

Rheo-optical approach of dispersion mechanism of agglomerated fillers in a polymer matrix under shear

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The mixing of carbon black or silica pellets and a matrix is achieved through two mechanisms: dispersion and distribution. To disperse implies to reduce the pellet size (around the millimeter) down to the aggregate size (a few tens of nanometers). This size is necessary to ensure the reinforcement of the matrix. Both dispersion and distribution processes are essential since they will define the end-use properties of the final product. Although the mixing of a filler and a matrix is a common operation, the elementary mechanisms responsible for the size reduction of the filler are not fully understood.

The objective of the present work was to study and better understand the mechanisms of dispersion of carbon black in a polymer matrix. A specially designed transparent counter-rotating rheometer was used in order to observe in-situ during shear the dispersion behaviour of carbon black pellets.

The behaviour of the carbon black N234 in a styrene butadiene copolymer was more specifically investigated. Two dispersion mechanisms were observed and characterized: rupture and erosion. The two mechanisms happen during a mixing operation in a batch mixer. The advantage of the rheo-optical approach is that by defining specific shear protocols, it was possible to study separately the two mechanisms.

Rupture was found to occur above a critical shear rate. Critical conditions for rupture were determined in two SBR matrices and for different carbon black pellet sizes. The condition for rupture was found to be based on a critical shear stress and to depend on the pellet size.

Erosion kinetics was determined. The effect of different parameters (pellet size, shear rate, stress and duration) on the erosion rate was investigated: The erosion process was shown to proceed via the detachment of a constant eroded volume per strain unit and to be driven by the energy supplied to the system.

The determination of dispersion criteria and laws for rupture and erosion brings new insights in the mixing operation.

Acknowledgements:

This work was part of a project supported by the European Community in the framework of the "Competitive and Sustainable Growth" program. The authors wish to thank all the partners including ThyssenKrupp Elastomertechnik, MFP Michelin, Snecma Propulsion Solide, Optigrade-TechPro, Polyflow, Cesame (U.C. Louvain) and T.U. Lodz for their collaboration in this project.