



Ultra-tough and super thermal-insulation nanocellular PMMA/TPU



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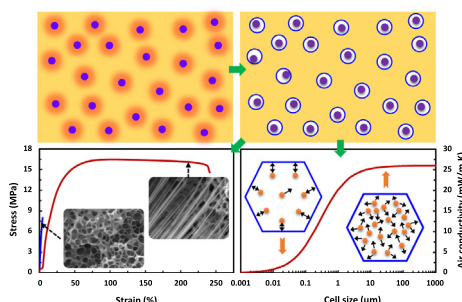
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HIGHLIGHTS

- A method for fabricating nanocellular polymers with tunable structures is reported.
- Nanocellular PMMA/TPU presents a super-tough property.
- Nanocellular PMMA/TPU with the expansion ratio of 8.0 presents a superinsulating property.

GRAPHICAL ABSTRACT



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ABSTRACT

Nanocellular polymers have been considered promising multifunctional materials with unique properties. The key challenge is to fabricate nanocellular polymers with adequate cell sizes and densities. Herein, we report a novel method to prepare nanocellular polymethylmethacrylate (PMMA)/thermoplastic polyurethane (TPU) with tunable structures. The nanocellular PMMA/TPU displays a ductile fracture behavior while the microcellular PMMA shows a brittle fracture behavior. The nanocellular PMMA/TPU presents a tensile toughness and an impact toughness which are respectively 180-fold and 762% higher than the microcellular PMMA. The nanocellular structure combined with the nanostructured TPU greatly promotes the movement, shear slip and nano-fibrillation of the polymer chains, thus leading to this remarkably enhanced toughness. The nanocellular PMMA/TPU with an average cell size of 205 nm and an expansion ratio of 8.0 displays a thermal conductivity of 24.8 mW/m·K and a high compressive strength, which is to the best of our knowledge for the first time to achieve this superinsulating performance with porous polymers. The reduced air's thermal conductivity due to the Knudsen effect combined with the reduced polymer's thermal conduction due to the large expansion ratio are responsible for this superinsulating performance. The multifunctional nanocellular material offers a promising solution for advanced thermal insulation applications.

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1. Introduction

Porous polymers offer lightweight materials with combined properties such as thermal/acoustic insulation, energy absorption and flexibility, which have been widely used in the automobile,