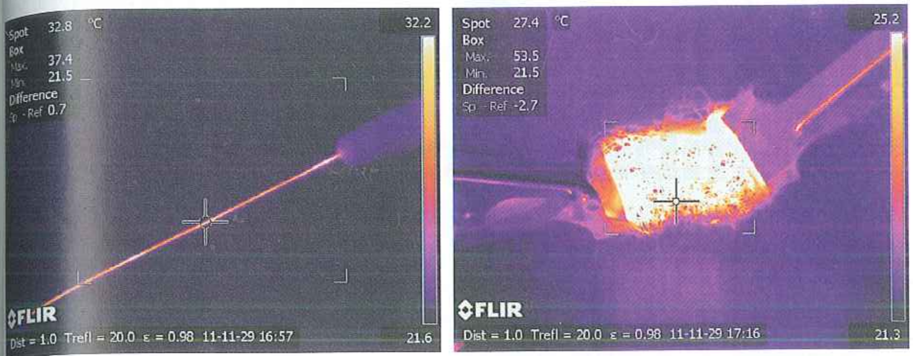
Fig. 4
Infrared camera image of single fiber (left) and nonwoven fiber mat (right)



lines. Up to 3.5 wt% of CNT, spinning parameters can be varied in the same range compared to the neat material. For higher concentrations, only lower melt draw ratios are possible because of the viscosity increase caused by CNT [6].

Electrical conductivity

After the extrusion of the fibers, electrical conductivity is checked to find the percolation threshold, defined by the CNT concentration, where the specific resistivity decreases over several orders of magnitude. Depending on the polymer type, percolation threshold can be found between 3 wt% (polypropylene) and 7 wt% CNT (polyethylene). The results for specific resistivity are illustrated in Fig. 2. At a concentration of 6 wt% the specific resistance is low enough to consider the fibers as electrically conductive.

The orientation of CNT plays an important role for the final conductivity, where both plastic deformation of the melt because of the drawing as well as shear forces in the spin plate orient the particles in fiber direction. The influence of the shear rate can be seen when different die diameters are used for extrusion. The results are displayed in Fig. 3.

Demonstration of heating

The heating of an as-spun fiber as well as a nonwoven fiber mat can be directly detected with an infrared camera. The results are displayed in Fig. 4. The single fiber can be heated with a difference of about 15 °C to the ambient temperature. This is already enough for applications close to the human body. The temperature of the fiber mat increases even more, since the surface resistance of the whole mat is much lower.

Conclusion

It was demonstrated that electrically conductive fibers can be directly melt spun. Therefore, electrical conductivity can be controlled by adding different CNT concentrations. The fibers are usable for heating elements, where the temperature (up to a difference of 15 °C for single fibers) can be controlled by the voltage applied to single fibers or textile fabrics. Possible applications of these heating fibers are seat heaters in vehicles. Conductive fibers with textile properties can be placed closer to the passenger and help reduce the power consumption of seat heaters. ■

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