Degradation Mechanism of Human Explanted Heavy Weight Polypropylene Hernia Meshes

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Statement of Purpose: Millions of patients in the United States have received surgically implanted mesh materials, yet the long-term performance and changes to these polymeric materials are not well characterized [1]. Understanding the tissue-material *in vivo* interaction is of critical importance in order to design biocompatible, long-term materials. However, the body's foreign body response is aggressive, making it difficult to predict any material's long-term biocompatibility. Our group has been acquiring explanted mesh materials for over two years and our current repository holds over 300 explanted mesh materials, primarily from hernia patients, but can also include polymeric materials from a variety of surgical subspecialties. The objective of the study was to analyze the physiochemical properties of explanted polypropylene meshes after their tenure *in vivo*.

Methods: Five heavy-weight polypropylene hernia meshes were explanted at the University Hospitals in Columbia, MO via an approved IRB. The length of implantation of the meshes was 5 months, 1 year, 5 years, 9 years, and 14 years. The meshes were cleaned and then subjected to a series of tests. Scanning Electron Microscopy (SEM) micrographs were used to determine any structural damage of the explanted mesh compared to pristine samples. Fourier transform infrared spectroscopy with ATR was utilized to evaluate changes in the chemical structure/functional groups on the surface of the material. Thermal gravimetric analysis (TGA) was utilized to examine relative percent (rate) weight loss of the explants as compared to pristine samples.

Results:

SEM: The heavy weight polypropylene specimens displayed surface damage as noted by pits, fissures, and an increase in surface roughness from the pristine. Figure 1 shows a representative micrograph of an explanted polypropylene mesh.

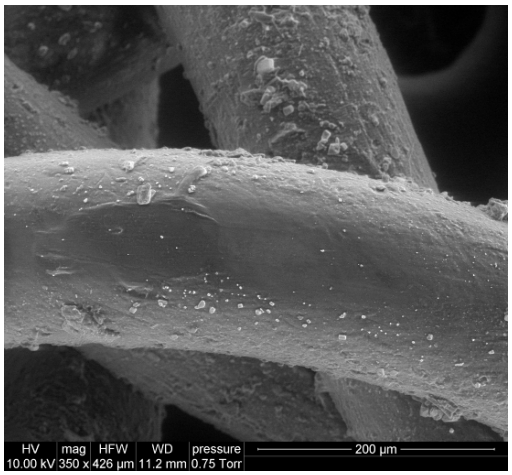

Figure 1. Micrograph of explanted polypropylene mesh that was implanted for 5 months.

FT-IR: As shown in Figure 2, the FT-IR scans displays carbonyl peaks (~1740 cm^{-1}) in the explanted samples while the pristine sample displayed the absence of this peak. This is indicative that the explanted samples are undergoing oxidation.

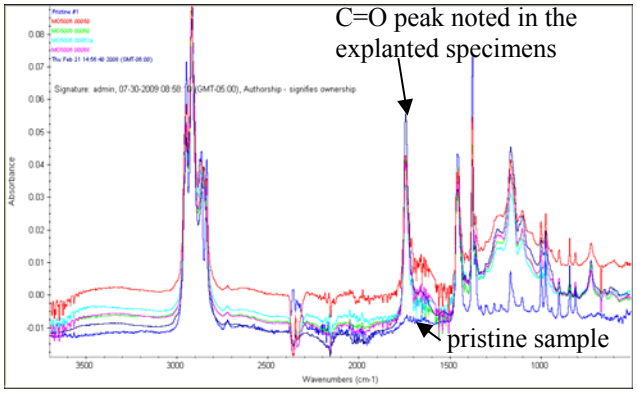

Figure 2. FTIR scans of the five explanted meshes and one pristine polypropylene mesh.

When polypropylene degrades, bonds are broken and free radicals are created along with chain scission. The free radicals may bond to oxygen to form carbonyl groups. The carbonyl (C=O) bond vibration peak is typically found at ~1740 cm^{-1} and it is indicative of oxidation. Utilizing the FT-IR data, this peak was integrated at the peak limits of 1650-1800 cm^{-1}. The three specimens that demonstrated the greatest area under the peak included specimens 22 (5 month implantation), 60 (5 years implantation), and 68 (9 years implantation). The patient with specimen 22 had a Body Mass Index (BMI) over 30 and was diabetic, while the patient with specimen 60 was not diabetic, but had a BMI over 46. And the patient with specimen 68 had a BMI over 73, was a diabetic, and was a nicotine user. The two specimens that displayed the lowest area under the carbonyl peak (50 (14 years implantation) and 63a (1 year implantation)), were not nicotine users, were not diabetics, and had lower BMIs.

TGA: The heavy weight polypropylene showed a significant difference ($p<0.05$) in percent weight loss as compared to the pristine for 4 out of 5 specimens; explant 50 was the only specimen that was not significantly different.

Conclusions: The polypropylene explant material did undergo degradation and oxidation. The micrographs displayed evidence of surface damage. The FT-IR scans indicated the presence of carbonyl groups which is indicative of oxidation while the TGA graphs indicated that the explant materials lost mass while *in vivo*. However, the results show that patient factors (BMI, diabetes) other than implantation time may influence the integrity of the material. These factors will be investigated in future studies.

References:

1. http://digestive.niddk.nih.gov/statistics/statistics.htm