Electrochemical Deposition of Ni/$Ti_3C_2T_x$ MXene Nanocomposite Coatings from a Boric Acid–Free Electrolyte

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Introduction

Electrochemical co-deposition was performed with direct current plating method at j= 1 A·dm^{-2} under controlled bath conditions (43–45 °C, pH 4.5) using a boric-acid free Ni-based electrolyte with $Ti_3C_2T_x$ MXene concentration varying between 0.2 and 1.0 g/L. The Ni/$Ti_3C_2T_x$ bath dispersion stability was studied with DLS. The mechanical properties of the plated nanocomposites were evaluted by microhardness and wettability tests. The structural and moprhological characteristic of the coatings were determined by SEM-EDS, XRD. Tafel polarization test and EIS was applied to get insights into the corrosion properties of the nanocomposites.

Dispersion analysis

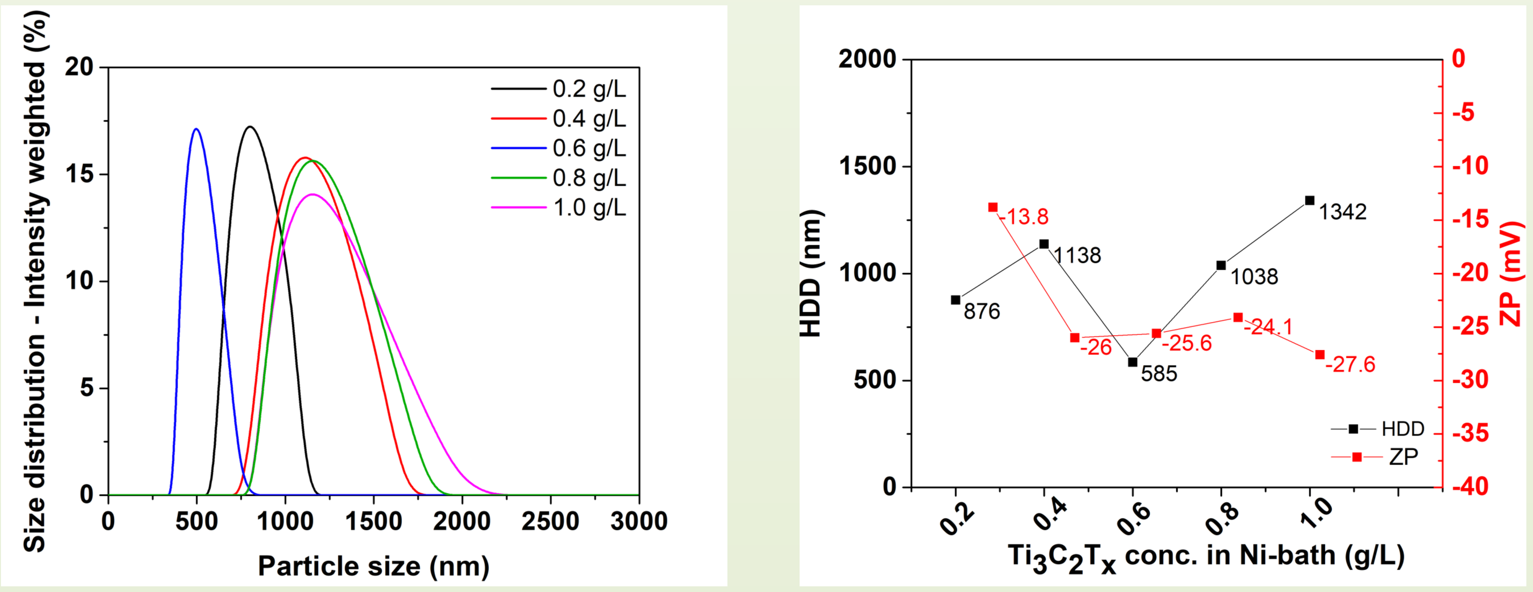


Figure 1. Particle size distribution (left) and HDD-ZP(right) of $Ti_3C_2T_x$ with SDS (ratio:1:2) in a Ni-bath.

Mechanical properties

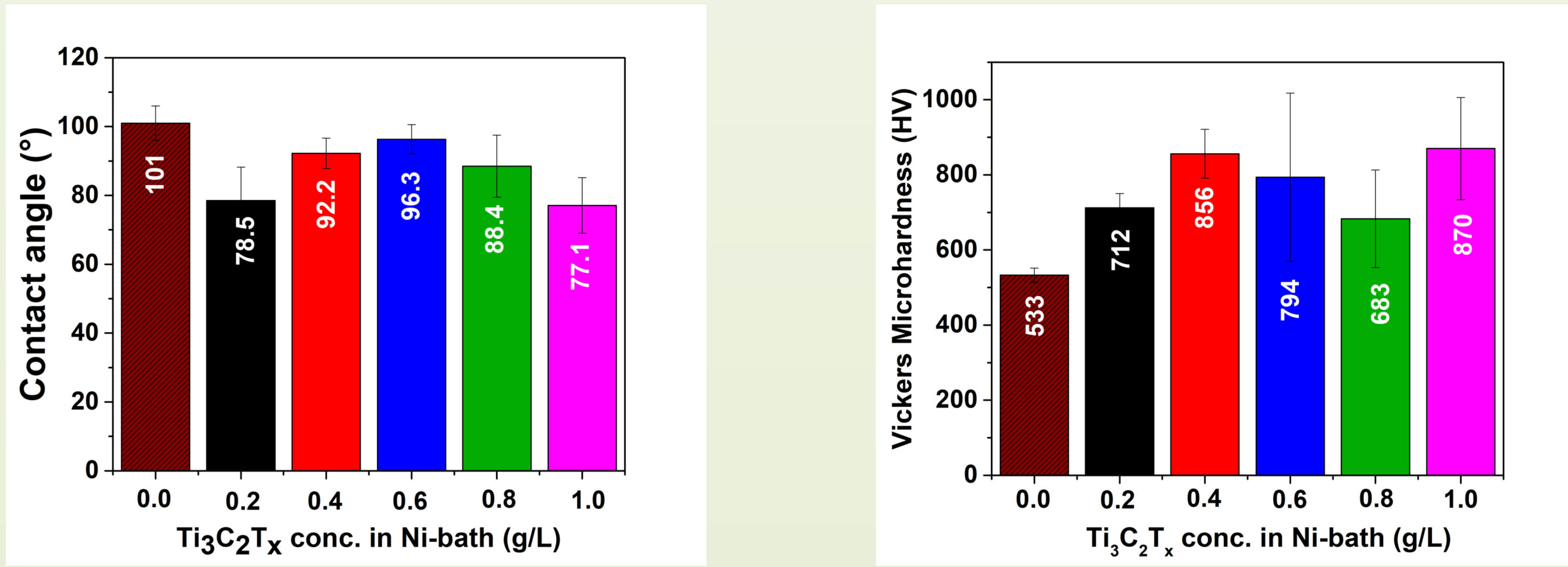


Figure 2. Contact angle (left) and Vickers hardness (right) with different concentrations of $Ti_3C_2T_x$ in the Ni-bath.

Structural, morphological and composition analysis

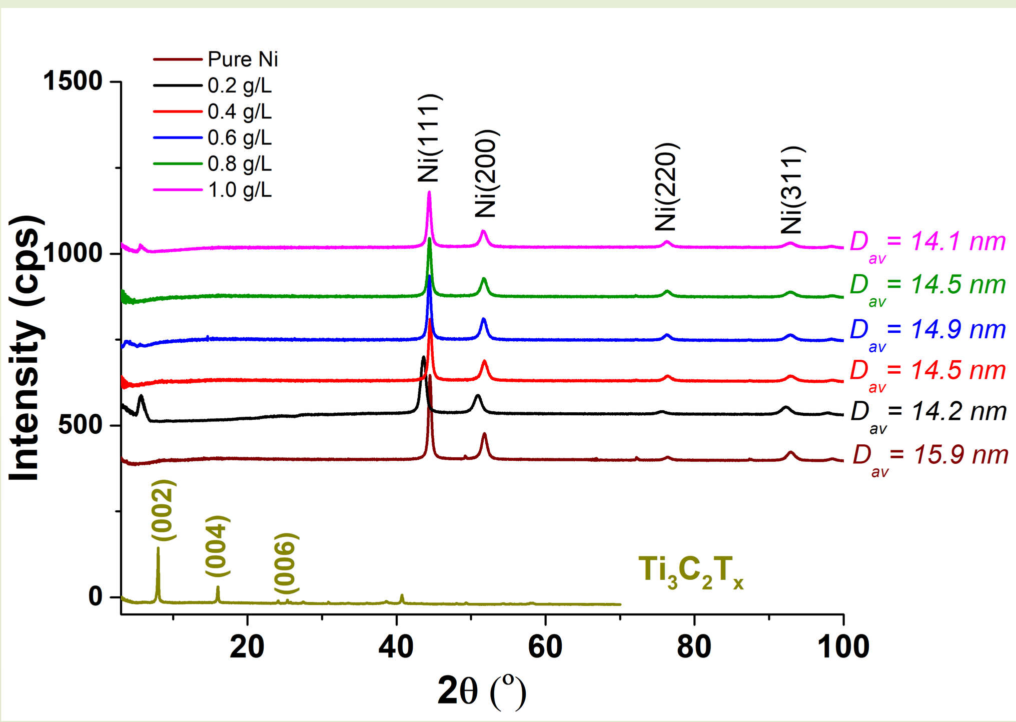
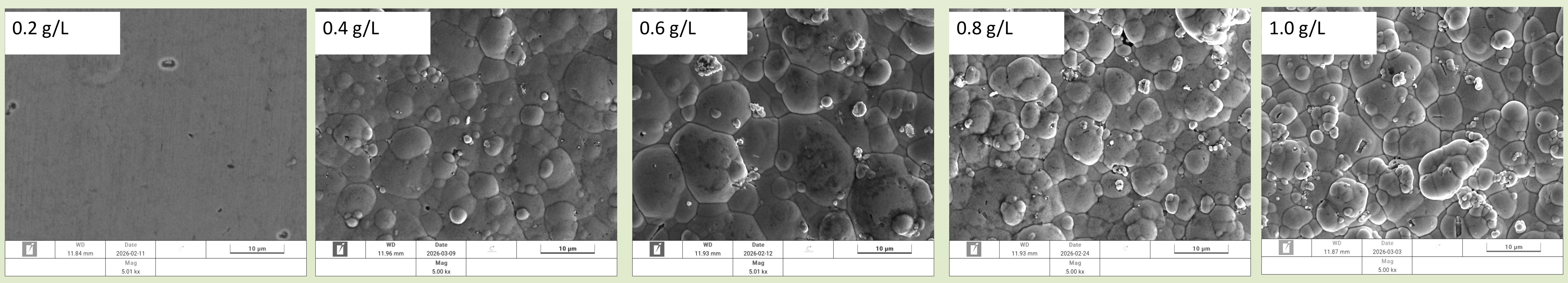


Figure 3. XRD-patterns of $Ti_3C_2T_x$, Ni and Ni/ $Ti_3C_2T_x$ nanocomposites with average Ni-crystallite sizes.



0.2 g/L	0.4 g/L	0.6 g/L	0.8 g/L	1.0 g/L
EDS-map analysis	EDS –map analysis	EDS-map analysis	EDS-map analysis	EDS-map analysis
Ni – 100.0 wt%	Ni – 92.0 wt%	Ni – 96.0 wt%	Ni – 96.7 wt%	Ni – 94.2 wt%
Ti – 0.0 wt%	Ti – 8.0 wt%	Ti – 4.0 wt%	Ti – 3.2 wt%	Ti – 5.8 wt%

Figure 4. SEM-EDS analysis of Ni/ $Ti_3C_2T_x$ nanocomposites with different concentrations of $Ti_3C_2T_x$ in the Ni-bath.

- **XRD**: Ni(111) is the preferred Ni-orientation. $Ti_3C_2T_x$ slightly reduced average Ni-crystallite sizes
- **SEM:** by increasing the conc. of $Ti_3C_2T_x$ in the bath the surface tends to be more porous
- **EDS:** ≥0.4 g/L indicating the presence of Ti in the Ni/$Ti_3C_2T_x$ coating

Electrochemical evaluation

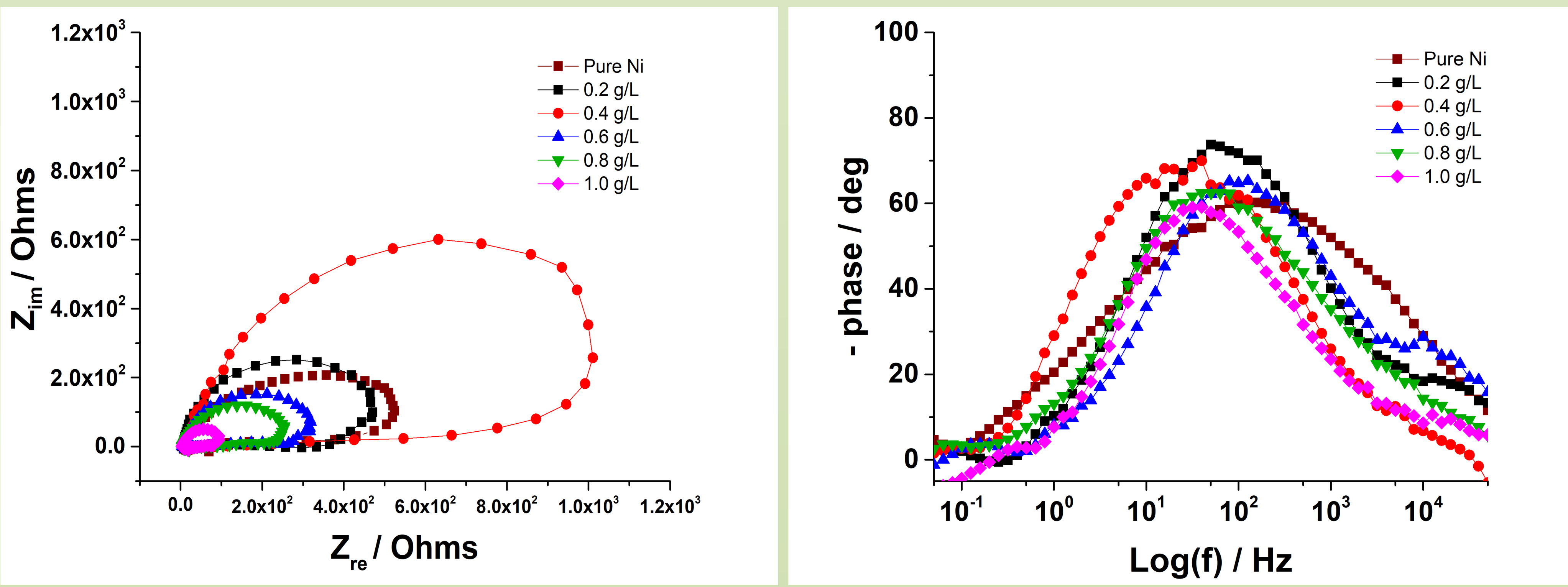


Figure 5. Nyquist plots (left) and Bode phases(right) of Ni/ $Ti_3C_2T_x$ nanocomposites recorded in 3.5% NaCl.

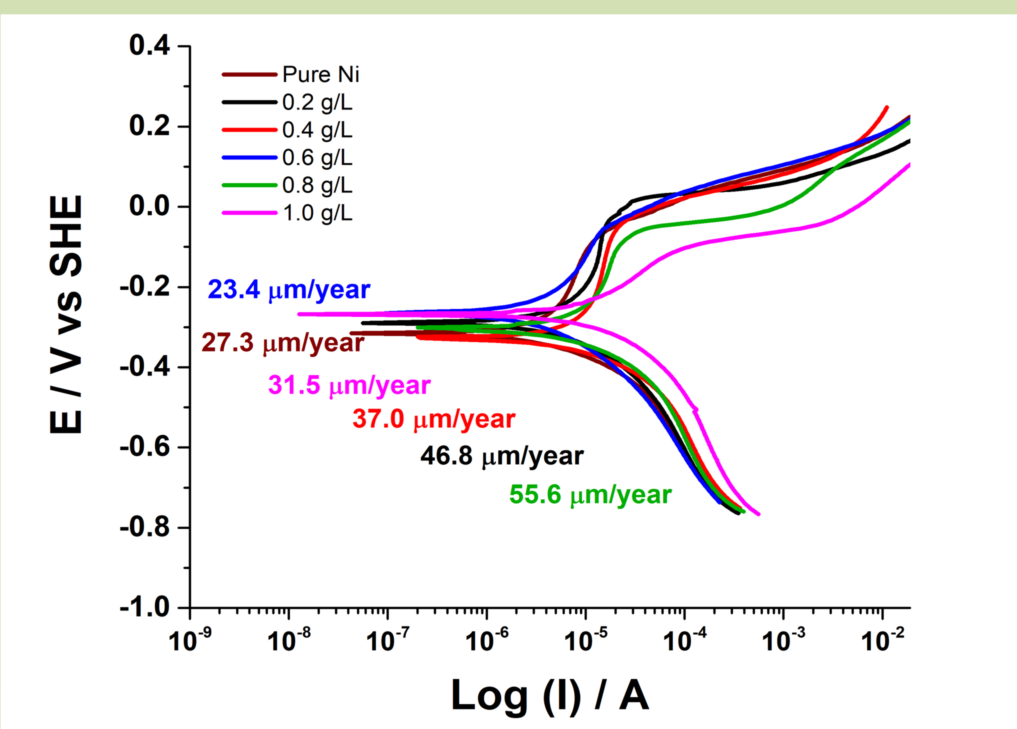


Figure 6. Tafel plots with calculated corrosion rates of Ni/ $Ti_3C_2T_x$ nanocomposites recorded in 3.5% NaCl.

- **EIS:** best at 0.4 g/L
- ✓ best barrier,
- ✓ compact coating
- **Tafel:** best at 0.6 g/L
- ✓ highest electrochemical stability
- ✓ better conductivity
- Overall best conc.: 0.6 g/L

Conclusions

- Between 0.4-1.0 g/L $Ti_3C_2T_x$ in the boric-acid free Ni-bath, the addition of SDS improved the colloidal stability of the dispersion|(ζ-potential|=26-28 mV).
- The presence of $Ti_3C_2T_x$ in the coating increases microhardness (up to 870 HV at 1.0 g/L) and enhances surface hydrophilicity compared to pure Ni.
- The preferred Ni-orientation is Ni(111) in all Ni/$Ti_3C_2T_x$ nanocomposite coatings.
- By increasing the $Ti_3C_2T_x$ conc. in the bath lead to more porous surface structure of the Ni/$Ti_3C_2T_x$ coatings.
- The EDS analysis confirmed the co-deposition of $Ti_3C_2T_x$ into the Ni-coating.
- The EIS results indicated that 0.4 g/L $Ti_3C_2T_x$ concentration in the bath resulted the most compact coating with largest charge transfer resistance.
- The coating plated from Ni-bath with 0.6 g/L $Ti_3C_2T_x$ displayed the lowest corrosion rate at 23.4 μm/year.

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References

[1] Tseluikin, et. al (2023). Study of Electrodeposition and Properties of Composite Nickel Coatings Modified with Ti3C2TX MXene. Coatings, 13(6), 1042.
[2] Fan, et. al (2023). Effect of Sodium Dodecyl Sulfate on Stability of MXene Aqueous Dispersion. Advanced Science, 10(24), 2300273.