Electronic supplementary information

Carbon Transmission of CO_2 Activated Nano-MgO Carbon Composites Enhances Phosphate Immobilization

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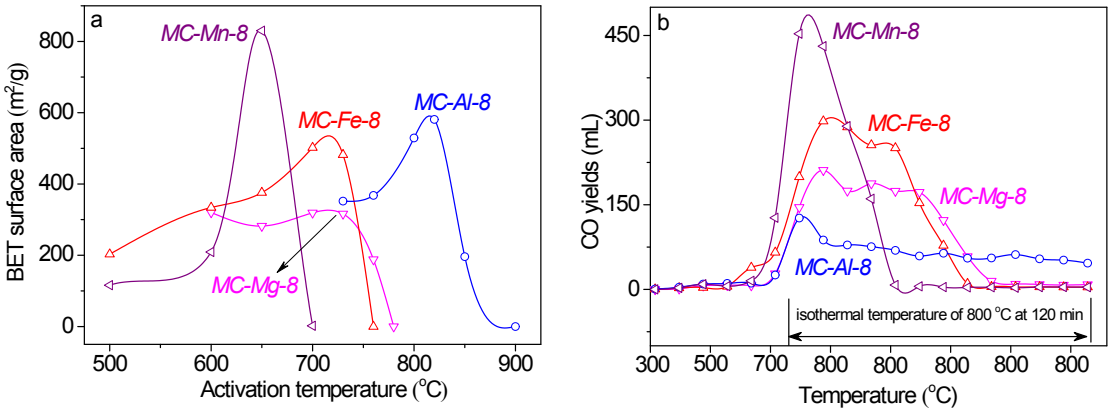

Fig. S1 (a) Effect of metal type on the BET surface area of MCs activated at different temperature, (b) effect of metal type on the CO yields during the preparation of MCs.

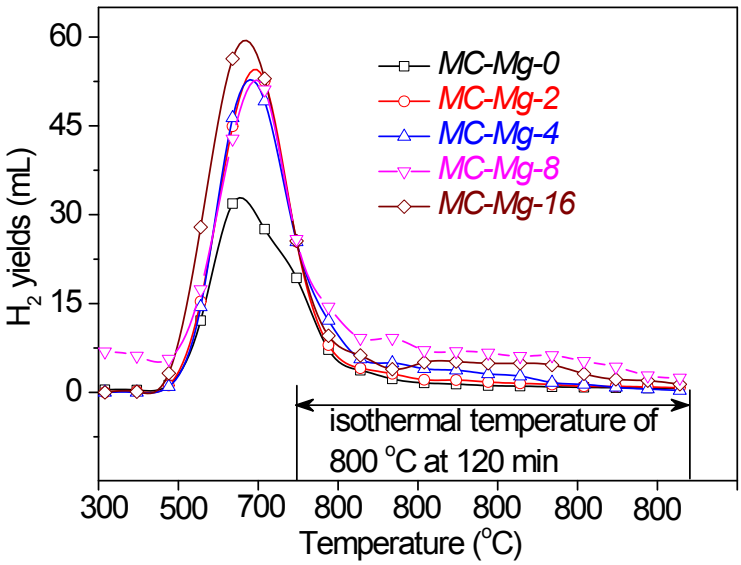

Fig. S2 Effect of $MgCl_2$ loading on the H_2 yields during the preparation of nano-MgO carbon composites.

Table S1 Basic parameters for the selected nano-MgO carbon composites used in the immobilization of phosphate

Sample	Activation temperature (°C)	S_{BET} (m^2/g)	S_{micro} (m^2/g)	C content (%)	Mg content (%)	Mean MgO particle size (nm)[a]	Mg leaching (%)
MC-Mg-0	800	1054	998	62.4	-	-	-
MC-Mg-2	760	685	586	56.7	6.83	15	32.5
MC-Mg-4	700	437	348	57.9	10.7	31	17.1
MC-Mg-8	700	345	258	51.4	17.0	42	10.3
MC-Mg-16	700	297	218	42.7	25.1	50	7.75

[a] Concluded from TEM images.

Table S2 Metal leaching and phosphate adsorption for the different nano metal oxide carbon composites (P: phosphorus, M: metal oxide, MO_x)

Sample	Metal leaching (mg/L)	P adsorption [a] (mg P/g *MC*)	P adsorption (mg P/g M)	P adsorption (mol P/mol M)
MC-Mn-8	16.1	130	357	0.82
MC-Mg-8	6.62	91	325	0.42
MC-Al-8	3.93	16	45.8	0.08
MC-Fe-8	0.13	3	5.96	0.01

[a] Concluded from Langmuir maximum capacity.

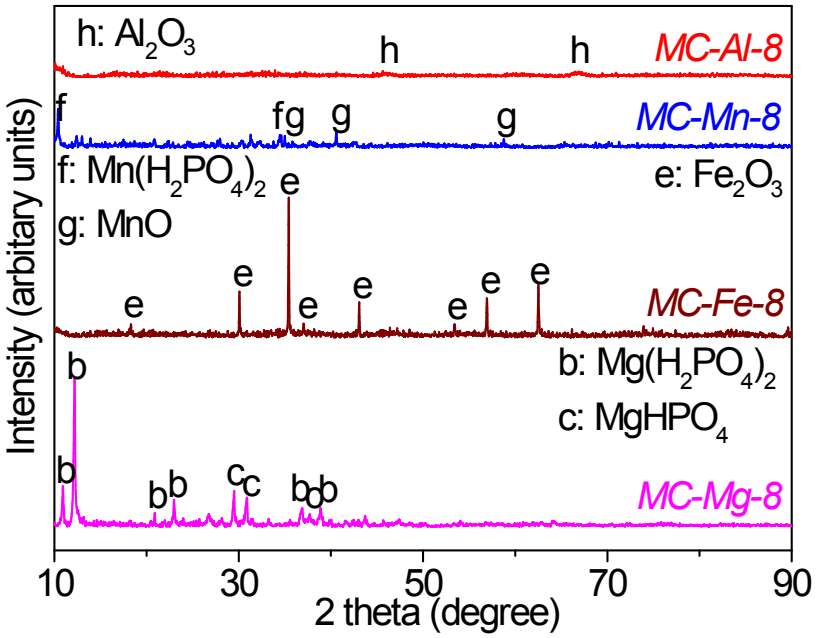

Fig. S3 XRD patterns of the as-prepared nano-metal oxide carbon composites after phosphate adsorption

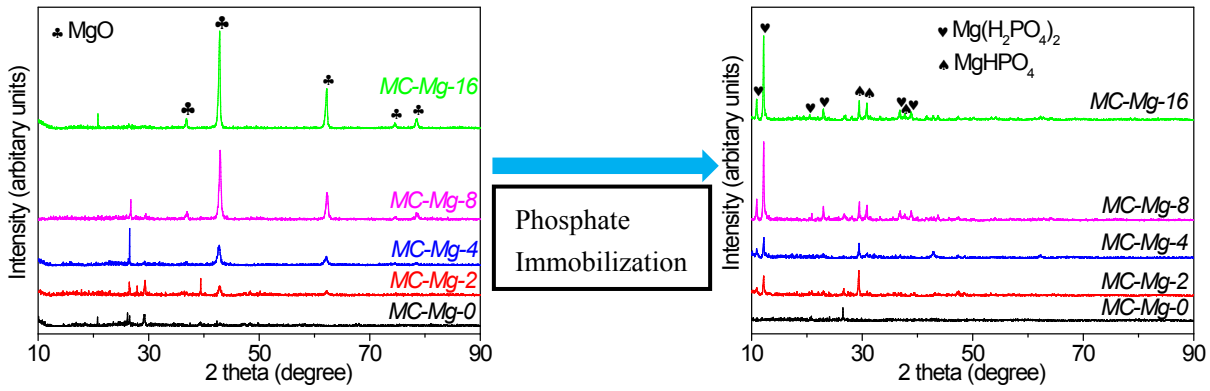

Fig. S4 XRD patterns of the as-prepared nano-MgO carbon composites and phosphate adsorbed samples (samples with optimal porosity are selected for analysis).

Note: Unmarked XRD signals represented the $CaCO_3$ and SiO_2 compositions derived from biomass.

Table S3 Comparisons of maximum phosphate adsorption capacity of different Mg-enriched adsorbents

Adsorbents	P adsorption (mg P/g adsorbent)	P adsorption (mg P/g MgO)	Reference
MgO nanoflake-modified diatomite	52.1	114	[34]
Artemia egg shell supported nano-$Mg(OH)_2$ composite	32.7	-	[12]
Mg-enriched engineered carbon	23.8	74.5	[16]
Mg-enriched biochar	117	-	[7]
MgO decorated magnetic biochar	121	355	[5]
MgO	500	500	this study
Nano-MgO carbon composite (*MC-Mg-16*)	294	705	this study

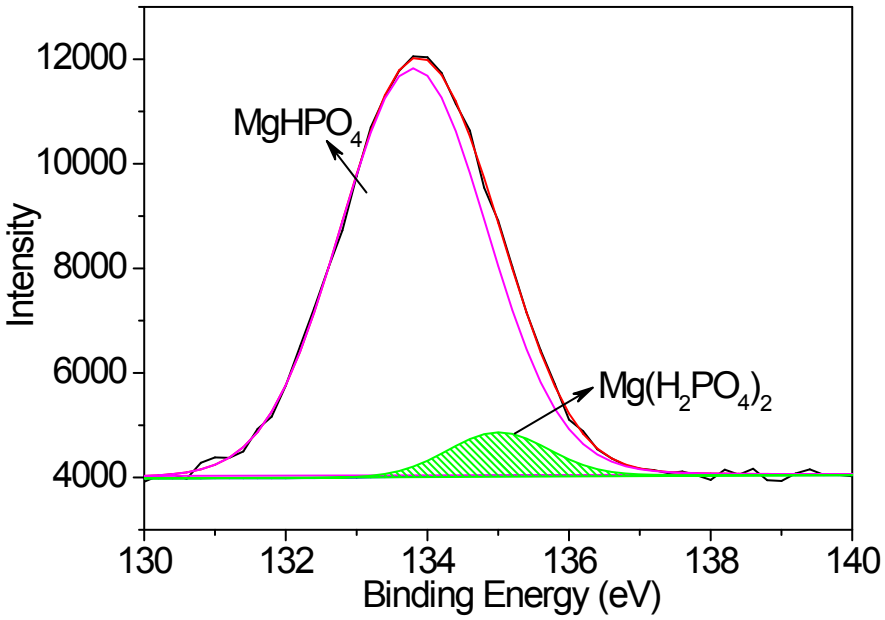

Fig. S5 XPS spectra of the P 2p2/3 regions for P-adsorbed nano-MgO materials.

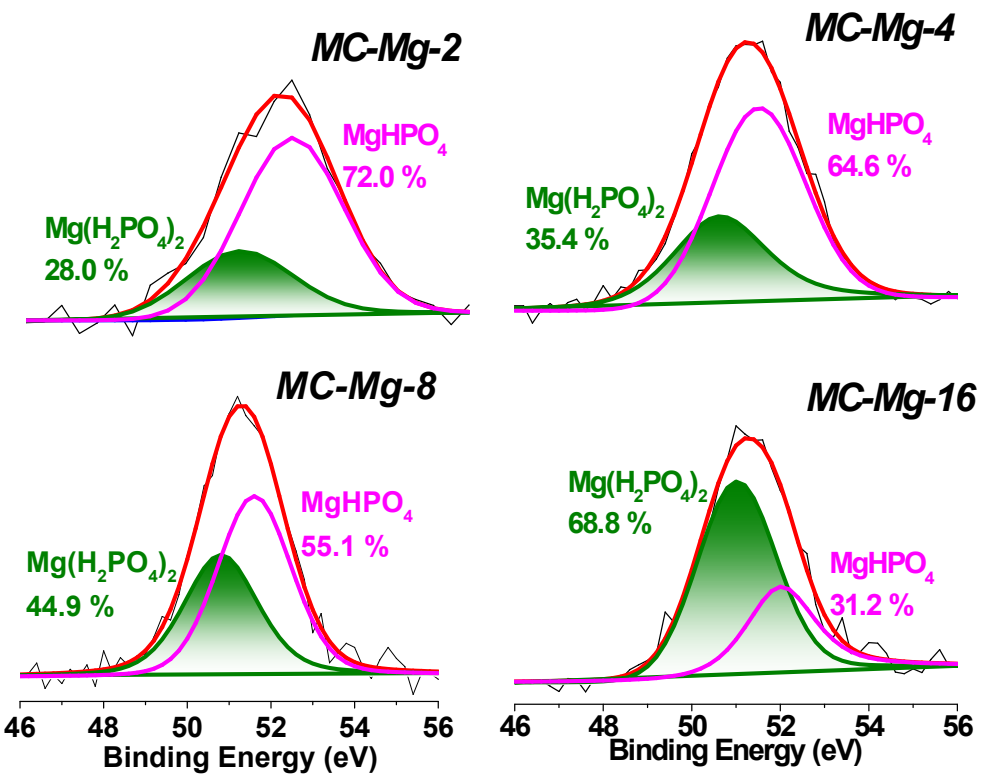

Fig. S6 XPS spectra of the Mg 2p regions for P-adsorbed nano-MgO carbon composites (CO_2 activation).

Table S4 Basic parameters for the N_2 and CO_2 activated *MC-Mg-2* samples

Sample	S_{BET} (m^2/g)	C content (%)	Mg content (%)	Mean MgO particle size (nm)[a]	Mg leaching (%)
MC-Mg-2 (CO_2 activation)	685	56.7	6.83	15	32.5
MC-Mg-2 (N_2 activation)	401	69.7	3.20	9	12.4

[a] Concluded from TEM images.

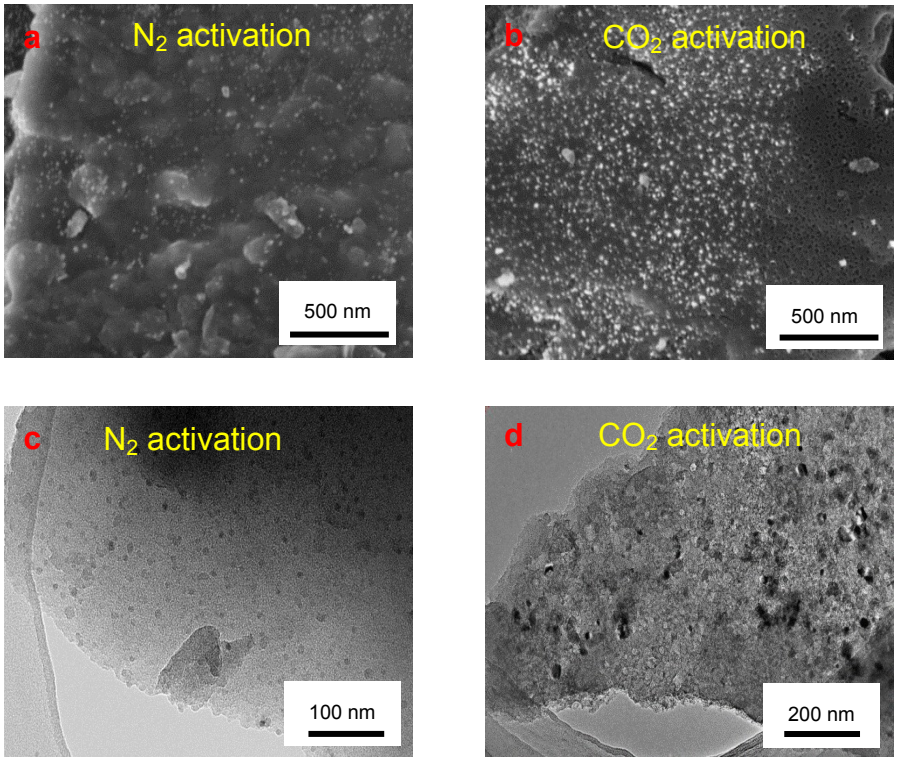

Fig. S7 SEM (a, b) and TEM (c, d) images for the N_2 and CO_2 activated *MC-Mg-2* samples.

Table S5 Characteristics of the Mg release and phosphate adsorption for N_2 and CO_2 activated *MC-Mg-2* samples (P: phosphorus)

Sample	Mg leaching (mg/L)	P adsorption (mg P/g MC)	P adsorption (mg P/g MgO)	P adsorption (mol P/mol Mg)	n($MgHPO_4$): n($Mg(H_2PO_4)_2$)[a]
MC-Mg-2 (CO_2 activation)	11.1	22	193	0.25	2.57
MC-Mg-2 (N_2 activation)	1.98	4	75	0.10	3.18

[a] Calculated from Mg 2p XPS spectra of P-adsorbed nano-MgO carbon composites.

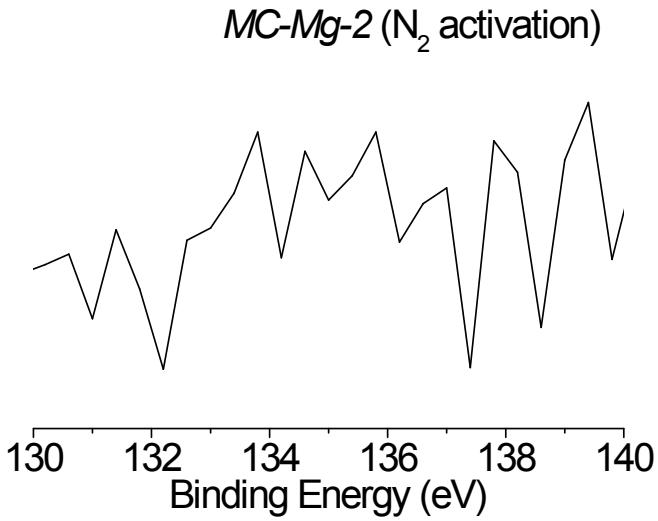

Fig. S8 XPS spectra of the P 2p2/3 regions for P-adsorbed *MC-Mg-2* sample from N_2 activation.