Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information

Development of intense yellow color $BiVO_4/ZrO_2$ composite coating for anticorrosive multifunctional cool roof

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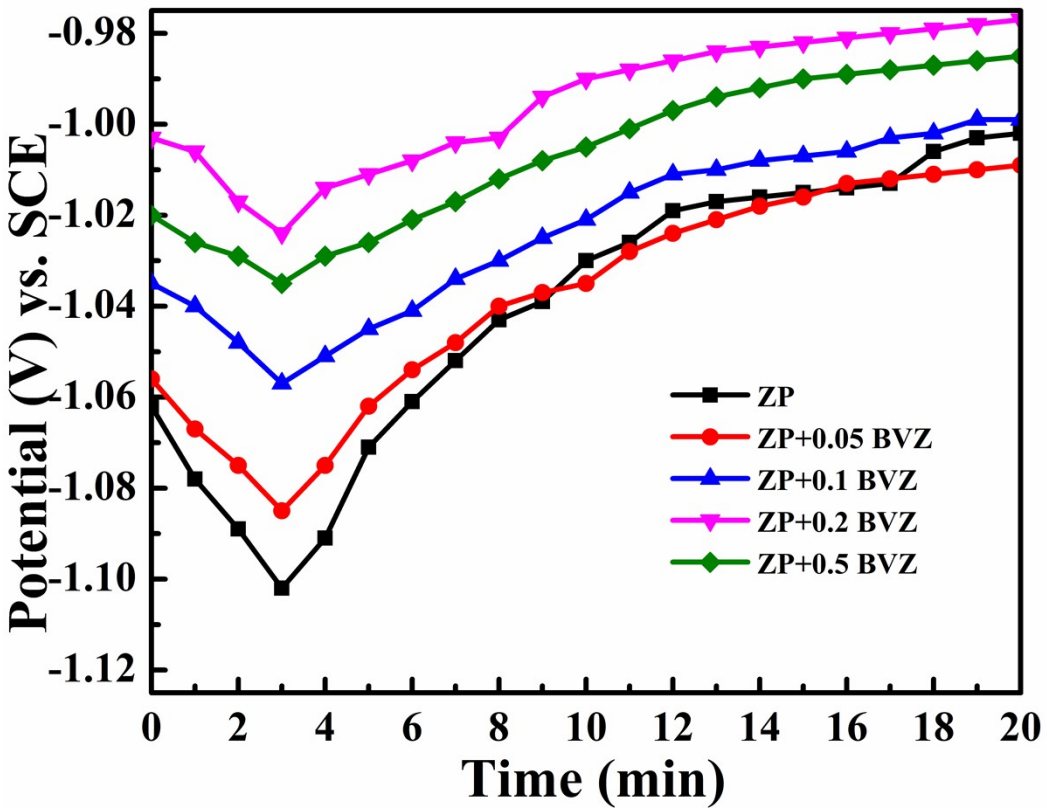

Fig. S1. The trend of potential-time curves obtained during the zinc phosphating process of galvanized steel in the presence and absence of BVZ composites

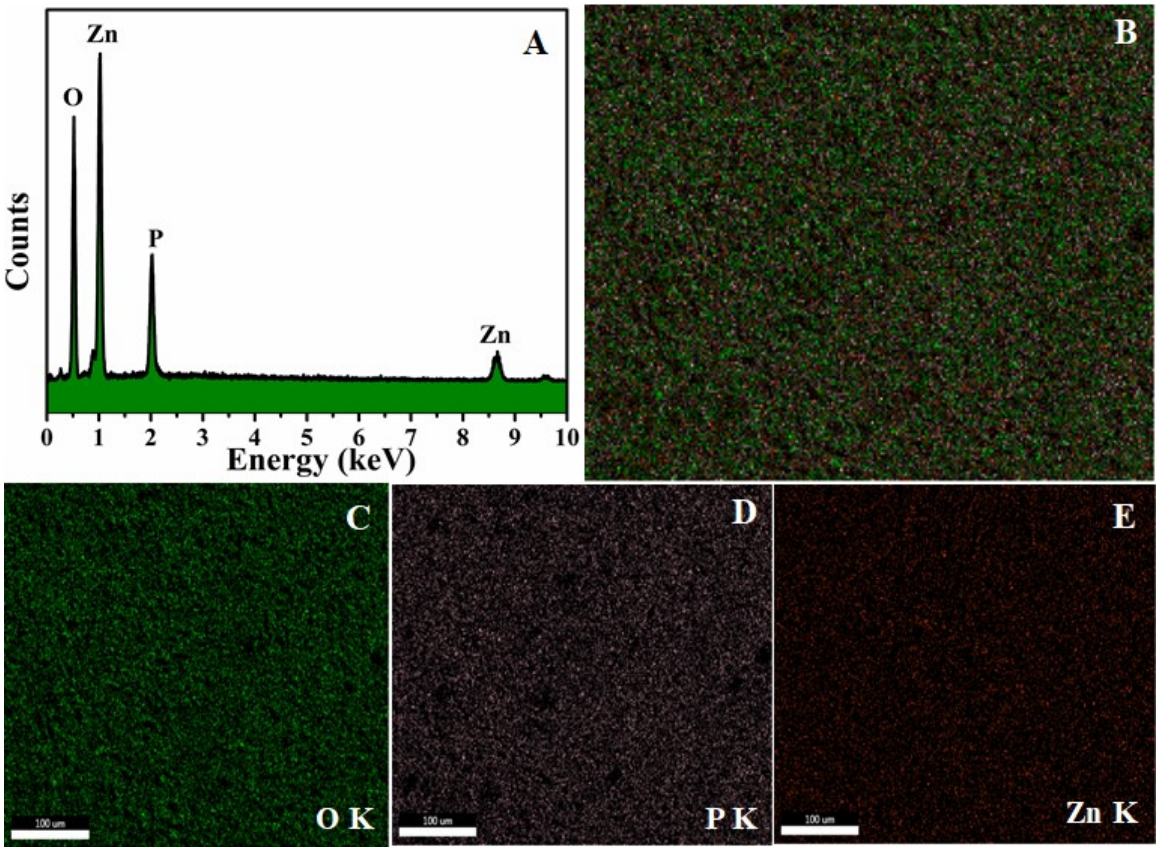

Fig. S2. (A) EDS spectrum and EDS elemental mapping spectrum of zinc phosphate coating developed from the bath in the absence of BVZ composite; (B) EDS layered image, (C) O K, (D) P K and (E) Zn K

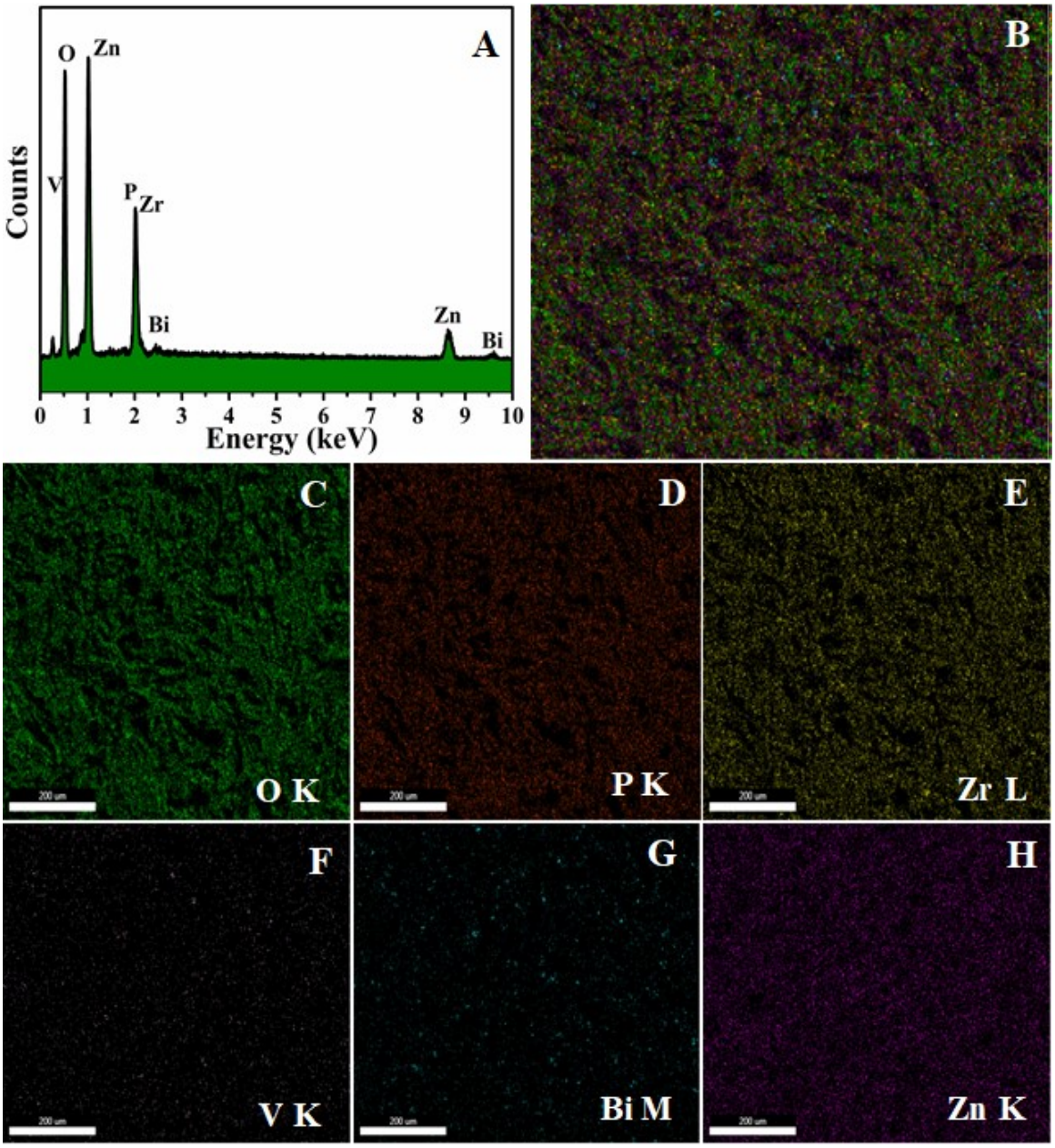

Fig. S3. (A) EDS spectrum and EDS elemental mapping spectra of zinc phosphate coating developed from the bath containing 0.05 wt.% of BVZ composite; (B) EDS layered image, (C) O K, (D) P K, (E) Zr L, (F) V K, (G) Bi M and (H) Zn K

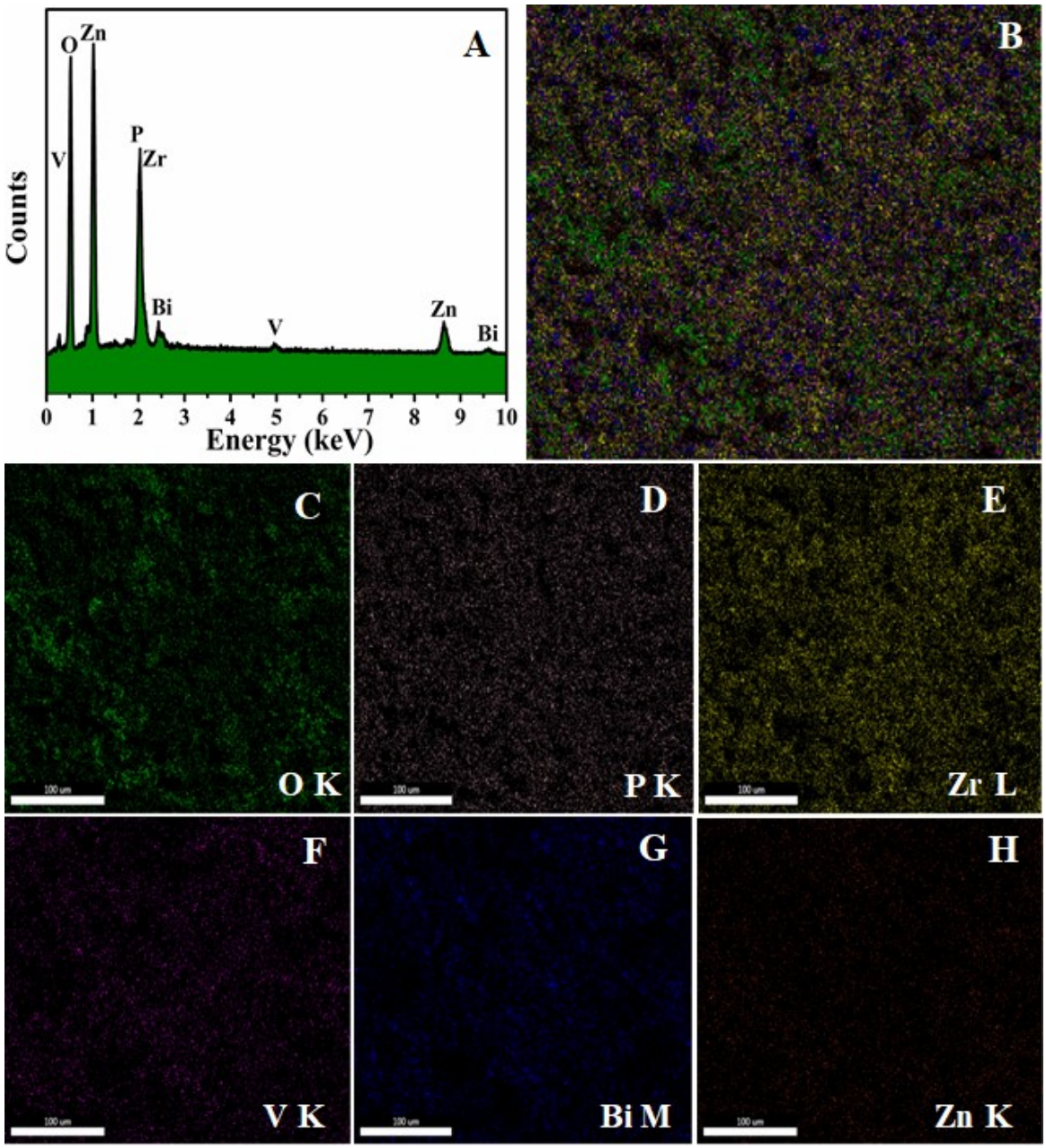

Fig. S4. (A) EDS spectrum and EDS elemental mapping spectra of zinc phosphate coating developed from the bath containing 0.1 wt.% of BVZ composite; (B) EDS layered image, (C) O K, (D) P K, (E) Zr L, (F) V K, (G) Bi M and (F) Zn K

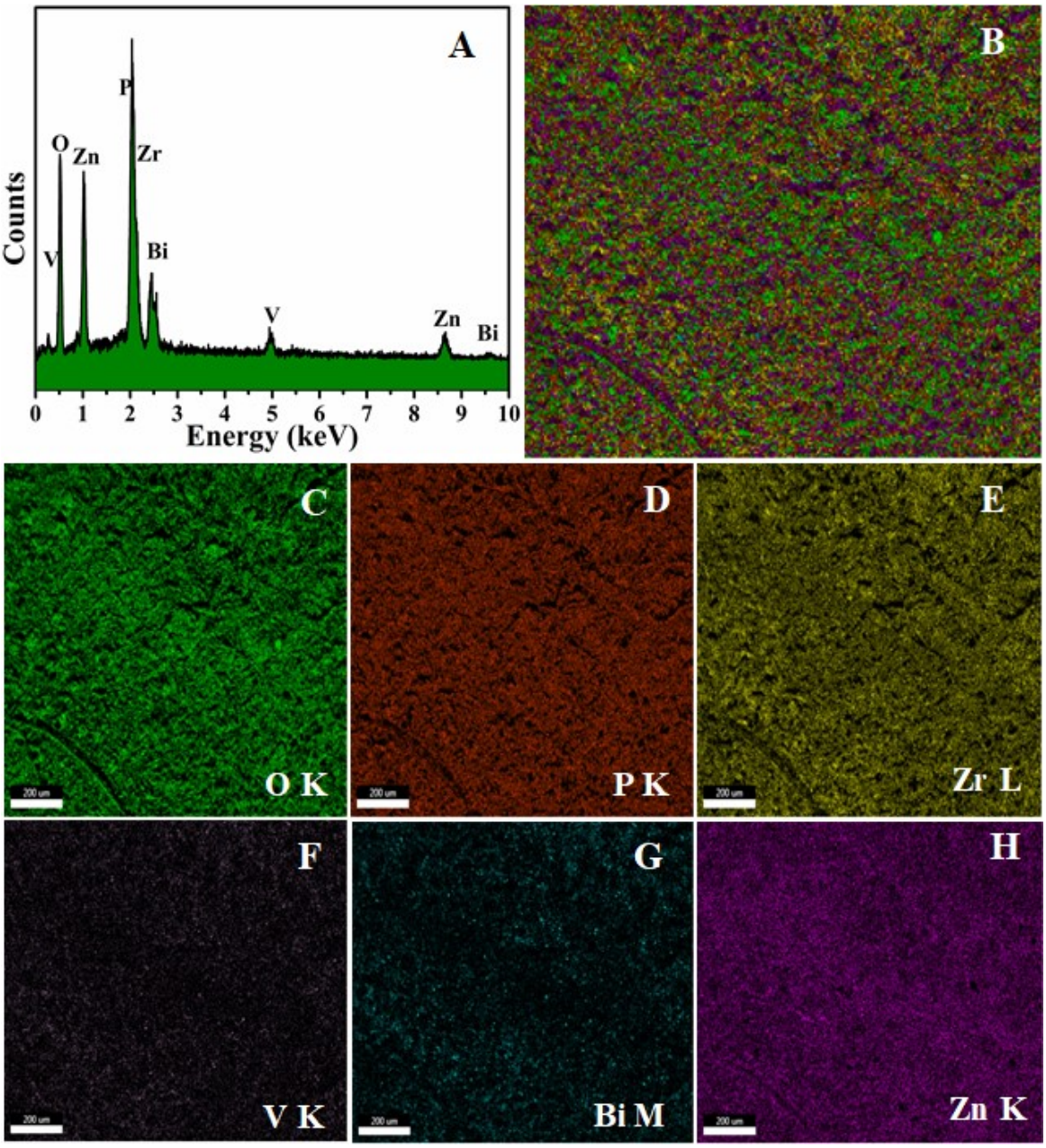

Fig. S5. (A) EDS spectrum and EDS elemental mapping spectra of zinc phosphate coating developed from the bath containing 0.2 wt.% of BVZ composite; (B) EDS layered image, (C) O K, (D) P K, (E) Zr L, (F) V K, (G) Bi M and (F) Zn K

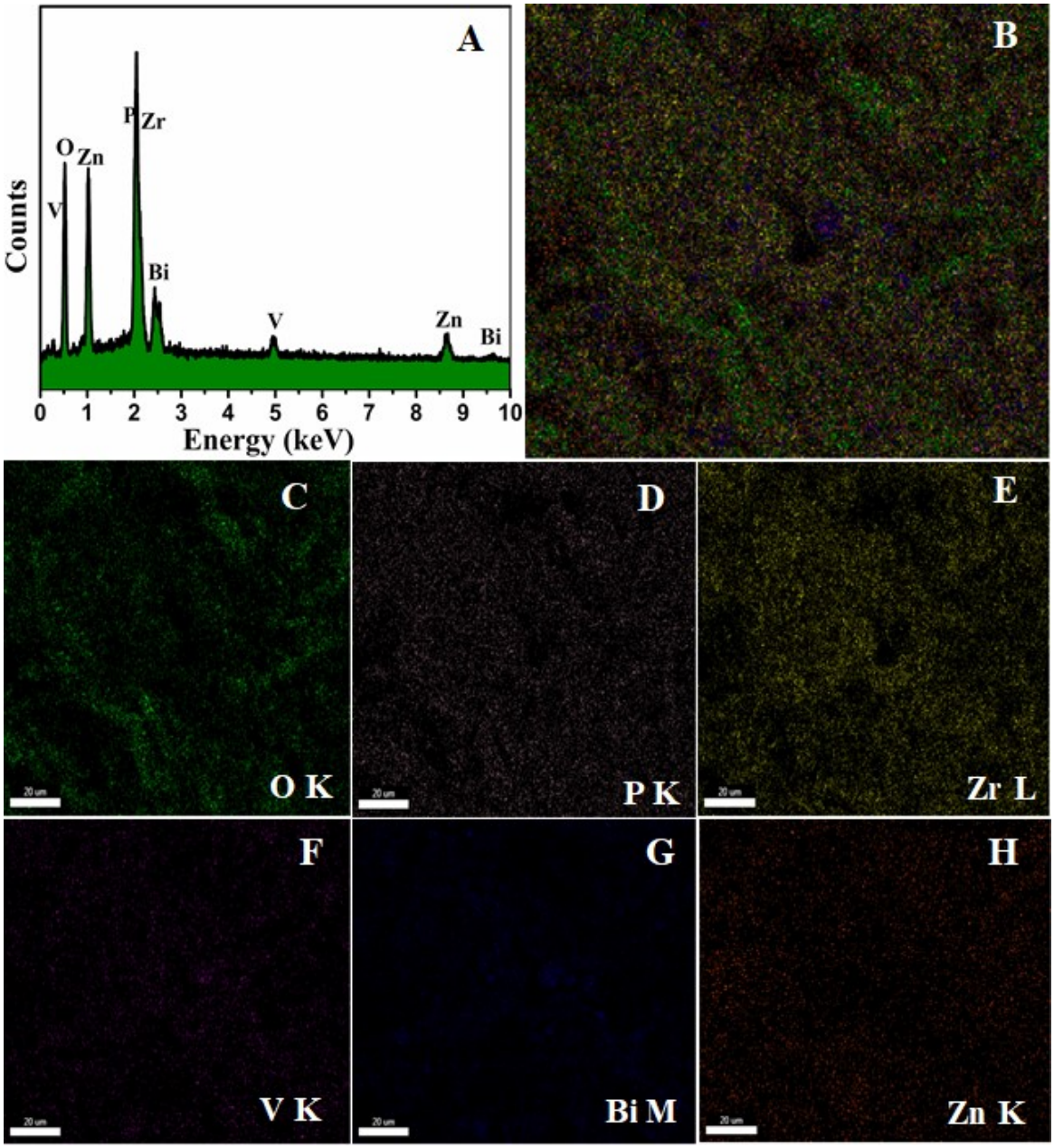

Fig. S6. (A) EDS spectrum and EDS elemental mapping spectra of zinc phosphate coating developed from the bath containing 0.5 wt.% of BVZ composite; (B) EDS layered image, (C) O K, (D) P K, (E) Zr L, (F) V K, (G) Bi M and (F) Zn K

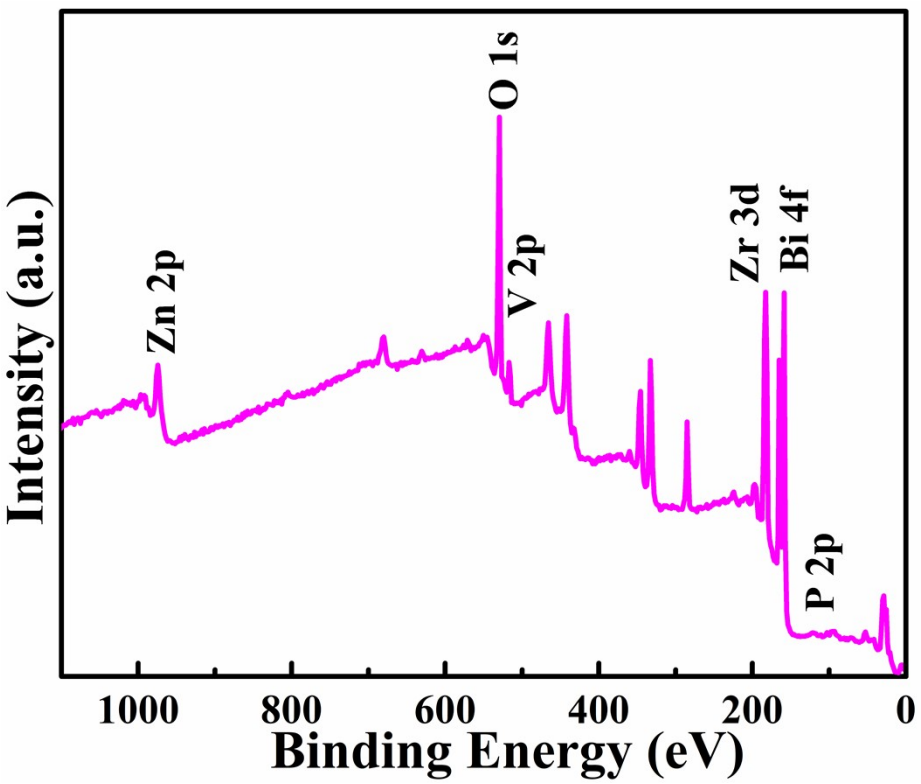

Fig. S7. XPS survey spectrum of zinc phosphate coatings developed from the bath containing BVZ composite

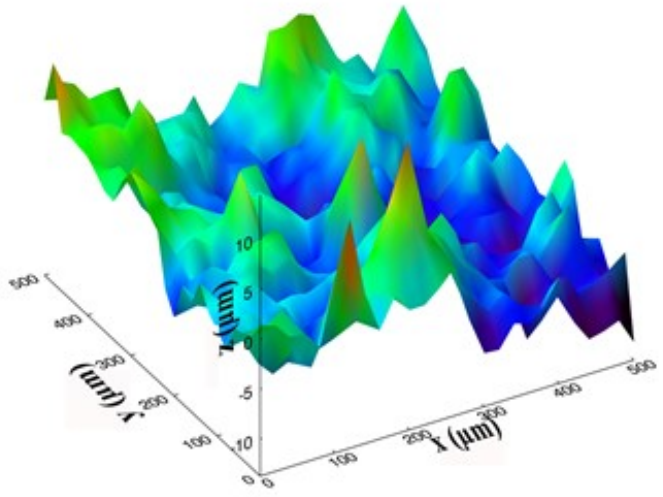

Fig. S8. OSP 3D images of bare zinc phosphate coatings

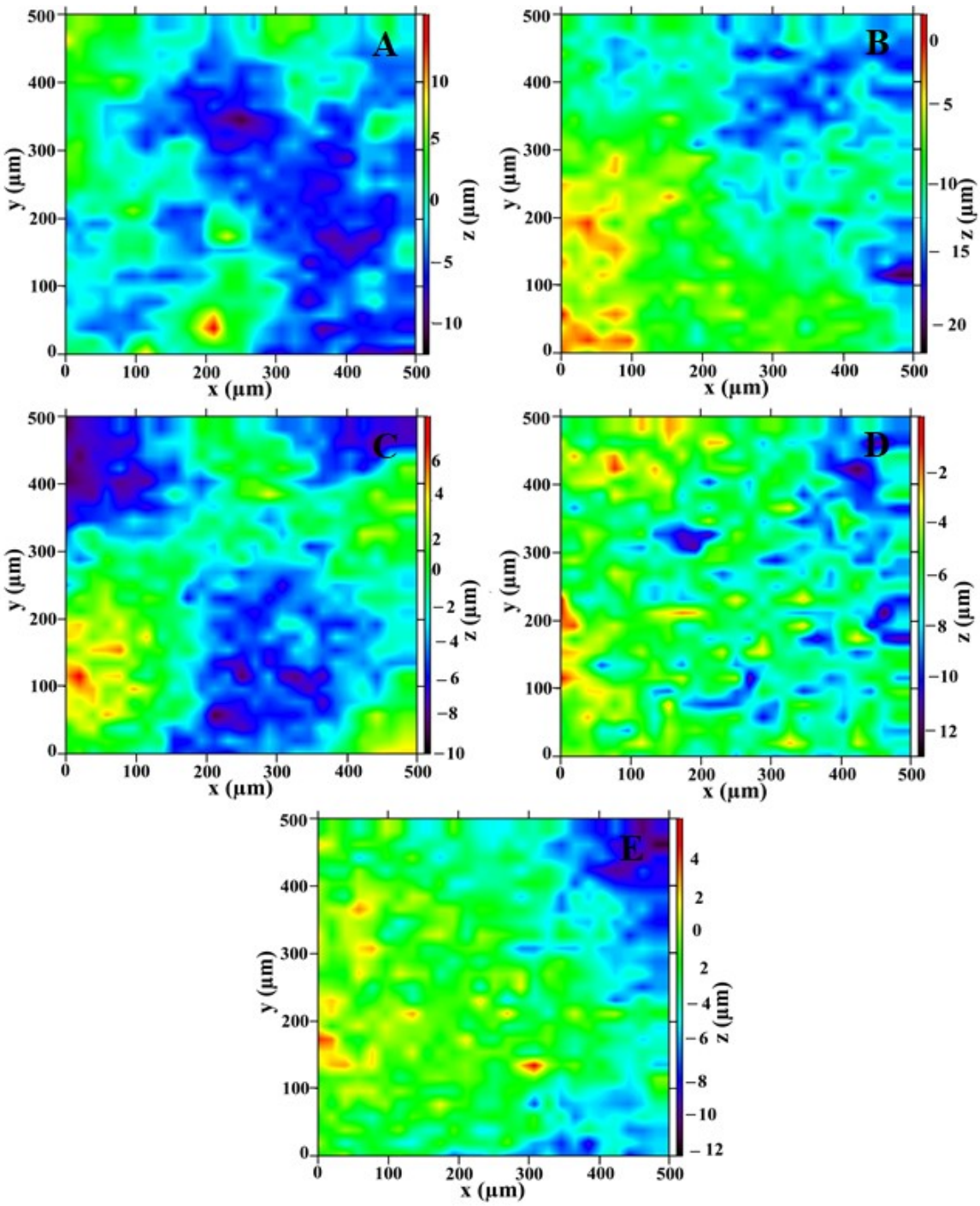

Fig. S9. OSP 2D images of zinc phosphate coatings developed from the bath containing different compositions of BVZ composite: (A) 0 wt.%, (B) 0.05 wt.%, (C) 0.1 wt.%, (D) 0.2 wt.% and (E) 0.5 wt.%

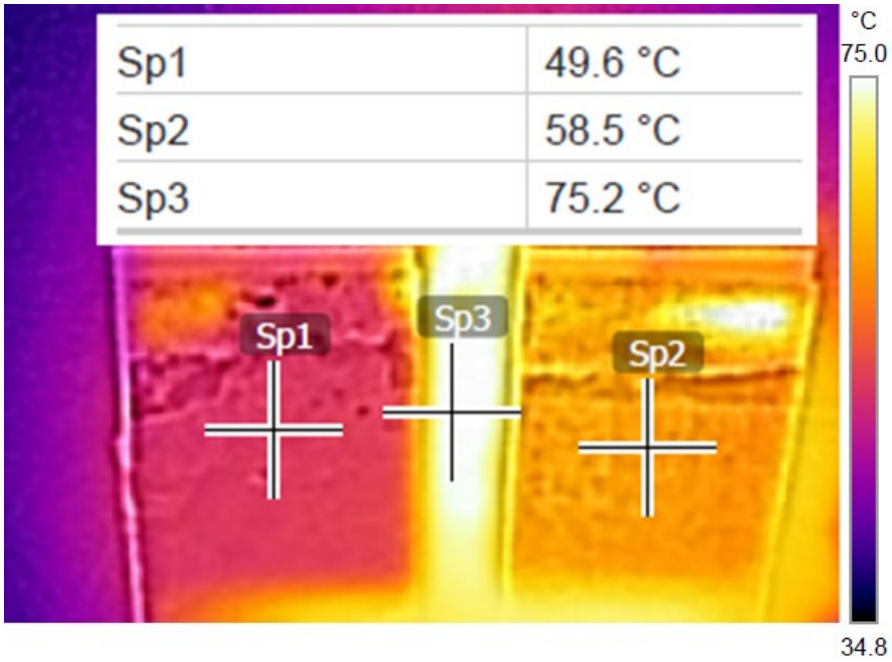

Fig. S10. FLIR thermal image of bare zinc phosphate coatings with and without BVZ composite (Sp1 – Temperature of zinc phosphate coating with BVZ composite, Sp2 – Temperature of zinc phosphate coating without BVZ composite, and Sp3 – Temperature of hot plate region)

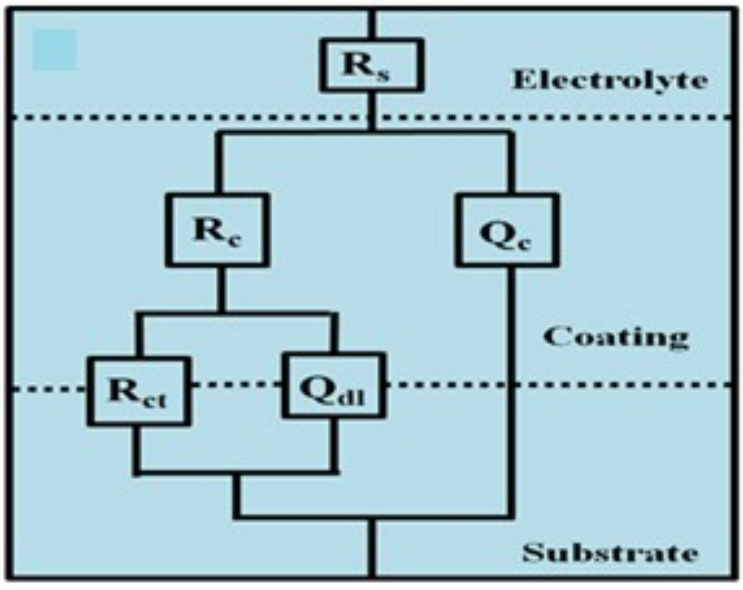

Fig. S11 equivalent circuit of of BVZ composite zinc phosphate coatings

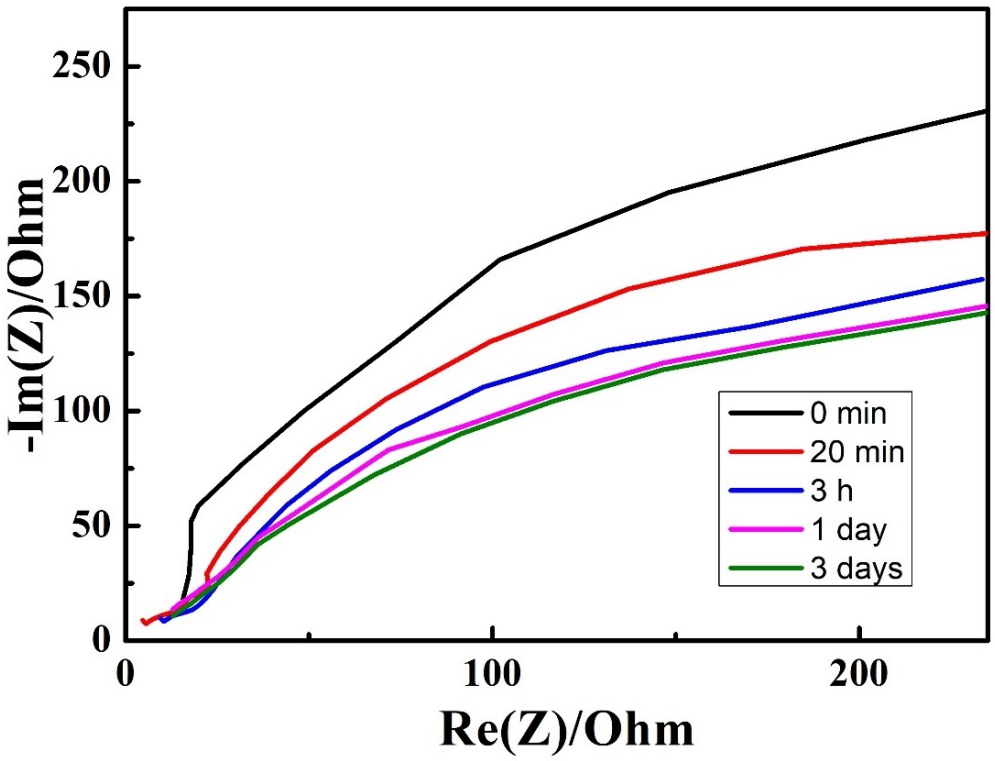

Fig. S12. Nyquist plots of 0.2 wt.% BVZ coating after 0 min, 20 min, 3 h, 1 day and 3 days immersion in 3.5 wt.% NaCl solution.

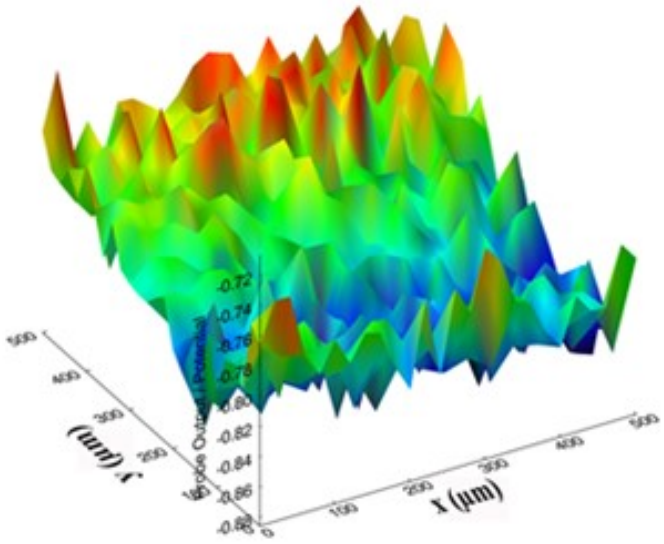

Fig. S13 3D SKPM images of (A) 0 wt.%,

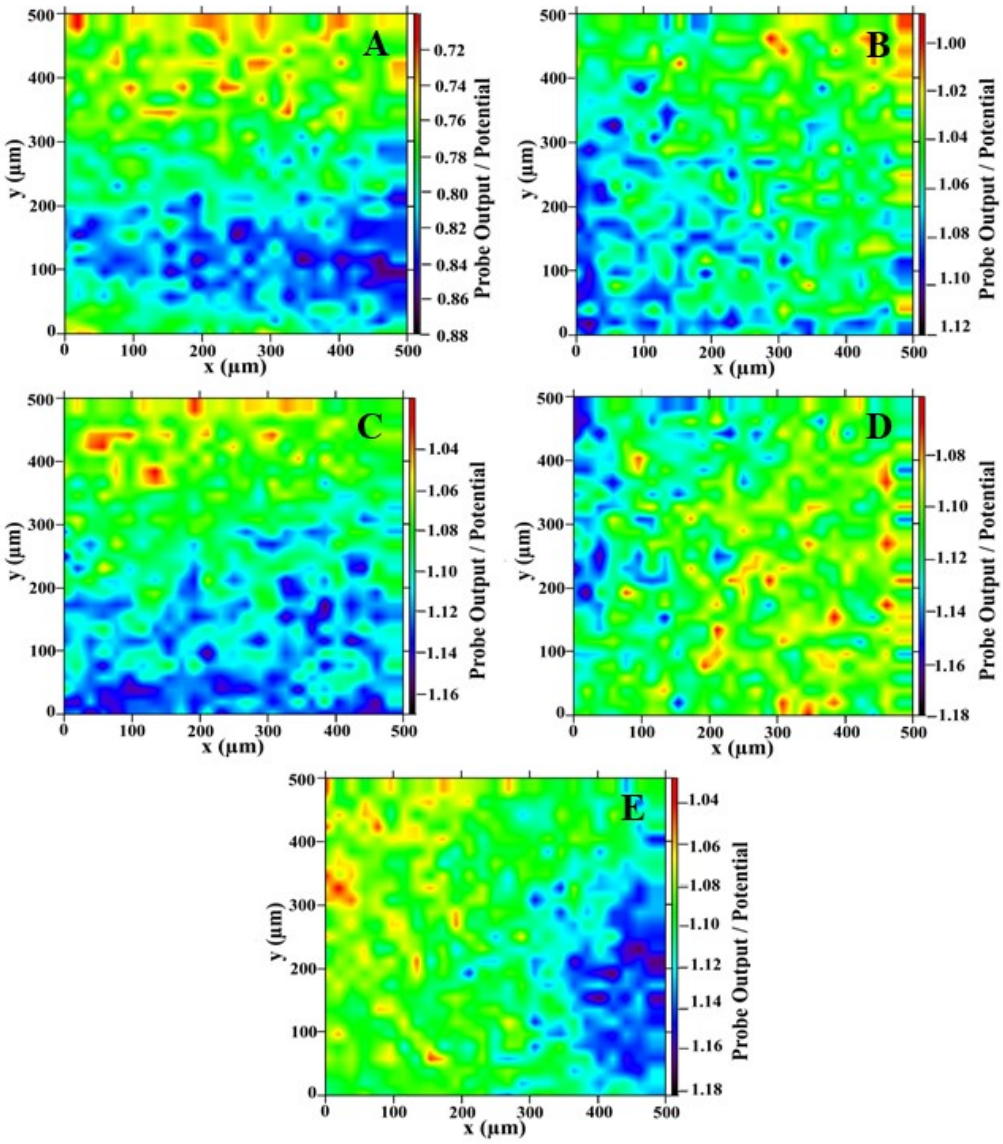

Fig. S14. 2D SKPM images of zinc phosphate coating developed from the bath containing different contents of BVZ composite; (A) 0 wt.%, (B) 0.05 wt.%, (C) 0.1 wt.%, (D) 0.2 wt.% and (E) 0.5 wt.%

Table S1. Phosphating bath composition

Sl. No.	Chemicals	Composition
1	Phosphoric acid (H_3PO_4)	16 mL/L
2	Zinc Oxide (ZnO)	1.2 g/L
3	Sodium Nitrite ($NaNO_2$)	16 g/L
4	Sodium Fluride (NaF)	2 g/L

Table S2. Comparison of roughness parameters of bare zinc phosphate coating and zinc phosphate coatings developed from the containing different amounts of BVZ composite

Coatings	S_a (µm)	S_q (µm)	S_p (µm)	S_v (µm)	S_t (µm)	S_{sk} (µm)	S_{ku} (µm)
Bare ZP	2.879	3.558	16.271	-9.342	25.613	-1.450	3.028
ZP + 0.05 wt.% BVZ	2.795	3.440	10.354	-10.882	21.236	-2.795	2.792
ZP + 0.1 wt.% BVZ	2.527	3.089	9.893	-6.981	16.874	-4.856	2.982
ZP + 0.2 wt.% BVZ	1.593	1.996	5.878	-6.061	11.949	-5.896	3.445
ZP + 0.5 wt.% BVZ	2.122	2.640	8.077	-8.936	17.014	-3.328	3.177

Table S3. Comparison of NIR reflectance and NIR solar reflectance of optimized BVZ composite incorporated zinc phosphate coating after exposure in different solutions

5% Chemicals	NIR reflectance at 1100 nm (R%)	NIR solar reflectance (R*%)
NaCl	45.02	53.90
NaOH	42.18	51.45
HCl	39.25	49.45
HNO_3	37.69	47.87

Table S4. Comparison of NIR reflectance and NIR solar reflectance of optimized BVZ composite incorporated zinc phosphate coating after exposure to the natural sunlight

Time duration exposure to sunlight (days)	NIR reflectance at 1100 nm (R%)	NIR solar reflectance (R*%)
0	51.92	58.97
10	51.71	58.77
20	51.60	58.55
30	51.49	58.42
40	51.29	58.27
50	51.22	58.17
60	51.16	58.07

Table S5. Temperature measurements in front and behind the coating surface

Sl. No.	coatings	Front coating temperature (°C)	Back coating temperature (°C)	Temperature difference (°C)
1	Bare ZP coating	62.4	56.1	6.3
2	BVZ zinc phosphate coating	52.6	40.8	11.8

Table S6. Electrochemical impedance parameters: bare zinc phosphate coating and different compositions of BVZ composite-based zinc phosphate coating

Coatings	R_S (Ω cm^2)	Q_C (F)	R_C (Ω cm^2)	Q_{dl} (F)	R_{ct} (Ω cm^2)
Bare ZP	11.60	26.31×10^{-6}	50.53	0.565×10^{-3}	137.7
ZP + 0.05 wt.% BVZ	11.23	9.85×10^{-6}	47.35	1.555×10^{-3}	175.3
ZP + 0.1 wt.% BVZ	14.02	20.45×10^{-6}	74.7	1.712×10^{-3}	341.6
ZP + 0.2 wt.% BVZ	22.16	3.09×10^{-6}	188.2	5.814×10^{-6}	765.4
ZP + 0.5 wt.% BVZ	12.72	6.519×10^{-6}	141.6	1.608×10^{-3}	647.4

Table S7 Comparision of corrosion resistance and reflectance data with reported data

Material	Reflectance	Corrosion resistance	Reference
$LiMg_{0.8}Co_{0.2}PO_4$	67%	Rct = 9.3 × 109 Ωcm_2	[1]
$NaZn_{0.9}Co_{0.1}PO_4$	64%	Rct = 8.8 × 106 Ωcm^2	[2]
Potassium titanate whiskers	48 %	Corrosion Rate = 7.531×10^{-4} mmpy	[3]
Green pigments ($Co_xZn_{1-x}O$)	30%	-	[4]
$Bi_{1-x}La_xFeO_3$	44.1%	-	[5]
SrCaP	-	Corrosion Rate = 2.79 ± 0.03 mmpy	[6]
BVZ composite	51.97%	Corrosion Rate = 1.099 mmpy	Present study

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