

EVALUATION OF SUSTAINABLE ALTERNATIVE FILLERS IN POLYMER SYSTEMS BY DYNAMIC MECHANICAL THERMAL ANALYSIS AND THE PAYNE EFFECT

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ABSTRACT

The present study evaluates the influence of four different alternative fillers incorporated into an elastomeric polymer matrix, with the aim of identifying sustainable and high-performance substitutes for conventional reinforcing filler. The selection of reinforcement materials exerts a substantial influence on the resulting properties of polymer materials, thereby necessitating a comprehensive understanding of the interaction between the matrix and the fillers. Dynamic Mechanical Thermal Analysis (DMTA) was employed to characterize the viscoelastic behavior of the polymer materials, with a particular emphasis on the glass transition temperature, traction-related parameters, and indicators relevant to rolling resistance. Furthermore, the Payne effect was measured in order to assess filler–filler interactions and the quality of the filler dispersion within the rubber matrix.

MATERIALS



Mixing process of polymer materials

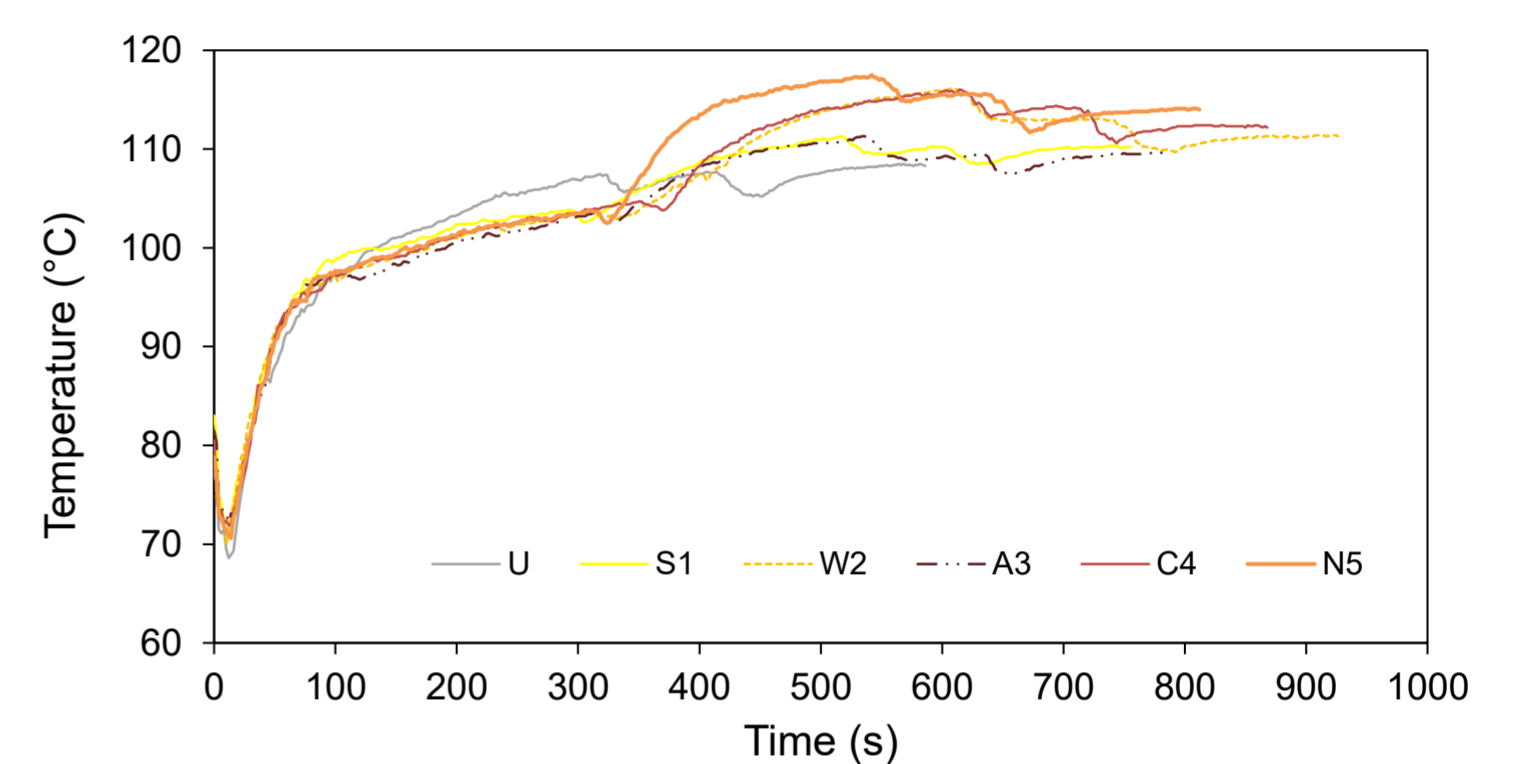


Fig. 1 Mixing process of polymer materials

Depending on the temperature increase during the incorporation of the filler into elastomeric polymer matrix. Follows: $U < S1 < A3 < W2 = C3 < N5$

DYNAMIC MECHANICAL THERMAL ANALYSIS

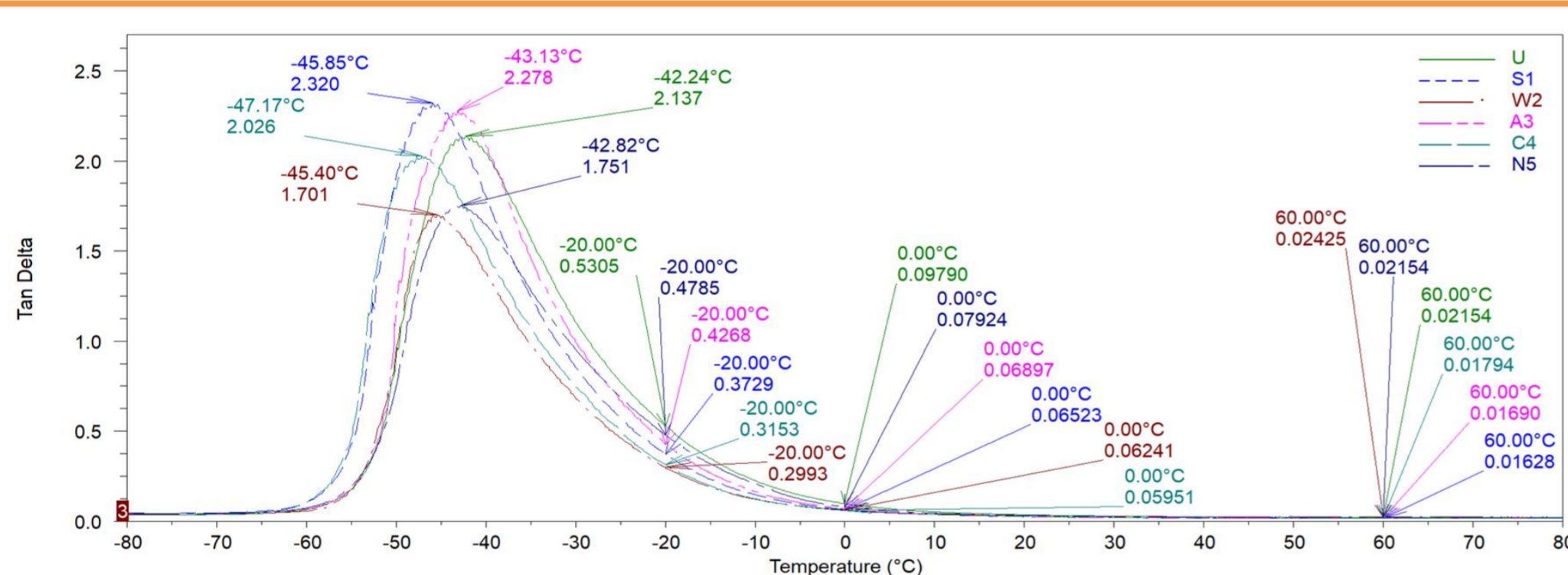


Fig. 2 Tan delta for polymer samples

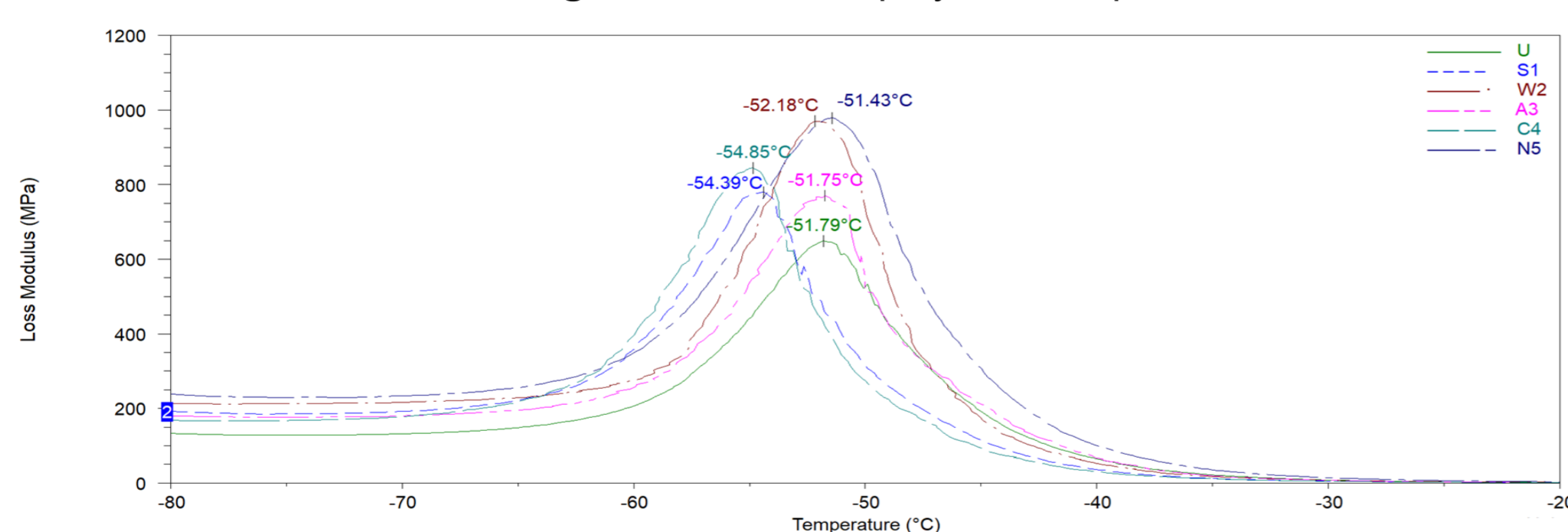


Fig. 3 Loss Modulus for polymer samples

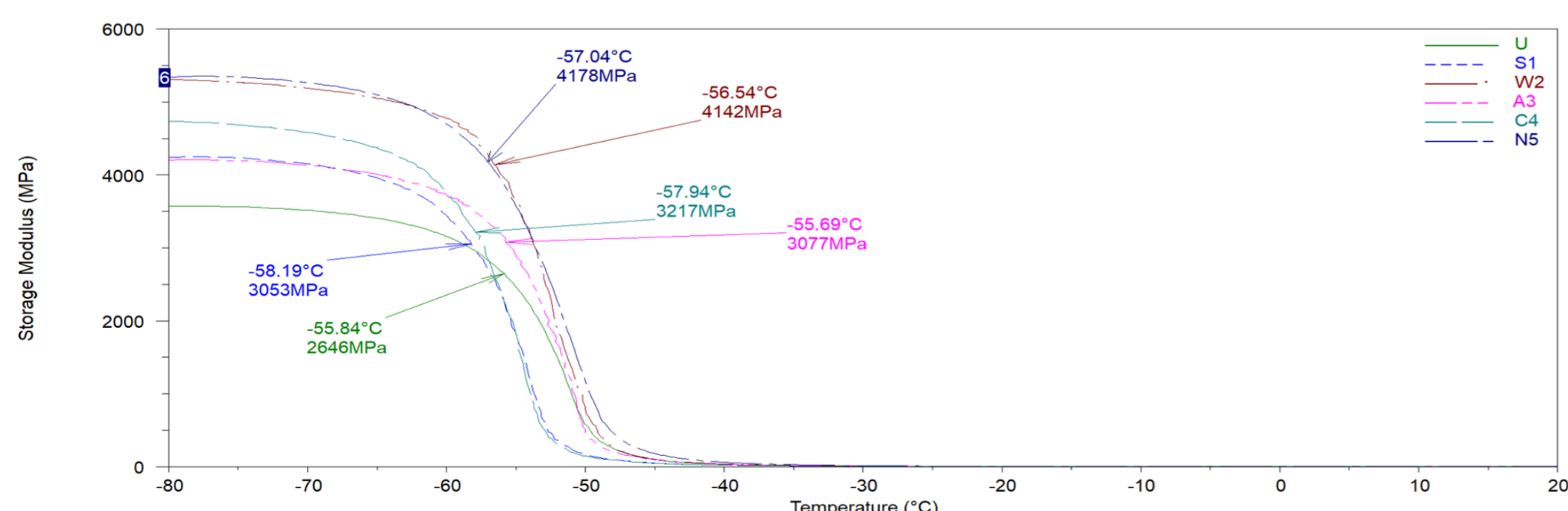


Fig. 4 Storage modulus for polymer samples

PAYNE EFFECT

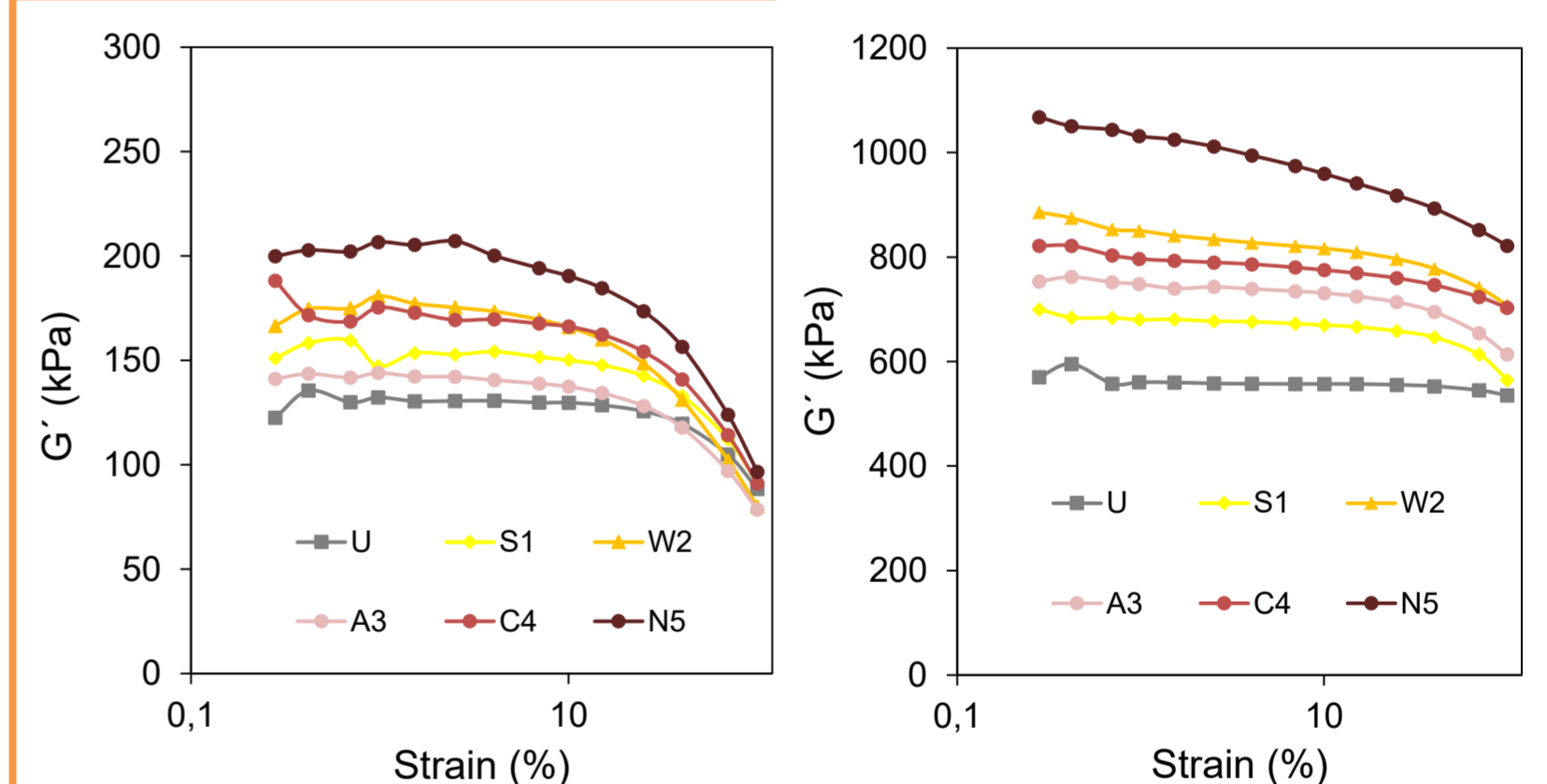


Fig. 5 The storage modulus (G') in the strain range for polymer samples a) uncure, b) cured

Tab. 1 Payne effect evaluation $\Delta G' = (G'_{0.28\%} - G'_{100.02\%})$ of polymer samples (BC- before cure, AC-after cure)

Sample	U		S1		W2		A3		C4		N5	
	BC	AC	BC	AC	BC	AC	BC	AC	BC	AC	BC	AC
$\Delta G'$	34	34	59	134	86	177	62	139	96	118	103	34

CONCLUSION

A comparative analysis of all the fillers that were tested demonstrated that the polymer material that contained wood flour and carbon black derived from the pyrolysis of waste tires, exhibited the most favorable performance. The results of the study demonstrate the potential of wood-based by-products and recycled pyrolytic residues as effective, environmentally beneficial fillers for polymer systems.

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