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Effect of extrusion speed and ATO content on rheological properties of plasticised PVC

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Abstract. Rheological properties of antimony trioxide (ATO) modified plasticised PVC were measured at different extrusion speeds (20-100) rpm. The results showed a positive effect of the presence of ATO accompanied with increased extrusion speed, where the rheological properties and gelation grade of PVC have been improved.

1. Introduction

The extrusion speed one of the important processing parameters in addition to temperature, time, and pressure which significantly and directly affect the characteristics of the final product. The speed should not be low because the polymer will probably stick to the extruder barrel walls because the material will stay long in the extrusion cylinder in addition to the high temperature and the weakness of the flowability. Also, the speed should not increase significantly because this will generate cracks on the surface of the extruded material, and in both cases, the properties of the final product will be affected [1-4]. Due to polyvinyl chloride (PVC) considered one of the sensitive polymers; where its properties are a function of processing history, so, the extrusion speed should be controlled and balanced with high accuracy for achieving optimum properties accompany with a homogeneous structure which improves the quality of the product and reduces the deformations [5-7].

2. Methodology

The following materials have been used to produce samples: polyvinyl chloride (PVC) type Ongrovil® S-5070, dioctyl-phthalate (DOP or DEHP) as plasticizer, calcium-zinc type Newstab-50 as heat stabilizer, Wax-E type Licowax® E as lubricant, and antimony trioxide (ATO) with (0-5) wt.%. The extrusion machine type Göttfert was used to prepare the second batch, where the material extruded to the desired shape in one step by Ø 20 extruder rod diameter at uniform pressure, compression force, and temperature. The temperatures range of the machine heaters were 140, 150, and 160 °C at a uniform rate. PVC was extruded at different speeds (20-100) rpm with and without ATO additions. DSC samples were produced according to the ISO 11357-1 standard [8] with 1mm width and 10mm thickness, and DSC test was done by Mettler Toledo DSC823e instrument to finish this test for gelation grade (G.G) measurement. The temperature range was 30 °C-240 °C; and the heating rate was 20°C/min.

3. Results and Discussion

The gelation grade (G.G) is affected by several factors, and the most important is speed and temperature of extrusion, and the change in the gelation grade (G.G) (increase or decrease) will also affect the rate of retraction, shear stress of the polymer, the presence of cracks, and the others properties of the PVC after extrusion, where they may be improved or reduced depending on the type of filler added to the polymer [1, 9]. From Figure.1 which represents the DSC traces of PVC, we see that the gelation grade increases as the speed increased, which considered as a function of extrusion speed. Figures 2, 3, and 4 which shows the behavior of the extruded PVC at different speeds after adding ATO in different



percentages (1, 3, 5) %wt. respectively, where we noted that there are a significantly increments in gelation grade after adding this oxide, and the improvement rate depends on the percentage of ATO.

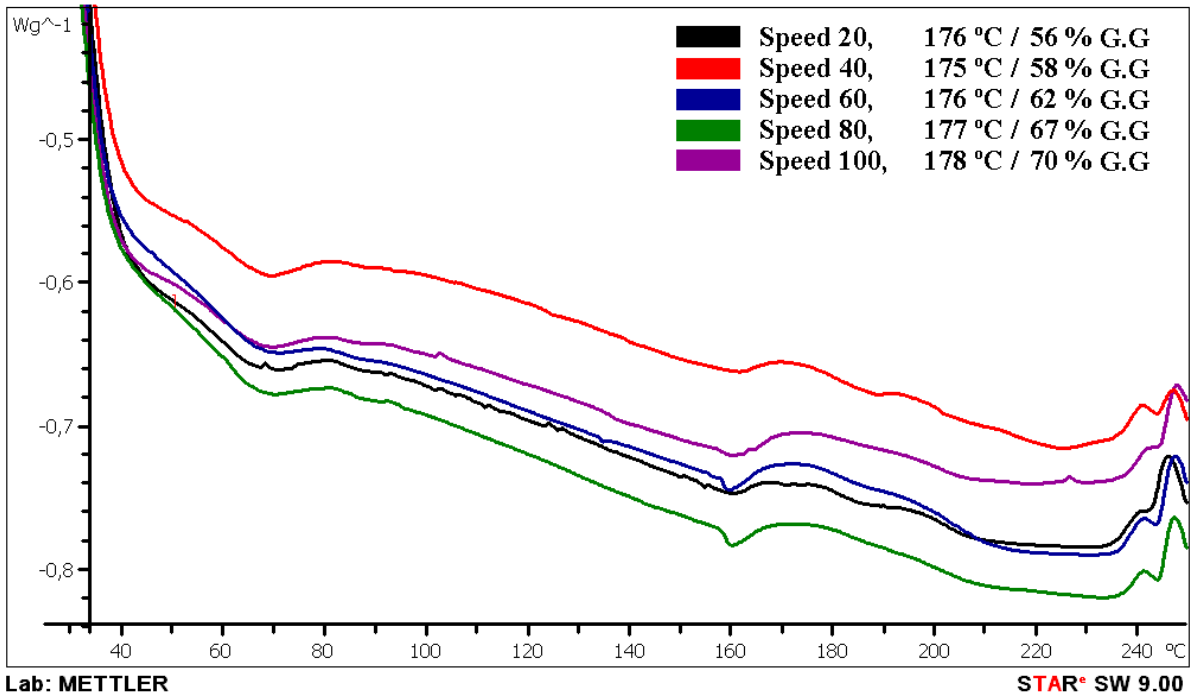


Figure 1. DSC traces of plasticised PVC at different extrusion speeds

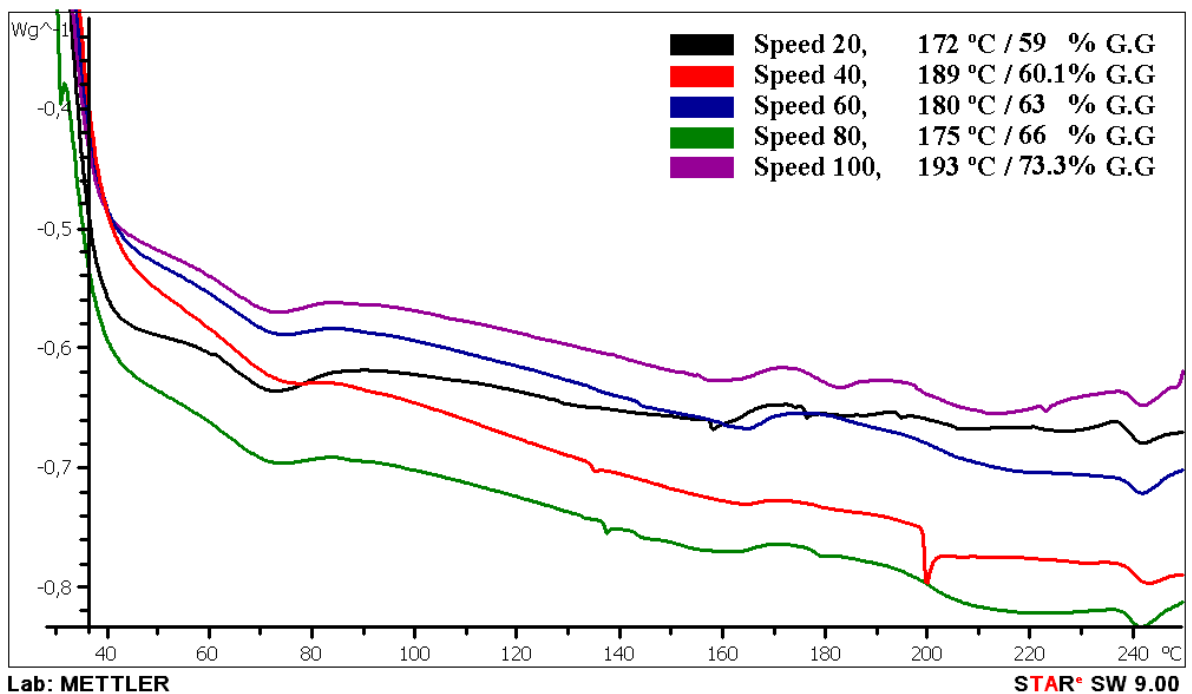


Figure 2. DSC traces of 1% ATO containing plasticised PVC at different extrusion speeds

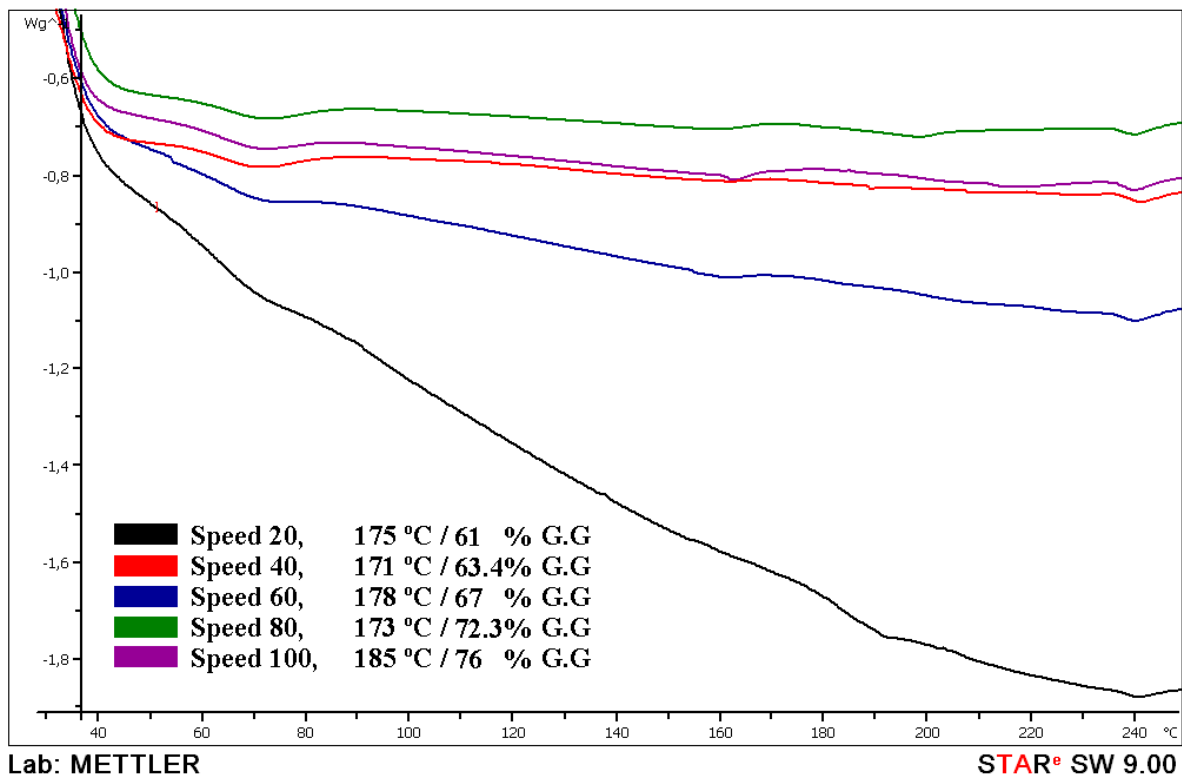


Figure 3. DSC traces of 3% ATO containing plasticised PVC at different extrusion speeds

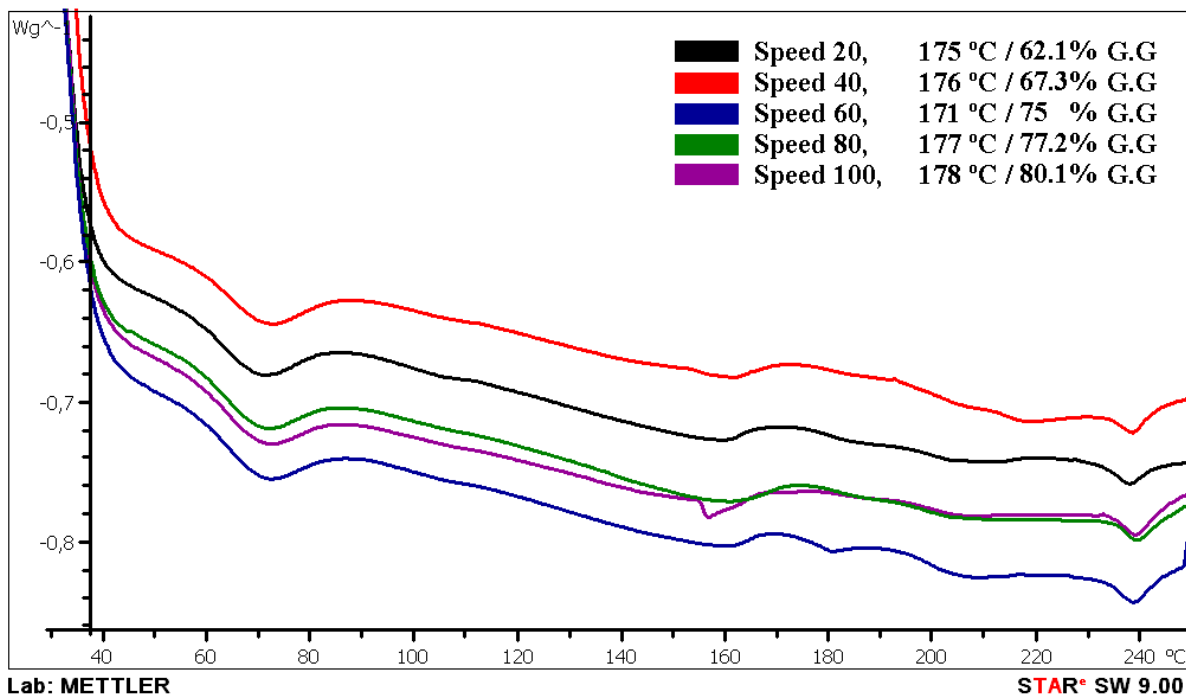


Figure 4. DSC traces of 5% ATO containing plasticised PVC at different extrusion speeds

4. Conclusion

1. The results prove that the DSC is a speed-dependent property (process dependent).
2. ATO additives improve DSC and the ratio of improvement depends on the percentage of ATO addition.
3. The best results obtained after adding ATO was at speed of 60 rpm, which are associated with maintaining the rest of the PVC properties.

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