

Electronic Supplementary Information

Confined growth of ultrasmall Rh nanocrystals on B- and N-codoped hollow carbon spheres for efficient methanol oxidation

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Supplementary Results

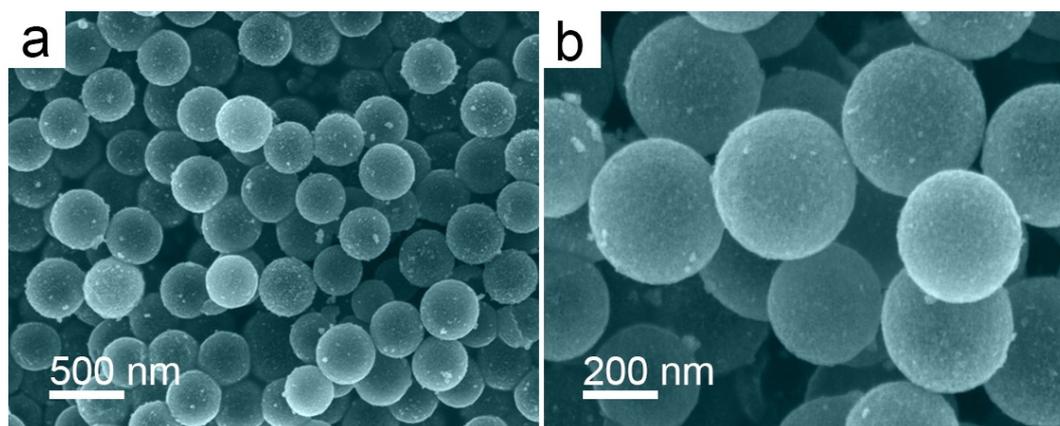


Fig. S1 FE-SEM images of the Rh/BNHCS catalyst at different magnifications.

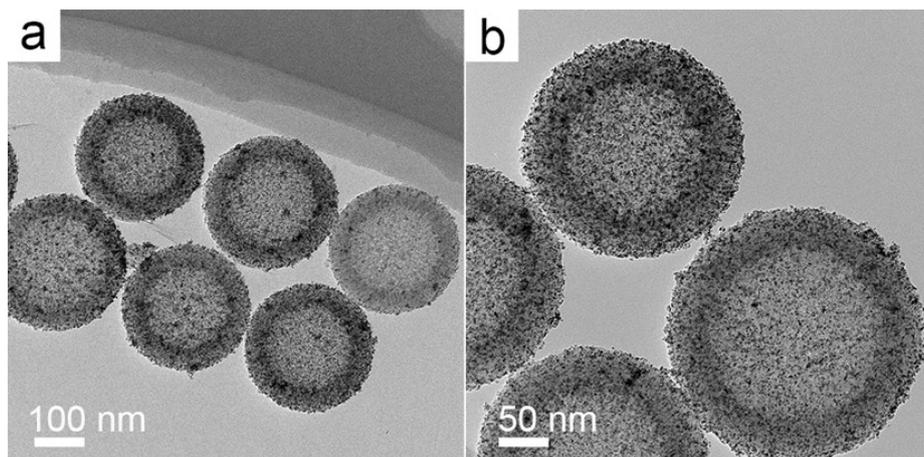


Fig. S2 TEM images of the Rh/BNHCS catalyst at different magnifications.

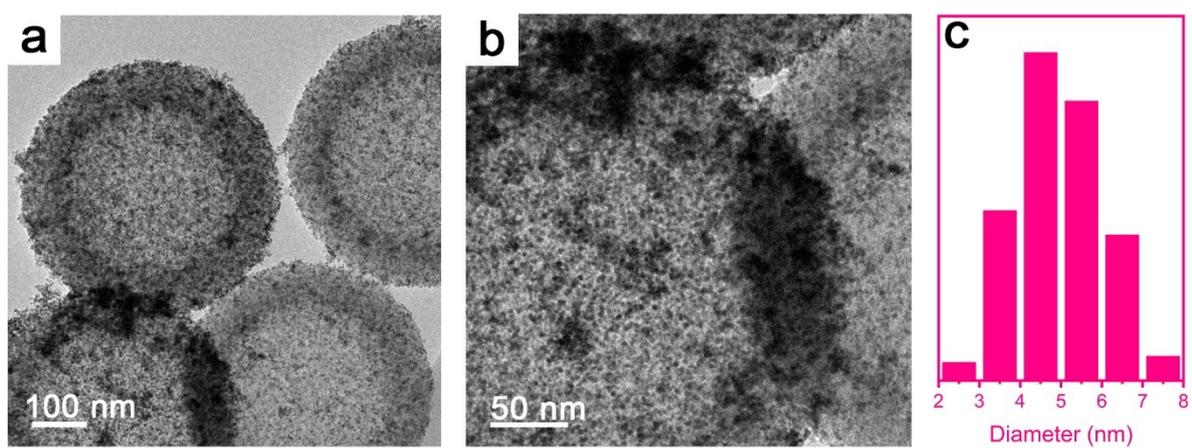


Fig. S3 (a-b) TEM images and (c) corresponding Rh size distribution of the Rh/HCS catalyst.

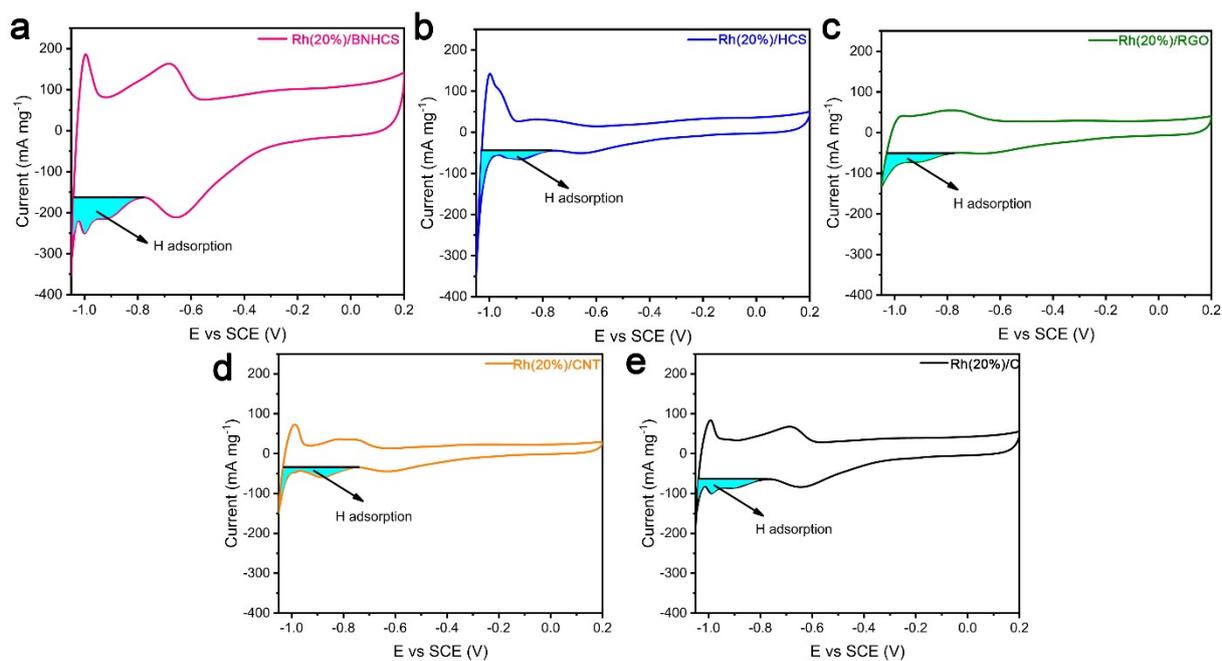


Fig. S4 CV curves of (a) Rh (20%)/BNHCS, (b) Rh (20%)/HCS, (c) Rh (20%)/RGO, (d) Rh (20%)/CNT, and (e) Rh (20%)/C electrodes in 1 M KOH solution.

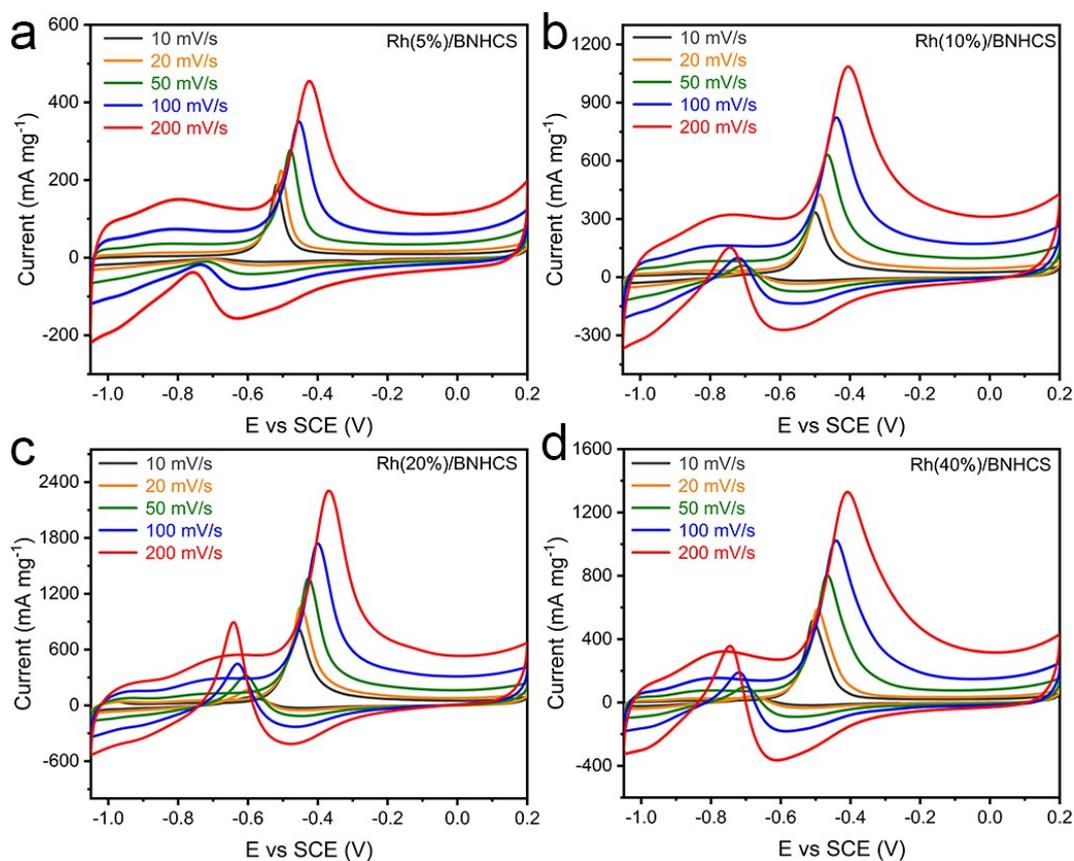


Fig. S5 CV curves of the (a) Rh(5%)/BNHCS, (b) Rh(10%)/BNHCS, (c) Rh(20%)/BNHCS, (d) Rh(40%)/BNHCS catalysts with different scanning rates.

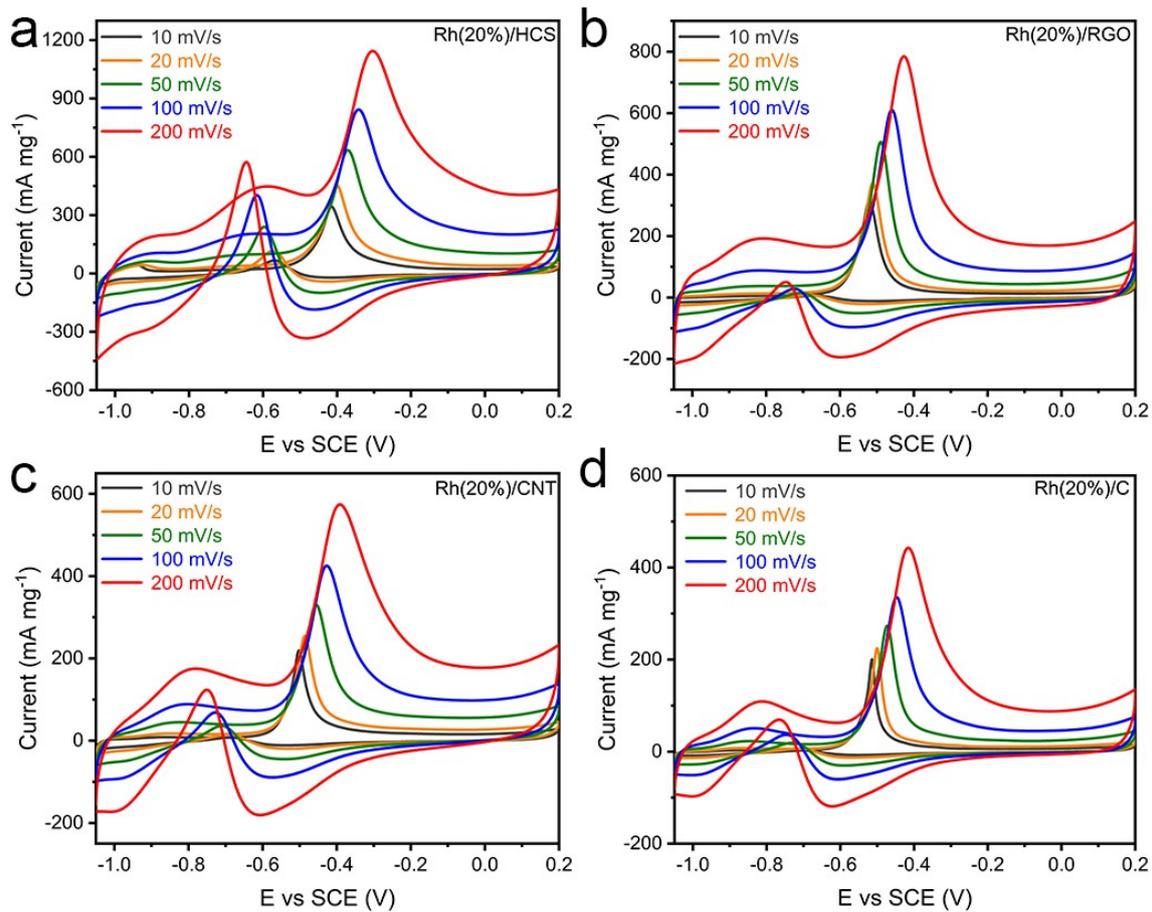


Fig. S6 CV curves of the (a) Rh(20%)/HCS, (b) Rh(20%)/RGO, (c) Rh(20%)/CNT, and (d) Rh(20%)/C catalysts with different scanning rates.

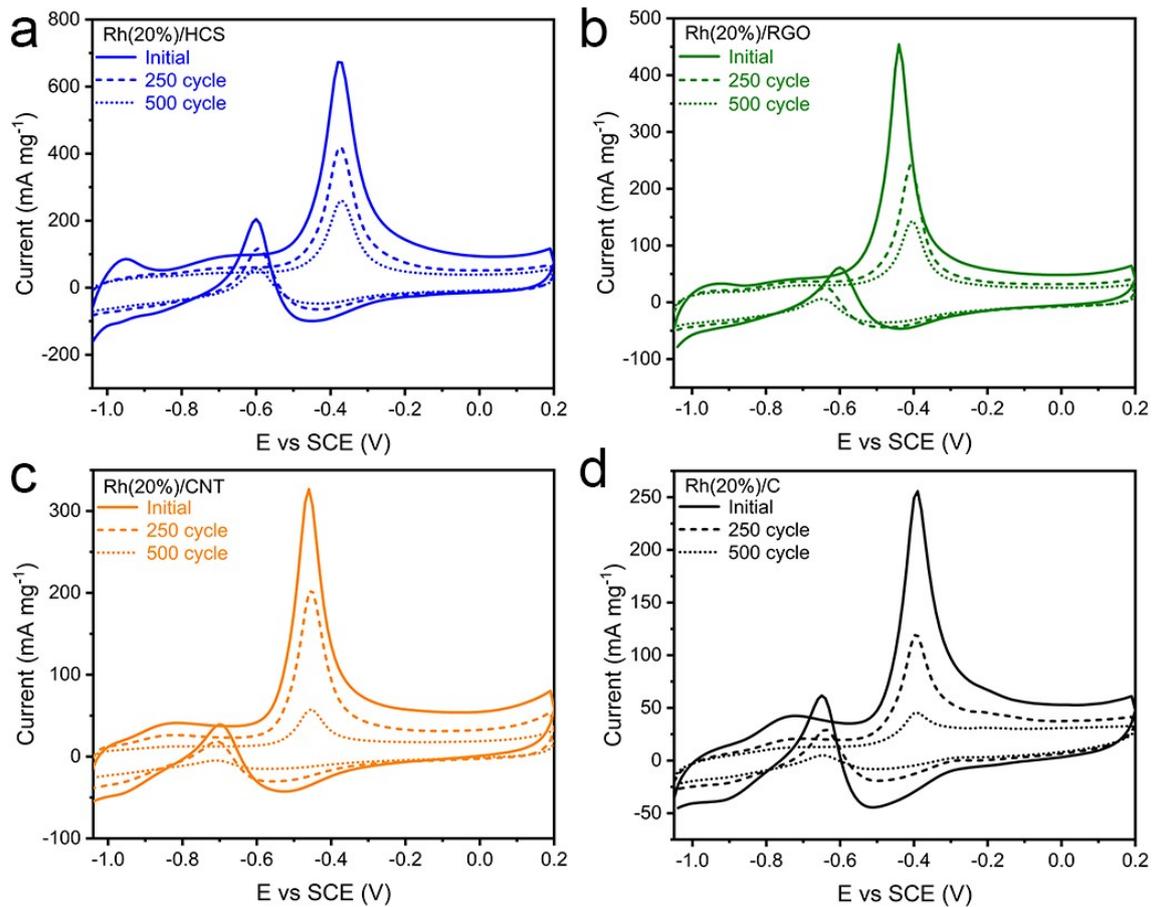


Fig. S7 Continuous CV curves of the (a) Rh(20%)/HCS, (b) Rh(20%)/RGO, (c) Rh(20%)CNT and (f) Rh(20%)/C catalysts in 1 M KOH with 1 M CH₃OH solution.

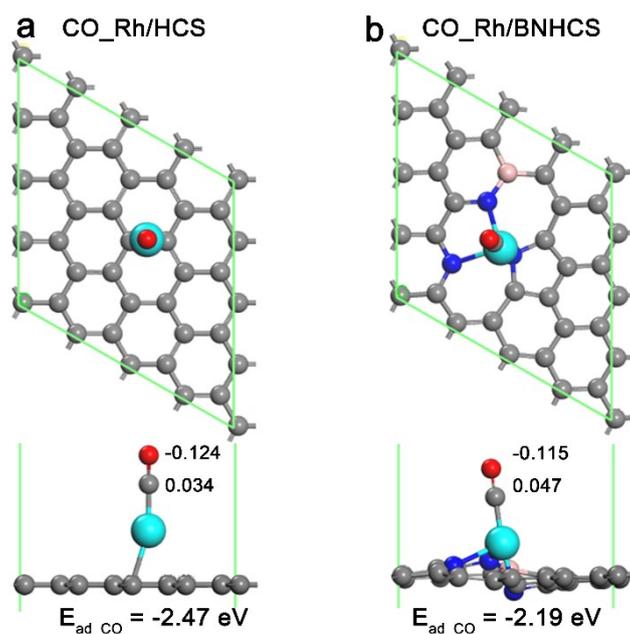


Fig. S8 The relaxed atomic structures for the adsorption of CO molecule on (a) Rh/HCS and (b) Rh/BNHCS. The gray and red balls represent C and O atoms, respectively.

Table S1. Comparison of catalytic performance of diverse electrocatalysts.

Catalysts	ECSA ($\text{m}^2 \cdot \text{g}^{-1}$)	Mass activity ($\text{mA} \cdot \text{mg}^{-1}$)	Specific activity ($\text{mA} \cdot \text{cm}^{-2}$)	Scan rate (mV s^{-1})	Electrolyte
Rh(5%)/BNHCS	62.9	630.9	1.00	50	1 M KOH + 1 M CH ₃ OH
Rh(10%)/BNHCS	77.7	803.8	1.04	50	1 M KOH + 1 M CH ₃ OH
Rh(20%)/BNHCS	113.4	1362.9	1.20	50	1 M KOH + 1 M CH ₃ OH
Rh(40%)/BNHCS	97.7	1051.4	1.08	50	1 M KOH + 1 M CH ₃ OH
Rh(20%)/HCS	79.6	643.5	0.81	50	1 M KOH + 1 M CH ₃ OH
Rh(20%)/RGO	57.9	450.1	0.78	50	1 M KOH + 1 M CH ₃ OH
Rh(20%)/CNT	51.4	330.7	0.64	50	1 M KOH + 1 M CH ₃ OH
Rh(20%)/C	51.2	237.5	0.53	50	1 M KOH + 1 M CH ₃ OH
Pt(20%)/C	27.6	182.1	0.61	50	1 M KOH + 1 M CH ₃ OH
Pb(20%)/C	41.5	240.3	0.58	50	1 M KOH + 1 M CH ₃ OH

Table S2. Comparison of methanol oxidation behaviors for the Rh(20%)/BNHCS catalyst with various state-of-the-art Rh-based electrocatalysts.

Catalysts	ECSA (m ² g ⁻¹)	Mass activity (mA mg ⁻¹)	Scan rate (mV s ⁻¹)	Electrolyte	Reference
Rh(20%)/BNHCS	113.4	1362.9	50	1 M KOH + 1 M CH ₃ OH	This work
Rh/CNT-MXene	89.4	911.0	50	1 M KOH + 1 M CH ₃ OH	[S1]
Rh/CNT-RGO	105.4	814.0	50	1 M KOH + 1 M CH ₃ OH	[S2]
Rh/SWCNH	102.5	784.0	50	1 M KOH + 1 M CH ₃ OH	[S3]
Rh/Ti ₃ C ₂ T _x	71.6	600.2	50	1 M KOH + 1 M CH ₃ OH	[S4]
Rh nanospheres	50.7	292.0	50	1 M KOH + 1 M CH ₃ OH	[S5]
Rh nanosheets	45.5	333.0	50	1 M KOH + 1 M CH ₃ OH	[S6]
Rh nanotubes	60.9	325.0	50	1 M KOH + 1 M CH ₃ OH	[S7]
Rh nanodendrites	43.4	256.0	50	1 M KOH + 1 M CH ₃ OH	[S8]

Table S3. The charge-transfer resistances (R_{ct}) of different catalysts.

Catalysts	R_{ct} value (Ω)	Error (%)
Rh/BNHCS	42.4	4.5
RH/HCS	25.7	4.3
Rh/C	350.0	3.0

References

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