3D-printing of attapulgite monoliths with superior low-temperature selective catalytic reduction activity: The influence of thermal treatment

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Supplementary material

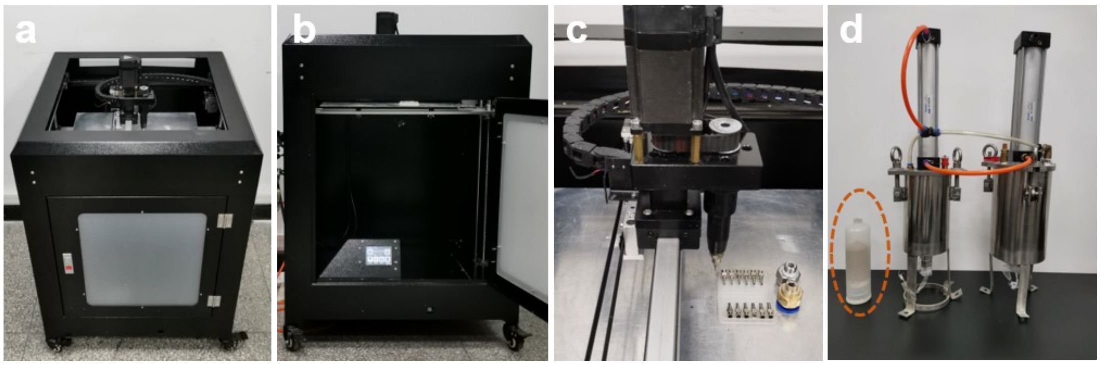

Fig. S1. The optical photos of home-made screw extrusion printer for direct ink writing: (a) The top view of the extrusion printer, (b) the front view of the extrusion printer, (c) the print nozzle, (d) the cartridges with different print capacities.

Table S1. Formulations of the designed attapulgite slurry for direct ink writing.

Formulation	ATP (g)	DW (g)	ATP/ DW	Solid content (%)
1	150	110	1.36	57.7
2	150	115	1.30	56.6
3	150	120	1.25	55.6
4	150	125	1.20	54.5
5	150	130	1.15	53.6
6	150	135	1.11	52.6
7	150	140	1.07	51.7
8	150	145	1.03	50.8
9	150	150	1.00	50.0

Table S2. Formulations of attapulgite slurry with adding alumina.

Formulation	ATP (g)	DW (g)	Al_2O_3 (g)	Al_2O_3 in total powder (wt.%)	Solid content (%)
7	150	140	0	0	51.7
10	150	140	5	3	52.5
11	150	140	10	6	53.3
12	150	140	15	9	54.1

Table S3. Relevant printing parameters of the screw-based extrusion printer for direct ink writing process.

Parameter	Set value	Description
Air pump pressure	0.4-0.5 MPa	The slurry stably extruded from the screw under constant pressure
Nozzle diameter	1.6 mm	Diameter size of print nozzle
Layer thickness	0.3 mm	Print thickness per layer
Line width	1.0 mm	Printing nozzle routing width
Printing speed	4-5 mm/s	Length of extrusion from nozzle per unit time

Table S4. XRF analysis of main components of attapulgite raw materials.

Entry	Oxide form	Content (%)	Standard error
1	SiO_2	61.47	0.24
2	Al_2O_3	17.10	0.19
3	MgO	7.39	0.13
4	Fe_2O_3	6.55	0.12
5	CaO	3.12	0.09
6	K_2O	2.31	0.08
7	TiO_2	0.876	0.044
8	P_2O_5	0.519	0.0026
9	MnO	0.181	0.009
10	Na_2O	0.141	0.007

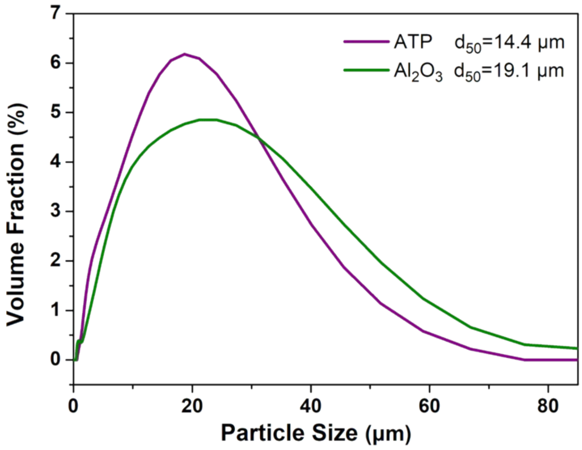

Fig. S2. Particle size distribution of attapulgite and alumina powder.

Table S5. Fineness characteristics of printing raw materials.

Entry	d_{10} (μm)	d_{50} (μm)	d_{90} (μm)	D [3,2] (μm)	D [4,3] (μm)
ATP	3.3	14.4	35.6	7.87	17.3
Al_2O_3	4.3	19.1	145.0	9.01	41.9

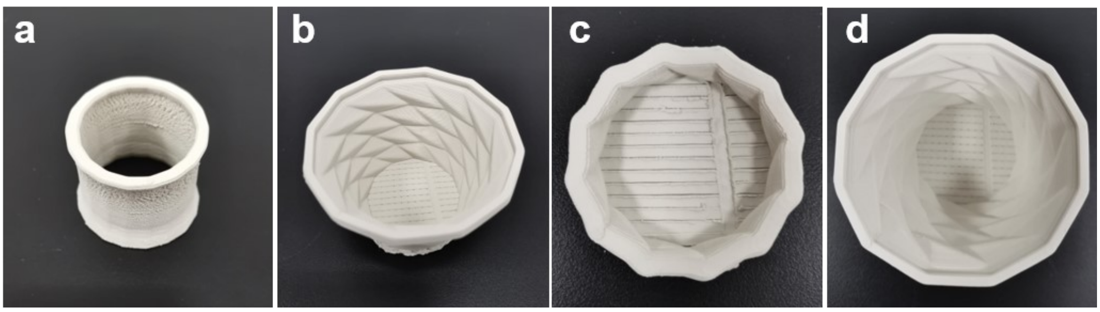

Fig. S3. The optical photos for various fine monolithic structures through direct ink writing of designed attapulgite slurry.

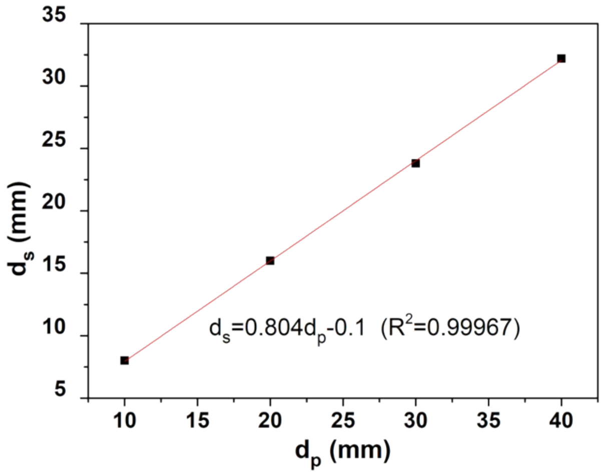

Fig. S4. The relationship between the printed diameter (dp) of different cylindrical structures and the solidified retention diameter (ds) after solidification.

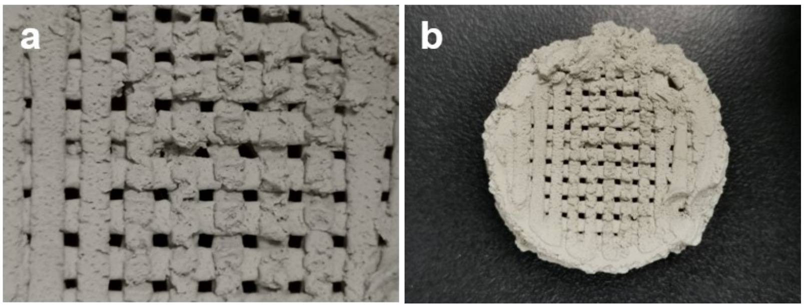

Fig. S5. The optical photos for the DIW sample of the addition of 9 wt.% alumina with rough printing effect.

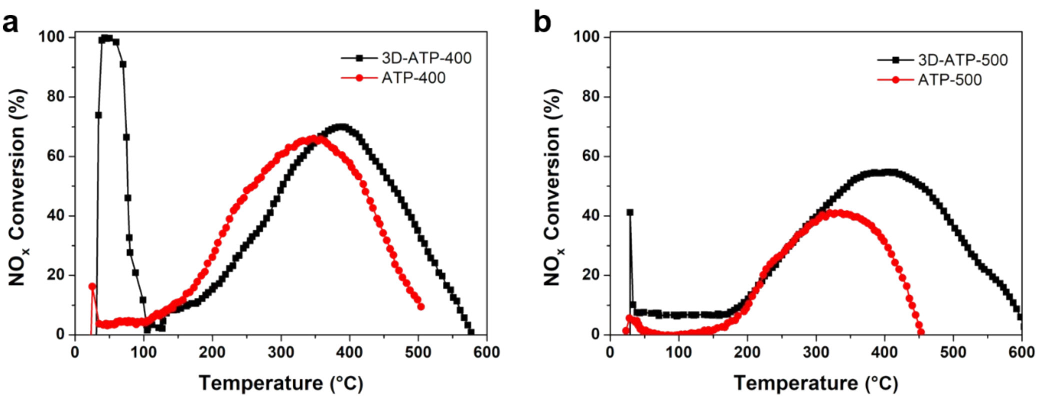

Fig. S6. Comparison of 3D-ATP-400 (a) and 3D-ATP-500 (b) catalysts with powder catalysts.