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Review Article

COATING OF NI TI WIRES- A REVIEW

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ABSTRACT
Metal components form a key part of orthodontia. Gold, stainless steel, nickel titanium alloys, among other metallic biomaterials, have been part of the orthodontic treatment kit since the twentieth century. These materials and in particular Nickel Titanium, possesses great properties and have been the corner stone of many orthodontic treatments. But, these metals have disadvantages that can cause difficulties for the treatment. Poor friction control, allergic reactions, and metal ionic release are some of the most common disadvantages found when using metallic alloys for manufacturing orthodontic appliances.In order to conquer such vulnerability, research has been piloted at aiming diverse approaches, such as coatings and surface treatments, which have been established to render these materials more appropriate for orthodontic applications. The purpose of this paper is to provide an overview of the coating and surface treatment methods performed on metallic biomaterials.

Key words:- Ni Ti wires, coatings, esthetic modifications.

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INTRODUCTION

NiTi alloy was developed in 1960 by William F. Buehler who worked at the Naval Ordinance Laboratory in Silver Springs, Maryland. The name Nitinol came from Nickel (Ni), Titanium (Ti), Naval Ordinance Laboratory (nol). The first Nickel titanium (NiTi) orthodontic alloy, introduced by Andraeson. This alloy was based on the research done by Buehler. Since their introduction, the wires made out of Niti alloys have become an important part of orthodontic treatment.

The composition of the wire has 55% Nickel and 45% Titanium. The first nickel-titanium orthodontic wire alloy was marketed by the Unitek Corporation who are now known as 3M Unitek. These alloys have low stiffness, super elasticity, high spring back, large elastic range and were brittle. The initial NiTi wires did not have shape-memory effect due to the cold-working of the wire.

Thus these wires were passive and were considered as an Martensitic-Stabilized alloy. Nickel, a known allergen, is released by nickel-titanium and stainless steel orthodontic alloys. Previous research showed high concentrations of nickel in the saliva and oral mucosa of patients wearing orthodontic appliances.

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Oral signs and symptoms of nickel allergy include burning sensation, gingival hyperplasia, angular cheilitis, erythema multiforme, stomatitis, popular perioral rash, and loss of taste, as well as others. In addition, orthodontic treatment carried out with fixed appliances provides a unique environment for colonization of microorganisms since orthodontic devices contain morphological irregularities that make it difficult for patients to maintain adequate oral hygiene [1].

1. Coating techniques and methods

The application of coatings is one of the methods that are available to alter the surface of materials. Numerous coating techniques and materials have been used with the objective of improving surface properties. However, some problems with coatings have arisen, mainly the delamination or wear of the coating. Nonetheless, investigations continue to find suitable materials and techniques to improve the properties of metallic biomaterials. Coating can be done with nano particles to improve friction [2].

The wires were later coated with a uniform and smooth nanoparticle film using 100 ml nano ceramics. The coating procedure described is a sol-gel thin film dip coating method. The coating procedure was verified by observing the surface topography of nano coated arch wires in an environmental scanning electron microscope (ESEM). The ESEM images prove that the surface topography of the coated wires was found to be smoother with less surface deteriorations as compared to the commercially available wires [3].

Commercially available straight length orthodontic wires of nickel-titanium (NiTi) were first cleaned under running water to discard any dust particles which will interfere with our coating procedure. The orthodontic wires were inserted into the bathtub containing nanoparticle solution for 30 min later the wires were removed from the tub and kept in a hanger where they further painted with nanoparticle solution. The wires were then air dried with the help of drier for 2 min.

The wire with the hanger was then placed in the hot air oven at 160°C for 3 min. In this way, the commercially available orthodontic wires were coated with nanoparticles. The ESEM gives us microscopic images of both wet and dry sample specimen. With the help of ESEM, we can examine the specimen in a faster and easy way. Another advantage of ESEM is that there is no need to modify the surface of the original specimen. In order to procure the ESEM images of coated and uncoated arch wires; 20 mm length of straight arch wires were taken. They were cleaned with distilled water to remove any precipitates.

Later the specimen were mounted in a machine holder and observed under field-emission ESEM. The images were recorded at ×500 magnification. The SEM study reveals that the orthodontic wires coated with nanoparticles has fewer surface irregularities than the commercially available uncoated wires. Thus, the surface topography of the coated wires was found to be smoother with less surface deteriorations as compared to the uncoated wires [2].

2. Esthetic modifications

Esthetically attractive orthodontic materials are desirable, especially for adults.[1,2] Although esthetic brackets made from plastic or ceramics are widely used for orthodontics, [3] most orthodontic arch wires are made of metal. Therefore, esthetic arch wires that complement brackets are highly desired for clinical orthodontics.

To this end, polymer wires with glass fiber reinforcements have been investigated but have yet to be used widely because of their brittleness and inability to withstand sufficient force. Coated arch wires, including metal wires coated with polymers, or rhodium-plated wires, have been developed are preferred by many patients because of their improved esthetic qualities. Coated metal arch wires are nickel-titanium wires treated with a polytetrafluoroethylene (PTFE), epoxy-resin, parylene-polymer, or less commonly palladium covering to impart an enamel hue. Manufacturers vary with regard to the coating material, thickness of the coating, and steps within the application process to maximize aesthetics, flake-resistance, and mechanical efficiency.

Currently, the two most common aesthetic arch wires on the US market are coated with either PTFE or epoxy-resin. PTFE coating is applied to an orthodontic wire by thermal spraying, a process in which finely heated materials are sprayed in a molten condition onto a surface to form a coating. Thermal spraying of PTFE onto an orthodontic arch wire entails, surface treatment of the wire by sandblasting (50-micron alumina) to support coating adhesion, “masking” or covering with tape areas that are not be treated, air-spraying atomized PTFE particles with clean compressed air to coat the wire, baking in a chamber furnace to cure the coating onto the wire, and removal of the masking tape.

The PTFE layer adds a minimal thickness (.0008 to .001 inch) to the arch wire. The challenge with coating metal arch wires is the lack of available metal primer. Coated metal arch wires with circumferential coating deliver statistically lower loading and unloading force levels than uncoated wires of the same nominal sizes. The lower force levels of coated wires may be attributed to: the thick aesthetic coating having a negative effect on the load-deflection properties, or a manufacturer’s use of a smaller-diameter wire to compensate for the thick coating, particularly for epoxy-coated arch wires. Additionally, the fragmentation of the coating adds increased frictional resistance and diminishes the aesthetic benefit.

Antimicrobial silver coatings

Ni Ti wires can be modified with silver coatings to produce anti-bacterial and anti-adherent properties. Surface modification of both stainless steel and nickel titanium orthodontic wires with silver was carried out by thermal evaporation method. The instrument used for coating is HINDHIVAC vacuum coating unit model no-15 F6 (Hind High Vacuum Co. Bangalore). It produces thin homogenous, uniform pure film coating of various metals to achieve controlled effects in various applications (Fig. 2). Pure silver (99.9 %) was used to obtain thin coating on orthodontic wire.

Silver was heated through its vaporization temperature in a closed chamber and vapors were allowed to pass through a valve which could be controlled according to the desired thickness. ultra sonication of the wires were done for 5 min in 2-propanol to remove adventitious macroscopic contaminations and were dried in a desiccator. After cleaning and sterilizing in an autoclave, the wires were pre weighted using an analytical balance (Xitij Instrument, Pune) and were stored in an airtight container. In a sterile beaker containing 10 mL of an MRS broth, an overnight-cultured lactobacillus culture broth was inoculated to a final concentration of 10 %.

After this, 1 mL of this suspension was pipetted into each of the tubes, and the wires were immersed in it and were incubated for 24 h at 37 °C inside the laminar air flow chamber or inoculators. Wires to which bacteria adhered were carefully removed and immersed in a 10 % formaldehyde solution for 30 min to immobilize the cells. After a careful rinse with distilled water, the wires were dried in a desiccator for 24 h. The weight change of the brackets during the bacterial adhesion test was recorded with an analytical balance. Silver has an important microbial effect.

The interaction of silver with thiol groups in enzymes and proteins plays an essential role in its antimicrobial action, although other cellular components, like hydrogen bonding, may also be involved. Silver has been proposed to act by binding to key functional groups of enzymes. It also causes the release of K^+ ions from bacterial plasma or cytoplasmic membrane, which is a site associated with many important bacterial enzymes, thus making it an efficient target site for silver action [5].

However, the use of silver must be undertaken with caution, since the concentration-dependent toxicity has been demonstrated. Silver has not been mentioned in the list of the hazardous heavy metals to public health but still accumulation in the environment should be considered. The amount silver essential to successfully carry out anti-adherent, antibacterial properties and the maximum lethal dose should be determined if its toxicity is to be avoided before it can be applied to orthodontic materials.

The silver coating on wires is purely surface based and may be prone to wear during arch wire sliding. Thus, it is critical to assess the durability and sustainability of silver coatings under clinical situations in the oral environment. Also, it would be prudent to determine whether the thin coating of silver would alter its mechanical properties.

Antimicrobial zinc coating

Surface modification of both stainless steel and nickel titanium orthodontic wires with silver was carried out by thermal evaporation method.

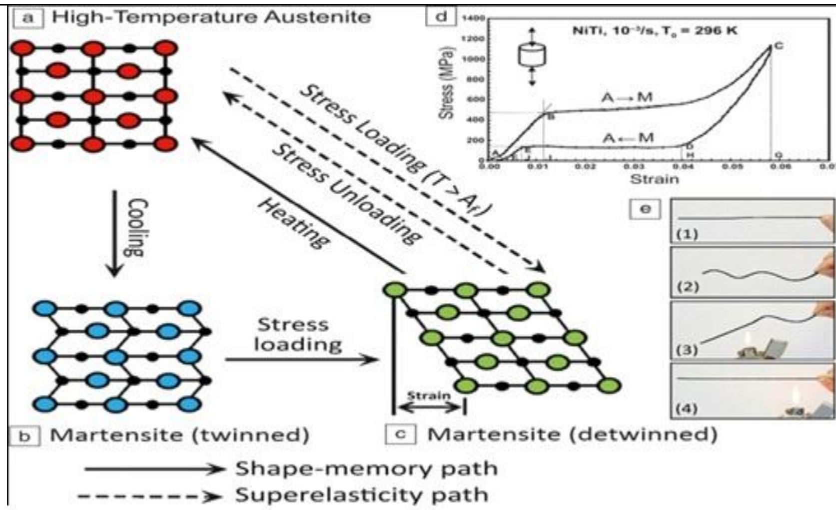
NiTi wires can be with ZnO nanoparticles. This increases their resistance to sliding and antibacterial activity against S. mutans. The reduction of friction between the bracket and arch-wire can improve the orthodontic force up to 50% and significantly facilitate the tooth movement. It also would decrease the treatment duration and the risk of apical root resorption. Besides, the increased proliferation of S. mutans during the treatment period is the main cause of the formation of WSL which is a common problem during the fixed orthodontic treatment with an estimated prevalence of 38% in the first 6 months and 50% at the end of the fixed orthodontic therapy [3].

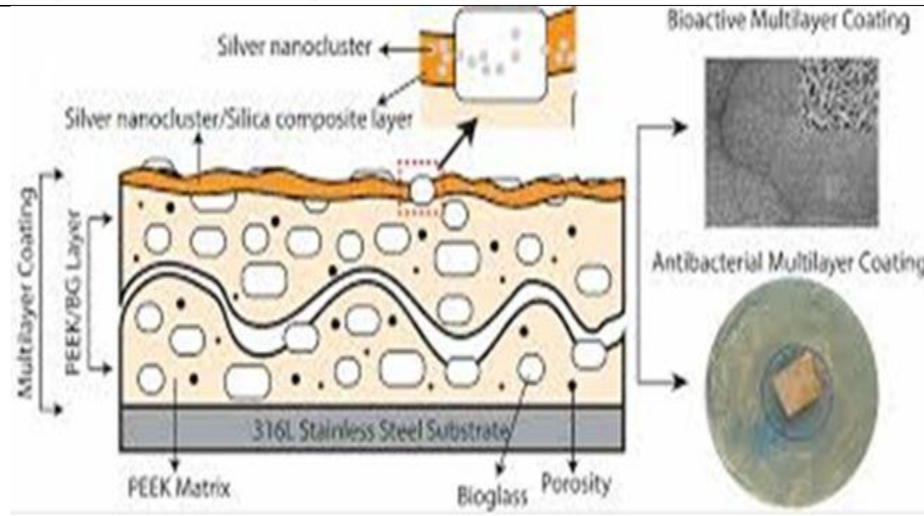
A stable and well-adhered ZnO nanocoating on the NiTi wires was obtained in the present study. The coating was stable even after in-vitro mechanical challenges such as repeated mechanical tests in the Instron machine and bending. The superior tribological behavior and long wear life of ZnO nano coatings as solid lubricants have been shown in previous studies. Also the ZnO-coated wires were whiter (more aesthetic) than the non-coated wires which may address the increasing demand for more aesthetic orthodontic appliances [4].

A unique coating on NiTi substrate was obtained using ZnO nanoparticles. The practical relevance of this study might be interesting given that ZnO nanocoating exhibits excellent antibacterial and biological properties together with superior frictional performance and corrosion property which may lead to the widespread use of this nanoparticle in future orthodontic and medical practice for safer treatment.

CONCLUSION

There is always scope for improvement and advancements. While NiTi wires have many desirable properties there are still a few disadvantages. Coating of NiTi offers a lot of scope for improvement. It shows potential to improve frictional properties, anti-bacterial nature, anti-adherent properties and esthetics. This is the right trend moving forward and the minor disadvantages in these coating techniques need to be worked upon.





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