

Photothermal catalytic oxidation of toluene over Pt-Mn₂O₃/CN nanocomposite catalyst

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Catalytic performance:

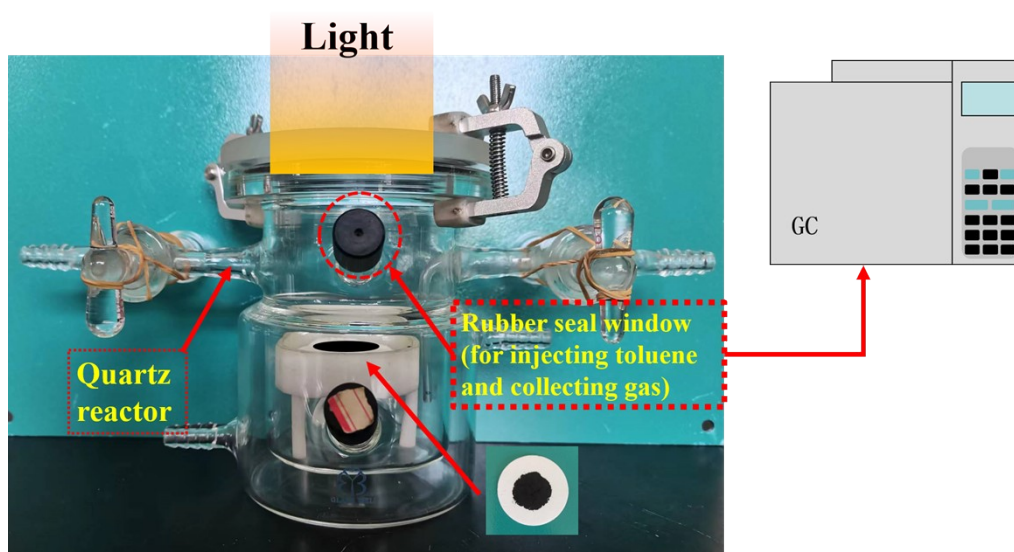


Fig. S1. The schematic diagram for illustration of static reaction setup.

Static reaction: The photo-induced thermocatalytic oxidation of toluene was conducted within a sealed cylindrical gas-phase reactor (450 mL) equipped with a quartz window (110 mm in diameter). The reactor's air composition mirrored that of actual ambient air and was meticulously controlled. Integration with a GC-MS gas chromatograph (GC), featuring a flame ionization detector (FID), facilitated real-time monitoring of intermediates produced during the degradation of toluene.

A precisely measured amount (0.1000 g) of catalyst was uniformly applied to a glass fiber filter membrane (50 mm in diameter and 0.1 μm aperture), which was subsequently positioned at the base of the reactor. Positioned above the quartz window was a 300 W Xe lamp (Perfect Light, micro 300), delivering UV-Vis-NIR light at an intensity of 300 mW cm^{-2} . The temperature variations throughout the reaction were tracked using a FLIR infrared thermometer.

The assessment of the degree of toluene mineralization relied on the increment in CO₂ production. Given the presence of CO₂ molecules in the air and the catalyst's ability to adsorb CO₂, the reactor underwent a 15-minute irradiation period to establish a stable CO₂ baseline. This baseline was crucial for the subsequent determination of CO₂ increment before the light was turned off. Following this, 0.86 μL of liquid toluene was introduced into the reactor through an inlet integrated into the hermetic seal. The calculated initial toluene concentration was approximately 400 ppm. After a 5-minute interval, allowing for the evaporation of all toluene molecules, the lamp was switched on to initiate the degradation process. CO₂ increment was quantified by subtracting the initial CO₂ content (pre-catalysis) in the reactor, and the corresponding percentage of toluene removal was subsequently calculated.

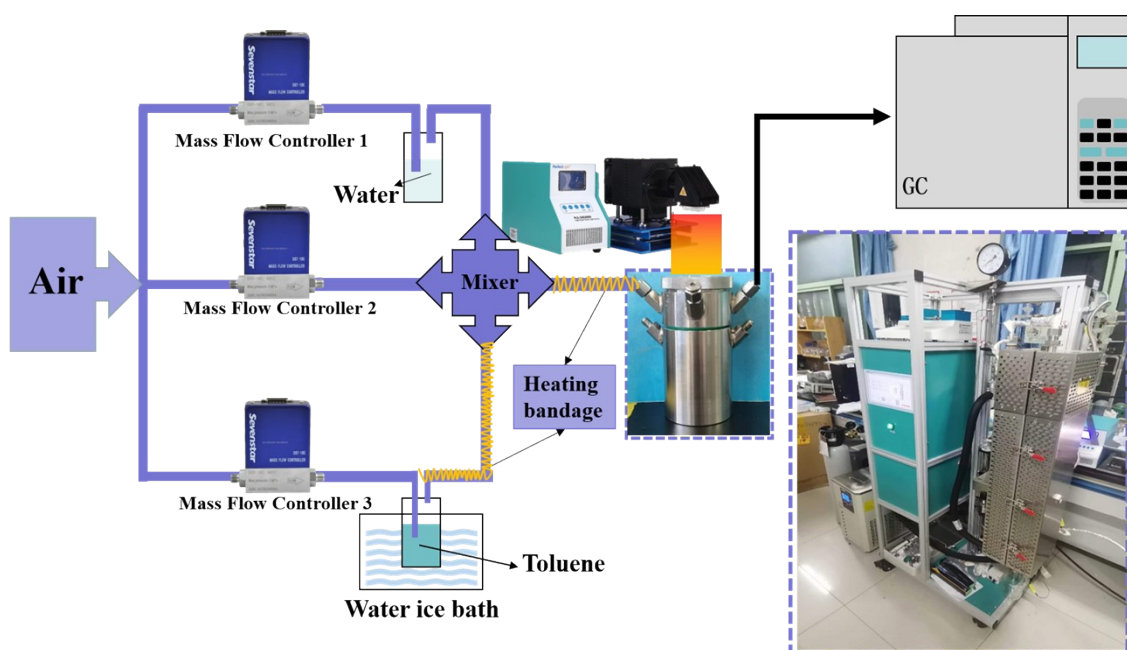


Fig. S2. The schematic diagram for illustration of continuous flow reaction setup.

Continuous flow reaction: To assess the catalytic efficacy more effectively, we employed a custom-made continuous flow reactor constructed from stainless steel with a fixed bed configuration. This apparatus was utilized to examine the photothermal catalytic performance of the catalyst in the presence of toluene. The reactor setup, as illustrated in Fig. S2, replicated daily illumination conditions, with the light intensity finely tuned to 300 mW cm⁻² through adjustments in the distance between the xenon lamp and the catalyst surface. Prior to experimentation, 100 mg of catalyst (40-60 mesh) was precisely weighed into the fixed bed microreactor made of stainless steel. Subsequently, a mixed reaction gas comprising 200 ppm toluene, 20 vol% O₂, and N₂, flowed through the reactor at a rate of 100 mL/min. The mass air speed of the catalyst, denoted as the Weight Hourly Space Velocity (WHSV), was meticulously regulated to 30000 mL·g⁻¹·h⁻¹. For real-time monitoring of toluene and carbon dioxide concentration changes at the microreactor outlet, a gas chromatograph (GC-7920) was

employed as the detector. The gas chromatograph operated with nitrogen as the carrier gas, and a Flame Ionization Detector (FID detector) was utilized to monitor organic gases.

$$C_7H_8 \text{ conversion (\%)} = [(C_7H_8)_{in} - (C_7H_8)_{out}] / (C_7H_8)_{in} * 100\%$$

$$CO_2 \text{ conversion (\%)} = [(CO_2)_{out} - (CO_2)_{in}] / (CO_2)_{theoretical} * 100\%$$

Where $(C_7H_8)_{in}$ is the initial concentration of toluene before the reaction, $(C_7H_8)_{out}$ is the concentration of toluene in the mixed gas after the reaction, $(CO_2)_{in}$ is the initial concentration of carbon dioxide before the reaction, $(CO_2)_{out}$ is the concentration of carbon dioxide in the mixed gas after reaction, and $(CO_2)_{theoretical}$ is the theoretical concentration of 200 ppm toluene completely converted into carbon dioxide.

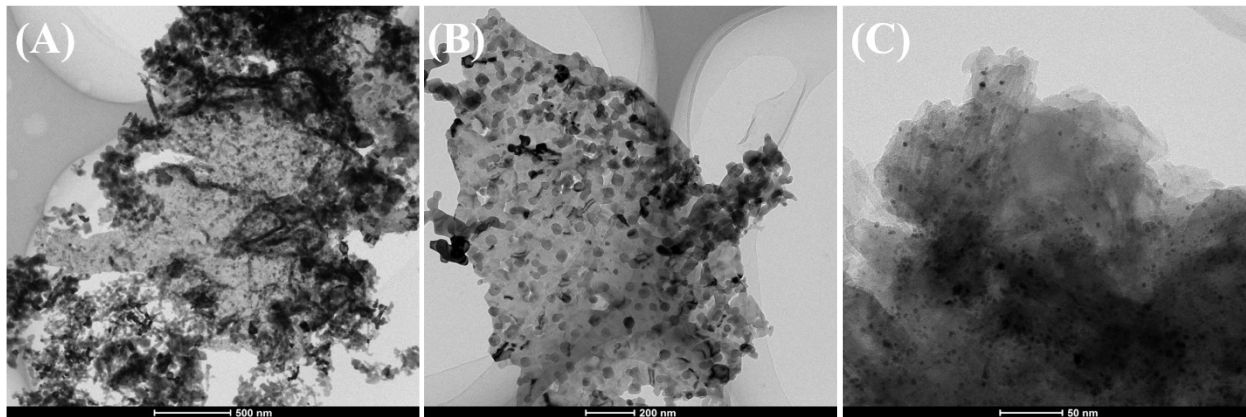


Fig. S3. TEM images at different magnifications of Pt-Mn₂O₃/CN catalysts.

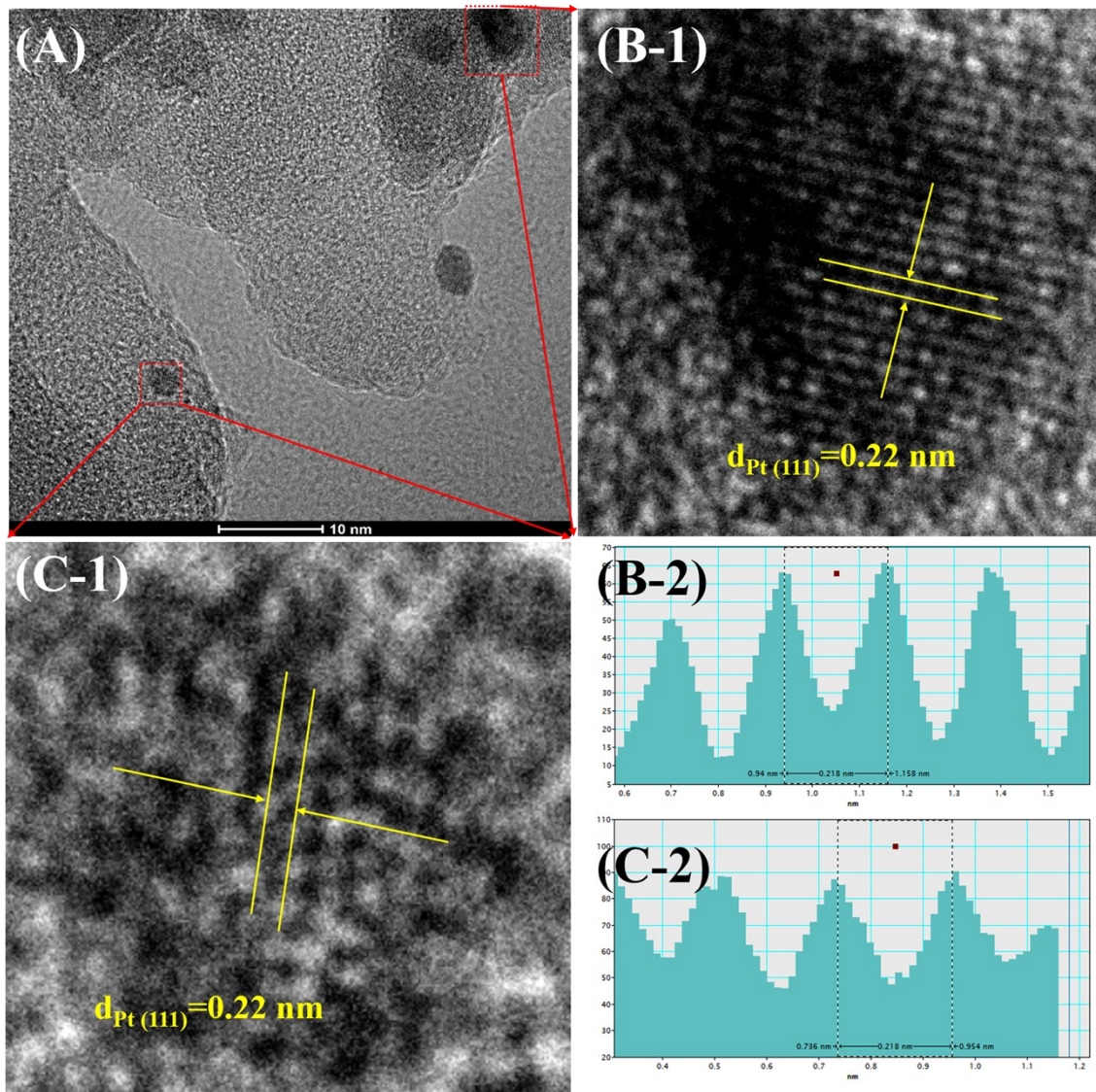


Fig. S4. (a) HRTEM images and (b-c) the enlarged figures of the selected area in the panel of Pt-Mn₂O₃/CN.

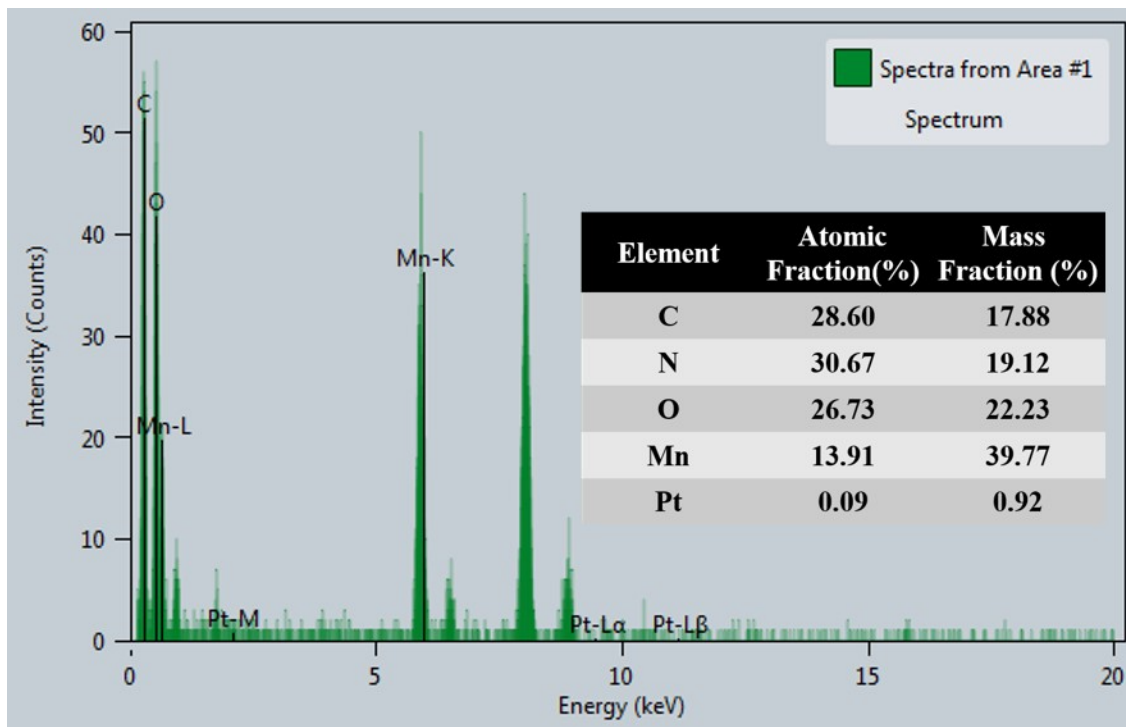


Fig. S5. The elements distribution of Pt-Mn₂O₃/CN catalysts.

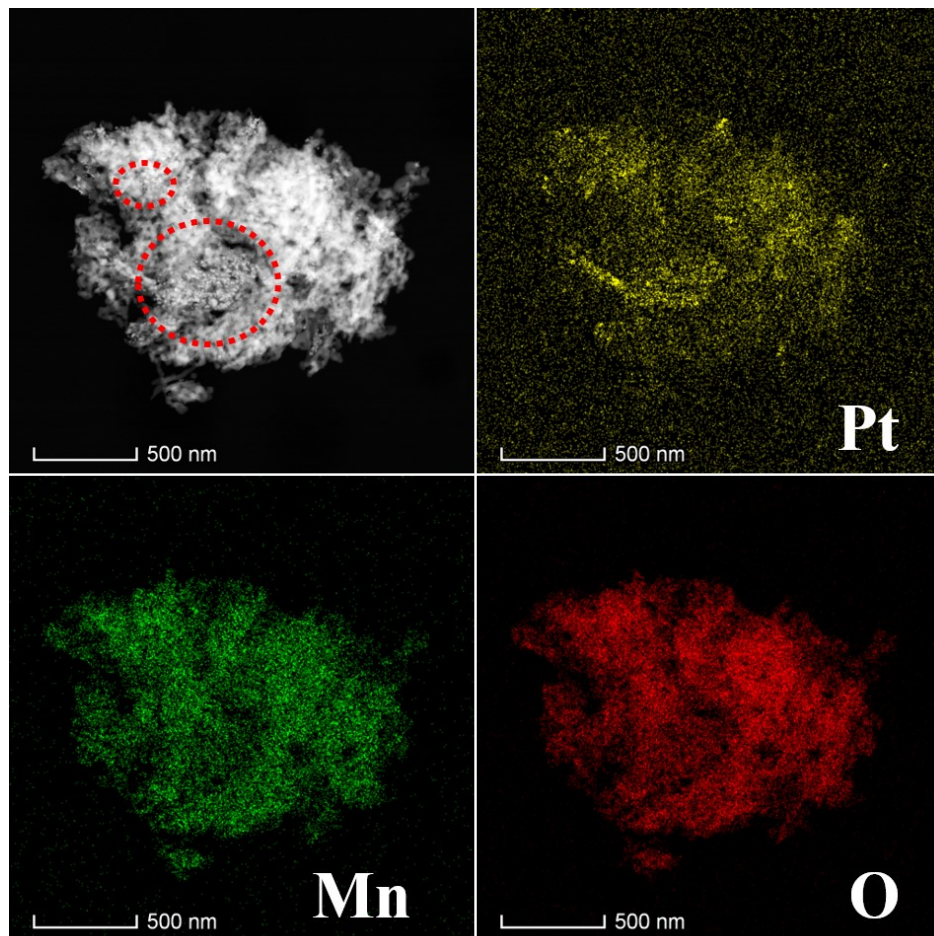


Fig. S6. TEM and EDS phase mapping of Pt-Mn₂O₃ catalysts.

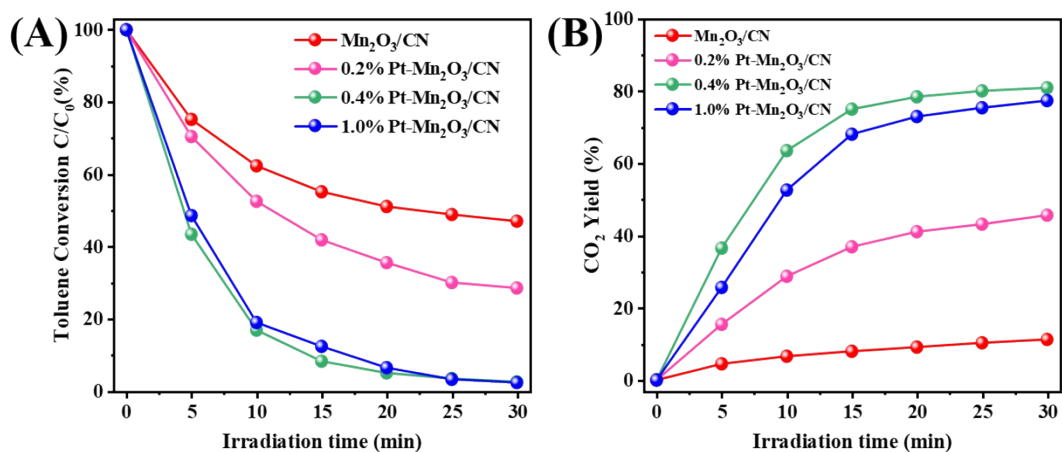


Fig. S7. Photothermal catalysts performance with different Pt contents.

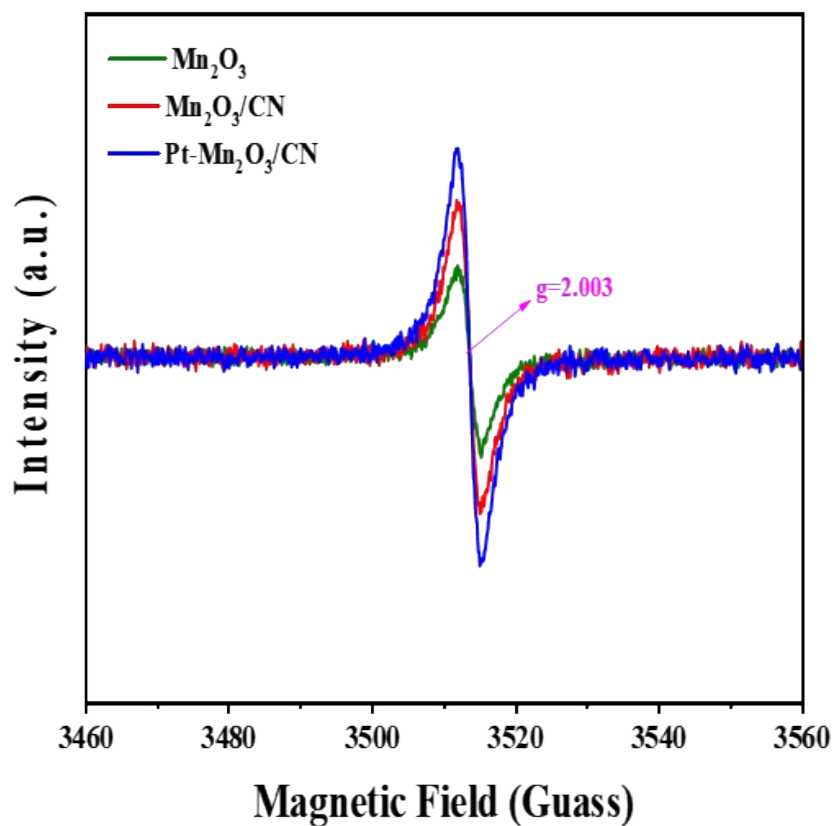


Fig. S8. EPR spectra of Mn_2O_3 , Mn_2O_3/CN and Pt- Mn_2O_3/CN catalysts.

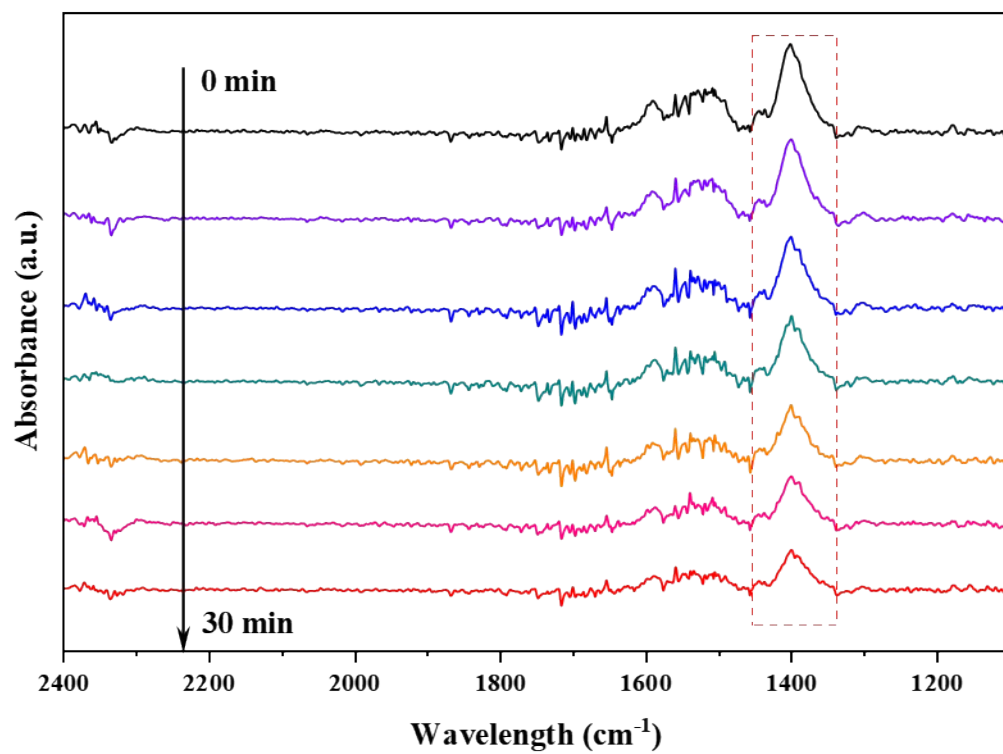


Fig. S9. In-situ DRIFTS spectra of toluene oxidation over Mn₂O₃ catalysts.