Assessing the Feasibility of Coal as an Eco-Friendly Filler in Phenolic Resin Composites: A Study of Thermal and Structural Properties

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INTRODUCTION

- Phenolic formaldehyde (PF) resins as thermoset polymers possess outstanding bonding properties, dimensional stability, and exceptional heat stability with major limitations—high brittleness and shrinkage.

- These physical properties can be enhanced with the inclusion of particulate fillers or electromagnetic materials.

- Coal, as a filler, has been used to improve both the thermal and mechanical properties of polymer materials.

- With respect to phenolic resins, the innate aromatic structure in coal suggests improved bonding is possible due to matching functionalities.

- Due to the environmental concerns associated with using coal as the primary source of energy generation, there has been a recent surge of interest in exploring alternative utilization options for coal.

OBJECTIVES

- To assess the feasibility of using coal as a filler in phenolic resins.
- This study utilizes thermal analysis techniques to understand better the curing kinetics based on coal rank and composition.
- To characterize cured coal-phenolic composites and establish a correlation with their kinetic behavior.

METHODS

- Differential Scanning Calorimetry (DSC) analysis, Perkin Elmer DSC HP 2000, Fourier Transform Infrared Spectroscopy (FTIR)
- Friedman Differential Isoconversional method
- Heat curing
- Analysis of IR Spectra
- Activation Energy values were computed at each degree of the curing stage.

SUSTAINABILITY ANALYSIS

- \[ \frac{\text{Degree of Cure (\%)}^{\circ}}{\text{Temperature (\degree C)}} \]

CONCLUSION

- The increasing Ea values observed in the 60% Pmix suggest a continuous crosslinking reaction between the phenolic resin and the sub-bituminous coal rank (PRB), which could be attributed to more reactive functional end-groups present in PRB relative to the anthracite coal rank (Itmann).

- 60% Itmann exhibits a diffusion-controlled reaction owing to the decreasing Ea value trend observed.

- The IR data supports an improved interaction between the coal (regardless of rank) and the phenolic resin in the cured 60% Pmix and 60% Itmann relative to the phenolic resin (100% phenolic).

ACKNOWLEDGEMENTS

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- Further mechanical analysis and characterization techniques are necessary to uncover the specific contribution of the coal rank to the physical properties of phenolic resins composites.

- The long-term durability of phenolic-based products.
- An increased lifespan of application diversification and market demand for phenolic resins will result in enhanced properties of compatible fillers.
- The improved product performance would lead to higher sales and manufacturing demands and sales.

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