

Evaluation of mechanical, thermal, and morphological characteristics of prosthetic feet with polypropylene matrix

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Abstract Background: The materials used in prosthetic components for lower limb amputees, which frequently could not support the essential dynamics for movement at slower rates, previously restricted their mobility. However, novel elements have enabled usability while aiding individuals in overcoming physical limitations.

Object: This study investigated the mechanical, thermal, and morphological properties of prosthetic feet.

Method: Employing a modular system technique, six polypropylene laminates reinforced with fibers (Kevlar, N-glass, Carbon, Perlon, and glass fibers) were created. These laminates were then put through tensile, compressive, impact, DSC, surface roughness, and SEM tests. The rule of mixtures was used to obtain density and volume fraction.

Results: Hybrid Perlon, carbon, and Kevlar fibers demonstrated the highest tensile, compressive strength, fracture toughness, impact performance, and surface roughness. According to DSC data, mixing different synthetic fibers had an impact on the crystallization temperatures, and the glass transition temperature rose as the number of layers increased. When compared to other hybrid materials, the Kevlar/carbon hybrid composite exhibited fewer flaws on its fractured surface, as indicated by SEM scans.

Conclusions: These results demonstrate the intriguing possibilities of orthopedic feet as well as the encouraging developments in biomedical engineering.

Keywords Amputation; mechanical testing; foot prosthetics; composite materials; thermal testing; morphological testing.

1. Introduction

An artificial device that replicates the role of an absent body part is called a prosthesis. Artificial limbs, often referred to as prosthetic limbs, are manufactured devices that offer amputees an alternative to their lost limb, thereby helping them regain some of the lost function. For lower limb prostheses to be effective, walking must be restored [1]. The fact that a majority of patients are not being targeted by current prosthetic foot technology is a serious problem. Developing nations are home to over 80% of the world's amputation victims [2]. According to a 2013 World Health Organization projection, up to 95% of the 30 million amputees who reside in underdeveloped nations do not have access to prosthetic equipment [3]. In low-income nations, the prosthetic foot's creation and manufacture are crucial, especially for amputees living in rural areas. The longevity of the prosthetic foot often determines the overall longevity of the prosthesis. To date, numerous artificial feet have been developed to meet the requirements of amputees in rural areas of low-income countries. The majority of these feet are produced locally in the country of intended use; however, others, such as the Snelson foot and the Geneva-made feet of the Global Committee of the Red Cross, are manufactured in advanced countries and then shipped to less-income countries [4].

When designing a prosthetic foot for underdeveloped nations, several key considerations should be taken into account. Durability, affordability, accessibility, manual manufacturing, local climate and working circumstances, ease of repair, ease of processing employing local production, replication by local staff, technical efficiency, biomechanical suitability, and maximum lightweighting are some of these factors [5]. When creating a functioning prosthesis in developing nations, several psychosocial factors must be considered in addition to environmental, economic, and physical aspects. For starters, a prosthesis needs to be able to move correctly to participate in some traditional customs of developing nations, such as sitting cross-legged, kneeling, walking barefoot, and bowing to elders or during worship [6]. The prosthetic foot should be able to swivel on the leg to adapt and achieve these postures. Furthermore, it has been noted that in both high- and low-income communities worldwide, the prosthetic's outward appearance plays a critical role in amputee satisfaction [7].

When choosing materials for prosthetic feet, several considerations must be taken into account to meet the unique needs of amputees. High compressive and tensile strength, resistance to shearing and corrosion, low density, versatility, and general stability are some of its key assets. The prosthetic foot must possess

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