

INTRODUCTION



Paraffin Wax is one of the important byproduct of the fractional distillation of crude oil.



Properties: non-toxicity, non-reactivity, water repellency, brittleness tendency, high heat capacity, odourlessness and lubricity.



Applications: pharmaceuticals, paper manufacturing, candle making, electrical insulators, rubber compounding & as phase change materials amongst many others.



Major Drawback: Low Thermal Stability & Low Thermal Conductivity

AIM

To explore strategies towards improving the thermal stability of paraffin wax using metal soaps of RSO and their admixtures

Thermal Characterization of Sustainable Materials from Metal Soaps/Paraffin Wax Blends

Oghenetega Ohwo*¹ and Theresa Egbuchunam²,

¹Department of Chemical Sciences, University of Africa, Toru Orua, Bayelsa State, Nigeria

²Department of Chemistry, Federal University of Petroleum Resources, Effurun, Nigeria

Email: tegaohwo@gmail.com

EXPERIMENTAL MATERIALS/METHODS

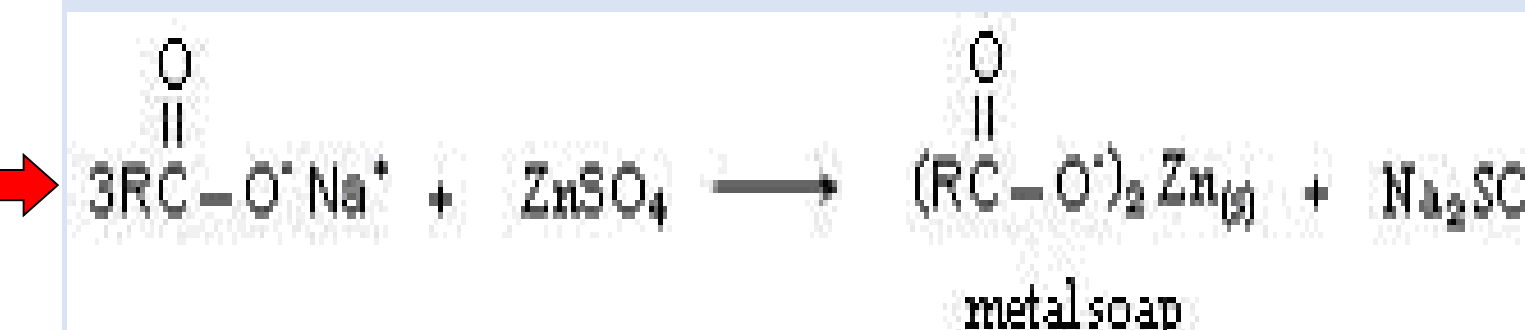
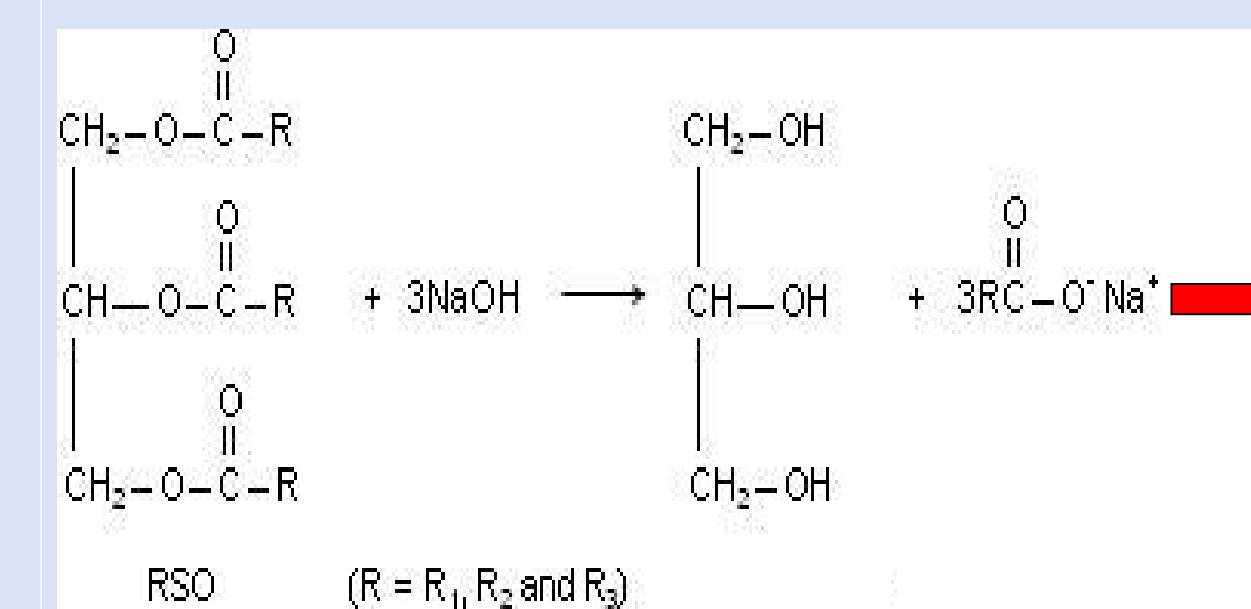
Rubber Seed



Rubber Seed Oil (RSO)



Saponification of Rubber Seed Oil



Ca and Zn metal soaps of rubber seed oil (RSO) were prepared by metathesis in aqueous alcoholic solution as described previously (Egbuchunam *et al.*, 2007).

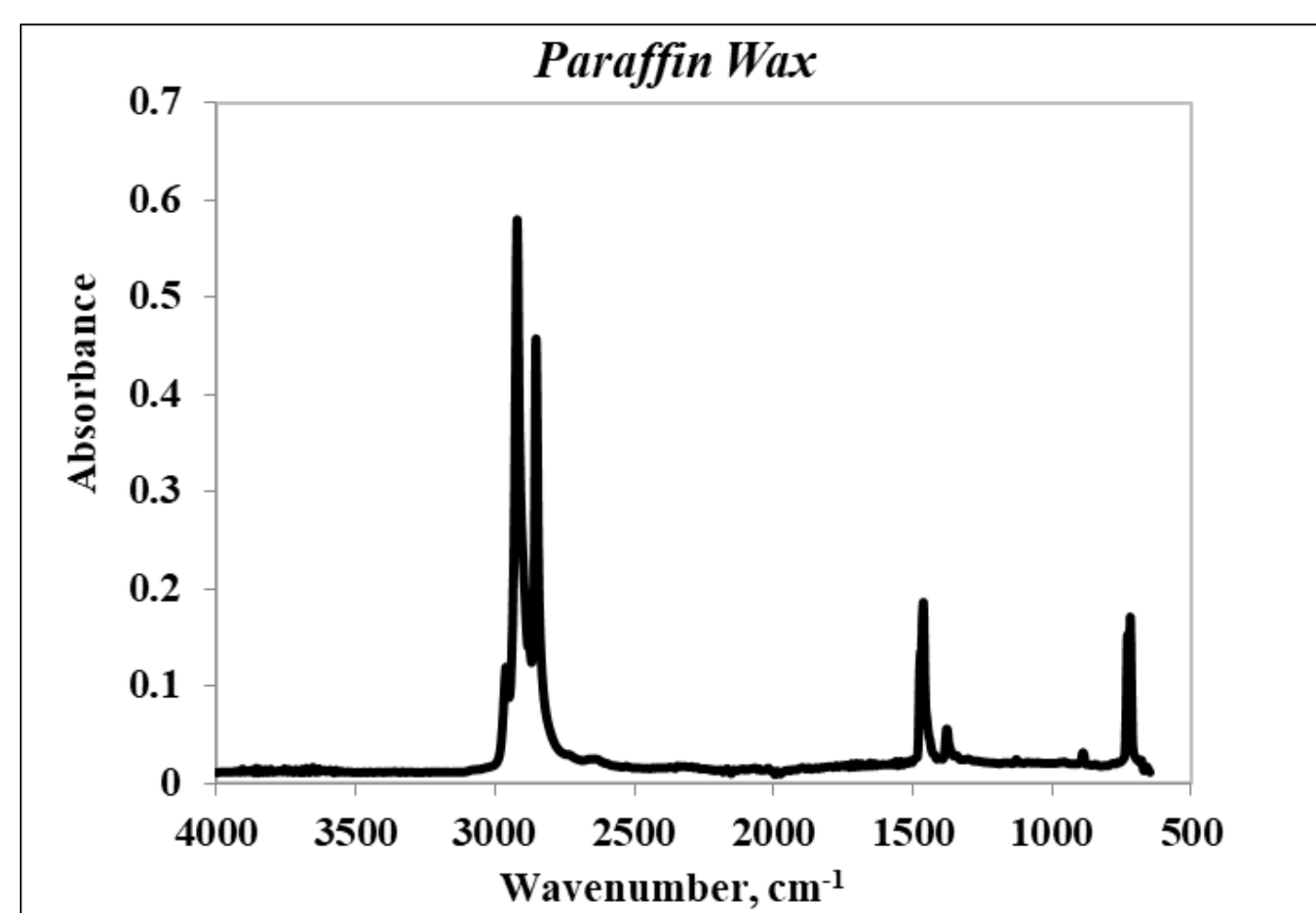
The metal soaps and pure paraffin wax were characterized using Fourier Transform Infrared Spectrophotometry (FTIR).

Thermal degradation studies were carried out using simultaneous TGA/DTA on: pure paraffin wax, paraffin wax stabilized with Ca and Zn soaps of RSO, paraffin wax stabilized with admixtures of calcium and zinc soaps of RSO.

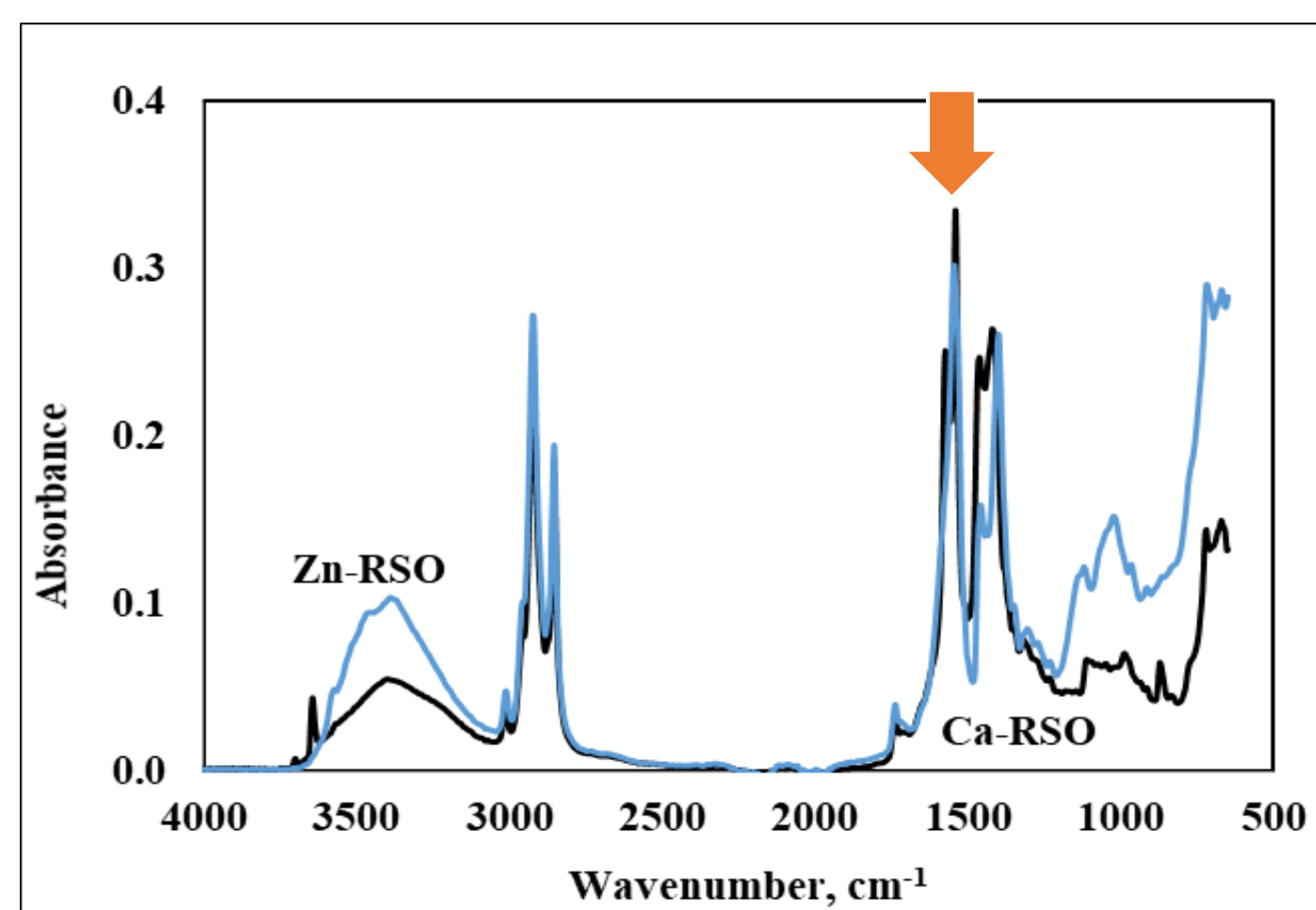
The kinetic parameters for the degradation process were determined using Broido's method (Balkose *et al.*, 2010) and Coats-Redfern's method (Pal *et al.*, 2023).

RESULTS & DISCUSSION

CHARACTERIZATION



FTIR spectrum of paraffin wax

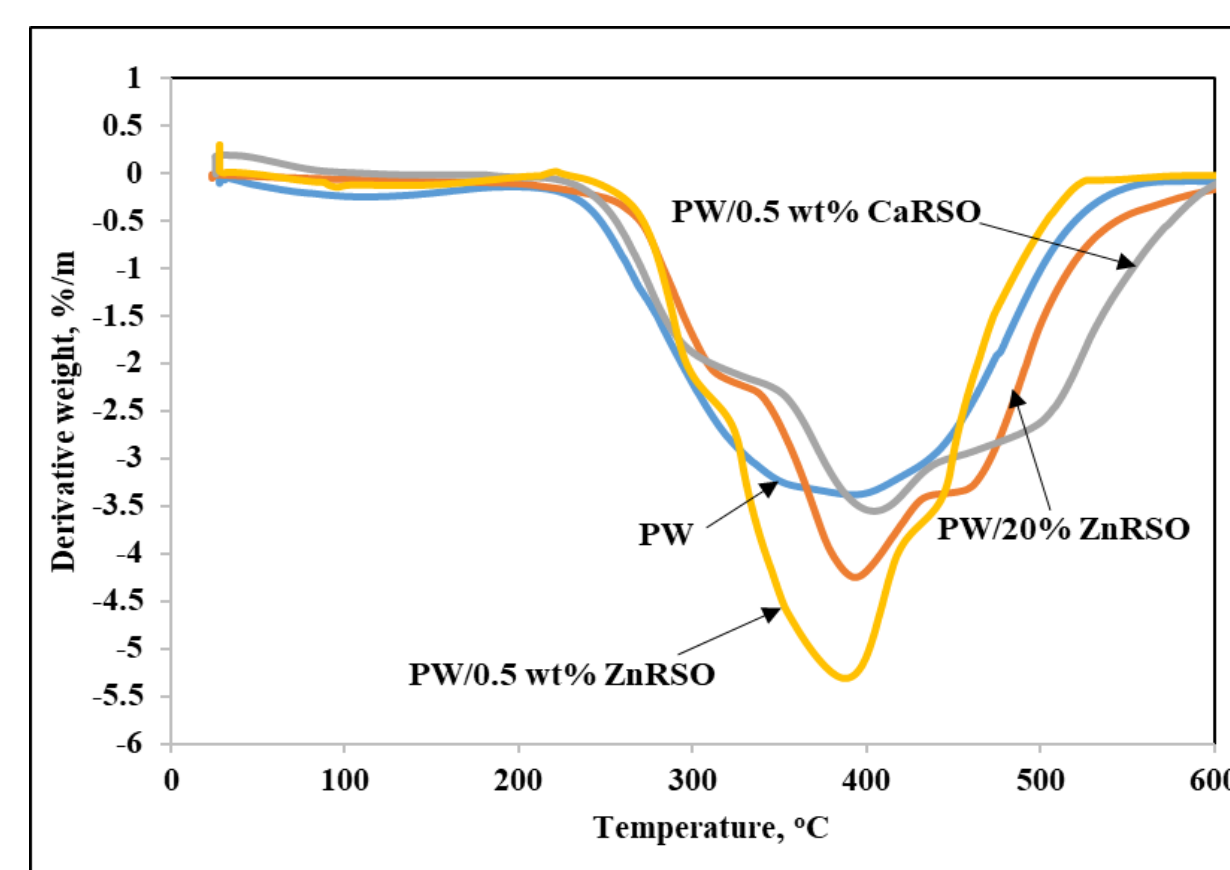


FTIR spectra of metal soaps of RSO

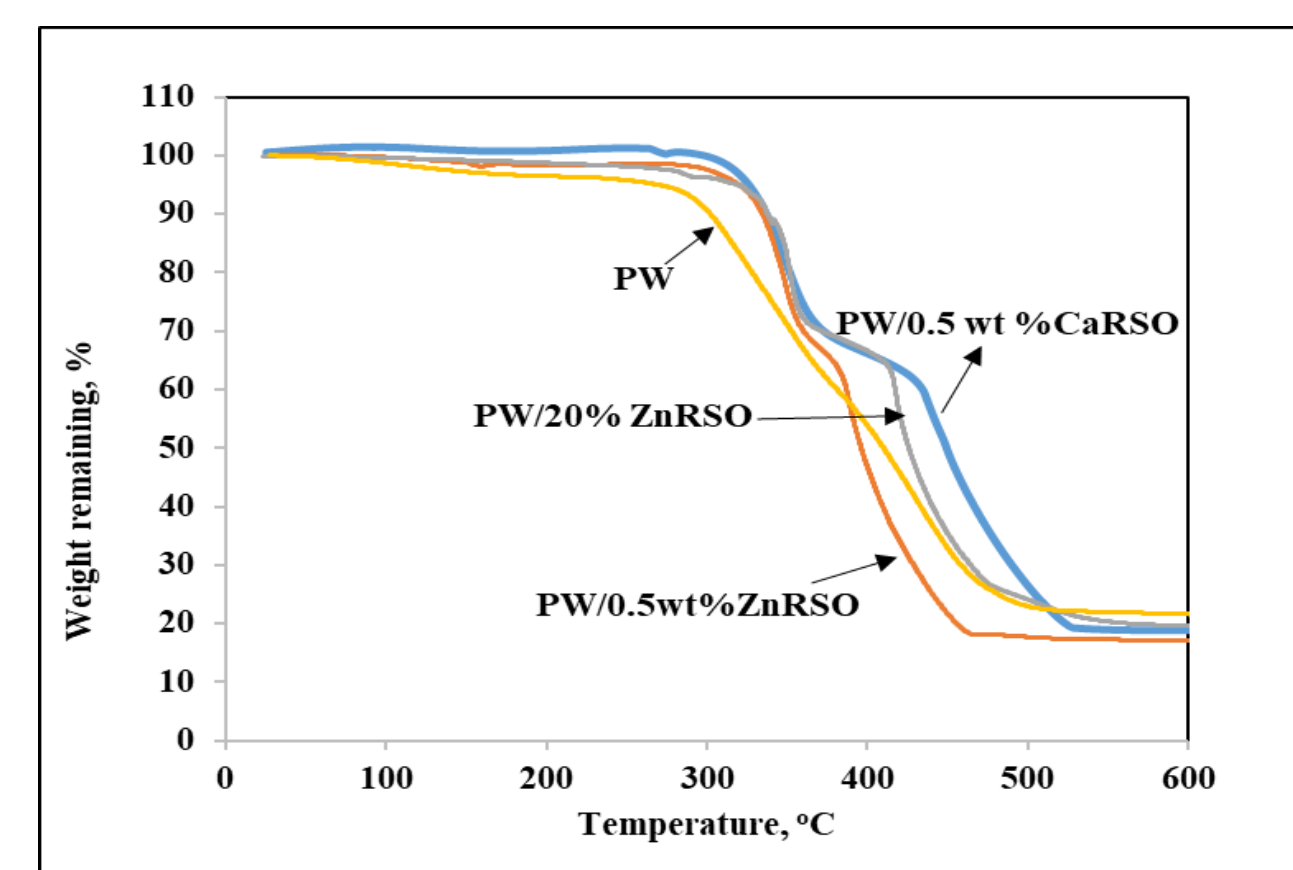
Metal soaps are usually identified by the characteristic strong asymmetric stretching band occurring in the 1500–1600 cm⁻¹ region

THERMAL STUDIES

Typical thermogravimetric and derivative curves for PW/metal soaps of RSO show multiple stages of decomposition in comparison with pure paraffin wax which exhibited a one – step decomposition around 270 °C. and was similar for all the blends



TYPICAL DTA CURVES OF PW/METAL SOAPS OF RSO BLENDS



TYPICAL TGA CURVES OF PW/METAL SOAPS OF RSO BLENDS

RELATIVE STABILITY OF PW/METAL SOAPS OF RSO BLENDS

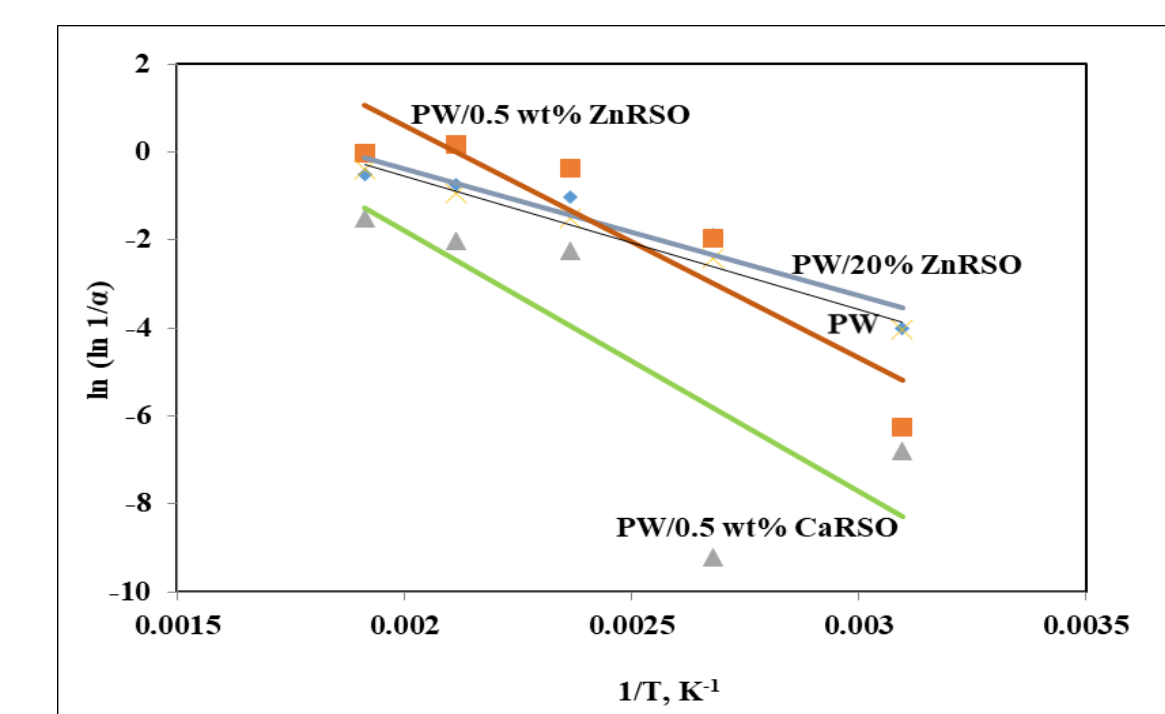
Samples	Mass loss (°C)				Residual weight at 500 °C (%)	Degradation Maximum, °C (T _{max})
	5%	10%	30%	50%		
PW	268.94	302.08	352.57	410.08	22.95	397.08
PW/0.1 wt% CaRSO	281.99	329.72	368.10	424.36	11.93	404.70
PW/0.2 wt% CaRSO	272.95	315.51	341.38	413.67	22.52	386.79
PW/0.5 wt% CaRSO	326.00	336.95	372.62	449.30	26.43	405.40
PW/0.1 wt% ZnRSO	240.72	274.38	329.55	390.22	13.66	398.67
PW/0.2 wt% ZnRSO	278.94	306.05	322.36	328.41	11.59	338.43
PW/0.5 wt% ZnRSO	319.97	334.75	360.24	396.17	17.71	388.52
PW/20% ZnRSO	318.19	337.89	371.56	425.89	24.12	394.11
PW/50% ZnRSO	313.89	308.80	367.78	453.51	21.25	485.27
PW/80% ZnRSO	313.26	340.05	371.22	428.76	13.08	411.36

KINETIC STUDIES

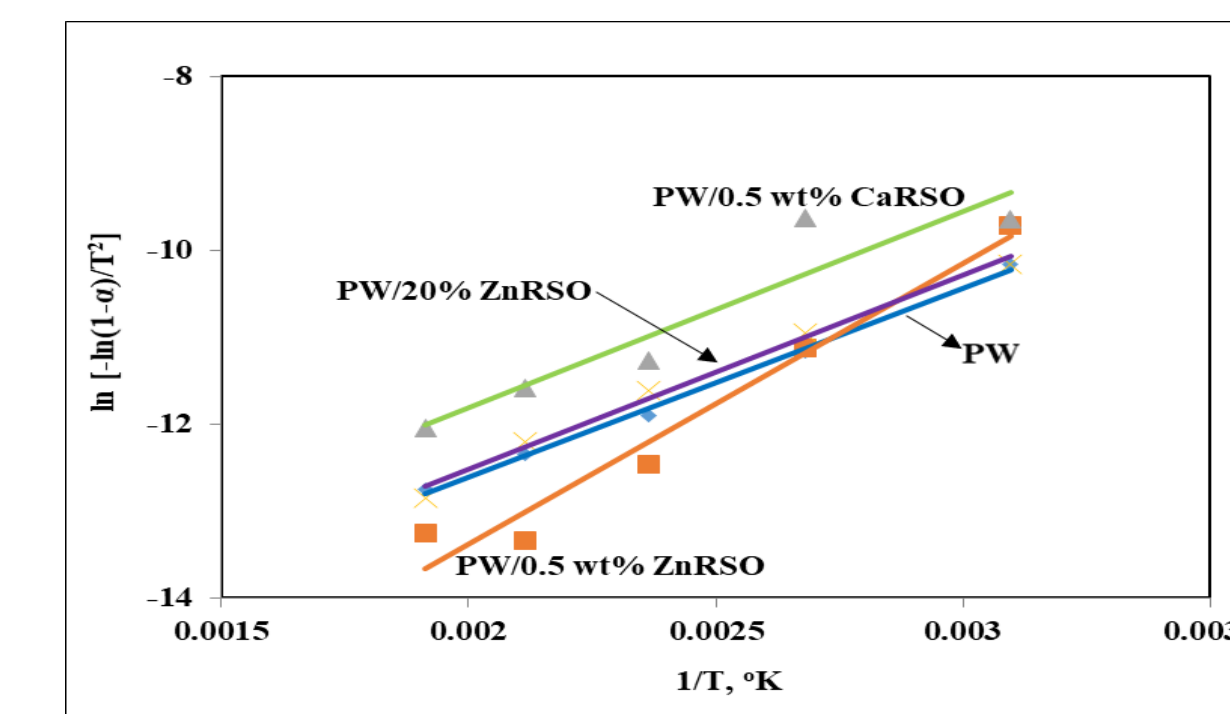
Kinetic Models for the Thermal Degradation of PW/metal soaps of RSO Blends

BROIDO'S: $\ln\{ \ln(1/\alpha) \} = -\frac{E}{RT} + \ln \frac{(RZT_m^2)}{\beta E}$

COAT-REDFERN'S: $\ln\left(\frac{\beta}{T^2(1-2RT/E)}\right) = \ln\left(-\frac{AR}{E \ln(1-\alpha)}\right) - \frac{E}{RT}$



Typical Broido plots for PW/metal soaps of RSO blends



Typical Coats-Redfern's plots for PW/metal soaps of RSO blends

KINETIC PARAMETERS OF PW/METAL SOAPS OF RSO BLENDS

Sample	Broido's Method				Coat-Redfern's Method			
	k min ⁻¹	E _a kJmol ⁻¹	A min ⁻¹	R ²	k min ⁻¹	E _a kJmol ⁻¹	A min ⁻¹	R ²
PW	2.427	34.74	2.21x10 ¹⁴	0.911	3.165	51.13	8.94x10 ¹³	0.996
PW/0.1wt% CaRSO	0.443	37.10	3.58x10 ¹⁴	0.923	0.490	58.12	7.33x10 ¹⁴	0.995
PW/0.2wt% CaRSO	1.137	35.78	2.71x10 ¹⁴	0.897	3.099	51.71	9.87x10 ¹³	0.991
PW/0.5wt% CaRSO	0.0012	55.92	3.34x10 ¹⁶	0.648	0.063	61.00	5.36x10 ¹⁴	0.885
PW/0.1wt% ZnRSO	2.815	34.57	2.19x10 ¹⁴	0.889	3.505	51.50	9.90x10 ¹³	0.988
PW/0.2wt% ZnRSO	0.225	38.42	6.98x10 ¹⁴	0.832	0.498	58.12	7.45x10 ¹⁴	0.974
PW/0.5wt% ZnRSO	0.024	41.48	1.13x10 ¹⁵	0.850	0.114	60.89	9.18x10 ¹⁴	0.962
PW/20% ZnRSO	0.036	44.67	1.69x10 ¹⁵	0.987	0.452	56.09	2.03x10 ¹⁴	0.990
PW/50% ZnRSO	0.646	36.61	3.32x10 ¹⁴	0.990	0.259	58.02	3.64x10 ¹⁴	0.983
PW/80% ZnRSO	0.020	41.42	8.93x10 ¹⁴	0.854	0.474	56.30	2.40x10 ¹⁴	0.999

IMPORTANT OUTCOMES

The residual mass obtained at 500°C was highest for PW/0.5 wt% CaRSO (26.43%) and PW/20% ZnRSO (24.12%).

The values obtained for the activation energies using Broido's equation was highest for PW/Ca-RSO at 0.5% and the admixture having 20% Zn content at 55.92 and 44.67 kJ/mol respectively.

The Coats-Redfern's kinetic model best described the thermal decomposition process with higher correlation coefficients approaching unity.

The results from this study suggests that using Ca single soap additive (≤ 0.5 wt%) and the admixture having 20% Zn content improved the thermal stability of paraffin wax

The data obtained in this study represent new findings and provide additional impetus for the development of value – added products from RSO obtained from rubber seed biomass

Metal soaps of RSO are biodegradable additives obtained from renewable resources that contributes to global sustainability and its commercialization remains a major challenge and on – going research based on improving these sustainable materials for use as additives in various industrial applications continues to be part of our future studies.

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