

THERMAL DEGRADATION OF POLY(VINYL CHLORIDE)/POLYSTYRENE BLENDS IN THE PRESENCE OF DERIVATIVES OF *Hura crepitans* SEED OIL.

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ABSTRACT

Poly(vinyl chloride) (PVC) is a versatile polymer that has found applications in various sphere of our daily life. However, it is intrinsically unstable at elevated temperatures usually employed in processing it into useful articles. The thermal stability of poly(vinyl chloride) (PVC) has been reported to improve in a blend with polystyrene (PS) and compatibility of the polymers was a factor which influenced the stabilization process. There has been no report of thermal stability of PVC/PS blends in the presence metal soap of seed oil. In this study, the thermal degradation of poly(vinyl chloride)/polystyrene (PVC/PS) blends in the absence and presence of metal soaps of *Hura crepitans* seed oil (HCSO) has been investigated in air and under nitrogen atmosphere. Metal soaps of *Hura crepitans* seed oil; Al, Ba, Ca, Mg and Zn were prepared by precipitation method involving metathesis in alcohol. Kinetics of thermal degradation of PVC and the blends were carried out titrimetrically in the temperature range 170-190 °C under nitrogen atmosphere. The interaction of the additives with PVC was studied with FTIR spectrophotometer while the melt properties of PVC and the blends were determined using differential scanning calorimeter. The thermal stability study of the polymer and the blends was carried with thermogravimetric analyzer under nitrogen and air atmospheres. In the absence of metal soaps, the kinetics of thermal degradation of PVC in PVC/PS blends, 95/5, and 90/10 ratios, measured titrimetrically under nitrogen atmosphere in the temperature range 170-190 °C, was determined by the rates of dehydrochlorination of the polymer. The rates of dehydrochlorination were of the order, $10^{-2} \text{ \%min}^{-1}$ and showed stabilization of PVC by PS in the blends. Specifically, at 190 °C, the rates of dehydrochlorination of PVC under nitrogen atmosphere were reduced by 23.7 and 11.2% for the 95/5 and 90/10 blends respectively with calculated activation energy of 50.7 kJ mol^{-1} for the process. In the presence of HCSO soaps of Al, Ba, Ca, Mg and Zn, there were marked reductions in stabilization of PVC by PS and were associated with increased polarity of the blends. Miscibility of the blends was enhanced by the soaps, as was evident from FTIR and DSC analyses, showing from the latter, single T_{gs} of 98.2 and 96.2 °C for 95/5 and 90/10 blends respectively. The enhanced stability of PVC in the blends by PS and reduced stability of the polymer in the presence of metal soaps were confirmed by thermogravimetry. PS enhanced thermal stability of PVC in PVC/PS blends while the presence of metal soaps of *Hura crepitans* seed oil in PVC/PS blends is antithetical to thermal stability of PVC.

Keywords: Thermal degradation, poly(vinyl chloride)/polystyrene) blends, *Hura crepitans* seed oil derivatives, kinetics, thermogravimetry.

INTRODUCTION

Poly(vinyl chloride) (PVC) is a versatile polymer of immense domestic and industrial applications, second only to polyolefins in total world output by volume. However, PVC is thermally unstable, degrading by dehydrochlorination reaction, yielding polyenes and other products[1,2]. The degradation may be affected by additives. In the presence of ionic liquids, PVC degradation by dehydrochlorination is reduced[3]. Similarly, the degradation of the polymer is mitigated by stabilizers which include organometallic compounds[4,5], metal soaps of carboxylic acids[6,7], Schiff bases[8,9], polyphosphates[10] and highly aromatic organic compounds[11]. Improved properties may be achieved also by blending PVC with a number of polymers, synthetic and natural. Specifically, blending of PVC with acrylonitrile-butadiene-styrene terpolymer resulted in improved process-ability and impact strength of the polymer[12,13]. Similarly, PVC/polyvinyl acetate blend, as mixtures and as graft copolymer showed improved thermal stability of PVC arising from chemical bonding of the polymer chains[14]. However, the thermal properties of PVC in blends depend on a number of factors which include, miscibility of the blends or the degree of phase dispersion[15], polarity of the medium, HCl solubility, HCl diffusion rate, interaction of HCl with polar groups and interaction of PVC with intermediates or products derived from degradation of the other polymer¹. Specifically, for the thermo-oxidative degradation of

poly(vinyl chloride)/biodegradable aliphatic-aromatic copolyester blends (PVC/AAC), the blend showed one T_g indicating miscibility of the components and the rate of dehydrochlorination of PVC decreased for blends containing more than 10% AAC[16]. Conversely, for PVC in blend with poly(isobornyl acrylate), two T_g s were observed indicating immiscibility of the polymers[17].

Similarly, for the thermal degradation of PVC/epoxidised liquid natural rubber (ELNR) blend, the presence of 20 and 50 mol% of epoxy group in LNR enhanced the thermal stability of PVC[18]. The observation that PVC is stabilized in the presence of polystyrene (PS) in PVC/PS blend has been ascribed to two factors, namely diffusion of HCl into the PS and reduction in the medium polarity, both of which hindered dehydrochlorination of PVC[19]. Interactions between the degradation products of PVC/PS blend have been reported by Ahmad et al [20] in thermal degradation of the blend. Furthermore, the dehydrochlorination stage and second stage of PVC were delayed by PS albeit, there was interaction between the polymers only when PS began to decompose[21]. The presence of metal salts can have profound influence on compatibility and degradation of polymer blends. Specifically, lithium acetate in PVC/polyoxymethylene (POM) blend increased the initial decomposition temperature of the blend. The action of the acetate on the polymers'

interfaces was adduced to intermolecular complexation[22]. The addition of Ca/Zn stabilizers to PVC/chlorinated polyethene (CPE) blend containing up to 30% CPE resulted in higher onset degradation temperatures than the corresponding unstabilized blends[23]. The blends were immiscible in the presence of the stabilizer as deduced from differential scanning calorimetric analysis.

There is the need to examine the effect of polarity on thermal stabilization of polyvinyl chloride/polystyrene blend. Accordingly, the present study is on the effect of metal soap derivatives of *H. crepitans* seed oil (HCSO) on the thermal degradation of PVC in PVC/PS blends in air and under nitrogen atmosphere. The kinetics of degradation of the blends and the results of thermogravimetric and differential scanning calorimetric analyses are presented and discussed.

MATERIALS AND METHODS

Materials

The seeds of *H. crepitans* plant, of the family Euphorbiaceae, were obtained from Abeokuta, Nigeria. They were air-dried, milled into granular form and the oil extracted by soxhlet extractor using petroleum ether (40-60 °C). PVC (Aldrich Co. USA), number average molecular weight (Mn) 0.9×10^5 , was purified by dissolution in cyclohexanone and precipitated in a large excess of methanol[24]. The polymer was filtered off, washed with methanol and air-dried at 50 °C.

Polystyrene (Aldrich Co., USA), Mn, 1.7×10^5 was used as supplied without further purification. Other materials which included chloroform, sodium thiosulfate and potassium iodide were used as supplied.

Preparation of metal soaps of HCSO

Preparation of the metal soaps of HCSO was by metathesis in an alcohol solution[7] using the following metal salts: BaCl₂. 2H₂O, MgCl₂.7H₂O, ZnSO₄.7H₂O, AlCl₃. H₂O and CaCl₂. 2H₂O. The oil (9.2g) was dissolved in 50 ml of hot ethanol and then treated with 20 ml of 20 % (w/w) sodium hydroxide to yield the sodium salt derivative. To the sodium salt derivative was added slowly, with continuous stirring, the appropriate metal salt. The metal soap precipitated and was washed with warm water, air-dried and recrystallized from its solution in benzene.

Fatty acid composition of HCSO

The fatty acid composition of HCSO was determined from their methylester derivatives using gas chromatography – mass spectrometry (GC-MS), model, Agilent 6890N – 5973N GC-MSD equipped with DB-5MS column (60m x 0.25mm x 0.15µm). Helium was the carrier gas at a constant flow rate of 1 mlmin⁻¹. The injector temperature was 250 °C and the column temperature was raised from 80 to 220 °C at 10 °Cmin⁻¹.

FTIR of PVC and PVC/PS blends

PVC powder (6.0 g) was added to 150 ml tetrahydrofuran (THF) at 25 °C[24]. After complete dissolution of the polymer, 15 ml aliquots of the solution were placed in clean petri dishes of 5-6 cm diameter at 25 °C. The thin films formed after evaporation of THF were dried in a desiccator before examination in the FTIR spectrometer model Nicolet Avatar 330 FTIR.

For the blends, appropriate mass ratios (95/5 and 90/10) of PVC/PS were dissolved in THF with continuous stirring for 12 hrs at room temperature, and for 5 hrs at 50 °C. The solutions of the blends were cast on glass plates and dried in a vacuum oven. The thickness of the films varied from 0.7 to 0.8 mm.

Kinetics of thermal degradation of PVC and PVC/PS blends

Thermal degradation of PVC and PVC/PS blends in the temperature range 170 – 190 °C was conducted in a degradation tube[25]. The latter was immersed in a thermostated oil bath maintained at the appropriate temperature and connected to a dry nitrogen source at flow rate of

600 mlmin⁻¹. The sample (1 g), with or without metal soaps (3 %w/w) was degraded in the tube, and the HCl evolved was passed into a standard solution of sodium hydroxide. The amount of HCl evolved at regular intervals was determined by back-titration of the sodium hydroxide solution with standard hydrochloric acid. The ratio of HCl evolved to the amount available in the polymer was used to determine the extent of dehydrochlorination of PVC.

Differential scanning calorimetry of PVC and PVC/PS blends

Differential scanning calorimeter (DSC Q20, module DSC with standard cell FC) at heating rate of 10 °Cmin⁻¹ to 500 °C and flow rate of 2 mlmin⁻¹ under nitrogen was used to determine the glass transition temperature T_g of PVC and PVC/PS blends.

Thermogravimetric measurements

Thermogravimetric measurements on PVC and the blends were conducted using Perkin-Elmer Pyris 6 thermogravimetric analyzer programmed at heating rate of 10 °Cmin⁻¹ up to a temperature of 700 °C under nitrogen and in air.

RESULTS AND DISCUSSION

The physico-chemical characteristics and fatty acid composition of *H. crepitans* seed oil are shown in Table 1. The oil content (%) of the seed is 54 with oleic acid as dominant fatty acid. It has

a saponification value of 212mgKOHkg⁻¹ suggesting preponderance of long chain fatty in the oil.

Table 1: Physico-chemical characteristics and fatty acid composition of *H. crepitans* seed oil

Parameter	Value
Oil Content (%)	54.32
Density (kgm ⁻³)	0.98
Flash Point (°C)	304
Refractive Index (@20°C)	1.5201
Kinematic Viscosity (@40°C) (mm ² s ⁻¹)	35.97
Iodine Value (gI ₂ 100g ⁻¹)	145
Saponification Value (mgKOHkg ⁻¹)	211.6
Peroxide Value (mEqkg ⁻¹)	6.14
Acid Value(mgKOHg ⁻¹)	18.34
Free Fatty Acid (mgKOHg ⁻¹)	8.02
Fatty Acids (%):	
Palmitic	4.54
Stearic	4.52
Oleic	68.96
Linoleic	1.75
Eicosenoic	1.54
Others	18.69
Total Unsaturation (%)	72.25

The oil content of the seed is similar to the oil contents of some oilseeds reported in the literature, *Allanblackia floribunda* (61%)[26]; *Ximenia americana* (50%)[27]. The dominant fatty acid is oleic at 69% with trace amounts of linoleic acid, 1.75%, and eicosenoic acid, 1.54%

giving total unsaturate of about 72%. The polyunsaturated nature of the oil was confirmed by iodine value of 145gI₂100g⁻¹ indicating that the oil is semi-drying.

The dehydrochlorination of PVC and PVC/PS blends under nitrogen in the temperature range

170 – 190 °C are presented in conversion plots (Fig. 1 and Fig. 2). The degree of dehydrochlorination was assessed from the time to attain 1% conversion, t_{DH} and the average rate of reaction up to 1% conversion, R_{av} . In the absence of metal soaps, PVC is stabilized by PS as evident from t_{DH} and R_{av} values. Specifically, at 190 °C, the t_{DH} for PVC (32 min) is increased by 31 and 12.5% for the 95/5 and 90/10 PVC/PS

blends respectively. The corresponding R_{av} is reduced by 20.8% for the 95/5 PVC/PS blend. Retardation in PVC dehydrochlorination in the presence of PS has been reported[19] and adduced to diffusion of HCl into the PS phase, reduction in polarity of the medium and concomitant reduction in the auto-catalytic effect of HCl .

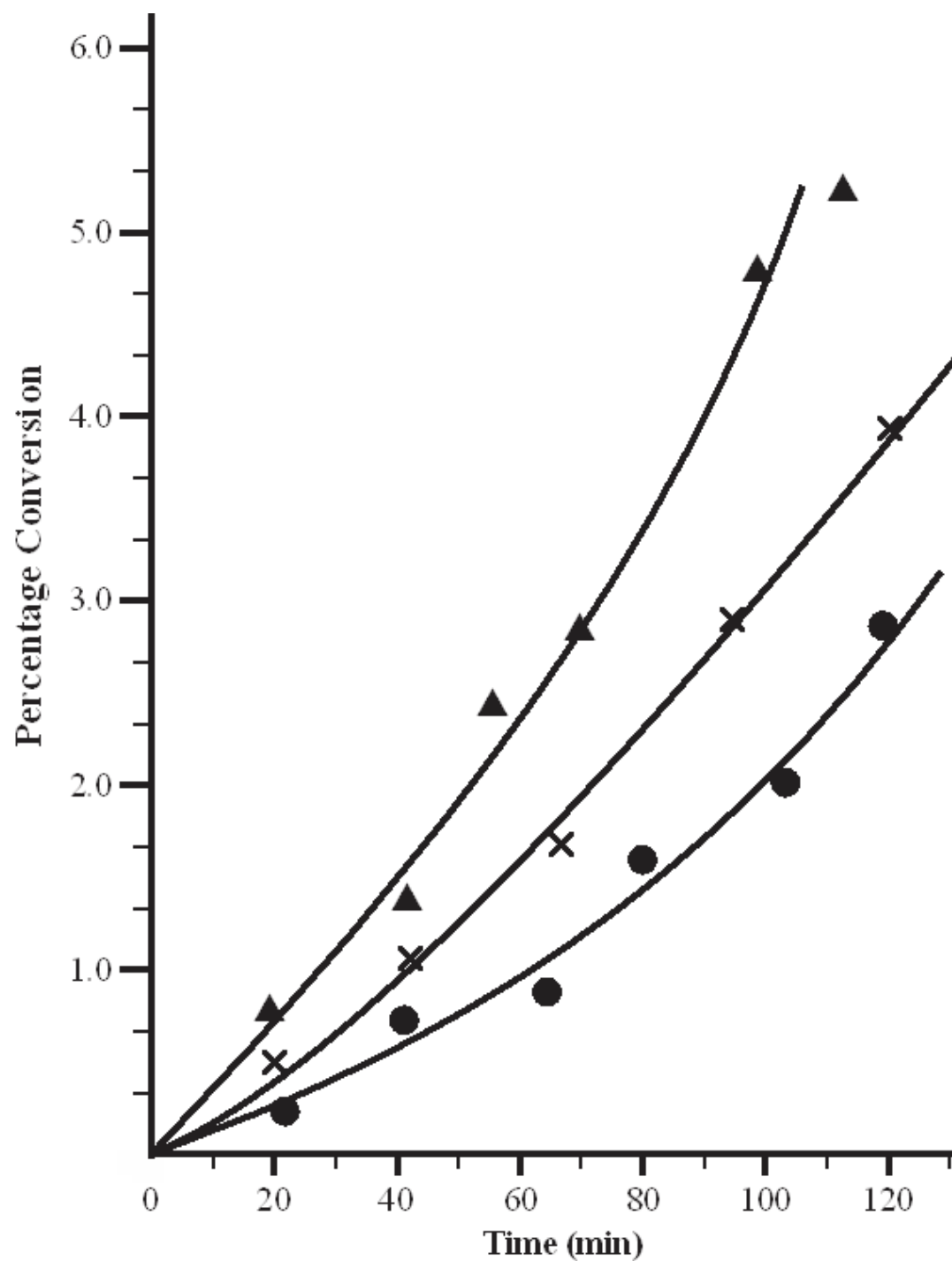


Fig. 1: Dehydrochlorination of PVC in nitrogen at 170°C (●), 180°C (X), and 190°C (▲)

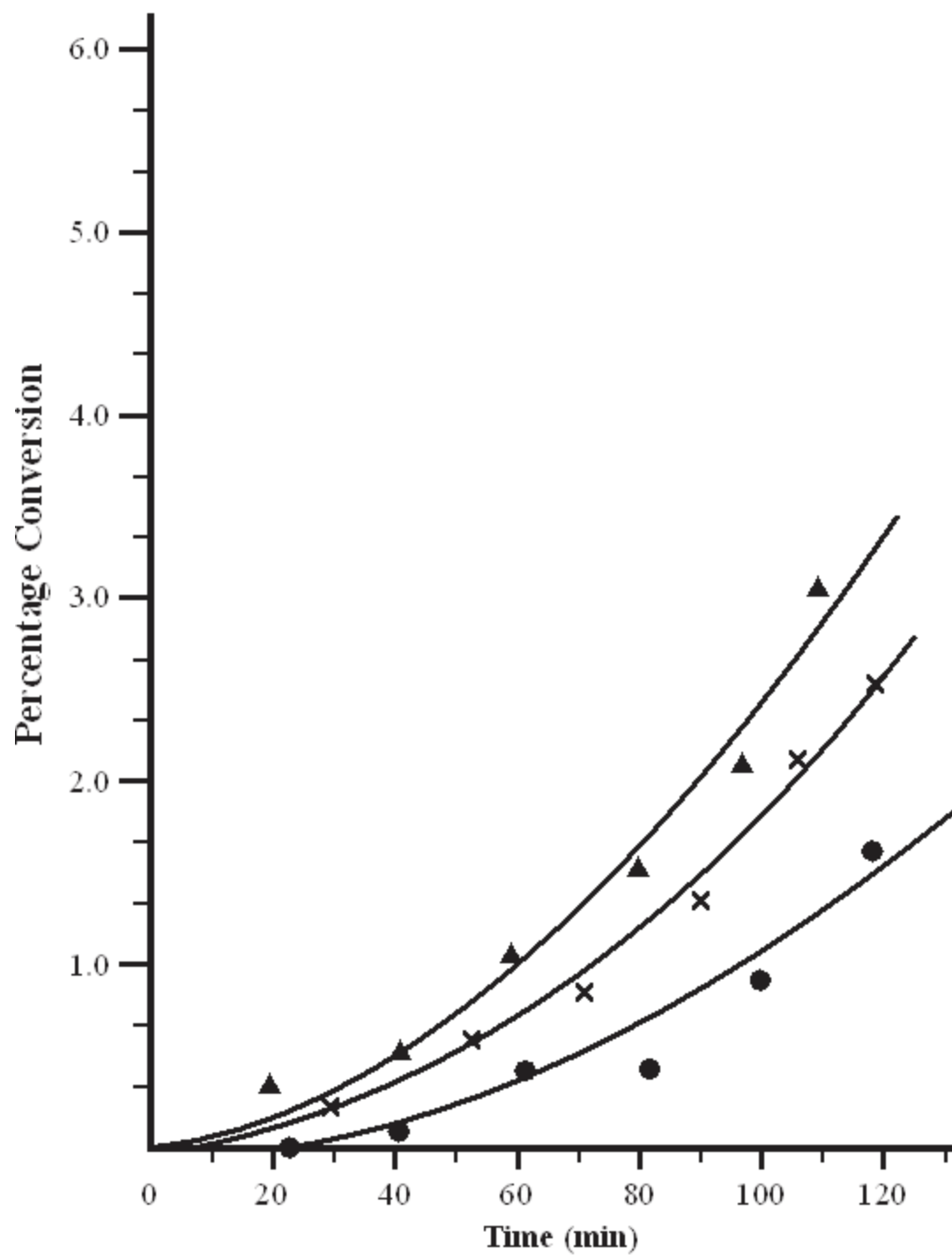


Fig. 2: Dehydrochlorination of PVC/PS (95/05) in nitrogen at 170°C (●), 180°C (X), and 190°C (▲)

on the degradation process. Further, retardation is adduced as arising from the reaction of chlorine radicals with tertiary hydrogen atom of PS and consequent scission of the latter[19]. In the presence of carboxylates, i.e., the metal soaps of HCSO, namely Al-HCSO, Ba-HCSO, Ca-HCSO,

Mg-HCSO and Zn-HCSO, the stabilizing effect of PS on PVC in the blend is reduced. The ratio of time for 1% degradation of PVC in the blend (t_{DH}) to the corresponding one for PVC only (t_{DH}^0) i.e., t_{DH}/t_{DH}^0 , is lowest in the presence of the zinc soap, i.e., 0.71.

Table 2: Kinetic data for thermal degradation of PVC/PS (95/5) blend in the presence of metal soaps of *H. crepitans* seed oil under nitrogen atmosphere

Sample	T (°C)	t _{DH} (min)	10 ² Rav (% min ⁻¹)	k (% min mol ⁻¹)	t _{DH} /t _{DH} ⁰	E kJmol ⁻¹
PVC	170	73	1.36	0.85	-	60.28
	180	45	2.22	1.38	-	
	190	32	3.12	1.95	-	
PVC/PS Blend (95/5)	170	76	1.31	0.86	1.04	50.76
	180	58	1.72	1.13	1.28	
	190	42	2.38	1.56	1.31	
Blend + Metal Soap (3% w/w):						
Al-HCSO	170	54	1.85	1.21	0.74	39.77
	180	47	2.12	1.39	1.04	
	190	34	2.94	1.93	1.06	
Ba-HCSO	170	56	1.78	1.17	0.76	47.80
	180	42	2.38	1.56	0.93	
	190	32	3.12	2.05	1.0	
Ca-HCSO	170	74	1.35	0.88	1.01	57.61
	180	48	2.08	1.36	1.06	
	190	38	2.63	1.73	1.18	
Mg-HCSO	170	74	1.35	0.88	1.01	40.78
	180	58	1.72	1.13	1.28	
	190	46	2.17	1.42	1.43	
Zn-HCSO	170	-	-	-	-	23.07
	180	32	3.12	2.05	0.71	
	190	28	3.5	2.34	0.87	

t_{DH}^0 , value for PVC only.

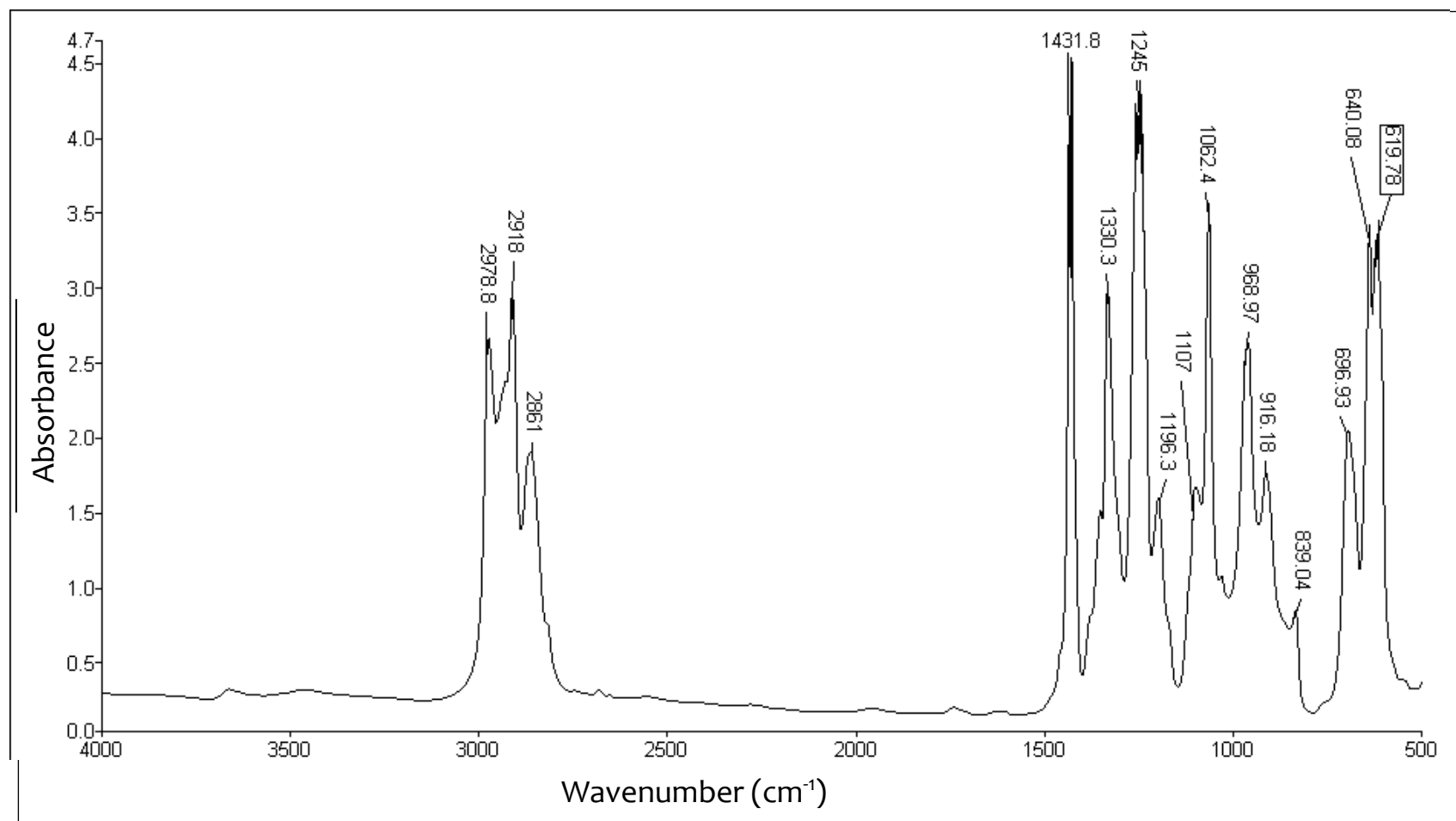


Fig. 3: FTIR spectrum of undegraded PVC film

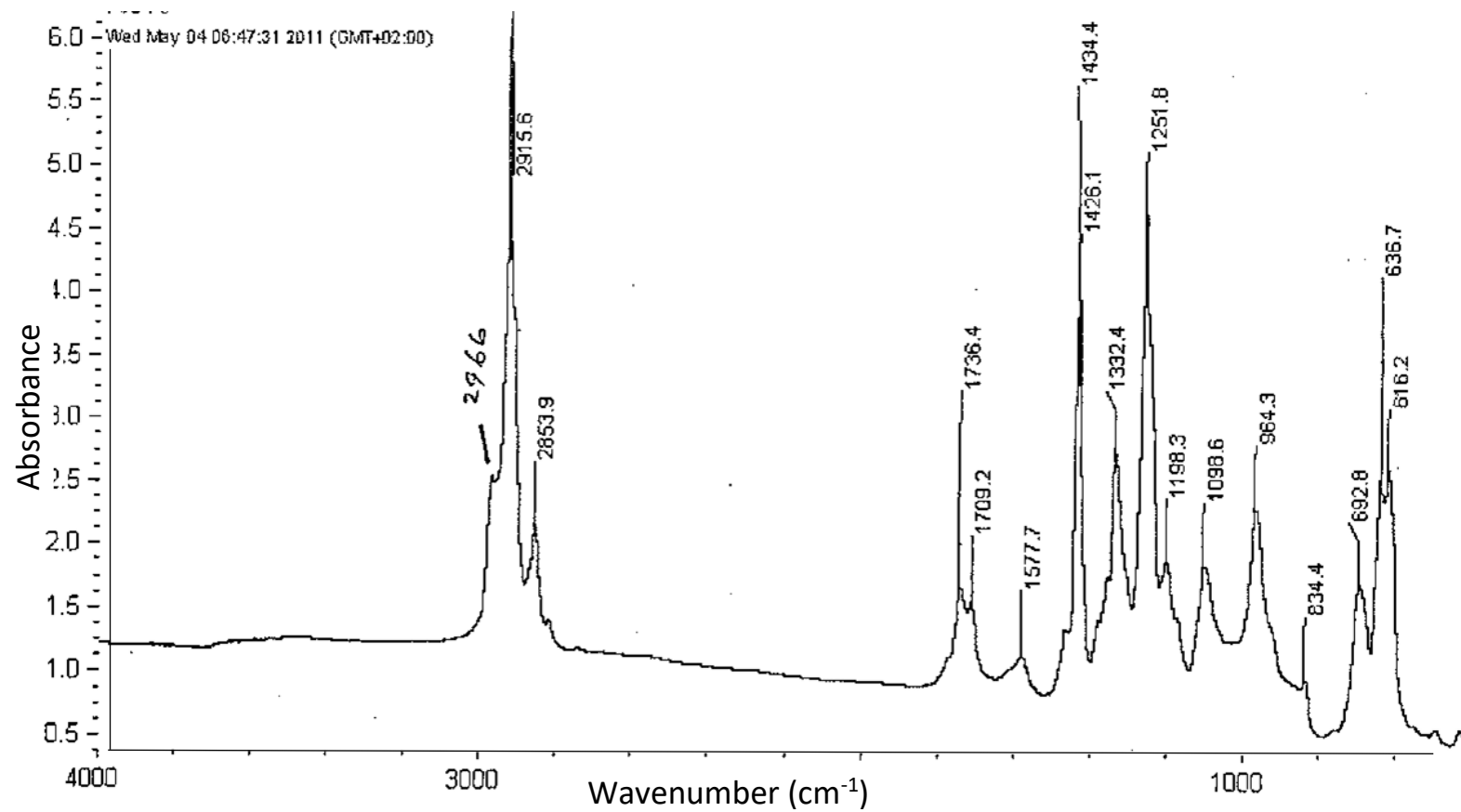


Fig. 4: FTIR spectrum of PVC/PS (95/5) blend, undegraded .

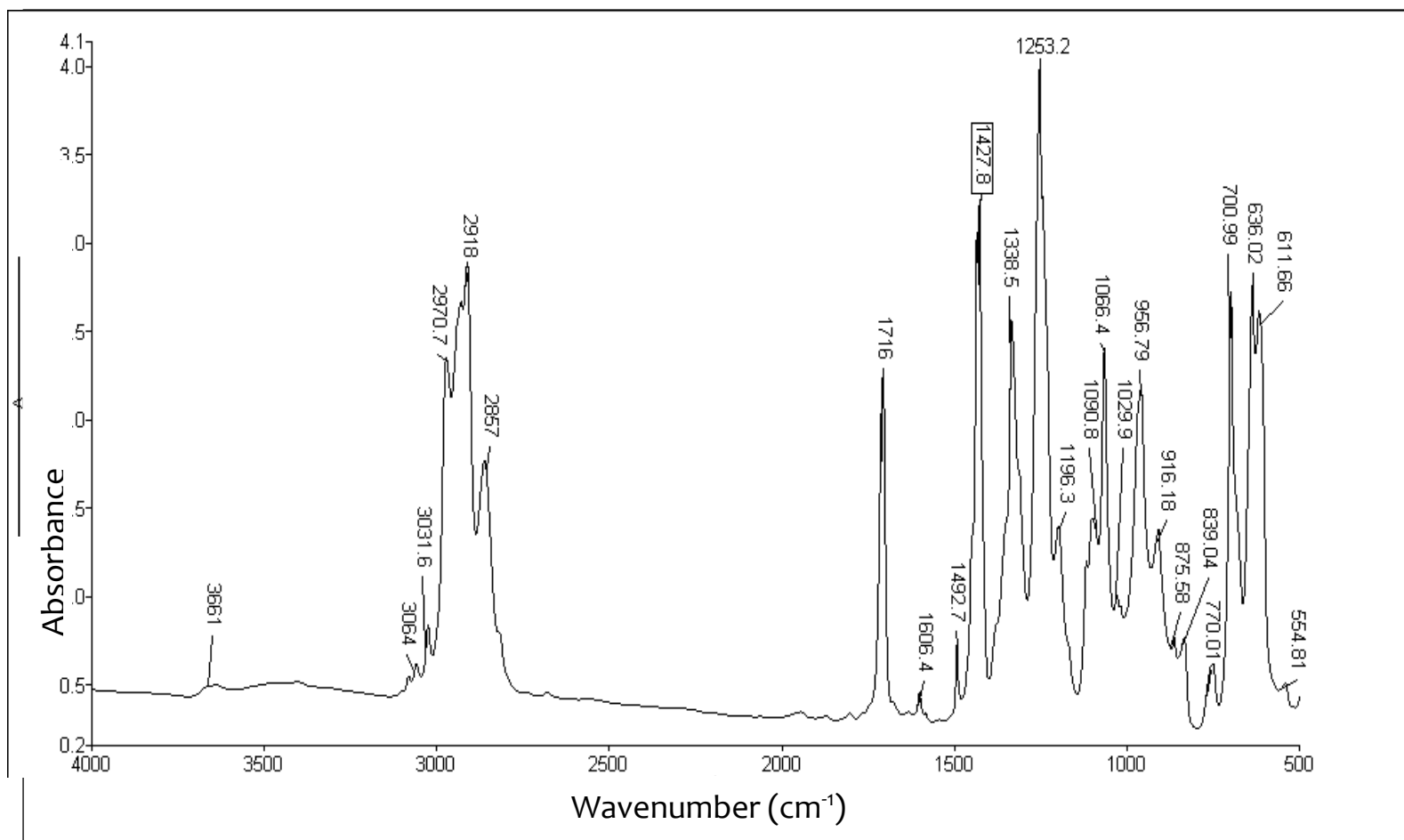


Fig. 5: FTIR spectrum of undegraded PVC/PS (90-10) film

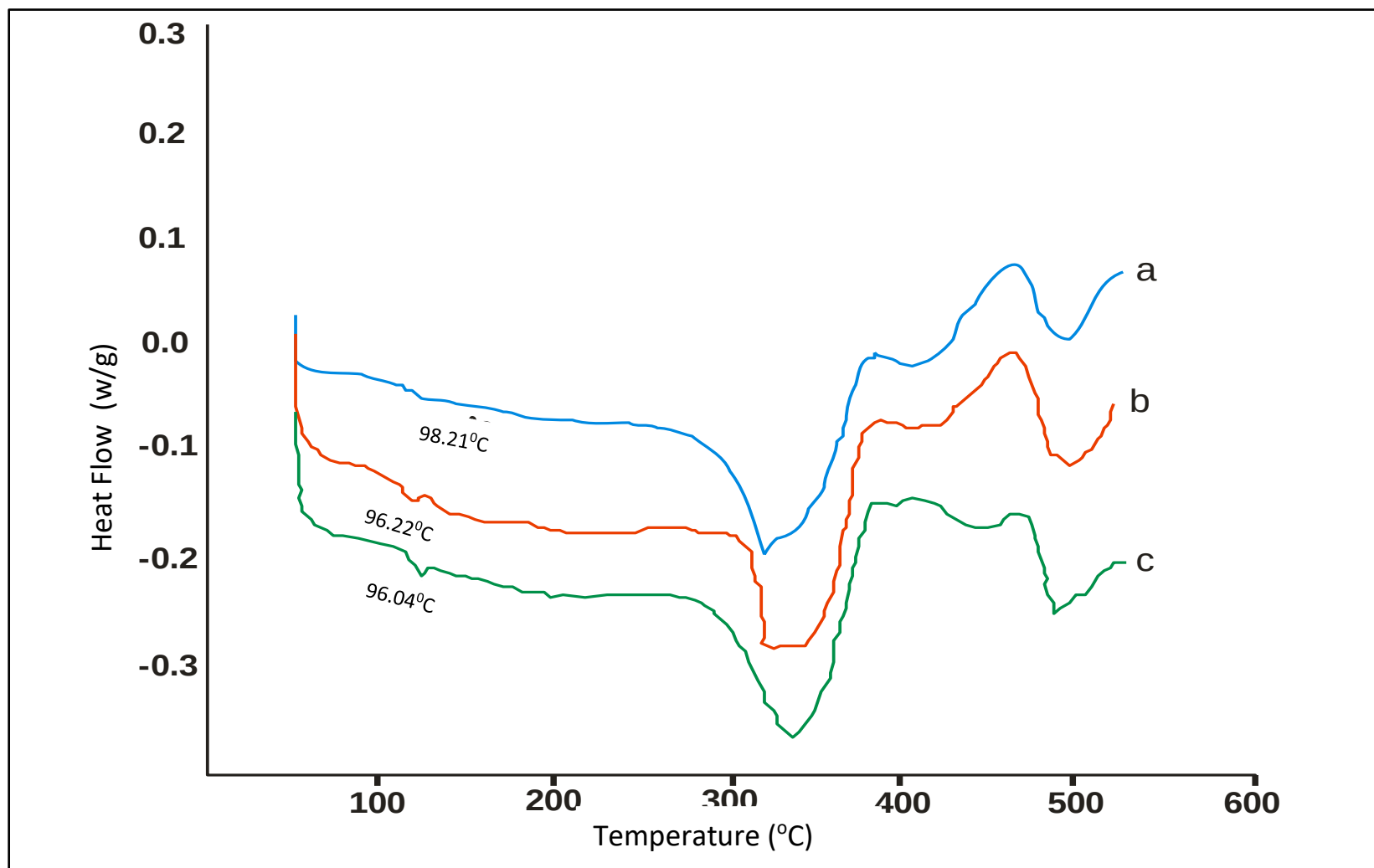


Fig 6: DSC curves of PVC and PVC/PS blends: (a) PVC/PS (95/5) (b) PVC/PS 90/10 (c) PVC/PS (100/0)

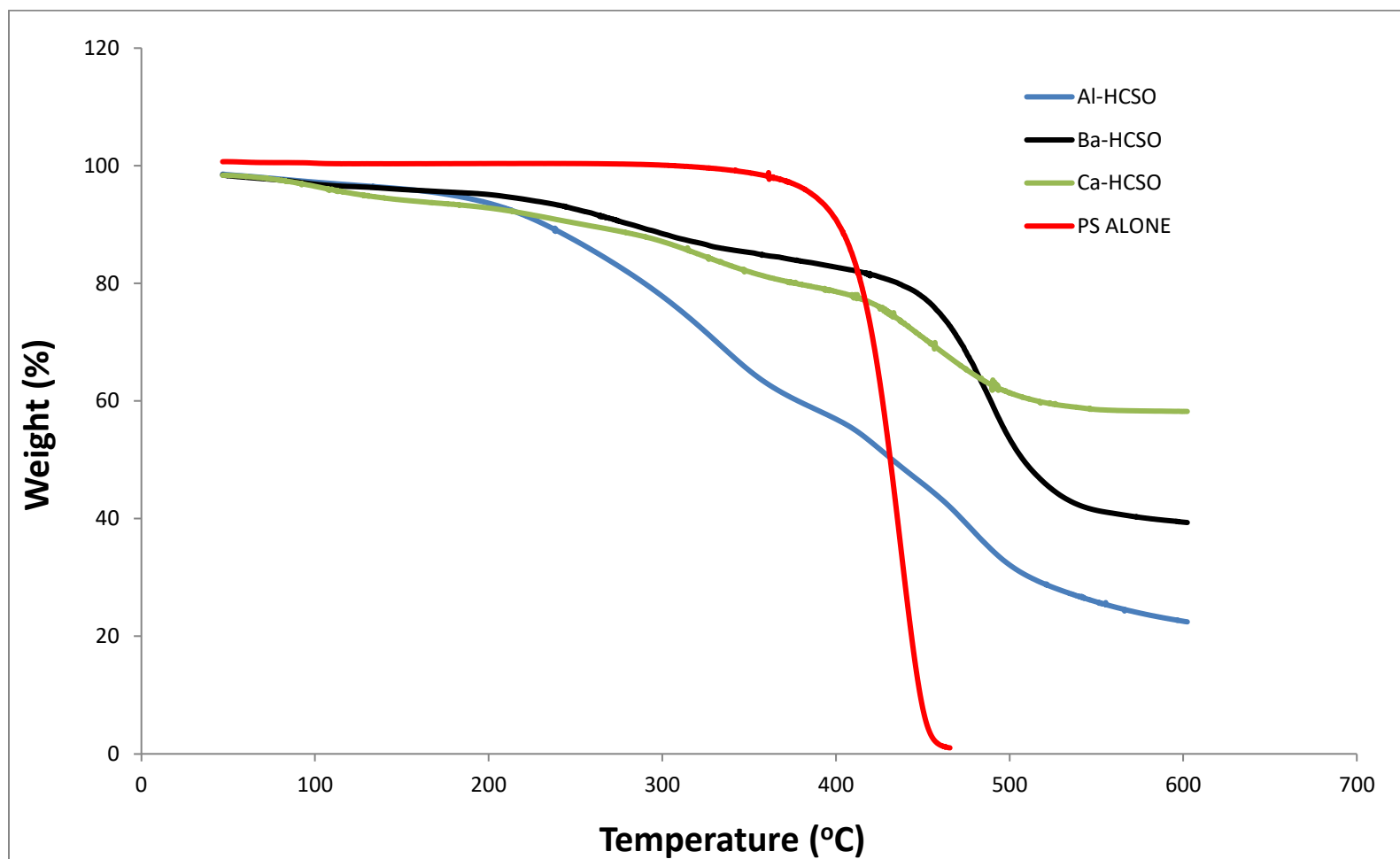


Fig.7: Thermograms for metal soap of HCSO; Al-HCSO, Ba-HCSO, Ca-HCSO and PS (Blank) in nitrogen

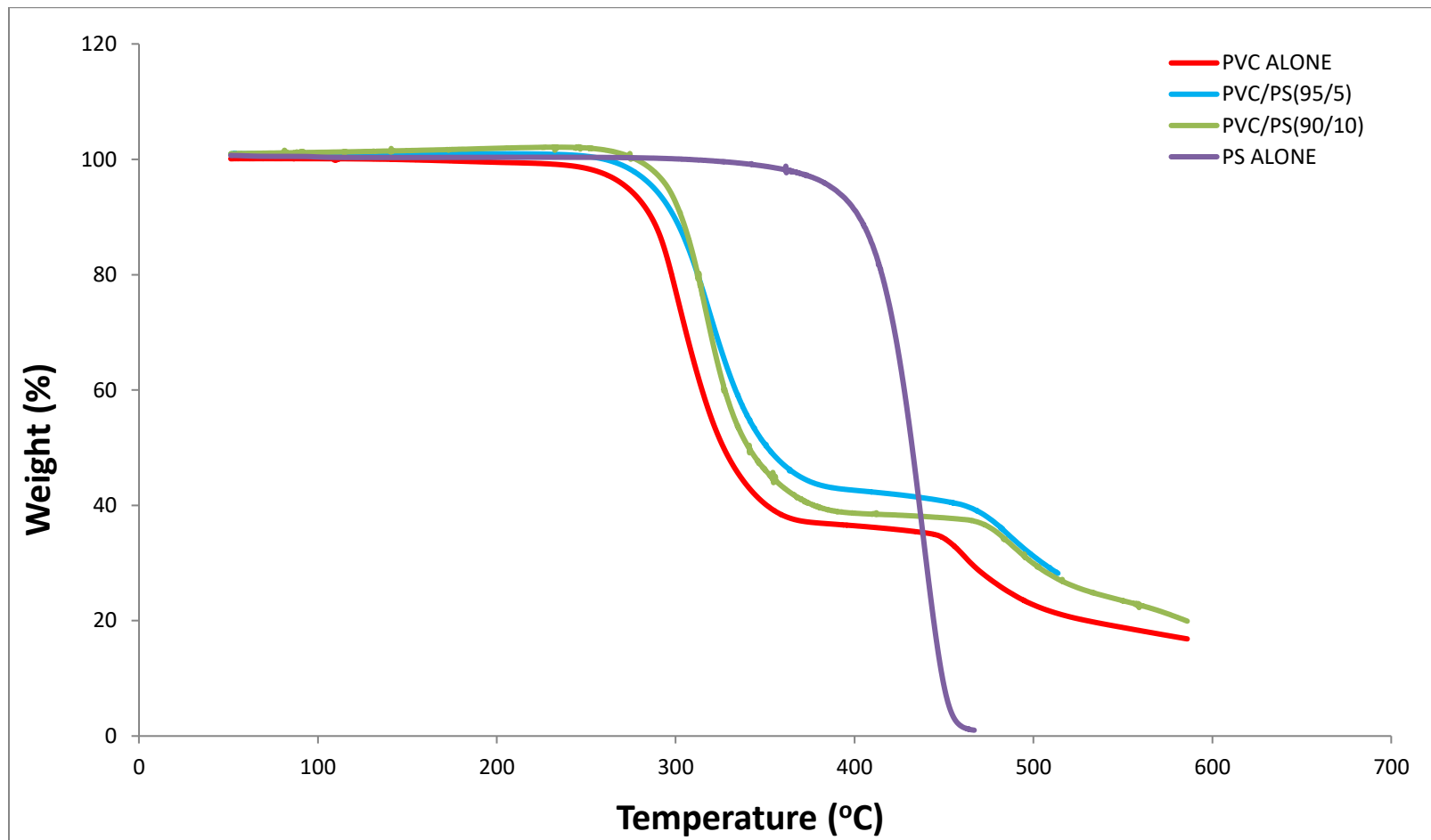


Fig. 8: Thermograms for PVC/PS blends (100/0), PVC/PS (95/5), PVC/PS (90/10) and PVC/PS (0/100) in nitrogen.

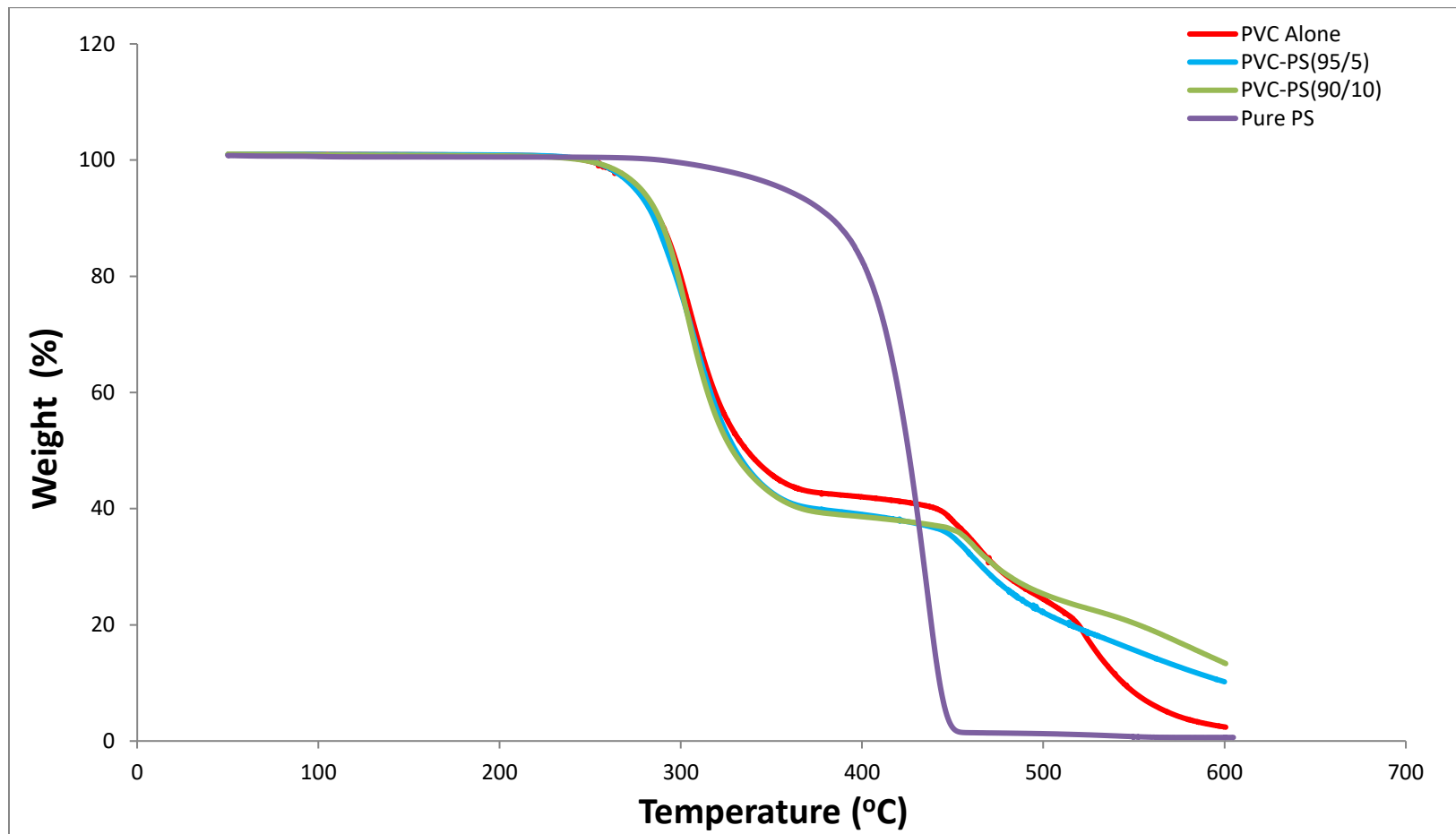


Fig. 9: Thermograms for PVC/PS blends (100/0), PVC/PS (95/5), PVC/PS (90/10) and PVC/PS (0/100) in air.

The reduced stability of PVC in the PVC/PS (95/5) blend may be ascribed to increased polarity of the blend by the presence of metal soaps and concomitant increase in the rate of HCl loss from PVC. This is corroborated by reduction in polarity in the 90/10 blend and the improved stability of PVC. Thus, the t_{DH}/t_{DH}^0 for 90/10 blend in the

presence of metal soaps are much higher by up to 32.4% than the corresponding values for the 95/5 blend at 170°C. The activation energies for the blends are the same i.e., 50.7 kJmol⁻¹. But in the presence of metal soaps, the activation energies are varied, the lowest value of 23.0 kJmol⁻¹ being for the blend with zinc soap.

Table 3: Kinetic data for thermal degradation of PVC/PS (90/10) blend in the presence of metal soaps of *H. crepitans* seed oil under nitrogen atmosphere

Sample	T (°C)	t _{DH} (min)	10 ² Rav (% min ⁻¹)	k (% min mol ⁻¹)	t _{DH} /t _{DH} ⁰	E kJmol ⁻¹
PVC	170	73	1.36	0.85	-	60.28
	180	45	2.22	1.38	-	
	190	32	3.12	1.95	-	
PVC/PS Blend (95/10)	170	62	1.61	1.11	0.84	50.71
	180	49	2.04	1.41	1.08	
	190	36	2.77	1.92	1.12	
Blend + metal soap (3% w/w):						
Al-HCSO	170	72	1.38	0.95	0.98	42.11
	180	50	2.0	1.38	1.11	
	190	34	2.94	2.04	1.06	
Ba-HCSO	170	72	1.38	0.95	0.98	51.86
	180	50	2.0	1.38	1.11	
	190	42	2.38	1.65	1.31	
Ca-HCSO	170	80	1.25	0.86	1.09	55.53
	180	62	1.61	1.11	1.37	
	190	44	2.27	1.57	1.37	
Mg-HCSO	170	76	1.31	0.91	1.04	57.23
	180	53	1.88	1.30	1.17	
	190	40	2.5	1.73	1.25	
Zn-HCSO	170	>120	-	-	-	29.87
	180	40	2.5	1.73	0.88	
	190	30	3.33	2.31	0.93	

t_{DH}^0 , value for PVC

Table 4: DSC data for PVC and PVC/PS blends

Sample	T _g (°C)	T _m (Peak) (°C)	T _D (Peak) (°C)
PVC	96.04	291.91	435.08
PVC/PS blend (95/5)	98.21	312.93	426.11
PVC/PS blend (90/10)	96.22	315.76	408.72

The interaction of PVC with the various additives was observed with FTIR spectrophotometer. The shifts in the frequency bands for –C-Cl stretch and for –C-H (as in CHCl) for PVC and PVC/PS blends suggest some interactions between PVC and PS. For undegraded PVC/PS (95/5) blend in the presence of Al-HCSO metal soap: -C-Cl stretch, 696cm⁻¹ and –C=O) stretch, 1744cm⁻¹; and for PVC/PS, (90/10) in the presence of Mg-HCSO: -C-Cl stretch, 699cm⁻¹ and –C=O) stretch, 1712cm⁻¹; –C-H (as in CHCl), 1259 and 1335cm⁻¹. The shifts in the frequency for –C-H (as in CHCl) may be

associated with hydrogen bonding with the carbonyl functional group of the metal soaps. Further, the –C-H stretch (as in benzyl) for styrene repeat unit occurs as follows in the blends [25,28]: 2915cm⁻¹ (PVC/PS ,95/5), 2922cm⁻¹ (PVC/PS, 95/5, Al-HCSO); 2918 cm⁻¹ (PVS/PS, 90/10) and 2924cm⁻¹ (PVC/PS, 90/10, Mg-HCSO). The shift in the –C-H frequency in the presence of metal soaps suggests interactions, in this case, arising from hydrogen bonding which enhances compatibility of PVC/PS blends.

Table 5: Weight losses for metal soaps at temperature up to 250 °C in air under nitrogen atmosphere

Metal soaps	Weight loss	
	Nitrogen	Air
Al-HCSO	14.73	12.94
Ba- HCSO	9.41	6.93
Ca-HCSO	8.71	8.33
Mg-HCSO	12.32	11.36
Zn-HCSO	9.57	8.55

The melt properties of PVC and the blends were determined using differential scanning calorimetric method. The glass transition temperature, T_g for PVC is 96.04 °C. The blends show single T_{gs} i.e., 98.2 and 96.2 °C for the 95/5 and 90/10 blends respectively which are intermediate between those of PVC and PS (T_g 101 °C)[29] suggesting miscibility of the components of the blends[30]. The T_{ms} for the blends are higher than the value for PVC by as much as 8%. This is consistent with the homogeneity of the blends and enhanced rigidity conferred by the benzene rings of polystyrene. The dissociation temperatures, T_D , are consistent with the higher stability of PVC in the 95/5 blend as observed from kinetics study.

A thermal stability study of the polymer and the blends was conducted using thermogravimetric analyzer. These results confirm the stabilizing effect of PS on PVC and are consistent with observed

lower weight losses for PVC in the blends compared to the value for PVC only. However, T_o , the onset degradation temperature, is considered inadequate for evaluation of thermal stability of polymers[23]. Thus, Table 7 shows the temperatures at which various extent of degradation of PVC in the blends occurred under nitrogen. The temperature at 1% degradation of PVC only (240 °C) is increased to 261 and 278 °C for the 95/5 and 90/10 PVC/PS blends respectively. In the presence of metal soaps, the temperatures for degradation of PVC/PS to attain 1-50% under nitrogen are lower than the corresponding ones for the blends without additives. These are consistent with results of kinetics of dehydrochlorination of PVC/PS blends under nitrogen. Degradation of PVC in the blends, as expected, is faster in air than nitrogen. This is evident in higher T_o values for the 90/10 blend in nitrogen in the presence of metal soaps (Table 6).

Table 6: Degradation characteristics for PVC/PS blends in the presence of metal

soaps in air and nitrogen atmosphere

Sample	T _o (°C)	Weight loss@ T _o (°C)	T _o (2 nd stage) (°C)
Air			
PS	400	-	-
PVC	281.48	60.44	445
PVC/PS Blend (95/5)	293.91	55.50	442.5
Blend + Metal Soaps (3% w/w):			
Al-HCSO	299.32	50.06	451.2
Ba- HCSO	299.60	50.70	451.2
Ca-HCSO	304.77	55.34	446.0
Mg-HCSO	296.25	48.74	455.2
Zn-HCSO	287.16	50.59	446.7
PVC/PS Blend (90/10)	288.20	58.50	462.5
Blend + Metal Soaps (3% w/w)			
Al-HCSO	284.0	52.49	455
Ba- HCSO	285.12	47.71	-
Ca-HCSO	285.15	54.47	447.5
Mg-HCSO	284.72	53.79	470
Zn-HCSO	269.52	32.34	435
Nitrogen			
PS	405	-	-
PVC/PS Blend 90/10	283.60	63.20	475.0
Blend + Metal Soaps (3% w/w):			
Al-HCSO	287.84	59.68	450.0
Ba- HCSO	288.29	59.11	452.5
Ca-HCSO	293.29	57.67	460.0
Mg-HCSO	284.03	60.10	453.7
Zn-HCSO	266.34	54.54	453.7

Table 7: Temperatures at which varying percentage degradations were attained for PVC and PVC/PS blends under nitrogen atmosphere

Sample	Temperature at which degradation attained					Residual @500 °C
	1%	5%	10%	30%	50%	
PVC	240	273	286	322	350	23
PVC/PS Blend (95/5)	261	286	298	322	350	30
Blend + Metal Soaps (3% w/w):						
Al – HCSO	236	274	288	312	339	26
Ca- HCSO	247	275	288	312	336	24
Zn-HCSO	201	258	272	300	332	24
PVC/PS Blend (90/10)	278	293	302	319	339	29
Blend + Metal Soaps: (3% w/w):						
Al-HCSO	248	274	287	307	326	18
Ba- HCSO	245	277	290	308	326	21
Ca-HCSO	254	278	290	309	329	23
Mg-HCSO	274	272	286	306	326	19
Zn-HCSO	-	-	244	289	313	18

CONCLUSION

The kinetics of dehydrochlorination of PVC shows the polymer is stabilized by PS in the 95/5 and 90/10 PVC/PS blends under nitrogen in the temperature range 170 – 190°C. At 190°C, the rate of dehydrochlorination of PVC is reduced by 20.8% in the 95/5 PVC/PS blend under nitrogen. Increased polarity by the presence of metal soaps in the blends results in marked reduction in stability of PVC by PS. FTIR spectra show evidence of interactions of PVC and PS in the blends at the molecular level, principally through hydrogen bonding in the presence of metal soaps, enhancing miscibility. The latter is confirmed by DSC which shows single T_{gs} ,

98.21 and 96.22°C, for the 95/5 and 90/10 blends respectively. The enhanced stability of PVC by PS in the blend and reduced stability of the polymer in the presence of metal soaps are confirmed by thermogravimetry.

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