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DENTAL TECHNIQUE

Laboratory technique for coloring titanium abutments to improve esthetics

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ABSTRACT

Titanium alloys are used for implant abutments onto which prostheses are attached. One major disadvantage of titanium abutments is their esthetics; the metallic gray color may show through the restorative material or through surrounding tissues. A laboratory technique using readily available household items is described that can alter the abutment color by anodization. (J Prosthet Dent 2016;115:409-411)

The titanium dioxide (TiO_2) layer is a thin film of approximately 20 nm, which provides a biocompatible surface and allows light to reflect off the titanium/titanium alloy layer beneath to produce a gray metallic hue.[1,2] One area of concern is the periimplant soft tissue site, where a graying of tissue is frequently reported.[3] To improve the optical properties of dental implants and components, thin-film coating techniques have been developed to mask metallic surfaces and improve the esthetic result.[4-7] As an alternative to coating the titanium with a secondary material, light interference effects can be used instead.[8] An electrochemical anodization technique was used to alter the TiO_2 nanosurface thickness, resulting in a colored surface. Many manufacturers offer anodized implants, abutments, and frameworks.[9] A positive electric probe is attached to the titanium (anode) to be colored, which is then submerged in an electrolytic solution, usually an acidic solution. When a voltage is applied to the electrolyte, current flows through, depositing electrons onto the titanium. The process is self-limiting and ceases once the anodized layer appropriate for the voltage used has been achieved.[10,11]

The post-anodized TiO_2 layer, although still transparent, now has a thickness that lies close to that of the visible light wavelength and can produce optical thin-film interference patterns.[10] The use of anodization alters the TiO_2 layer thickness, resulting in a colored surface without altering the surface chemistry, yet maintaining the surface biocompatability.[12] The color of a titanium-based abutment can be improved for a restoration that has some translucency if it has a yellow hue. Similarly, periimplant soft tissue esthetics has benefitted from an induced yellow coloration.[6] The anodization color produced is, however, dependent upon the electrical potential difference between the cathode and anode.[12] The

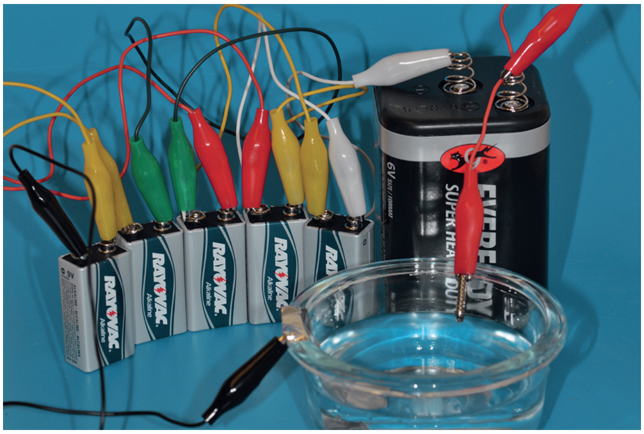

Figure 1. Battery cells configured in series (positive terminal of 1 cell connected to negative terminal of next).

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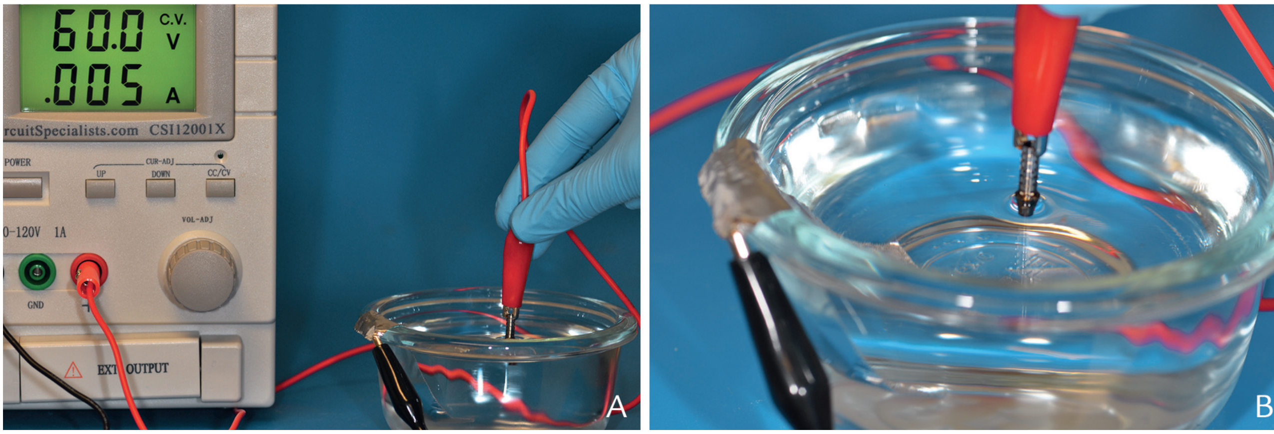

Figure 2. A, Bench top power supply producing 60 VDC with cathode (black negative terminal attached to aluminum foil), anode (red positive terminal attached to titanium alloy abutment), and glass vessel with trisodium phosphate (TSP) solution. B, Close up showing color changes developing.

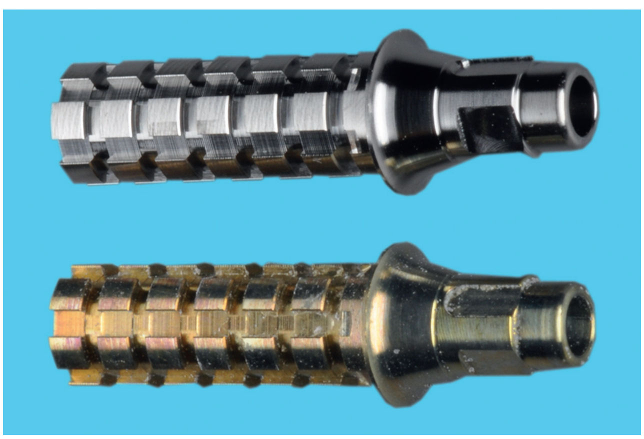

Figure 3. Titianium abutment anodized at 60 VDC, producing a yellow/gold color (bottom) compared with original abutment (top).

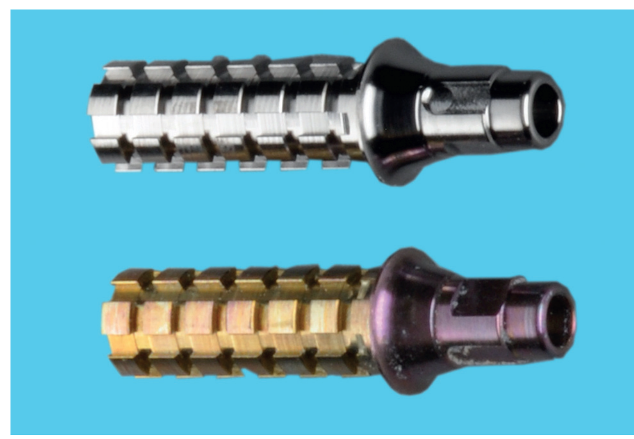

Figure 4. Abutment has been dual anodized (bottom). Tissue aspect has been anodized at 85 VDC for pink hue compared with original non-anodized abutment (top).

yellow color can be readily achieved by electrochemical anodization using commonly available materials such as cleaning agents, acids, and diet soda as the electrolyte and common batteries to provide volts of direct current (VDC). For example, to achieve 60 VDC, 6 flat 9-V battery cells and one 6-V square battery cell are linked in series (Fig. 1). An advantage of this technique is that it uses components that are readily available and inexpensive. In the laboratory setting, a VDC power generator (CS112001S) may be more appropriate, providing a more variable controlled voltage supply. The generator produces a less sensitive technique allowing multiple or bicolored component formation, for example a pink hue for gingival areas and yellow for the restoration. The technique requires knowledge of which voltage to use (yellow 60 VDC, pink 80 to 85 VDC), clean titanium surfaces, and a few seconds for the colorization process to occur. It is economically viable for definitive abutments, bars, or multiple units, especially when thin tissues exist and optimal esthetics are demanded. This is especially true when the only or most appropriate abutment available is titanium-based. If an error is made and the color induced is undesirable, the oxide surface of titanium-based materials can simply be repolished and returned to its clear state. Currently, many manufacturers promote anodized color coded components such as titanium alloy healing abutments for identification purposes; these appear to hold up well in the oral environment and to have no detrimental effects.

This laboratory technique can be used on any titanium-based material, including interim abutments, definitive abutments, or bars.[9] By increasing the thickness of the TiO_2 layer, a variety of colors can be produced using light interference patterns.

TECHNIQUE

1. Prepare a digital bench top power supply device (VDC digital bench power supply CS112001X;

Circuit Specialists) or use 6 flat 9-V battery cells and one 6-V square battery cell linked in series to provide a 60-V or higher VDC (Fig. 1).
2. Fill a 250 mL glass vessel with distilled water, add 1 g of trisodium phosphate (TSP)/90 heavy duty cleaner (Red Devil Equipment Co), and allow the cleaner to fully dissolve. This provides an electrolytic solution for anodization.
3. Attach the negative terminal of the power supply to a 3-×6-cm piece of aluminum cooking foil (Reynold's wrap; Reynolds Consumer Products LLC) to act as the cathode and submerge the foil within the water/TSP solution (Fig. 2).
4. Attach the positive (anode) terminal of the power supply to the clean titanium-based abutment at a site that will not be immersed. Make sure that the anode does not contact the solution for optimum current flow through the titanium component.
5. Carefully submerge the abutment in the electrolyte; do not allow the terminal lead clip to make contact with the solution. If any part of the submerged abutment should not be colored, mask with wax before dipping (Fig. 2).
6. Turn on the power supply. Grasp the terminal lead clip attached to the abutment. Make sure to hold the insulated wire and avoid contact with the bare clip or abutment.
7. Hold the abutment in the electrolyte for 5 seconds; some effervescence will occur during the electrochemical anodization. Once the anodization is complete, no further electron deposition occurs because the process is self-limiting.
8. Depending upon the voltage used, different colors can be achieved from yellow to magenta, blue, pink, and green.
9. At 60 VDC, a yellow coloration results. This works well under a restoration that has some translucency (Fig. 3). The tissue aspects of a titanium-based abutment can be made pink with an 85 VDC achieved by eight 9-volt batteries with two 6-volt batteries in series (Fig. 4).
10. Remove the abutment, check the uniformity of color (best assessed under white light condition), disconnect the clips, wash the abutment in deionized water, and confirm the desired color has been achieved.
11. Important: Even relatively small voltages can induce electrical shock. Do not touch the terminal leads (positive and negative) together or allow either lead to come in contact with the electrolyte solution when the power supply is turned on. Wear insulating rubber gloves or equivalent protection.

SUMMARY

The technique described provides a straightforward, inexpensive, and rapid way to permanently alter the color of titanium-based alloys using a natural light phenomenon. The esthetics of both the restoration and the soft tissues for an implant restoration with color changes may be improved by thin-film interference.

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