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Tin-Catalysed vs Non-Catalysed Curing of Epoxidized Soybean Oil: Insights from Isoconversional Analysis

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INTRODUCTION & AIM

The development of bio-based epoxy thermosets requires a clear understanding of how curing mechanisms affect processing and final material performance. Although epoxidized soybean oil (ESO) is a promising renewable precursor, its cure behavior can vary significantly depending on the presence of catalysts such as tin-based compounds. In this study, the primary objective is to systematically evaluate how the tin catalyst influences the curing kinetics of ESO/MTHPA/DEH35 systems. Specifically, we aim to:

(i) compare catalysed and non-catalysed formulations under non-isothermal DSC conditions;

(ii) determine the activation energy profile as a function of conversion using the Friedman isoconversional method;

(iii) identify mechanistic transitions associated with thermal activation and autocatalytic behavior; and

(iv) validate the kinetic model through α_exp vs. α_pred correlation. By focusing on these objectives, this work seeks to provide reliable kinetic parameters and mechanistic insights that support the optimization of processing conditions and the design of more efficient bio-based epoxy networks.

RESULTS & DISCUSSION

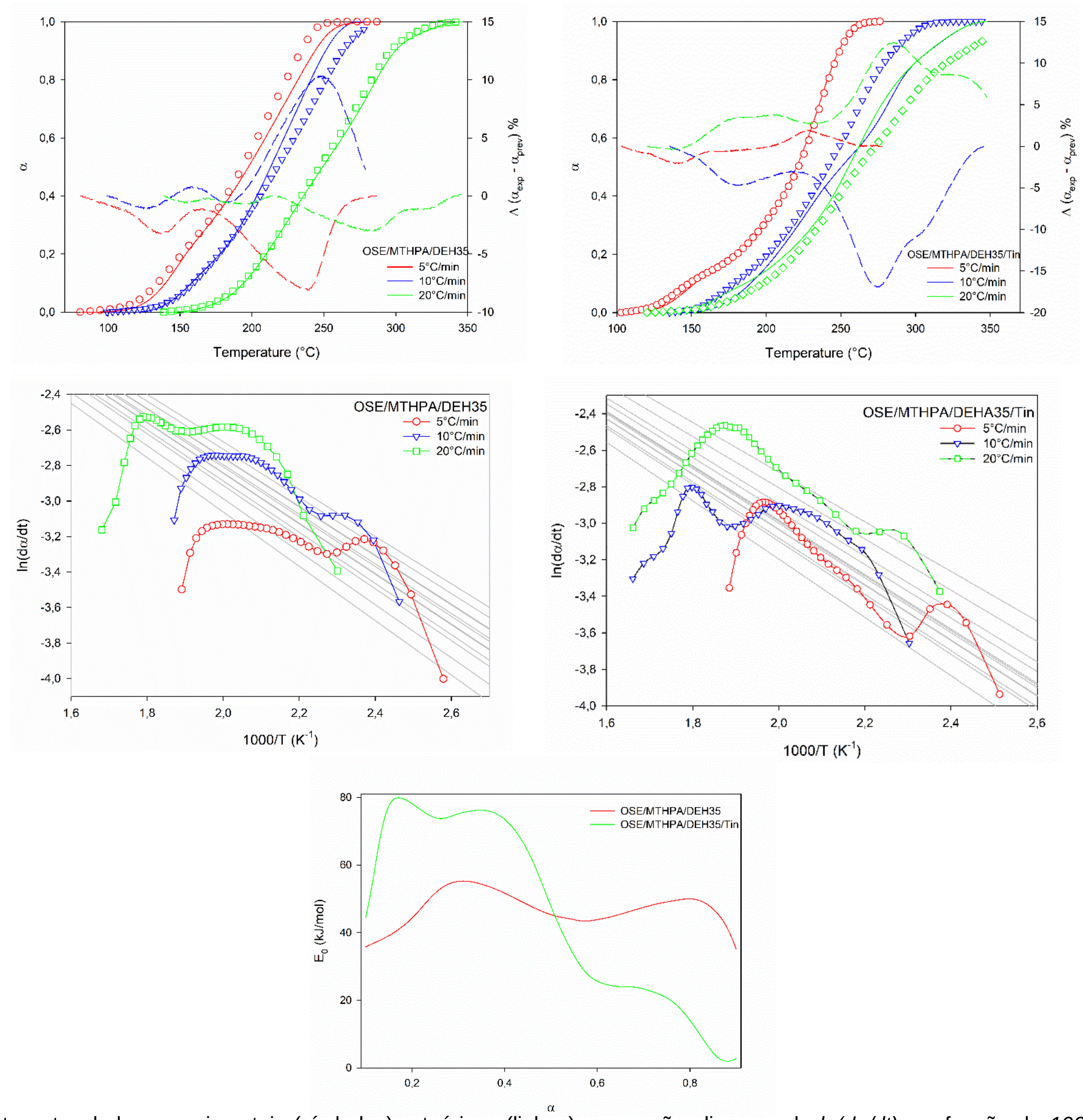
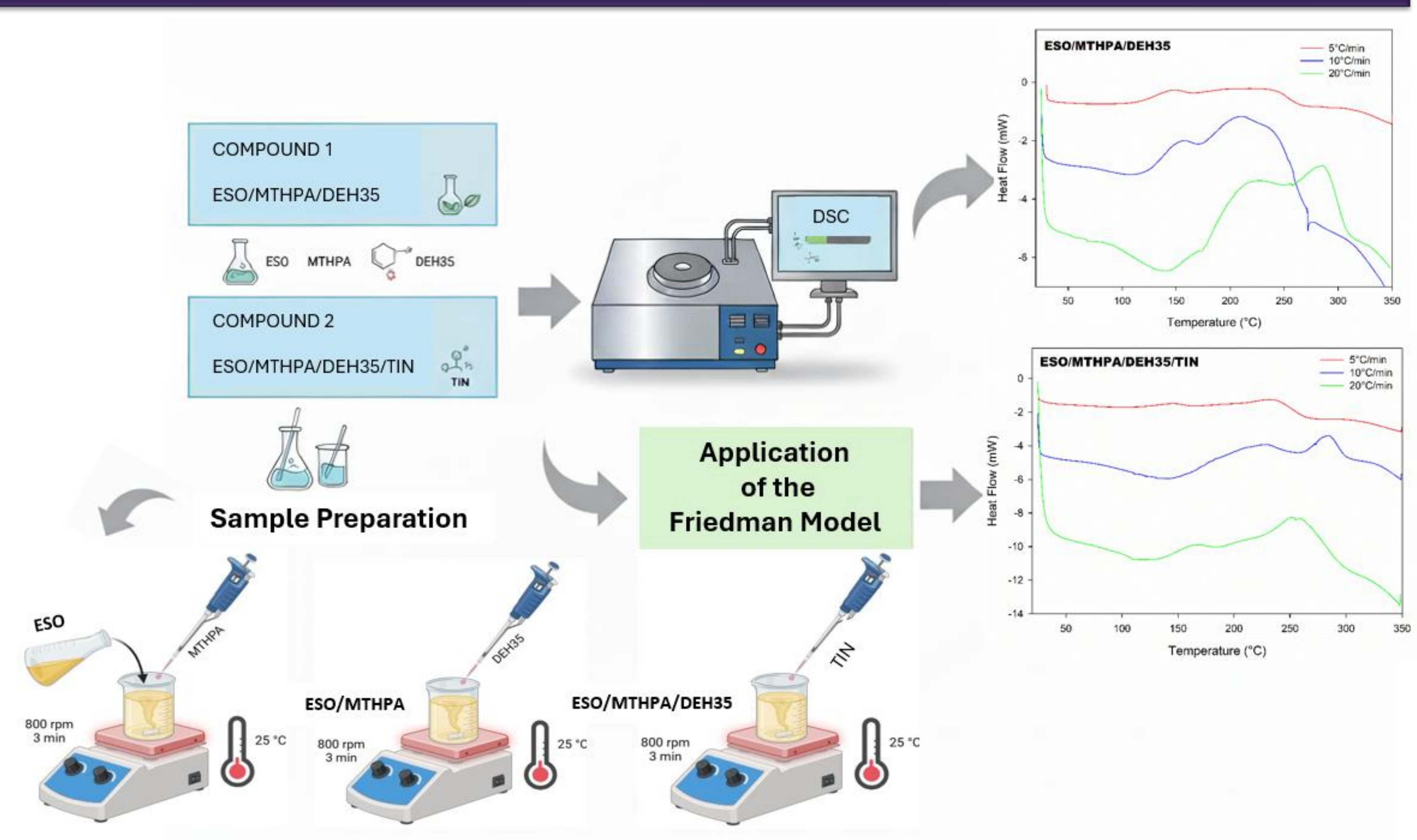


Figura 1. Ajuste entre dados experimentais (símbolos) e teóricos (linhas), regressões lineares de *ln(dα/dt)* em função de *1000/T* e variação da energia de ativação (Ea) obtidas pelo modelo isoconversional de Friedman para os sistemas OSE/MTHPA/DEH35 e OSE/MTHPA/DEH35/TIN, nas taxas de aquecimento de 5, 10 e 20 °C/min.

METHOD



CONCLUSION

•The curing behavior of ESO-based thermosets is strongly influenced by the presence of tin catalyst.

•The non-catalysed system exhibits a single-stage, thermally governed mechanism.

•The tin-catalysed system presents a multiphase mechanism, starting with a high-energy activation step followed by rapid autocatalytic propagation.

•The isoconversional Friedman method effectively captures these mechanistic transitions and is a valuable tool for optimizing cure schedules in bio-based epoxy networks.

FUTURE WORK / REFERENCES

•Extend modelling to other isoconversional techniques (KAS, OFW).

•Apply model to fiber-reinforced ESO composites to correlate kinetics with mechanical performance.

•Investigate influence of different tin catalyst concentrations on network architecture.

•Simulate complete cure cycles to optimize industrial processing.

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