**Knee Wear of Antioxidant-Stabilized UHMWPE under Aggressive Accelerated Aging Protocol**

J.L. Tikka, V.S. Narayan, T.D. Render

+DePuy Orthopaedics Inc., Warsaw, IN

jtikka@its.jnj.com

**Introduction**

Long-term success of TKA depends on several factors including wear, fracture resistance, and oxidative stability. A recent evaluation has shown that when accelerated aging protocols are extended out to 40 days, an antioxidant-stabilized UHMWPE outperformed non-irradiated GUR 1020, by remarkably retaining its mechanical properties, while the reputed oxidatively stable material experienced a significant decrease in DNI toughness and an increase in oxidation index [1, 2].

Preliminary assessments on the wear performance of crosslinked and remelted UHMWPE, aged up to 14 days, are encouraging [3, 4]; however limited wear results have been reported when an accelerated aging protocol is extended over longer periods. This is important considering 14 days of accelerated aging corresponds to only 4 years in vivo [5], while clinically relevant oxidation may occur at longer periods. This study therefore investigates wear performance of a novel hindered phenol-based antioxidant-stabilized UHMWPE, that has been irradiated to a nominal dose of 75 kGy, henceforth referred to as AOX™, and aged for 40 days.

**Materials and Methods**

Testing was conducted on PFC Sigma mobile bearing components (DePuy, Warsaw, IN), using cast CoCr femoral components, CoCr polished tibial trays and size 3, 10mm PFC Sigma RP-F™ tibial inserts with reinforcement pins removed. AOX™ tibial inserts were subjected to aging conditions described in the Dartmouth aging protocol [6] for a period of 40 days. These tibial inserts were run against non-aged AOX™ as a control. Tibial trays were secured to the lightweight plastic boats with acrylic cement to the femoral shaft, which interfaced with the flexion-extension input of the simulator.

Components were tested using a six-station knee simulator (AMTI, Watertown, MA). The input profiles were programmed per the gait cycle prescribed in ISO/CD 14243-1:2002. Each station was lubricated via recirculating bovine calf serum (Hyclone Laboratories, Logan, UT) at 37° ± 2°C, diluted to 25%, treated with sodium azide at a concentration of 0.2% mass fraction to retard bacterial growth and 20mM EDTA (7.45 g/L) to prevent calcium precipitation. Prior to testing, the tibial inserts were presoaked in reverse-osmosis filtered water at room temperature for 87 days.

Femoral/tibial component pairs were maintained for the duration of the test, switching banks every 1.5 M cycles in order to accommodate any difference from one side of the machine to the other. Vertical load was applied with 604in medial/lateral load offset. Loaded soak controls were used to account for wear specimen fluid absorption. Gravimetric wear was measured using an analytical balance (XP205, Mettler-Toledo, Watertown, MA). The input profiles were programmed per the gait cycle

Following wear testing, FTIR analysis was performed per ASTM F 2102 to characterize the oxidation index of wear tested samples, load soak samples, and untested samples that were soaking in R.O. water for the duration of the test.

**Results**

Figure 1 provides the individual gravimetric wear per interval over 6.0M cycles. The data is summarized in Table 2.

**Discussion**

The Student’s t-test of the average wear rates in the knee simulator provided a p-value of 0.01 indicating the wear of artificially aged AOX™ was statistically different from that for non-aged AOX™. However, this statistically significant difference in the wear rates is very small and would not be practically relevant particularly since the mechanical properties under such aging conditions have been shown to be remarkably maintained for AOX™ as compared to that for most materials which lose their mechanical properties under these conditions [1, 2]. Oxidation index characterization was conducted on all parts after being subjected to aging and subsequent wear testing and summarized in Table 2. The data confirms that there are no real changes resulting from the aging process after wear testing.

**Acknowledgements**

The authors would like to thank Matt Dressler and Grant Magnier for their contributions to this study.

**References**


---

**Table 1 – Average tibial group wear over 6.0M cycles**

<table>
<thead>
<tr>
<th>Poly Group</th>
<th>Wear Rate (mg/Mcyc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOX™</td>
<td>3.6 ± 0.2</td>
</tr>
<tr>
<td>Aged AOX™</td>
<td>4.2 ± 0.1</td>
</tr>
</tbody>
</table>

**Table 2 – Oxidation Characterization by FTIR**

<table>
<thead>
<tr>
<th>Poly Group</th>
<th>ASTM O.I. (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn AOX™</td>
<td>0.372 ± 0.020</td>
</tr>
<tr>
<td>Worn Aged AOX™</td>
<td>0.356 ± 0.012</td>
</tr>
<tr>
<td>Load Soak AOX™</td>
<td>0.352 ± 0.057</td>
</tr>
<tr>
<td>Load Soak Aged AOX™</td>
<td>0.346 ± 0.018</td>
</tr>
<tr>
<td>Soak AOX™</td>
<td>0.410 ± 0.040</td>
</tr>
<tr>
<td>Soak Aged AOX™</td>
<td>0.355 ± 0.024</td>
</tr>
</tbody>
</table>

---

Poster No. 1139 • ORS 2011 Annual Meeting