SEBS (STYRENE - ETHYLENE - BUTADIENE - STYRENE) ANALYSIS THROUGH INJECTION REPROCESSING AND RHEOLOGICAL CHARACTERIZATION

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Abstract: Thermoplastic rubbers are materials that combine the characteristics of good processability of thermoplastics with the physical properties of vulcanized rubber. SEBS is a SBS which has been subjected to a hydrogenation process, through the polybutadiene chain is eliminated. This new rubber has a high resistance to environment, temperature, UV radiation, etc. without losing the properties of a thermoplastic, making them useful in applications where a standard SBS is not useful.
This study focuses on the rheological characterization of virgin and reprocessed SEBS through successive cycles of injection, by analyzing the variation of properties with the thermal degradation, especially one of the most important: viscosity.

1. INTRODUCTION.

SEBS is a thermoplastic material which combines successfully the properties of an elastomer (rubber) with low costs of processing thermoplastics.
The main representative of these compounds with the characteristics of thermoplastic elastomer is SEBS (Styrene - ethylene - butadiene - styrene). The excellent resistance to aging of all compounds based on SEBS is due to the absence of the double chain in the polymeric structure. Flexibility in the formulation of the polymer allows the production of wide ranges of hardness for different applications in industry.
Its main features are:
Remarkable range of hardness and elastic modulus.

- Excellent resistance to aging.
- Wide range of colors with white base.
- Very good processability at low temperatures.
- Resistant to high temperatures.

Regarding the characteristics of processing that indicates the manufacturer:

- Thermoplastic Material.
- Excellent processing characteristics using conventional methods.
- Reduced cycle times.
- Access to more sophisticated processing techniques: hot camera, co injection, co extrusion, etc.
- Simple Recycling.

The reprocessing and recycling of thermoplastic materials [3-8] is very interesting for the conservation of the environment, because it reduces the disposal of waste and makes better use of the material, especially when the price of the raw material is high, as is the case of SEBS.
Injection molding is one of the different manufacturing processes that use this type of material, which is of great importance for the quantity of products that are made daily.
CAE Simulation tools available in the market to understand and analyze the injection process, such as Molflow Plastics Inside 6.2 ®, use the values of the parameters of the Cross-WLF model to reproduce the rheological behavior of materials during injection process.
When these parameters are not included in the simulator for a given thermoplastic, you must have previously calculated one of the most important rheological properties of the material to characterize: the viscosity.

The viscosity of thermoplastics is an important property when choosing which process conditions (temperature and time of injection, mold temperature, etc..) should be used in the injection of such materials.
High viscosity makes the filling of the cavity in the mold difficult, but the low viscosity can cause burrs on parts.
The capillary rheometer, used for the calculation of viscosity, is an instrument for measuring the rheological properties of materials, both in effort and in controlled strain. Capillary rheometry is a technique based on the extrusion of a sample through a capillary nozzle and records the output pressure drop through the same nozzle at a known volumetric flow rate. The capillary rheometers are formed by a temperature controlled barrel incorporating one or more precision bores fitted to the nozzle exit. Some pressure transducers are mounted immediately above the nozzles to record the pressure drop while the material is being extruded. [1 and 2]
The main objective of this study was to determine the effects that the reprocessing of thermoplastic elastomer SEBS results in one of their most important properties when being processed by injection viscosity.
For the development of this study, we used the SEBS thermoplastic elastomer virgin Megol, exactly DP1261/s Cristallo E251 ®, which is characterized within the range of SEBS available, by low hardness and transparency.
Next step has been using reprocessed parts from sprues and standardized test pieces previously injected into a mold for tensile tests.
For the injection has been used Meteor 270/75 injection of Mateu & Solé ® and rheological analysis has been developed using capillary rheometer ThermoHaake Rheoflixer MT ®. The temperature used in the extrusion of material into the rheometer was 165°C (temperature is also used for the injection of parts and recommended by the manufacturer), with nozzles 10, 20 and 30 mm. The tests were conducted according to ISO 11,443.
It is of undoubted interest to study the variation of viscosity when the material is reprocessed.

2. EXPERIMENTAL

For the development of this study, we used the SEBS thermoplastic elastomer virgin Megol, exactly DP1261/s Cristallo E251 ®, from the Italian manufacturer Plastiche Applicazioni Industriali, whose characteristics, within the range of SEBS available, make it unique thanks to its low hardness and transparency.
Next step has been using Megol DP1261/s Cristallo E251 reprocessing parts from sprues and standardized test pieces previously injected into a mold for tensile tests, using blades from the ground due to the impossibility of carrying it out through a traditional mill.
The injection was carried out by injection into a Meteor 270/75 Mateu & Solé ® machine. There were five injection cycles and ground, as indicated below, sufficient to determine the behavior of the material after reprocessing. The rheological analysis was developed using the capillary rheometer ThermoHaake Rheoflixer MT ®. The temperature used in the extrusion of material into the rheometer was 165 ° C (temperature is also used for the injection of parts and recommended by the manufacturer.) The shear rates were studied in the range of 100 to 10000 s-1. The rheometer is equipped with three different nozzles, each with 1 mm in diameter, but with L / D of 10, 20 and 30. The tests were conducted according to ISO 11,443.

3. RESULTS AND DISCUSSION

The reprocessing of the material has been carried out for five consecutive injection processes, in a prepared pan shaped pieces for tensile test pieces. The experiment began with the virgin material and after each injection parts and sprues were crushed to return to reprocessing.After each injection, removed enough material to make the study of rheology for the capillary rheometer. As the ISO 11443 standard five trials were conducted for each material, passing through the three nozzles and temperature of 165 ° C, holding a total of 75 trials.

In the following charts, Figure 1 shows the pressures obtained in the three nozzles rheometer and the five materials.

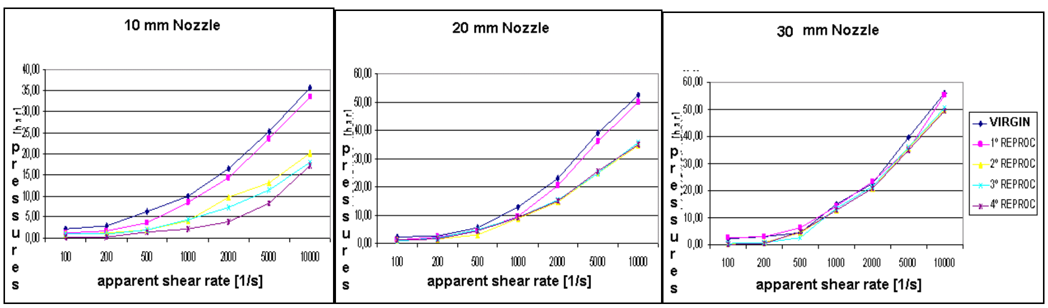

Figure 1. Pressures obtained in the capillary rheometer for the three nozzles and the five materials.

Having obtained the apparent pressure curves with the three nozzles it is transformed into shear stress and shear rate respectively using Bagley correction and Rabinowitsch. The viscosity of the material was calculated with the ratio of the two values.

The viscosity of the material was calculated with the ratio of the Bagley and Rabinowitsch correction, equation (1)

$$\mu_{corr} = \frac{\tau_{corr}}{\gamma_{corr}} \quad (1)$$

τ_{corr} [Pa] virgin	1129,98	1177,14	2675,67	2569,46	18824,38	20050,00	28281,25
γ_{corr} [1/s] virgin	28,83	301,83	496,26	954,68	1946,79	6089,69	-2571,81
μ_{corr} [Pa/s] virgin	39,20	3,90	5,39	2,69	9,67	3,29	-11,00
τ_{corr} [Pa] 1º reproc.	1783,75	1671,88	3009,38	7247,50	11262,50	12593,75	24300,00
γ_{corr} [1/s] 1º reproc.	701,30	266,75	545,56	1060,41	2173,98	6533,12	43325,75
μ_{corr} [Pa/s] 1º reproc.	2,54	6,27	5,52	6,83	5,18	1,93	0,56
τ_{corr} [Pa] 2º reproc.	690,18	416,88	2785,63	10262,80	13925,63	28412,50	37106,25
γ_{corr} [1/s] 2º reproc.	1287,99	207,24	459,98	914,28	1907,36	7805,62	4327,79
μ_{corr} [Pa/s] 2º reproc.	0,54	2,01	6,06	11,23	7,30	3,64	8,57
τ_{corr} [Pa] 3º reproc.	111,25	668,13	1225,00	4241,08	8183,69	16878,57	40756,25
γ_{corr} [1/s] 3º reproc.	86,12	179,40	479,13	1002,46	2040,53	4927,84	9375,98
μ_{corr} [Pa/s] 3º reproc.	1,29	3,72	2,56	4,23	4,01	3,43	4,35

τ_{corr} [Pa] 4º reproc.	623,04	468,13	3342,50	10698,75	16715,63	29075,00	40000,00
γ_{corr} [1/s] 4º reproc.	142,30	197,95	459,61	920,77	1932,65	7979,43	3915,45
μ_{corr} [Pa/s] 4º reproc.	4,38	2,36	7,27	11,62	8,65	3,64	10,22

Table 1. Viscosity of the five materials tested (corrected values). Nozzle L / D = 10

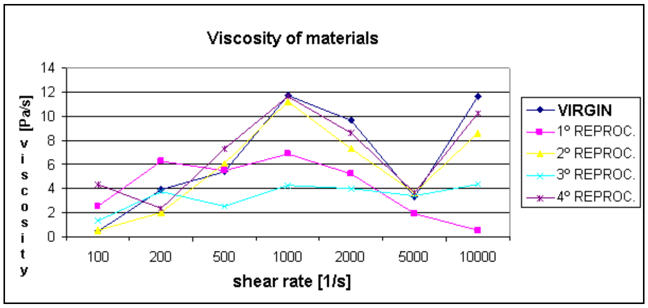

Figure 2 Viscosity of the five materials.

4. CONCLUSIONS.

In conclusion, as experimental graphs obtained show, there is a regular and linear increase in viscosity with increasing the number of reprocessing. The behaviors are similar to virgin material SEBS Megol DP1261/s Cristallo E251 ® and successive reprocessed. The first reprocessing shows a downward peak linear behavior differs from the rest of reprocessed.

These results also indicate that there is no thermal degradation over successive reprocessed, which gives it an interesting feature from the point of view of material recovery.

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