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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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Xin Li, Patrice Berthod, Estelle Kretz. Corrosion study in artificial saliva of dental alloys based on cobalt and chromium, using electrochemical stationary methods and EIS. 2018 European Corrosion Congress (Eurocorr 2018), Sep 2018, Cracovie, Poland. . hal-03199698

**HAL Id: hal-03199698**

**<https://hal.science/hal-03199698>**

Submitted on 15 Apr 2021

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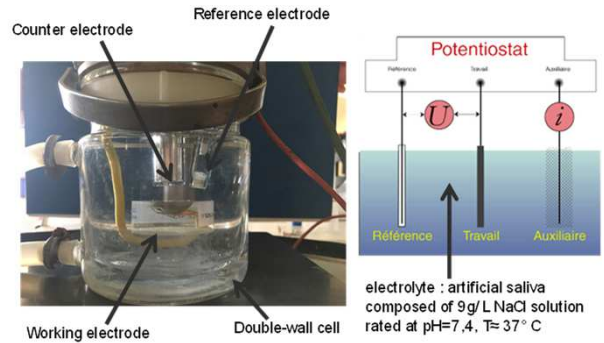
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Dental cobalt alloys devoted to the constitution of frameworks strengthening fixed partial dentures may be based on cobalt and chromium but other elements such as tungsten, molybdenum and silicon, for example, can be also present in their chemical 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

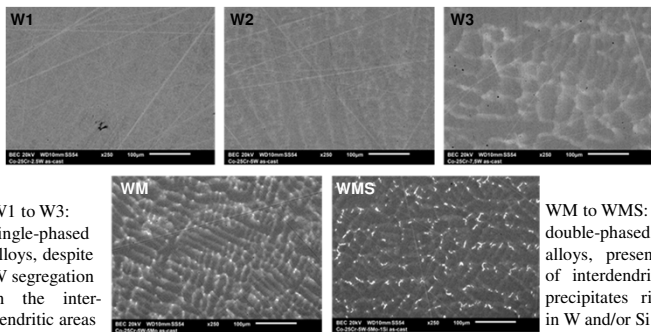
Alloy name	Weight fractions of elements
W1	72.5%Co-25%Cr-2.5%W
W2	70%Co-25%Cr-5%W
W3	67.5%Co-25%Cr-7.5%W
WM	65%Co-25%Cr-5%W-5%Mo
WMS	64%Co-25%Cr-5%W-5%Mo-1%Si



Five cobalt-based alloys synthesized by high frequency induction melting

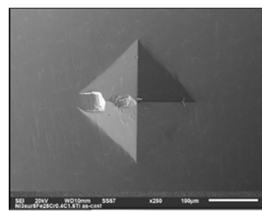
Mounted as electrodes; subjected to electrochemical stationary methods and impedance spectroscopy for studying the corrosion behavior in a reconstituted buccal milieu, after a 2h-immersion at free potential

## Results



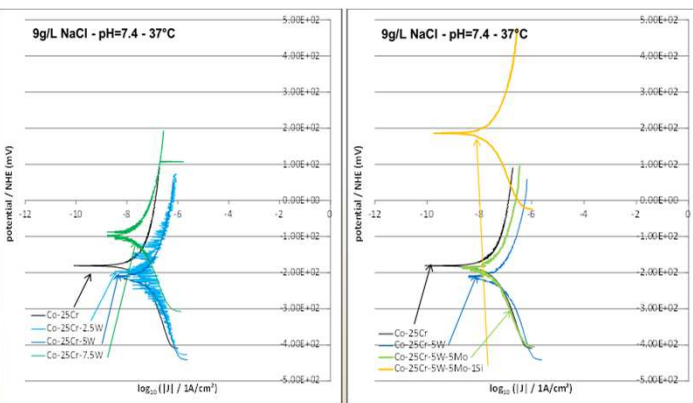
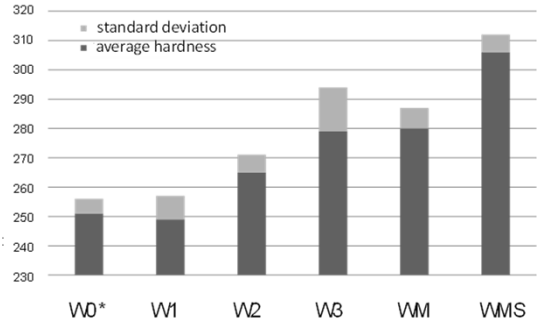
W1 to W3: single-phased alloys, despite W segregation in the inter-dendritic areas

WM to WMS: double-phased alloys, presence of inter-dendritic precipitates rich in W and/or Si



By regards to the tungsten-free alloy (Co-25Cr; W0: alloy from E. Kretz' own work):

- W ↑ → hardness ↑
- Mo added → hardness ↑
- Mo+Si added → hardness ↑



Alloy	$\beta_c$ (mV/decade)	$\beta_a$ (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	$\beta_c$ (mV/decade)	$\beta_a$ (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  $2 \times 10^{-5}$  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/cm<sup>2</sup>

### 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·cm<sup>2</sup>
- $C_{dl}$  staying around  $2 \times 10^{-5}$  Farad/cm<sup>2</sup>

## 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.