HYBRID POLYMER COMPOSITE BIPOLAR PLATES FOR PEM FUEL CELLS

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Hydrogen is widely recognised as a key energy carrier for achieving EU climate neutrality by 2050, positioning hydrogen-powered PEM fuel cells as an important clean-energy technology due to their fast start-up, high efficiency, and zero emissions [1]. Within PEMFCs, bipolar plates (BPs) are essential components; nevertheless, they are also the main contributors to weight, size, and cost [2]. Polymer–carbon composites have emerged as a promising alternative to the traditional materials, carbon and metal, because they offer tunable properties and easier manufacturing [3]. However, single-filler graphite composites often fail to meet DOE targets for electrical conductivity (> 100 S cm^{-1}) and flexural strength (> 40 MPa) simultaneously [4,5].

To address these limitations, this work explores a dual-filler system combining synthetic graphite (SG) with thermally expanded graphite (TEG). Epoxy-based composites with a fixed total filler content of 75 wt.% and varying TEG content (5, 10, and 20 wt.%) were fabricated and evaluated. Electrical characterization reveals that increasing TEG content leads to saturation of in-plane conductivity, likely due to insufficient polymer wetting and the formation of voids that interrupt conductive pathways. These microstructural discontinuities are further evidenced by a notable decrease in through-plane conductivity at 20 wt.% TEG.

Flexural testing demonstrates that while pure epoxy exhibits a flexural strength and modulus of 73.7 MPa and 2138 MPa, respectively, the incorporation of 75 wt.% SG decreases strength to 44 MPa. Hybrid SG/TEG systems partially recover mechanical performance, with flexural strengths of 53.5 MPa at 5 wt.% TEG.

Overall, the results highlight the trade-offs between filler composition, microstructural integrity, and multifunctional performance. The study shows that low TEG contents can enhance mechanical behaviour without compromising electrical performance, offering a viable pathway toward lightweight, conductive, and mechanically robust composite bipolar plates for PEMFC applications.

References

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