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MINERAL LOADING AND DEFORMABILITY IN BIO TPU COMPOSITES WITH BARIUM SULFATE

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Introduction

Flexible polymer composites containing dense mineral particles are candidates for applications that require both conformability and potential attenuation of ionizing radiation. Barium sulfate ($BaSO_4$) provides a radiopaque inorganic phase, while thermoplastic polyurethane (TPU) supplies a deformable, melt-processable matrix. Previous investigations of TPU/$BaSO_4$ systems show that filler incorporation can modify rheological, structural and thermal properties [1]. Research on modified $BaSO_4$ surfaces also demonstrates that interfacial adhesion affects mechanical performance [2].

This study examines a partially bio-based TPU (Bio-TPU) to establish how increasing $BaSO_4$ content changes density, hardness, extension before failure and thermal response. The objective is to identify compositions that accommodate substantial mineral loading while retaining processability and deformability. Radiation shielding is considered a prospective application requiring separate validation.

Materials and methods

Bio-TPU/$BaSO_4$ formulations containing 10, 20 and 40 wt% filler were compared for physical and mechanical properties. The components were conditioned, compounded using a twin-screw extruder, cooled and granulated. Test specimens were subsequently obtained by injection molding. Density, Shore A hardness, melt flow index (MFI) and elongation at break were evaluated. Differential scanning calorimetry (DSC), using successive heating and cooling cycles over 30–250 °C, examined the initial thermal response and its evolution after thermal conditioning.

The interpretation combines composition-dependent physical properties with the calorimetric response. Density and hardness quantify distinct effects of filler addition, while MFI and elongation describe flow under the test conditions and deformation before failure. No direct X-ray or gamma-ray attenuation measurements were performed.

Results and conclusions

Increasing $BaSO_4$ loading from 10 to 40 wt% raised density by approximately 20%, from 1.27 to 1.52 g/cm³, while hardness increased by only three Shore A units (Table 1). Substantial mineral incorporation therefore caused a relatively modest change in indentation resistance.

Table 1 - Density and hardness of Bio-TPU/$BaSO_4$ composites

$BaSO_4$ (wt%)	Density (g/cm³)	Hardness (Shore A)
10	1.27	77
20	1.36	79
40	1.52	80

The 40 wt% formulation exhibited an elongation at break of 634% and an MFI of 56 g/10 min under the reported conditions. Successful compounding and injection molding support its thermoplastic processability. Extension before failure does not establish elastic recovery or resistance to repeated deformation, which require cyclic tests.

DSC showed filler-dependent changes in thermal-event positions and shapes, with differences between initial and subsequent cycles consistent with physical reorganization and processing-history effects. Polymer–filler interactions and dispersion influence elastomer composite behavior [3], but these measurements do not establish a specific interfacial mechanism or uniform particle distribution.

Bio-TPU/$BaSO_4$ thus offers increased density with substantial retained deformability. The 40 wt% composition merits further investigation by microscopy and cyclic mechanical testing. Attenuation measurements at defined photon energies and specimen thicknesses are needed before its suitability for radiation shielding can be established.

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