

Supporting Information

Electrical and Thermal Stimulus-responsive Nanocarbon-based 3D Hydrogel Sponge for Switchable Drug Delivery

Sang-Yu Park^a, Ji-Hye Kang^{b,c}, Han-Sem Kim^c, Ji-Young Hwang^{a}, and Ueon Sang Shin^{b,c*}*

^a Innovative Carbon-Bio-Convergence Lab., Korea Carbon Industry Promotion Agency (kcarbon), 110-11 Ballyong-ro, Deokjin-gu, Jeonju 54853, Republic of Korea

^b Department of Nanobiomedical Science, BK21 FOUR NBM Global Research Center for Regenerative Medicine, Dankook University, Cheonan 31116, Republic of Korea

^c Institute of Tissue Regeneration Engineering (ITREN), Dankook University, 119 Dandae-ro, Dongnam-gu, Cheonan 31116, Republic of Korea

* Correspondence addresses to jyhwang@kcarbon.or.kr and usshin12@dankook.ac.kr

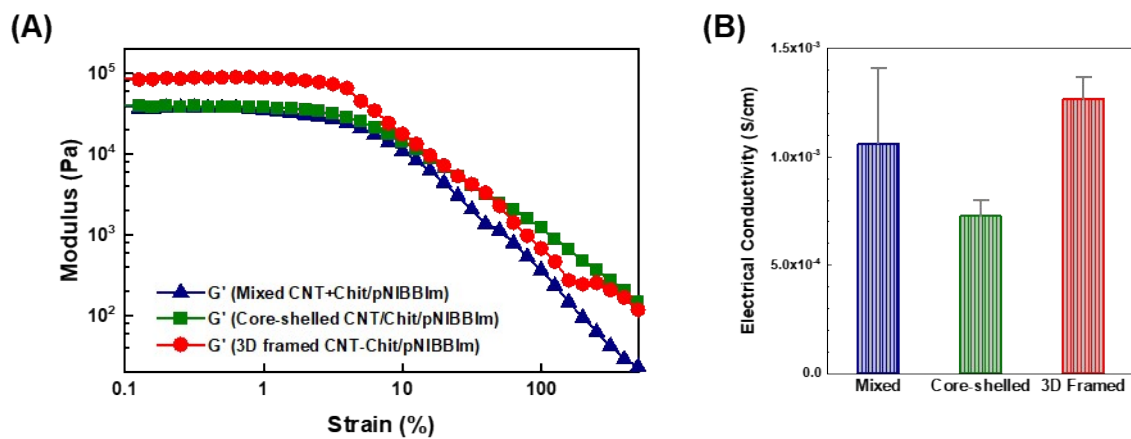


Fig. S1. Mechanical and electrical properties of each hydrogel. (A) Comparative plot of the G' values and (B) the electrical conductivity of the three hydrogels.

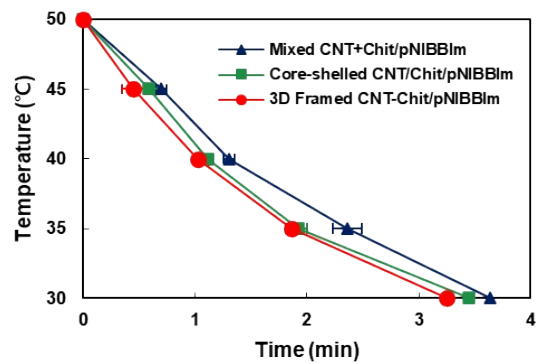


Fig. S2. Cooling experiments of each hydrogel. Temperature ($^{\circ}\text{C}$) decreasing of the three hydrogels according with time.

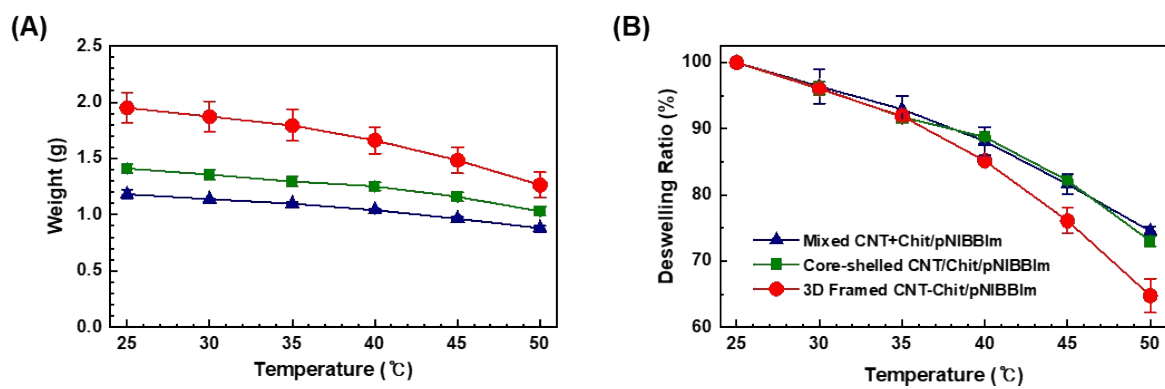


Fig. S3. Analysis of swelling and deswelling properties. (A) Weight changes from 50 to 25 °C of the three hydrogels and (B) relative deswelling ratio of the gel types of each hydrogel.

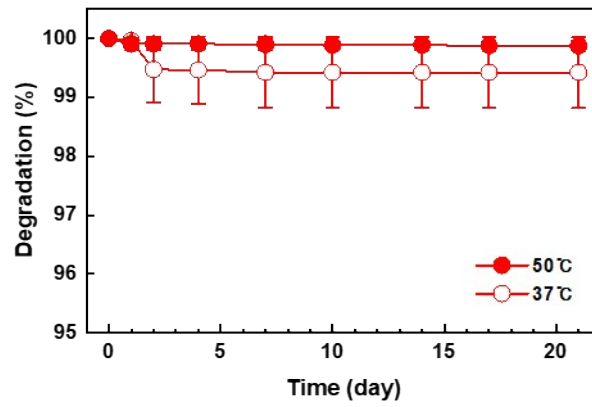


Fig. S4. Degradation of the 3D framed CNT-Chit/pNIBBIIm hydrogel at 37 °C and 50 °C for 21 days (n=3).

Table S1. Summary of characteristics of each hydrogel.

Sample Name	Storage modulus (kPa)*	Critical strain (%)	Surface resistivity (Ω/sq)	Volume resistivity ($\Omega\cdot\text{cm}$)	Electrical conductivity (S/cm)	ΔT_{pt} ($^{\circ}\text{C}$)	T_{pt} ($^{\circ}\text{C}$)	R_{hsw} (%)**	KTP loading (mg/mg)
Mixed CNT+Chit/pNIBBIm	35	9.96	1279.8 ± 475.6	1022.3 ± 380.9	$1.06 \times 10^{-3} \pm 0.35 \times 10^{-3}$	36-44	39	25.4	3.17 ± 0.17
Core-shelled CNT/Chit/pNIBBIm	38	9.96	1731.3 ± 161.2	1385.3 ± 128.9	$0.73 \times 10^{-3} \pm 0.07 \times 10^{-3}$	36-42	40	27.0	3.14 ± 0.23
3D framed CNT-Chit/pNIBBIm	89	6.28	701.5 ± 23.4	793.3 ± 61.2	$1.27 \times 10^{-3} \pm 1.01 \times 10^{-3}$	36-42	39	35.2	3.86 ± 0.05

* Modulus indicates the maximum elastic response of three types of hydrogels.

** Swelling ratio (R_{hsw}) within phase transition temperature range (ΔT_{pt}) and average phase transition temperature (T_{pt}) for three types of hydrogels within the temperature range from 50 $^{\circ}\text{C}$ to 25 $^{\circ}\text{C}$.