TRIBOLOGICAL EVALUATION OF HYDROGELS FOR ARTIFICIAL ARTICULAR CARTILAGE

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ABSTRACT

Bacterial cellulose (BC) is a natural and biocompatible gel with unique properties, such as high water holding capacity, ultra-fine fibre network and high strength that make it an interesting material for biotribological purposes. In this work, unmodified BC pellicles were grown from *Gluconacetobacter xylinus* in order to be used as tribological samples against bovine articular cartilage (BAC) in the presence of phosphate buffered saline (PBS). The tribological assessment was accomplished using reciprocating pin-on-flat tests at 37ºC at constant sliding frequency (1 Hz) and stroke length (8 mm). Contact pressures ranging from 0.8 to 2.4 MPa were applied. The friction coefficient was monitored and the release of total carbohydrates into the lubricating solution was followed by means of the phenol-H_2SO_4 method as an attempt to evaluate wear losses. Low friction values (~ 0.05) combined with the preservation of the mating surfaces (BC and BAC) indicate the potential of BC to be used as artificial cartilage for articular joints.

INTRODUCTION

BC has proved promising for the treatment of chronic wounds and burns, as artificial cardiovascular tissues, and as scaffolds for guided regeneration of bone, nerve and cartilage [1]. However, in order to extend the application of BC to load-bearing applications, such as the articular cartilage, the tribological response of this material needs to be investigated under conditions mimicking the in vivo situation.

Either as scaffolds to promote new tissue growth or as a surrogate material working in harness with natural cartilage, numerous materials and combinations had been proposed, and special attention has been dedicated to hydrogels, although very few authors have focused on their tribological response [2].This study describes the tribological properties of BC,a particular kind of hydrogel,against bovine articular cartilagein the presence of a saline solution.

RESULTS AND DISCUSSION

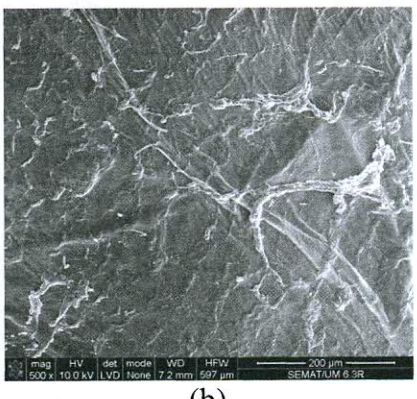
Table 1 presents the friction values obtained for the different contact pressures. Very low friction values, in the range 0.046-0.058, were measured. Comparing the obtained friction results with the values around 0.03 indicated in the literature for self-mated cartilage tribocouples in simulated physiological media [3], it can be concluded that, from the frictional point of view, BC is a gel with potential to be used as artificial cartilage for articular joints.

Table.1. Friction coefficient values for bacterial cellulose/bovine articular cartilage contacts in the presence of PBS (test duration = 30 min)

Contact pressure, p (MPa)	Friction coefficient
0.80	0.058±0.004
1.60	0.049±0.002
2.40	0.046±0.002

The morphological wear features of BC after sliding under p=2.4 MPa, for 30 min, are shown in the SEM micrograph of Fig 1 (a), which is also representative of the worn surface appearance resulting from the reciprocating sliding under lower contact pressures (p=0.8 MPa and p=1.6 MPa). BC worn surface is mainly characterised by high plastic deformation, where BC layers tend to be displaced by the combined effect of normal applied load and tangential friction force resulting from the reciprocating motion. These layers and intertwined nano-fibres of displaced material, appear to be strongly seized to the original pellicle. Signs of conventional wear mechanisms such as adhesion and abrasion were not evidenced by BC worn surfaces.

(a)



(b)

Fig. 1. Worn surface of BC after 30 min sliding (p=2.4 MPa) (a) and after a 6 h-long test (p=0.8 MPa) (b).

For 6 h-long test under p=0.8 MPa(Fig. 1(b)) the morphological features of BC worn surface are similar to those of the worn surface resulting from a short duration test (Fig 1 (a)). Determination of total glucose in solution by the release of particles or fibres to the lubricating medium, showed no correlation between the calculated mass dissolved and test duration or contact pressure. This fact indicates that the surface damage of BC by wear occurred essentially by displacement and deformation of material layers with negligible mass loss attributable to wear. In addition, no signs of surface damage were evidenced on the opposing articular cartilage contact surfaces. This result highlights BC/natural articular cartilage as a potential tribosystem for in vivo applications.

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