Tribological study of Oral Care silica

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1. Introduction

Teeth are usually cleaned using a toothpaste, consisting of abrasive silica, bioactive agents, organic thickening agents, in a carrier fluid, with a filament based toothbrush. The mechanisms involved in the cleaning of teeth and toothpaste abrasivity are not yet well understood despite various measurements of wear performed during the last 25 years [1, 5]. The effectiveness of a brushing is related to multiple key parameters: mechanical parameters such as size, shape and hardness of the abrasive granules, brushing load and speed, stiffness and orientation of the brush; chemical parameters such as pH of both toothpaste and saliva and toothpaste actives. There is, however, no clear understanding of how these parameters affect cleaning effectiveness.

This study focuses mainly on the effect of mechanical parameters, as a first step for a better understanding of the tribological behavior of oral care silica. The tribological approach, based on the third body concepts, gives a method of interpretation of the contact dynamics by taking into account the role of the mechanism, the first bodies and third body.

2. Experimental details

Reciprocating motion tests are performed for the parametric study. Two experimental toothbrushes type, Oral B and Duopole (2 different designs) are used. Loads and brushing speeds choice is based on measurements taken during in vivo experiments (using instrumented toothbrush), from literature and from the norm ISO 11609. Thus 7 loads values ranged from 1.5 to 5N and 5 brushing speeds from 30 to 150 mm/s have been tested. Acrylic plates (PMMA) are used as a substitute for human dentine. The formulation of the 4 experimental slurries (model toothpaste) was provided by Solvay Silica (three with silica powders of various abrasive level and one with calcium pyrophosphate). Tests have also been performed without slurry (dry) to highlight the deformation of the filaments related to the evolution of the friction coefficient μ (Fig. 1).

3. Results

The reconstitution of the tribological behavior of the oral care silica is built, based on third body flows related to the friction results. The flows of third body are evaluated on the basis of post-mortem observations of filaments and PMMA and in-situ by using video films through PMMA. In order to compare the different third bodies formed during the tests, Optic Microscope, environmental high resolution Scanning Electron Microscope (SEM) (Fig. 2) and Transmission SEM are used. This work highlights the effect of the first body (stiffness and trim shape of the filament) on the activation of a silica internal flow between one filament and PMMA. Turbulences are created by the circulation of the liquid part of the slurry between the tufts and filaments, which also has an effect on the solid particles flows. Clues to understand the mechanism's involved are given, showing the multi-scales and multi-physical aspects of the problem.

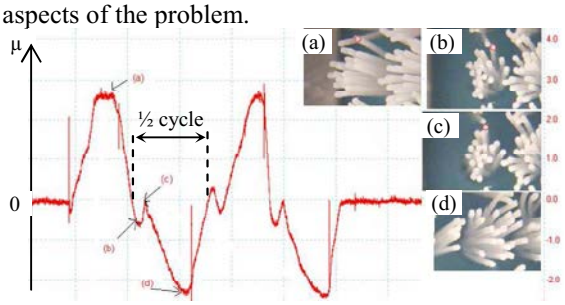

Figure 1: Deformation of filaments without slurry

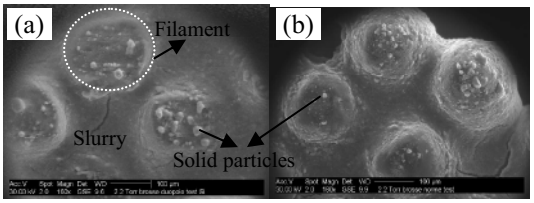

Figure 2: SEM analysis, (a) Duopole, (b) Oral B

4. References

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