EFFECTS OF RECYCLING ON MECHANICAL AND THERMAL PROPERTIES OF POLYSTYRENE

H.DJIDJELLI * and D. BENACHOUR**

*Laboratory of organic materials, University of Bejaia Algeria .
**Polymer Engineering Department , University of Setif, Algeria.

Abstract : A commercial Polystyrene (M_w =2.5 10^5, MFI =14.80) was extruded repeatedly from one to eight times at 190 °C .The effects of extrusion process on physical and chemical properties of polystyrene were investigated using : -Average molecular weight
-Izod Impact strength ;
-Thermal properties (TGA, DTA) .
The results showed that processing of polystyrene leads to degradation. In fact, a decrease of 23 % in the average molecular weight was observed for the 8th cycle sample and a reduction in impact strength by 34% was also noticed for the 4th cycle sample.

1. INTRODUCTION

Extrusion is the most widely used technique to process thermoplastics , with over one-half of all thermoplastic materials being processed in this manner [1].The significance of studying the effect of extrusion on the properties of thermoplastics stems from the need to recycle such materials while conserving their useful properties. Some basic studies have been reported on the effect of recycling on the properties of polystyrene using a capillary rheometer [2 - 4].
In contrast , relatively little has been published about a recycling polystyrene using an extruder machine.

2. EXPERIMENTAL

Polystyrene used was a commercial product (EDISTIR) from Montedison and characterized by a melt flow index of 14.80 g/10 min.
We extruded the polystyrene repeatedly at the same conditions . After each extrusion , the product was pellitized. Enough material was sampled for subsequent testing and the rest fed back to the extruder .

A GPC method was used to obtain molecular weights and the molecular weight distributions. The experimental conditions were as follow :
solvent is toluene ; temperature 25°C ; concentration : $15.4.10^{-4}$ g/ml.
The column set was calibrated by injecting polystyrene standards with narrow distributions.
Molecular weight (MW) were calculated by computer programm.

Polystyrene was extruded at high shear stresses (80tr/mn) at 190°C in Battenfeld Model monovis extruder.

 CCC 1022-1360/98/$ 10.00

The impact strenght was calculated on the basis of 5 samples. The dimensions are 62 x 12 x 0.8 mm^3.

Thermal stability of the recycled samples were measured in a SETARAM TGTDA92 thermal analyser . The studies were carried over the temperature range 20-500 °C in N_2 atmospher, at a heating rate of 10° C/min .

3. RESULTS AND DISCUSSION

3.1. Gel permeation chromatography

The change in the average molecular weight is illustrated in fig.1. A significant molecular weight decrease was observed after 2 cycles. This decrease was evaluated to 23% in the average molecular weight around the 8^{th} cycle.

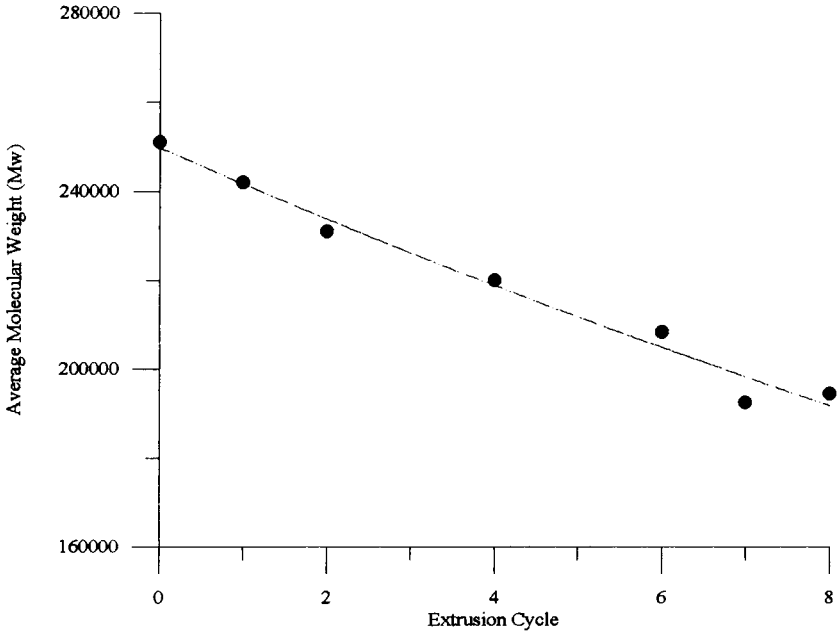

Fig.1 Change in Average Molecular Weight (Mw) with a reprocessing.

According to figure 1, we observe clearly that the extrusion implies an intense shearing of macromolecular chains which indicate a decrease of the average molecular weight . We also notice that degradation assigns essentially the macromolecules of high molecular weight. The reduction of the average molecular weight increases the fluidity of polystyrene in its melted state.

3.2. Impact strength

The results indicate a reduction in impact strength for the recycled product (reduction of 34% at 4th cycle), as shown in figure 2.

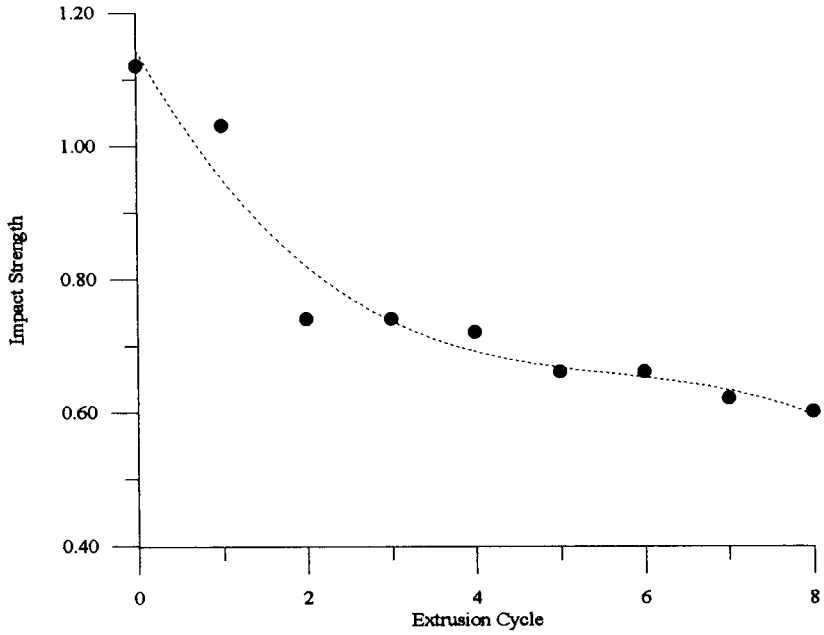

Fig.2 Izod impact strength of Polystyrene as a function of extrusion cycle.

We also notice in figure 2 that the impact strength decreases when the polystyrene is recycled further. This reduction of the impact strength is due to the degradation by the repeated extrusion cycle which induce the fragilisation of material. These results are in good relationship with those obtained in the tests of GPC and MFI.

3.3. Thermal analysis

Figures 3 and 4 show the mass loss and the rate of mass loss curves, respectively. Analyzing thermograms , we can see that the range of temperatures 25 - 300 °C doesn't indicate any sign of thermal degradation for the different samples. We also observe that the begining of decomposition (Td) is more fast in the virgin sample (fig.3), while the rate of degradation is more important in the recycled sample (fig.4).

The effect of extrusion cycle has consequently increased the degradation speed and this could be explained by the scission of macromolecular chains when the number of cycles of extrusion increases. Additionaly, we thougth that this process of depolymerization affects in first, the longer molecular chains.

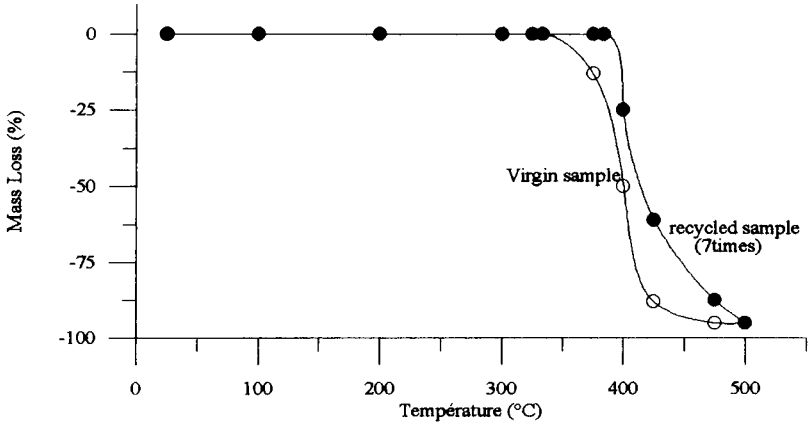

Fig.3 Mass loss of polystyrene as a function of temperature.

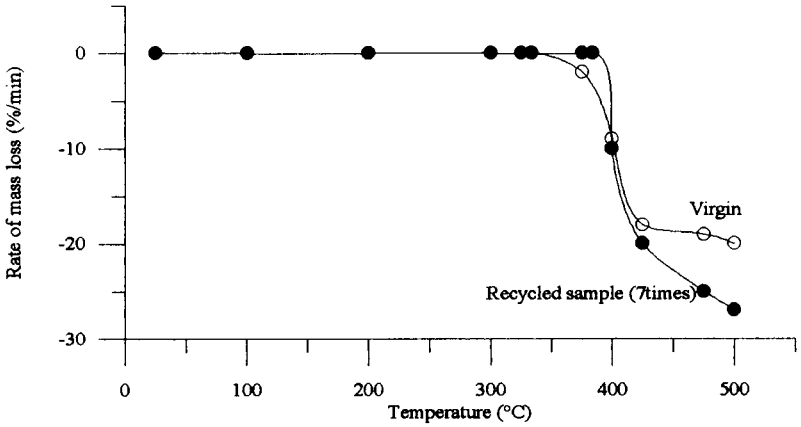

Fig.4 Rate of mass loss as a function of temperature.

4. CONCLUSIONS

These results confirm that reprocessing of polystyrene induces changes in mechanical and thermal properties as well as in the average molecular weights .

Extusion process affects essentially the high macromolecular chains of polystyrene.

References :

[1] PAUL. W. SPRINGER, ROBERT S. BRODKEY and R . EMERSON LYNN , Polym. Eng. Sci. , vol 15, n°8, 588-593 , 1975.

[2] KENT B. ABBAS and ROGERT PORTER, J. Appl. Polym. Sci., vol. 20 , 1301-1302 , 1976.

[3] ZAHVICH, A.T.P, TAKACS, Ann. Tech. Conf. Soc. Plast. Eng., vol. 50, n°1, 1992.

[4] FARES MOHAMED M. , YALCIN , Polystyrene thermal analysis spectrometry , Analyst (Cambridge,U.K) 1994.