# Influence of surface morphology on mechanical properties of polyethylene. Tribological consequences in a biomimetic environment.

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## 1. Abstract

It is known that wearing of the polyethylene part of implants is the primary cause of premature failure of total joint replacements [1]. In this study, using atomic force microscopy technique and tribological methods, we have investigated the influence of polyethylene surface morphology on mechanical properties, wear and friction.

## 2. Introduction

The only known treatment for severe osteoarticular diseases is the replacement of the joint surface with an orthopedic prosthesis. However, the lifespan of these implants is limited at approximately 10 years due to the wearing of polyethylene part. The final goal of our study is to improve the properties of polyethylene by grafting biological molecules on the surface of the material. In order to reach this goal we have initiated a study to determine how different types of morphology influence the mechanical and bio-tribological properties of polyethylene.

## 3. Materials and methods

For our study, we have used samples of ultra high weigh molecular polyethylene with four different types of surfaces obtained by different types of polishing (samples A,B and C) and one with a high-speed turning machine (sample D). The friction coefficient is measured using a homemade bio-tribometer that allows in situ visualization of the contact between the flat surface of the sample and a plane-convex surface of a glass. The tests last 540 min (2027 cycles) using a TRIS-buffered saline solution as lubricant.

Nanoindentation was applied to test the mechanical properties of the material using AFM technique. Mechanical properties such as Young modulus are used initially, to establish if it will interfere with friction tests. Further, in our study, the elastic properties will be used to determine influence of chemical treatments applied to samples.

## 4. Results and discussion

The measures for elastic modulus show no difference for the polished types of samples, reaching a value of approximately 3 GPa, thus we were able to separate this parameter for the friction test that will depend only on the surface characteristics.

The four types of topographies with their characteristics are shown in table 1.

Table 1.

| Type of topography | Profilometer Ra [μm] | Friction coefficient |
|---|---|---|
| A | 0.43 | 0.045±0.0008 |
| B | 0.25 | 0.035±0.0004 |
| C | 0.55 | 0.040±0.0003 |
| D | 0.52 | 0.019±0.0004 |

As we can see in table 1, the value for Ra is similar for type A, C and D, however the morphology is different for each one of the samples. Thus, type A and C surfaces are characterized by roughness picks that are flattened for type C and more sharp for type A, type D presents concentric stripes, and type B is characterized by the so called “third body platelets” morphology.

Each type of surface structure sets the velocity accommodation mode that explains the value of friction coefficient. For example, type D has the lowest value of friction coefficient due to the regularity and the form of stripes, which allows that during friction, peaks are drawn until particles are detached and enter between peaks forming a blend with the TRIS solution (Fig1.(b)). These conclusions were made based on different test realized on chemical treated polyethylene surface.

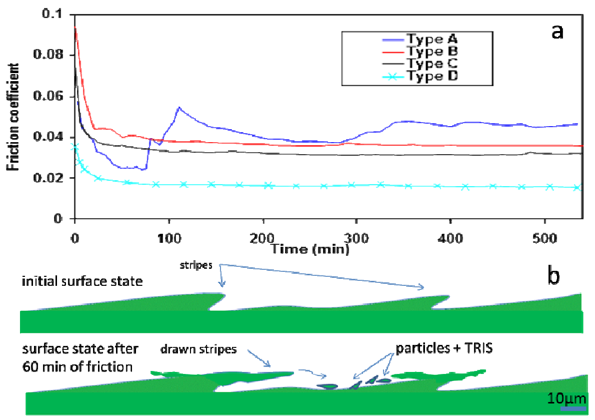


Fig. 1(a) Variation of friction coefficient with time ; (b)sectional view of the surface of sample D

## 6. References

[1] A. Buford et al, “Review of wear mechanisms in hip implants” Materials & Design volume25, 2004, 385-393