Nitroxide-Mediated Controlled Degradation of Polypropylene

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Introduction

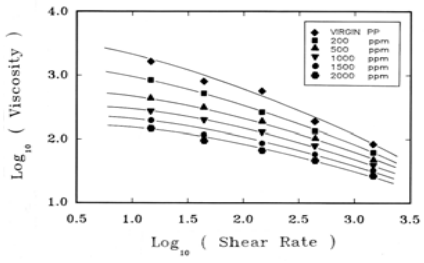
- Controlled-Rheology Polypropylenes (CRPP) have been produced industrially for years using reactive extrusion processes which employ peroxides as free radical initiators
- Nitroxides (NORs) are well-known as powerful stabilizers to protect plastics from the negative influence of light and heat, and NORs are potentially easier in handling during processing
- A PP-based NOR with the trade name Irgatec CR76 has been recently developed by CIBA Chemicals and might be potential substitute for peroxides
- Preliminary experimental results exhibit a qualitative difference between Irgatec CR 76 and commonly used peroxides[1]

MFR-modified CRPP

1. Typical industrial applications of MFR-modified CRPP[2]

MFI (230 °C / 5 kg)	End Use
2	Compression molding, pipes
1-5	Extrusion blow moldings
5-15	Biaxially oriented moldings
5-15	Film tapes
5-15	Monofilaments
5-20	General injection moldings
30	High-speed injection moldings
30-40	Flat films
40-80	Staple fibres
60	Spun-bonded fabrics

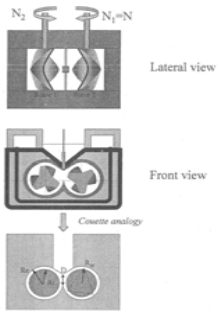
2. Modification of viscosity vs. shear rate @ various ppm of Peroxide[2]



Objectives/Experimental Steps

- To compare the effectiveness of NOR and Peroxides on the degradation of CRPP under different experimental conditions than the preliminary ones
- The degradation of CRPP takes place in a batch reactor (Haake Mixer), so the chart of Torque vs. Temperature can be obtained
- The degradation in the Haake Mixer happens at the same conditions (Temperature, rpm and % of NOR or Peroxide) with the preliminary one
- Subsequently, the Melt Flow Rate (MFR) of each product can be measured

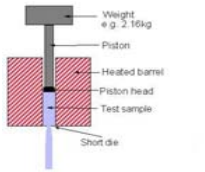
Haake Mixer



Experimental Characteristics

- Mixer: Batch Mixer Haake Rheocord 90
- Rotor speed: 100 rpm
- Temperatures of the Mixer, that were used, before the entrance of the reactants: 230 ^{0}C, 250 ^{0}C, 270 ^{0}C, 290 ^{0}C
- Reactants fed in the beginning of every experiment
- Total experimental duration: 5 minutes
- Polymer: PP, Profax PDC-1280, provided by Basell Polyolefins, with MFR equal to 1.2
- NOR: Irgatec CR76, a PP-based compound of NOR, in pellets form, provided by Ciba Chemicals
- Peroxide: Luperox 101, 2,5-Bis(tert-butylperoxy)-2,5-dimethylhexane, 90%, in liquid form, provided by Aldrich
- Concentrations of Irgatec CR76 used: 0.75%, 1.5% and 3% (w/w%). They correspond to 250, 500 and 1000 ppm of NOR respectively
- Concentration of Luperox 101 used: 250 ppm, dissolved in ethanol

Melt Flow Rate

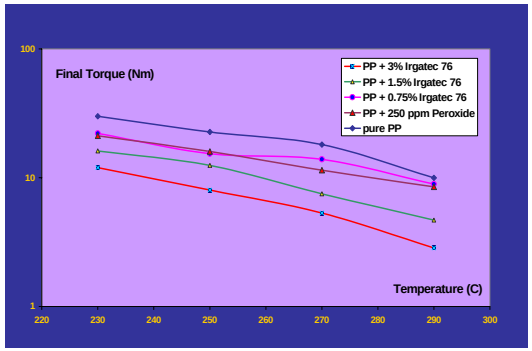


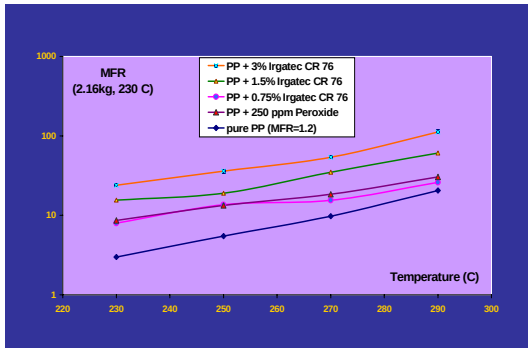
Melt Flow Rate (MFR) of each product is being measured, according to the ASTM standards[3]

Temperature: 230 ^{0}C
Weight: 2.16 kg
Die: diameter = 2.0955 mm, Length= 8 mm
Duration of flow: 10 minutes

Results

Haake Mixer and Capillary Rheometer results/analysis





Concluding Remarks

- At low concentrations, peroxide initiator and NOR perform similarly in terms of resulting MFR
- At a given NOR concentration, the MFR increases with reaction temperature
- Immediate future steps: Rheological characterization and Molecular Weight Distribution of the products

References

[1] Rudolf Pfaendner, *Hindered amines beyond stabilization: radical generators for efficient polymer modification*, presentation, Polymer Processing Society 2003, Athens, 2003

[2] C. Tzoganakis, J. Vlachopoulos, A. E. Hamielec, *Controlled degradation of Polypropylene*, Chemical Engineering Progress, v. 84, n. 11, November 1988, p. 47-49

[3] ASTM, Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer, D 1238 04c