EVALUATION OF THE FATIGUE PROPERTIES OF RUBBERY BIOMATERIALS USING THE HYSTERESIS METHOD

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INTRODUCTION

Thermoplastic elastomers (TPE) constitute a relatively new group of polymeric materials classified as a separate category of rubbers. TPEs do not need to be vulcanized and therefore offer many advantages over chemically crosslinked elastomers, while being processible as classical thermoplastics. High performance TPEs with good solvent resistance, elasticity, tear strength and flex fatigue properties have found a wide range of applications in medicine such as medical tubing or equipment parts. Selected TPEs are also used for implant applications [1].

This paper will discuss the dynamic fatigue properties of medical grade silicone (SIL), a chemically crosslinked elastomer, and polyurethane (PU), a TPE, and two new TPE biomaterials: polystyrene-*b*- polyisobutylene-*b*-polystyrene (SIBS), recently FDA-approved as medicated coronary stent coating, and a segmented polyester TPE containing dimerized fatty acid (PED).

METHODS

Fatigue testing was carried out using a servo-hydraulic test machine with a digital controller (Instron 8400/8800), equipped with a 200-N load cell, a 10 kN cylinder and an environmental chamber. For all tests, the load ratio $R = \sigma_{min}/\sigma_{max}$ was held constant at 0.1. The strain was measured as the real-time clamp displacement. The possible phase shift between the stress and strain signals were minimized below 20 µs by the experimental set-up. Testing in simulated body fluid (SBF) was carried out at 24 and 37°C. Testing was carried out using the SILT (Stepwise Increasing Load Test) and SLT (Single Load Test) methods. The DynMat Hysteresis Measurement Software V.1.1.0.1 was used for the evaluation of the hysteresis loops [2].

RESULTS AND DISCUSSION

With SILT, SIL showed extremely low dynamic modulus, and large instantaneous elastic deformation. SIBS performed much better, with nearly ten times higher modulus than SIL, bridging the gap between SIL and PU. PED showed an intermediate behavior between SIBS and PU. SIBS and PED both displayed high damping. Figure 1 shows the hysteresis loop patterns. SIBS30 shows the largest area under the hysteresis loop, indicative of its high damping. The hysteresis

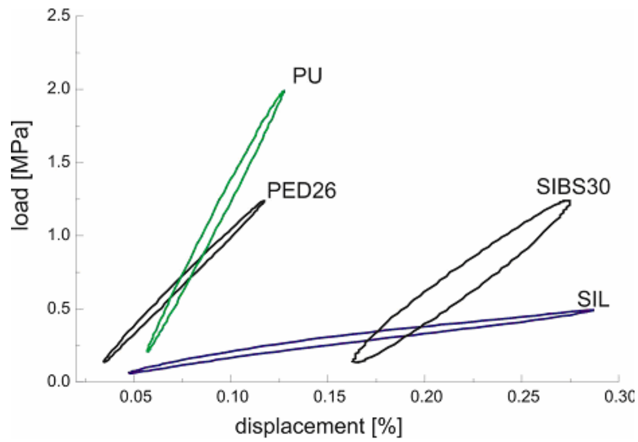

Figure 1: Hysteresis loop patterns.

loop of SIL exhibits large displacement at low forces. The much broader hysteresis loops of PU and SIBS compared to PED indicate structural changes, accompanied with high energy dissipation and larger creep.

SIBS demonstrated superior creep resistance compared to SIL *in vitro* (SBF, 37 °C), approaching the performance of PU and PED.

CONCLUSIONS

The hysteresis method seems to be a useful new method to evaluate the dynamic behavior of biomaterials. The recently developed dendritic SIBS materials are expected to have improved dynamic fatigue and creep properties, on account of their branched structure [3]. This, coupled with the biocompatibility of SIBS, predicts a bright future for this novel biomaterial.

REFERENCES

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