Supporting Information

Dual Suppression Effect of Magnetic Induction Heating and Microencapsulation on Ice Crystallization Enables Low-Cryoprotectant Vitrification of Stem Cell-Alginate Hydrogel Constructs

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Movie Captions

Movie S1. Cell encapsulation using a tube-in-tube capillary microfluidic device.

Movie S2. Collection of the cell-laden microcapsules.

Movie S3. Nano-warming of vitrification solution by MIH of Fe_3O_4 NPs.

Movie S4. Rapid cooling and conventional warming of vitrification solution in plastic straw.

Movie S5. Conventional warming of vitrification solution with Fe_3O_4 NPs in plastic straw.

Movie S6. Cryomicrocopic study of CPA (including 1M DMSO, 1MEG and 1.3 M trehalose) solution.

Movie S7. Cryomicrocopic study of CPA solution with Fe_3O_4 NPs.

Movie S8. Cryomicrocopic study of alginate hydrogel containing CPA solution.

Supplementary Tables

Table S1 The viability (%) of non-microencapsulated pADSCs under different conditions. (Mean ± SD, n=4)

Groups	0 A	5 A	15 A	25 A
0.1% NPs		20.3 ± 4.3	19.3 ± 7.5	24.6 ± 4.1
0.5%NPs		28.4 ±5.8	26.8 ± 4.3	16.3 ± 6.2
1%NPs		15.1 ± 3.1	13.6 ± 3.7	9.91 ± 1.4
Fresh	95.1 ± 1.5			
No NPs	11.5 ± 2.1			

Table S2 The viability (%) of microencapsulated pADSCs under different conditions. (mean ± SD, n=4)

Groups	0A	5 A	15 A	25 A
0.1% NPs		62.2 ± 1.5	65 ± 5.2	63.1 ± 1.5
0.5%NPs		79.2 ± 1.7	82.3 ± 3.6	76.2 ± 6.3
1%NPs		76.6 ± 2.7	78.2 ± 4.3	72.4 ± 1.5
Fresh	95.3 ± 2.1			
No NPs	63.5 ± 6.4			
CPA treatment	91.7 ± 3.7			

Supplementary Figures

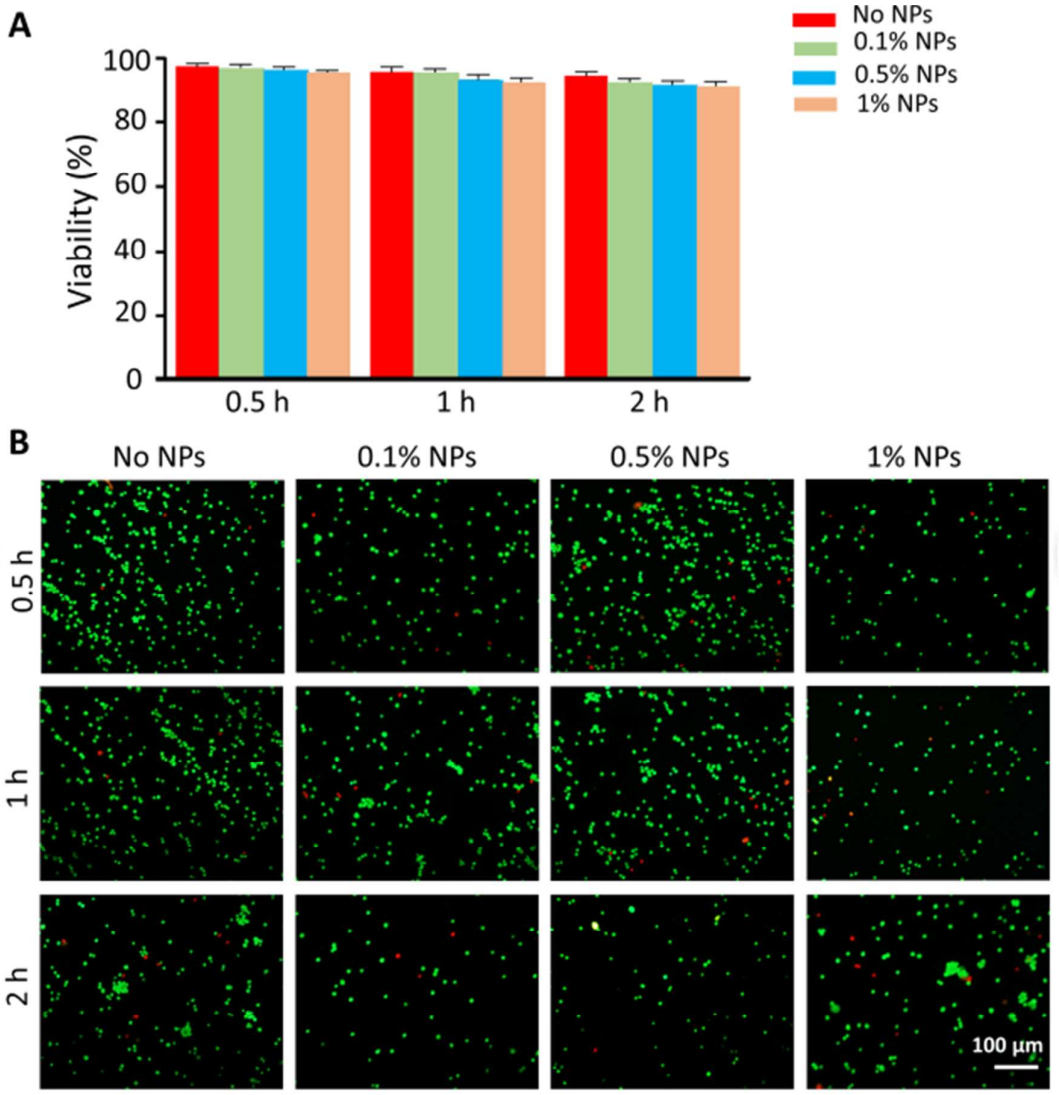

Figure S1. Cytotoxicity of Fe_3O_4 NPs at 4 °C. A) Viability of pADSCs under various conditions quantified by live/dead (green/red) double staining. B) Typical fluorescence images of pADSCs under the various conditions. Live cells were stained green and dead cells were stained red with acridine orange (AO) and ethidium bromide (EB), respectively. The cells were treated with different concentrations (0.1, 0.5, and 1% (w/v)) of NPs for 0.5, 1, and 2 h. Cytotoxicity is minimal under all the conditions.

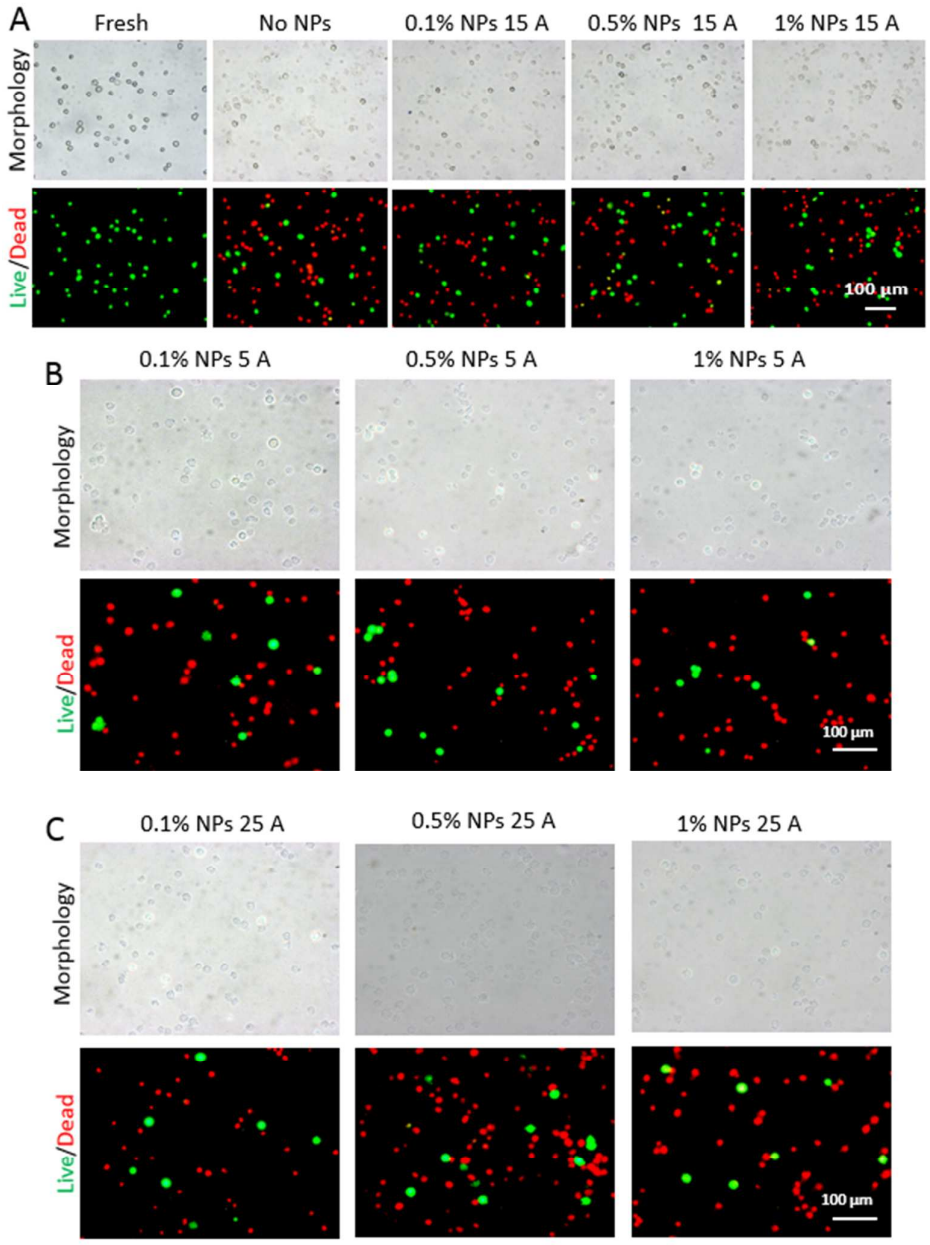

Figure S2. Effect of nano-warming on non-encapsulated pADSCs after cryopreservation by low-CPA vitrification. Representative DIC images and fluorescence micrographs of the morphology and viability of pADSCs are shown for different conditions: *i.e.*, fresh, and post-vitrification with no NPs or with three different concentrations of NPs with nano-warming by MIH under an AC magnetic field (5, 15 and 25 A).

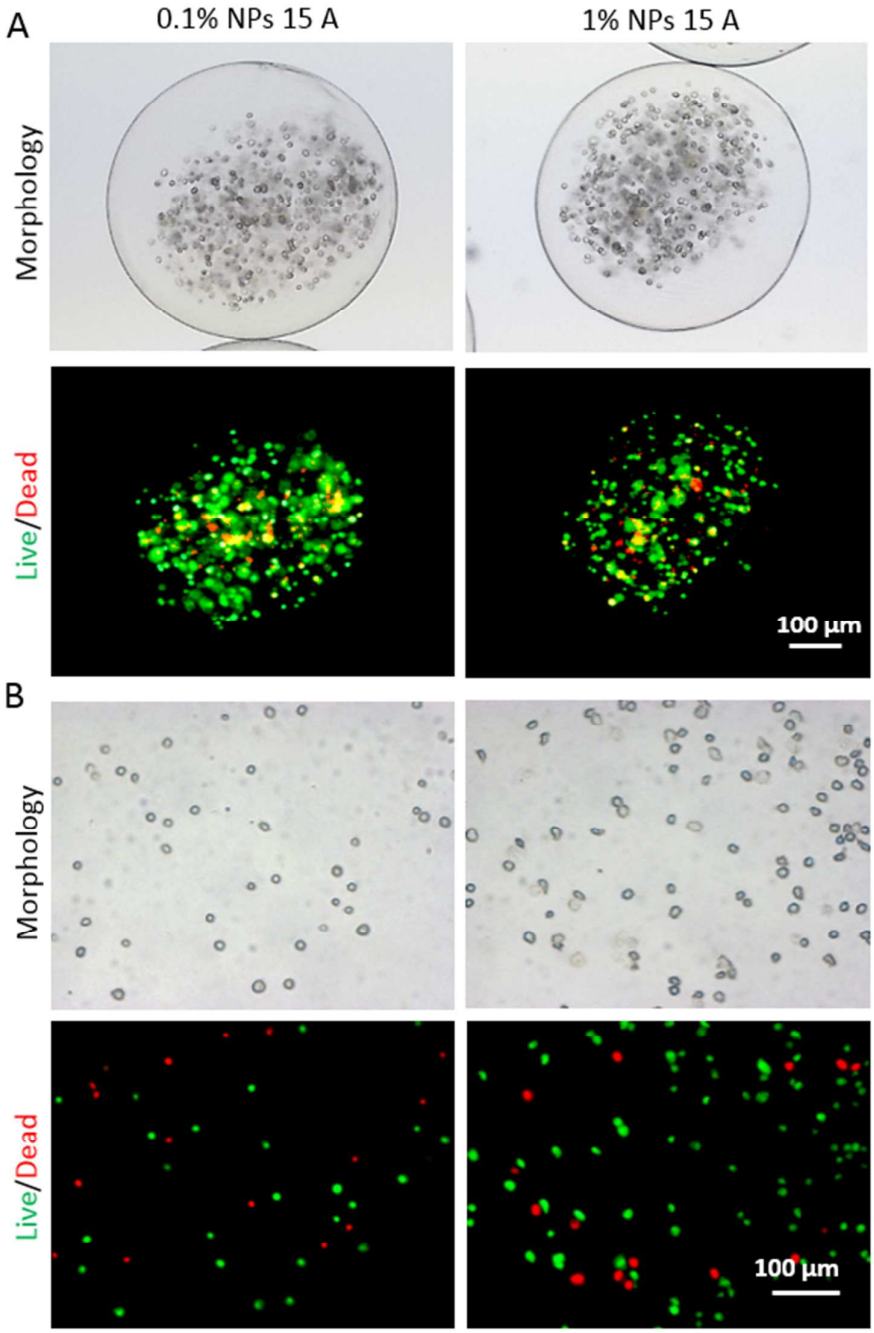

Figure S3. Morphology and viability of microencapsulated pADSCs post-vitrification with nano-warming with 0.1 and 1% (w/v) NPs under an alternating magnetic field (15 A). A) Typical DIC and fluorescence images showing the morphology and viability of pADSCs in microcapsules. B) The morphology and viability of pADSCs released out of microcapsules.

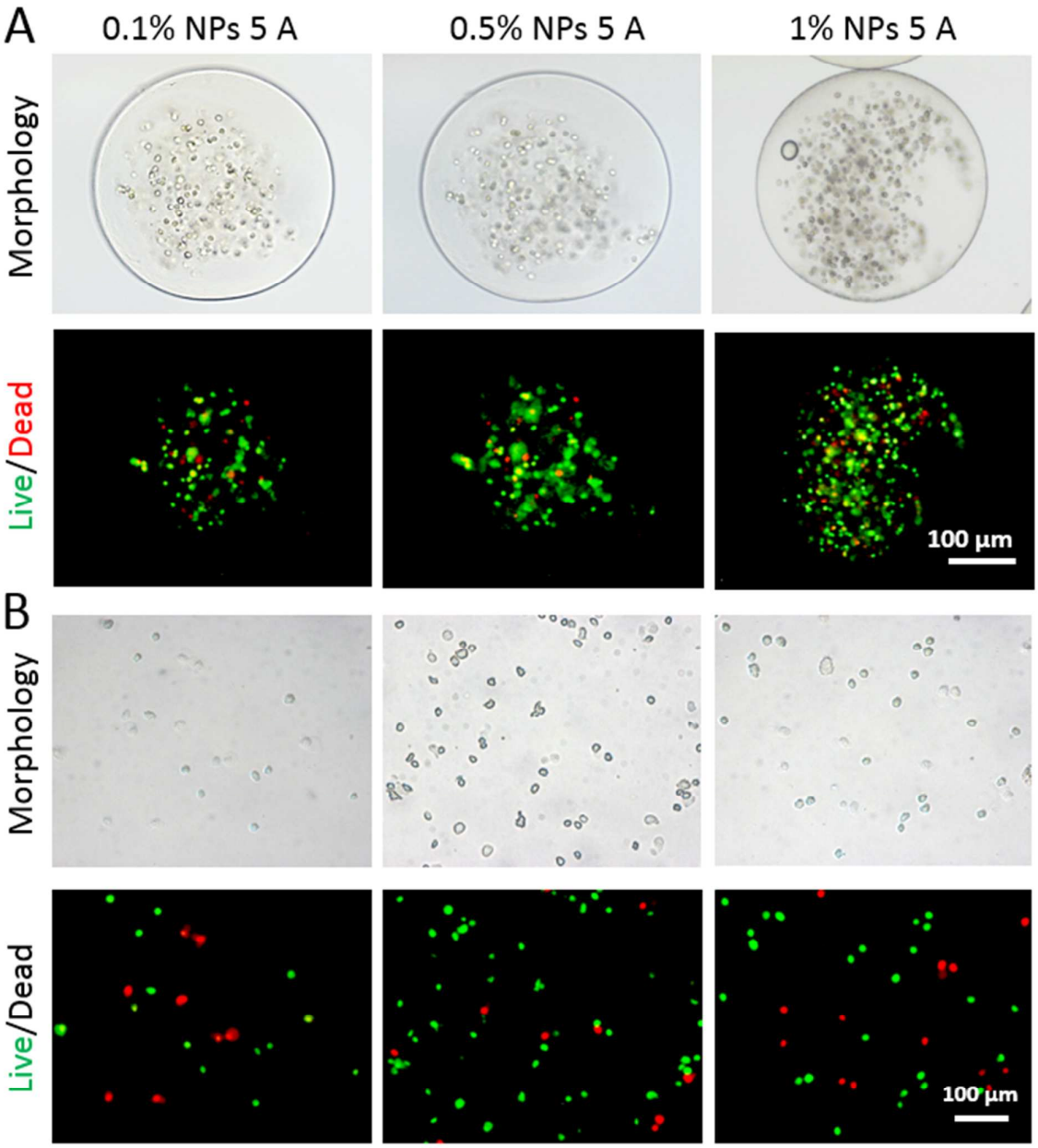

Figure S4. Morphology and viability of microencapsulated pADSCs after vitrification with 0.1, 0.5, and 1% (w/v) NPs for nano-warming under an alternating magnetic field (5 A). A) Typical DIC and fluorescence images showing the morphology and viability of pADSCs in microcapsules. B) The morphology and viability of pADSCs released out of microcapsules.

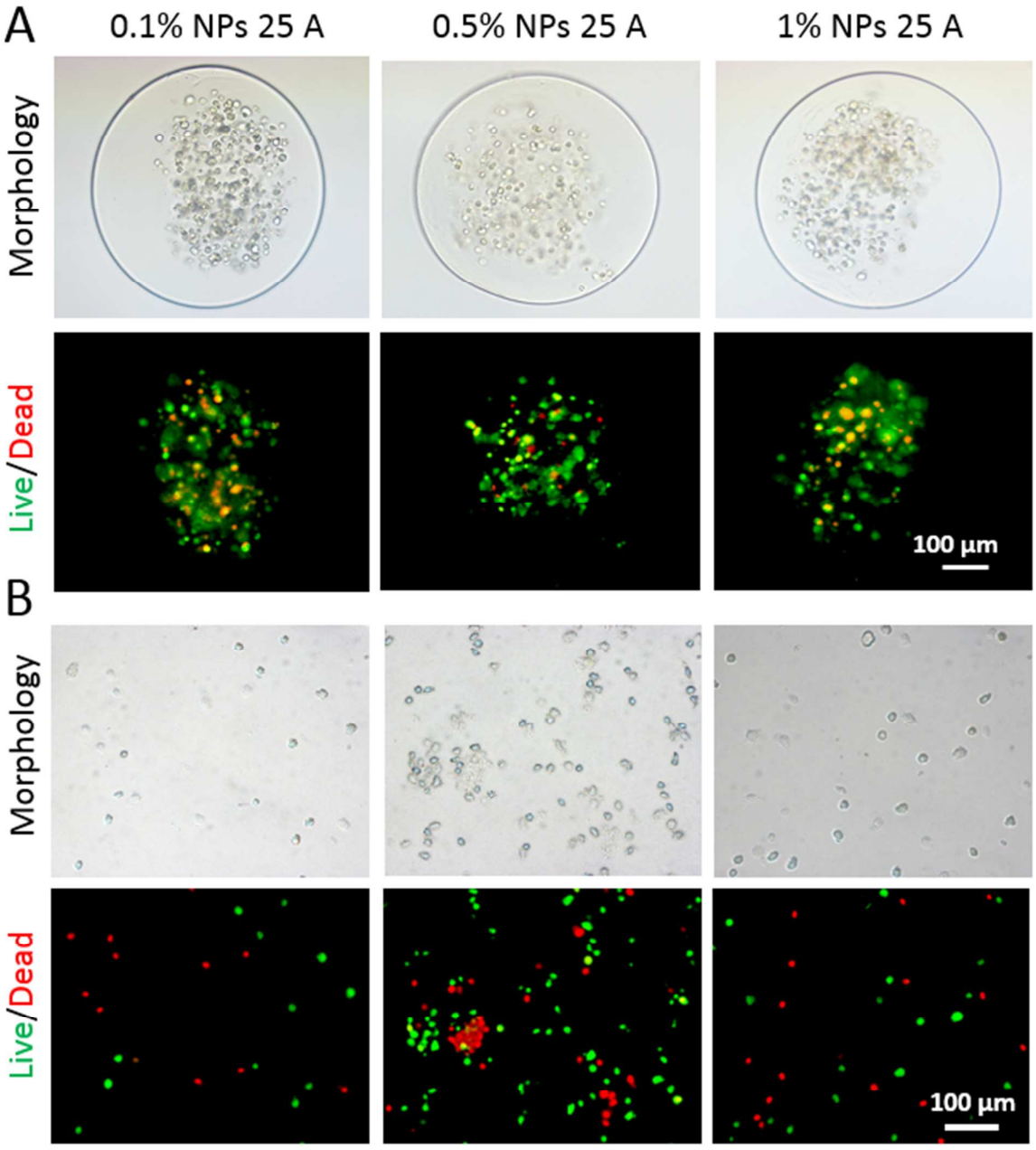

Figure S5. Morphology and viability of microencapsulated pADSCs after vitrification with nano-warming with 0.1, 0.5, and 1% (w/v) NPs for nano-warming under an alternating magnetic field (25 A). A) Typical DIC and fluorescence images showing the morphology and viability of pADSCs in microcapsule. B) The morphology and viability of pADSCs released out of microcapsules.

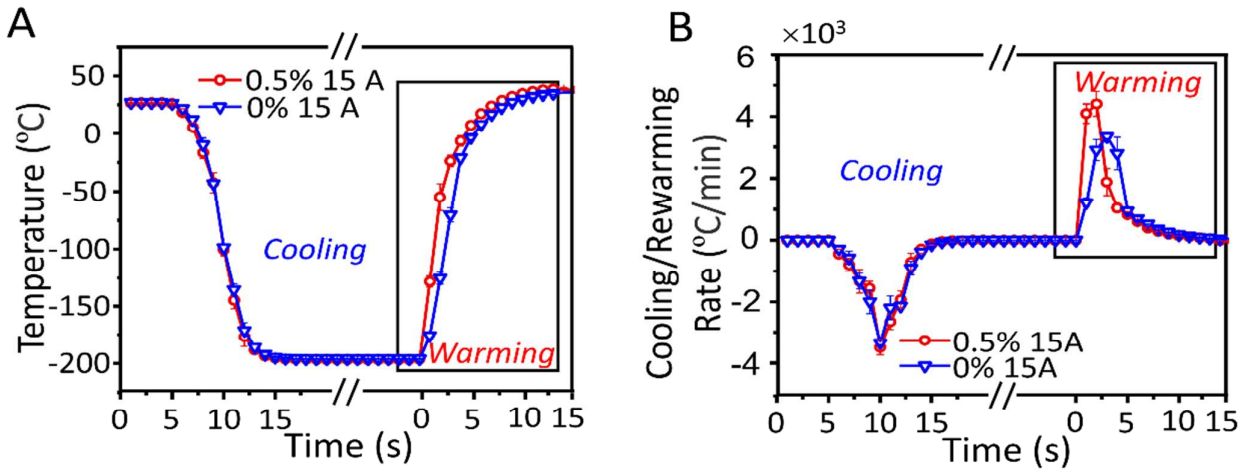

Figure S6. Effect of nano-warming on the thermal profiles and cooling/warming rates during low-CPA vitrification. A) Thermal profiles during cooling and warming. B) Cooling and warming rates calculated from the thermal profiles. Vitrification solution: 1 M EG, 1 M DMSO, and 1.3 M trehalose in medium. NP concentration (w/v): 0.0 and 0.5%; and current: 15A.