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Prudente A[1], Riccetto C[1], Simões M[1], Pires B[1], de Oliveira M[1]
1. *UNICAMP*

IN VITRO STUDY OF SURFACE MOPHOLOGY AND HIDROPHILICITY OF PURE POLYPROPYLENE MESH AND WITH PVA IMPREGNATION: IS THERE A PHYSICAL CHARACTERISTICS MODIFICATION WITH COATINGS?

Hypothesis / aims of study

Cell attachment may be strongly influenced by the surface of implantable biomaterials (1). This knowledge has led to proposals based on surface modification in order to increase hydrophilicity of implantable biomaterials for improving cell seeding and cell attachment (2).

Poly (vinyl alcohol) (PVA) is a highly hydrophilic polymer, with low toxicity and good biocompatibility (3). S-nitrosoglutathione (GSNO) plays a key role in the regulation of angiogenesis, inflammation and wound healing. In this work, we impregnated polypropylene (PP) meshes with PVA and PVA+GSNO and observed hydrophilicity and its surface modifications and local release of GSNO.

Study design, materials and methods

By coating PP meshes with immersion method, we obtained samples impregnated with pure PVA and with PVA+GSNO in two final concentrations of GSNO: 40 µmol/g and 400 µmol/g. Scanning electron microscopy was used for the morphological analysis of plain and impregnated PP meshes. Before this evaluation, the samples were manually stretched to 50% of their initial length in order to evaluate the adherence of the impregnations. Hidrophilicity was measured by contact angles between the air/water interfaces. For this porpouse we utilized an optical tensiometer. Kinetic curves of GSNO released over time were obtained by chemiluminescence using a nitric oxide analyzer.

Results

Surface morphology (Fig 1A): PVA deposits can be seen at the knots of the knit and mesh porosity was preserved. Given the small amount of PVA impregnated in the meshes and its capacity of withstanding more than 100% of elongation before breaking, the impregnations are not expected to reduce the flexibility of the meshes. Although manual stretching led to some detachment of PVA from the surface of the filaments, it can be seen that the PVA deposits stay firmly retained in the inter-filament spaces of the knots. Therefore, PVA fragments are not expected to be released during mesh implantation, since the stretching of the meshes during surgical handling must be much less intense than the stretching used for the present morphological evaluation.

Kinetics of GSNO release (Fig 1B): The PVA matrix provides a fast release (plateau about 90 s) of GSNO. The observed plateau values are compatible with the 10 times difference in the GSNO concentration in the two different impregnations.

Contact angle measurements - θ (Fig 2): Pure PVA impregnation leads to a decrease of θ from 111° to 66°. The presence of GSNO (also a polar hydrophilic molecule) in the PVA film does not significantly change the θ values. Thus, cells and proteins are expected to interact strongly with the PVA regions of the coated PP meshes.

Interpretation of results

Successful tissue integration to biomaterial surfaces depends strongly on cell/biomaterial interactions, which are in turn influenced by the wettability of the biomaterials and other factors such as surface roughness. As a typical hydrophobic polymer, comprised of –CH2(CH3)- repeat units, PP has very low polarity, poor surface properties and poor wettability. On the other hand, PVA, with hydroxylated -CH2OH- repeat units, is a highly hydrophilic polymer, which is strongly solvated by water through hydrogen bonding.

The measured contact angles (θ) can be considered to reflect the average chemical nature of the mesh surfaces. Impregnation of the PP meshes with pure PVA leads to a decrease of θ from 111° to 66°. This result is in accordance with the lower critical surface tension of PVA compared to the PP and corresponds to an increase in the water adhesion tension. Thus, cells and proteins are expected to interact strongly and more extensively with the PVA regions of the coated PP meshes. If these cells are fibroblasts, this effect may lead to a denser collagen deposition and consequently to a better mesh fixation.

PVA or PVA/GSNO impregnation leads to a significant increase in the hydrophilicity and preserves the porosity of PP meshes. PVA deposits stay firmly attached in the intra-knot spaces, from where GSNO can be locally released to the surrounding tissue.

It can be seen that the PVA matrix provides a fast release of GSNO to the aqueous reception medium, what is in accordance with the high solubility of GSNO in water. The kinetic curves show that the total amounts of GSNO released come to a plateau after about 90 s. The observed plateau values are compatible with the 10 times difference in the GSNO concentration in the two different impregnations. From this period ahead, one may consider that only traces of GSNO will be released. This kinetic behavior means that this formulation is not capable of providing a slow GSNO release pattern. Thus, any biological effect of GSNO on the tissue surrounding the mesh will be acute and associated with a burst release.

Concluding message

Impregnation of monofilament PP meshes with physically crosslinked PVA or PVA/GSNO leads to a significant increase in the hydrophilicity of PP meshes, while preserving their porosity. PVA and PVA/GSNO depositis stay firmly attached in the intra-knot spaces of the meshes, from where GSNO can be locally released to the surrounding tissue. These results indicate that impregnation of PP meshes with PVA or PVA/GSNO could be a new strategy to reduce the frequency of clinical complications associated with mesh extrusion.

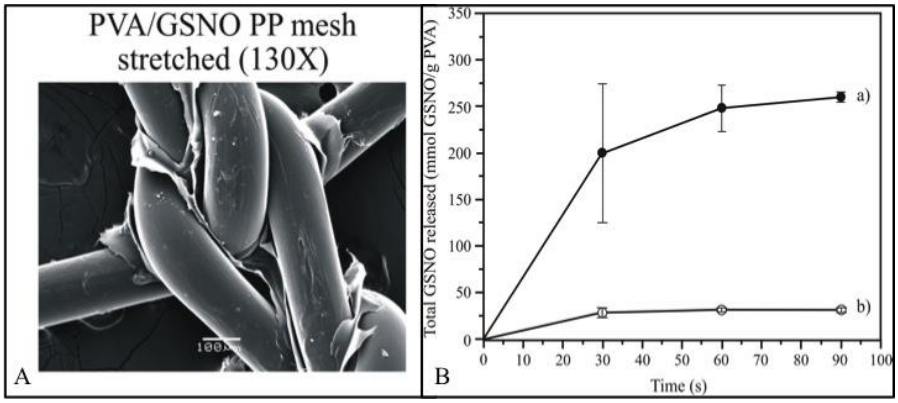

Figure 1: (A) SEM micrographies of PVA/GSNO impregnated PP meshes (before and after manual stretching).PVA deposits can be seen at the knots of the knit and mesh porosity was preserved ; (B) The PVA matrix provides a fast release (plateau about 90 s) of GSNO

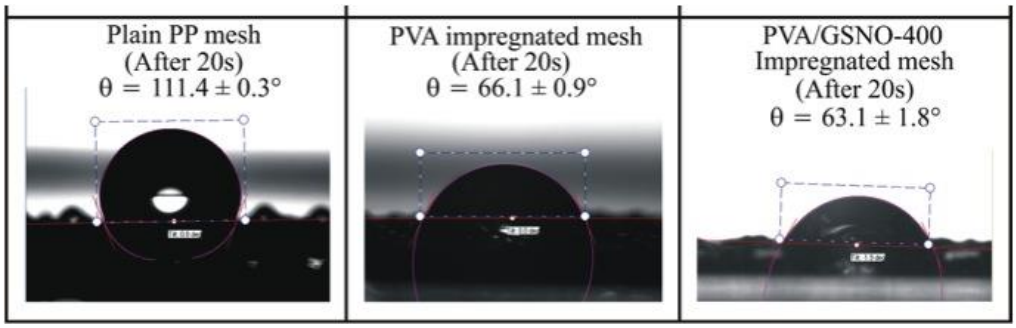

Figure 2: Contact angle measurements showing the profile of water drops on the surfaces of plain PP meshes and of PP meshes impregnated with PVA and PVA/GSNO, after 20 s of drop deposition (t = 20). PVA impregnated meshes decreases the angle. GSNO doesn't change it.

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Disclosures

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