Tensile strength testing of bio-polyethylene and recycled polyethylene as alternative materials for ankle foot orthoses

Brogan Comstock, B.S.; Ryne Fuhrmark, B.S.; Janet Trujillo, B.S.; Department of Prosthetics and Orthotics
Advisor: Dr. Mojtaba Kamyab, PhD, CPO (Ir); Department of Prosthetics and Orthotics

Background

- There is a need for sustainable practices, responsible consumption and production, and increased health and well-being[1]. This has spurred research and creation of bio-plastics, plastics that are sourced from renewable resources, biodegradable, or mixed resources[2].
- The ***purpose*** of this research was to address a commercially available bio-polyethylene (bio-PE) and a recycled polyethylene (recycled-PE) as alternative materials for ankle foot orthosis (AFO) fabrication compared to the traditional petroleum based polyethylene (traditional-PE)[3].
- ***Hypothesis:*** bio-PE will have no significant difference in tensile strength at failure when compared to traditional-PE.

Methods

- **Materials**: Bio-polyethylene (sugar cane based), recycled polyethylene, traditional polyethylene (petroleum based)
- **Equipment:** Instron 8502 Fatigue System
- **Procedure**
  1. Three dog bone samples per material were laser cut
  2. Tensile strength testing at Proteor (Irvine, CA) at 2.5 in/min
  3. Qualitative observations of vacuum forming, material properties in oven, ease of finishing, and general material workability during the fabrication of ankle foot orthoses

Figure 1

ASTM D638 Type 1 Specimen

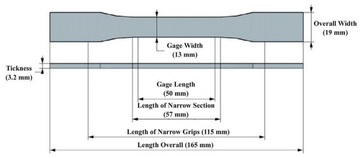


Figure 2

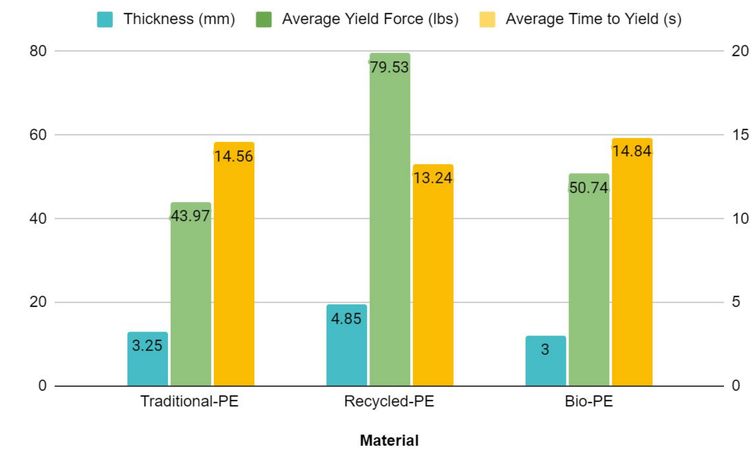
Recycled-PE, Bio-PE, & Traditional-PE AFOs

Results

- Recycled polyethylene had the highest yield strength compared to traditional polyethylene and bio-polyethylene had a comparable yield strength to the traditional.
- Direct comparisons cannot be made as the recycled-PE is 2mm thicker, which may confound the yield force findings.
- Average yield time was similar across the three conditions.

Graph 1

Average yield force, material thickness, and time to yield for three plastic conditions



Material Workability

Traditional-PE	*Recycled-PE*	*Bio-PE*
• Typical plastic workability • Material shrunk slightly • More difficult to cut • Difficult to get smooth	• Material retracted when heated • Smoked in oven • Strong acrid smell • Melted quickly when grinding	• Material retracted when heated • Did not seal well • Strong acrid smell • Felt more brittle when complete

Conclusions

- The recycled polyethylene has the greatest amount of tensile strength between the three materials, while bio-polyethylene was also greater than traditional polyethylene. Thus, both materials could be a viable alternative to traditional polyethylene.
- Limitations: lack of sustainable materials typically used in AFOs, varied thicknesses of test materials, and small sample size.

Clinical Applications

- The findings of this study suggest the use of polyethylene alternatives in upper extremity orthoses, spinal orthoses, or orthoses for non-ambulating individuals is viable.

Future Directions

- Future research should explore the cyclic loading test capabilities of fabricated ankle foot orthoses made from bio-polyethylene and bio-polypropylene for direct clinical implications.

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