Properties of POSS-PCU Nanocomposites for Biomedical Application

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Introduction

Hybrid organic–inorganic nanocomposites can combine the advantages of both organic and inorganic materials. Nanoporous polyhedral oligomeric silsesquioxanes (POSS) have received extensive research attention as a nano-scale building block for the preparation of hybrid nanocomposites. Incorporation of POSS has been shown to have a drastic effect on the structure and physical properties of segmented polyurethane. In this study, we focus on the improvement of the surface properties of a polyurethane thin film by utilizing the inherent characters of POSS. A polyurethane system has been synthesized and characterized with the hard segments being molecularly modified with different concentrations of nanostructured POSS molecules.

Results

For the POSS-PCU hybrid nanocomposite, not only the characteristic bands of reference polyurethane (PCU), but also the absorption bands at 1109 cm⁻¹ representative of Si–O–Si stretching vibrations were observed (Figure 1). It appears that viscosity is somewhat lower for the POSS-containing structures. This could be due to an effect of composition on Mark-Houwink parameters (Figure 2). The increase of the POSS concentration generally results in a higher modulus and a lower maximum elongation ratio. The attachment of the rigid POSS molecules in the hard segments probably enhances the stiffness of the modified domains at the molecular level and dispersed in the polymer matrix at the molecular level. This can improve the overall modulus of the soft segment dominant matrix (Figure 3).

While the surface of the PCU sample is smooth with no apparent surface features, the POSS-PCU blends exhibit raised roughness. Increments in surface hydrophobicity may also be related to the surface roughness.

The contact angles are dramatically enhanced and the total surface energy of polyurethanes is reduced. (Table 3) The ζ-potentials of the pure PCU membrane are only at strongly basic pH values in the negative range. Then ζ-potentials become negative with increasing content of POSS (Table 4).

Endothelial cells (ECs) were obtained from human umbilical cord veins by an adaptation of the method of Jaffe et al. Confocal microscopy was performed in order to observe ωV expression. After seven days of culture the ECs seeded on the polymer were ωV-positive (Figure 5). ECs seem to proliferate, spread, and keep their phenotype on polymer surfaces. CellTiter-Blue Cell Viability Assay shows that the endothelial cells attachment on the surface increases with incorporation of POSS compared with PCU (Figure 6). The use of these nanocomposites to coat NiTi stents is reported elsewhere³.

Conclusions

This study confirms that the POSS nano-particle structure was chemically incorporated in the PCU rather than making a physical mixture. While microscopy, spectroscopy, contact angle analyses all indicate dramatic modification of surface properties for these nanocomposites, bulk properties are only minimally affected by incorporation of POSS in the PCU matrix. Preferential segregation of POSS moieties on the surface makes the surface hydrophobic. This is the reason for the improved biological properties; including higher endothelial cell attachment.

References


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