OPTIMIZATION OF ELECTROCHEMCAL DEPOSITION OF $Zn\text{-}Mn\text{-}Al_2O_3$ COMPOSITE COATINGS

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INTRODUCTION

The Zn alloy coatings that have found the broadest application range, are Zn-Ni, Zn-Fe, Zn-Co, Zn-Sn and Zn-Mn alloy. On the other hand, the Zn composite coatings, obtained by using electroplating baths with various dispersive fine phases, which may be both hard phases, such as SiC, Al_2O_3, MoS_2, TiO_2, SiO_2 and Si_3N_4, and soft phases such as polytetrafluoroethylene (PTFE) or graphene. The improvement of different features of a composite coating depends mainly on the size and the percentage of the incorporated fine particles, as well as on their distribution in the metallic matrix [1-3]. This work focuses on the development of a novel Zn-alloy-composite coating, i.e. the coating that will benefit from the insertion of both an additional metal and a ceramic particle into the zinc matrix.

THE AIM OF THE WORK: probing the electrodeposition of $Zn\text{-}Mn/Al_2O_3$ composite coatings from chloride bath and characterizing the obtained coatings in terms of their morphology and corrosion resistance.

EXPERIMENTAL

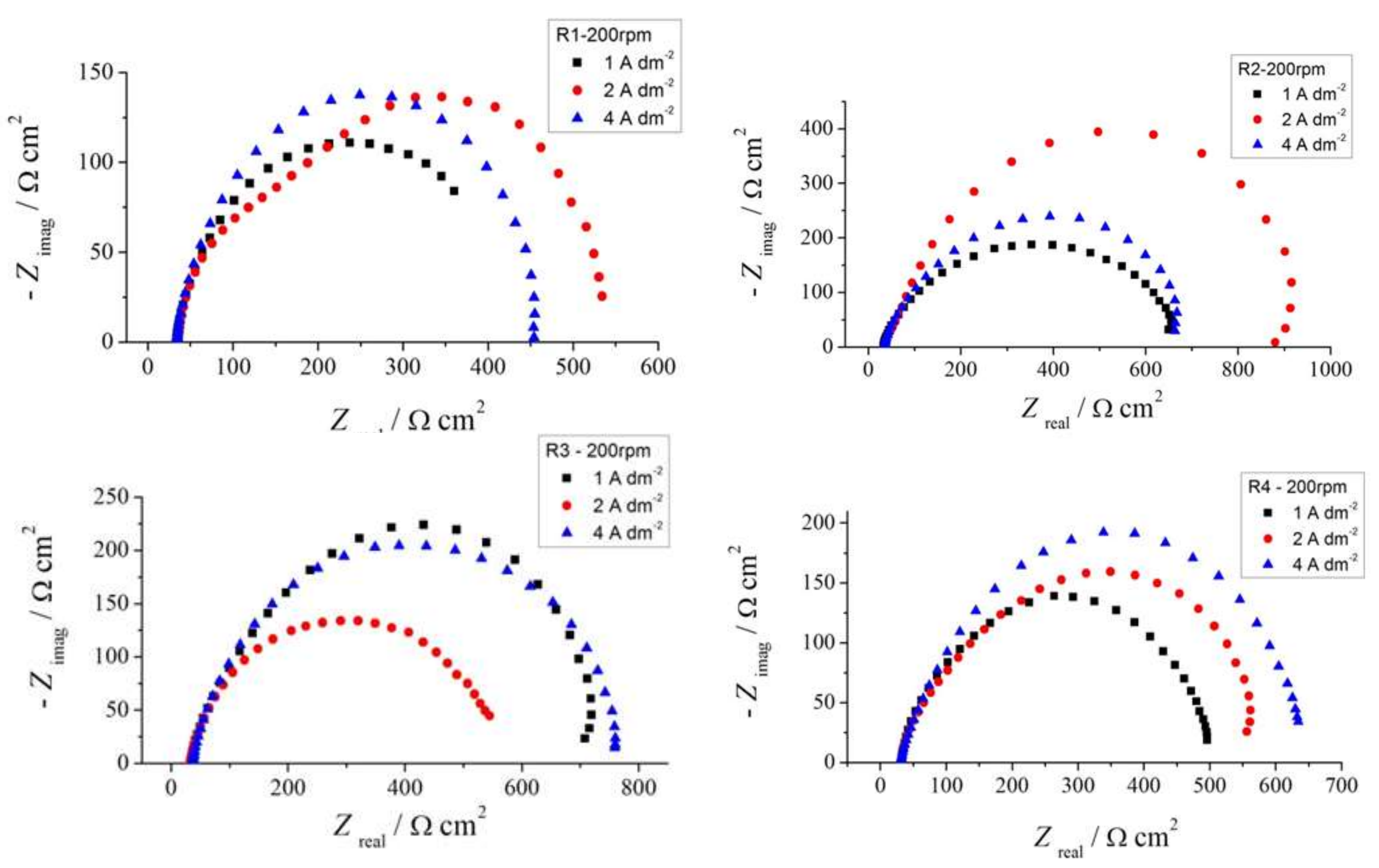
- **Plating parameters:** chloride additive-free plating baths, temperature of 25 ºC, deposition current density: 1-5 A dm^{-2}, agitation: magnetic stirring, ultrasound, Al_2O_3 particles: 300 nm, 10 µm
- **SEM/EDX, EIS, polarization measurements:** chemical content, morphology, corrosion resistance in 3% NaCl

RESULTS AND DISSCUSION

Influence of $Mn^{2+} : Zn^{2+}$ ion ratio in the bath

Plating bath	R1 (mol·dm^{-3})	R2 (mol·dm^{-3}) $[Mn^{2+}]:[Zn^{2+}]=1:1$	R3 (mol·dm^{-3}) $[Mn^{2+}]:[Zn^{2+}]=1:2$	R4 (mol·dm^{-3}) $[Mn^{2+}]:[Zn^{2+}]=2:1$
KCl	3	3	3	3
H_3BO_3	0,42	0,42	0,42	0,42
$ZnCl_2$	0,45	0,45	0,45	0,45
$MnCl_2x4H_2O$	-	0,45	0,25	0,9
Al_2O_3	1,00	1,00	1,00	1,00
10 µm Al_2O_3 magnetic stirring, 1-4 A dm^{-2}				

Electrochemical impedance spectroscopy



Morphology (optical images) : R2

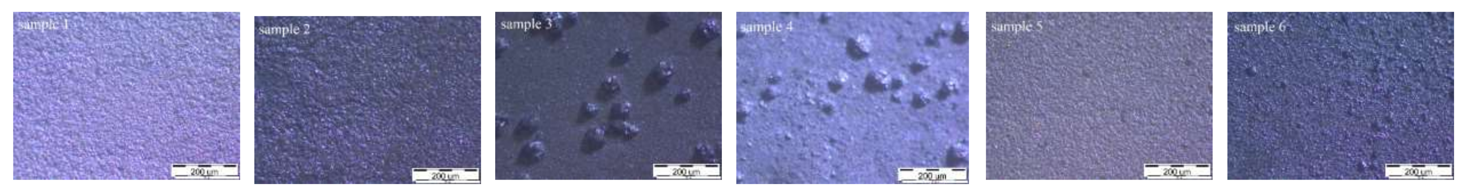
1 A dm^{-2} 2 A dm^{-2} 4 A dm^{-2}

Chemical content
Mn: 0,075 – 1,0 wt %
Al: 0,14 - 4,0 wt. %

R2, R3, 4 A dm^{-2}: the highest corrosion stability
4 A dm^{-2} the most homogenous morphology

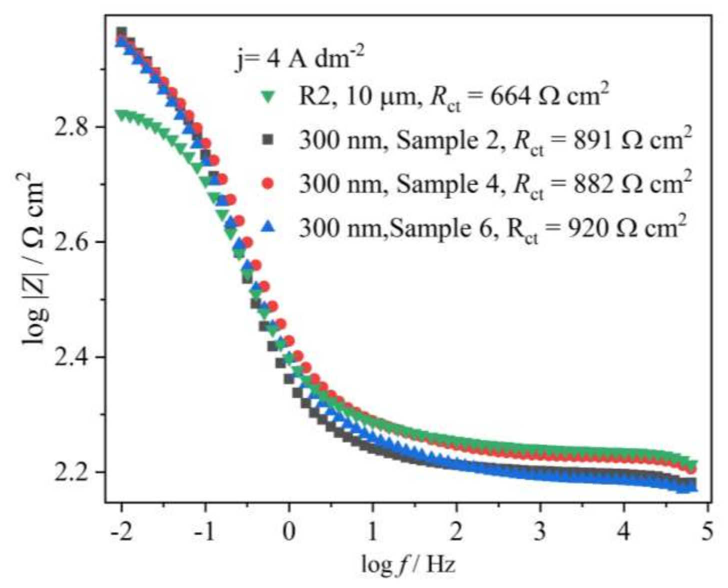
1:1 $Mn^{2+} : Zn^{2+}$, 300 nm Al_2O_3 particles

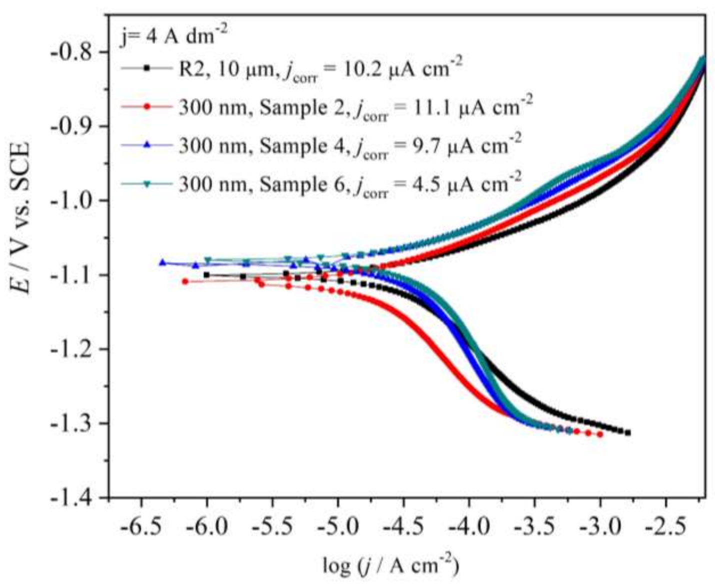
Sample No.	Deposition c.d.	Deposition conditions	wt.% Mn	wt.% Al	calculated wt.% Al_2O_3	wt.% O
1	5 A dm^{-2}	magnetic stirrer	5.8	0	0	12.2
2	4 A dm^{-2}		5.2	0	0	11.5
3	5 A dm^{-2}	magnetic stirrer + Al_2O_3	5.3	2.6	4.8	13.8
4	4 A dm^{-2}		4.7	2.4	4.5	11.0
5	5 A dm^{-2}	ultrasound + Al_2O_3	5.9	1.0	1.8	12.8
6	4 A dm^{-2}		4.9	0.7	1.3	9.7



Optical images: all samples showed non-porous and compact structure formed by dissimilar grains

Comparison of corrosion performance of the coatings with alumina particles of different dimensions (10 µm or 300 nm)





Conclusions:
The optimal parameters:
- **300 nm Al_2O_3 particles**
- **$[Mn^{2+}]:[Zn^{2+}]=1:1$**
- **ultrasound agitation**
- **deposition c.d 4 A dm^{-2}**

References
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