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HYDROTHERMAL SYNTHESIS OF $ZnTa_2O_6$, $ZnNb_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ PSEUDO-BINARY OXIDE NANOMATERIALS WITH ANTICORROSIVE PROPERTIES

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Abstract

$ZnTa_2O_6$, $ZnNb_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ pseudo-binary oxide nanomaterials were synthesized through the hydrothermal method at 250° C. Obtained materials were characterized by X-ray diffraction, UV-VIS measurements, field emission-scanning electron microscopy and atomic force microscopy techniques. The anticorrosion characteristics of the obtained compounds were also evaluated after deposition on carbon steel in 0.5 M Na_2SO_4 media by open circuit potential measurements and potentiodynamic polarization technique with Tafel representation.

Aims

The present study presents the obtaining of $ZnTa_2O_6$, $ZnNb_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ pseudo-binary oxides nanomaterials by using the hydrothermal method at 250 ºC. Also, are presented results regarding structural, morphological, topographical and optical characterizations of the named materials, and the results regarding the corrosion inhibition efficiency for each obtained nanomaterial evaluated in 0.5 M Na_2SO_4 media.

Methods and Results

The hydrothermal synthesis method was used to obtain the pseudo-binary oxide nanomaterials type: $ZnTa_2O_6$, $ZnNb_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$. The used starting materials during the synthesis, in a molar ratio of 1 :1, were listed in Table 1. The pH values of the synthesis were fixed at 13, using NaOH (97%, Merck), resulting an alkaline medium. The prepared mixtures for the syntheses were heated in teflon autoclaves at 250 oC for 12 hours.

Table 1. The starting materials used to obtain pseudo-binary oxide nanomaterials.

The pseudo-binary oxide nanomaterial	Precursor 1	Precursor 2	Molar ratio
$ZnTa_2O_6$	$Zn(CH_3COO)_2$ x $2H_2O$ (98%, Sigma-Aldrich)	Ta_2O_5 (99% Sigma-Aldrich)	1 :1
$ZnNb_2O_6$		Nb_2O_5 (99%, Merck)	
$MgTa_2O_6$	$Mg(CH_3COO)_2$ x $4H_2O$ (99%, Sigma-Aldrich)	Ta_2O_5 (99% Sigma-Aldrich)	
$MgNb_2O_6$		Nb_2O_5 (99%, Merck)	

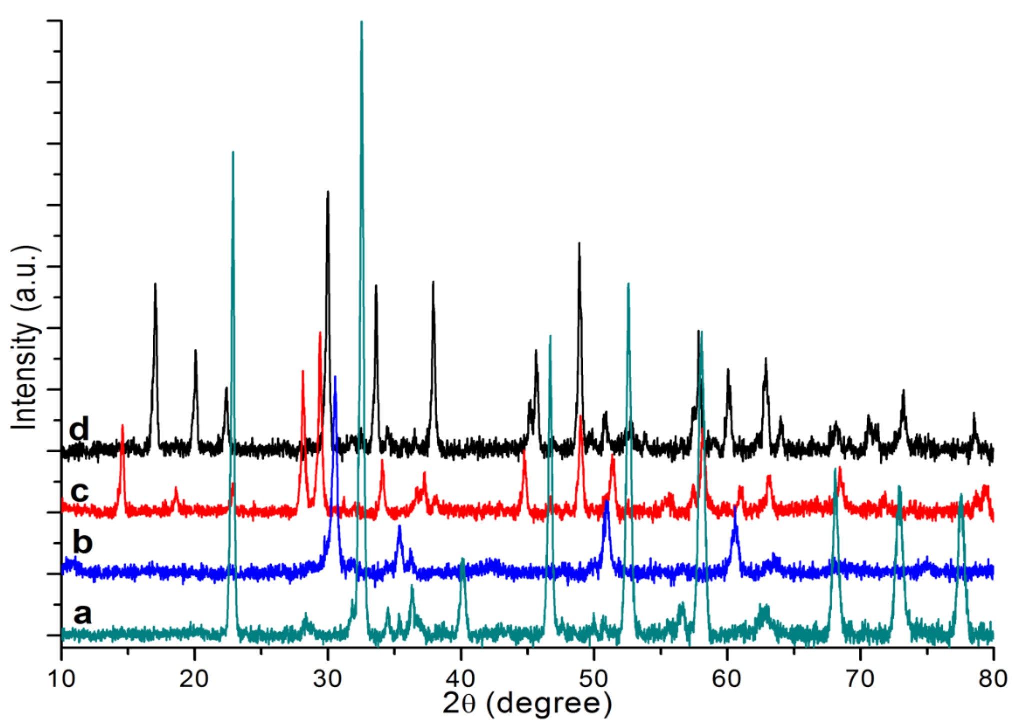

Figure 1. The XRD patterns of: (a) $ZnTa_2O_6$, (b) $ZnNb_2O_6$, (c) $MgTa_2O_6$ and (d) $MgNb_2O_6$ materials prepared through the hydrothermal method.

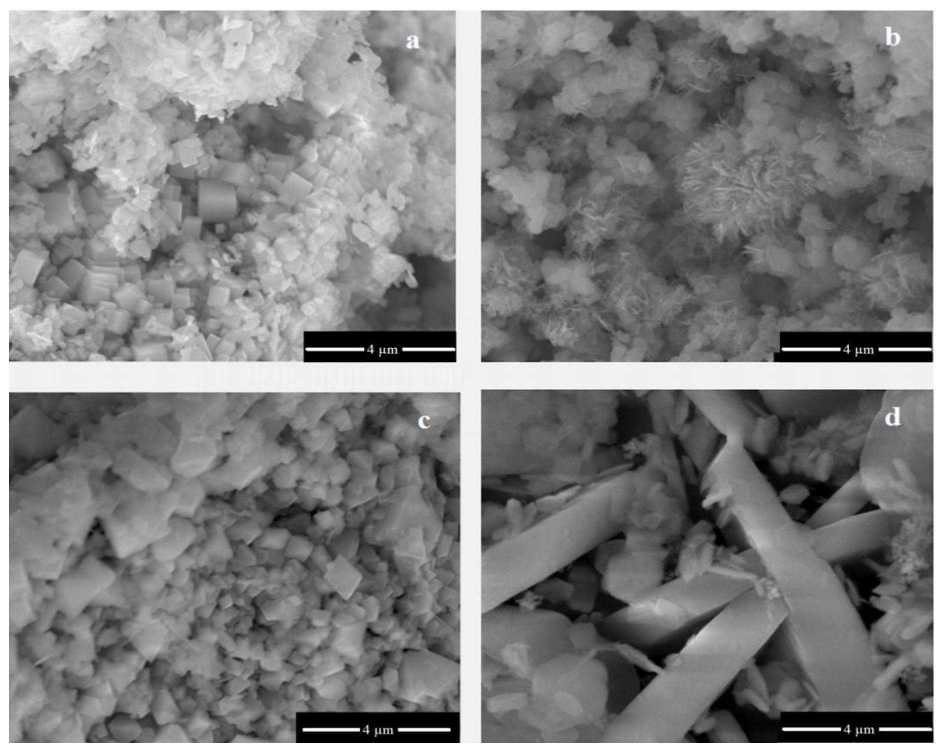

Figure 2. Scanning electron microscopy images for (a) $ZnTa_2O_6$, (b) $ZnNb_2O_6$, (c) $MgTa_2O_6$ and (d) $MgNb_2O_6$ nanomaterials.

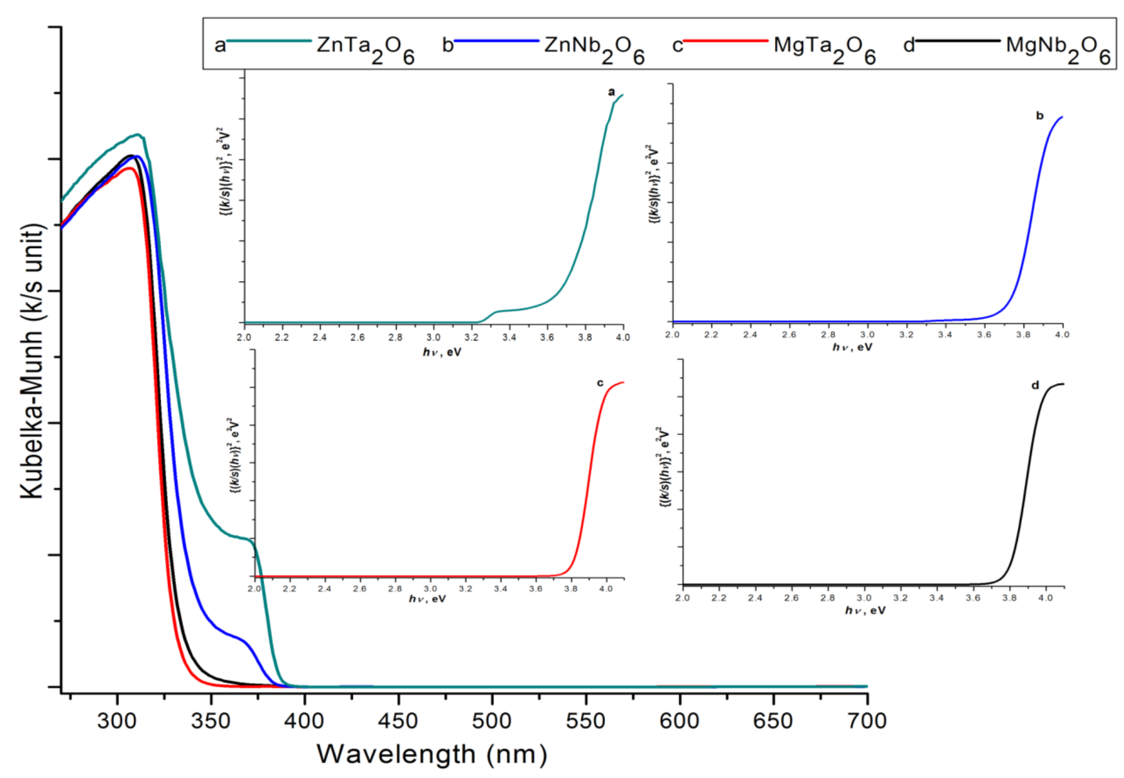

Figure. 3. Absorption spectra of (a) $ZnTa_2O_6$, (b) $ZnNb_2O_6$, (c) $MgTa_2O_6$ and (d) $MgNb_2O_6$nanomaterials. From the inset plot were obtained the optical band gaps.

It is to be mentioned that for the pseudo-binary oxide nanomaterials which contain Ta, are preserved cubic shapes beside irregular shapes (Figure 2 (a) and (c), while in the morphology of the pseudo-binary oxides with Nb content, the accicular shapes of the agglomerates is preserved (Figure 2 (b) and (d)).

From the absorption spectra (Fig. 3) can be observed the maximum absorption peak for each sample as it follows: 311 nm for $ZnTa_2O_6$, 311 nm for $ZnNb_2O_6$, 308 nm for $MgTa_2O_6$ and also 308 nm for $MgNb_2O_6$. The values are the same for the compounds containing Zn and also the same values for the compounds containing Mg, the presence of Nb or Ta does not seems to influence the absorption. the optical band gaps were estimated for the obtained materials as it follows: E_g ($ZnTa_2O_6$) = 3.6 eV, E_g ($ZnNb_2O_6$) =3.72 eV, E_g ($MgTa_2O_6$) = 3.8 eV and E_g ($MgNb_2O_6$) = 3.76 eV.

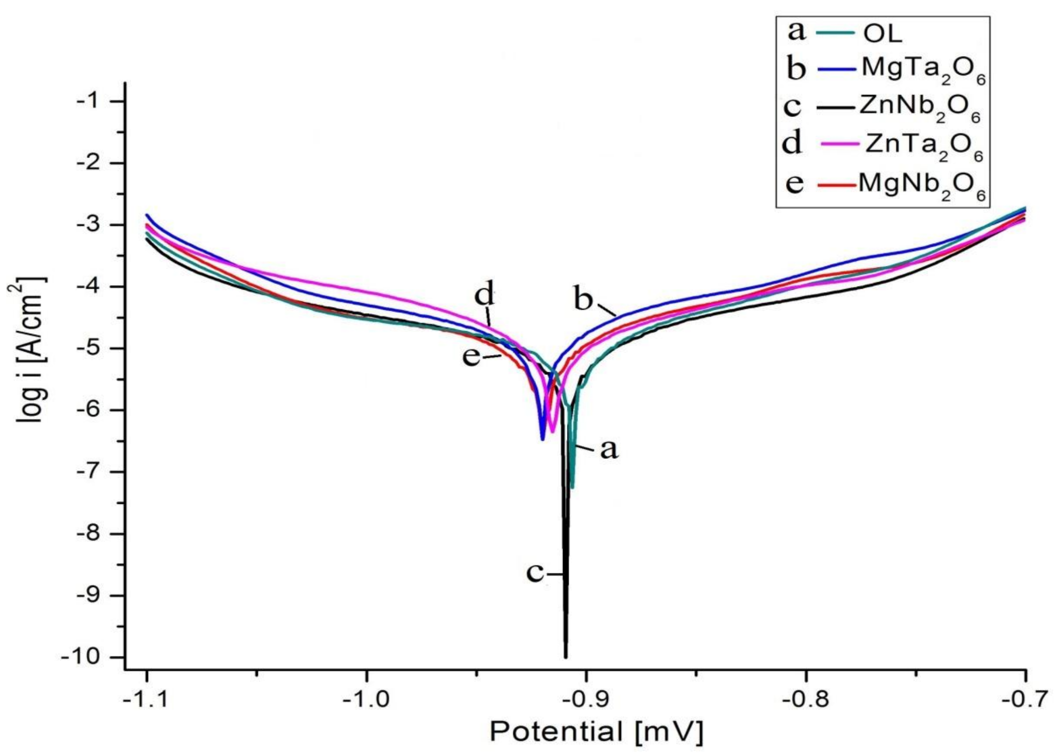

Figure 4. Tafel representation of polarization curves recorded in 0.5 M Na_2SO_4 for the studied electrodes: (a) OL, (b)$MgTa_2O_6$, (c) $ZnNb_2O_6$, (d) $ZnTa_2O_6$ and (e) $MgNb_2O_6$.

Table 2. Tafel parameters of the investigated electrodes after 30 minutes immersion in 0.5 M Na_2SO_4 solution.

Electrode	E_{corr} / V	i_{corr} / µA cm^{-2}	*Rp* / kΩ cm²	v_{cor} / µm Y^{-1}	*IE* / %
Bare OL	–0.916	24.08	1.53	104.1	–
$ZnTa_2O_6$	–0.908	10.53	1.98	45.54	56.27
$ZnNb_2O_6$	–0.922	15.17	1.31	65.59	37
$MgTa_2O_6$	–0.921	11.73	1.93	50.74	51.28
$MgNb_2O_6$	–0.910	9.83	2.36	42.52	59.17

As it can be seen in **Table 2**, where the calculated parameters from the Tafel plots are summarized, the corrosion potential (E_{corr}) of the OL electrode is -0.916 and the corresponding corrosion current density (i_{corr}) is 24.08 µA / cm². The polarization curves were shifted towards the region of lower corrosion current densities in thepresence of $ZnNb_2O_6$ and $MgTaO_6$ and the polarization curves shifted towards the region of higher corrosion current densities in the presence of $ZnTa_2O_6$ and $MgNb_2O_6$. The inhibition efficiencies (*IE*) were calculated : $ZnTa_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ were obtained values of *IE* over 50%.

Conclusion

$ZnTa_2O_6$, $ZnNb_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ pseudo-binary oxide nanomaterials were obtained through the hydrothermal synthesis method. The inhibition efficiency for the obtained materials was calculated and for $ZnTa_2O_6$, $MgTa_2O_6$ and $MgNb_2O_6$ nanomaterials were obtained values of *IE* over 50%. Taking into consideration that the tested materials containing Zn and Mg in combination with Ta and Nb did not completely satisfied our expectations, we believe that a further approach using materials containing Mn in combination with Ta and Nb will add a benefit to the efficiency of corrosion.

Acknowledgements

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