Study of Nucleating Agent And Their Effects On Polypropylene

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Introduction

Polypropylene is a thermoplastic semi crystalline material that belongs to the Polyolefin group. The unique structure feature of PP and the structure-property relationship of the same makes PP a material of choice in the areas from consumer goods appliances to highly engineered automotive parts. The structure –property relationship and crystallization behavior of PP has been a subject of discussion since years. It is established that on cooling of PP melt crystallization sets in around some defect sites present in the molten matrix. These defect sites create an active site for crystal growth and termed as nucleation sites {1-3}. In general self crystallization of PP from the melt is a slow process..

Polypropylene based materials are widely used in automotive applications due to their excellent balance of properties and low cost. Further improvements in properties can be achieved through the use of Nucleating agents. These additives function by promoting the crystallization of Polypropylene during molding, providing a wide range of benefits including improved molding productivity, increased modulus without sacrificing impact strength and enhanced thermal properties. [4]

Experimental

Materials

A Polypropylene Material having Melt Flow Index 25gm/10 min, (Polyolefin Company Pvt. Ltd) compounded with different types of Nucleating agents and the experimental study was carried out with various loadings of nucleating agents. The physical characteristics of additives with Description can be found in the Table-1

Blending, Specimen preparation and conditioning: Thermoplastic polyolefin compounds were compounded in counter rotating ZE25 Twin screw extruder. Finally compounds were palletized and injection molded into test specimens. Injection molded sample were conditioned for 48 hours in humidity chamber before testing. 23 deg C ambient temperature and 65% relative humidity were maintained.

The mechanical properties of samples were measured with an Instron model 3366 according to ASTMD 638 & D790. The notched Izod impact strength was measured using a Ceast tester at 25 ° C according to ASTM D 256 [5].obtained from 3.2 mm thickness injection molded samples.

Results and Discussion

In Fig. 1 is shown the variation of notched impact strength with different nucleation loading for the different systems. In case of TiO2 there is one gradual increase which is more important at higher levels because all the other three are showing a flattening off criteria at higher loadings. The reasoning for the same can be attributed to the mechanism of nucleation by the different systems as well as is attributed to their own behavior on the polymer matrix, its crystallizability and stress transfer characteristics.

Fig 2 is showing the variation of Young's Modulus on bending of the different systems. An increase in Young's modulus indicates the materials response towards deformation is stronger with higher degree of elasticity and hence better load bearing capacity.

In Fig 5 is shown the variation of tensile strength at maximum load with time. This is a semi logarithmic plot while the time axis is logarithmic. The straight lines clearly indicate that tensile strength change is proportional to time and nucleating agents increase the rate of increase in tensile strength and Young's Modulus. All the trend lines follow a general equation of the form:

$$S_t = A* Ln (t) + (S_i)\ldots\ldots \quad (1)$$

Here S_t is the tensile strength at time t and S_i is the initial tensile strength or tensile strength at 2.0 min. The equation however gives us good idea for the rate of change of properties. Rearranging Equation 1 yields

$$(S_2-S_1)/Ln (t) = A \qquad \ldots\ldots \quad (2)$$

Thus relative change in tensile strength with respect to time is expressed by the constant A. The constant A in turn appears to be a practical measure of the rate of change of physical properties with time and the same is tabulated in Table 2 for different nucleation systems.

Although all the graphs perfectly fit with these types of equation with constant A determined as plotted in Table 2, has one practical drawback since at time 0, the equation fails to determine any value. This on the other hand is explicable in that at time 0, i.e. at the moment when the melt is just started cooling polymer crystallization has not set in and the whole system is in a so called transient state.

The graphs presented in fig 5 follow a trend that can be expressed by a simple formula as:

$$(S_2-S_1)/ (T_2-T_1) = E*(T_2-T_1) {}^\wedge F \quad \ldots\ldots \quad (3)$$

Here the constants E and F are related to nucleating agent and the activity of the nucleating agent. A careful examination of the results clearly indicates that with increase in Nucleating agent A, E and F decreases

initially and gets constant at higher levels of nucleating agent. On the other hand the factor S_1 increases.

Conclusions

Nucleation is a powerful way to improve physical and mechanical properties of Polypropylene. In this exercise we observed the effect of Nucleation in case of Homopolymer with IRGASTAB NA-02 along with other nucleating agents. At certain level of dosing the effect observed with Irgastab NA11 and Irgastab NA02 is similar but at higher levels the effect of Irgastab NA02 is more significant as compared to other.[4]

A Further outcome of this project is that we can use these criteria for reducing cycle time. A correlation of these data with cooling and hold time in Injection Molding is in Progress.

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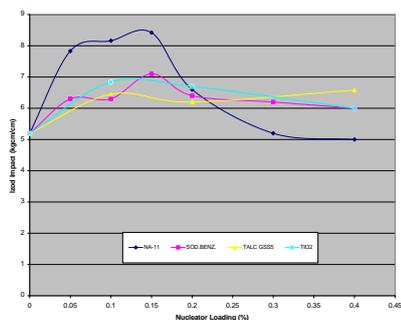
Fig:1 Izod impact variation

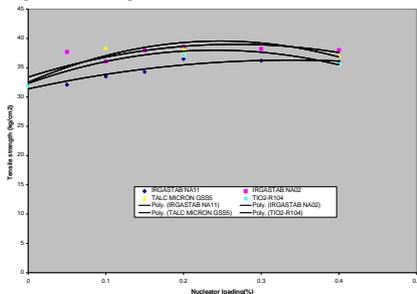Fig: 2 Young's Modulus Variation with Time

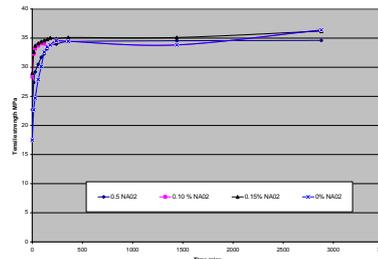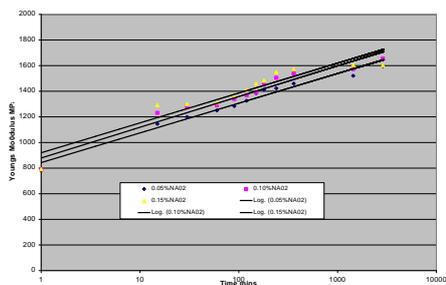Fig: 3 Tensile strength with different Nucleators

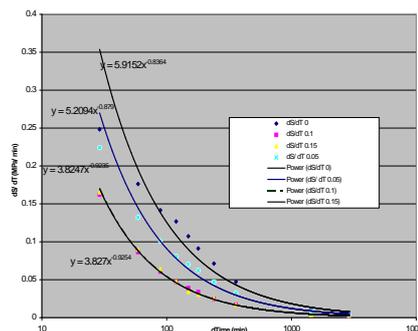Fig: 4 Tensile strength vs Time Factor with NA02

Fig: 5 Relative Change of Tensile Strength with Time vsTime

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TABLE-1

ADDITIVES	PARTICLE SIZE(µM)	SPECIFIC GRAVITY	RESOURCES
IRGASTAB ® NA11 UH	4.5	0.2	SD Fine-chem Ltd
IRGASTAB ® NA 02	<3	1.44	SD Fine-chem.Ltd
TALC-MICRON GSS5	1.8	2.7	Golcha groups
TIO2-R104	-	4.2	Du-Pont

TABLE-2

NA02 %	0	0.05	0.1	0.15
A	2.59	1.635	0.823	0.82
S1	17.9	23.8	30.1	29.7
E	5.9	5.2	3.9	3.8
F	-0.83	-0.879	-0.923	-0.985

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