Supporting information

Electric field-assisted MnO_2 nanomaterials for rapid capture and in-situ delivery of circulating tumour cells

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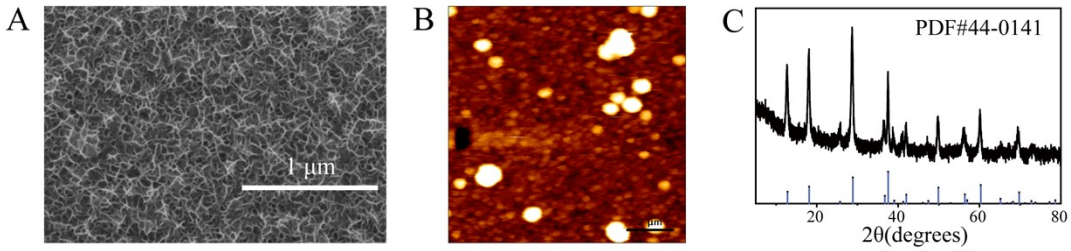

Figure S1. SEM image (A), AFM data (B), and XRD patterns (C) of the MnO_2 substrate.

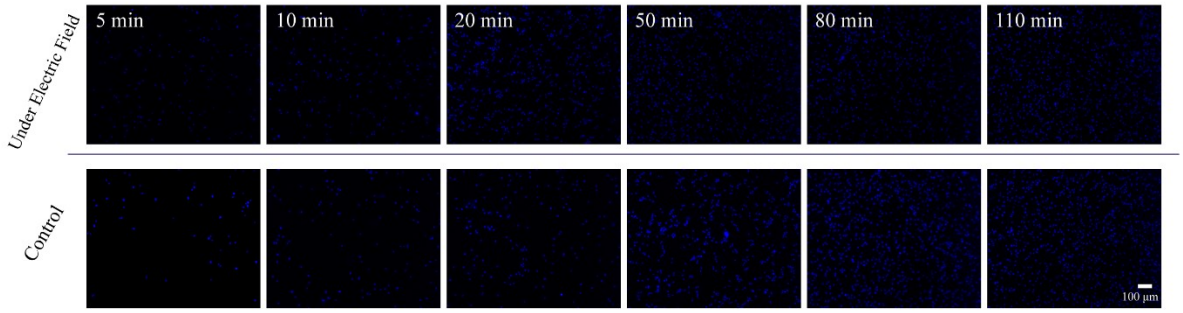

Figure S2. A representative group of sequential time snapshots (5, 10, 20, 50, 80, and 110 min) of fluorescence images when the MCF-7 cells were captured under two different conditions: apply accelerate electric field and only rely on gravity. Scale bar =100 μm.

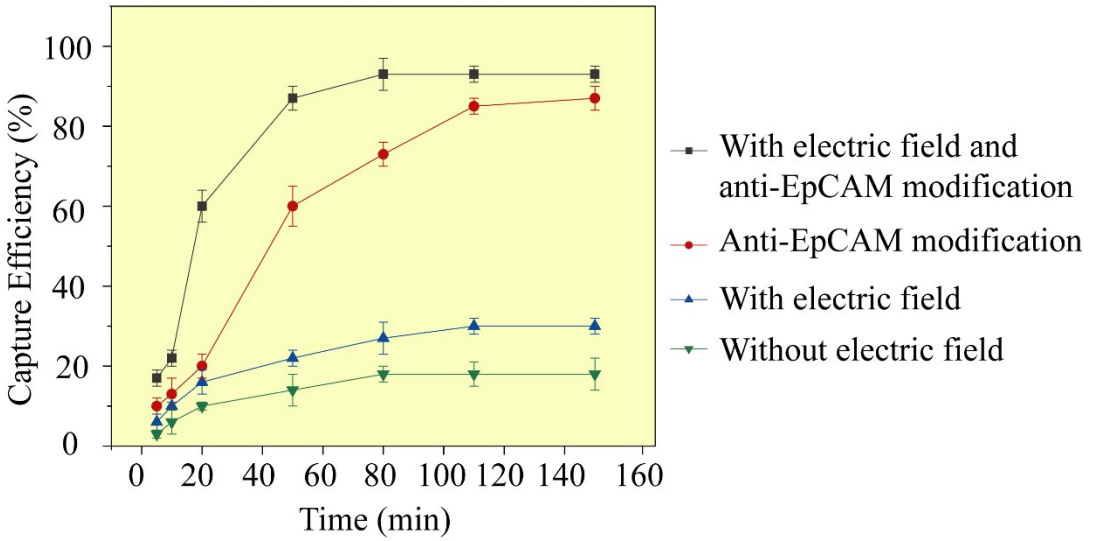

Figure S3. The cell-capture efficiencies of MCF-7 cells on the MnO_2 substrate under four different conditions: modified or not, apply accelerate electric field or not. Cell capture efficiency is defined as the ratio of attached cells to the number of total loaded cells.

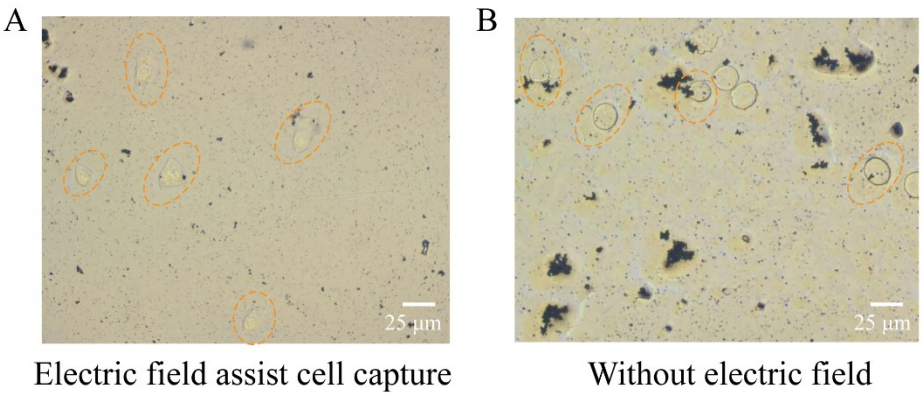

Figure S4. Bright field images of captured cells with and without electric field.

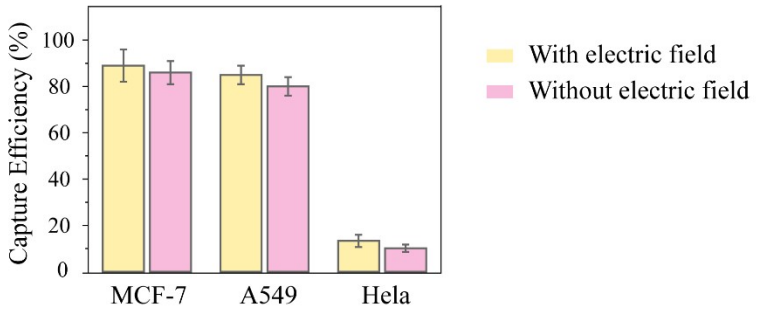

Figure S5. Quantitative capture efficiency of three different cancer cell (anti-EpCAM positive cells: MCF-7, A549; anti-EpCAM negative cells: Hela) under electric field or not.

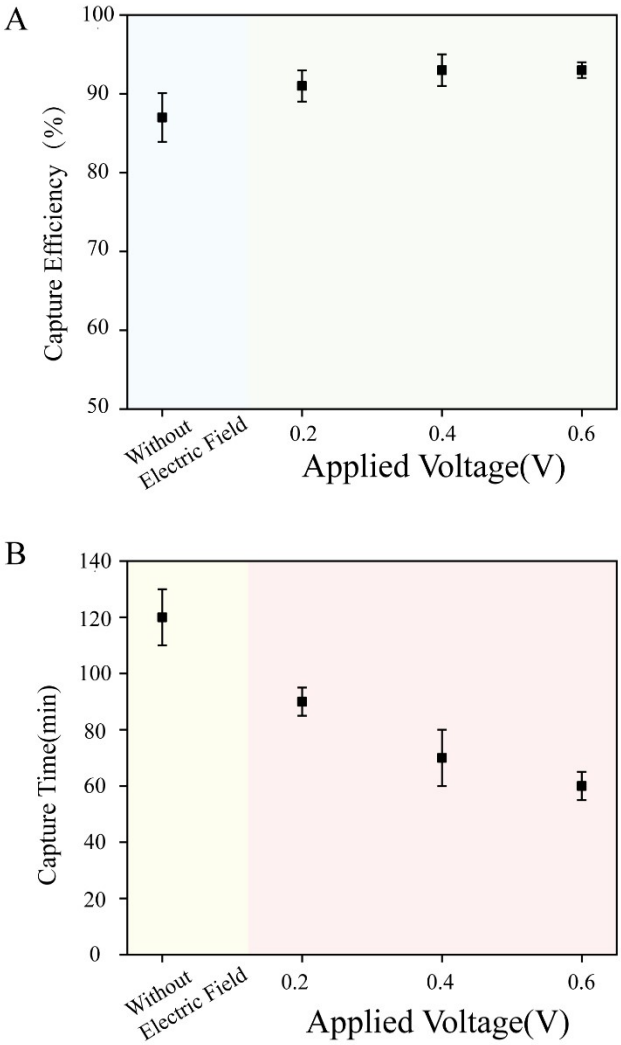

Figure S6. (A) Cell capture efficiency under different electric field. (B) Cell capture time under different electric field.

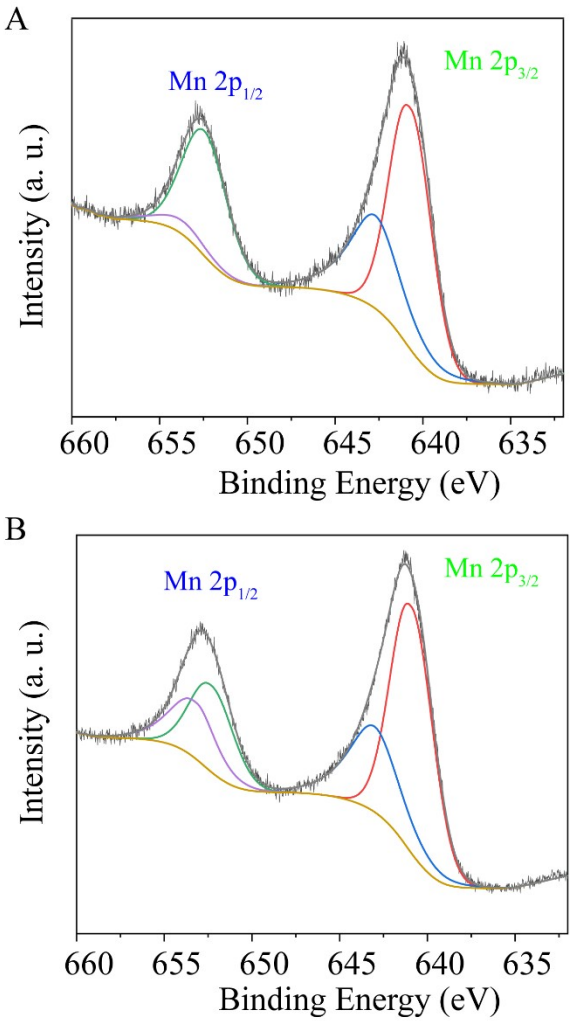

Figure S7. XPS spectrum of MnO_2 nanofilm before (A) and after (B) the surface dissolution reaction.

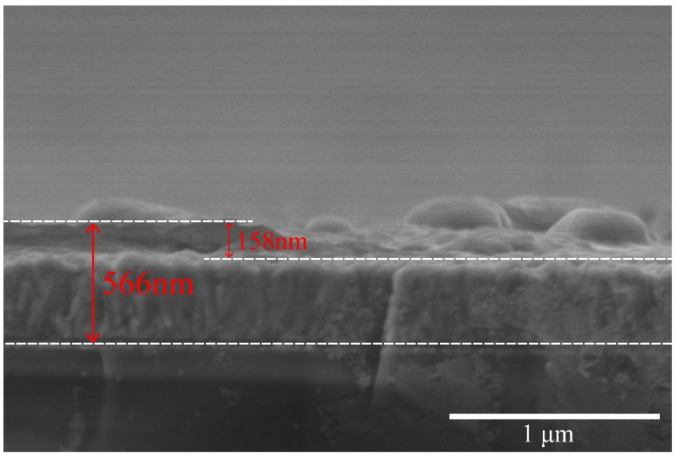

Figure S8. SEM image of the cross section. Before dissolution reaction (left), after the reaction (right). Scale bar =1 µm.

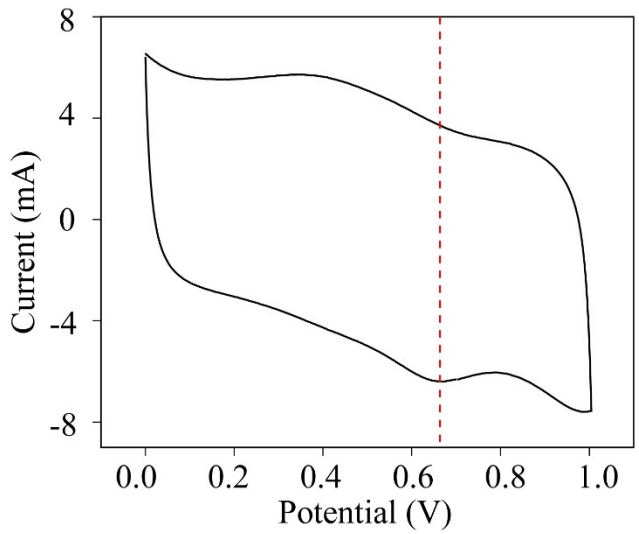

Figure S9. The CV curve at scan rate of 10 mV/s of MnO_2 substrate at a voltage window of 0.0-1.0 V in 1 × PBS solution. The working electrode is a MnO_2 substrate., the counter electrode is FTO, the reference electrode is a Hg electrode.

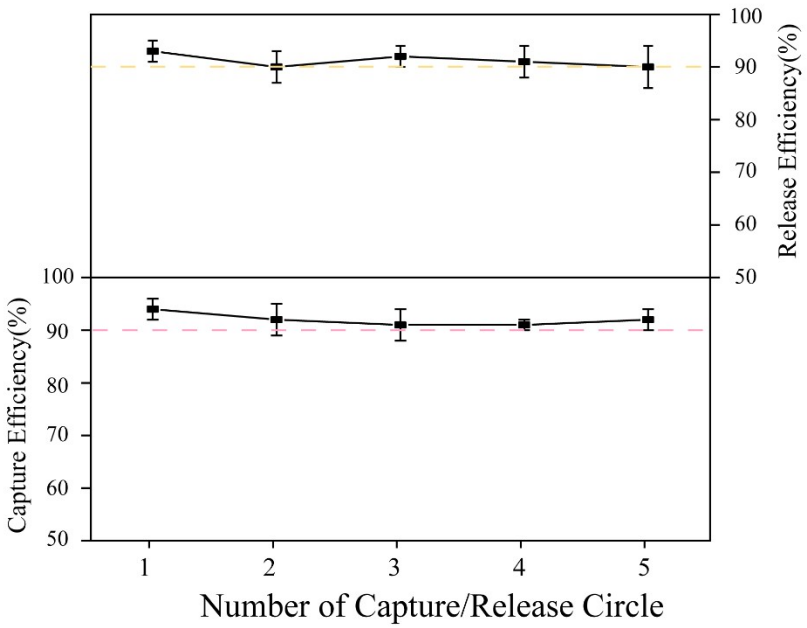

Figure S10. Variation in cell capture and release efficiencies after repeated antibody modifications using the same MnO_2 substrate.

Table S1. Comparison of the proposed cell release method with other methods.

Release Method	Release Time	Ref
Chemical treatment (acid）	More than 10 min	1-4
Chemical regent	About 20 min	5-8
Heat	About 10 min	9-10
Electrochemistry	30s-30 min	11-13
This method	8 s	

Table S2. Comparison of the proposed cell capture method with other methods.

Capture Method	Capture Time	Ref
Immunomagnetic beads	More than 80 min	14-16
Nanomaterials	More than 90 min	6-7, 10, 17
Microfluidic device	More than 120 min	18-21
Gradient centrifugation	About 120 min	22
method	About 70 min	

Table S3 Quantification of CTCs per mL of 20 patients and 6 healthy volunteers blood samples. (The cells purity was defined as the ratio of captured CTCs against the total captured cells.)

Blood Species	Sample No.	Gender(F/M)	Age	CTC count(1 mL whole blood)	Purity（%）
Lung cancer patients	1	F	65	4	50
	2	M	59	2	14.3
	3	M	69	11	55
	4	M	55	3	20
	5	F	58	8	53.3
	6	F	61	5	62.5
	7	F	60	11	64.7
	8	M	52	13	72.2
	9	M	56	2	66.7
	10	F	49	10	55.5
Breast cancer patients	11	F	45	8	47
	12	F	49	2	50
	13	F	56	12	42.9
	14	F	51	11	55
	15	F	64	15	78.9
	16	F	39	5	25
	17	F	48	12	50
	18	F	41	2	66.7
	19	F	52	7	35
	20	F	43	10	62.5
Healthy volunteers	1	M	27	0	0
	2	F	29	0	0
	3	F	45	0	0
	4	M	38	0	0
	5	F	63	0	0
	6	M	58	0	0

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