



HAL
open science

Study of the behaviour of different dental alloys in case of exposure to high and very high potentials

Pascal de March, Patrice Berthod, Maxime Helfer

► To cite this version:

Pascal de March, Patrice Berthod, Maxime Helfer. Study of the behaviour of different dental alloys in case of exposure to high and very high potentials. Eurocorr 2010, Sep 2010, Moscou, Russia. . hal-03712404

HAL Id: hal-03712404

<https://hal.science/hal-03712404>

Submitted on 3 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Study of the behaviour of different dental alloys in case of exposure to high and very high potentials

Pascal DE MARCHI^{1,2}, Patrice BERTHOD², Maxime HELFER^{1,3}

Faculté des Sciences et Technologies

¹Faculty of Dentistry, Department of Prosthesis, U.H.P. Nancy 1, 96 avenue de Lattre De Tassigny, B.P. 50208, 54000 Nancy, France

²Institut Jean Lamour (UMR CNRS 7198), Faculty of Sciences and Techniques, U.H.P. Nancy 1, B.P. 70239, 54506 Vandoeuvre-lès-Nancy, France

³Laboratoire de Thermodynamique des Milieux Polyphasés (EA 3099), École Nationale Supérieure des Industries Chimiques 1 rue Grandville, B.P. 20451, 54001 Nancy, France

Most of the dental alloys used in prosthetic dentistry are composed of noble elements as gold, platinum, palladium, ... Other ones are also generally very resistant against corrosion in the buccal milieu although they are based on nickel and chromium, thanks to their easiness to become passive. However, exposed to high potentials in a three-electrodes cell, they can know significant anodic currents, as it can be seen near the end of the anodic parts of polarization runs in artificial saliva. Since high potentials can be sometimes achieved in reality (e.g. intensive aeration of saliva), it can be interesting to extrapolate such situations in order to see how these alloys can be significantly deteriorated in some extreme situations.

Chemical compositions of the studied alloys: eight parent alloys and four post-solder alloys

HIGH NOBLE ALLOYS	Au	Pt	Pd	Ga	In	Other elements
dSIGN98	86	12	/	/	/	2.0 Zn
Aquarius Hard	86	8.5	2.6	/	1.4	
dSIGN91	60	/	31	1.0	8.4	
Lodestar	52	/	39	1.5	8.5	
W	54	/	26	/	1.5	16 Ag - 2.5 Sn
NOBLE ALLOY	Au	Pt	Pd	Ga	In	Other elements
dSIGN59	/	/	59	/	2.7	28 Ag, 8.2 Sn - 1.3 Zn
PREDOMINANTLY BASE ALLOYS	Ni	Cr	Mo	W	Si	Other elements
4ALL	61	26	11	/	1.5	/
Pisces Plus	62	22	/	11	2.6	2.3 Al

(alloys used for the metallic frameworks reinforcing fixed partial dentures)

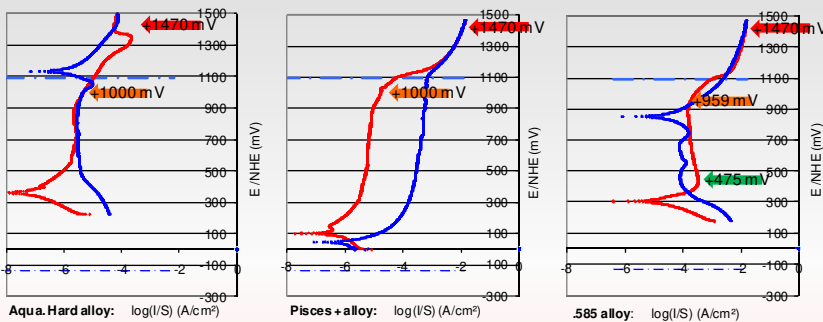
POST-SOLDER ALLOYS	Au	Ag	Cu	Ga	Other elem ^{1,2}	for
.650	65	13	20	2		dSIGN98
.615	61	13	17	/	7.6 In	d91, d59, Lodestar
.585	59	16	18	7	/	Aquarius Hard
LFWG	56	27	/	/	16 Zn	W, Pisces Plus, 4ALL

Preparation of the Fusayama saliva

(acidified to pH=2.3 with lactic acid and heated to 37°C)

Chemical products	Concentrations
KCl	0.4 g/L
NaCl	0.4 g/L
CaCl ₂ · 2H ₂ O	0.906 g/L
NaH ₂ PO ₄ · 2H ₂ O	0.690 g/L
Na ₂ S · 9H ₂ O	0.005 g/L
urea	1 g/L

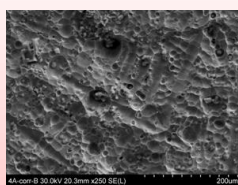
Examples of initial polarization curves and of the constant potentials applied



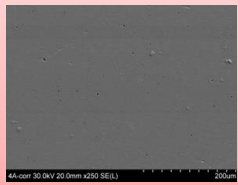
Surface deterioration and ICP analyses of the artificial saliva

ICP results for the electrolyte after the 72 hours-tests at imposed anodic potential typically the "nothing", "traces", "low", "MEDIUM", "HIGH" and "VERY HIGH" notations correspond respectively to the following ranges: < 1ppb, between 1 and 10 ppb, between 10 and 100 ppb, between 100 and 1000 ppb, between 1000 and 10 000, and more than 10 000ppb.

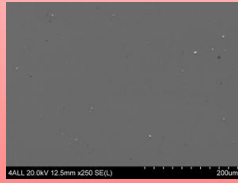
dSIGN59	59% Pd	28% Ag	2.7% In	8.2% Sn	1.3% Zn
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Pd(OH) ₂	Ag ⁺	In ³⁺	Sn(OH) ₄	Zn ²⁺
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +400mV	Pd ⁰	Ag ⁰ /Ag ⁺	In ³⁺	Sn(OH) ₄	Zn ²⁺
4ALL	61% Ni	26% Cr	11% Mo		
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Ni ²⁺	HCrO ₄ ⁻	MoO ₃		
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Ni ²⁺	HCrO ₄ ⁻	HMoO ₄ ⁻		
Pisces Plus	62% Ni	22% Cr	11% W		
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Ni ²⁺	HCrO ₄ ⁻	WO ₃		
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Ni ²⁺	Cr(OH) ₃	WO ₃		



4ALL parent alloy after 72h of polarization at +1470mV/NHE



after 72h of polarization at +1000mV/NHE



initial microstructure

dSIGN98	86% Au	12% Pt	2% Zn
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	PtO ₂	Zn ²⁺
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	PtO ₂	Zn ²⁺
Aqua.Hard	86% Au	8.5% Pt	2.6% Pd
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	PtO ₂	Pd(OH) ₂
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	PtO ₂	Pd(OH) ₂
dSIGN91	60% Au	31% Pd	1.0% Ga
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	Pd(OH) ₂	Ga ₂ O ₃
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	Pd(OH) ₂	Ga ₂ O ₃
Lodestar	52% Au	39% Pd	1.5% Ga
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	Pd(OH) ₂	Ga ₂ O ₃
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	Pd(OH) ₂	Ga ₂ O ₃
W	54% Au	26% Pd	16% Ag
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	Pd(OH) ₂	Ag ⁺ /Ag ₂ O
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	Pd(OH) ₂	Ag ⁺
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +500mV	Au ⁰	Pd ⁰	Ag ⁰

Correspondence with the Pourbaix's domains and semi-quantitative ICP results

.650	59% Au	16% Ag	18% Cu	7.2% Ga
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	Ag ⁺	Cu ²⁺	Ga ₂ O ₃
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +959mV	Au ⁰	Ag ⁰	Cu ²⁺	Ga ₂ O ₃
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +475mV	Au ⁰	Ag ⁰	Cu ²⁺	Ga ₂ O ₃
.615	61% Au	13% Ag	17% Cu	7.6% In
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +430mV	Au ⁰	Ag ⁰ /Ag ⁺	Cu ²⁺	In ³⁺
.650	65% Au	20% Cu	13% Ag	2% Ga
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +430mV	Au ⁰	Cu ²⁺	Ag ⁰ /Ag ⁺	Ga ₂ O ₃
LFWG	56% Au	27% Ag	16% Zn	
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1470mV	Au(OH) ₃	Ag ₂ O ₃ /Ag ⁺	Zn ²⁺	
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +1000mV	Au ⁰	Ag ⁰	Zn ²⁺	
crit. 1 Mol/L or 10 ⁻¹⁰ Mol/L if +490mV	Au ⁰	Ag ⁰ /Ag ⁺	Zn ²⁺	

The dental alloys studied here are very corrosion-resistant, thanks to their high contents in noble elements (Au, Pt, Pd), or to the fact that their main elements can get easily passivated (e.g. Cr). However, their long-time exposure to a very high potential may lead to detectable corrosion for some of these alloys. Fortunately, such high potentials (+1000mV/NHE) are not probable in real situation, since this should suppose, for example, a saliva extremely aerated on long times. Furthermore potentials 500mV higher are of course strictly not possible to achieve in natural conditions. But it was interesting to see that the alloys, even of the High Noble category, did not behave all similarly.