THERMOPLASTIC MASTERBATCHES

GraphiSTRENGTH Advanced Materials

IDEALLY DISPERSED MULTI-WALL CARBON NANOTUBES FOR ELECTROSTATIC DISCHARGE PROTECTION

DILUTION GUIDE

Introduction:

Added in thermoplastics, Graphistrength® multi-wall carbon nanotubes (MWNT) bring numerous benefits to applications that require precisely controlling the electrical conductivity while optimally retaining the mechanical and physical properties of the matrix.
However, desired properties are achieved only if the proper degree of MWNT dispersion is ensured. In order to help its customers and ensure consistent performances, Arkema performs the initial dispersion of MWNT in various thermoplastic matrices. Naturally, it's also important that the Graphistrength® Masterbatches dilution to the final concentration be done in optimal conditions. This paper gives some information about this key dilution step.

Masterbatch description:

All of Graphistrength® Masterbatches contain perfectly dispersed MWNT at a typical concentration of 20% by weight. Graphistrength® Masterbatches are manufactured under specific mixing and dispersion conditions that don't alter the original features of MWNT.

Masterbatch dilution by extrusion / compounding:

The dilution of Graphistrength® Masterbatches into high quality compounds can be achieved with standard equipments used in thermoplastics compounding assuming that their mixing energy is sufficient. Twin-screw extruders or kneaders have been successfully used in Arkema's facilities. Generally, typical final MWNT loadings in compounds are in the range 1 to 5 wt% depending on the matrix and the targeted performances.

Key parameters for masterbatch dilution:

- *Viscosity*

Figure 1 on the next page shows the viscosity of Graphistrength® Masterbatch, the neat matrix and two diluted compounds at different shear rates. Graphistrength® Masterbatch and compounds viscosity is orders of magnitude higher than the neat polymer and exhibits a strong shear thinning effect.
This behavior is typical with MWNT and clearly conditions the selection of the equipment i.e. twin-screw-extruders.

- *Selection of the matrix for dilution*

All the data we got in our compounding facilities show that it's better to use a low viscosity resin for diluting the Graphistrength® Masterbatches. With low viscosity resins, it's easier to get compounds where the dispersion of MWNT is optimal. As a consequence, the electrostatic discharge (ESD) protection can be obtained at lower loadings of MWNT.

- *Temperature*

The temperature in the extruder must be as high it is possible for the thermoplastic under consideration. It's a good way to lower viscosity and improve dilution and dispersion of MWNT. Here also, this parameter has direct consequence on the ESD properties of the compounds.

- *Other parameters*
    - Screw profile: The data we got in our compounding facilities show that screw profiles with very high shearing effect must be prohibited. The screw profiles typically used for polymer alloys can be successfully applied.
    - Processing of dried polymers is preferable. Graphistrength® Masterbatches are dried and sent in hermetic packaging. If you keep it open during a long time, it is better to dry Graphistrength® Masterbatches again (see the typical drying conditions in the *Technical Data Sheets*).

Compounds processing:

The dilution of Graphistrength® Masterbatches provides high quality compounds, which can then be processed on most equipments (extrusion, blow molding, injection molding).
Here also the process conditions have to be optimized and a high temperature is particularly requested to ensure optimal ESD properties.

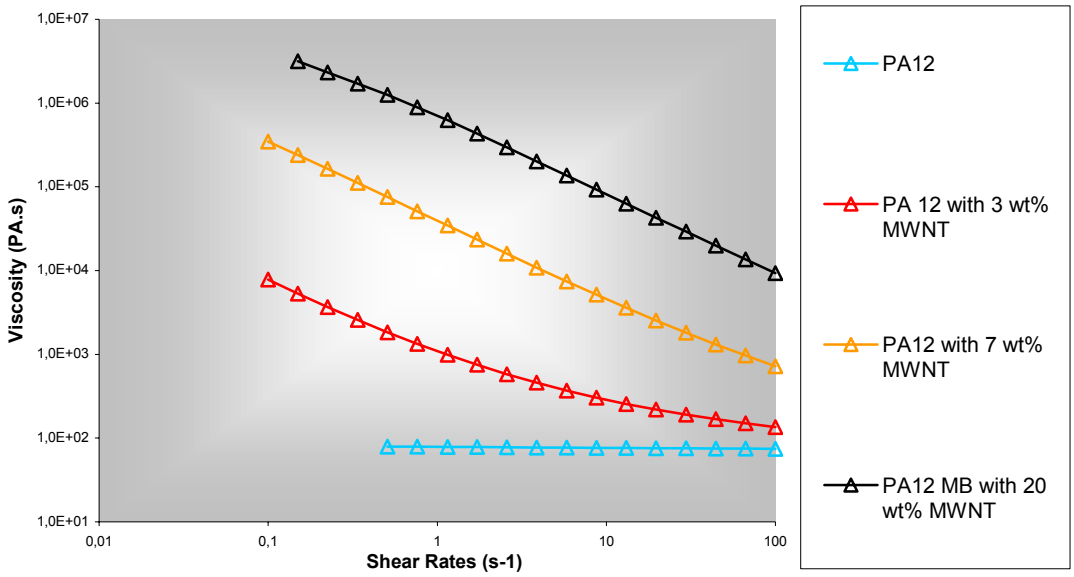

Figure 1: Viscosity of Graphistrength® C M1-20, PA12 and diluted compounds as a function of shear rates. These curves are intended solely for indicating the viscosity evolution with MWNT content but they don't replace the reader's own evaluations and experimentation

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