UNIVERSITAS GADJAH MADA
Pengembangan Matriks Campuran Polypropylene dan Polylactic Acid melalui Pemrosesan Ulang yang Dilelehkan Menggunakan Hot Air Convection dan Aplikasinya pada Self-Healing Komposit Serat Karbon
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INTISARI

Pengembangan campuran polypropylene (PP) dan polylactic acid (PLA) berpotensi menghasilkan material termoplastik yang mendukung keberlanjutan. Namun, ketidakcocokan kedua polimer menyebabkan sifat campuran dipengaruhi oleh kondisi pemrosesan dan riwayat termal, terutama pada proses daur ulang dan *self-healing*. Penelitian ini bertujuan menganalisis hubungan proses–struktur–sifat campuran PP/PLA yang diproses menggunakan *hot air convection*, meliputi optimasi parameter manufaktur, daur ulang, *self-healing* komposit serat karbon, serta pengaruh *grinding*, *sieving*, dan *mixing*.

Penelitian dilakukan dalam empat tahap, yaitu optimasi rasio PP/PLA, suhu pelelehan, dan tekanan menggunakan metode Taguchi; analisis perubahan sifat campuran selama beberapa tahap daur ulang; analisis pemulihan sifat mekanis komposit serat karbon bermatriks PP/PLA selama *self-healing*; serta analisis pengaruh *grinding*, *sieving*, dan *mixing* hingga menghasilkan mikropolimer. Karakterisasi dilakukan menggunakan *Fourier Transform Infrared Spectroscopy* (FTIR), *Differential Scanning Calorimetry* (DSC), *Thermogravimetric Analysis* (TGA), *Scanning Electron Microscopy* (SEM), dan sinar-X, sedangkan sifat mekanis dievaluasi melalui pengujian tarik, lentur, dan impak.

Hasil penelitian menunjukkan bahwa parameter optimum diperoleh pada rasio PP/PLA 75/25 % berat, suhu pelelehan 178,8 °C, dan tekanan 20 kPa. Daur ulang menunjukkan adanya tahap optimum pada R2 sebelum porositas dan degradasi material menjadi dominan. *Self-healing* komposit serat karbon mencapai pemulihan optimum pada R3 yang terutama berkaitan dengan densifikasi matriks, pengurangan cacat dan porositas, serta perbaikan antarmuka PP/PLA–serat karbon, bukan pembentukan ikatan kimia baru. *Grinding*, *sieving*, dan *mixing* hingga ukuran mikropolimer sekitar 260 μm juga meningkatkan kinerja mekanis melalui peningkatan kontak antarmuka. Secara keseluruhan, kinerja PP/PLA ditentukan oleh evolusi struktur akibat riwayat proses, terutama perubahan porositas, morfologi, mobilitas rantai, antarmuka, kristalinitas, dan stabilitas termal. Temuan ini menjadi dasar pengembangan PP/PLA yang dapat diproses ulang dan memiliki potensi *self-healing* berbasis pemulihan fisik.

Kata Kunci: PP/PLA, *Hot air convection*, Daur ulang, Self-healing, Komposit serat karbon

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ABSTRACT

The development of polypropylene (PP) and polylactic acid (PLA) blends has the potential to produce thermoplastic materials that support sustainability. However, the incompatibility between the two polymers causes the properties of the blend to be influenced by processing conditions and thermal history, particularly during recycling and self-healing processes. This study aims to analyze the process–structure–property relationships of PP/PLA blends processed using hot air convection, including the optimization of manufacturing parameters, recycling, self-healing of carbon fiber composites, and the effects of grinding, sieving, and mixing.

The research was conducted in four stages: optimization of the PP/PLA ratio, melting temperature, and pressure using the Taguchi method; analysis of changes in the properties of the blend during multiple recycling stages; analysis of mechanical property recovery in carbon fiber composites with a PP/PLA matrix during self-healing; and analysis of the effects of grinding, sieving, and mixing to produce micropolymer particles. Characterization was performed using Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM), and X-ray imaging, while mechanical properties were evaluated through tensile, flexural, and impact tests.

The results show that the optimum parameters were obtained at a PP/PLA ratio of 75/25 wt%, a melting temperature of 178.8 °C, and a pressure of 20 kPa. Recycling exhibited an optimum stage at R2 before porosity and material degradation became dominant. Self-healing of the carbon fiber composite achieved optimum recovery at R3, which was primarily associated with matrix densification, reduction of defects and porosity, and improvement of the PP/PLA–carbon fiber interface, rather than the formation of new chemical bonds. Grinding, sieving, and mixing to produce micropolymer particles of approximately 260 μm also improved mechanical performance through enhanced interfacial contact. Overall, the performance of PP/PLA blends is governed by structural evolution resulting from processing history, particularly changes in porosity, morphology, chain mobility, interfacial characteristics, crystallinity, and thermal stability. These findings provide a basis for developing PP/PLA blends that can be reprocessed and have potential for self-healing through physical recovery mechanisms.

Keywords: *PP/PLA, Hot air convection, Recycling, Self-healing, Carbon fiber composite*