
Supporting Information

Comprehensive evaluation of surface potential characteristics on mesenchymal stem cells' osteogenic differentiation

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Table S1. The positive and negative potential surfaces of the materials promoted the osteogenic differentiation of the cells (positive potential surface (P), negative potential surface (N))

Material	Potential properties	Potential strength / charge density	Cell types	Best effect	Reference
HA	P / N	5.2 $\mu\text{C}/\text{cm}$	mMSC	P > N	<i>Key Engineering Materials</i> 2012 ,529-530, 357-360
HA	P / N	0.05 $\mu\text{C}/\text{cm}^2$.	Wistar rats	N > P	<i>Journal of Biomedical Materials Research Part A</i> 2010 ,79A (3), 627-634
BiFeO ₃	P / N	75 mV (KFM)	MSCs	P > N	<i>Advanced Functional Materials</i> 2017 , 27 (47)
LiNbO ₃	P / N	78 $\mu\text{C}/\text{cm}^2$	MSCs	P > N	<i>Advanced Healthcare Materials</i> 2015 ,4 (7), 998-1003
PVDF	P / N	d33=32 pc/N	hMSCs	N > P	<i>Journal of Biomedical Materials Research Part A</i> 2015 ,103 (3), 919-928

From these results, it could be seen that the relative strength of positive potential and negative potential promoting osteoblastic differentiation of cells is controversial.

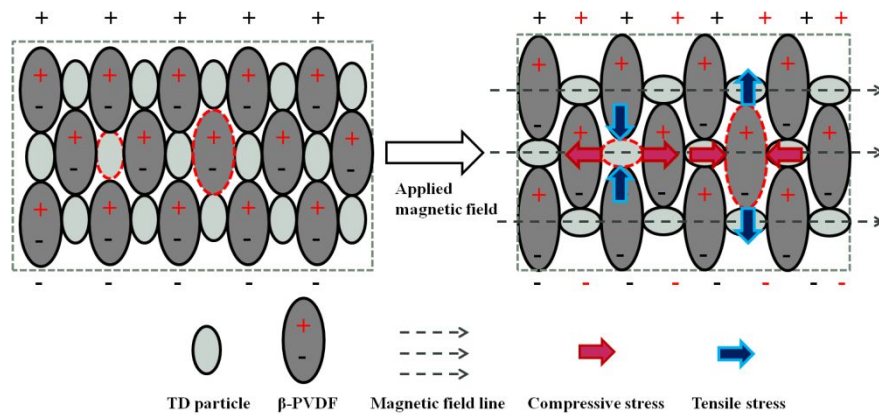


Figure S1. The schematic diagram of magneto-electric coupling of TD/P (VDF-TrFE) magneto-electric film. Under the magnetic field drive, the TD particles undergo magnetostriction, squeeze the piezoelectric phase PVDF matrix, and generate magneto-electric coupling to change the surface potential of the films.

Table S2 Piezoelectric coefficient of 13 % TD/P (VDF-TrFE) magneto-electric film under different electric field strength. The films could be stable poled under the electric field strength of 52 V/ μm , but when the electric field improved to 60 V/ μm , the films were at risk of breakdown.

Electric field strength (V/μm)	0	45	52	60
Positive potential film d_{33} (pc/N)	0	+10	+12	+14
Negative potential film d_{33} (pc/N)	0	- 10	- 12	- 14

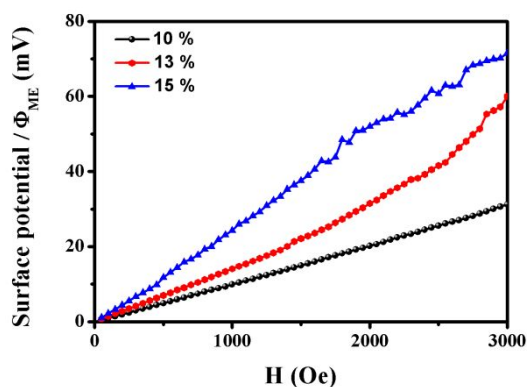


Figure S2. The magnetoelectric properties of poled TD/P (VDF-TrFE) magnetoelectric film with different TD weight percentage content. The $|\phi_{ME}|$ of 13% and 15% film were similar, but the 15 % film was difficult to be polarized, so the 13 % film was the best in magnetoelectric properties in a film that can be stably polarized.

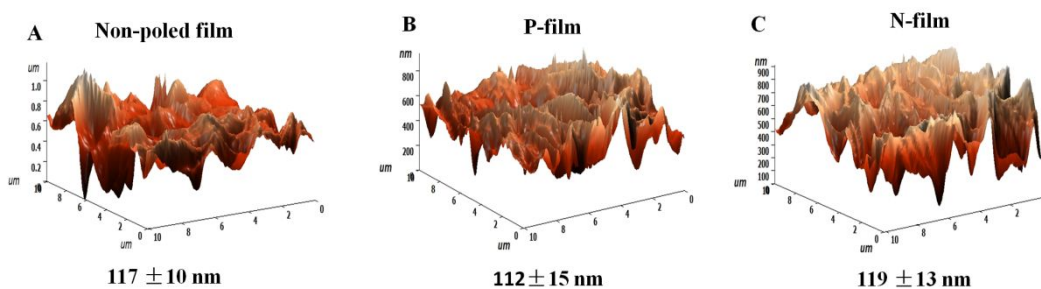


Figure S3. The surface average roughness (Ra) of non-poled film (A), positive potential film (P-film) and negative potential film (N-film) (B, C) were determined to 117 ± 10 nm 112 ± 15 nm and 119 ± 13 nm, respectively.

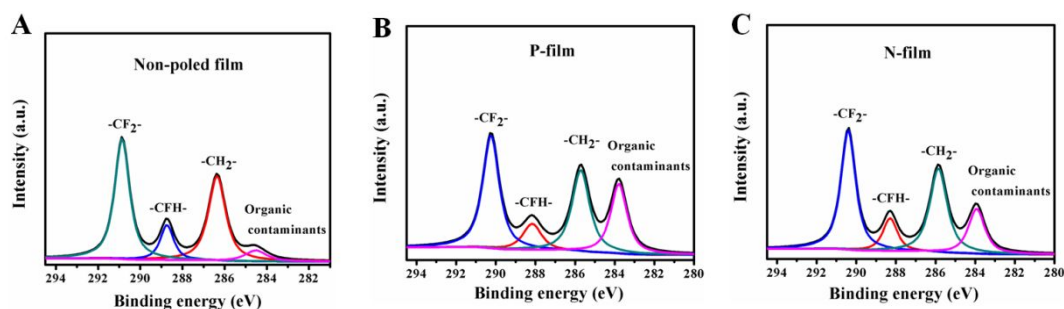


Figure S4. C 1s XPS spectra of non-poled film (A), P-film and N-film (B, C), respectively

Table S3. Summary of C 1s XPS spectra of 13 % TD/P (VDF-TrFE) magnetoelectric film.

Sample	Bind energy(eV)				Ratio
	-CF ₂ -	-CFH-	-CH ₂ -	Organic contaminant	-CH ₂ -/-CH ₂ -
Non-poled film	290.86	288.73	286.36	284.52	0.81
Positive potential film	290.40	288.29	285.85	283.93	0.83
Negative potential film	290.24	288.12	285.71	283.79	0.78

Table S4. The correlation of thickness of NdFeB magnet with magnetic field intensity generated in PMMA support

Thickness of the magnet (mm)	Approximate magnetic field intensity (Oe)
0	0
10	1400
14	2100
20	2800
25	3200

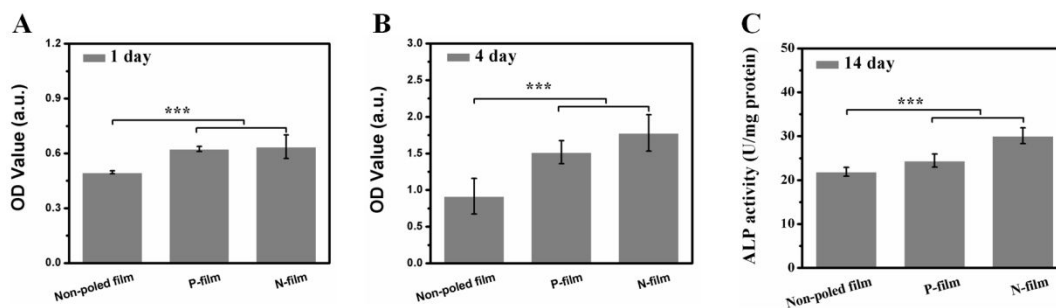


Figure S5. The adhesion (A), proliferation (B) and ALP activity (C) of MSCs cultured on non-poled film, P-film and N-film.

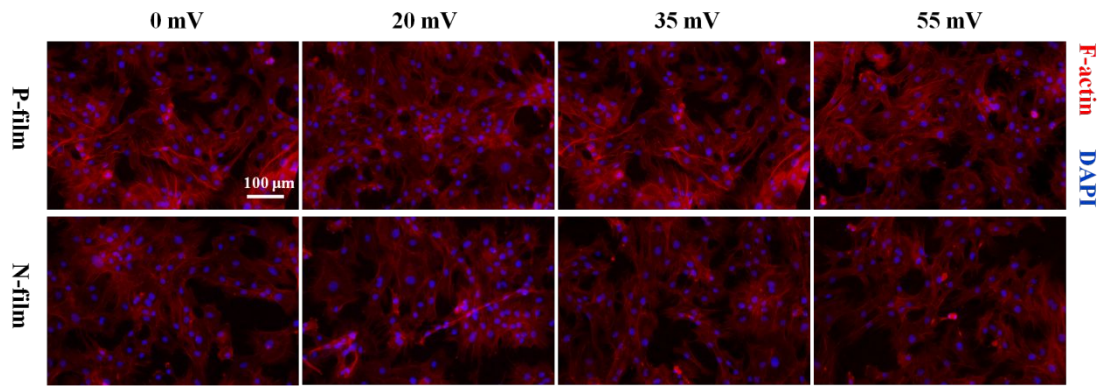


Figure S6. Cellular morphology of MSCs on P-film and N-film. The CLSM images of MSCs culture for 7 day

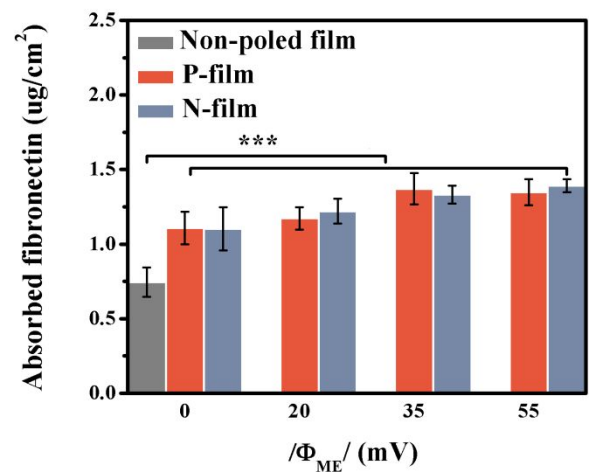


Figure S7. Adsorption density of FN protein on non-poled film, P-film and N-film.

Table S5. Primers Used for RT-PCR.

Gene	forward primer sequence (5'-3')	reverse primer sequence (5'-3')
$\alpha 5$	AGACATCCACTCCCTCTACAA	AGTAGGTCATCTAGCCCATCTC
$\beta 1$	ATCCAATTGTAGCAGGCGTGGTT	GACCACAGTTGTCACGGCACTC
Runx-2	CCTGAACTCTGCACCAAGTCCT	TCATCTGGCTCAGATAGGAGGG
OCN	GCAATAAGGTAGTGAACAGACTCC	CCATAGATGCGTTTGTAGGCGG
β -actin	AATGTGGCTGAGGACTTTG	GGGACTTCCTGTAACCACTTATT



Figure S8. High-voltage polarization device.

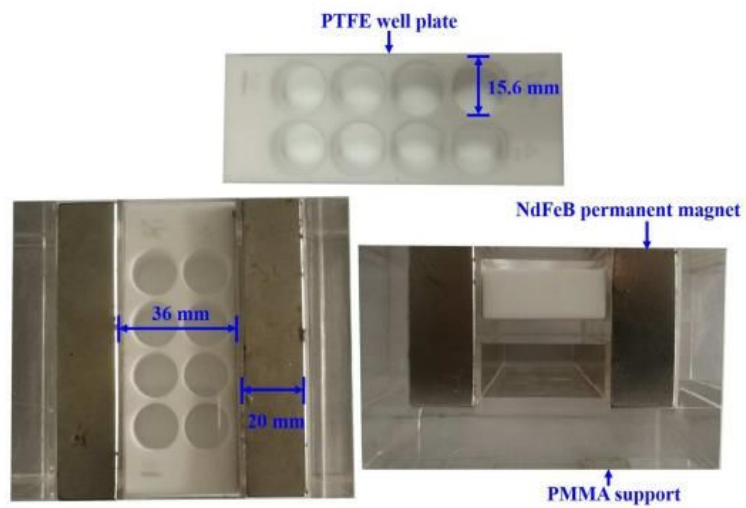


Figure S9. Home-mode equipments for cell culture under magnetic field.