Electronic Supplementary Information (ESI)

Valuable Carbon Nanomaterials Directly Prepared from CO_2 via Sonication in Pure Water

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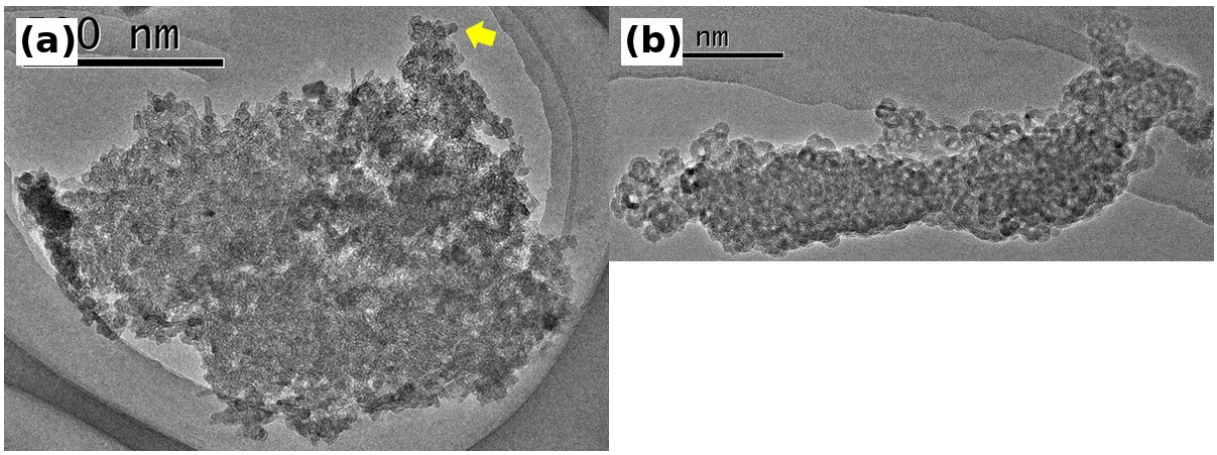
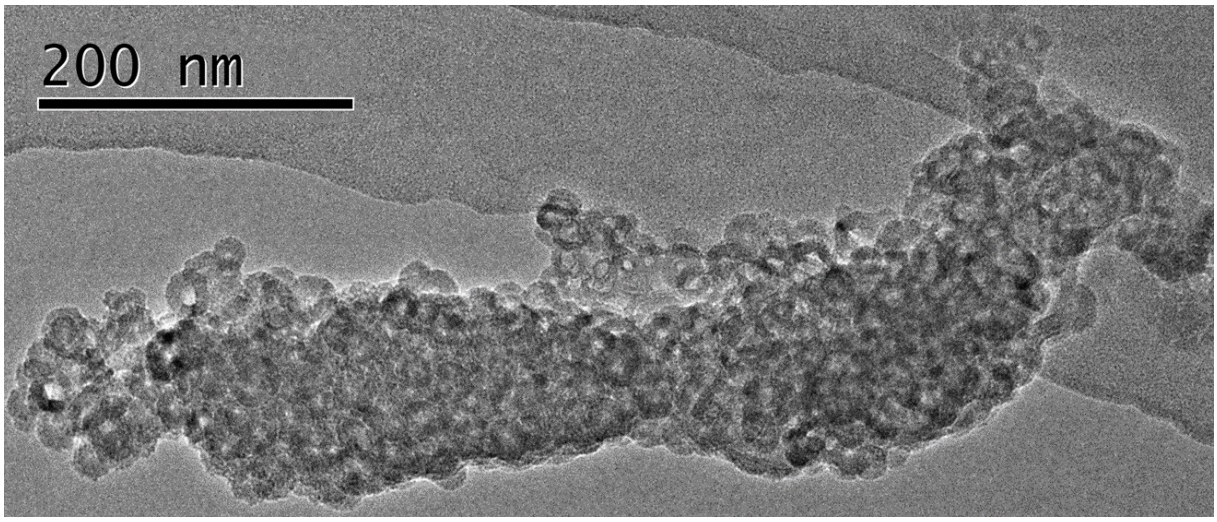
Fig. S1. Low-magnification TEM survey panels (representativeness).



Caption: Low-magnification TEM survey panels acquired from multiple grids/regions under identical conditions to demonstrate representativeness of the as-made, CNO-enriched mixed carbon. Panel (a) shows CNOs together with minor filamentous (nanotube-like) and sheet-like objects; the yellow arrow highlights a hollow-cored polyhedral particle (cf. Fig. 1a in the main text). Panel (b) shows a region dominated by CNOs. Images are ex situ and are not time-resolved.

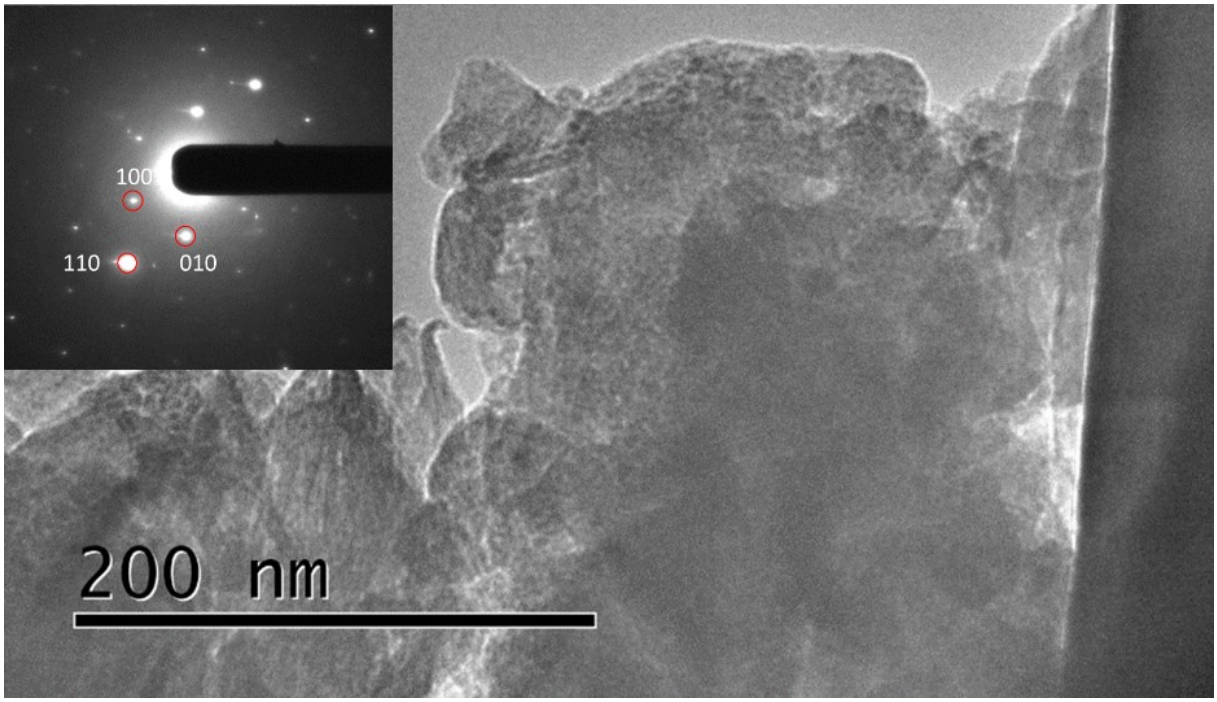
Fig. S2. Evidence for $Ca(OH)_2$ formation after sonication



Caption: Representative TEM image of solids recovered after sonication, showing plate-like crystallites consistent with $Ca(OH)_2$ (portlandite).

Fig. S3. Atmospheric CO_2 uptake experiment

Protocol summary (for Fig. S3): $Ca(OH)_2$-saturated aqueous solutions were aged for 4 days at room temperature under either ambient air (open to air) or an N_2 headspace (CO_2-depleted, sealed). After aging, any solids were collected by light centrifugation, rinsed with deionized water, dried, and analyzed by TEM and selected-area electron diffraction (SAED).



Caption: Characterization of solid recovered under ambient air. Representative TEM images and SAED patterns of the solid obtained after 4-day pre-equilibration of a $Ca(OH)_2$-saturated solution under ambient air. SAED from single particles shows single-crystal diffraction spots consistent with aragonite $CaCO_3$; no calcite features were observed in the examined regions. Scale bars as indicated.

Table S1. Mass balance for CO_2-uptake control

Condition	Aging time	Recovered solid	Note
Ambient air	4 days	≈34 mg ($CaCO_3$)	Carbonate precursor formed in open air.
N_2 headspace (CO_2-depleted)	4 days	trace / negligible (unquantifiable)	Suppressed precursor formation.

Table S2. TOC (TC–IC) and NPOC quantification and QA/QC

Analyte	Value (mg C L^{-1})	LOD (mg C L^{-1})	LOQ (mg C L^{-1})	Note
TC (total carbon)	23.23	0.04	0.12	680 °C catalytic oxidation–NDIR (TOC-V).
IC (inorganic carbon)	8.47	0.006	0.019	Acidification–NDIR (TOC-V).
TOC (TC – IC)	14.75	—	—	Computed from same-lot TC and IC.
NPOC	14.83	0.05	0.16	Acidify (1 M HCl; 1.5%) + sparge 1.5 min.

Note: TOC is reported for clarified supernatants; values represent lower-bound carbon yields because insoluble/retained fractions were not recovered by filtration or acid leaching.

Carbon quantification by TC–IC (TOC) and NPOC. TOC/TC–IC/NPOC measurements were performed by Shimadzu Techno-Research, Inc. (Japan). Liquid samples were handled in glass vials with fluoropolymer-lined caps; headspace was minimized, samples were kept cold (approx. 4 °C), and analyses were completed within 48 h. Total carbon (TC) and inorganic carbon (IC) were measured on the same lot, and TOC was calculated as TOC = TC − IC. Non-purgeable organic carbon (NPOC) was measured on the same lot after acidification to pH ≤ 2 and gas purging to remove IC and purgeable organics. Detection was based on catalytic high-temperature oxidation (approx. 680–1000 °C) to CO_2, followed by NDIR (or coulometry), depending on the instrument configuration. Clarified supernatants were prepared by light centrifugation (see Table S2 for RCF/rpm). LOD/LOQ, calibration, blanks, laboratory control samples (LCS), replicates (RSD), and acceptance criteria are summarized in Table S2.

Yield calculations. Carbon mass m_C (mg) = TOC (mg C L^{-1}) x V_sup (L). Percent yield (vs input $CaCO_3$) = 100 x m_C / m_$CaCO_3$,in. Percent C-conversion (vs carbon in $CaCO_3$) = 100 x m_C / (0.12 x m_$CaCO_3$,in).

Table S3. Electrical conductivity dataset

Condition	EC (μS cm^{-1})	Temperature	Note
Before sonication	31.4	25 °C (compensated)	$CaCO_3$ suspension.
After sonication	50.2	25 °C (compensated)	Increase consistent with more dissolved ionic species.

Note S1. Additional discussion

Any discussion of sonochemically generated radicals is presented here as a potential side process; radical yields were not quantified in this study and are not required to describe the acid–base CO_2 capture/precipitation pathway.

Where direct time-resolved evidence is not available, claims are framed as proposed/consistent with observations.