Nano-Composites Manufactured by the Use of Compressed Carbon Dioxide

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Rapid prototyping is already a well established manufacturing process for single parts and design studies. Laser sintering allows the production of parts with basically any shape needed for application. Compared to injection moulding processes sintering techniques are more flexible and avoid high costs which typically arise for the injection mould. Because of this advantages laser sintering is increasingly used as rapid manufacturing process for special parts or even small series. Therefore, the properties of the used polymers have to be improved. For powder coating systems polymers with improved properties are needed as well. Depending on the application, corrosion- and UV-durability, scratch resistance, flexibility and diffusion tightness etc. are needed.

In this contribution results of a research project for the production of powderous polymer composites are presented. For the micronisation of the polymers a high pressure technique is used. In the so called PGSS (Particles from Gas Saturated Solutions) process a polymer melt is mixed under high pressure with a carbon dioxide stream. During the homogenisation of the two streams carbon dioxide is partly dissolved in the melt. This gas enriched melt is finally depressurized into a spray tower. Caused by the volume increase of the expanding gas, fine droplets are formed. In addition the gas cools down and the droplets freeze. If the process parameters are adjusted well, spherical particles are formed.

To improve the properties of polymers nano-particles are admixed to the polymer melt. Especially for the laser sintering process additional benefits are expected. The nano-particles could contribute to a higher absorption of the laser light and could improve the form stability of the parts during the sintering process. In addition polymers, filled with nano-particles, are expected to have a better impact and scratch resistance. These improved properties would also be beneficial for coating applications.

The main challenge is the formation of a homogeneous dispersion of polymer melt and nano-particles. Due to the high agglomeration affinity of the nano-particles, the dispersing in polymers is characterized by high time- and energy-efforts. Especially for the dispersing step, the auxiliary carbon dioxide offers additional possibilities. During the processing with the PGSS-technique, the gas is dissolved in the polymer. This leads to the reduction of the melt viscosity and the surface tension. Both effects support the dispersing and mixing step.

The principal flow scheme of the process is illustrated in figure 1. The polymer is molten with an extruder and fed to the high pressure PGSS process. The nano-particles are injected in a stream of compressed carbon dioxide and admixed in the metering-zone of the extruder, where particles and CO_2 are dispersed in the polymer melt before reaching the spraying process.

This process combines the mixing-step of polymer and nano-particles in one single plant with the PGSS process, which is used for the micronization of the polymer composites. With this technique, composites of different polymers, like PBT or POM, and zinc oxide or modified bentonites were formed. In figure 2, a TEM picture of such a composite is shown. The black dots indicate the nano-particles which are homogenously dispersed in the polymer matrix.

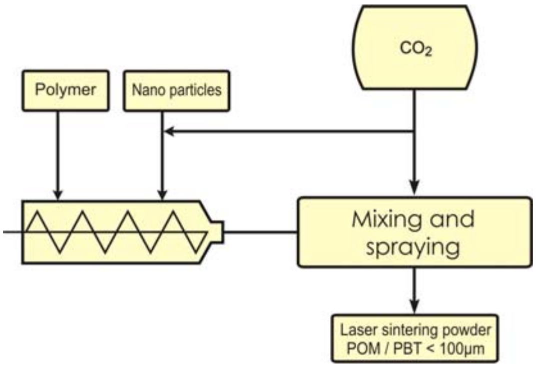

Figure 1: Flow scheme of the high pressure process

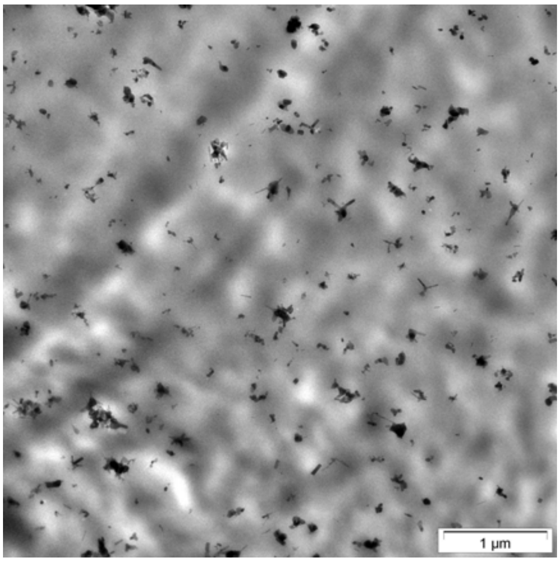

Figure 2: PBT particle with dispersed nano-particles