UNIVERSITAS
GADJAH MADA
Studi Sifat Mekanis Komposit Hybrid Epoksi/ Serat Daun Nanas/Graphene Nanoplatelets
Rynof Scoot Putra, Prof. Dr. Ir. Kusmono, S.T., M.T., IPM., ASEAN Eng.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

Serat daun nanas (*Pineapple Leaf Fiber*/PALF) merupakan serat alam yang berpotensi sebagai penguat komposit karena memiliki densitas rendah, kekuatan spesifik tinggi, dan tersedia melimpah sebagai limbah pertanian. Namun, sifat hidrofilik PALF menyebabkan ikatan antarmuka dengan matriks epoksi yang bersifat hidrofobik menjadi kurang optimal. Oleh karena itu, dilakukan modifikasi permukaan serat melalui perlakuan alkali dan butirilasi, serta penambahan *Graphene Nanoplatelets* (GNPs) sebagai *nanofiller* untuk meningkatkan karakteristik serat dan sifat mekanis komposit. Penelitian ini bertujuan mengkaji pengaruh perlakuan alkali, butirilasi, dan penambahan GNPs terhadap karakteristik serat serta sifat mekanis komposit hibrid epoksi/serat daun nanas searah.

Penelitian dilakukan melalui tiga tahap, yaitu optimasi perlakuan alkali menggunakan variasi konsentrasi NaOH sebesar 2%, 5%, 7%, dan 9%, optimasi perlakuan butirilasi menggunakan variasi konsentrasi *butyric anhydride* sebesar 1% dan 3%, serta fabrikasi komposit epoksi/PALF searah dan komposit hibrid epoksi/PALF/GNPs dengan variasi kandungan GNPs sebesar 0; 0,2; 0,6; dan 1 wt.%. Fabrikasi komposit dilakukan menggunakan metode *hot press molding* pada tekanan 50 bar pada *pressure gauge*, yang setara dengan tekanan efektif teoritis sebesar 1,78 bar pada permukaan cetakan komposit, dengan suhu 90 °C selama 30 menit. Karakterisasi serat dilakukan menggunakan FT-IR, *water contact angle* (WCA), pengukuran diameter, dan uji tarik, sedangkan komposit dikarakterisasi melalui FT-IR, pengujian densitas, porositas, tarik, bending, ketangguhan impak, dan *interlaminar shear strength* (ILSS).

Hasil penelitian menunjukkan bahwa perlakuan optimum serat diperoleh pada perlakuan 2% NaOH dan 3% *butyric anhydride*. Perlakuan 2% NaOH meningkatkan kekuatan tarik serat sebesar 17,79% (dari 366,46 MPa menjadi 431,66 MPa) dibanding tanpa perlakuan. Selanjutnya perlakuan 2% NaOH + 3% *butyric anhydride* pada serat meningkatkan kekuatan tarik sebesar 10,04% (dari 366,46 MPa menjadi 403,25 MPa). Selain itu perlakuan 2% NaOH dan 3% *butyric anhydride* juga mengurangi komponen amorf berdasarkan hasil analisis FT-IR dan menaikkan nilai WCA dari 46,09° menjadi 68,12°. Perlakuan optimum tersebut juga meningkatkan sifat mekanis komposit, yaitu kekuatan tarik sebesar 22,52%, kekuatan bending 14,20%, ketangguhan impak 58,73%, dan *interlaminar shear strength* (ILSS) 15,28% dibandingkan komposit tanpa perlakuan. Penambahan 0,6 wt.% GNPs menghasilkan sifat mekanis terbaik dengan kekuatan tarik 142,01 MPa, kekuatan bending 50,38 MPa, ketangguhan impak 53,32 kJ/m², ILSS 173,36 MPa, densitas 1,218 g/cm³, dan porositas 9,232%. Penambahan GNPs hingga 1 wt.% menyebabkan penurunan sebagian sifat mekanis akibat aglomerasi nanopartikel. Dengan demikian, kombinasi perlakuan alkali, butirilasi, dan penambahan 0,6 wt.% GNPs terbukti efektif meningkatkan karakteristik serat dan performa mekanis komposit hibrid epoksi/serat daun nanas searah.

Kata kunci: serat daun nanas (PALF), *Graphene Nanoplatelets* (GNPs), komposit hibrid, epoksi, perlakuan alkali, butirilasi, sifat mekanis

UNIVERSITAS
GADJAH MADA
Studi Sifat Mekanis Komposit Hybrid Epoksi/ Serat Daun Nanas/Graphene Nanoplatelets
Rynof Scoot Putra, Prof. Dr. Ir. Kusmono, S.T., M.T., IPM., ASEAN Eng.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

ABSTRACT

Pineapple Leaf Fiber (PALF) is a natural fiber with great potential as a reinforcement for polymer composites due to its low density, high specific strength, and abundant availability as an agricultural waste. However, the hydrophilic nature of PALF results in poor interfacial bonding with the hydrophobic epoxy matrix. Therefore, fiber surface modification through alkali treatment and butyrylation, along with the incorporation of *Graphene Nanoplatelets* (GNPs) as a nanofiller, was employed to improve the fiber characteristics and the mechanical properties of the composites. This study aimed to investigate the effects of alkali treatment, butyrylation, and GNP addition on the characteristics of PALF and the mechanical properties of unidirectional epoxy/PALF hybrid composites.

The research was conducted in three stages, consisting of alkaline treatment optimization using NaOH concentrations of 2%, 5%, 7%, and 9%, butyrylation treatment optimization using *butyric anhydride* concentrations of 1% and 3%, and fabrication of unidirectional epoxy/PALF composites and hybrid epoxy/PALF/GNPs composites with GNPs contents of 0, 0.2, 0.6, and 1 wt.%. The composites were fabricated using the *hot press molding* method at a pressure of 50 bar on the *pressure gauge*, corresponding to a theoretical effective pressure of 1.78 bar on the composite mold surface, and maintained at a temperature of 90 °C for 30 minutes. Fiber characterization was performed using *Fourier Transform Infrared* (FT-IR) spectroscopy, *water contact angle* (WCA) measurements, diameter measurements, and tensile testing. Composite characterization included FT-IR analysis, density and porosity measurements, tensile, flexural, impact, and *interlaminar shear strength* (ILSS) tests.

The results showed that the optimum fiber treatment was achieved using 2% NaOH followed by 3% *butyric anhydride*. The 2% NaOH treatment increased the tensile strength of the fiber by 17.79% (from 366.46 MPa to 431.66 MPa) compared with the untreated fiber. Furthermore, the combination of 2% NaOH and 3% *butyric anhydride* increased the fiber tensile strength by 10.04% (from 366.46 MPa to 403.25 MPa). In addition, the 2% NaOH and 3% *butyric anhydride* treatments reduced the amorphous components based on FT-IR analysis and increased the WCA value from 46.09° to 68.12°. The optimum treatment also improved the mechanical properties of the composites, resulting in increases of 22.52% in tensile strength, 14.20% in flexural strength, 58.73% in impact toughness, and 15.28% in ILSS compared with the untreated composite. The addition of 0.6 wt.% GNPs produced the best mechanical performance, with a tensile strength of 142.01 MPa, flexural strength of 50.38 MPa, impact toughness of 53.32 kJ/m², ILSS of 173.36 MPa, density of 1.218 g/cm³, and porosity of 9.232%. Increasing the GNP content to 1 wt.% led to a reduction in several mechanical properties due to nanoparticle agglomeration. Therefore, the combination of alkali treatment, butyrylation, and the addition of 0.6 wt.% GNPs was proven to be effective in improving the fiber characteristics and the mechanical performance of unidirectional epoxy/PALF hybrid composites.

Keywords: *Pineapple Leaf Fiber* (PALF), *Graphene Nanoplatelets* (GNPs), hybrid composites, epoxy, alkali treatment, butyrylation, mechanical properties