Investigation of the structure of multiwall carbon nanotubes in polymer matrix

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Abstract. In the last ten years carbon nanotube composites are in the focus of the researchers. Concentration series were prepared using carbon nanotube containing master blend by IDMX mixer. In the experiments polypropylene, polycarbonate and ABS polymers were used as matrix materials. The prepared materials were characterised by scanning electron microscopy. The carbon nanotubes can be seen on the fractured surfaces. We did not find any sign of agglomerates in the materials. The nanocomposites were investigated by LP-FTIR method. The specimens were irradiated with 1 W for 1 minute by CO\textsubscript{2} laser. The polymer matrix was burnt or charred by the CO\textsubscript{2} laser; the structure of the carbon nanotubes in the matrix was studied. The carbon nanotubes create a physical network in the polymers we used.

1. Introduction
Polymers are widely used for different purposes. Sometimes we need materials which have interesting properties. In these cases different types of polymers are mixed or composites are made. So mixing is a very important procedure in plastics industry. Mixing of polymers is carried out in melt to achieve homogeneous properties. In our department a dynamic mixing unit is used to make composites. This is the IDMX mixer (Infinitely Variable Dynamic Shear Mixer), it is shown in figure 1. The IDMX mixer has got rotors and stators to achieve effective mixing of different materials [1].

Nowadays nanoparticles are in the focus of researchers. Carbon nanotube is one type of fullerenes. There are two types of carbon nanotubes: single wall and multiwall carbon nanotubes (figure 2). Carbon nanotubes have got very interesting properties because of their geometry. Their width is only some nanometres but their length can be a millimetre as well. The usage of carbon nanotube-polymer composites is very important because of the increase of the conductivity of the polymer [2,3]. Carbon nanotube decreases the resistance of the polymer, so electrostatic discharge can be avoided. It was also found that the mechanical properties (modulus, strength) can be enhanced by adding carbon nanotube to virgin polymer [4, 5]. In addition, other properties like thermal stability, fire behaviour and others can be influenced favourably by using carbon nanotube [6-8].
2. Experimental
Multiwall carbon nanotubes (MWCNT) and different types of polymers were mixed by IDMX mixer. 0.5%, 1%, 2%, 4% and 8% carbon nanotube content was used in polypropylene matrix. Reused polycarbonate (PC) and ABS were mixed with 0.5%, 1% and 1.5% multiwall carbon nanotubes. The polycarbonate was ANJALON J100V (J&A Plastics GmbH), the polypropylene was homopolymer TIPPLEN H649FH (TVK), the ABS was POLYMAN HH3 (Polyman Plastics Inc.).
Master blends of multiwall carbon nanotubes were used in the experiments: MB-6015-00 (Hyperion Catalyst, USA) contained 15% multiwall carbon nanotubes and 85% polycarbonate. The MB-3020-01 (Hyperion Catalyst, USA) contained 15% multiwall carbon nanotubes and 85% polypropylene.
Test pieces were injection moulded by ARBURG Allrounder 270 U 350-70. The specimens were broken in liquid nitrogen. SEM images of the fractured surface were taken. The structures of some nanocomposites were also investigated by LP-FTIR method [9]. The specimens were irradiated with 1 W for 1 minute by CO₂ laser. The charred surfaces were investigated by SEM method. The nanocomposites were investigated by Mass Loss Calorimeter. The test pieces were heated on 600°C for 1 hour. Images of the charred rest were made by SEM method.

3. Results and discussion
The structure of the nanocomposites was investigated by electron microscope method. The specimens were broken in liquid nitrogen. SEM images of the fractured surface were taken. The fractured surface of polypropylene – 05% multiwall carbon nanotube composite is shown in figure 3.
The fractured surface of 1% multiwall carbon nanotube, 9% polycarbonate and 90% ABS composite is shown in figure 4.

The carbon nanotubes appear in the phase surface. Some interaction appears between the two immiscible polymers because the carbon nanotube.

The structures of some nanocomposites were investigated by LP-FTIR method, too. The specimens were irradiated with 1 W for 1 minute by CO₂ laser. The results were the following. PP + 0,5% MWCNT nanocomposite burnt. PP + 8% MWCNT nanocomposite charred. 20% ABS + 79% PC + 1% MWCNT nanocomposite charred and melted. 30% ABS + 69% PC + 1% MWCNT nanocomposite poorly charred and melted. 70%ABS + 29% PC + 1% MWCNT nanocomposite poorly charred and melted. 80% ABS + 19% PC + 1% MWCNT nanocomposite poorly charred and melted.

The charred surfaces were investigated by SEM method. Two of the images are shown in figure 5 and figure 6.
In figure 5 and figure 6 the structure of the nanotubes can be seen. There is a continuous physical network created by multiwall carbon nanotubes.

The nanocomposites were heated on 600°C for 1 hour by Mass Loss Calorimeter. Images of the charred residue were made by SEM method. Some of the images are shown in figure 7 – figure 10.
Figure 7. SEM images of PP + 0.5% MWCNT after heating.

Figure 8. SEM images of 20% ABS + 79% PC + 1% MWCNT after heating.

Figure 9. SEM images of 80% ABS + 19% PC + 1% MWCNT after heating.
The physical network of the multiwall carbon nanotubes can be observed. The polymer matrix was burnt by heating, the carbon nanotubes compose network. It can be established that the network appears by 0.5% multiwall carbon nanotube content as well.

4. Summary
Nanocomposites were made by IDMX mixer using different types of polymers and multiwall carbon nanotubes. Polypropylene homopolymer, polycarbonate and ABS were used as matrix materials. The fractured surfaces of the nanocomposites were investigated by SEM method. The multiwall carbon nanotubes can be studied by the images. The distribution of the nanotubes is uniform; no agglomerates were found.

The structure of the multiwall carbon nanotubes in the matrix materials was studied by LP-FTIR and heating methods. The matrix was burnt on the surface of the nanocomposites. The charred residue was investigated by SEM images. The multiwall carbon nanotubes were seen in the photos, they create physical network in the matrix.

5. References
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