Electronic Supplementary Information (ESI)

Wood-inspired dual-scale directional channel cellulose bioreactors with high mass transfer efficiency for continuous flow catalytic green conversion

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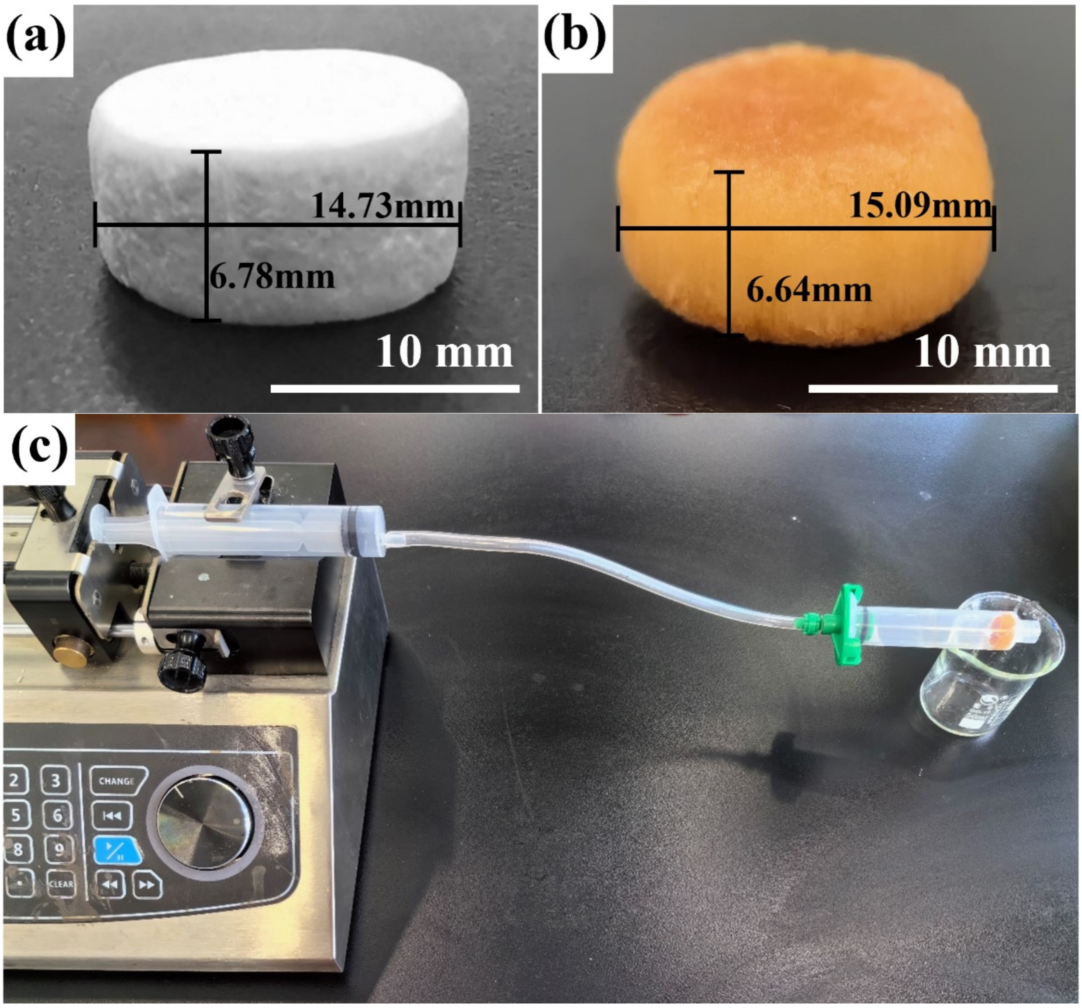

Fig. S1 Digital images of (a) cellulose reactor in white color with a diameter of 14.73 mm and a height of 6.78 mm. The digital images of (b) enzyme immobilization cellulose reactor in orange color with a diameter of 15.09 mm and a height of 6.64 mm. (c) Digital image of continuous fluid catalytic device. Among them, a 20 mL syringe fixed on the injection pump is used for substrate addition. The bioreactor was placed in a 10 mL syringe at the end of the hose connection. The inner diameters of 20mL and 10mL syringes are 18.61 and 15.12mm, respectively. Moreover, the injection pump was purchased from Baoding Dichuang Electronic Technology Co., Ltd, and the flow rate was adjusted in the range of 5 mL/h-20 mL/h.

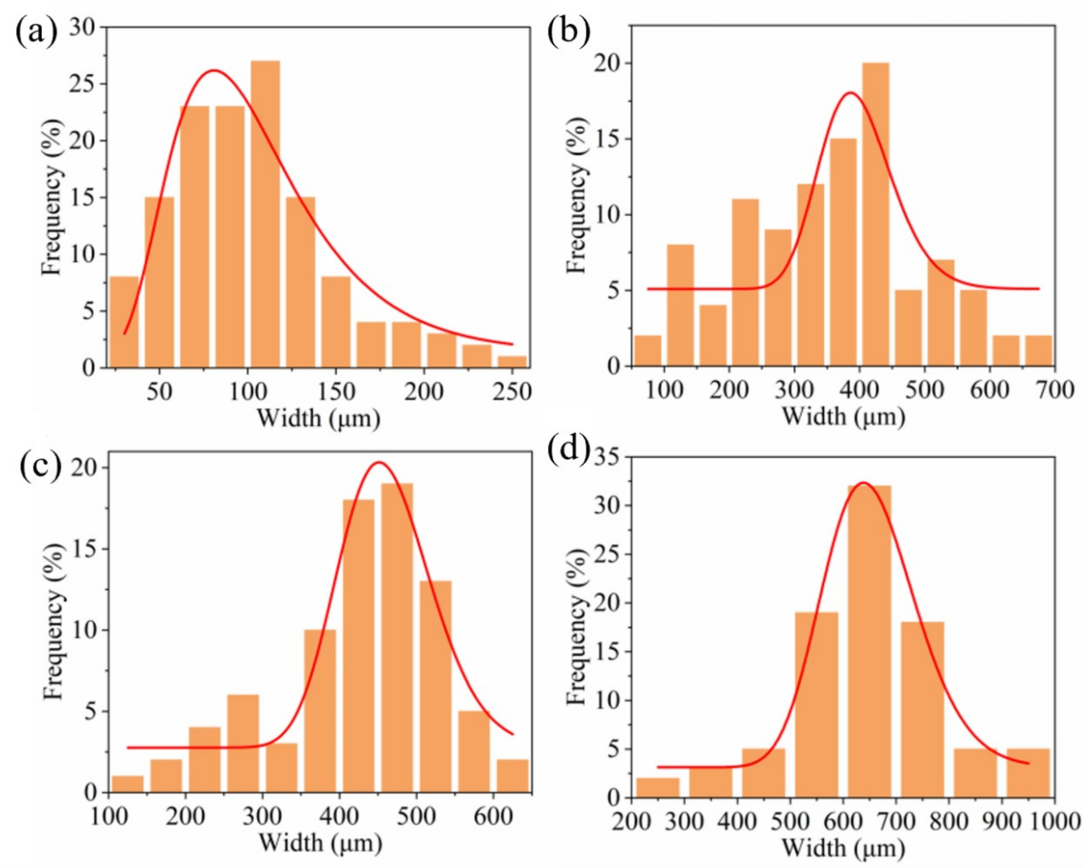

Fig. S2 Aperture analysis: (a) copper substrate; (b) aluminum substrate; (c) iron substrate; (d) stainless steel substrate.

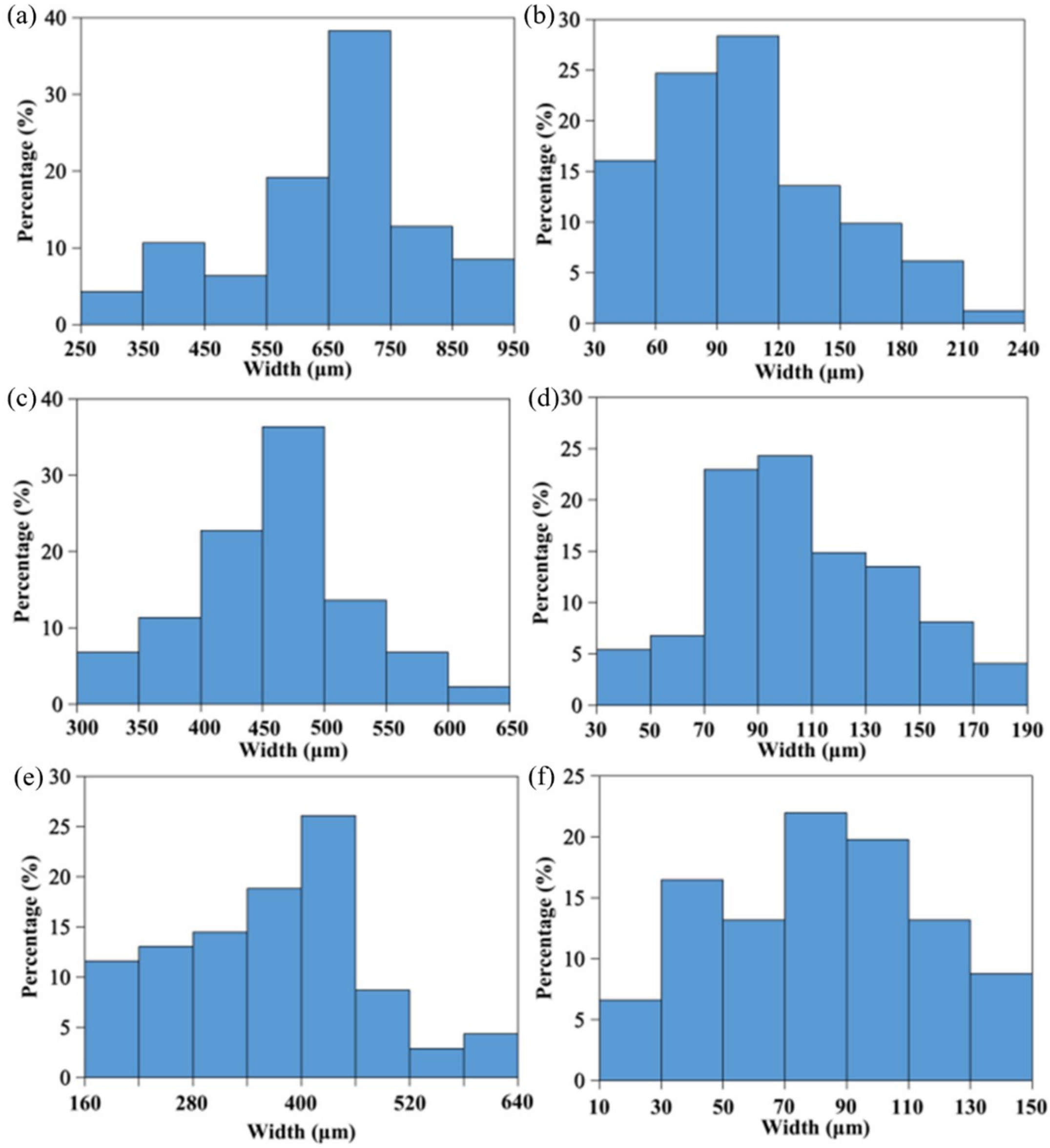

Fig. S3 Statistical analysis of channel size ratio of different materials: (a-b) Size statistics of large channel and small channel of copper-304 stainless steel material; (c-d) Size statistics of large and small channels for copper-iron materials; (e-f) Size statistics of large channels and small channels for copper-aluminum materials.

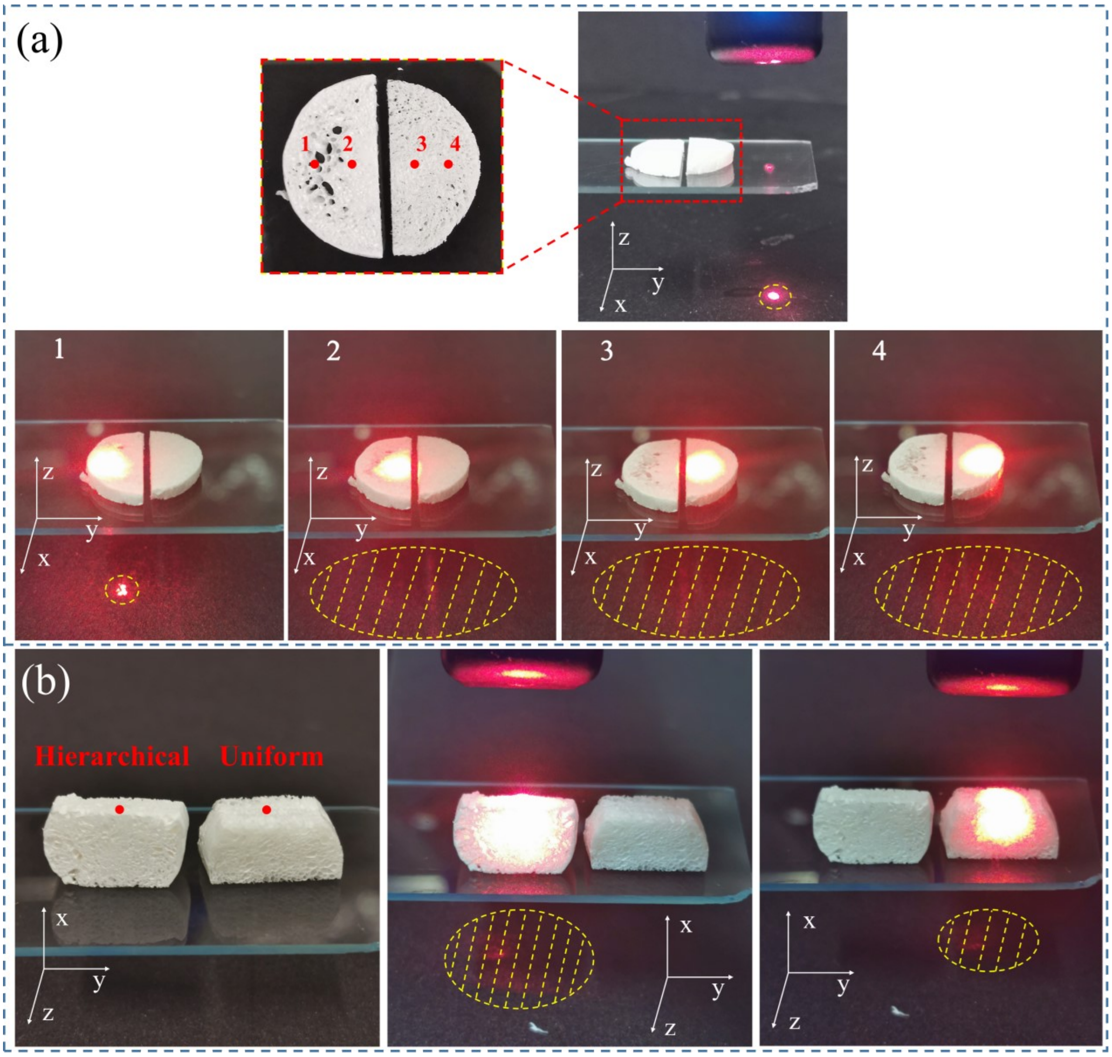

Fig. S4 Light transmission test: (a) Longitudinal section; (b) Radial section.

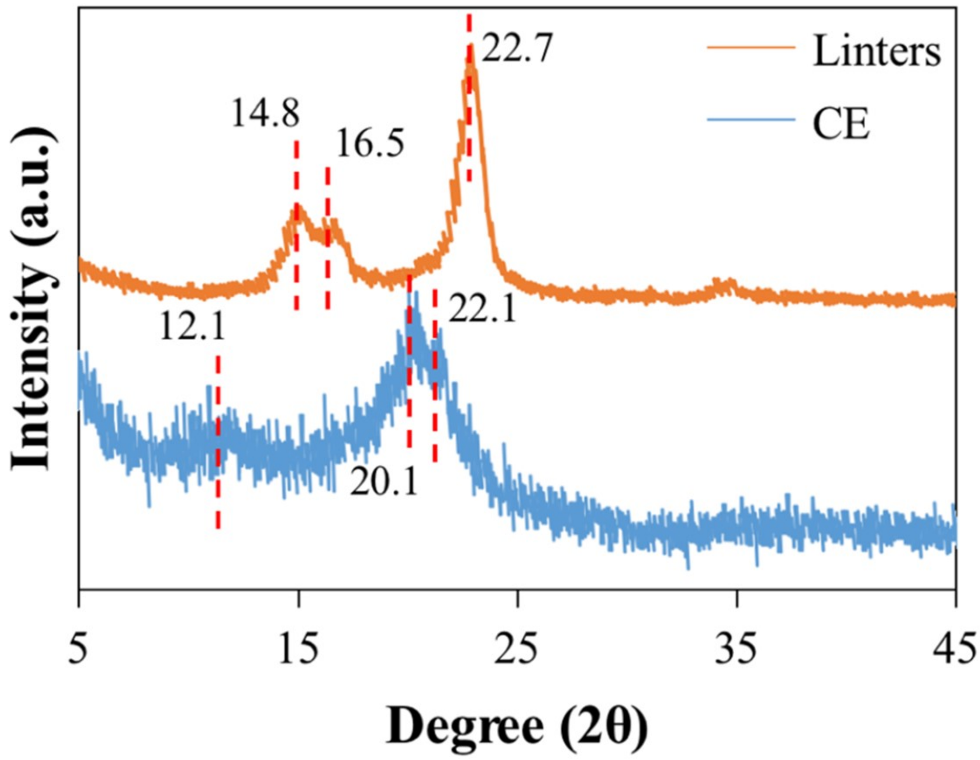

Fig. S5 XRD spectra for Linters and CE.

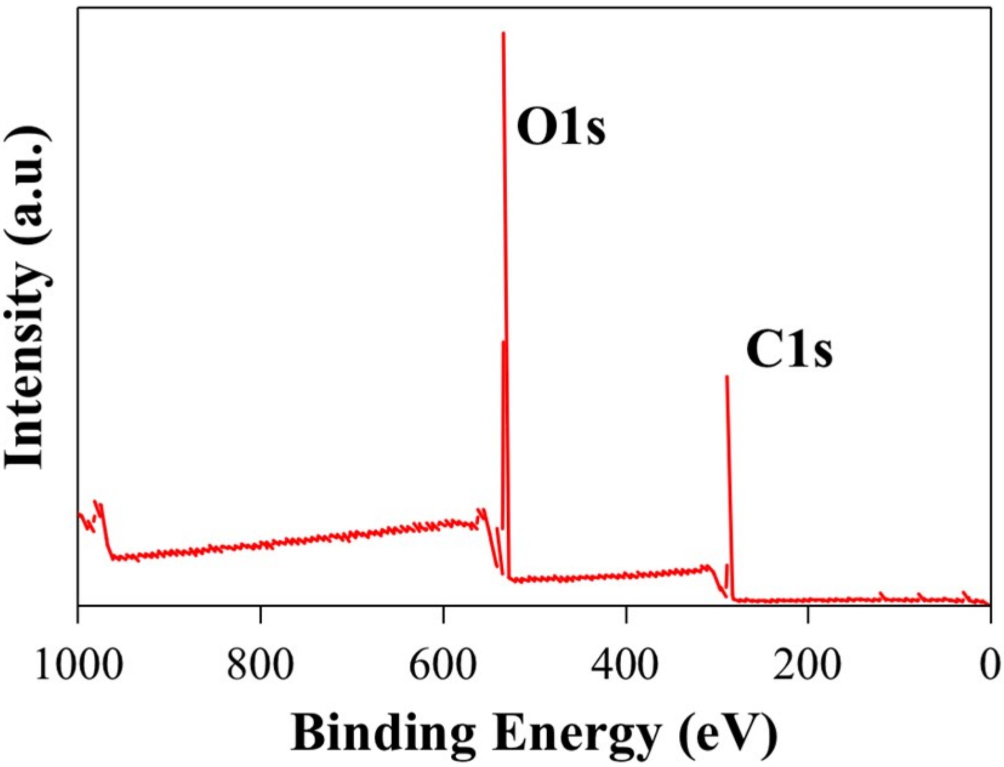

Fig. S6 XPS spectrum analysis of CE-STs.

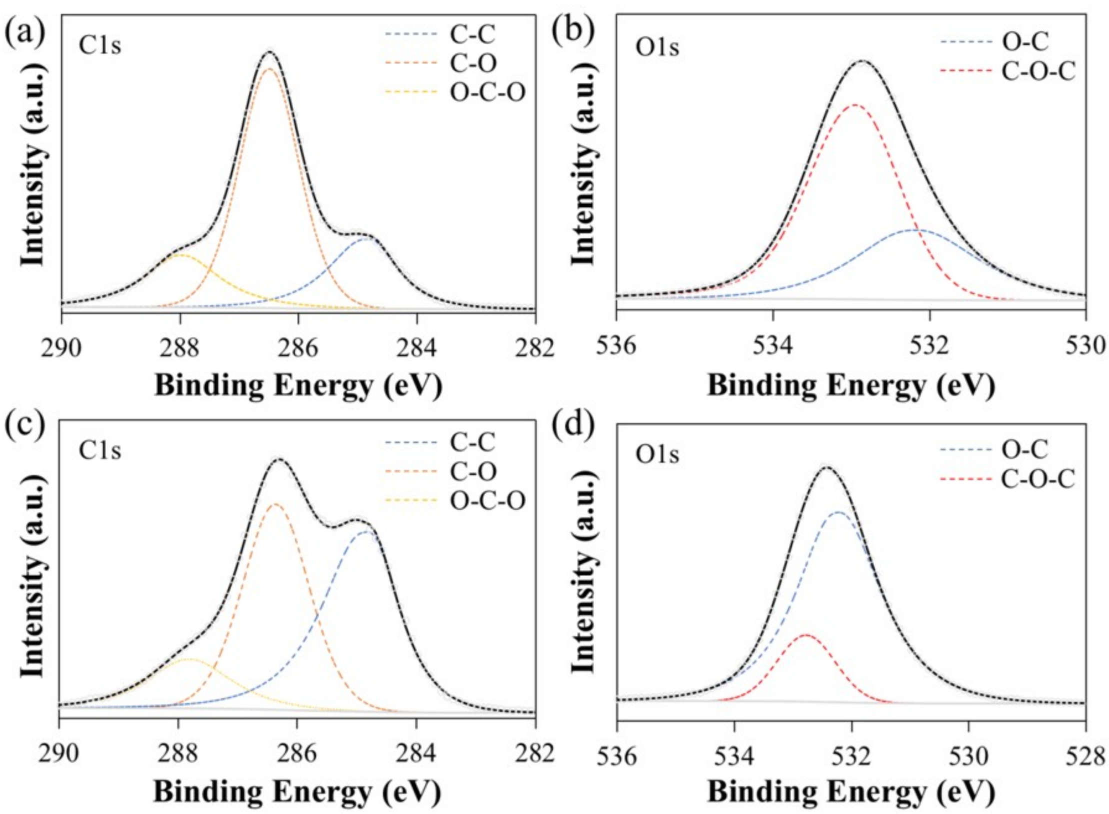

Fig. S7 XPS spectrum analysis of different materials: (a-b) CE-STs; (c-d) CER-1/6.

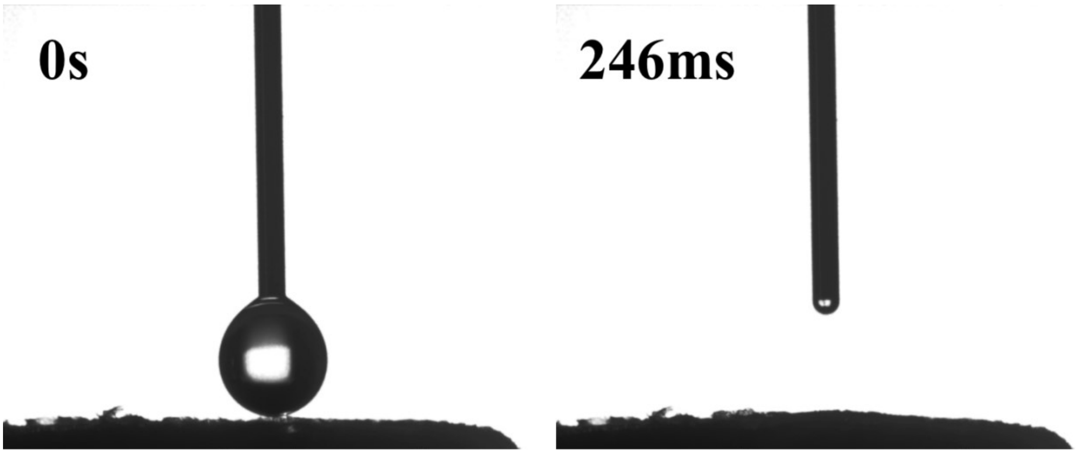

Fig. S8 The dynamic water contact angles of CER-1/6.

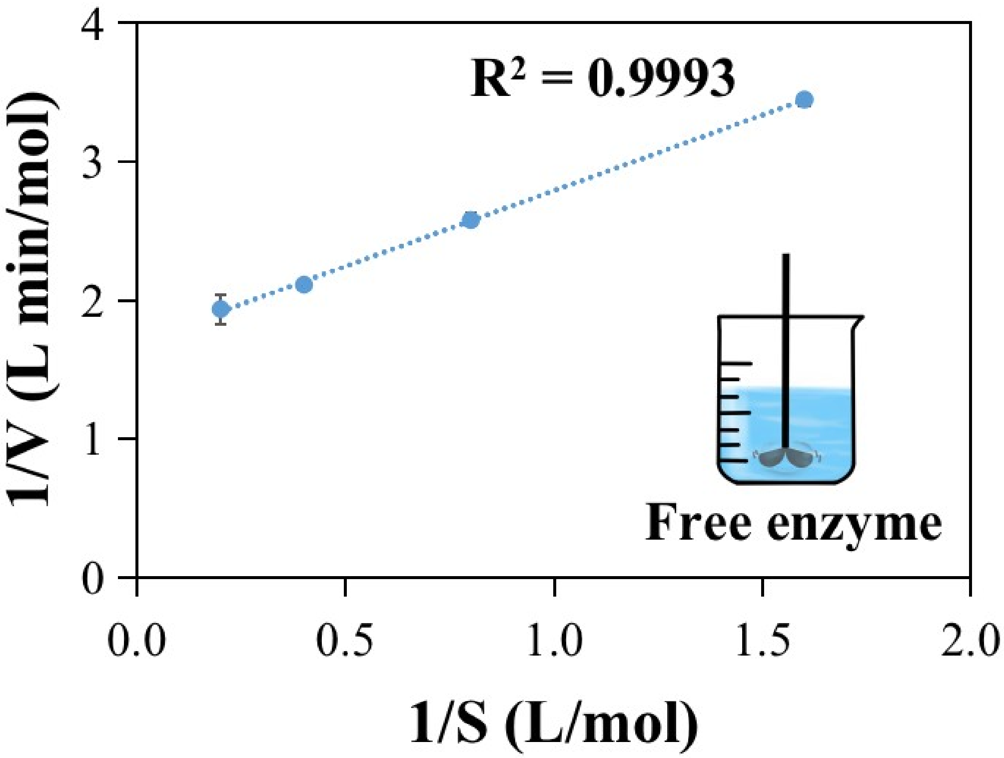

Fig. S9 Kinetic curves of free enzyme.

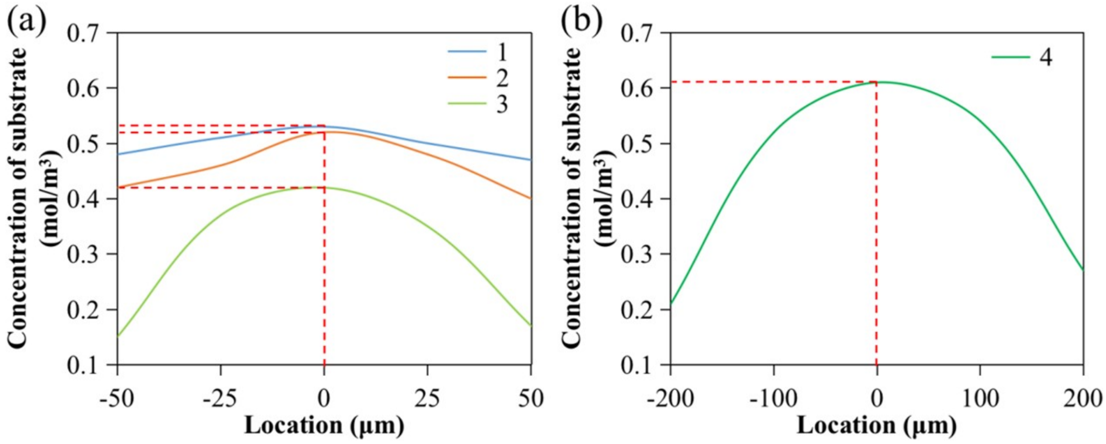

Fig. S10 Concentration variation curves of (a) Zone 1-3 and (b)Zone 4 within the channel.

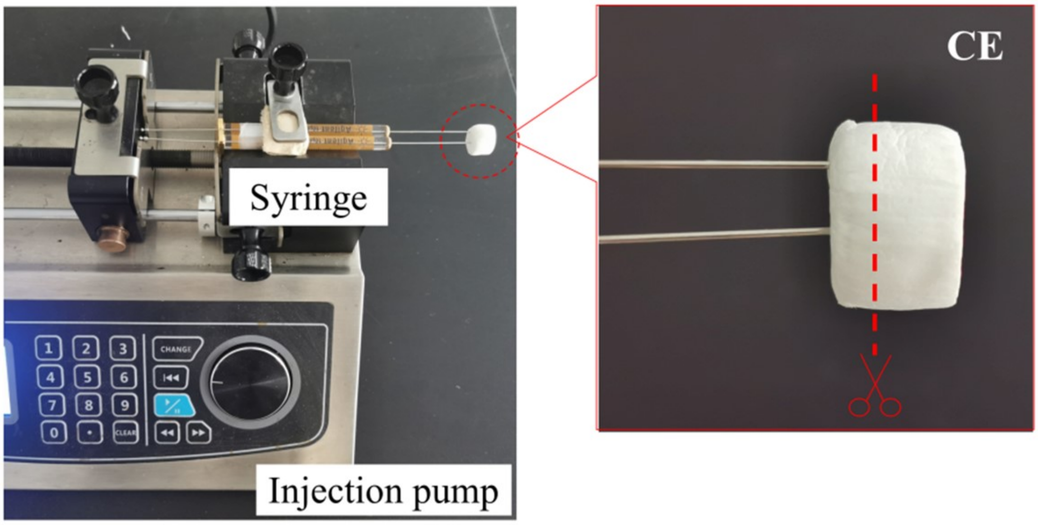

Fig. S11 Diagram of the diffusion experimental device.

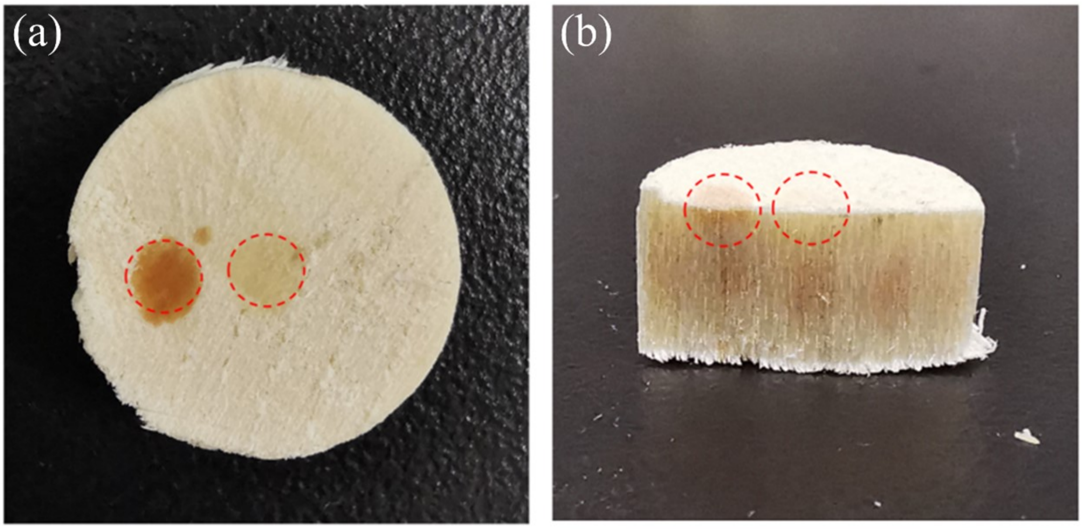

Fig. S12 The diffusion of the solution inside the wood: (a) top and (b) cross-sectional views.

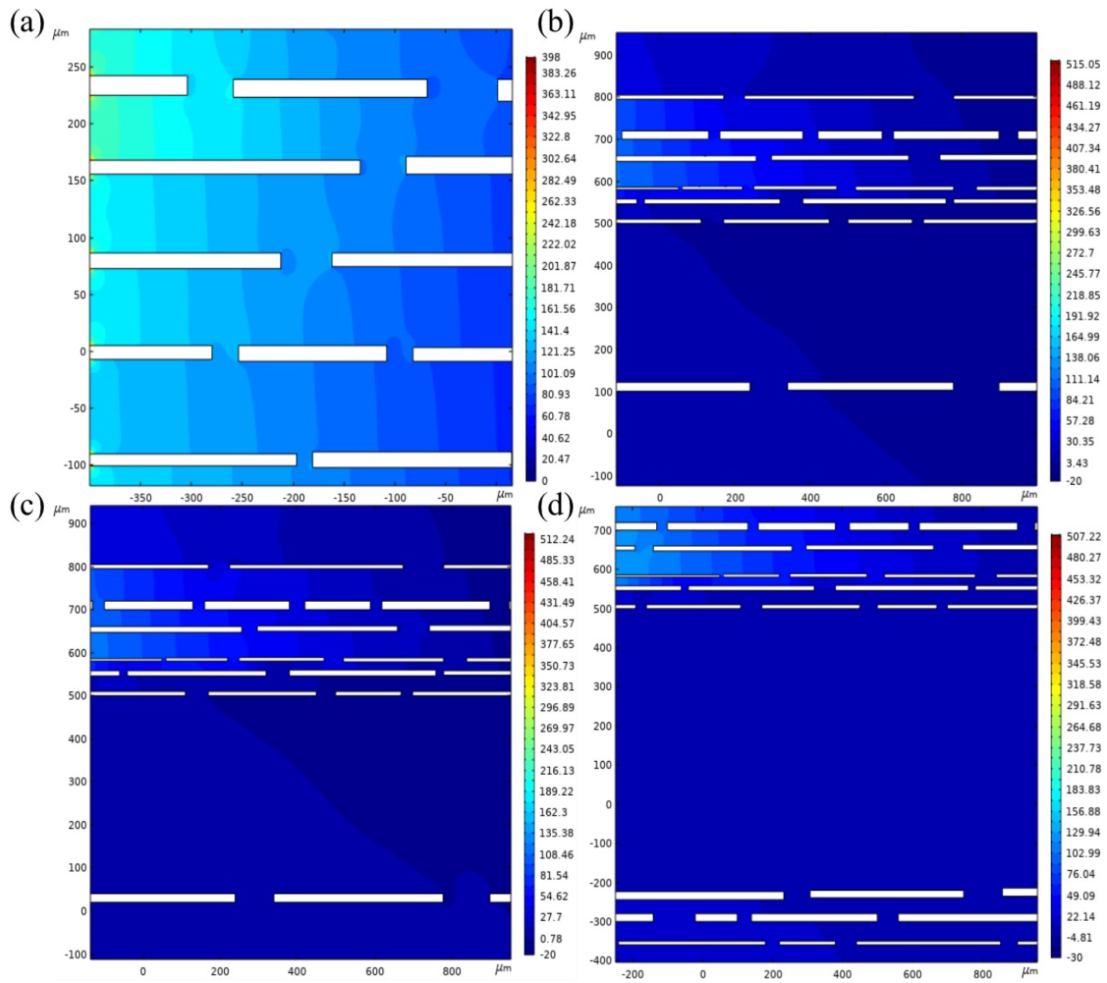

Fig. S13 Simulated cloud diagram of pressure inside the reactor with uniform channel and dual-scale channel: (a) CER-1/1; (b) CER-1/4; (c) CER-1/5; (d) CER-1/6.

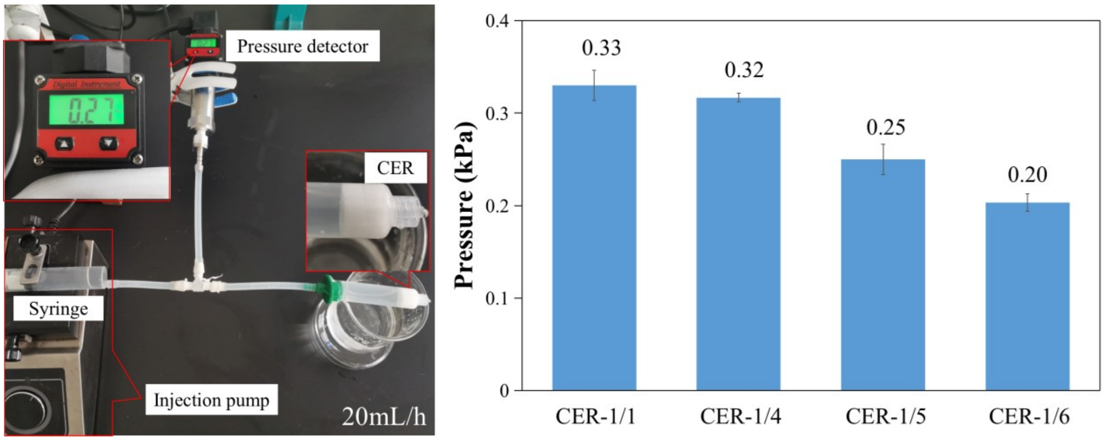

Fig. S14 Determination of flow pressure for CER-1/1, CER-1/4, CER-1/5 and CER-1/6.

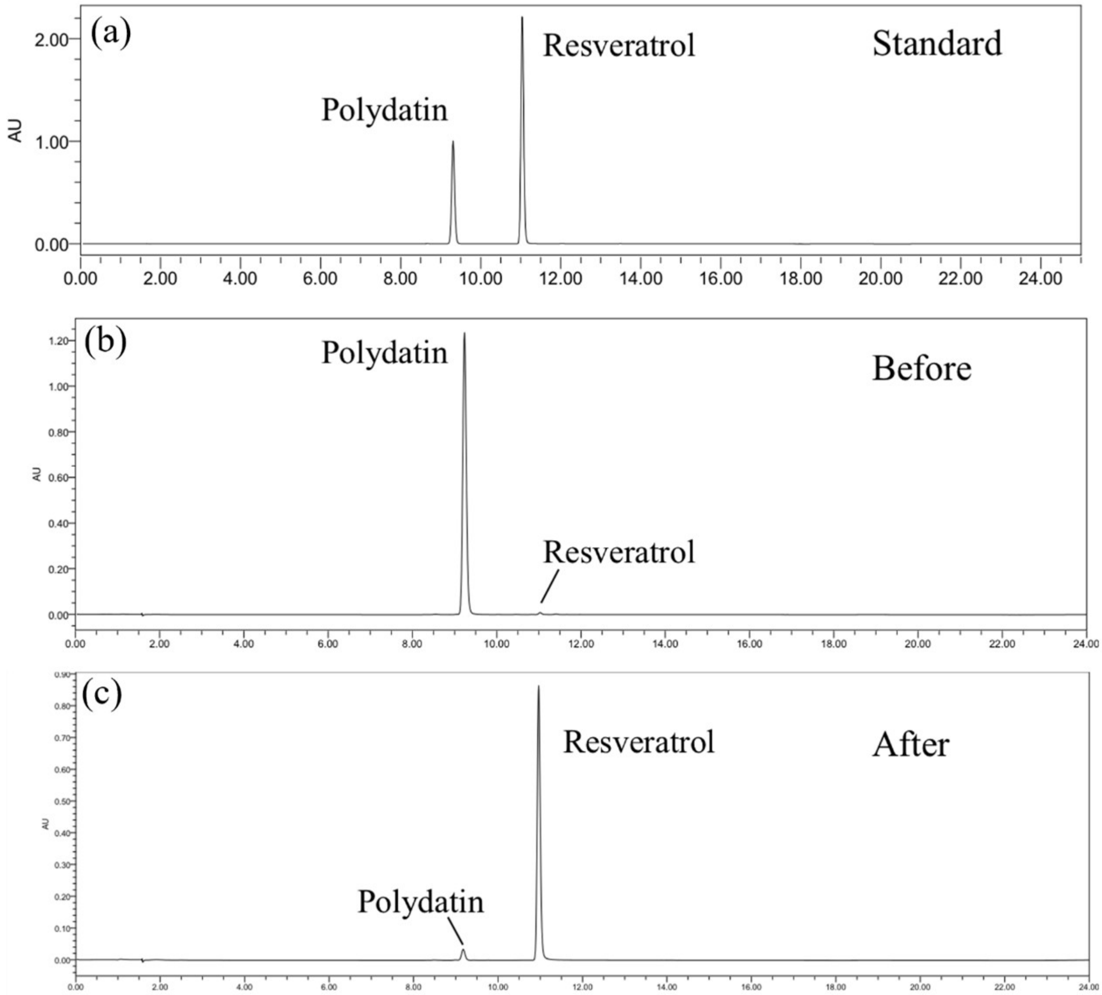

Fig. S15 HPLC chromatogram of (a) standard, (b) before and (c) after the catalytic reaction.

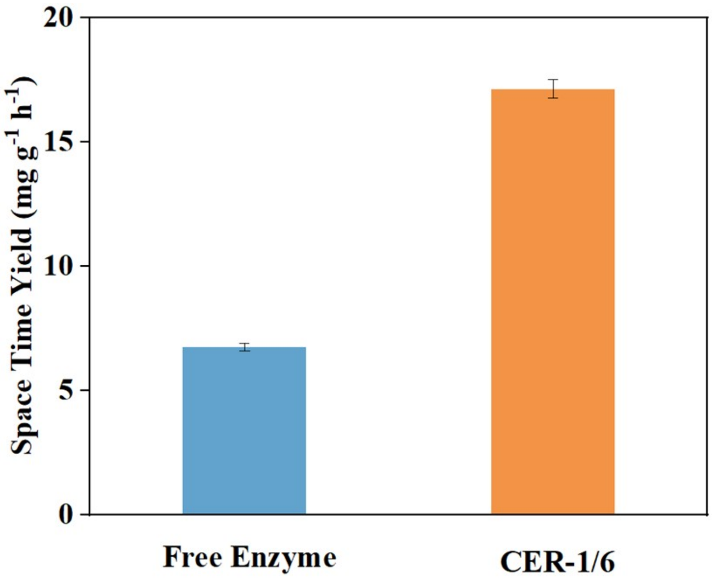

Fig. S16 Space-time-yield of free enzyme and CER-1/6.

Table S1 The thermal conductivity of different materials

	Thermal conductivity（W/mK）
Copper	401
Aluminum	237
Iron	80
304 Stainless Steel	34

Table S2 Physical parameters for different materials

	Crystallinity (%)
Linters	98.256
CE	58.462

Table S3 Analysis of protein secondary structure content

	Secondary structure contents (%)			
	α-helix	**β-sheet**	**β-turns**	**Random coil**
Free Enzyme	30.25	33.93	20.08	15.74
CER-1/6	20.55	24.47	35.20	19.78

Table S4 XPS data C 1s and O 1s

		CE-STs		CER-1/6	
		Binding energy (eV)	**Component content (%)**	**Binding energy (eV)**	**Component content (%)**
C1s	C-C	284.60	21.90	284.80	45.33
	C-O	286.49	59.63	286.36	41.38
	O-C-O/C=O	287.96	18.47	287.81	13.29
O1s	C-OH	532.15	33.05	532.20	82.24
	C-O-C	532.94	66.95	532.77	17.76

Table S5 Comparison of different directional channel reactor of conversion performance, from polydatin into resveratrol

Methods	K_m [mM]	V_{max} [mmol min^{-1}]	Conversion Times (h)	Conversion Rate (%)
A cellulose reactor with uniform directional channel [15]	3.5	1.4	3h	98.69
A porous directional channel xylem reactor [18]	5.0	0.8	4h	99.44
CER-1/6	1.8	1.1	2h	98.58