Galvanic Corrosion Between Titanium Implants and Dental Alloys

By Paul Cascone
Sr. Vice President, Research & Development, The Argen Corporation

Paul Cascone, of Argen's Research & Development department, describes the results of a corrosion study on JelstarNoble. The study reconfirms previous works that illustrated the issues caused by using non-precious alloys in conjunction with titanium implants and demonstrates why JelstarNoble is a superior alloy to use with titanium.

What is a galvanic reaction?
A galvanic reaction occurs when two dissimilar metallic materials are placed in contact. The contact results in the flow of electrical current. The amount of current (or intensity of the reaction) and the duration of the reaction are dependent upon the nature of the materials coming in contact.

During the 1970's there was a lot of research on galvanic reactions due to the ever increasing number of alloys available in the market place at that time. The usual result was a tarnish reaction or darkening of one of the alloys in vivo. The topic of galvanic reactions has again arisen due to the widespread use of titanium implants. In this case the galvanic reaction may result in serious corrosion. The concern has stimulated numerous studies on the interaction of titanium and dental alloys. This article is a summary of those studies and provides a scientific basis for why JelstarNoble by Argen is such a unique dental alloy.

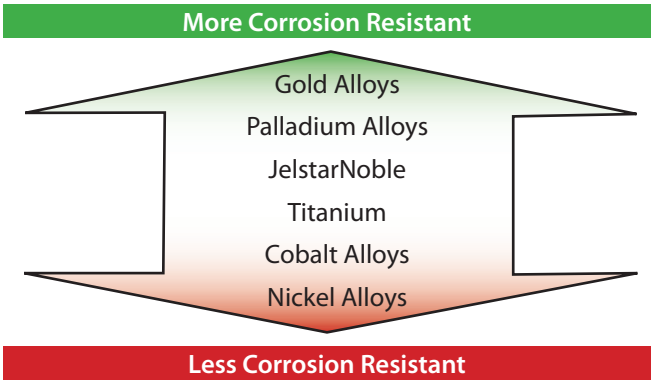

Figure 1. The electrochemical series for dental materials.

Why is JelstarNoble different?
The addition of ruthenium to a cobalt chrome alloy imparts a significant increase in corrosion resistance. In order to find out how significant a study was conducted at the University of Alabama, known for their expertise in electrochemical corrosion, comparing JelstarNoble with other alloys. The results of the study are included in the discussion below.

Scientific Background
The electrochemical series is normally a good predictor for the estimation of galvanic reactions. The metals are listed in the order of their chemical reactivity or electrode potentials, the most reactive at the bottom and the less reactive at the top (Figure 1).
The prediction is always that any given material will corrode any material below it in the series. It is a known fact that two dissimilar materials will generate some galvanic reaction. The question is if the reaction is of clinical significance.

RESULTS OF STUDIES:

Gold alloys coupled with titanium.
The gold alloy will corrode the titanium but the reaction stops almost instantaneously due to the formation of a very adherent titanium oxide film. This effectively prevents the flow of any current shutting the reaction down. The galvanic reaction is not clinically significant.

Palladium alloys coupled with titanium.
The palladium alloys will corrode the titanium but the reaction stops almost instantaneously. The galvanic reaction is not clinically significant. The standard alloy for use with implants has become a high palladium silver-free alloy.

JelstarNoble alloy coupled with titanium.
JelstarNoble was tested at a university using the same methodology as used in the references. Figure 2 shows the results. The chart shows that JelstarNoble when in contact with titanium reacts in the same manner as palladium alloys. This surprising result is due to the ennobling effect of the ruthenium addition. JelstarNoble is the only cobalt alloy to demonstrate this type of reaction.
The result demonstrates that it is safe to use JelstarNoble against implants.

Traditional cobalt chromium alloys coupled with titanium.
In this case the titanium is above the cobalt alloy resulting in the corrosion of the cobalt alloy. This reaction is at a low current but cobalt ions will be released. This coupling is not advisable due to the uncertainty of knowing if and when the reaction stops. The galvanic reaction may be clinically significant depending upon the circumstances.

Nickel chromium alloys coupled with titanium.
Titanium is higher than the nickel alloys resulting in corrosion of the nickel alloy. Unlike the situation with cobalt, however, the current is higher so more nickel ions are released. Also the reaction does not slow down over time. This coupling is dangerous since the mechanical integrity of the alloy is at risk. Also the local tissue is inundated with nickel ions which may result in an allergic reaction. The galvanic reaction is very clinically significant.

This chart shows that JelstarNoble will not corrode when in contact with titanium (positive values).

All other non-precious alloys will corrode against titanium (negative values).
(Adapted from a study performed at the University of Alabama to be published.)

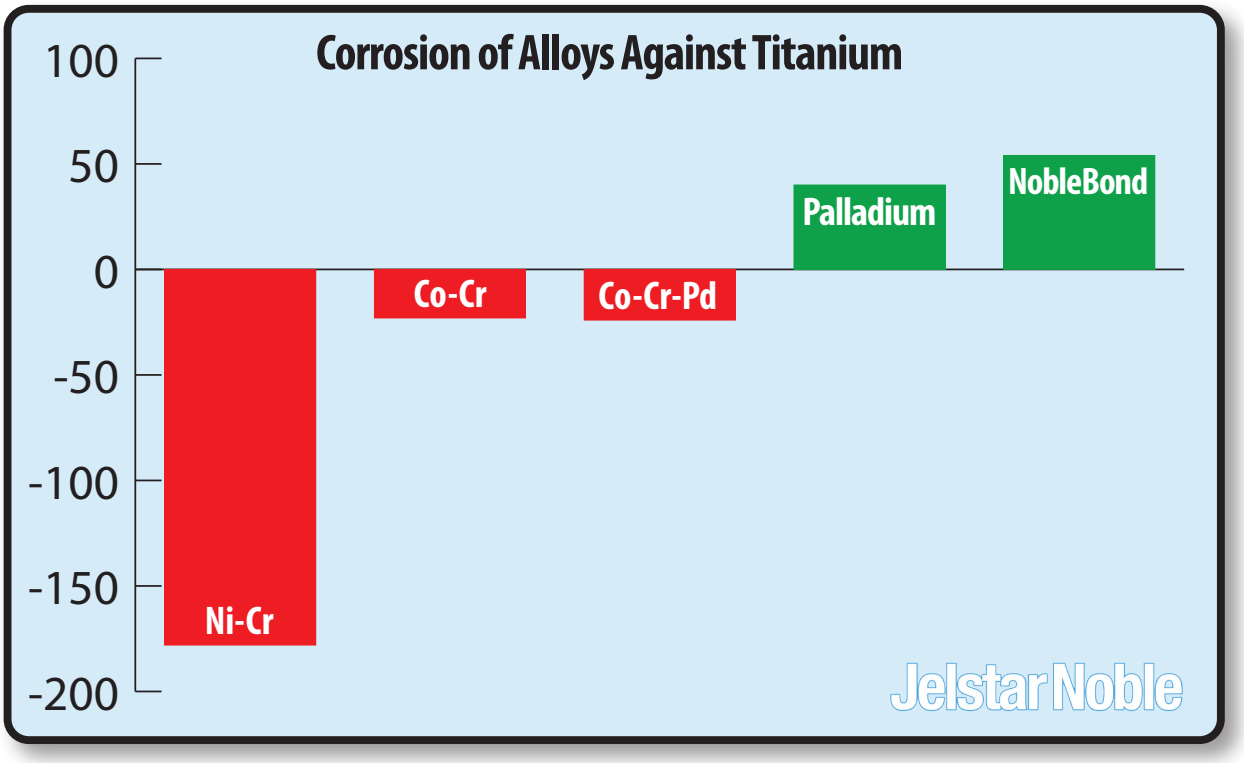

Figure 2. JelstarNoble coupled with titanium.

References:
[1] "Study of Galvanic Corrosion between Dental Alloys", Dr. Zurcher, in "Biocompatibility ,allergies and resistance to corrosion: a global scientific approach", pp 43-53 1993, METALOR.
[2] "Galvanic corrosion behavior of titanium implants coupled to dental alloys", M. Cortada, et al, Journal of Materials Science:Materials in Medicine,pp 287-293 Vol11,No5, Kluwer Academic Publishers, 2000.
[3] "Galvanic corrosion behavior of implant suprastructure dental alloys", N.M. Taher and A.S. Al Jabab, Dental Materials, pg 54-59,Vol 19, No 1 , Elsevier Science, 2004.