

Table S1 The primer pairs of osteogenic gene ALP, COL-I, OCN, Runx2, and GAPDH.

Gene	Direction	Sequence (5' - 3')
ALP	Forward	CCAACCTCTTTTGTGCCAGAGA
	Reverse	GGCTACATTGGTGTGAGCTTTT
COL-I	Forward	GGTATGCTTGATCTGTATCTGC
	Reverse	AGTCCAGTTCTTCATTGCATT
OCN	Forward	CTGACAAAGCCTTCATGTCCAA
	Reverse	GCGGGCGAGTCTGTTCACTA
Runx2	Forward	CGGCCCTCCCTGAACTCT
	Reverse	TGCCTGCCTGGGATCTGT
GAPDH	Forward	GTCGTGGAGTCTACTGGTGTC
	Reverse	GAGCCCTTCCACAATGCCAAA

Table S2. Secondary structures of BMP-2 at the initial, binding, adsorption, debinding, and desorption states on HAP and Zn-HAPs.

		$\alpha$ -helix (%)	$\beta$ -sheet (%)	$\beta$ -turn (%)	$\beta$ -bend (%)	Random coil (%)
Initial secondary structure		$13.3 \pm 1.4$	$42.3 \pm 1.4$	$10.2 \pm 1.6$	$7.6 \pm 1.3$	$22.1 \pm 1.3$
HAP	Binding	$14.6 \pm 1.5$	$43.7 \pm 0.1$	$8.2 \pm 1.3$	$6.0 \pm 0.8$	$22.8 \pm 0.6$
	Adsorption	$11.5 \pm 0.9$	$44.4 \pm 2.2$	$9.9 \pm 2.1$	$8.3 \pm 1.2$	$21.5 \pm 1.7$
	Debinding	$11.9 \pm 0.3$	$43.7 \pm 1.7$	$8.0 \pm 1.9$	$9.6 \pm 1.7$	$21.5 \pm 1.3$
	Desorption	$9.9 \pm 1.6$	$45.0 \pm 1.4$	$8.4 \pm 1.3$	$10.7 \pm 1.8$	$20.7 \pm 1.3$
Zn1-HAP	Binding	$12.7 \pm 0.9$	$43.1 \pm 0.8$	$8.9 \pm 0.5$	$7.7 \pm 0.8$	$21.8 \pm 1.0$
	Adsorption	$12.1 \pm 1.0$	$40.1 \pm 2.4$	$8.1 \pm 1.0$	$8.3 \pm 1.0$	$25.0 \pm 1.7$
	Debinding	$11.2 \pm 1.4$	$43.9 \pm 1.6$	$8.4 \pm 1.6$	$6.6 \pm 0.7$	$22.4 \pm 1.1$
	Desorption	$10.5 \pm 1.9$	$40.5 \pm 3.9$	$9.3 \pm 1.4$	$6.9 \pm 1.1$	$25.3 \pm 2.5$
Zn2.5-HAP	Binding	$10.8 \pm 0.9$	$43.5 \pm 0.4$	$10.8 \pm 1.5$	$7.5 \pm 0.4$	$23.6 \pm 0.9$
	Adsorption	$11.1 \pm 1.7$	$41.6 \pm 2.0$	$10.0 \pm 1.5$	$7.3 \pm 1.3$	$25.3 \pm 1.7$
	Debinding	$11.7 \pm 0.8$	$43.5 \pm 0.8$	$9.3 \pm 0.2$	$6.8 \pm 0.5$	$24.1 \pm 0.6$
	Desorption	$10.7 \pm 1.1$	$41.6 \pm 1.6$	$9.5 \pm 1.6$	$6.4 \pm 0.7$	$25.9 \pm 1.6$
Zn5-HAP	Binding	$15.5 \pm 1.0$	$43.4 \pm 0.7$	$7.2 \pm 1.3$	$5.9 \pm 0.2$	$22.5 \pm 0.7$
	Adsorption	$11.8 \pm 0.7$	$41.7 \pm 1.8$	$9.8 \pm 1.7$	$7.8 \pm 0.6$	$24.8 \pm 1.8$
	Debinding	$11.8 \pm 0.9$	$42.5 \pm 0.4$	$11.7 \pm 1.2$	$7.8 \pm 0.6$	$24.1 \pm 0.3$
	Desorption	$12.1 \pm 2.0$	$42.9 \pm 2.9$	$9.1 \pm 2.2$	$6.6 \pm 1.3$	$23.4 \pm 2.0$
Zn10-HAP	Binding	$12.2 \pm 0.4$	$43.4 \pm 0.7$	$8.6 \pm 0.4$	$7.5 \pm 0.3$	$24.6 \pm 0.7$
	Adsorption	$11.7 \pm 0.8$	$42.2 \pm 1.2$	$9.4 \pm 0.8$	$7.0 \pm 1.0$	$23.9 \pm 1.2$
	Debinding	$12.3 \pm 0.4$	$41.1 \pm 1.2$	$10.1 \pm 0.9$	$6.7 \pm 1.1$	$24.1 \pm 1.2$
	Desorption	$11.5 \pm 1.0$	$38.2 \pm 3.2$	$8.8 \pm 1.8$	$8.5 \pm 1.2$	$26.2 \pm 2.5$

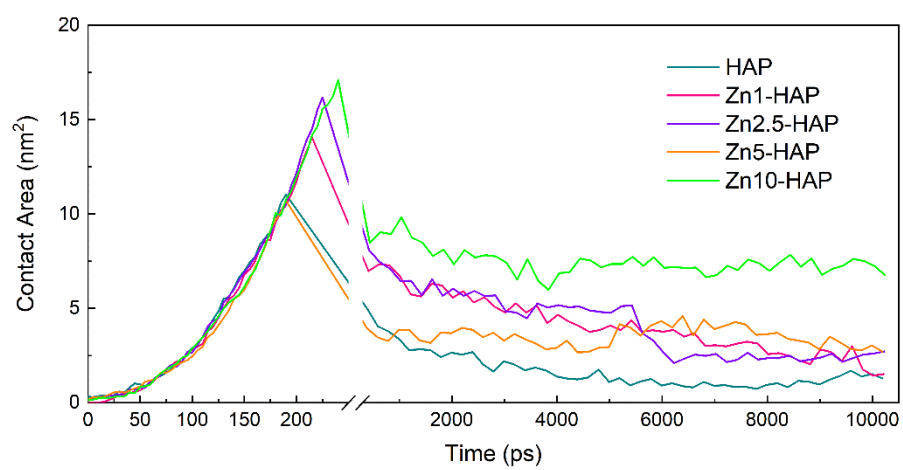


Figure S1. Contact area of BMP-2 upon HAP/Zn-HAPs during the binding and adsorption processes.

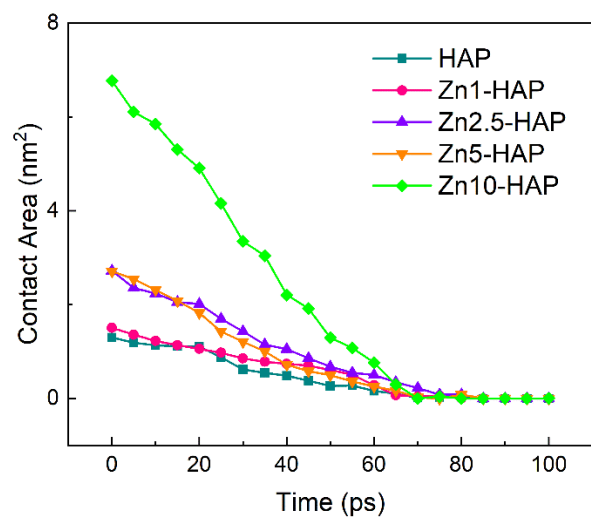


Figure S2. Contact area of BMP-2 upon HAP/Zn-HAPs during the debinding process.

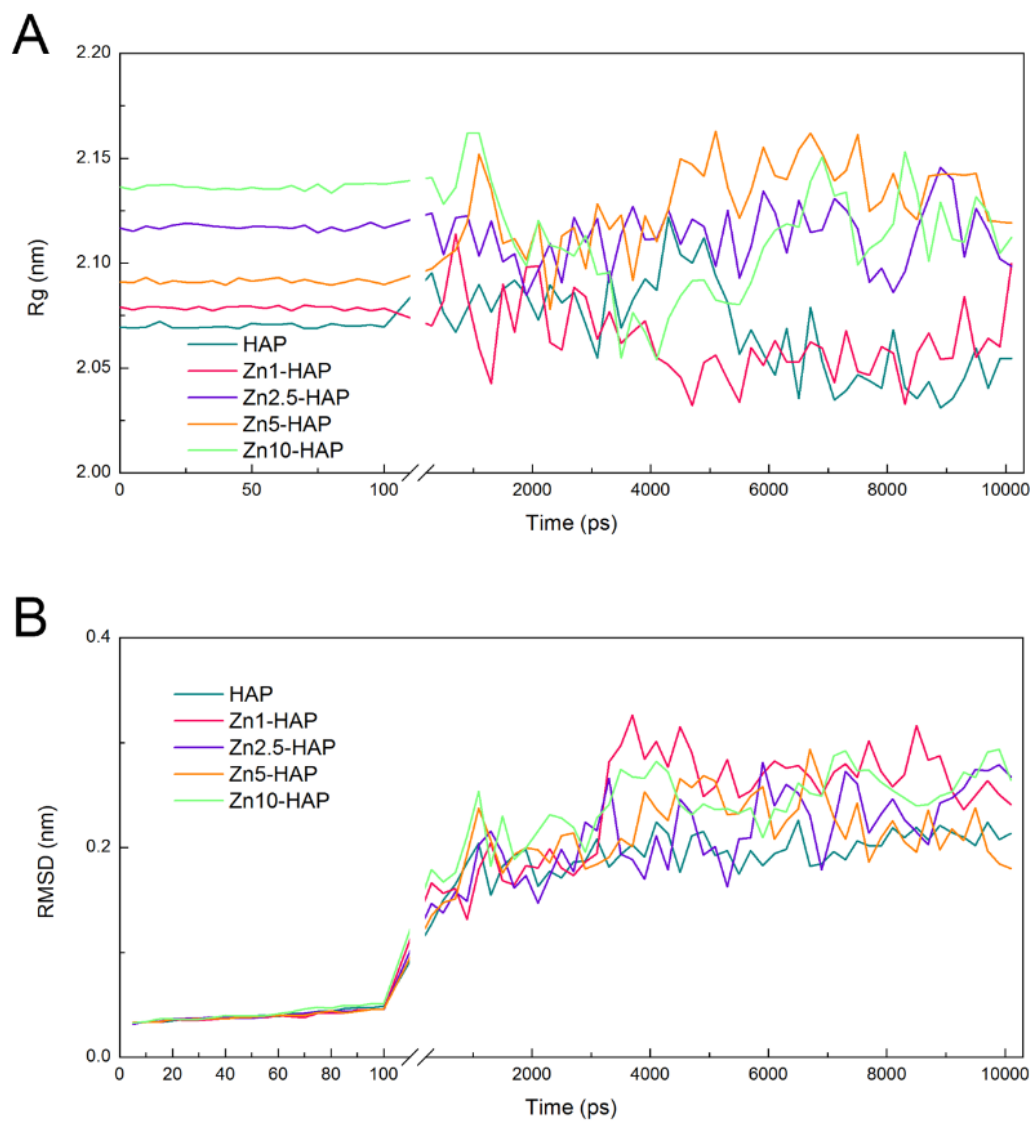


Figure S3. Rg (A) and RMSD (B) of BMP-2 upon HAP/Zn-HAPs during the debinding and desorption processes.

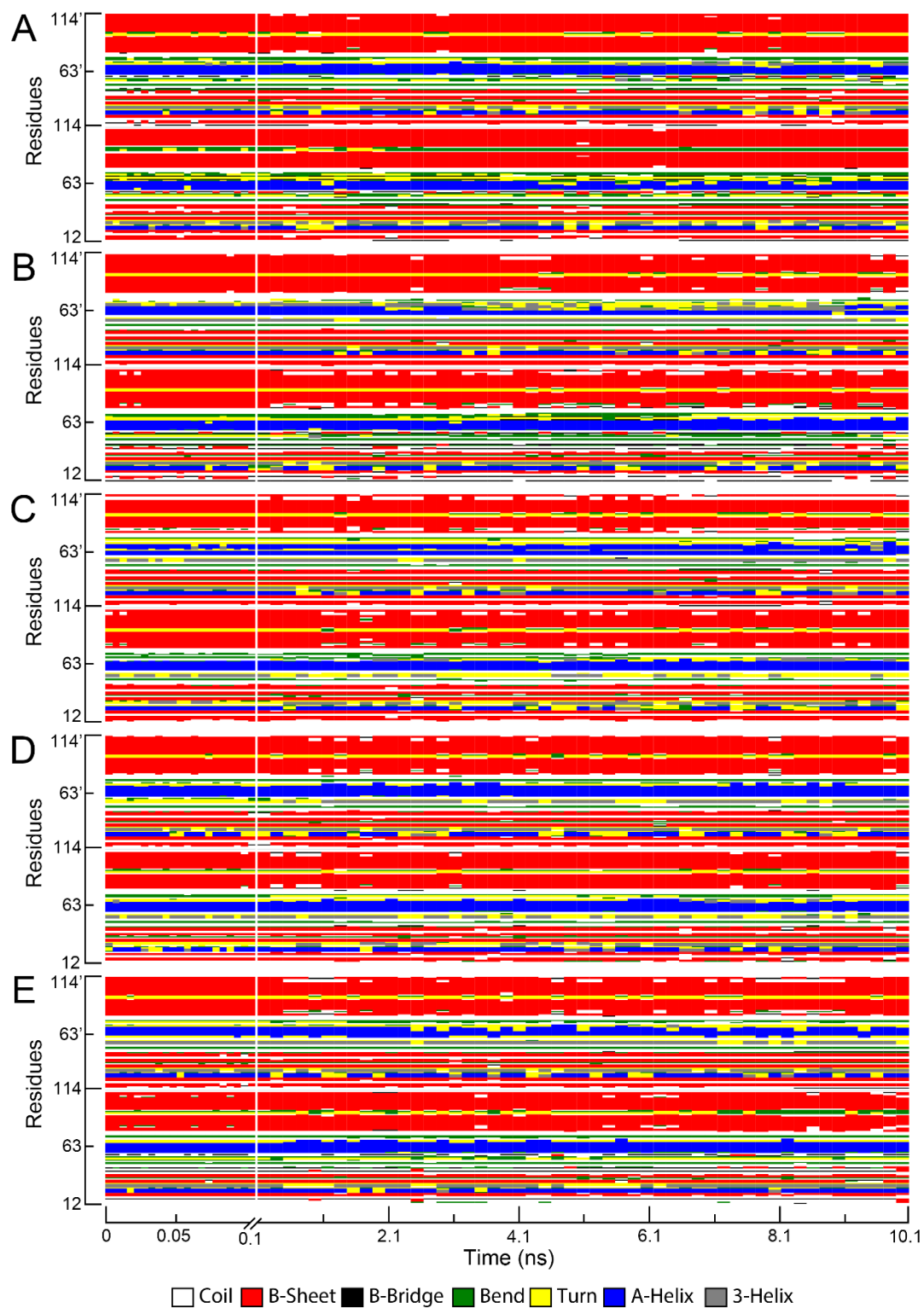


Figure S4. Secondary structures of BMP-2 upon HAP and Zn-HAPs during the debinding and desorption processes. (0 to 0.1 ns: debinding process; 0.1 to ~10.1 ns: desorption process. A, HAP; B, Zn1-HAP; C, Zn2.5-HAP; D, Zn5-HAP; E, Zn10-HAP.).

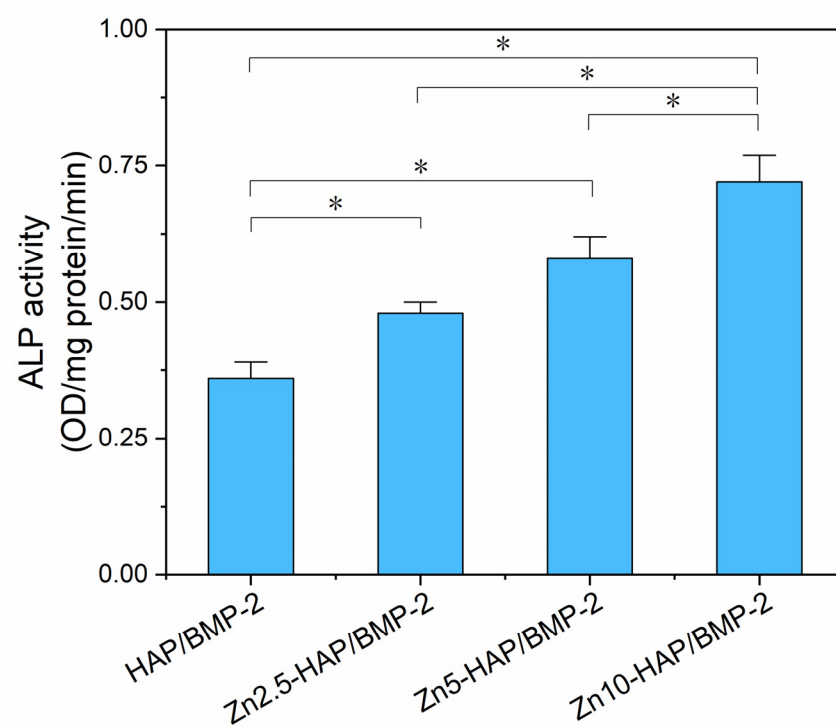


Figure S5. ALP activity of C2C12 cells cultured with HAP/BMP-2 and Zn-HAPs/BMP-2 for 3 days.

\*,  $p < 0.05$ , compared with corresponding samples.