

Corrosion of base metal alloys in vitro

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Corrosion of base metal alloys was studied by placing the alloys in artificial saliva for 2 months and then determining the concentration of metal ions in the saliva. The distribution of the attack on the surface was examined.

The results indicated that the amount of metal ions in the artificial saliva could be related to the Cr content of the alloy. When the Cr content exceeded 16% very little corrosion was observed. The corrosive attack was located at Cr depleted areas, grain boundaries. The Cr depletion probably resulted from coring during solidification.

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Corrosion resistance is an important parameter when choosing alloys for dental application. The in vitro corrosion of dental alloys have previously been evaluated using potentiostatic techniques (1, 2). Even though this is an excellent technique for studying corrosion mechanisms, only indirect information can be obtained on corrosion rate or amount of metal dissolved. The purpose of the present investigation was to evaluate corrosion resistance using a simple dissolution technique in which the amount of Ni, Co and Cr ions was determined after submersion of alloys in an artificial saliva. The surface topography after corrosion was also assessed.

MATERIALS AND METHODS

The alloys used in the investigation are listed in Table 1 and the compositions in Table 2. The specimens were cast in an induction casting machine except for specimens for metal G which was pure Ni. The specimens were 1.7 mm thick and had a surface area of 1.6 cm². They were ground on silicon carbide paper through 600 grit and placed on a glass plate in a beaker containing 50 ml artificial saliva (1). The beakers were open to air and were placed in a water bath at 37 °C for two months. Duplicate measurements were made on one specimen after approximately 0.2 mm were removed from the surface by grinding.

The composition of the alloys were determined using X-ray fluorescence, atomic absorption and emission spectrometry. After the corrosion test was terminated 10 ml IN HCL was added to the artificial saliva. The sample was kept in the solution for another 10 min. The sample was then removed from the solution which was diluted to 100 ml. The Co, Ni and Cr content of the artificial saliva were determined by atomic absorption.

Microscopic examinations were performed directly on the corroded specimen surface and differences in composition were evaluated using a scanning electron microscope supplied with an energy dispersive detector.

RESULTS

The highest Ni content was found in the artificial saliva where pure Ni had been placed (Table 3). The Ni dissolution increased as the Cr content of the alloys decreased. Cr and Co release was only found for low Cr-containing alloys.

The surface topography of the corroded specimens indicated that the corrosive attack became more severe as the Cr content of the alloys decreased (Fig. 1). The surface structure also indicated that the attack was not uniform and the grain boundary areas appeared to be severely corroded.

Results from the energy dispersive detector indicated that the corroded areas in alloy

Table 1. Alloys used in the investigation

Alloy	Manufacturer	Code
Wironit	BEGO Bremer Goldschlägerei Wilh. Herbst.	A
Vitallium	Howmedica International Inc.	B
Wironium	BEGO Bremer Goldschlägerei Wilh. Herbst.	C
Wiron S	BEGO Bremer Goldschlägerei Wilh. Herbst.	D
Gemini II	Kerr Manufacturing Co.	E
Ultratek	Ivoclar AG	F
Pure Ni		G

F (Fig. 1 F) were depleted in Cr and enriched in Ni compared to the less corroded area in the same specimen (Fig. 2).

DISCUSSION

When the Ni ion release from pure Ni and from Ni containing dental alloys were compared, it was apparent that the Ni ion release was reduced as much as by a factor of 110, when the Ni content of the alloy was reduced

Table 2. Compositions of the alloys used in the investigation

Code	Ni	Co	Cr	Mo	Mn	Fe	Al	Be	Si
A	0.1	67	28	5	0.3	0.1	+	+	0.6
B	0.1	59.9	30.3	5.1	0.8	0.1	+	+	0.6
C	0.2	64.4	27.2	6.2	0.4	0.65	+	+	1.5
D	71.5	0.15	16.4	4.7	3.5	0.12	4.4	+	1.3
E	79.7	0.1	12.5	1.8	+	0.1	3.1	1.2	0.3
F	84.2	0.5	8.5	2.5	+	0.16	2.9	1.2	+
G	99.9	-	-	-	-	-	-	-	-

+ Not detected

- Not analyzed

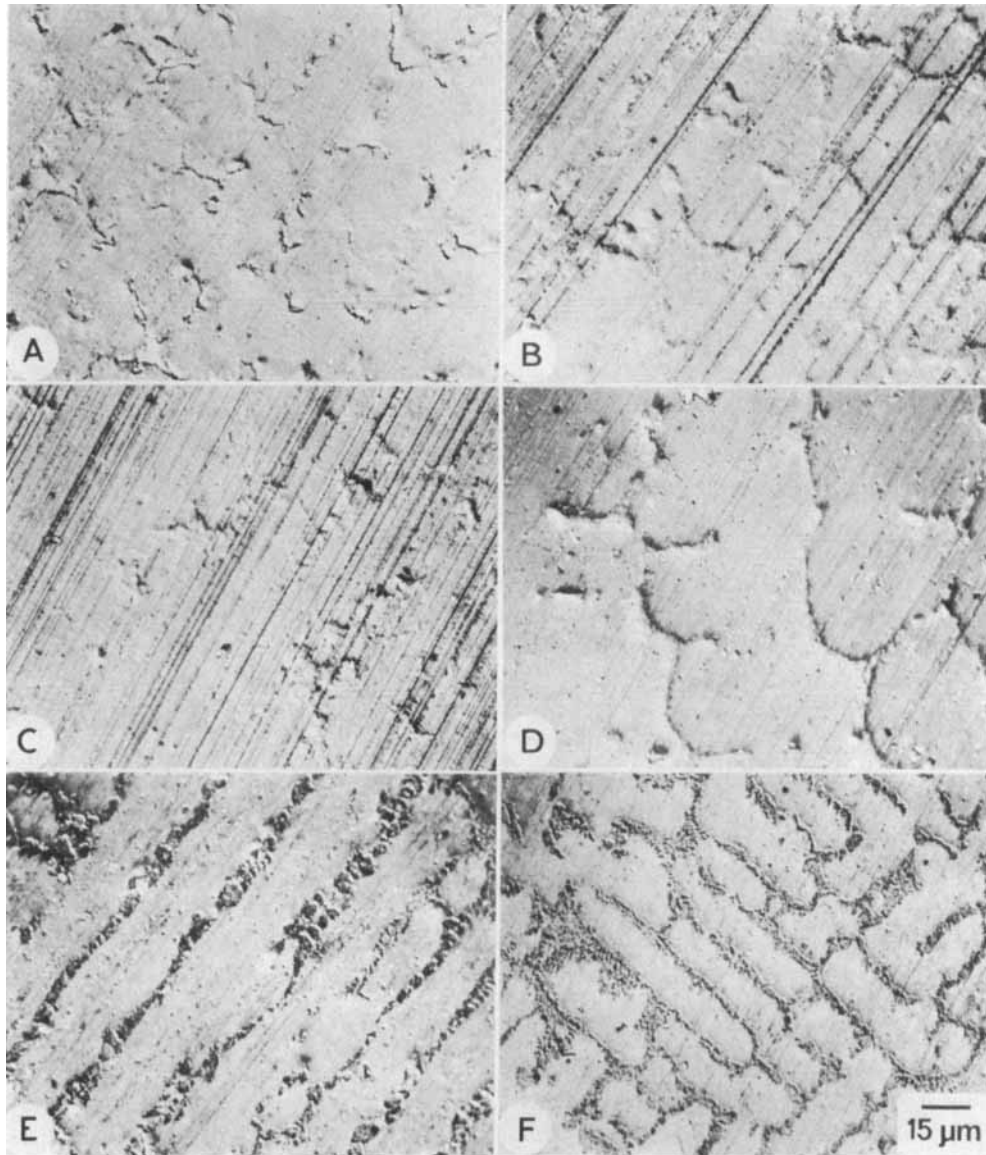


Fig. 1. Photo micrograph of the corroded surface of alloys A, B, C, D, E, F. (625 x)

Table 3. Metal ion content of 50 ml artificial saliva after 2 months (mean and standard deviation two tests) (ppm)

Code	Ni	Co	Cr
A	< 0.2	< 0.2	< 0.2
B	< 0.2	< 0.2	< 0.2
C	< 0.2	< 0.2	< 0.2
D	1.3 ± 0.4	< 0.2	< 0.2
E	54.5 ± 7.8	< 0.2	1.4 ± 1.1
F	44.4 ± 21.8	< 0.2	2.2 ± 2.8
G	148.0 a)	< 0.2	< 0.2

a) only one test performed

from 100% to 70%. These results demonstrated that the corrosion rate of the alloys tested were strongly dependent on the Cr content. When the Cr content was reduced to 16%, detectable amounts of ions in the saliva were observed. The major corrosive attack appeared at grain boundaries which were found to be Cr depleted regions. Cr segregation is believed to have occurred during the solidification, since the alloys were tested in their "as cast" conditions.

Sarkar & Greener (2) have found from electrochemical measurements that nickel-base dental alloys are active in Ringers solution. Results from two Ni-base alloys in this study suggested a similar behavior. Other studies show increased corrosion for alloys with lower Cr content than 16% (1). Some influence of the amount of Mo and Mn on corrosion was also indicated. The number of alloys with different compositions in this study was not large enough to establish such a relationship.

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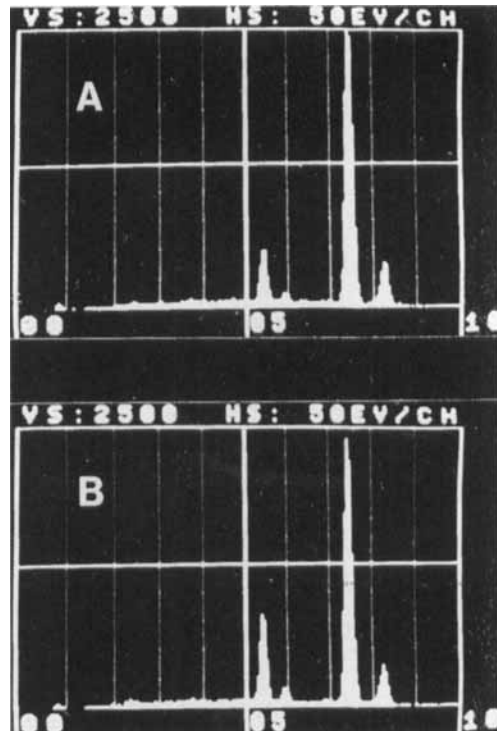


Fig. 2. Energy dispersive detector spectra (EDAX) of grain boundary region (A), and matrix region (B) of alloy F, (left line Cr, right line Ni).

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