

RESEARCH ARTICLE

Development of a 3D-printable matrix using cellulose microfibrils/
guar gum-based hydrogels and its post-printing antioxidant activity

Supplementary File

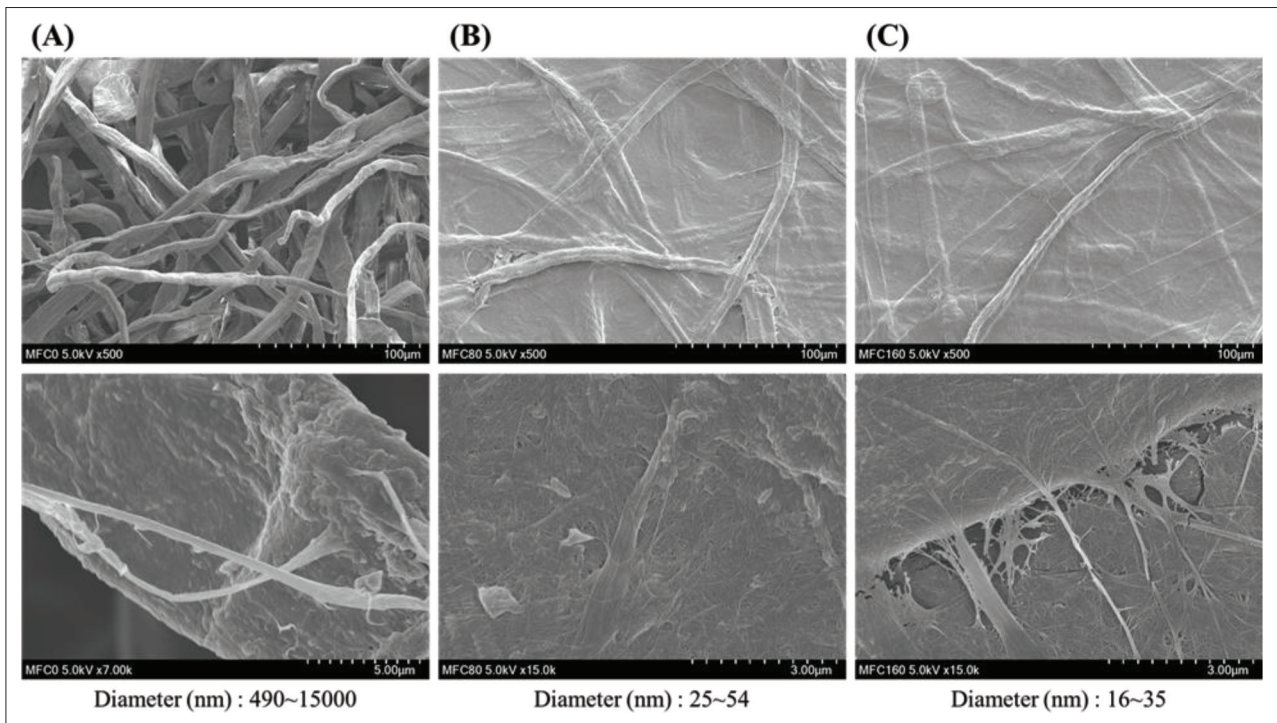


Figure S1. Morphology of cellulose microfibrils produced at different blending times. (A) 0 min, (B) 80 min, and (C) 160 min.

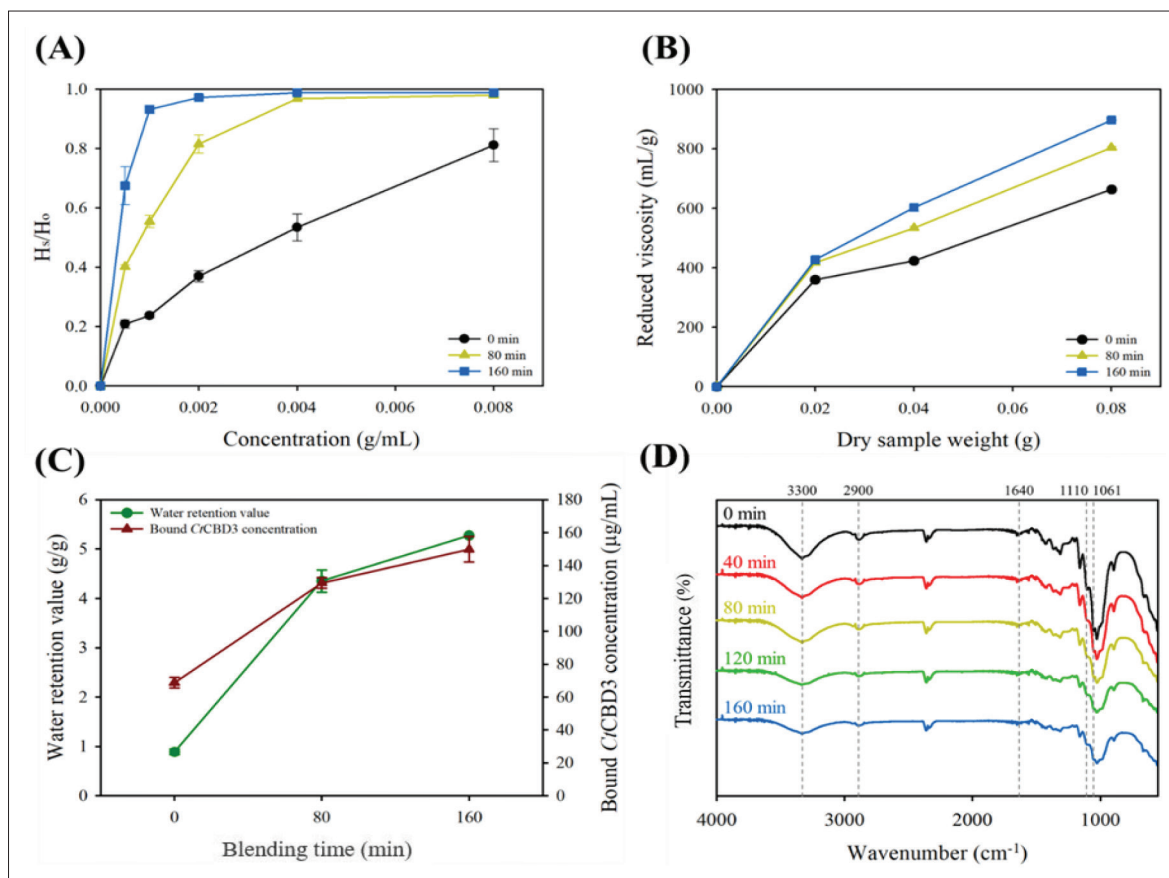


Figure S2. Effect of different blending times on (A) sedimentation, (B) reduced viscosity, (C) water retention value and C/CBD3 binding ability, and (D) FTIR spectra of cellulose microfibrils.

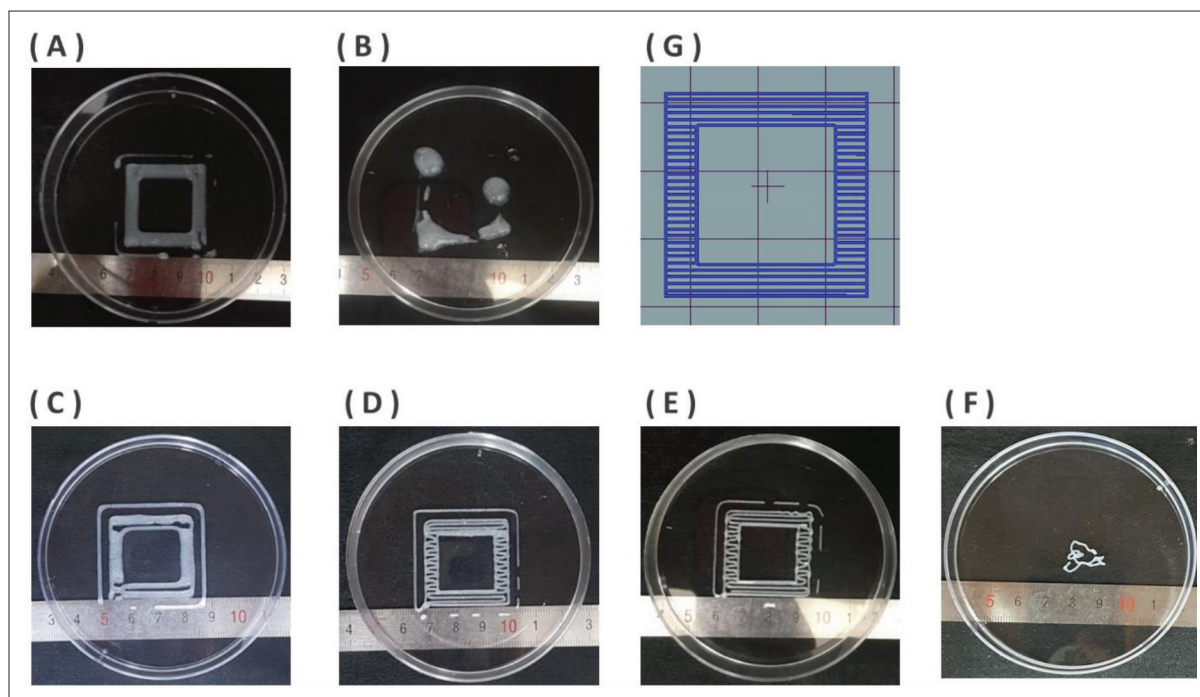


Figure S3. 3D-printed CMFs with different types of hydrocolloid such as (A) alginate, (B) starch, and (C–F) guar gum at different concentrations from 1% to 7% using (G) 2D design.

Table S1. Dimensions of a 2D square and 3D cube printed using 1% CMF with the addition of different concentrations of guar gum

Designed shape		w/1% gg	w/3% gg	w/5% gg	w/7% gg
2D Square	Overall width (cm)	3.2	3.19 ± 0.00 ^a	3.21 ± 0.01 ^b	3.21 ± 0.01 ^b
	Line width (cm)	0.6	0.57 ± 0.06 ^a	0.61 ± 0.03 ^a	0.58 ± 0.01 ^a
Designed shape		w/ 3% gg	w/ 4% gg	w/ 5% gg	
3D Cube	Width (cm)	1.6	1.72 ± 0.02 ^b	1.48 ± 0.01 ^a	1.48 ± 0.02 ^a
	Length (cm)	1.6	1.65 ± 0.01 ^b	1.54 ± 0.02 ^a	1.56 ± 0.01 ^a
	Height (cm)	1.0	0.42 ± 0.02 ^a	0.96 ± 0.01 ^b	0.99 ± 0.01 ^c
	Volume (cm ³)	2.56	1.17 ± 0.00 ^a	2.16 ± 0.03 ^b	2.27 ± 0.01 ^c
	Dimensional error (%)		54.30 ± 0.01 ^b	15.63 ± 0.01 ^b	11.33 ± 0.01 ^a

Data are expressed as mean ± standard deviation ($n = 3$).

^{a-c} In the same row with different letters are significantly different at $p < 0.05$.

Abbreviations: gg, guar gum; N.E., not extruded; w/, 100 mL of 1% (w/v) CMFs.

Table S2. The appearance of the printed constructs based on printing parameters

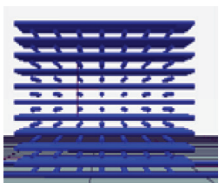
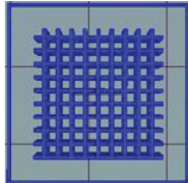
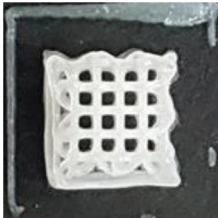

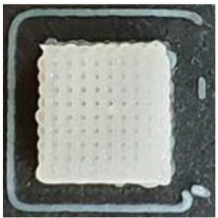
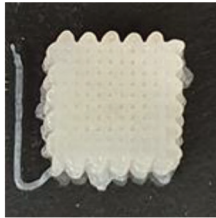
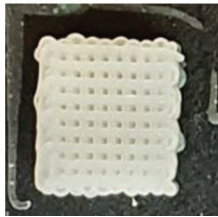
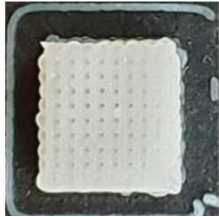
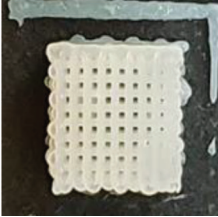

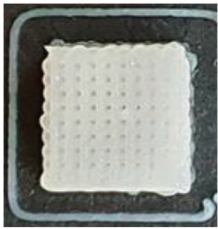
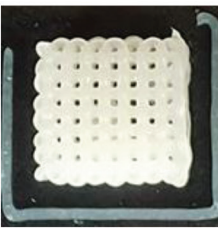


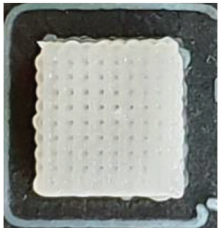
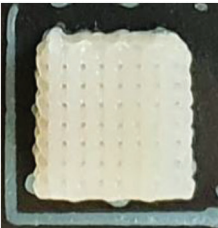
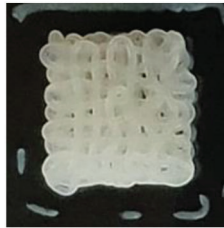
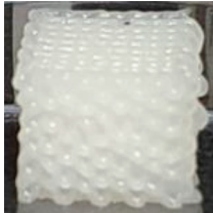







	Side view	Top view			
Designed shape					
Infill density (%)	30	40	50	60	
					
Printing speed (mm/s)	1	5	10	-	
					
Nozzle diameter (mm)	0.4	0.8	1.0	1.5	
					
Layer height (mm)	0.3	0.4	0.5	0.6	
					

Table S3. Stability of the ink printed during storage

	Storage time (h)			
Treatment time (min)	0	3	6	12
0				
Dimensional error (%)	12.76 ± 0.81 ^{a,A}	24.69 ± 1.70 ^{b,B}	30.58 ± 4.10 ^{b,C}	40.00 ± 3.09 ^{a,D}
30				
Dimensional error (%)	11.88 ± 1.53 ^{a,A}	21.11 ± 1.63 ^{a,B}	26.06 ± 1.75 ^{a,C}	30.66 ± 2.33 ^{a,D}

Data are expressed as mean ± standard deviation ($n = 3$).

^{a-b} In the same column with different letters are significantly different at $p < 0.05$.

^{A-D} In the same row with different letters are significantly different at $p < 0.05$.

Table S4. pH value of the respective substances and composite hydrogel or borax-treated hydrogel for CMFs, guar gum, and borax

Sample	pH value				
1% CMFs	4.96 ± 0.05				
GG	6.33 ± 0.02				
1 M Borax	9.46 ± 0.02				
Various concentration of GG	1%	3%	5%	7%	
CMFs/GG	6.04 ± 0.05 ^a	6.31 ± 0.02 ^b	6.33 ± 0.01 ^b	6.37 ± 0.02 ^b	
CMFs/GG/1 M Borax	7.16 ± 0.01 ^a	7.13 ± 0.02 ^a	7.17 ± 0.02 ^a	7.19 ± 0.05 ^a	

Data are expressed as the mean ± standard deviation ($n = 3$).

^{a-b} In the same row with different letters are significantly different at $p < 0.05$.

Abbreviations: CMFs, cellulose microfibrils; GG, guar gum.