Electronic Supplementary Material (ESI) for Environmental Science: Nano.


# Supplementary Information for

## An Electron-Donating System Composed of $C_{IDS}$@CFO@$F^0C^0$ catalyst for Sustainable Generation of Free Radical to Inactivate Pathogens

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## Experimental Procedures

### (1) Characterization of the SED system

The crystallographic structure was measured by X-ray diffractometer with $2\theta$ = 10°-80° (XRD-6000, SHIMADZU, Japan). BET (3H-2000PS1) was utilized to detect the surface area and pore features of the catalyst. The surface morphology of the samples was analyzed by SEM (JSN-6380LV) and EDS was performed to determine the element distribution with the same machine. The hysteresis loops were measured at 25℃ on the vibrating magnetometer (VSM-7300, Lakeshore, USA). The surface elements were determined by X-ray photoelectron spectroscopy (XPS, Thermo Fischer, ESCA Lab 250Xi, USA). Leaching concentrations of metal were detected by an inductively coupled plasma-atomic emission spectrometry (ICP-OES, iCAP7200 HS Duo, Thermo Fisher Scientifific, UK). The culture medium for E. coli was purchased from Beijing Oberstar Biotechnology Co., LTD. $C_{IDS}$@CFO@$F^0C^0$ + *E.coil* and *E.coil* were placed in LB medium (three groups of parallel samples were set), and the experiment was carried out according to the detection steps of the kit after reaction for 2 hours. Repeat the preceding steps twice. And the bioassay kit including malondialdehyde assay kit, superoxide dismutase assay kit and $Na^+K^+$-ATP enzyme activity assay kit, were from Shanghai Solebao Biological Technology Co., LTD. The absorbance of the kit was measured with FC microplate reader (Thermo Fisher Technology, USA). The electron paramagnetic resonance (EPR) spectrometer (JEOL FA-200, Japan) was used to detect ROS.

### (2) Detection of •OH by kit

The corresponding application solution was prepared according to the kit instructions. After 3 min of prewarming at 37 ° C, the following procedure was performed.

| | Blank sample | Standard sample | Control sample | measured sample |
|---|---|---|---|---|
| Double steaming water (mL) | 0.4 | 0.2 | 0.2 | |
| 0.03% $H_2O_2$ standard application solution (mL) | | 0.2 | | |

| | | | | |
|---|---|---|---|---|
| Substrate application solution (mL) | | | 0.2 | 0.2 |
| The sample (mL) | | | | 0.2 |
| Reagent 3 Application solution (mL) | 0.4 | 0.4 | 0.4 | 0.4 |
| The timing was mixed while reagent 3 was added. The reaction was incubated at 37 ° C for 1 min and then terminated by the immediate addition of chromogenic agent. | | | | |
| Chromogenic agent (mL) | 2 | 2 | 2 | 2 |
| After mixing well, the mixture was left at room temperature for 20 minutes. The absorbance value A of each sample was determined by microplate reader at 550nm wavelength. | | | | |

Calculation formula of •OH capacity:

$$\text{The ability to produce •OH (U/mL)} = [(A_{measure} - A_{contrast}) / (A_{standard} - A_{blank})] * C_{standard} * 1/V_{sample} * 1000$$

$C_{standard}$: Concentration of standard, 8.824mmol/L;

$V_{sample}$: Amount of sampling, 0.2mL.

**(3) Detection of $•O_2^-$ by kit**

| | Control sample | Standard sample | measured sample |
|---|---|---|---|
| Reagent 1 application solution | 1.0 | 1.0 | 1.0 |
| Double steaming water (mL) | 0.05 | | |
| 0.15mg/mL Vc standard (mL) | | 0.05 | |
| The sample (mL) | | | 0.05 |
| Reagent 2 | 0.1 | 0.1 | 0.1 |
| Reagent 3 | 0.1 | 0.1 | 0.1 |
| Reagent 4 Application solution (mL) | 0.1 | 0.1 | 0.1 |
| After mixing well, the samples to be tested were placed in a constant temperature water bath at 37 ° C for 40 minutes. | | | |
| Chromogenic agent (mL) | 2.0 | 2.0 | 2.0 |
| After mixing, the mixture was allowed to stand for 10 min at room temperature. The absorbance value A of each sample was determined by microplate reader at 550nm wavelength. | | | |

Calculation formula of $•O_2^-$ capacity:

$$\text{The ability to produce } •O_2^- \text{ (U/mL)} = [(A_{measure} - A_{contrast}) / (A_{contrast} - A_{standard})] * C_{standard} * 1000$$

$C_{standard}$: Concentration of standard, 0.15mg/mL.

## Results and discussion

**Fig. S1. (a) XRD patterns of $C_{IDS}$@CFO@$F^0C^0$, (b) XRD patterns of materials prepared with different ratios of Fe and Co**

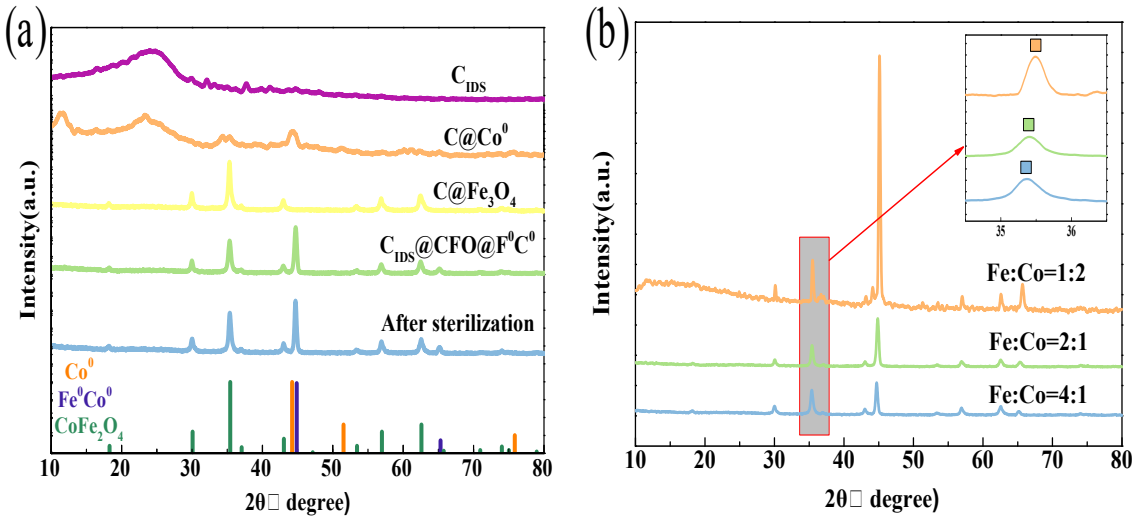


**Fig. S2. (a) SEM images of $C_{IDS}$ and $C_{IDS}$@CFO@$F^0C^0$ and (b) EDS of $C_{IDS}$@CFO@$F^0C^0$, (c) and (d) TEM images of $C_{IDS}$@CFO@$F^0C^0$**

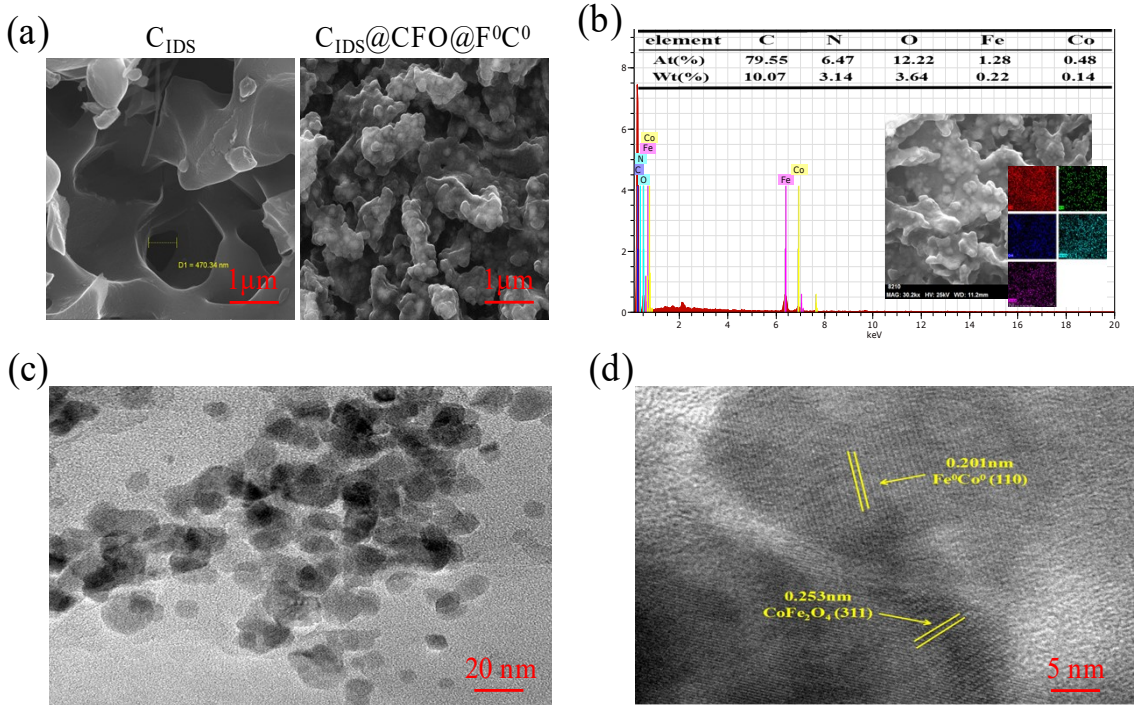

**Fig. S3. Nitrogen adsorption/desorption isotherms and BJH pore size distribution of (a) $C_{IDS}$ and (b) $C_{IDS}$@CFO@$F^0C^0$**

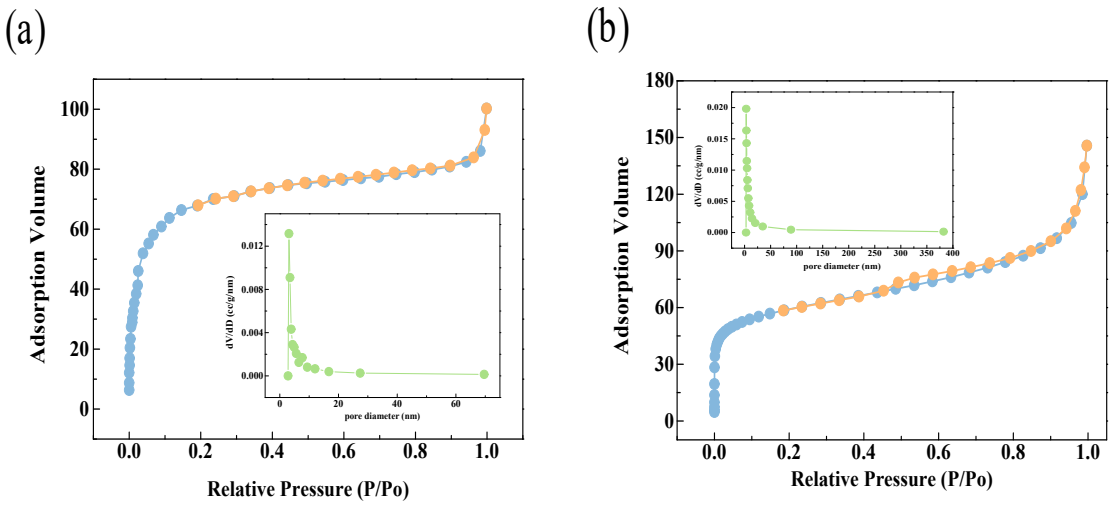


**Fig. S4. Electrochemical impedance spectroscopic analysis of $C_{IDS}$@CFO@$F^0C^0$, C@$Co^0$ and C@$Fe_3O_4$**

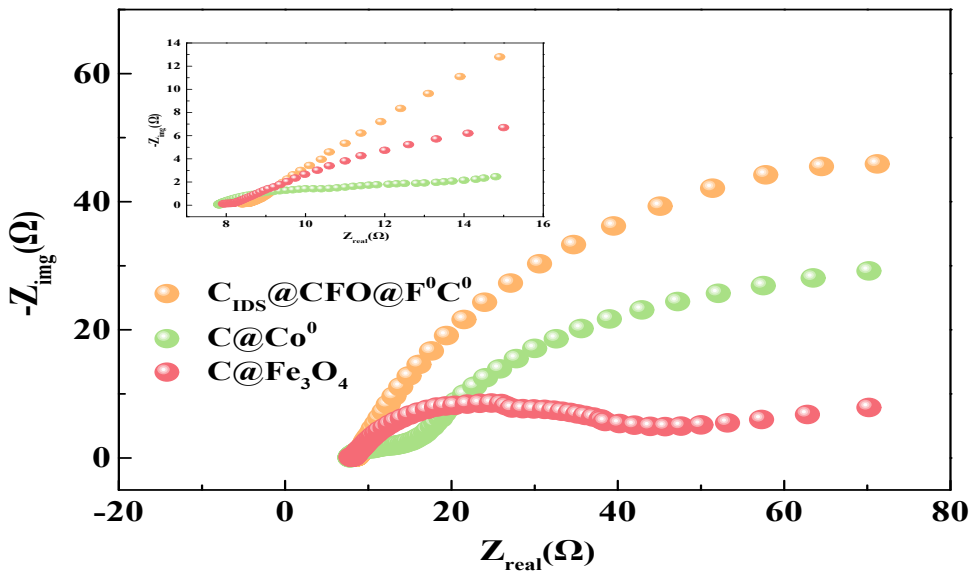

**Fig. S5. Contrast Fig. of green fluorescence intensity by FDA staining with and without the SED system**

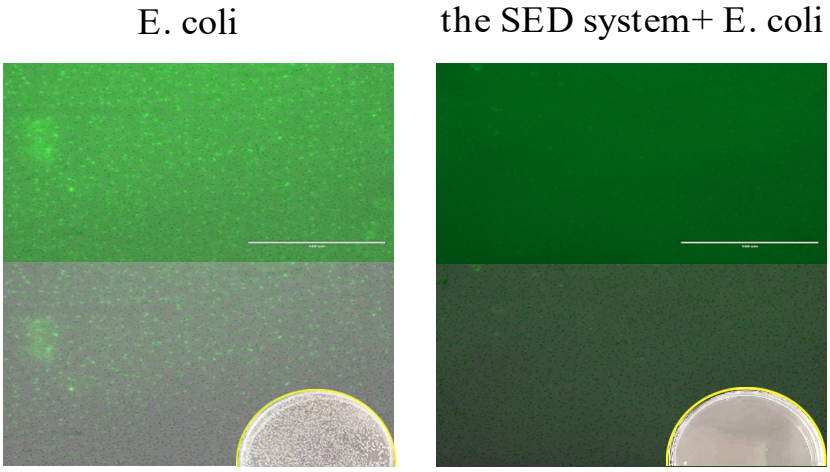


**Fig. S6. Experiment of inactivation of *Staphylococcus aureus* by SED system.**

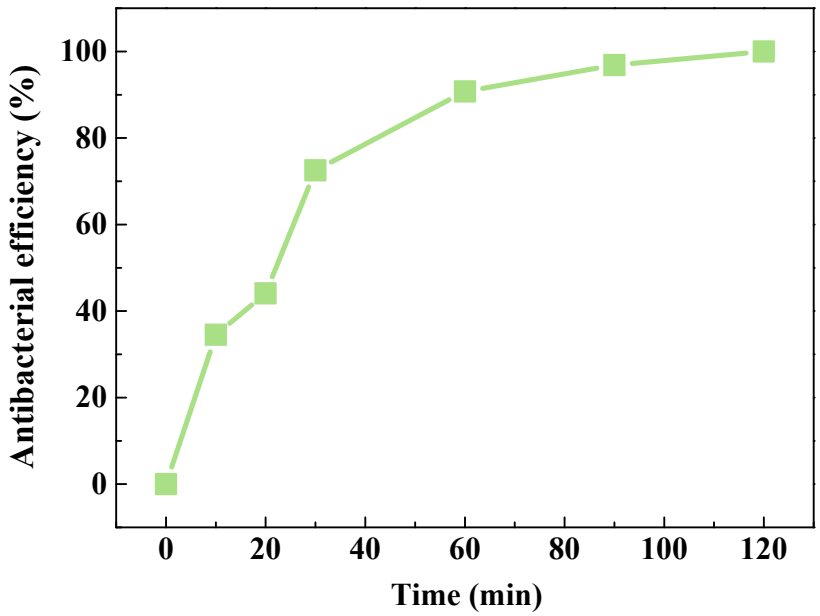

**Fig. S7. Magnetic hysteresis curve at 300K of the SED system**

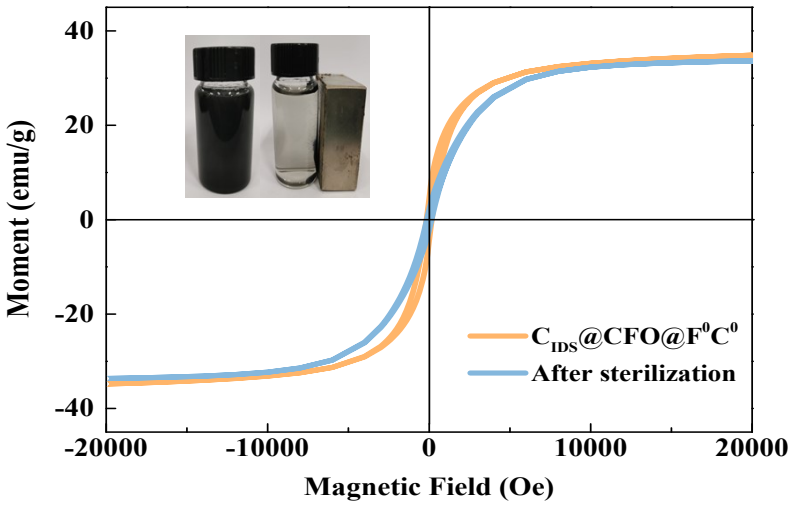


**Fig. S8. The comparison of inactivation was compared with different oxygen conditions in SED system**

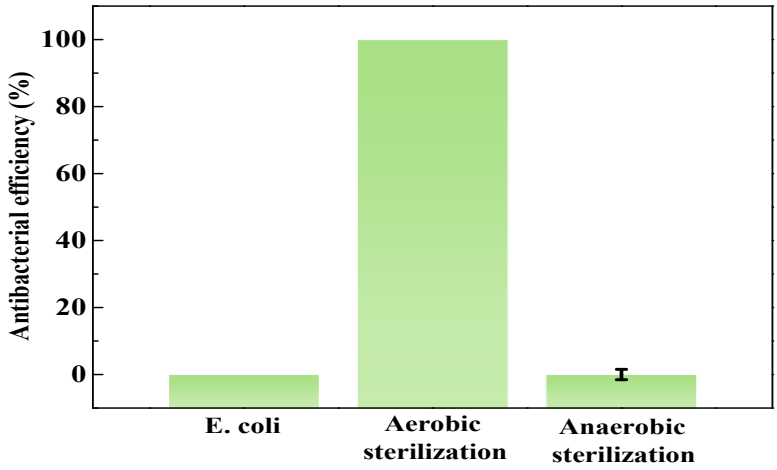

**Fig. S9. EPR spectrum of $\bullet O_2^-$ in (a) $C_{IDS}$, (b) C@$Co^0$, (c) C@$Fe_3O_4$ and (d) $C_{IDS}$@CFO@$F^0C^0$**

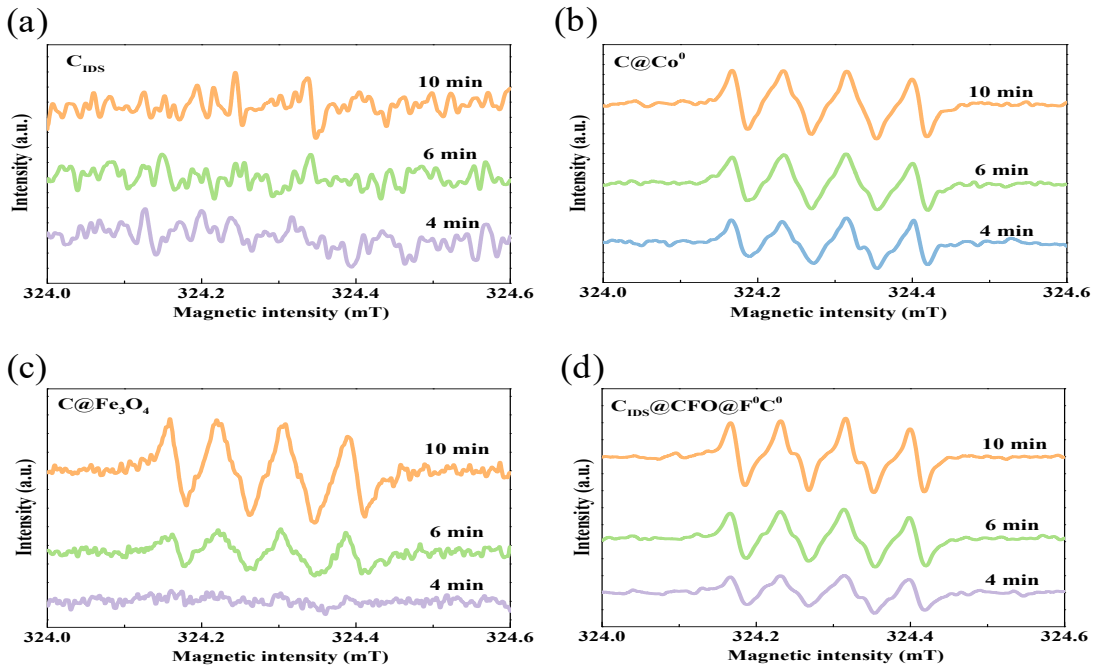


**Fig. S10. EPR spectrum of •OH in (a) $C_{IDS}$, (b)C@$Co^0$, (c) C@$Fe_3O_4$ and (d) $C_{IDS}$@CFO@$F^0C^0$**

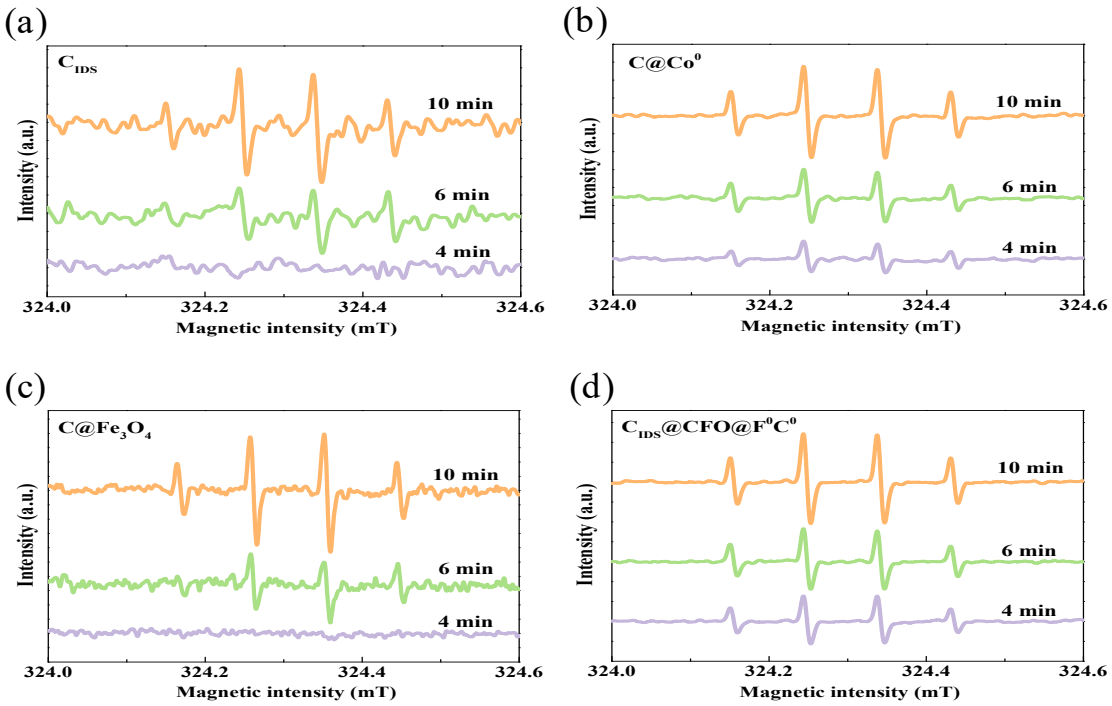


**Fig. S11. EPR spectrum of different materials in (a) $\bullet O_2^-$, (b)$\bullet OH$**

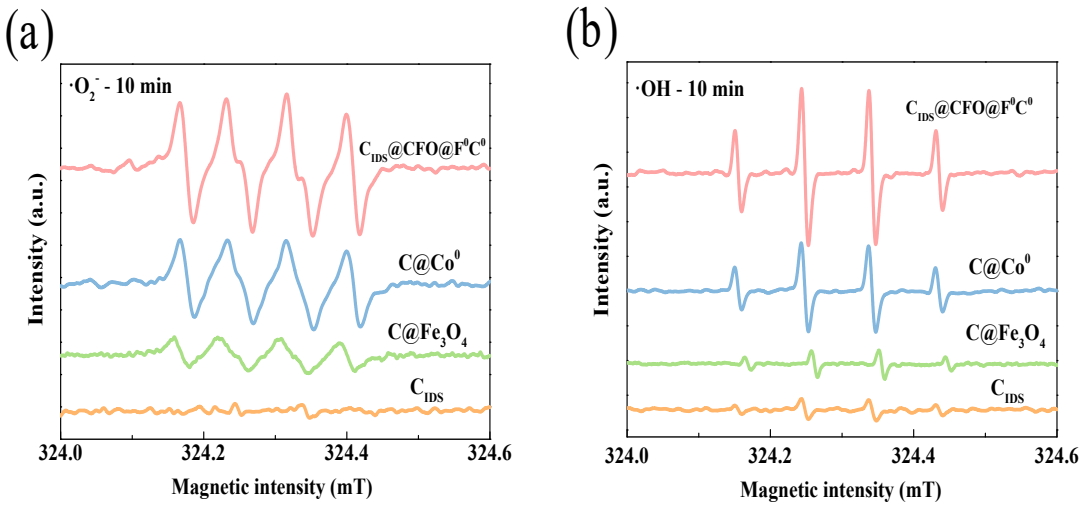


**Fig. S12. (a) C 1s, (b) N 1s and (c) O 1s spectrum of XPS of $C_{IDS}$@CFO@$F^0C^0$ after one time inactivation**

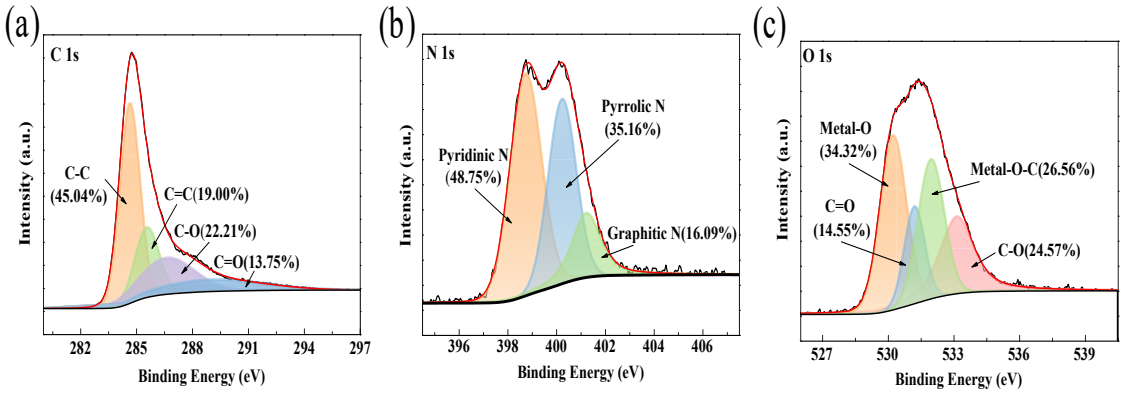


**Fig. S13. (a) C 1s, (b) N 1s and (c) O 1s spectrum of XPS of $C_{IDS}$@CFO@$F^0C^0$ after six times inactivation**