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Study of the Corrosive effect of Enzymatic, Multi-Enzymatic, and Sodium Hypochlorite Solutions on Surgical-Grade Stainless Steel Instruments used in the Operating Room Area of the Clinical Hospital

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Abstract

Surgical instruments play a fundamental role in the success of surgical procedures. They have traditionally been manufactured from stainless steel due to its corrosion resistance and ease of sterilization. However, exposure to corrosive substances during cleaning and disinfection can affect their integrity over time.

This study investigates the corrosive effect of enzymatic, multi-enzymatic and sodium hypochlorite solutions on surgical grade stainless steel instruments. Samples were immersed in solutions under different concentrations and their breakdown potential was measured. Likewise, tests were carried out using normal ringer's serum as a medium, which is employed according to ISO 10993-15 standard, to evaluate the corrosion resistance of materials used for prostheses.

The results showed that the breakdown potential depends on the concentration of the solution and temperature. Enzymatic and multi-enzymatic solutions do not pose a significant risk if kept within recommended concentrations. However, normal ringer's serum induces corrosion from 8 hours of exposure.

This study provides relevant information for cleaning and maintaining surgical instruments in order to optimize their performance and safety.

Keywords: Surgical instruments; Stainless steel; Corrosion; Enzymatic; Hypochlorite

Introduction

Surgical procedures require the use of instruments that meet strict quality and safety standards to ensure the success of interventions and patient health. Stainless steel has traditionally been widely used in their manufacture due to its corrosion resistance, durability and ease of sterilization [1].

However, during cleaning and disinfection, instruments are exposed to potentially corrosive substances such as enzymatic, multi-enzymatic and sodium hypochlorite [2]. This could affect their integrity and functioning over time [3, 4]. On the other hand, during longer surgical procedures, instruments remain in prolonged contact with body fluids [1], which can also induce corrosion.

This work aims to establish the consequences of using enzymatic solutions and disinfection on corrosion of surgical grade stainless steel instruments, by evaluating their breakdown potential and surface morphology. Likewise, tests were carried out with the instruments in ringer's serum, simulating their exposure to body fluids. The results provide relevant information to optimize their maintenance and increase their useful life.

Background

Various studies have shown that corrosion is one of the most frequent causes of incorporation of surgical instruments [3, 5]. This is mainly due to the action of body fluids, chemical agents present in cleaning solutions and poor practices by medical personnel during handling [4, 6].

A survey of surgical area professionals [3] revealed that 24% of discarded instruments showed signs of corrosion. This demonstrates the need to determine the concrete effect of the products used in cleaning.

Sodium hypochlorite has traditionally been used for disinfection, whose corrosive action on metals is known [2]. As an alternative, there are enzymatic and multi-enzymatic preparations whose aggressiveness on metal surfaces has not been fully established.

It is necessary to establish safe ranges of concentration that allow effective disinfection without compromising the integrity of the instruments. This will result in less premature discard and cost savings for health centers.

Methodology

Materials and Methods

Surgical grade martensitic stainless steel instrument samples manufactured by Reda Instrumente approximately 1 cm^3 were used. The study solutions were prepared in tap water with the idea of simulating the same working conditions of the operating theatre at increasing concentrations of Enzymex L9 enzymatic, Bonzyme multi-enzymatic and concentrated X.5 sodium hypochlorite, within concentration ranges established as adequate to carry out disinfection within aseptic requirements. The probes were subjected to immersion in the solutions for a controlled time, evaluating visual and morphological changes using SEM.

The breakdown potential was determined using a Gamry G-300 potentiostat and polarization curves according to ISO 10993-15.

To simulate exposure to body fluids, normal ringer's serum was used following a similar procedure to that already mentioned. The results were statistically analyzed.

Variables

Enzymatic concentration: 4-6 ml/L.
Multi-enzymatic concentration: 6.5-8.5 ml/L.
Hypochlorite concentration: 0.01-0.03 ml/L.
Immersion time: Up to 21 days, in ringer's serum: 8-32 hours.

Results and Discussion

Breakdown Potential

Polarization curves were constructed for each concentration, as shown in Figures 1 to 3, based on which the OCP (Open Circuit Potential) and EP (Breakdown Potential) were determined.

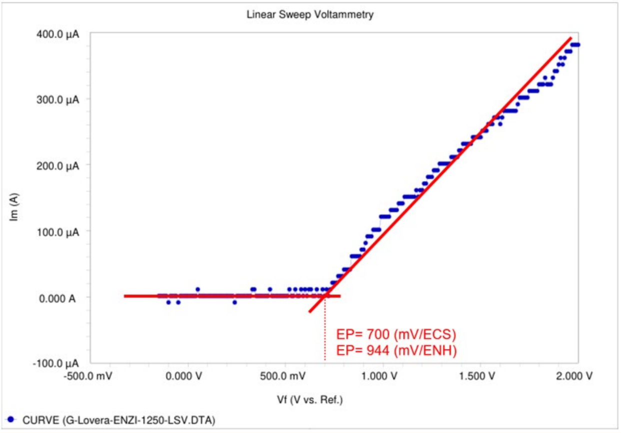

Figure 1: Polarization curve, stainless steel immersed in 5 ml/L enzymatic solution.

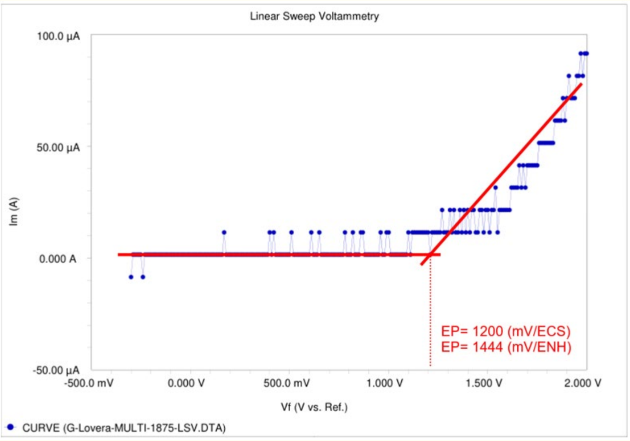

Figure 2: Polarization curve, stainless steel immersed in 7.5 ml/L multi-enzymatic solution.

The breakdown potential values decreased as the solution concentration increased (Tables 1-3), coinciding with greater aggressiveness. However, in all situations the EP exceeded 600 mV/ENH, which is the limit established by the US FDA. Except for the 6 ml/L Enzymatic solution.

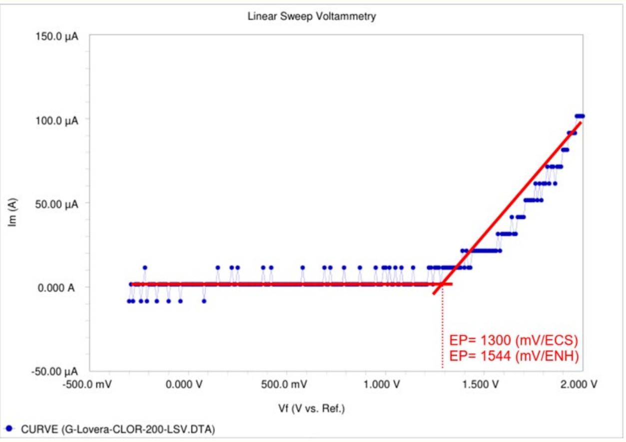

Figure 3: Polarization curve, stainless steel immersed in 0.02 ml/L sodium hypochlorite solution.

Code	***Concentration (ml/L)***	***OCP (mV/ENH)***	***EP (mV/ENH)***
ENZI-1000	4	58.3	1004
ENZI-1125	4.5	-3.8	994
ENZI-1250	5	111.3	944
ENZI-1375	5.5	6.4	844
ENZI-1500	6	6.0	794
ENZI-1250Pt	5	424.8	1644

Table 1: Results obtained from enzymatic solution diluted to different concentrations.

Code	***Concentration (ml/L)***	***OCP (mV/ENH)***	***EP (mV/ENH)***
MULTI-1625	6.5	-45.9	1244
MULTI-1750	7	-63	1394
MULTI-1875	7.5	-38.1	1444
MULTI-2000	8	-89.9	1594
MULTI-2125	8.5	-137.5	1244
MULTI-1875Pt	7.5	594.9	1644

Table 2: Results obtained from multi-enzymatic solution diluted to different concentrations.

Code	***Concentration (ml/L)***	***OCP (mV/ENH)***	***EP (mV/ENH)***
CLOR-100	0.01	-80.7	1494
CLOR-200	0.02	-50.6	1544
CLOR-300	0.03	-78	1494
CLOR-200Pt	0.02	812.3	2244

Table 3: Results obtained from sodium hypochlorite solution diluted to different concentrations.

Within the range evaluated, the enzymatic and multi-enzymatic solutions did not demonstrate significant harmful effects on the stainless steel (EP>600mV). On the other hand, hypochlorite induced lower corrosion resistance, especially at concentrations of 0.02 ml/L (Table 3).

In all three cases, using platinum instead of stainless steel, it was observed that the EP exceeded the other values, showing the stability of the solution and reliability of the results obtained.

Time-controlled Immersion

No visual or morphological changes were observed after 21 days of exposure to enzymatic, multi-enzymatic and sodium hypochlorite solutions within the established ranges.

However, when dipping the probes in normal ringer's serum, oxidation formation was detected after 8 hours. In addition, a progressive percentage increase in mass loss and deposition was quantified over time of contact (Table 4 and Figure 4).

Probe	***Time (h)***	***Mass loss (%)***	***Deposited mass (%)***
SUERO-1	8	0.01	0.01
SUERO-2	16	0.03	0.01
SUERO-3	24	0.04	0.02
SUERO-4	32	0.06	0.03

Table 4: Percentage table of mass loss due to corrosion and deposited mass in a defined time.

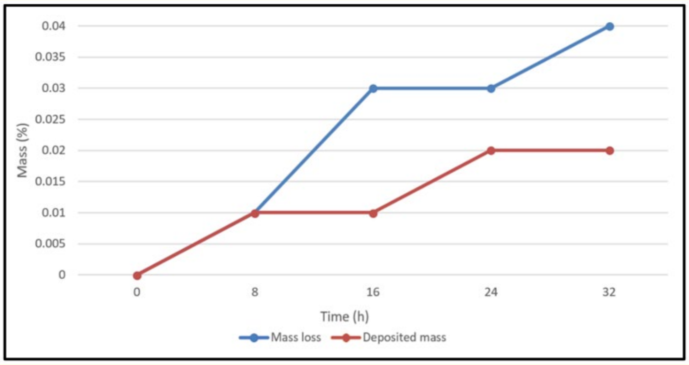

Figure 4: Graphical representation of the percentage masses lost and obtained by deposition over time of exposure.

Scanning Electron Microscope

Thanks to the electron microscope, it was possible to evidence changes on the surface of the probes that were immersed in the different solutions (Figure 5).

Micro-corrosion traces were detected on samples exposed to enzymatic and sodium hypochlorite solutions (Figures 5 and 6). On the other hand, probes treated with ringer's serum showed considerable damage to their surface.

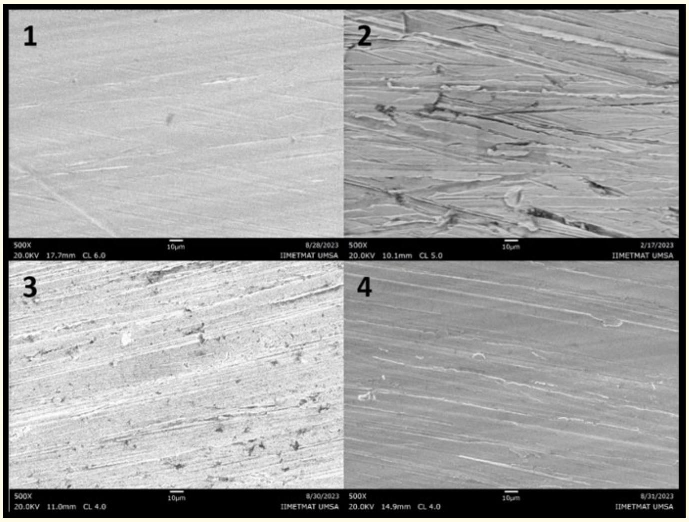

Figure 5: SEM photomicrographs with 500x resolution, secondary electron detector. 1) Untreated. 2) Enzymatic solution. 3) Multi-enzymatic solution. 4) Solution with sodium hypochlorite.

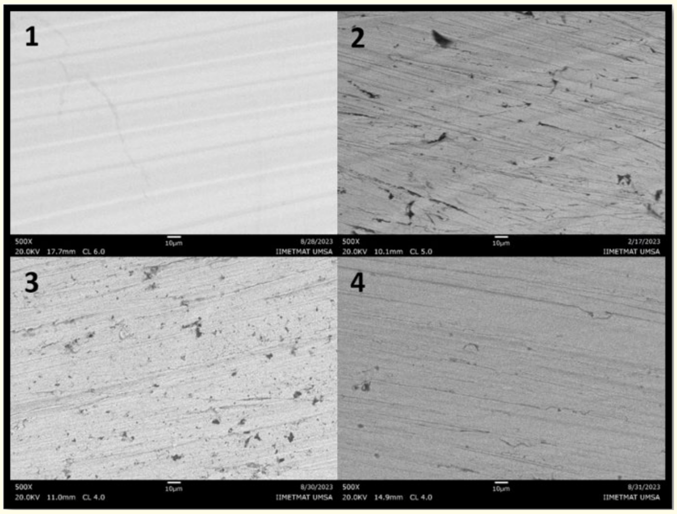

Figure 6: SEM photomicrographs with 500x resolution, backscattered electron detector. 1) Untreated. 2) Enzymatic solution. 3) Multi-enzymatic solution. 4) Solution with sodium hypochlorite.

Conclusions

The study established that the breakdown potential of surgical grade stainless steel depends directly on the concentration of the cleaning solutions used. Enzymatic and multi-enzymatic solutions do not pose a risk to instruments as long as recommended dilutions are respected and exposure time does not exceed 24 hours.

On the other hand, ringer's serum induces corrosion in relatively short exposure periods, which could compromise the integrity of instruments during prolonged surgical procedures.

The results obtained are relevant for optimizing cleaning and disinfection procedures for surgical instruments. It is recommended to strictly monitor instruments after long procedures to detect possible corrosion damage induced by body fluids.

It is also important to provide constant training to medical personnel regarding the proper use of cleaning solutions, recommended concentrations and maximum exposure times. This will result in a longer useful life of instruments and lower associated replacement costs.

Recommendations

Strictly follow manufacturers' recommended concentrations to avoid unintentional corrosion.

Limit prolonged contact of instruments with body fluids through periodic cleaning and disinfection during long surgeries.

Constantly monitor instruments, especially after prolonged procedures, detecting signs of corrosion.

Maintain continuous communication with manufacturers to obtain updated guidelines for instrument use and maintenance.

Periodically train medical personnel on handling, cleaning and care of instruments to prevent damage.

Conduct more studies to better understand the effects of cleaning solutions on other materials and medical devices.

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