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1. Introduction One of the possible methods of improving the properties of thin Cr coatings is the formation of nano-composites. The aim of the current work was to incorporate rare earth (CeO₂, La₂O₃ or CeO₂/La₂O₃) particles into the Cr coating by electrochemical precipitation from an environmentally friendly Cr(III) electrolyte and to improve the mechanical properties (microhardness, friction coefficient and wear rate) of Cr coatings.

2. Results

Component	Oxalate bath, gL ⁻¹	Deposition conditions
Cr ₂ (SO ₄) ₃ ·6H ₂ O	150	$i_c = 40 \text{ A dm}^{-2}$
Na ₂ C ₂ O ₄	35	$t = 20 \text{ }^\circ\text{C}$;
H ₃ BO ₃	30	pH 1.5;
Na ₂ SO ₄	60	magnetic stirring rate
Al ₂ (SO ₄) ₃ ·18H ₂ O	100	350 rpm;
NaF	15	electrodeposition
CeO ₂ /La ₂ O ₃ particle	0, 2, 5, 10 and 15	time 20 min.

Table 1. Chrome oxalate bath composition and deposition condition

The coatings were characterized using SEM, EDS, XRD and microhardness test. The contact profilometer was used to determine the wear profiles of the Cr and composite coatings.

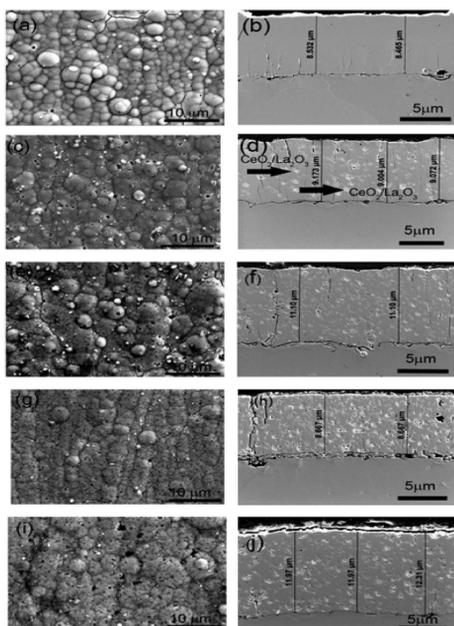


Fig. 1. Dependence of the morphology and SEM pictures of cross-sections of Cr–CeO₂ / La₂O₃ composites at CeO₂ / La₂O₃ concentrations: (a,b)-Ce0, (c,d)-Ce2, (e,f)-Ce5, (g,h)-Ce10 and (i,j)-Ce15.

	La ₂ O ₃		CeO ₂	
	a, angst.	crystallite, nm	a, angst.	crystallite, nm
CeO ₂ /La ₂ O ₃	11.5772	22.62 ± 0.18	5.4796	19.60 ± 0.18
Ce2	11.5984	26.65 ± 0.37	5.4859	22.84 ± 0.22
Ce5	11.6290	32.70 ± 0.23	5.4857	24.75 ± 0.29
Ce10	11.5871	27.94 ± 0.10	5.4814	22.68 ± 0.41
Ce15	11.5941	28.45 ± 0.25	5.4860	23.30 ± 0.35

Table 2. Lattice constants and crystallites size of CeO₂ and La₂O₃ nanoparticles incorporated into chromium coating. Lattice constants and crystallites size calculated from XRD pattern using Hadler-Wagner method for different CeO₂/La₂O₃ concentrations samples.

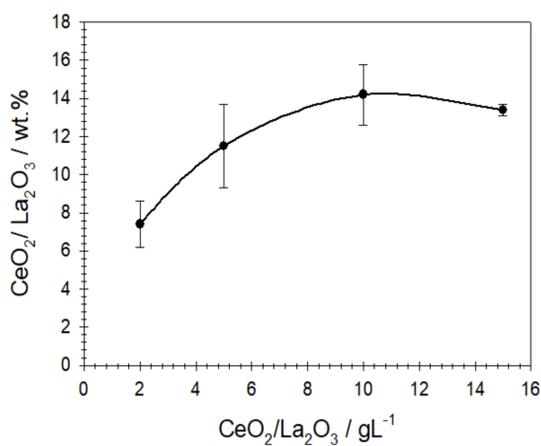


Fig. 2. Dependence between the incorporation of CeO₂ / La₂O₃ nanoparticles into the Cr matrix and CeO₂ / La₂O₃ concentration in the chromium electrolyte: (a)-Ce0, (b)-Ce2, (c)-Ce5, (d)-Ce10 and (e)-Ce15.

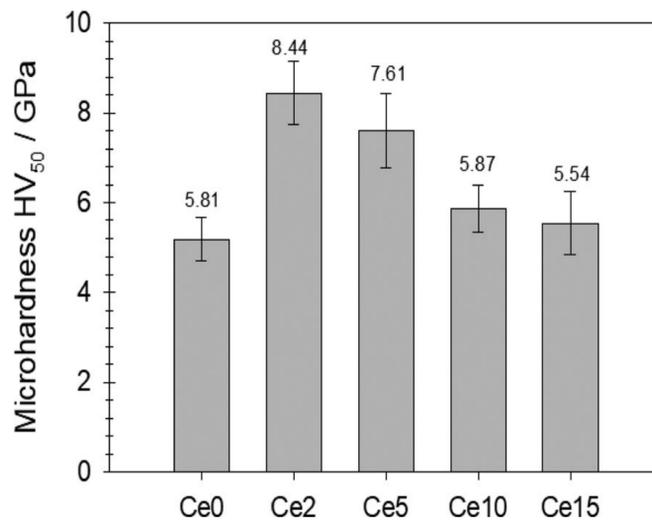


Fig. 3. Influence of CeO₂ / La₂O₃ concentration in the chromium electrolyte on the microhardness (HV) of Cr–CeO₂ / La₂O₃ composites.

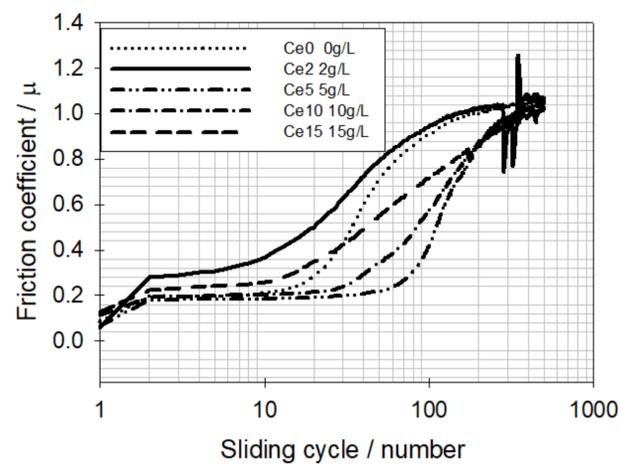


Fig. 4. Influence of CeO₂ / La₂O₃ concentration in the chromium electrolyte on the friction coefficient (COF) of Cr–CeO₂ / La₂O₃ composites: (a)-Ce0, (b)-Ce2, (c)-Ce5, (d)-Ce10 and (e)-Ce15.

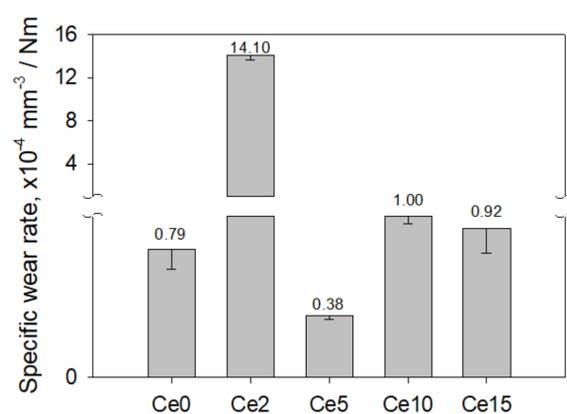


Fig. 5. Influence of CeO₂ / La₂O₃ concentration in the chromium electrolyte on the specific wear rate of Cr–CeO₂ / La₂O₃ composites.

3. Conclusions.

1. For the first time, the Cr–CeO₂ / La₂O₃ composite has been electrochemically deposited in a sulphate Cr (III) bath with an oxalate complexing agent.
2. The cross-section SEM and EDS analysis confirmed the incorporation of CeO₂/La₂O₃ particles into the Cr matrix.
3. XRD analysis revealed that incorporation of CeO₂/La₂O₃ particles into the Cr matrix does not change its state and the Cr matrix remains fine-crystalline (crystallites size < 1 nm).