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Supporting Information

Ultra-small Co_3O_4 particles embedded into N-doped carbon derived from ZIF-9 *via* half-pyrolysis for activating peroxymonosulfate to degrade sulfamethoxazole

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1. Experimental

1.1 Materials and methods

Cobalt acetate tetrahydrate ($Co(CH_3COO)_2 \cdot 4H_2O$, Sinopharm Chemical Reagent Co., Ltd., AR), benzimidazole ($C_7H_6N_2$, Shanghai Macklin Biochemical Co., Ltd., AR), Ethanol (Tianjin Tiantai, AR), PMS ($2KHSO_5 \cdot KHSO_4 \cdot K_2SO_4$, Shanghai Aladdin Biochemical Technology Co., Ltd. ≥42%), SMX ($C_{10}H_{11}N_3O_3S$, Shanghai Saen Chemical Technology Co., Ltd., AR), $Na_2S_2O_3$ (Sinopharm Chemical Reagent Co., Ltd., AR), KCl (Shanghai Macklin Biochemical Co., Ltd., AR), $NaHCO_3$ (Tianjin Guangfu Technology Development Co., Ltd., AR), KH_2PO_4 (Beijing Beihua Fine Chemicals Co., Ltd., AR), Humic acid sodium salt ($C_9H_8Na_2O_4$, Shanghai Macklin Biochemical Co., Ltd., AR), Furfuryl alcohol ($C_5H_6O_2$, Shanghai Macklin Biochemical Co., Ltd., AR), *tert*-Butanol ($C_4H_{10}O$, Shanghai Macklin Biochemical Co., Ltd., AR), *p*-Benzoquinone ($C_6H_4O_2$, Adamas Reagent Co.,Ltd., AR) were employed in this work without further purification.

1.2 Characterization

Scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDX, AZtecLive UltimMax100) were observed by Hitachi Regulus 8100. Transmission electron microscope (TEM) was characterized by FEI Tecnai G2 F20. Fourier transform infrared (FT-IR) spectra were acquired on a Thermoscientific Nicolet 4700 Fourier Transform Infrared Spectrometer with KBr pellet. X-ray diffraction (XRD) data were collected on a PANalytical B.V. Empyrean powder diffractometer using a Cu Kα source (λ = 1.5418 Å) over the range of 2θ = 5.0−80.0°. The sorption isotherm for N_2 was measured by using a Micromeritics ASAP 2460 analyzer with ultra-high-purity gas (99.999% purity). X-ray photoelectron spectroscopy (XPS) was recorded using Escalab 250XI X-ray electron spectrometer (VG Scientific, America). Electron paramagnetic resonance (EPR) spectra were recorded on a Bruker A300 spectrometer.

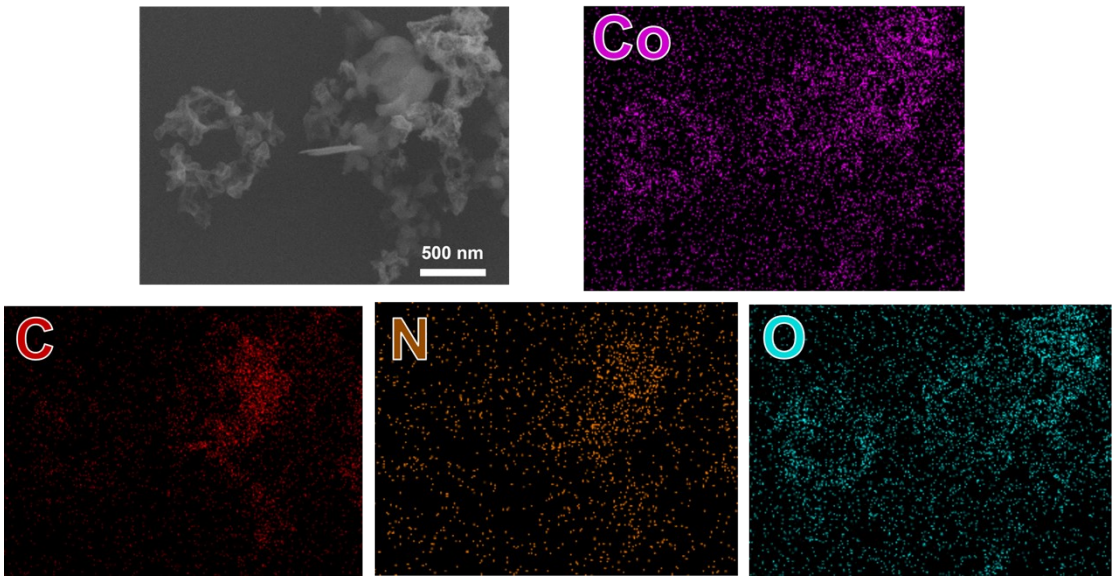

Fig. S1. The EDS-mapping of Co_3O_4@NC-350.

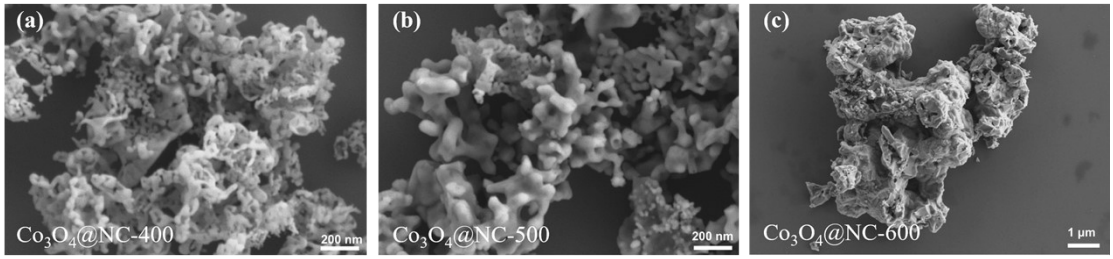

Fig. S2. The SEM images of Co_3O_4@NC-400, Co_3O_4@NC-500, Co_3O_4@NC-600

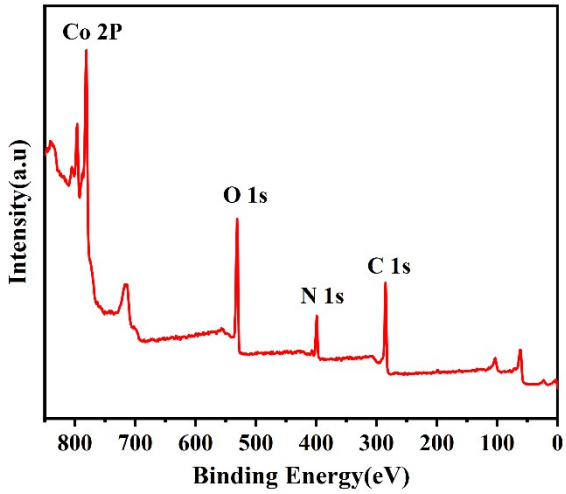

Fig. S3. The survey XPS spectrum of Co_3O_4@NC-350.

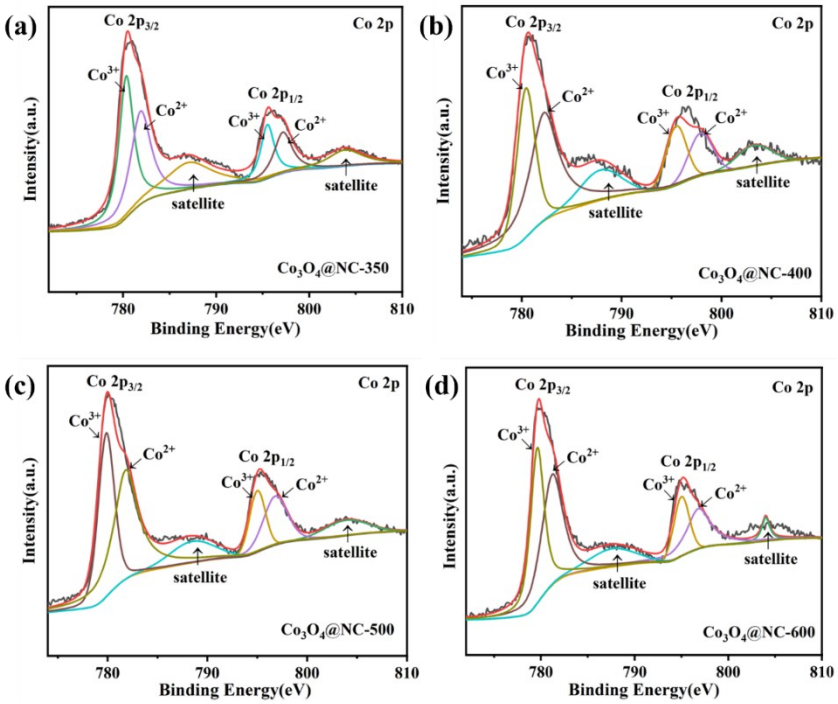

Fig. S4. The high-resolution XPS spectra of Co_3O_4@NC-350, Co_3O_4@NC-400, Co_3O_4@NC-500, and Co_3O_4@NC-600.

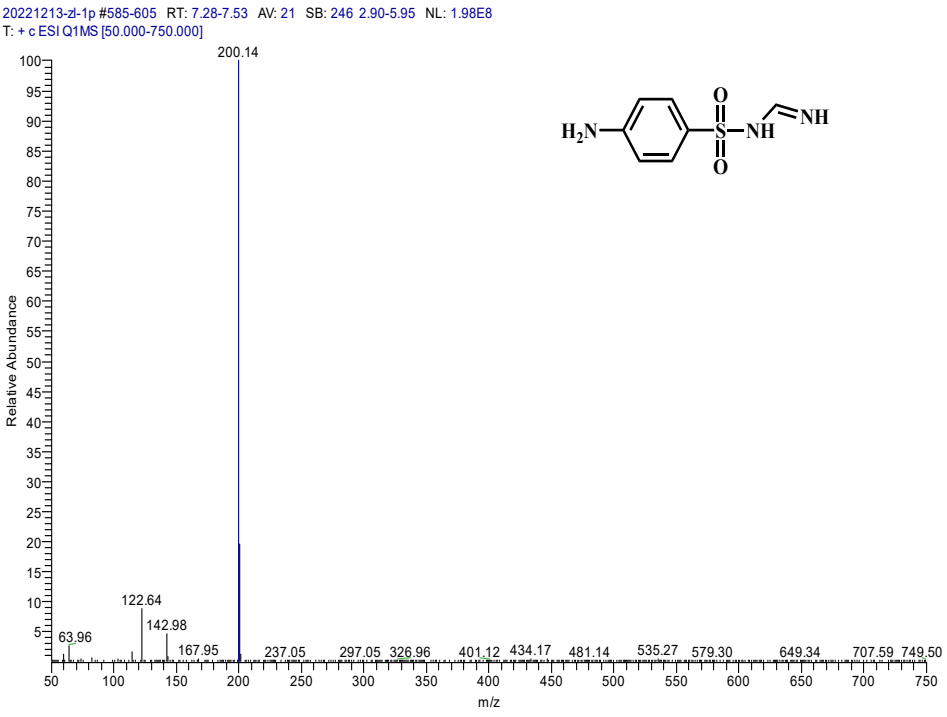

Fig. S5. Mass spectra of 200 in SMX degradation products.

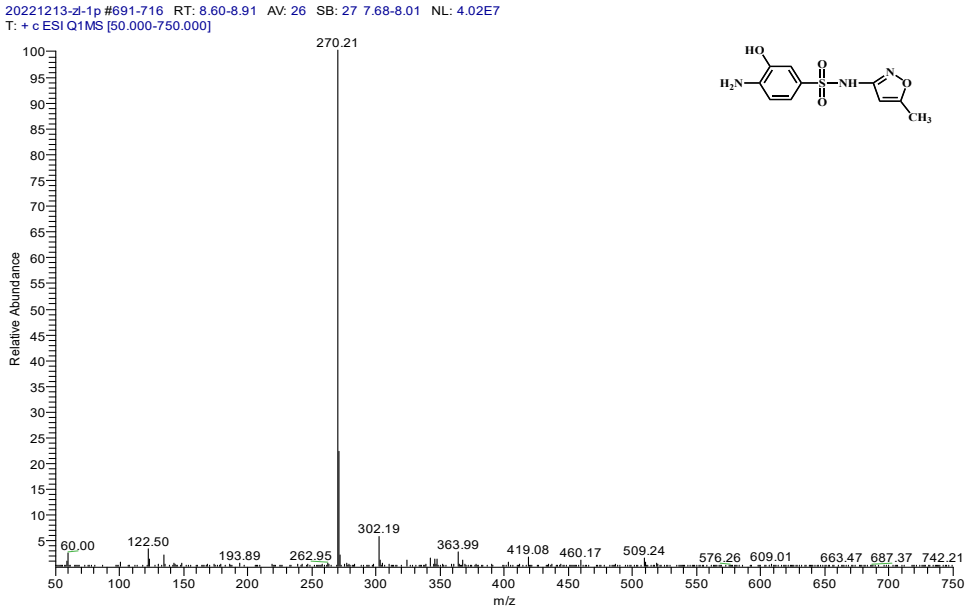

Fig. S6. Mass spectra of 270 in SMX degradation products.

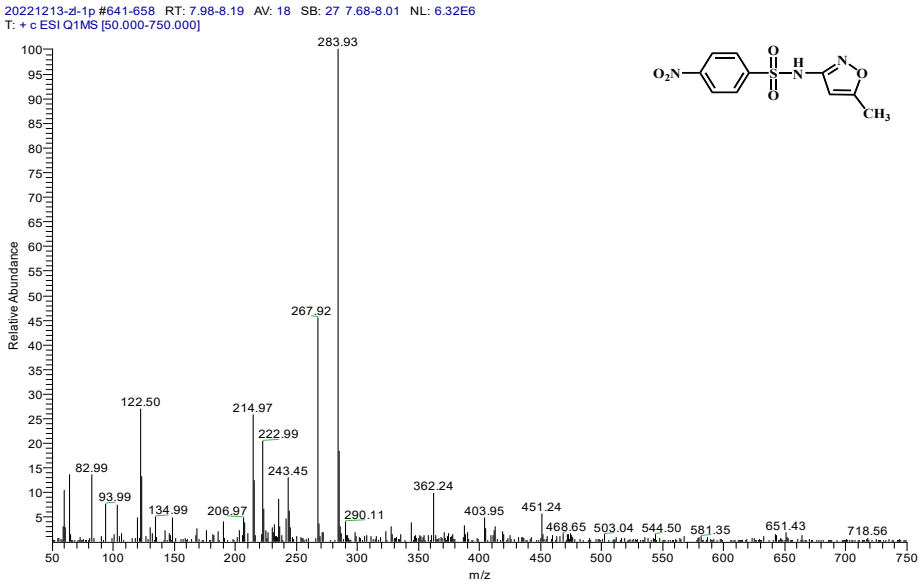

Fig. S7. Mass spectra of 284 in SMX degradation products.

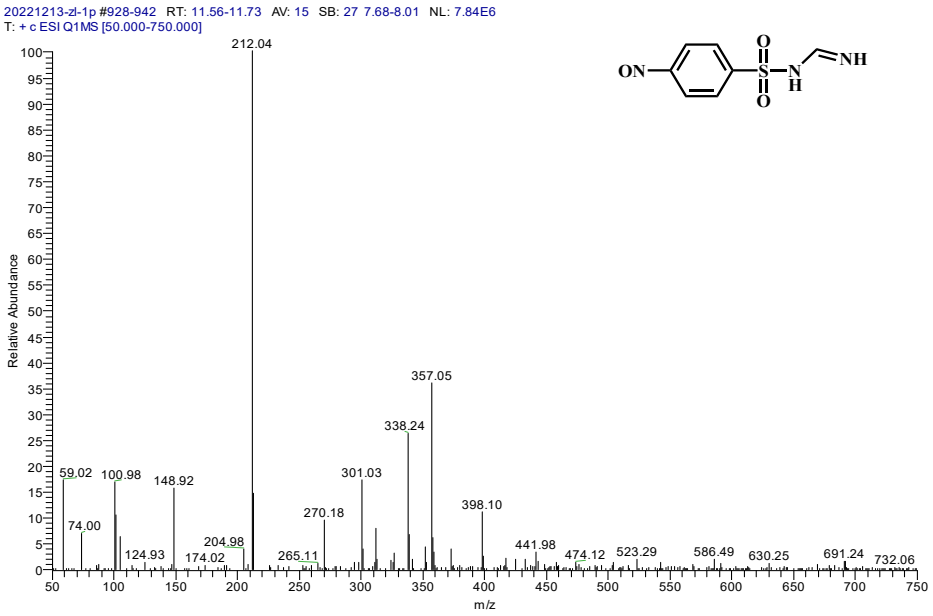

Fig. S8. Mass spectra of 212 in SMX degradation products.

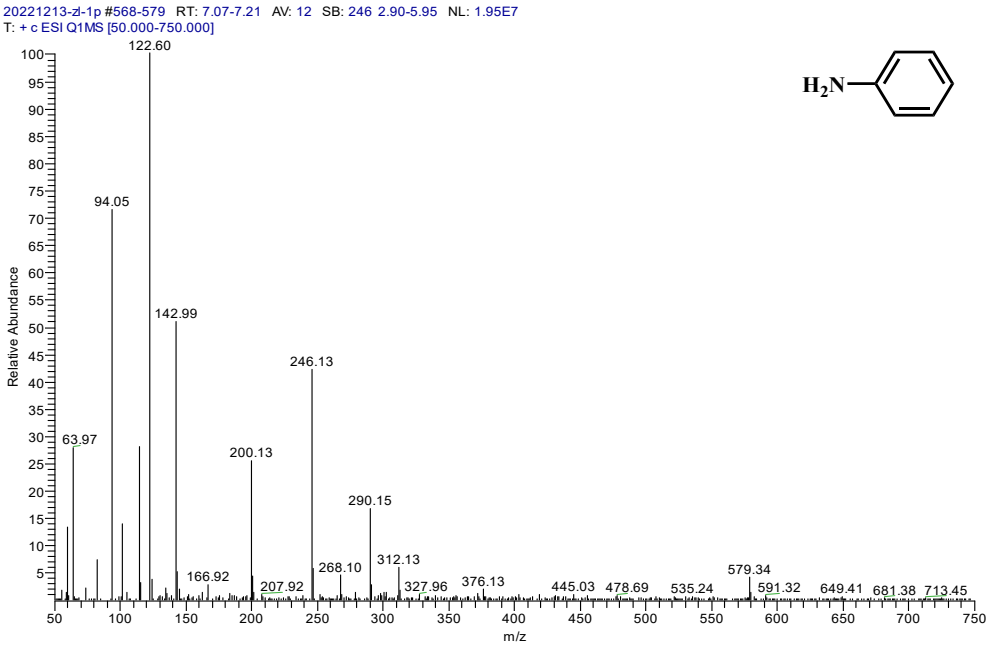

Fig. S9. Mass spectra of 94 in SMX degradation products.

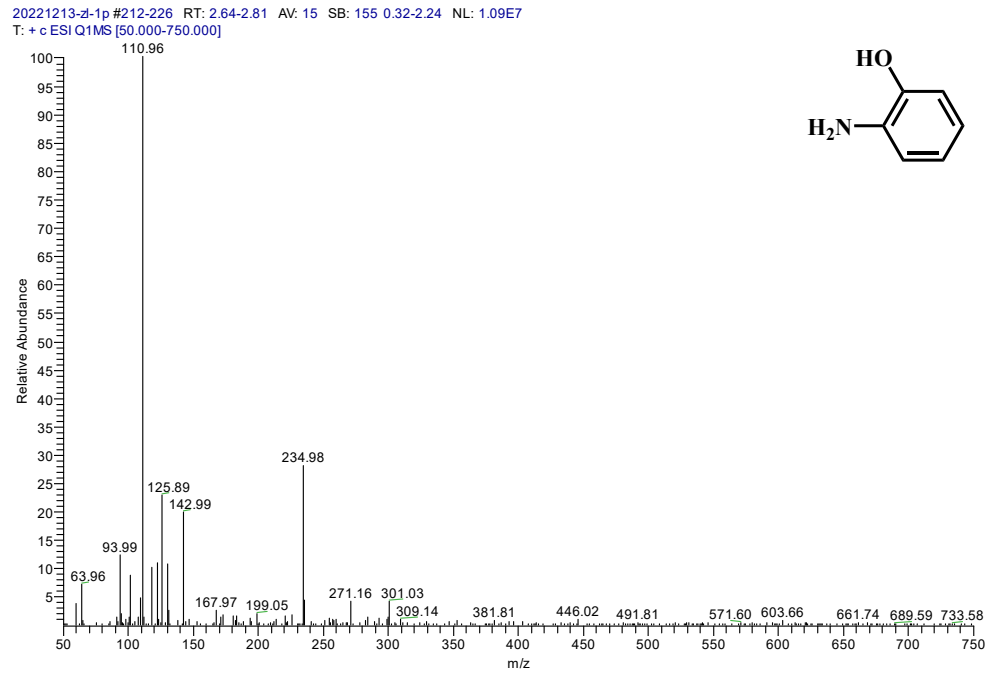

Fig. S10. Mass spectra of 110 in SMX degradation products.

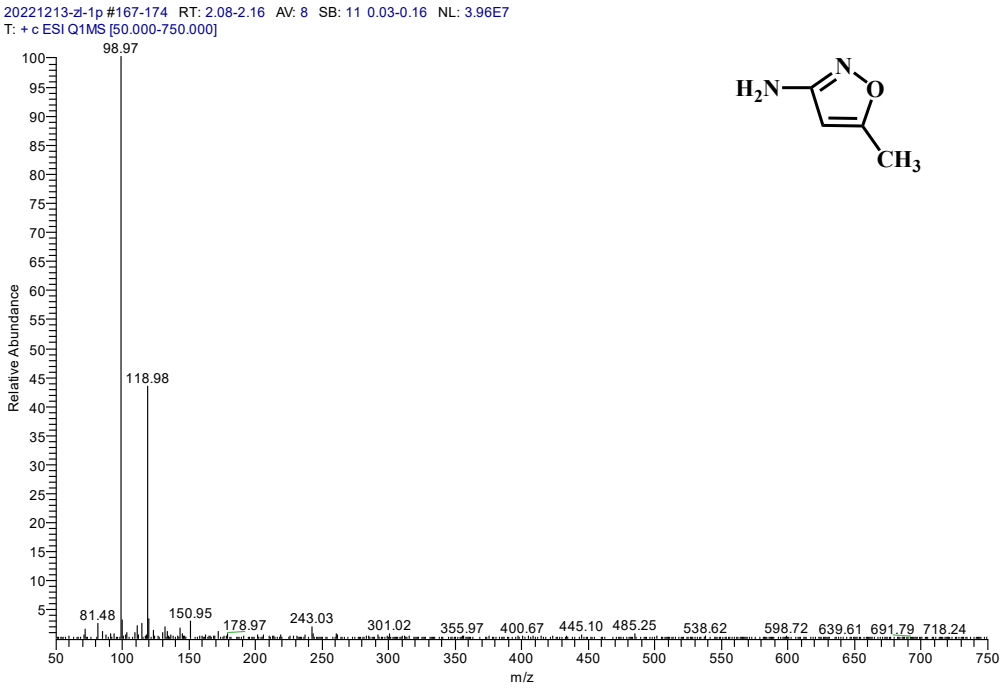

Fig. S11. Mass spectra of 99 in SMX degradation products.

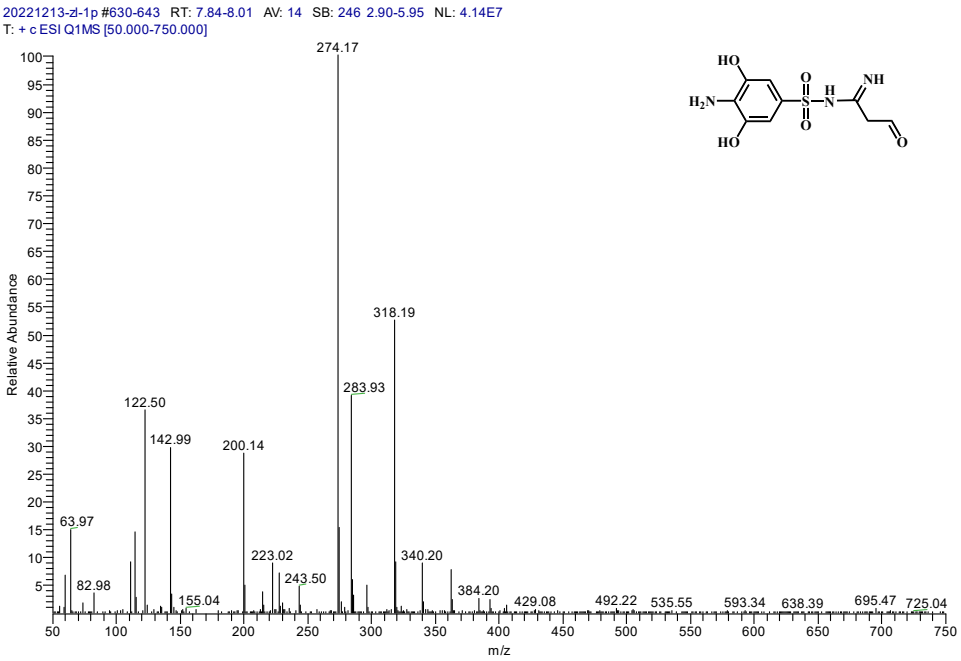

Fig. S12. Mass spectra of 274 in SMX degradation products.

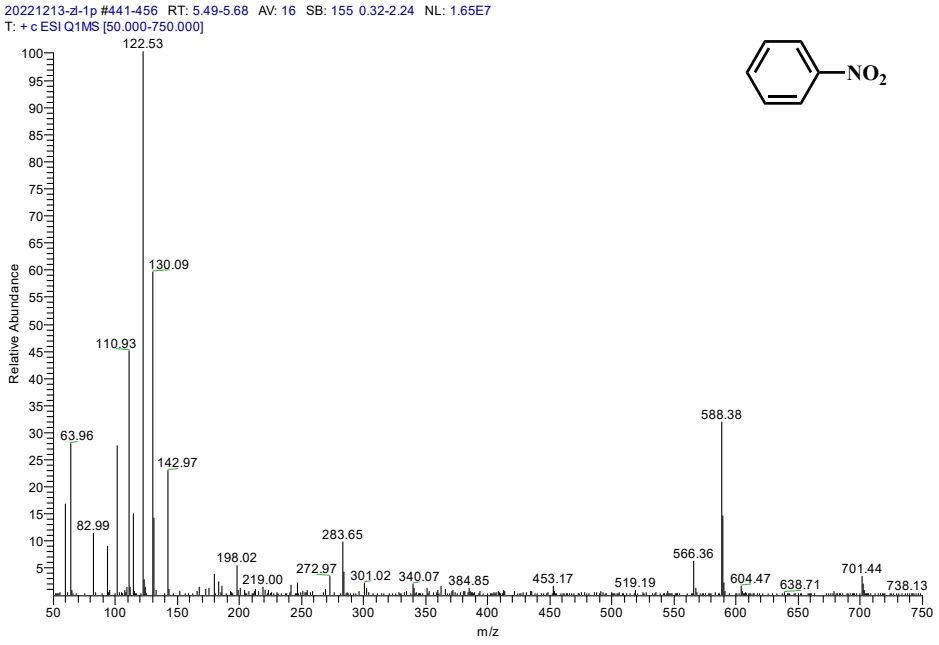

Fig. S13. Mass spectra of 123 in SMX degradation products.

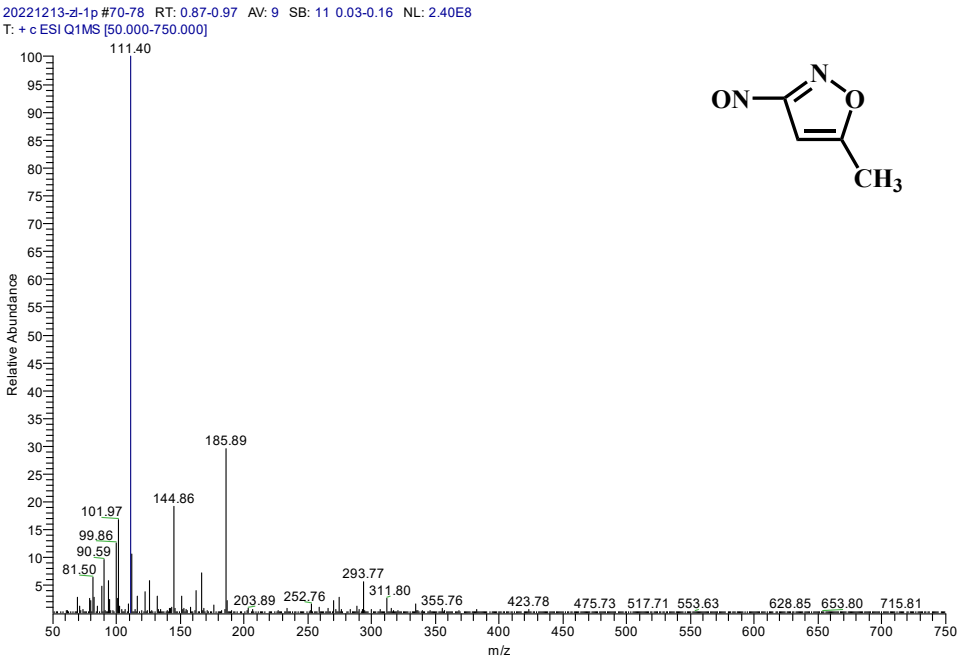

Fig. S14. Mass spectra of 111 in SMX degradation products.

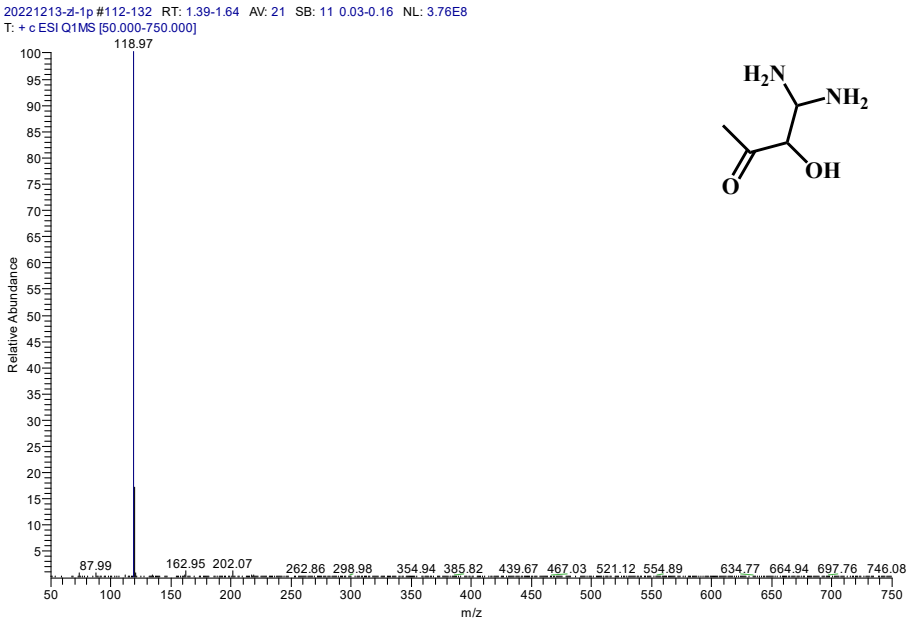

Fig. S15. Mass spectra of 119 in SMX degradation products.