# Graphene Sheets Embedded Carbon Films for Reducing Friction of Archwire-Bracket in Orthodontic Treatment

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Minimizing the friction force between the archwire and bracket during the orthodontic treatment has attracted worldwide interest. With the deposition of graphene sheets embedded carbon (GSEC) films on the stainless steel archwire, low friction coefficients of less than 0.20 were achieved in artificial saliva environment. The low friction mechanism is attributed to be the formation of salivary adsorbed layer and graphene sheets containing transfer film on the contact interfaces. The outstanding frictional performances of the GSEC film coated archwires make them good candidates for clinical orthodontic treatment applications.

**Keywords:** graphene sheets, carbon film, orthodontic archwire, low friction, artificial saliva

## 1. Introduction

Orthodontic treatment is the restoration of the abnormally positioned teeth for human beings. The fixed orthodontic appliance consisting of archwire and bracket has been extensively applied for the dental clinical applications. The relative sliding of the archwire to bracket produces first static and then kinetic friction forces, which greatly affects the tooth movement efficiency. The achievement of low friction forces could strongly reduce the risk of root resorption and patient pain, shorten the treatment time, and improve both anchorage control and direction of tooth movement [1]. Therefore, the objective of this research is to reduce the friction coefficients between the stainless steel archwire and bracket.

## 2. Experimental

Carbon films were produced on the commercial stainless steel archwires with a customized mirror confinement electron cyclotron resonance (ECR) plasma sputtering system under various substrate bias voltages from +5 V to +50 V [2]. Friction and wear behaviors of the archwires sliding against brackets were systematically evaluated with a home-built reciprocating sliding tribometer under artificial saliva environment.

## 3. Results & Discussion

Graphene sheets embedded carbon (GSEC) films were successfully fabricated onto the stainless steel archwires under substrate bias voltages of +20 V and +50 V without any interlayer. It was clearly observed that graphene nanocrystallites with different cluster sizes were dispersed into amorphous carbon matrix by using transmission electron microscopy.

Both static and stable friction coefficients of the archwire-bracket contacts sliding in artificial saliva conditions decreased with the deposition of carbon films on the archwires, as shown in Figure 1. Specifically, friction coefficient of archwire and bracket in artificial saliva environment strongly decreased from 0.52 to 0.12 with the fabrication of carbon films on the archwires. The friction coefficient varied between 0.12 and 0.16 with the change of substrate bias voltage, suggesting a superior friction behavior of the carbon films deposited archwires.

The low friction mechanism is argued to be the formation of salivary adsorbed layer and graphene sheets containing tribofilm on the contact interfaces. The clarification of the low friction mechanism is beneficial for designing low friction archwire-bracket system for clinical orthodontic applications.

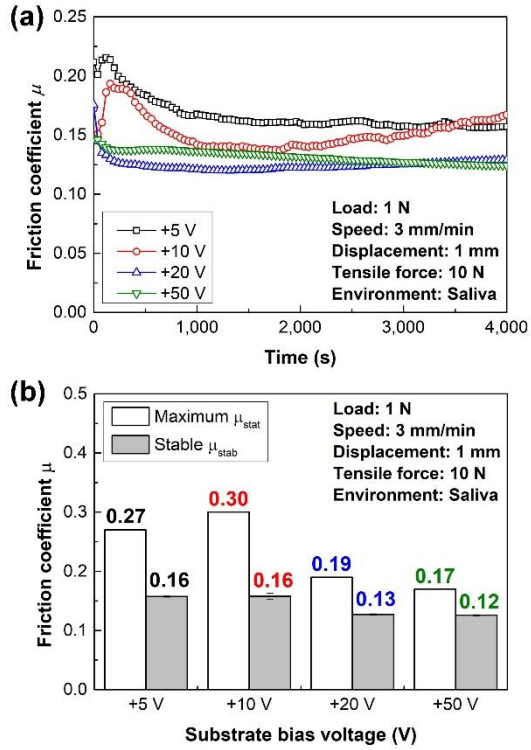


Figure 1: Friction behavior of the carbon film coated archwires. (a) Mean friction coefficients. (b) Maximum static friction coefficients and stable average friction coefficients.

## 4. References

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