Supplementary Information (SI) for Reaction Chemistry & Engineering.
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Supporting Information

Metallic nickel-anchored biochar with non-metallic heteroatom modification: Remarkably effective catalyst for steam reforming of methane

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1. Preparation of catalysts

The bamboo chopsticks were fully dried in an oven at 110°C, then crushed and sieved in a pulverizer to produce 30-40 mesh material. Firstly, Firstly, use a volumetric flask to dilute 85% H_3PO_4 to 40%, according to the impregnation ratio ($m_{pure}H_3PO_4$/mC) of 2, weighing a certain amount of raw materials of 30-40 mesh moso bamboo, mixing it with H_3PO_4 and impregnating it at room temperature for 10h. Then it was transferred to an oven at 100°C for 12h. Then it was transferred to a tube furnace and heated up to 500°C under N2 atmosphere at 10°C/min for a certain period of time, and after cooling to room temperature it was washed with deionized water to pH=7. Finally, drying resulted in the desired support, which was named C2-500-z (z=1h/1.25h/1.5h/1.75h/2h) according to the different roasting times. The support that was also not activated with H_3PO_4 was named C500. The catalysts were prepared by the co-impregnation method. The required ($Ni(NO_3)_2$•$6H_2O$), ($Ce(NO_3)_3$•$6H_2O$) and support were weighed according to the theoretical loading of wt20% (where the molar ratio of Ni and Ce is 1:1), and the nitrate salt was dissolved in deionized water, stirred until the nitrate salt was completely dissolved and then the carrier was added, and then the catalyst was ultrasonicated at room temperature for 15 min, and then transferred to a magnetic stirrer and stirred at 60 ℃ until the solution was almost completely evaporated, and then it was kept at 100 ℃ in the oven for 12 h, and then transferred to a tube furnace. The catalyst was then transferred to a tube furnace and heated up to 600 °C at 5 °C/min under N_2 atmosphere for 3 h. The obtained catalyst was named Ni-Ce/C2-500-z accordingly. The Z412Q hydrocarbon steam reforming catalyst produced by SHANGDONG QILU KELI CHEMICAL INSTITUTE CO, LTD.

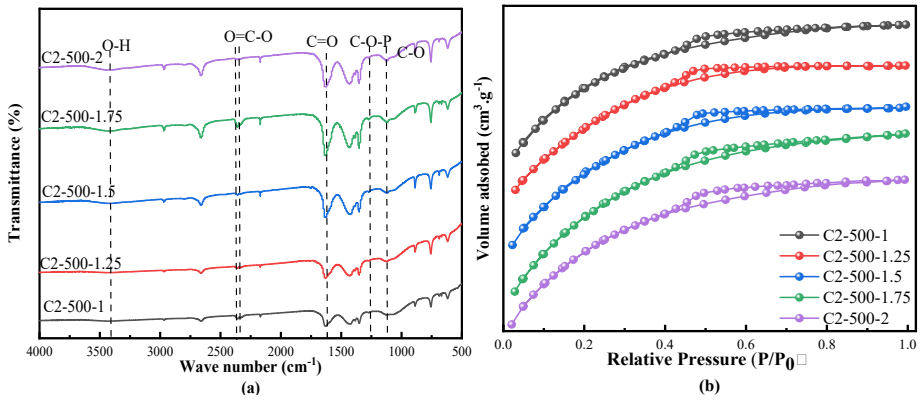
2. Characterization of catalyst

FTIR characterization on a Fourier infrared spectrometer Vertex70. N_2 adsorption-desorption

characterization was carried out using micromeritics asap 2460 equipment under the following test conditions: atmosphere of vacuum He, treatment at 300 °C for 5 h, cooling to room temperature and then cryogenic testing under liquid nitrogen (-196 °C), and calculation of specific surface area based on the BET equation. Specific surface area from BET method. Total micropore pore volume. Calculated according to the t-plot method. Total mesopore pore volume, evaluated by the BJH method. Total pore volume. Calculated according to the single point method. Average pore size, evaluated by the BET method. XRD using Smart Lab 9kw X-Ray Diffractometer, conditions are 45kV/200mA with a sweep of 10°/min or 2°/min. Scherrer's equation for calculating Ni(111) grain size $D = \frac{K\gamma}{B\cos\theta}$ (D is the grain size, K is Scherrer's constant, B is the half-peak width of the diffraction peak of the measured sample, θ is the Bragg angle, and γ is the wavelength of Cu Ka radiation) The instrument used for TEM and HRTEM was the FEI Tecnai G2 F20 America FEI test condition with an accelerating voltage of 200 kv. The catalysts were subjected to H_2-TPR using a Chem BET Pulsar TPR/TPD automated chemical adsorbent apparatus with a ramp rate of 10°C/min and a support gas of a mixture of H_2 and Ar. XPS was tested at monochromatic Al Ka (hv =1486.6 eV) with a power of 150 W and 400 μm beam spot conditions using a Thermo ESCALAB 250XI America Thermo. Agilent ICPOES720 equipment was used, with reference to the IEC62321 aqua regia method, the sample dosage was 0.05g.

3. Results

3.1 BET



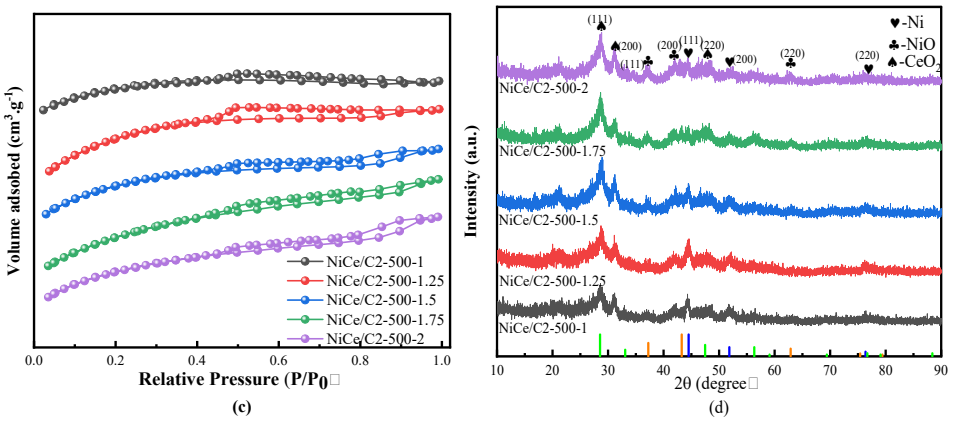


Fig S1 (a) FTIR characterization with different supports. N_2 adsorption–desorption (b) supports (c)catalysts. (d) XRD patterns of all catalysts

Table S1 Comparison of structural parameters of supports and catalysts

Samples	BET surface area/$m^2 \cdot g^{-1}$	Pore volume/$cm^3 \cdot g^{-1}$	Average pore diameter/nm	$D_{Ni(111)}$/nm
C2-500-1	2258	1.496	2.764	/
C2-500-1.25	2135	1.259	2.354	/
C2-500-1.5	2314	1.421	2.357	/
C2-500-1.75	2514	1.537	2.445	/
C2-500-2	2319	1.408	2.428	/
Ni-Ce/C2-500-1	422	0.298	2.774	17.8
Ni-Ce/C2-500-1.25	1113	0.636	2.248	17.0
Ni-Ce/C2-500-1.5	967	0.617	2.549	16.5
Ni-Ce/C2-500-1.75	1130	0.730	2.583	15.4
Ni-Ce/C2-500-2	888	0.653	2.943	19.1

3.2 EDS

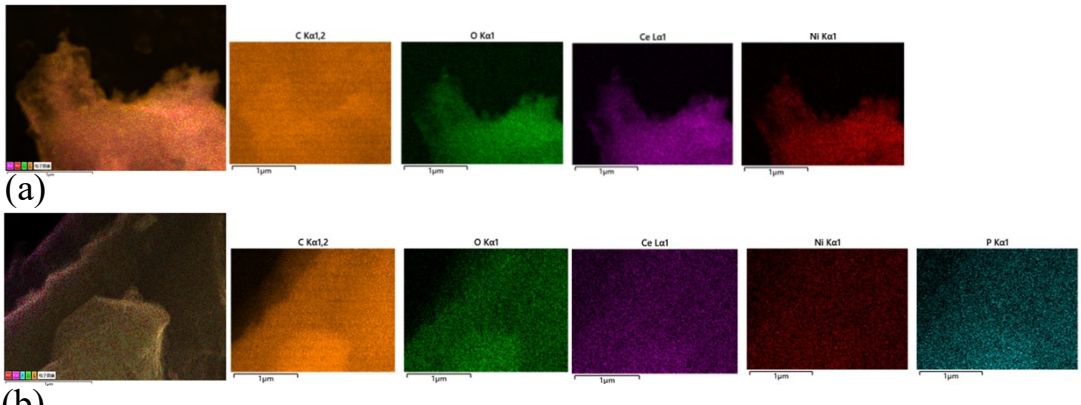


Fig S2.EDS (a) Ni-Ce/C500, (b) Ni-Ce/C2-500-1.75

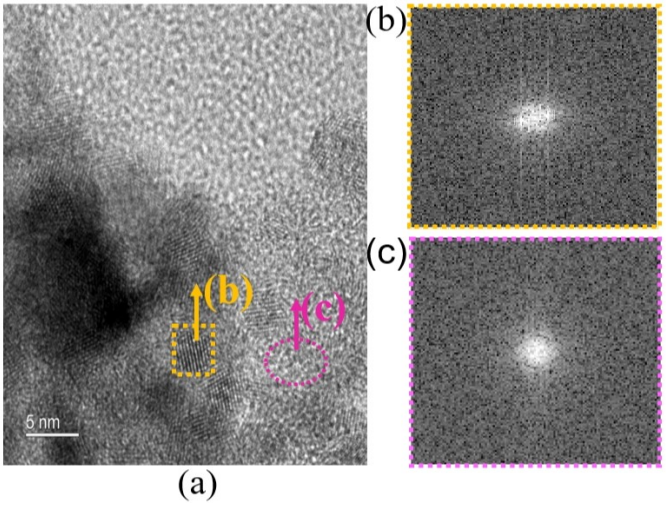


Fig S3. HRTEM (a) and the corresponding FFT images (b, c) of Ni-Ce/C2-500-1.75