Supplementary Information

Core-shell Structured Cobalt-oxide Nanoparticles and Single Co Atoms Supported on Graphene for Selective Hydrodeoxygenation of Syringol to Cyclohexanol

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Preparation of GO and rGO

Graphene oxide (GO) used in this research was prepared following the modified Hummers' method. In brief, the flake graphite was first mixed with $NaNO_3$ and H_2SO_4 mixture in an ice-water bath. Then the mixture was gradually added with $KMnO_4$ and underwent oxidation reaction at 35 ℃ for 2 h. Next, the mixture was diluted by water (twice the volume of H_2SO_4) and heated at 90 ℃–98 ℃ for 15 min. Then, the reaction mixture was gradually added with sufficient water (about six times the volume of H_2SO_4) under vigorous stirring with the temperature decreased to 50 ℃–60 ℃ and added with H_2O_2 (30 %). Finally, the mixture was allowed to stay at room temperature for 24 h. The as-prepared GO was purified by repeated centrifugation and washing. Reduced graphene oxide (rGO) was obtained following the previously reported method.[39] In brief, the obtained GO was suspended in water by ultrasound, added with ammonia, and reduced with hydrazine hydrate (80% in water) at 90 ℃–98 ℃, followed by filtering and washing with hot deionized water. The filter cake was dried with the freeze-drying method to obtain rGO. N was incorporated into the rGO network via the hydrothermal reduction of GO by using N_2H_4 and ammonia as reducing reagents.

Table

Table S1 Property description of the supports and the corresponding catalysts.

Catalyst	Element mass fraction (%)				S_{BET} ($m^2 \bullet g^{-1}$)
	C	H	O	N	
rGO	83.6	1.7	10.2	4.5	489
Gr	98.7	0.3	-	-	191
$Co_{2.5}$/rGO					385
$Co_{1.0}$/Gr					167

Figures

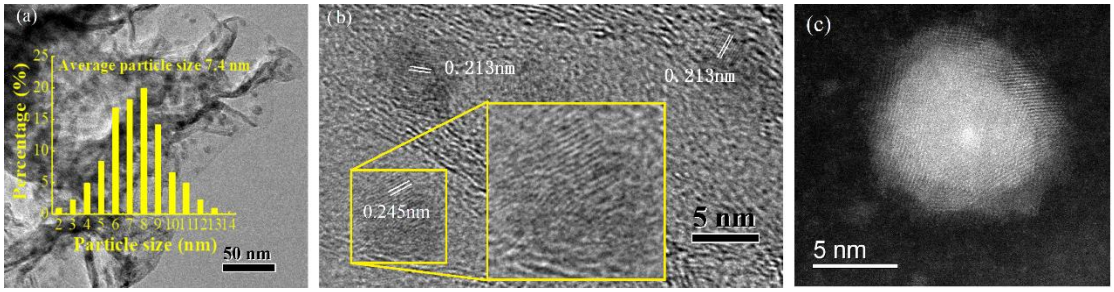

Fig. S1 Electron microscope images of the fresh $Co_{2.5}$/rGO catalyst: (a) TEM image and particle size distribution; (b) HRTEM image; (c) HAADF-STEM image of a core-shell structured nanoparticle

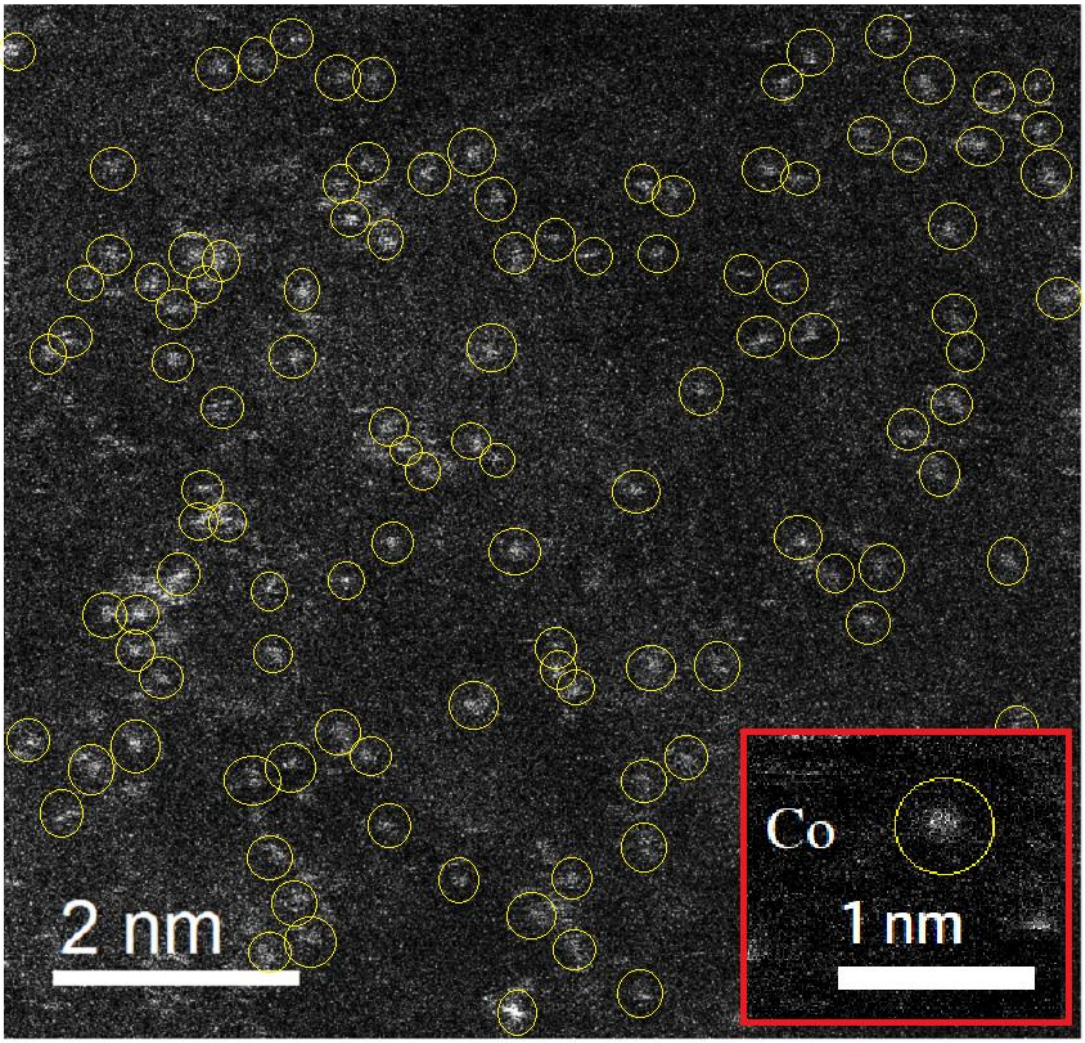

Fig. S2 HAADF-STEM image of single Co atoms of the $Co_{2.5}$/rGO catalyst

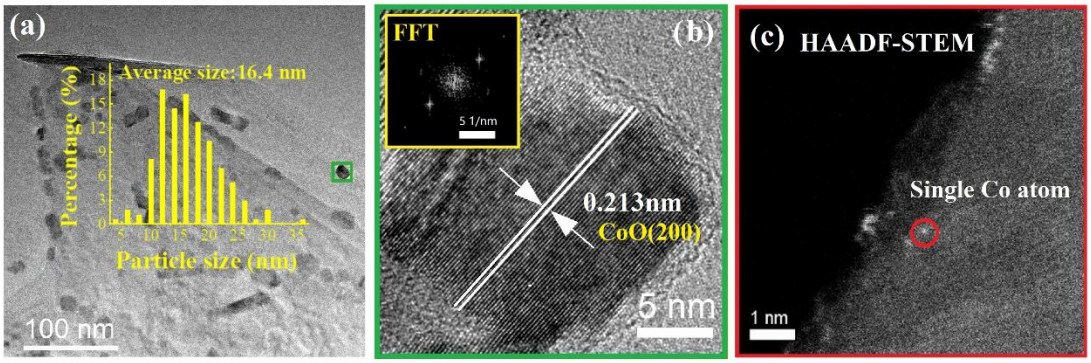

Fig. S3 Electron microscope images of the $Co_{2.5}$/Gr catalyst：(a) TEM image and particle size distribution; (b) HRTEM image and corresponding fast Fourier transform (FFT) of a nanoparticle from the green square area in (a); (c) HAADF-STEM image of single Co atoms in the $Co_{2.5}$/Gr catalyst

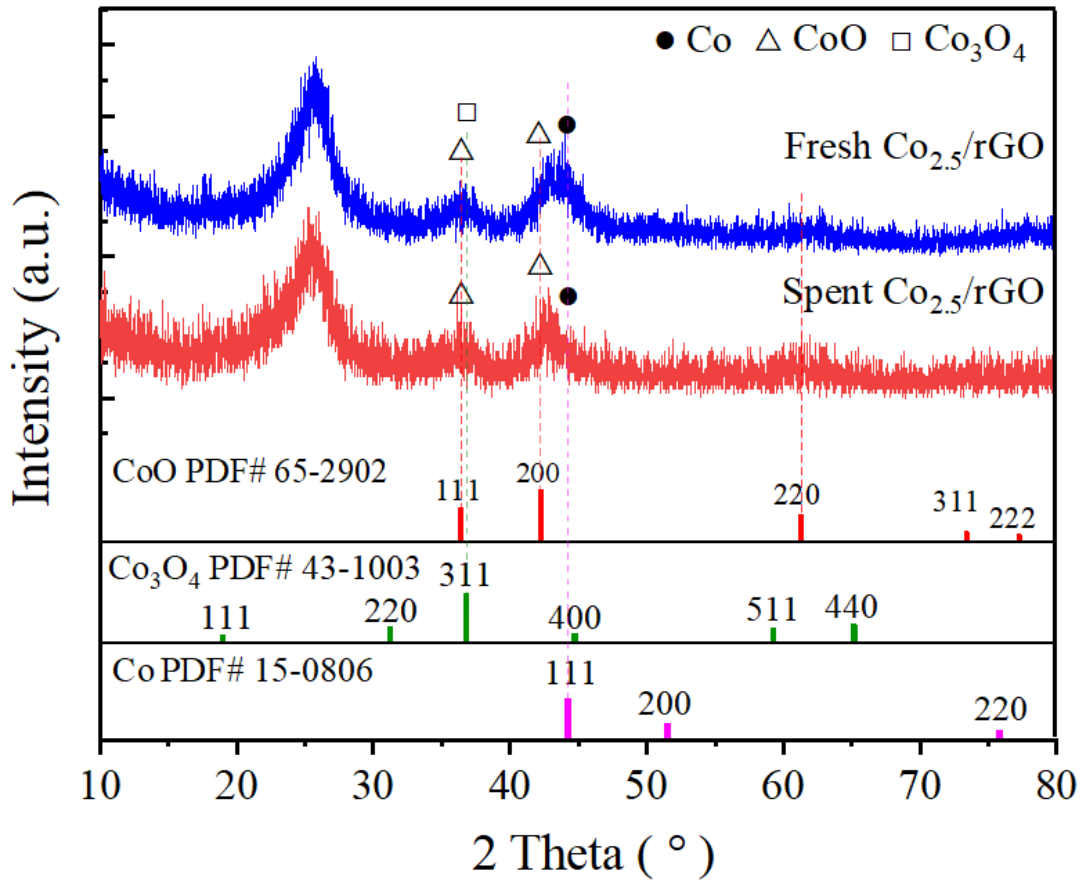

Fig. S4 XRD patterns of the fresh and spent $Co_{2.5}$/rGO catalysts

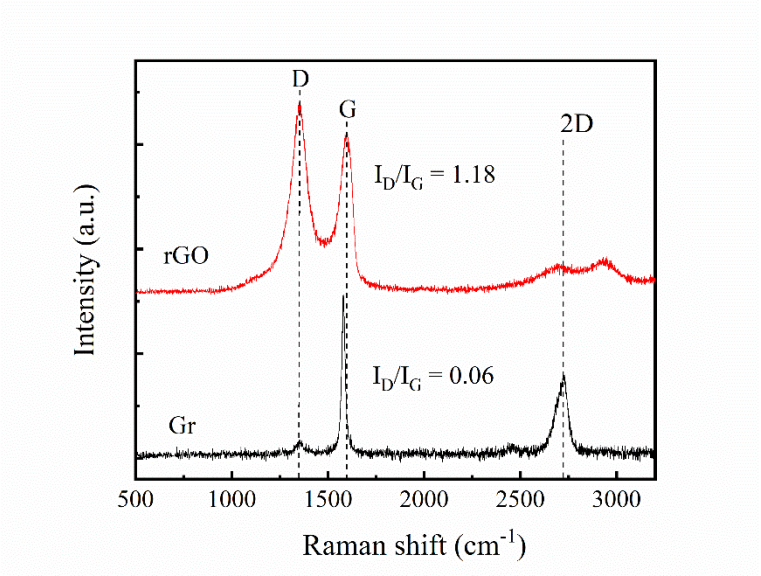

Fig. S5 Raman diagrams of $Co_{2.5}$/rGO and $Co_{2.5}$/Gr.

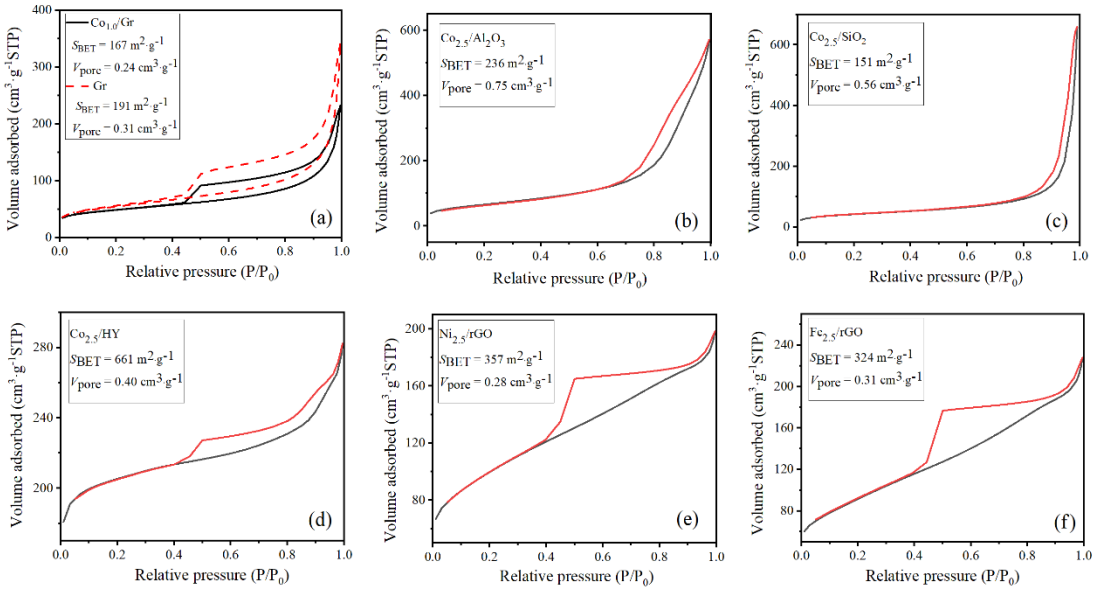

Fig. S6 N_2-sorption characterizations of the catalysts