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Corrosion study in artificial saliva of dental alloys based on cobalt and chromium, using electrochemical stationary methods and EIS

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HAL Authorization

Xin Li¹, Patrice Berthod^{1,2}, Estelle Kretz¹

¹Faculty of Science and Technologies, University of Lorraine, 54500 Vandœuvre-lès-Nancy, France

²Institut Jean Lamour, 2 allée André Guinier, Campus Artem, University of Lorraine, 54000 Nancy, France

patrice.berthod@univ-lorraine.fr

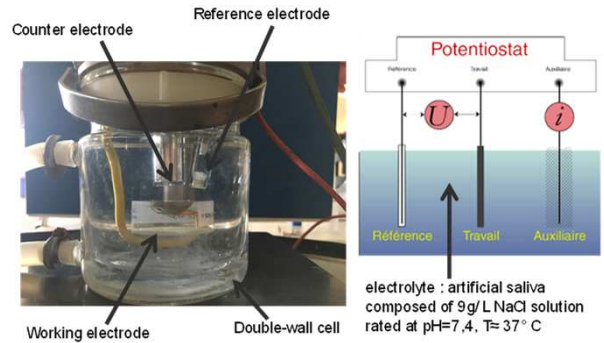
Faculté des Sciences et Technologies

INSTITUT JEAN LAMOUR

Dental cobalt alloys devoted to the constitution of frameworks strengthening fixed partial dentures may be based on cobalt and chromium but other elements such as tungsten, molybdenum and silicon, for example, can be also present in their chemical composition for mechanical reasons. In contrast with the alloys of the High Noble and Noble categories which are rich in gold or platinum, these cheaper alloys may be threatened by corrosion. The topic of this work is to characterize the electrochemical behavior, in a NaCl 9g/L aqueous solution rated at pH=7.4 and T=37°C, of six alloys based on cobalt and containing 25 wt.%Cr, with special focus on the effect of the presence of W (2.5, 5 and 7.5 wt.%), Mo (5 wt.%) and/or Si (1 wt.%) with contents typical of the ones of commercial dental alloys. The six alloys were all elaborated by high frequency induction foundry under inert atmosphere. The stationary electrochemical tests were driven according to the Stern-Geary and Tafel methods, or following the cyclic polarization technique. Electrochemical Impedance Spectroscopy was also applied.

Experimental

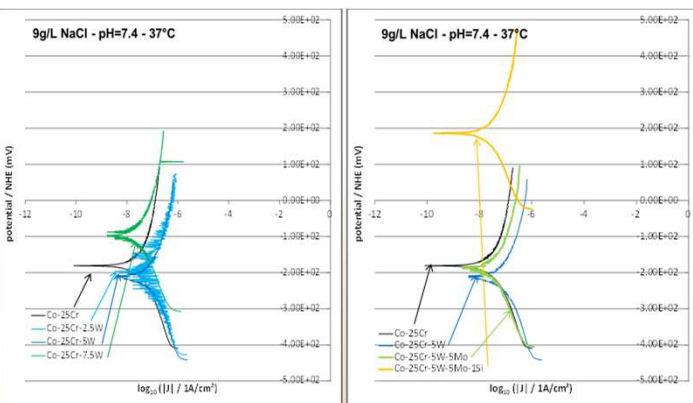
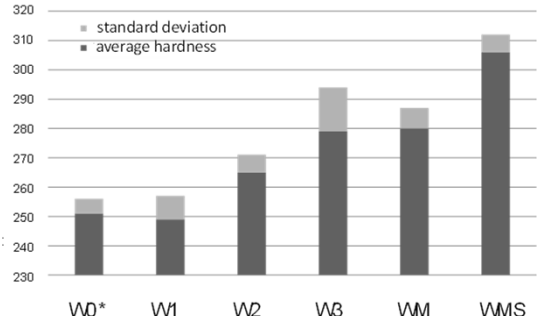
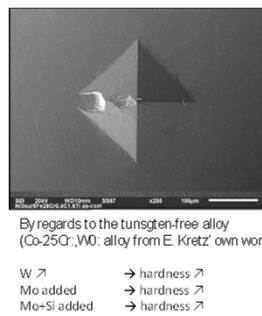
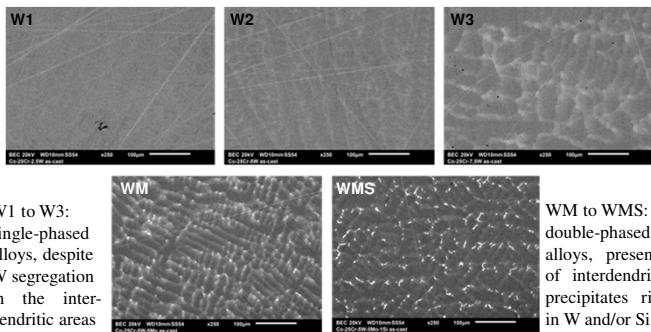
Alloy name	Weight fractions of elements
W1	72.5%Co-25%Cr-2.5%W
W2	70%Co-25%Cr-5%W
W3	67.5%Co-25%Cr-7.5%W
WM	65%Co-25%Cr-5%W-5%Mo
WMS	64%Co-25%Cr-5%W-5%Mo-1%Si



Five cobalt-based alloys synthesized by high frequency induction melting

Mounted as electrodes; subjected to electrochemical stationary methods and impedance spectroscopy for studying the corrosion behavior in a reconstituted buccal milieu, after a 2h-immersion at free potential

Results



Alloy	β_a (mV/decade)	β_c (mV/decade)	E_{corr} (mV/NHE)	i_{corr} ($\mu A/cm^2$)
W0	164	261	-182	0.031
W1	104	112	-196	0.026
W2	172	213	-213	0.073
W3	181	241	-98	0.033

Alliage	β_a (mV/decade)	β_c (mV/decade)	E_{corr} (mV/NHE)	i_{corr} ($\mu A/cm^2$)
W0	164	261	-182	0.031
W2	172	213	-213	0.073
WM	185	219	-194	0.038
WMS	184	220	-181	0.028

EIS results

$R_p = R_t$ since R_e extremely low

The R_t or R_p of the (W1, W2) alloys are, in all cases, lower than the (W3, WM, WMS) ones

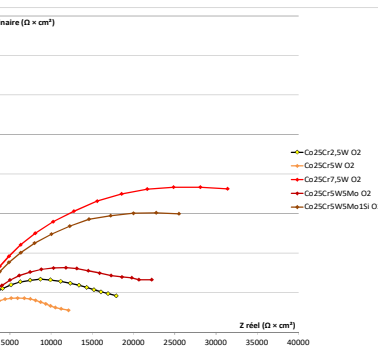
For the medium half circles, R_t & R_p vary from $10k\Omega \cdot cm^2$ (for W1 and W2) to $15-35k\Omega \cdot cm^2$ (for W3, WM and WMS)

Double layer capacity: no systematic differences: all around 2×10^{-5} Farad / cm^2



Tafel runs:

- No systematic variation versus the W content (but 5wt.%W seems particularly deleterious)
- Adding Mo and/or Si seems lowering corrosion of the 5wt.%W-containing ternary alloy
- all corrosion current densities lower than 100nA/cm²



EIS runs:

- Half circles not completed for 1Hz to 100kHz
- Poor reproducibility of EIS for a given alloy (from five runs for each of them)
- R_t ranging from 10 to 35kΩ·cm²
- C_{dl} staying around 2×10^{-5} Farad/cm²

Conclusion

The presence and content of tungsten and silicon in the studied alloys have indisputable effects on the microstructures and the hardness (thus on the mechanical behavior) of these {Co-25Cr}-based alloys. In another way, despite some discrepancies between the results issued from the stationary methods and the EIS ones, all the studied alloys are highly resistant against corrosion in the (simple) artificial saliva considered here. As suggested by some free-potential follow-up (not showed here but rapid then slow increase in E_{ocp}) and cyclic polarization runs (not showed here too but absence of any anodic peak, and suspected transpassivation), one can guess that all alloys are more or less already passivated when the Tafel and EIS experiments are started. This may be notably the origin of lack of reproducibility of the EIS results. Anyway all these cobalt-based alloys behaved very well and are obviously very corrosion resistant, probably thanks to the 25wt.% of chromium that they all contain.