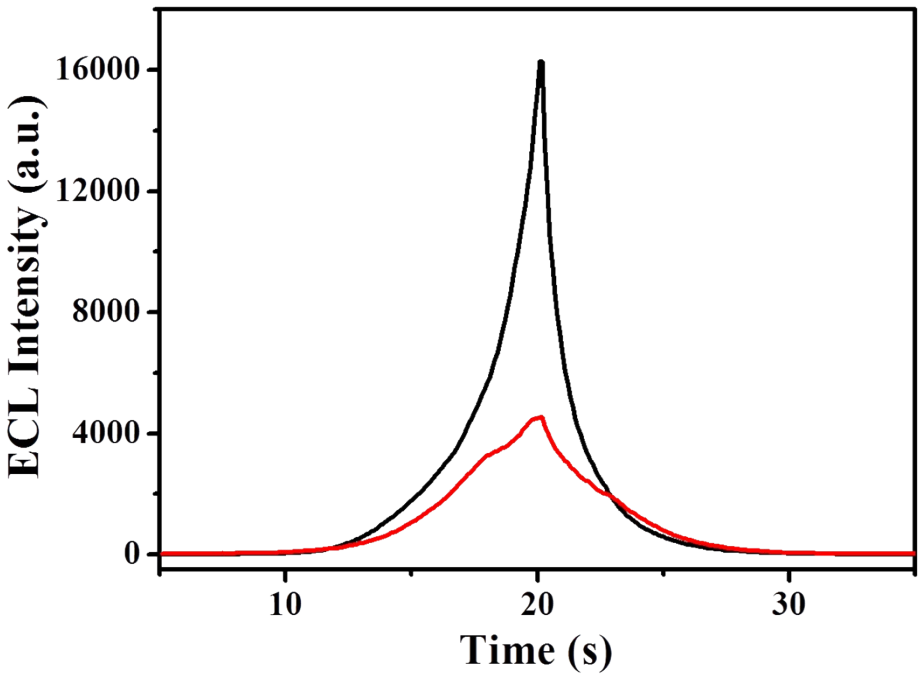

Figure S3. Comparison of ECL intensity of $NaBiF_4$:Yb^{3+}/Er^{3+} UCNPs in PBS (0.1 M, pH 7.4) with (black curve) or without 0.1 M $K_2S_2O_8$ (red curve). The scan rate was 100 mV s^{-1} and the PMT voltage was 800 V, respectively.

Table S1 Comparison of ECL intensity for different materials with or without doping elements.

materials	ECL intensity (a.u.)
$NaBiF_4:Yb^{3+}/Er^{3+}$ UCNPs	14600±114.2
$NaBiF_4:Yb^{3+}$ UCNPs	3500±56.8
$NaBiF_4$ UCNPs	440±15.6

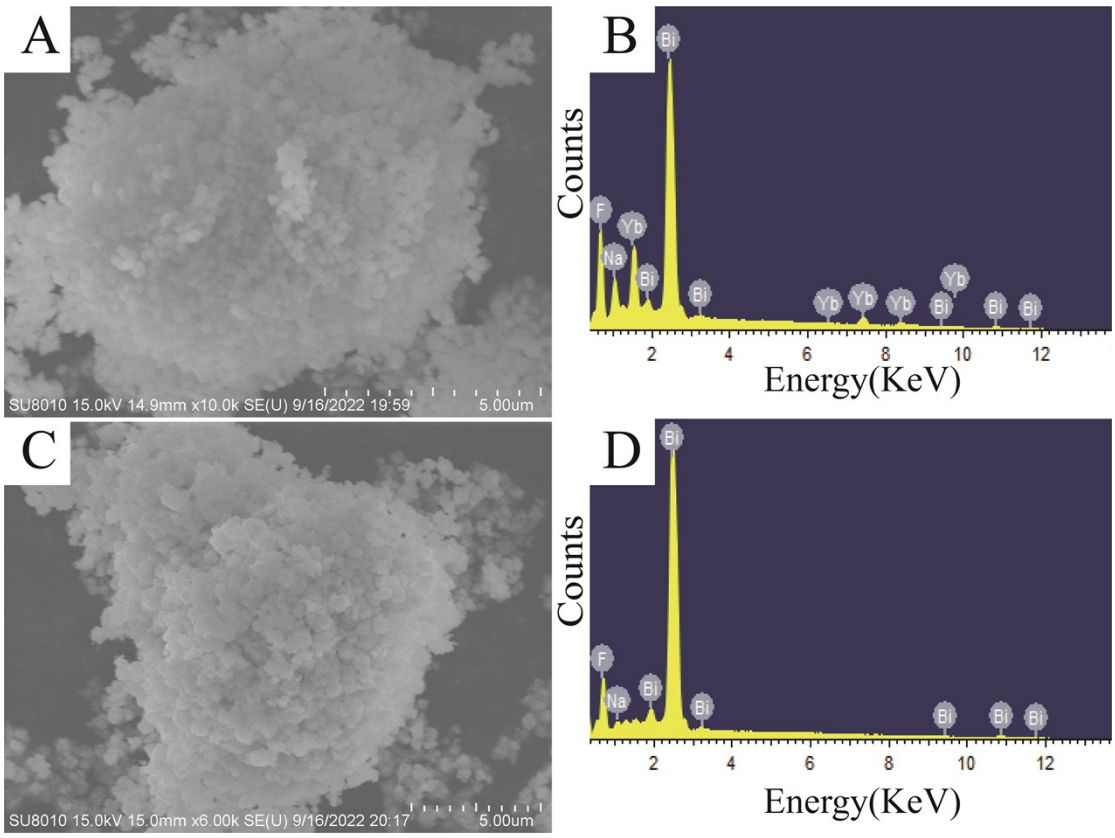

Figure S4. (A) SEM image and (B) EDS of $NaBiF_4$:Yb^{3+} UCNPs, (C) SEM image and (D) EDS of $NaBiF_4$ UCNPs

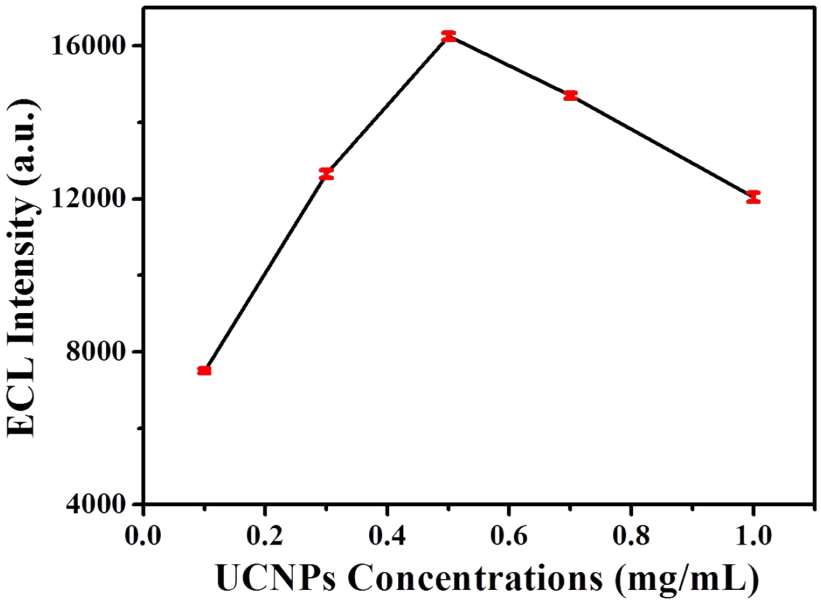

Figure S5. Effect of the concentration of UCNPs solution on ECL intensity of $NaBiF_4$:Yb^{3+}/Er^{3+} UCNPs/GCE. Electrolyte: PBS (0.1 M, pH 7.4) with 0.1 M $K_2S_2O_8$. The scan rate was 100 mV s^{-1} and the PMT voltage was 800 V, respectively..

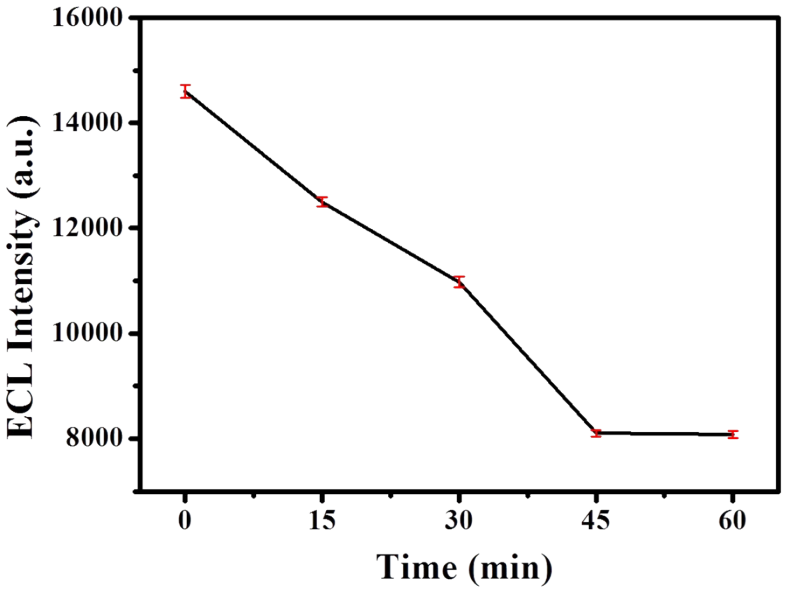

Figure S6. Effect of incubation time on ECL intensity of *E. coli* O157:H7 antibody/Au/$NaBiF_4$:Yb^{3+}/Er^{3+} UCNPs/GCE. The electrode was incubated with 10^4 CFU mL^{-1} *E. coli* O157:H7 suspension solution for 0, 15, 30, 45 and 60 min. Electrolyte: PBS (0.1 M, pH 7.4) with 0.1 M $K_2S_2O_8$. The scan rate was 100 mV s^{-1} and the PMT voltage was 800 V, respectively.

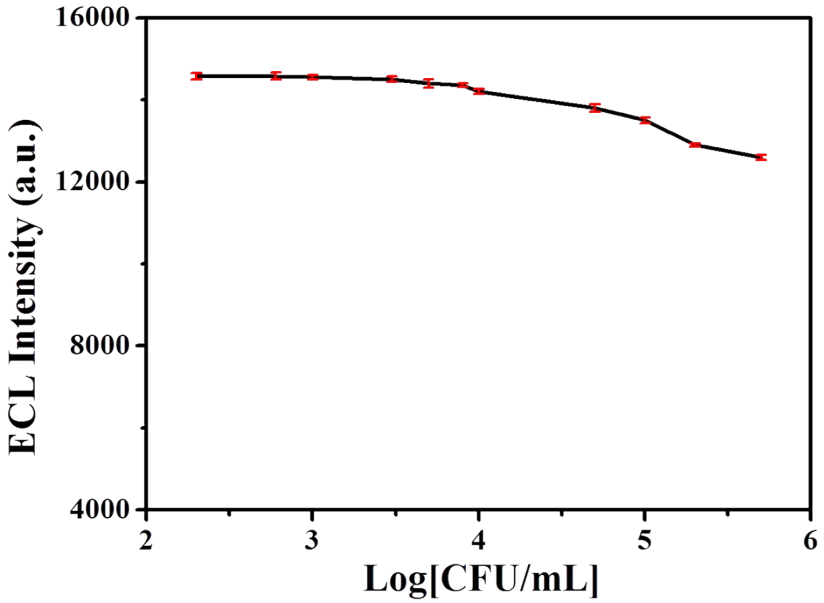

Figure S7. The relationship between the ECL peak intensity and the logarithm of *E. coli* Top 10 concentrations with the anti- *E. coli* O157:H7/Au/ $NaBiF_4$:Yb^{3+}/Er^{3+} UCNPs/GCE incubated with *E. coli* Top 10. The concentrations of *E. coli* Top 10 is 200, 600, 1000, 3000, 5000, 8000, 10000, 50000, 100000, 200000 and 500000 CFU mL^{-1}, respectively. Error bar=RSD (n=5).

Table S2 The long-time stability of as-prepared biosensors.

samples	ECL intensity (0 day, a.u.)	ECL intensity (7 day, a.u.)	ECL intensity (14 day, a.u.)	Percentage of remained intensity
Biosensor 1	14680	14331	13800	94%
Biosensor 2	14640	14108	13545	92.5%
Biosensor 3	14515	14240	13710	94.5%

Table S3 The selectivity and specificity of the biosensor.

samples	Incubated bacteria (CFU/mL)	ECL intensity (a.u.)	RSD comparing with blank
Biosensor with antibody 1	*E. coli* O157:H7, *E. coli* JM109, *E. coli* DH5α and *E. coli* Top, 1000	11243±82.7	2.4%
Biosensor with antibody 2	*E. coli* O157:H7, 1000	11520±103.9	
Biosensor without antibody 1	*E. coli* O157:H7, 10000	15359±95.6	4.6%
Biosensor without antibody 2	*E. coli* Top 10, 10000	15327±112.3	4.8%
Biosensor without antibody 3	No	16100±125.6	