Balance between low corrosion rate and convenient conductivity for anodic applications

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MOTIVATION

The process of electro-dewatering (EDW) for sludge treatment is environmentally bearable, economically more convenient and permits the useful recovery of materials and energy. However, it presents a corrosion problem in their anodic parts that might reduce EDW process efficiency. Mixed metal oxides (MMO) coatings are well use as a solution for anodic parts of this technology. However, MMO coated anodes show a reduced corrosion resistant, what reduces its time of life in service.

The objective of this work is to define an alternative coating for using like an anode, ensuring a low corrosion rates balanced with a convenient conductivity for EDW process.

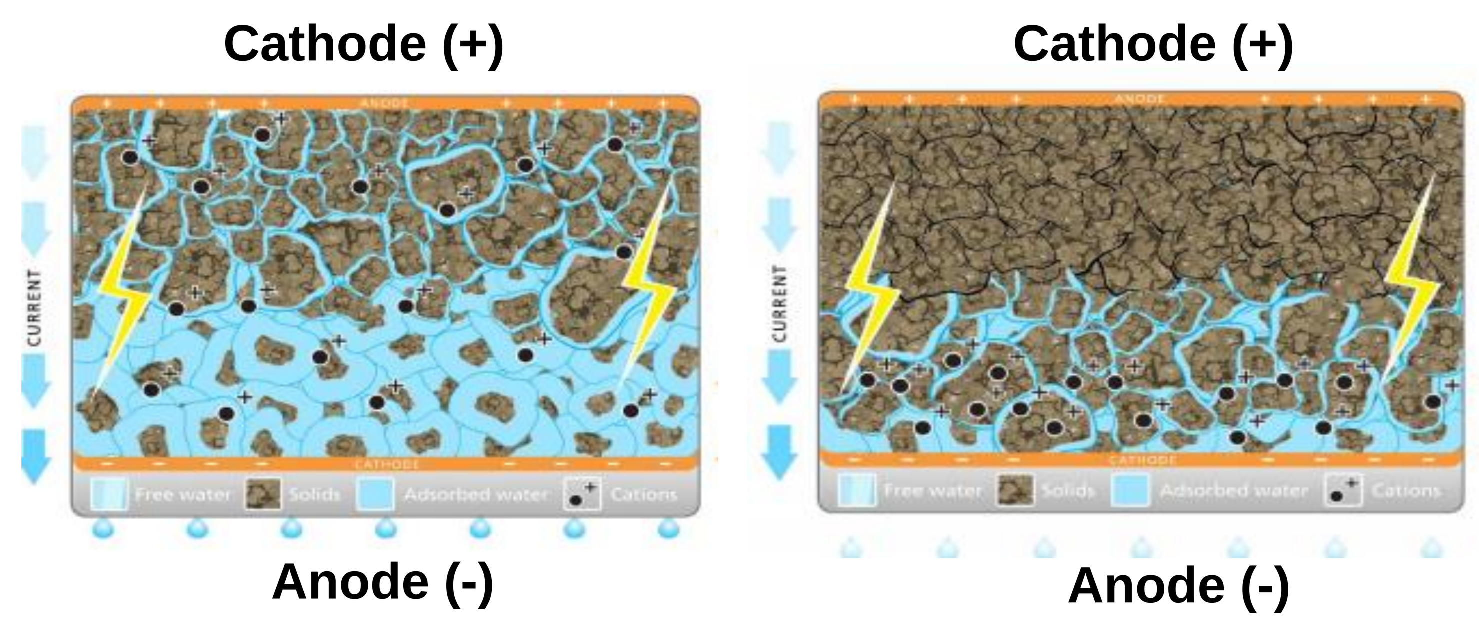

Figure 1. Electrodewatering process

EXPERIMENTAL METHODS

Several coatings were developed in 304 ss, 316 ss and Ti alloy, using magnetron sputtering physical vapor deposition (MS-PVD) based on two layers made of a first thin film of Ti and second thin film of transition metal deposition coating (based on Zr, Ta, Nb and Hf).

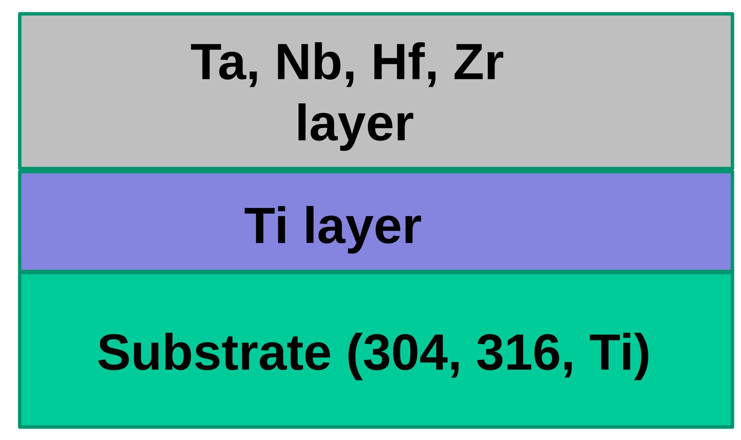

Figure 2. Scheme of the developed layers.

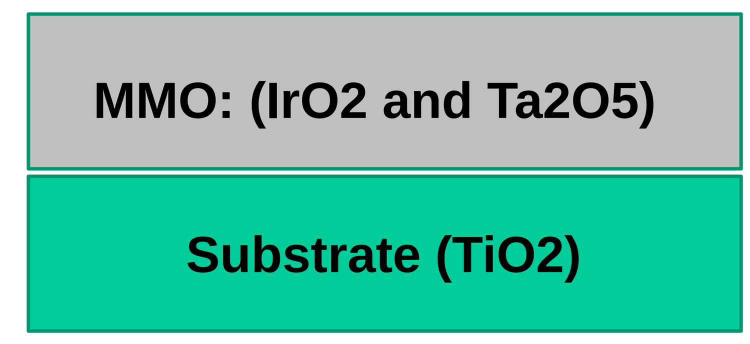

Figure 3. Scheme of the MMO coating configuration

Main parameters of the processes were similar in all of them: temperature (~350ºC), time of each layer (2h), vacuum chamber $8x10^{-3}$ mbar and power (80W).

Thickness of the metal coating depended on the sputtering rate of each metal.

Table 1. Thickness of the different layer configuration

Coatings	Ti	Zr	Nb	Ta	Hf	MMO
Thickness (nm)	250	250-350	800-900	1200-1500	1600-1800	2.800

EXPERIMENTS

For characterization of the coatings and substrates, 10 samples for each bilayer and substrate were made and compared with MMO coated commercial sample. Then, corrosion resistant characteristics were studied. Conductivity were measured in critic points of the cycle after five successive tests from the calculation of conductance. Electrochemical experiments tests, were controlled at pH 7.0 and 37C±0.2ºC, using slugde simulated as electrolyte by a Gamry system.

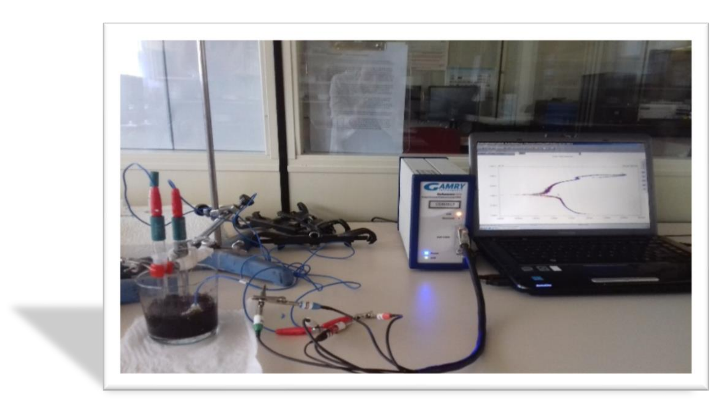

Figure 4 . Configuration of corrosion tests

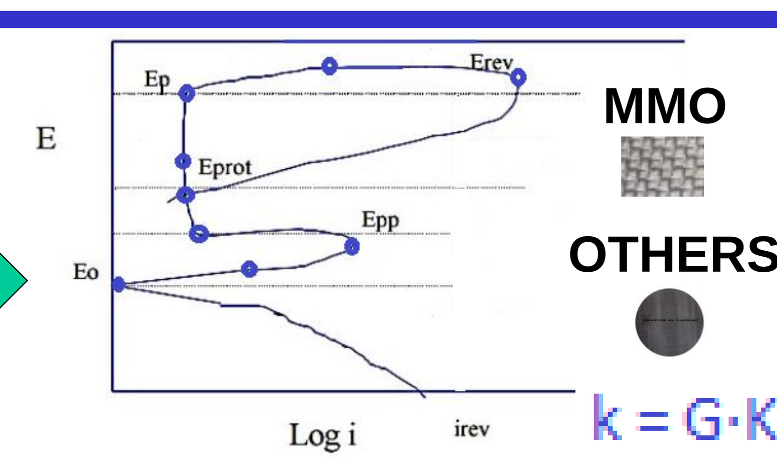

Figure 5 . Critic points selected for conductivity measurement

RESULTS AND DISCUSSION

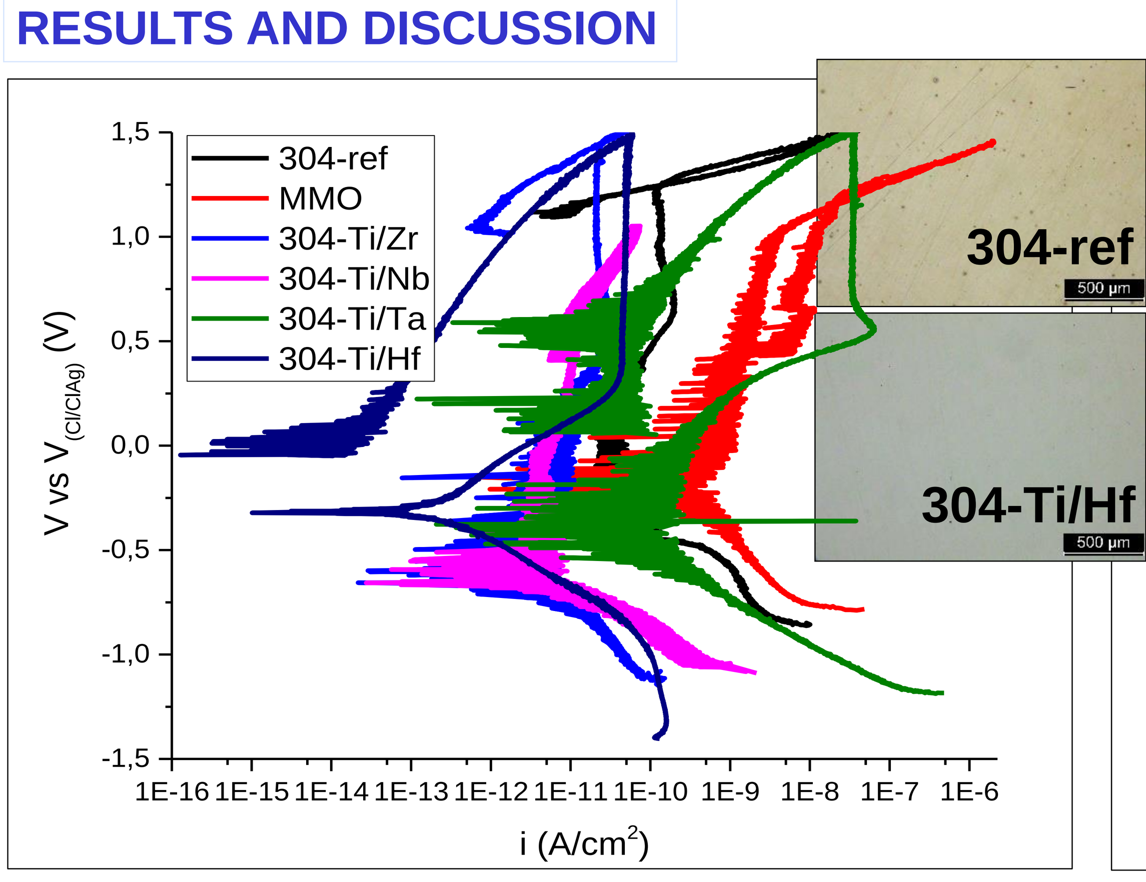

Figure 6. Polarization curves for 304ss base material

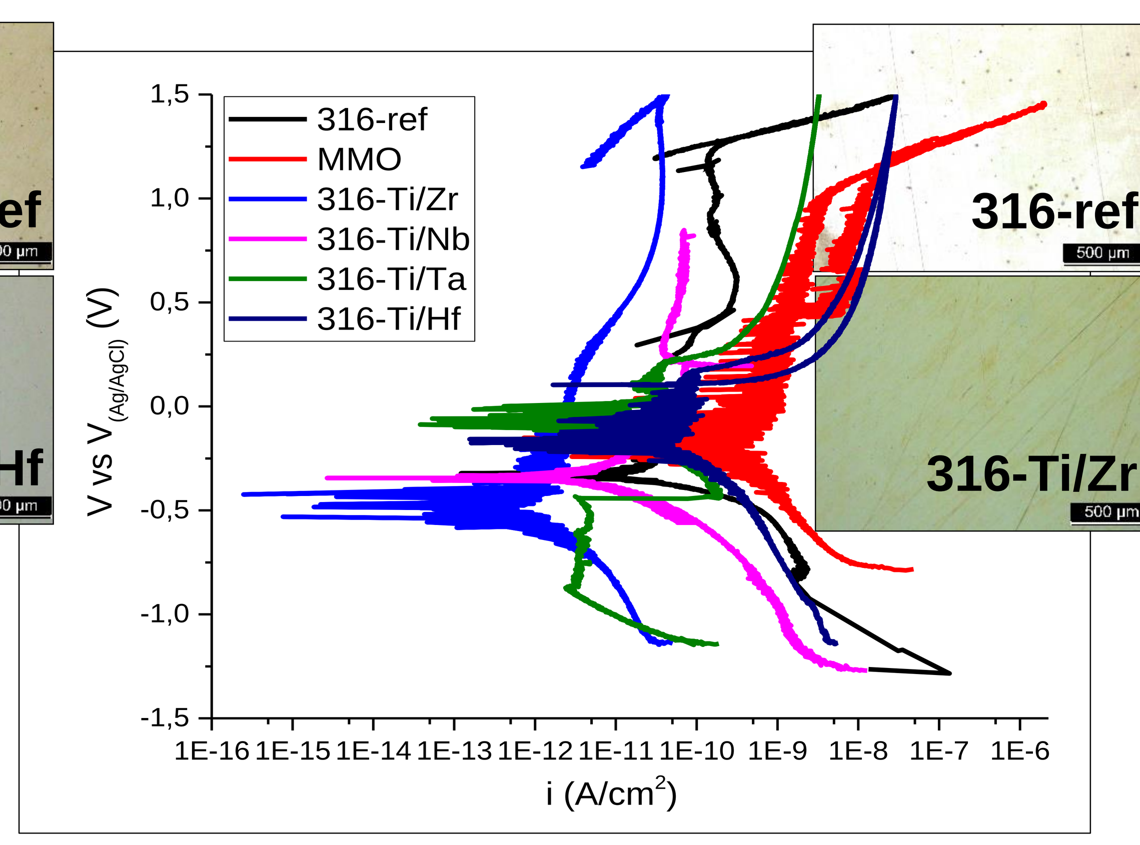

Figure 7. Polarization curves for 316ss base material

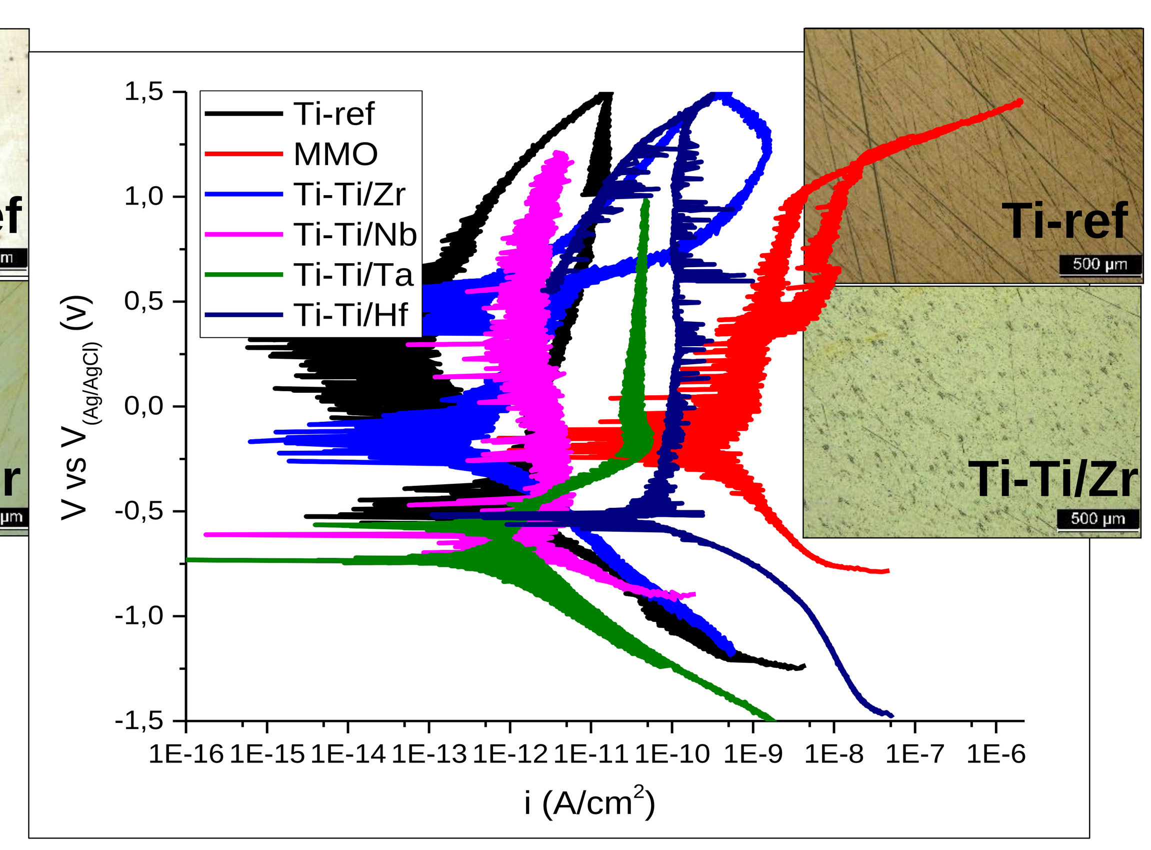

Figure 8. Polarization curves for Ti alloy base material

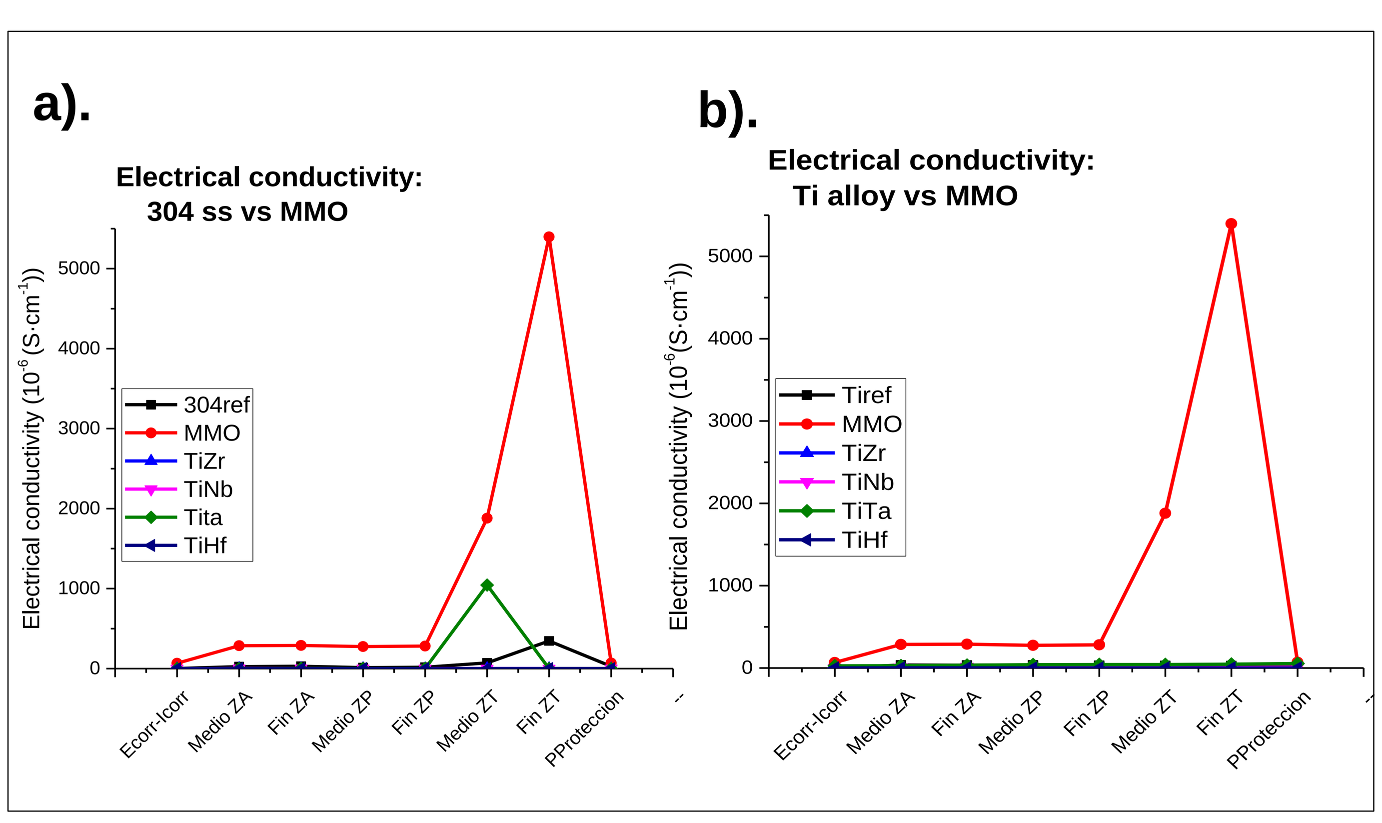

Figure 9 . Conductivity after five polarization cycles: a). 304 vs MMO, b). Ti alloy vs MMO

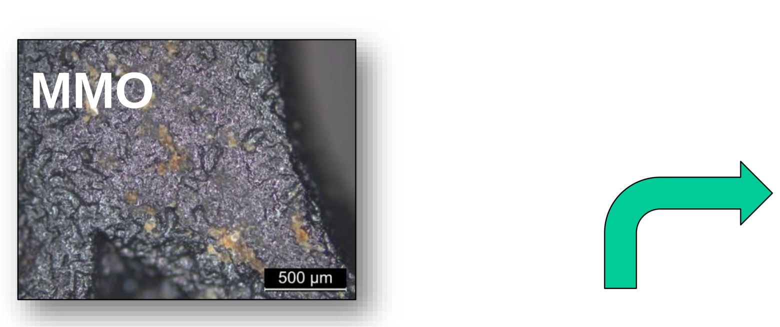

Table 2. Corrosion measurements: 316-Ti/Hf vs MMO

	MMO	316-Ti/Hf
Ecorr (mV)	112,0	-72,7
Icorr (A)	$25,0·10^{-6}$	$2,4·10^{-9}$
Ba (V/dec)	8,9	$514,3·10^{-3}$
Bc (V/dec)	$174,1·10^{-3}$	$248,1·10^{-3}$
Vcorr (mm/year)	$6,0·10^{-2}$	$5,7·10^{-4}$

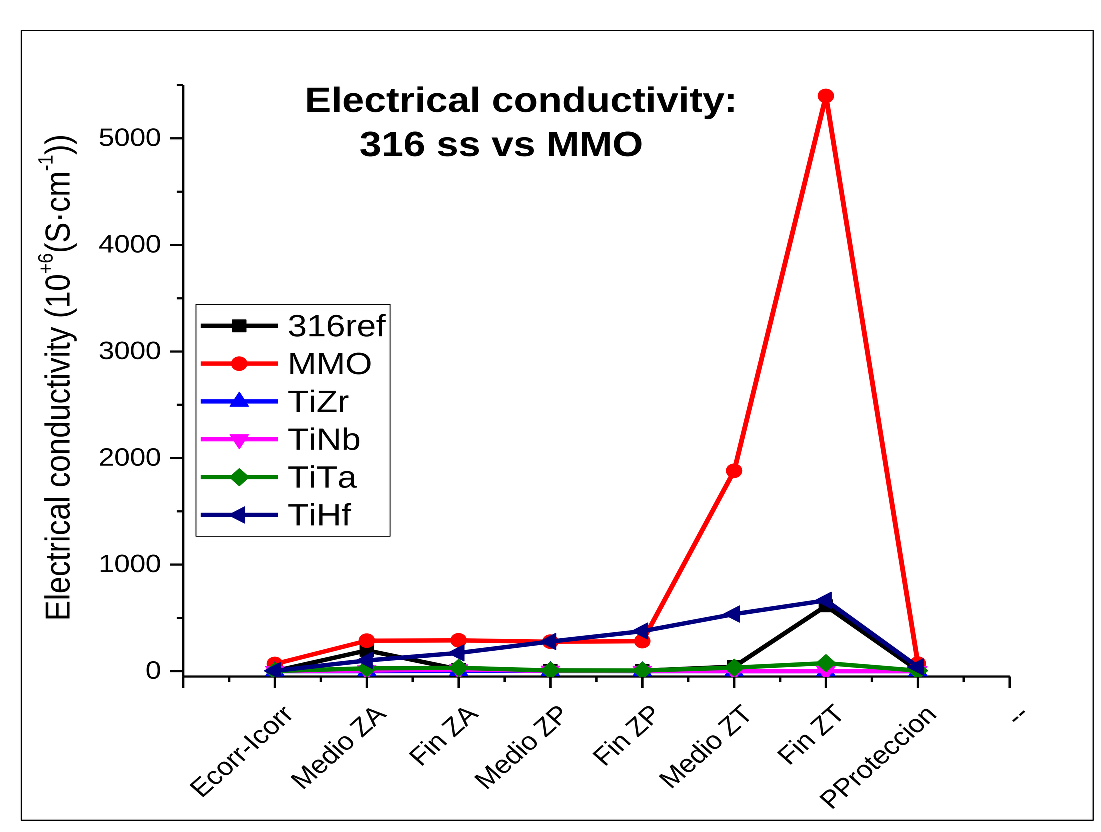

Figure 10 . Conductivity after five polarization cycles (316 vs MMO)

CONCLUSIONS

1. Corrosion decreases the electrical conductivity of the material after five polarization cycles.
2. Several coatings base on Ti and the transition metal coating (Zr, Nb, Hf or Zr) on 304 ss, 316 ss and Ti alloy, show better corrosion behaviour in comparison to MMO commercial simples.
3. Working between -1.5 and 1.5 V during EDW process we can sure that using a Ti/Hf coated 316 anode the conductivity of it is similar like MMO commercial anode but with an improved corrosion protection, a corrosion rate reduction of four times in comparison to MMO commercial. anode.

ACKNOWLEDGEMENTS

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REFERENCES

1. Paolo Gronchi, et al., 'Electrode surface treatments in sludge electro-osmosis dewatering', Materials and Manufacturing Processes. 32, 11, 2017.
2. Simone Visigalli et al., 'Performance of electro-osmotic dewatering on different types of sewage sludge', Environmental Research, 157:30-36, 2017.
3. C. Díaz et al., 'Reduction of corrosion current of CoCralloys by post-PIII oxidation', Surf. & Coat, 256, 59-63, 2014.
4. Mohd Anas Mohd Sabri et al., 'Effect of corrossion on the electrical conductivity of metals and polymer composite', Sciences and Engineering, 59:81–85, 2012.5.
5. Mohamad Najmi Masri et. al., 'Electrical conductivity and corrosion protection properties of conductive paint coatings', Anti-Corrosion Methods and Materials, 54:204-208, 2010.