

INTISARI

Salah satu tantangan utama dalam aplikasi 3D *printing* adalah pemilihan material filamen yang memiliki sifat mekanik, termal, dan proses yang sesuai dengan kebutuhan aplikasi. Umumnya, filamen terbuat dari termoplastik murni seperti polipropilen (PP), poliaktid acid (PLA), dan sebagainya. Namun demikian, sifat mekanis termoplastik murni biasanya relatif rendah sehingga perlu ditambahkan dengan penguat yang selanjutnya dikenal sebagai filamen komposit. Penelitian ini menggunakan *recycled polypropylene* (rPP) sebagai matriks dan serbuk sekam padi (*rice husk*). Material ini dipilih karena jumlah sampah plastik PP dan limbah sekam padi melimpah dan belum dimanfaatkan secara optimal. Tetapi, karena perbedaan kompatibilitas antara rPP dengan RH di mana rPP bersifat hidropobik dan RH bersifat hidrofilik maka mengakibatkan adesi yang lemah antara keduanya. Untuk meningkatkan ikatan antar muka di antara rPP dan RH maka dilakukan asetilasi pada RH (*acetylated rice husk*, ARH) dan penambahan *coupling agent* jenis *polypropylene grafted maleic anhydride* (PP-g-MA). Penelitian ini bertujuan untuk mengkaji pengaruh kandungan RH, ARH, dan PP-g-MA terhadap sifat mekanik, termal, dan penyerapan air dari filamen komposit rPP/RH/PP-g-MA.

Filamen komposit dibuat dengan menggunakan mesin *single screw extruder* pada suhu *nozzle* 175 °C. Pelet rPP, RH, ARH, dan PP-g-MA dikeringkan di dalam oven pada suhu 80 °C selama 2 jam sebelum dicampur. Proses asetilasi dilakukan dengan menggunakan *acetyl anhydride* yang dicampur dengan asam sulfat. Kandungan RH dan ARH divariasikan yakni 0; 0,5; 1; 1,5; 2 wt%. Selanjutnya, pada filamen rPP/ARH ditambahkan PP-g-MA dengan variasi 0, 5, 10, 15 wt%. Filamen dikarakterisasi melalui pengamatan visual, pengukuran diameter, analisis FT-IR, XRD, pengujian penyerapan air, dan uji tarik.

Hasil penelitian menunjukkan bahwa penambahan 1 wt% RH pada filamen meningkatkan kekuatan tarik hingga 8,8% dibandingkan dengan rPP murni. Namun, jika kandungan RH melebihi 1 wt%, kekuatan tarik justru menurun. Proses asetilasi pada RH meningkatkan sifat hidrofobisitas, yang memperkuat ikatan antara matriks rPP dan ARH, serta meningkatkan kekuatan tarik dan kristalinitas. Penambahan 1 wt% ARH meningkatkan kekuatan tarik filamen komposit hingga 20,97%, tetapi penambahan lebih dari 1 wt% ARH menghasilkan efek sebaliknya. Penambahan 10 wt% PP-g-MA pada filamen komposit rPP/1ARH menaikkan kekuatan tarik hingga 33,77% dibandingkan dengan filamen rPP murni. Selanjutnya, penambahan RH dan ARH meningkatkan penyerapan air, sementara penambahan PP-g-MA dapat menurunkan penyerapan air, dengan filamen yang mengandung 15 wt% PP-g-MA menunjukkan tingkat penyerapan air terendah.

Kata kunci: filamen komposit, *recycled polypropylene* (rPP), *rice husk* (RH), *acetylated rice husk* (ARH), 3D *printing*

ABSTRACT

One of the main challenges in 3D printing applications is the selection of filament materials that have mechanical, thermal, and process properties that match the application needs. Generally, filaments are made from pure thermoplastics such as polypropylene (PP), polylactic acid (PLA), and so on. However, the mechanical properties of pure thermoplastics are usually relatively low, so it is necessary to add reinforcement, which is known as composite filament. This research uses recycled polypropylene (rPP) as the matrix and rice husk powder. These materials were chosen because the amount of PP plastic waste and rice husk waste is abundant and has not been optimally utilized. However, due to the compatibility difference between rPP and RH, where rPP is hydrophobic and RH is hydrophilic, it results in weak adhesion between the two. To improve the interfacial bond between RPP and RH, acetylation of RH (acetylated rice husk, ARH) and addition of coupling agent type polypropylene grafted maleic anhydride (PP-g-MA) were conducted. This study aims to examine the effect of RH, ARH, and PP-g-MA content on the mechanical, thermal, and water absorption properties of rPP/RH/PP-g-MA composite filaments.

The composite filaments were made using a single screw extruder machine at a nozzle temperature of 175 °C. The rPP, RH, ARH, and PP-g-MA pellets were dried in an oven at 80°C for 2 hours before blending. The acetylation process was carried out using acetic anhydride mixed with sulfuric acid. The RH and ARH contents were varied to 0, 0.5, 1, 1.5, and 2 wt%. Furthermore, PP-g-MA was added to the rPP/ARH filaments with variations of 0, 5, 10, 15 wt%. The filaments were characterized through visual observation, diameter measurement, FT-IR analysis, XRD, water absorption testing, and tensile testing.

The results showed that the addition of 1 wt% RH to the filaments increased the tensile strength up to 8.8% compared to pure rPP. However, if the RH content exceeds 1 wt%, the tensile strength actually decreases. The acetylation process on RH increases the hydrophobicity, which strengthens the bond between the rPP matrix and ARH, and improves the tensile strength and crystallinity. The addition of 1 wt% ARH increased the tensile strength of the composite filaments by 20.97%, but the addition of more than 1 wt% ARH produced the opposite effect. The addition of 10 wt% PP-g-MA to rPP/1ARH composite filaments raised the tensile strength to 33.77% compared to pure rPP filaments. Furthermore, the addition of RH and ARH increases water absorption, while the addition of PP-g-MA can decrease water absorption, with filaments containing 15 wt% PP-g-MA showing the lowest water absorption rate.

Keywords: composite filament, recycled polypropylene (rPP), rice husk (RH), acetylated rice husk (ARH), 3D printing