Effect of MoS_2 additive on corrosion and tribocorrosion property of plasma electrolytic oxidation coating on titanium

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ABSTRACT

Plasma electrolytic oxidation (PEO) technology as a novel and attractive surface engineering process has been widely used for preparation of functional oxide coatings on light alloys such as aluminum, magnesium, zirconium, and titanium. In this study, we fabricated the MoS_2 decorated composite oxide layers on pure titanium by using PEO treatment under pulsed DC power with unipolar mode in alkaline phosphate- and aluminate-based solutions with 0~3 g/L MoS_2 nanoparticle additions. The influence of MoS_2 nanoparticle addition on the microstructure, mechanical property, corrosion resistance and tribocorrosion behavior of PEO composite coating on pure titanium was investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), field-emission electron probe microanalysis (FE-EPMA), surface profilometry (α-step), scratch adhesion testing, pin-on-disc wear testing and potentiodynamic polarization measurement in 3.5 wt% NaCl solution. The experimental results obtained from scratch adhesion testing and potentiodynamic polarization measurements show that PEO composite coating with 2.5 g/L MoS_2 nanoparticles addition exhibits optimal adhesion strength and corrosion resistance. Furthermore, the results of XRD and SEM-EDS indicate that regardless of the presence or absence of MoS_2 nanoparticle additives, the PEO composite coatings on pure titanium are primarily composed of aluminum titanate (Al_2TiO_5) and rutile-phase titanium dioxide (TiO_2). The FE-EPMA data reveal that MoS_2 particles are mainly well distributed at the interface between the PEO coating and pure titanium substrate. The tribocorrosion behavior of MoS_2 nanoparticle decorated PEO composite coatings was carried out by potentiodynamic polarization measurement in 3.5 wt% NaCl solution under wear mode. As similar to static potentiodynamic polarization measurement, the PEO composite coating with 2.5 g/L MoS_2 nanoparticles addition also displays optimal tribocorrosion resistance in this study. In summary, the adhesion strength, wear resistance and corrosion/tribocorrosion resistance of Al_2TiO_5–rutile TiO_2 composite coating on pure titanium can be improved by increasing MoS_2 nanoparticles addition. The optimal concentration of MoS_2 additive is 2.5 g/L.

Keywords: plasma electrolytic oxidation (PEO), MoS_2, corrosion, tribocorrosion, titanium

Sample		#M0	#M1	#M2	#M3	#M4
Electrolyte Concentration -g/L-	$NaAlO_2$			3		
	$Na_3PO_4 \cdot 12H_2O$			10		
	KOH			1		
	MoS_2	**0**	**1.5**	**2**	**2.5**	**3**
	SLS	0	1	1	1	1
Duty cycle (%)				50		
Frequency (Hz)				1000		
Current setting (A)				4		
maxima working voltage (V)				0~450		
Processing time (min)				10		

Table. 1. The experimental details regarding PEO treatment used in this study

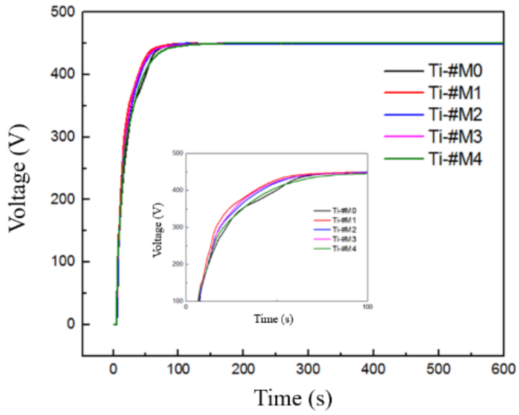


Fig. 1. The voltage-time curves recorded during PEO process with various concentrations of MoS_2 additives.

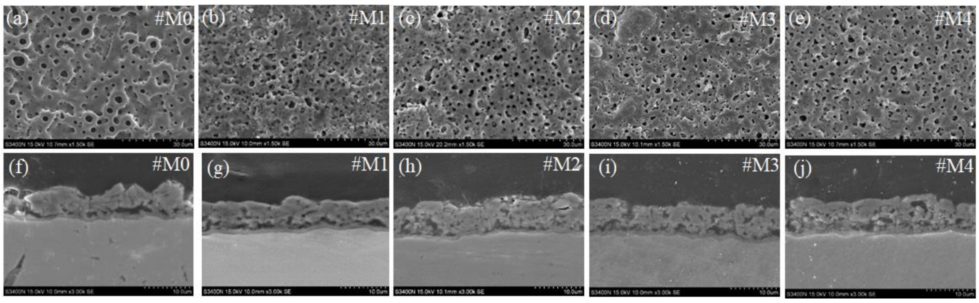


Fig. 2. surface morphology (a-e) and cross-sectional (f-j) SEM images of PEO composite coatings on titanium with various concentrations of MoS_2 additives: (a) M0 (0 g/L); (b) M1 (1.5 g/L); (c) M2 (2.0 g/L); (d) M3 (2.5 g/L); (e) M4 (3.0 g/L); and cross-sectional images of (f) M0 (0 g/L); (g) M1 (1.5 g/L); (h) M2 (2.0 g/L); (i) M3 (2.5 g/L); and (j) M4 (3.0 g/L).

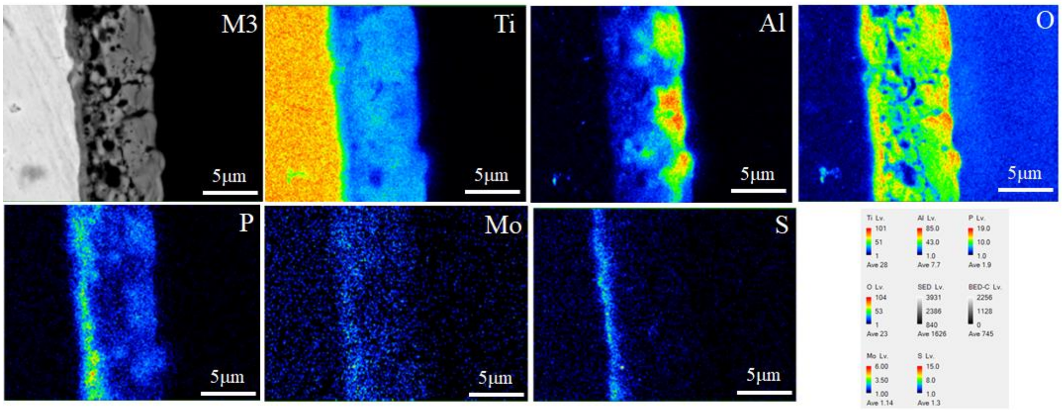


Fig. 3. Cross-sectional EPMA mapping images of PEO composite coatings on titanium with 2.5 g/L of MoS_2 additives (M3).

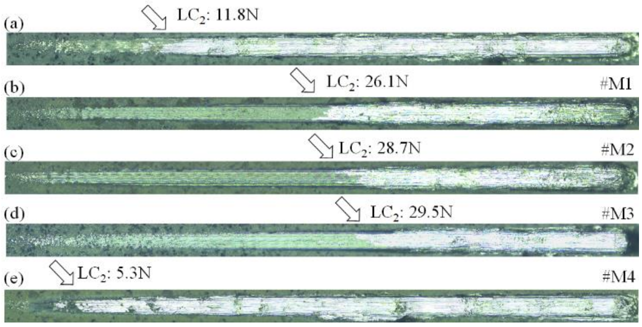
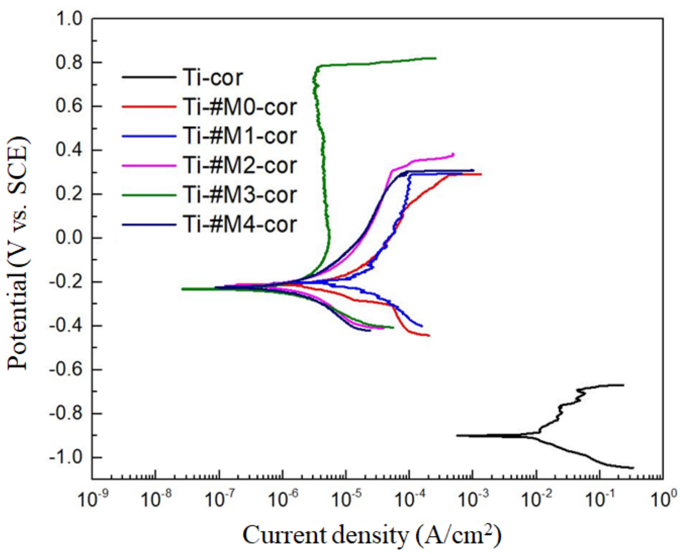


Fig. 4. OM images captured after scratch testing for PEO composite coatings on titanium with various concentrations of MoS_2 additives.



Samples	I_{corr}(A/cm^2)	E_{corr}(V)
Ti-cor	1.240×10^{-2}	-0.908
#M0-cor	5.618×10^{-6}	-0.213
#M1-cor	4.621×10^{-6}	-0.193
#M2-cor	3.121×10^{-6}	-0.215
#M3-cor	4.494×10^{-7}	-0.237
#M4-cor	8.411×10^{-7}	-0.216

Fig. 5. Potentiodynamic polarization curves (tribocorrosion) for PEO composite coatings on titanium with various concentrations of MoS_2 additives.