# Study of the Properties of PVC /ABS Blends

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**Summary:** The aim of this work is to study the properties of PVC and ABS blends. For that, variable compositions of blends from 0 to 100 wt % were realized. Their physico-chemical properties were determined by differential scanning calorimetric analysis (DSC) and Fourier transform infra-red spectroscopy ( FTIR ). The variation of the mechanical properties such as tensile behaviour, impact resistance and hardness was studied according to the composition of blend . The influence of a plasticizer introduced at a level of 30 wt % on the same mechanical properties has been considered.

## Introduction

Polymer blends can combine the attractive properties of several polymers into one and thus, can improve deficient characteristics of a particular polymer. They offer numerous economic benefits. Blending permits to generate rapidly and economically a desired set of properties: mechanical, chemical, barrier and others. Furthermore, blending technology is used to enhance polymer waste recycling [1].

Poly (acrylonitrile-co-butadiene-co-styrene) (ABS) is used in an extensive range of applications because of its excellent balance of mechanical properties, processing latitude, recyclability and economics. It consists of a two phase system, the polybutadiene rubber phase and the styrene-acrylonitrile co polymer (SAN) rigid phase. The rubber phase is finely dispersed and embedded in the rigid SAN phase matrix [2].

When poly (vinyl chloride) (PVC) and ABS are mixed, it is probable that PVC interacts easier with the SAN phase than with the rubber phase considering their respective polarities. So, in the ABS /PVC blend, the interaction between SAN and PVC is an important factor for optimum compatibility. This interaction is influenced by the acrylonitrile (AN) content in SAN. It has been reported that SAN, containing about 12-26 wt % AN, is miscible with PVC and is immiscible outside this range [3]. Homogeneous mixtures can be formed by the addition of a small amount of compatibilizers [4]. ABS is often blended with PVC to impact-modify the notch sensitivity of PVC. The impact properties of the blend are greatly increased compared to PVC [5,6]. It has been shown that impact strength can be enhanced by the addition of a small amount of SAN whose AN content is 25 wt % as a compatibilizer [7].

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In this work, we have investigated the compatibility of commercial grades of PVC and ABS by using the differential scanning calorimetry (DSC) and the Fourier transform infrared spectroscopy (FTIR). In addition, the influence of blend composition on mechanical properties such as impact resistance, hardness and tensile behaviour has been considered in presence and absence of a PVC plasticizer to look into its influence on the degree of compatibility between the two polymers.

## Experimental

Commercial grades of resins and additives listed in table 1 were used.

For compatibility investigation, the polymers were first purified by dissolution in tetrahydrofuran (THF), by precipitation with distilled water and by drying. To look if a specific interaction is present between PVC and ABS, the purified polymers have been used to prepare the samples used in DSC and FTIR investigation. For DSC analysis, blends of variable compositions (0 – 100 wt % ) were dissolved in THF, co precipitated with distilled water and dried under vacuum at 40°C during 72h.

Table 1. Compounds used in this study.

| Compounds | Source |
|---|---|
| PVC 4000M | ENIP-SKIKDA (ALGERIA) |
| ABS | BASF (GERMANY) |
| Lead bibasic phosphite (heat stabilizer) | HENKEL (GERMANY) |
| Stearic acid (lubricant) | HENKEL (GERMANY) |
| Di (ethyl-2hexyl) phtalate (plasticizer) | BASF (GERMANY) |

Glass transition temperatures were measured with a Perkin Elmer DSC-7 apparatus. Each blend was heated under nitrogen from 0 to 200°C with a heating rate of 10°C/mn. The same blends were film casted from THF solutions and analyzed with a Philips type PU 9800 FTIR spectrophotometer.

Formulations realized for mechanical characterization are reported in table 2 . Polymers and additives were mixed in a two roll-mill at 185°C during 5 mn. The samples to be used in mechanical properties determination were then pressed in a hydraulic press at 200°C for 45s under a pressure of 150 MPa. They were water cooled under pressure for 3 min. After this time of water cooling, the temperature of the plates was about 60 °C. Considering the total time of the material in the roll-mill and in the press, PVC still presents a residual stability in all the blends considered as evidenced by a static test of thermal stability which was carried out. The specimens were cut from these plates in different shapes depending on the mechanical test carried out.

Table 2. Formulations realized for mechanical characterization.

| Compounds | Composition in parts[a)] |
|---|---|
| PVC | 0 - 100 |
| ABS | 100 - 0 |
| Lubricant | 1 part per 100 parts PVC |
| Heat stabilizer | 1 part per 100 parts PVC |

[a)] the same formulations were realized in presence of 30 parts of plasticizer per 100 parts of PVC.

Notched Izod impact resistances were determined with a Zwick machine equipped with a (10,8 J) pendulum according to the ASTM D 256 -73. A shore D type durometer was used for determining the hardness of the blends according to the DIN 53505. Measurements of tensile properties were undertaken using an ADAMEL LHOMARGY DY 25 testing machine according to the ISO 37.

## Results and discussion

Thermograms obtained by DSC analysis of the studied PVC/ABS blends (Fig. 1), show that there are two distinct glass transition temperatures (Tg) in the whole composition range

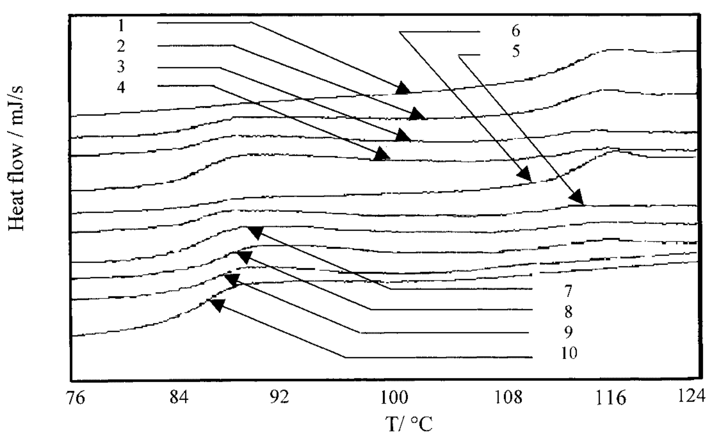


Fig. 1: DSC thermograms for PVC, ABS and some of their blends containing different wt % of PVC; 1 = ABS, 2 = 20 % of PVC, 3 = 30 % of PVC, 4 = 40 % of PVC, 5 = 50 % of PVC, 6 = 60 % of PVC, 7 = 70 % of PVC, 8 = 80% of PVC, 9 = 90 % of PVC, 10 = PVC.

which was considered. The Tg's values are reported in table 3. They are included between the Tg of PVC (85°C) and the Tg of the rigid SAN phase (114°C). It has been reported that the Tg of the rubber phase polybutadiene is at about (-80°C) [8]. Hence, the PVC /ABS blends can be considered to be an incompatible system.

Table 3. Glass transition temperature (Tg) of PVC, ABS and PVC /ABS blends.

| wt % of PVC | Tg (°C) | |
|---|---|---|
| 0 | 114 | |
| 20 | 113.00 | 87.00 |
| 30 | 112.00 | 86.00 |
| 40 | 113.00 | 87.00 |
| 50 | 112.00 | 86.00 |
| 60 | 112.50 | 86.00 |
| 70 | 111.50 | 89.00 |
| 80 | 111.80 | 88.00 |
| 90 | 106.00 | 87.80 |
| 100 | 85 | |

The FTIR spectra of PVC, ABS and some PVC/ABS blends are shown in Fig. 2. ABS spectra is characterized by the presence of a nitrile peak at $2238 cm^{-1}$ [9]. PVC has no absorbing band in this region.

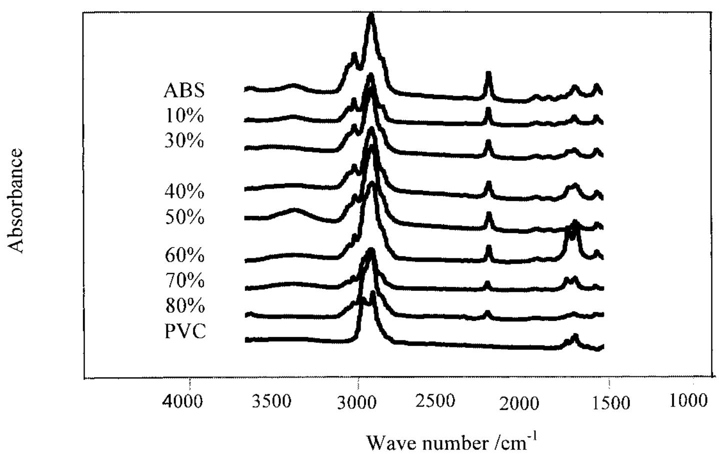


Fig. 2: FTIR spectra of PVC, ABS and PVC/ ABS blends containing different wt % of PVC.

The specific interaction between –C ≡ N group of SAN and –CH group of PVC will shift the nitrile characteristic peak. No shift has been observed for all blends compositions considered. So immiscibility of the two polymers studied as observed by DSC is due to the absence of a specific interaction.

Fig. 3 shows the variation of notched Izod impact resistance according to blend composition in presence and absence of a PVC plasticizer.

ABS presents a better impact resistance than PVC due to the rubber polybutadiene phase. For rigid blends (without plasticizer) , the effect of ABS on enhancing notched impact resistance of PVC is observed for blends containing more than 50 wt % of ABS.

Blends containing plasticizer have better notched impact resistances than blends without plasticizer and blends with more than 50 wt % of PVC do not break. Hence simultaneous presence of ABS and plasticizer has greatly contributed to increase notched impact resistance.

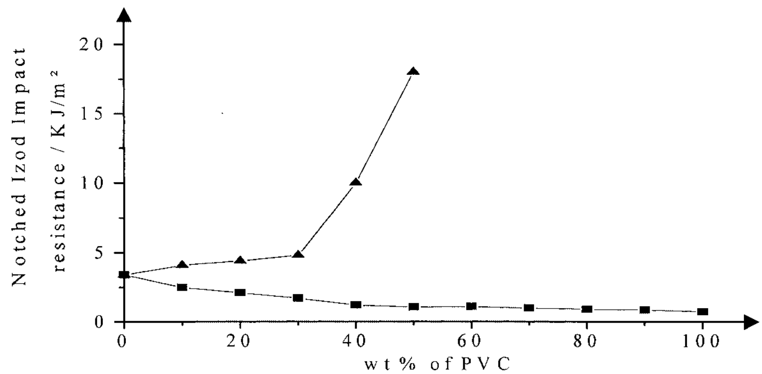


Fig. 3: Variation of notched Izod impact resistance according to blends composition;
▪ = Without plasticizer, ▴ = With plasticizer.

Fig. 4 shows the variation of hardness according to the blend composition. It can be noted

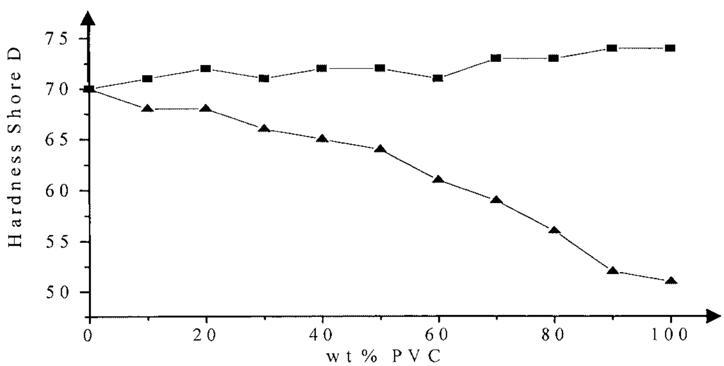


Fig. 4: Variation of hardness according to blends composition;
▪ = Without plasticizer, ▴ = With plasticizer.

that hardness is proportional to the amount of PVC for blends without plasticizer and inversely proportional to the amount of PVC for blends containing plasticizer. Hence, the blends flexibility due to the plasticizer decreases the resistance to penetration and then explains the lower values obtained for hardness for a same blend composition.

Tensile behaviour of the various blends which were studied is illustrated in Fig. 5 (without plasticizer) and in Fig. 6 (with plasticizer) .The comparison between the charge-elongation curves shows that the presence of plasticizer has modified tensile behaviour of PVC/ABS blends.

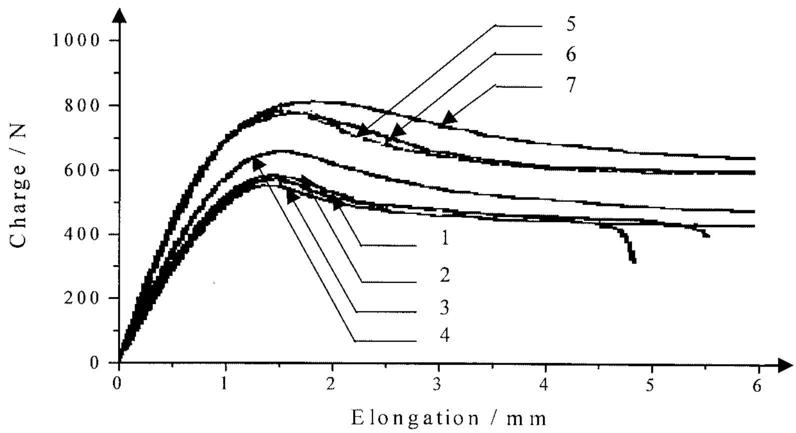


Fig. 5: Tensile behaviour of PVC /ABS blends in absence of plasticizer; 1 = ABS, 2 = 10% PVC, 3 = 30% PVC, 4 = 50% PVC, 5 = 70% PVC, 6 = 90% PVC, 7 = PVC.

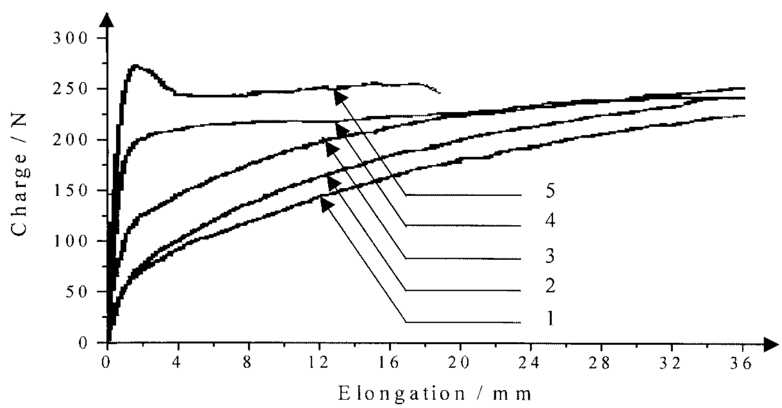


Fig. 6: Tensile behaviour of PVC / ABS blends in presence of plasticizer; 1= PVC, 2= 90% PVC, 3= 80% PVC, 4= 60% PVC, 5= 50 % PVC.

From the stress-strain curves, Young's modulus (E), which was computed from the initial slope of the curves, tensile stress at break and strain at break were determined and evaluated as a function of composition blend. Young's modulus (Fig. 7) increases as the amount of PVC was raised in the rigid blends.

The presence of plasticizer decreases Young's modulus for the same blend composition. This feature indicates diminution of chains interactions due to plasticizer.

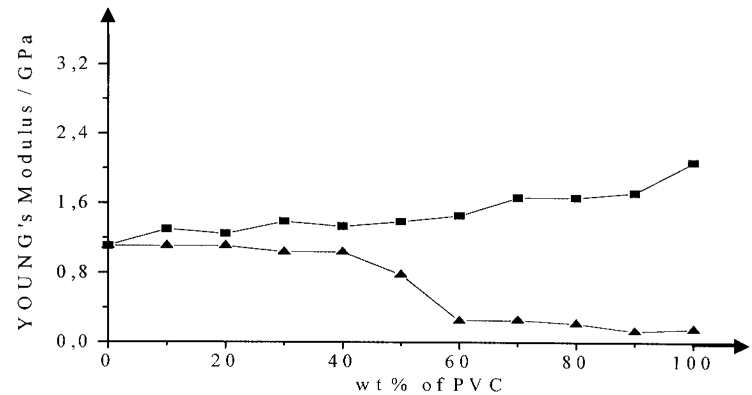


Fig. 7: Variation of Young's modulus with blends composition;
■ = Without plasticizer, ▲ = With plasticizer.

Fig. 8 illustrates the variation of strain at break with blends composition. The higher values of strains at break were observed for blends with plasticizer. Moderate variations of the same characteristic were observed for rigid blends indicating the strength of chains interactions.

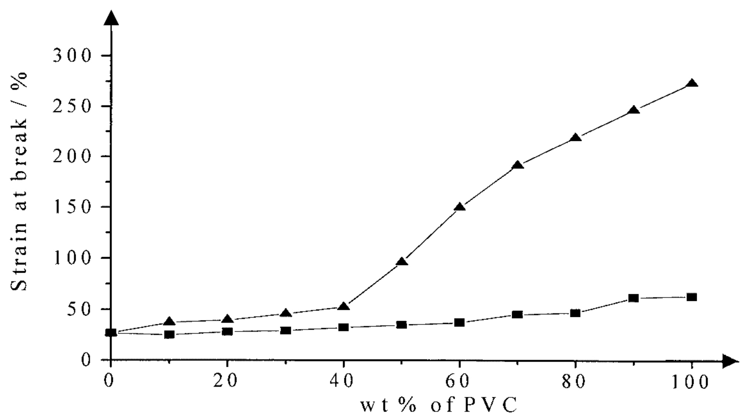


Fig. 8: Variation of strain at break with blends composition;
■ = Without plasticizer, ▲ = With plasticizer.

The higher values of stress at break were obtained for rigid blends particularly for the ones containing more than 60 wt % of PVC (Fig. 9). For plasticized blends, stress at break decreases when increasing the PVC level in the blends.

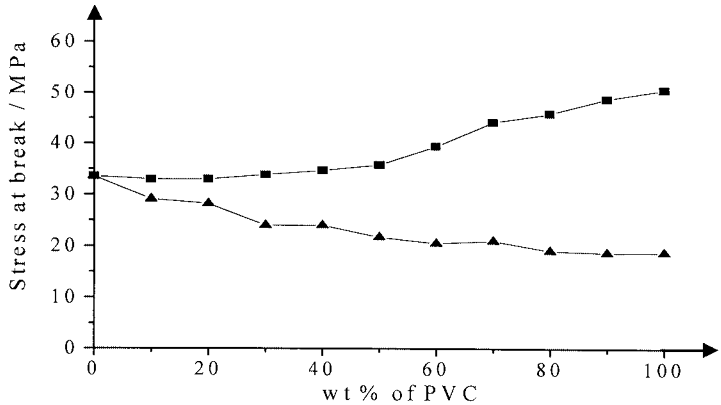


Fig. 9: Variation of stress at break with blends composition ;
▪ = Without plasticizer, ▴ = With plasticizer.

## Conclusion

DSC analysis of the studied PVC/ABS blends showed that these two commercial grades of polymers are incompatible in the whole composition range which was considered. This is due to the absence of a specific interaction between the rigid SAN phase and the PVC as shown by FTIR investigation. The considered mechanical properties are influenced by the respective levels of PVC and ABS in the blends and by the presence or the absence of the PVC plasticizer. The presence of ABS improves moderately the notched impact resistance of PVC while simultaneous presence of ABS and plasticizer enhances greatly the same property. The corresponding blends containing more than 50 wt % of PVC do not break.

Hardness of ABS is slightly enhanced by the presence of rigid PVC and strongly decreased by the presence of plasticized PVC.

Tensile behaviour of the studied PVC/ABS blends is modified by the addition of the plasticizer. Young's modulus, tensile stress at break and strain at break are dependent on the blend composition and on the presence or the absence of plasticizer.

All the obtained results show that a set of mechanical properties can be generated by blending rigid or plasticized PVC with ABS.

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