Investigation into the migration potential of carbon black nanoparticles from food packaging plastics into food

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Introduction

Carbon Black (CB) finds application in plastic materials used for food packaging. Primary particles of CB aggregates are in the nanoscale range. Therefore, CB falls under the European definition of a nanomaterial and needs to be subjected to risk assessments. One way to assess the risk would be to determine whether exposure to this substance via migration of particles is possible. However, industrial produced CB lacks of elements that allow sensitive detection and common analytical techniques are not capable to respect the particulate nature of CB. In this study asymmetric flow filed-flow fractionation (AF4) and Multi-angle laser light scattering (MALLS) was introduced as an analytical tool that was suitable to separate, characterize and quantify CB particles in food simulants from migration tests.

Materials and Methods

Two different types of CB were provided as dry powder and also as CB-polymer nanocomposite plaques (2,5 % and 5,0 % loadings into polystyrene (PS) and low density polyethylene (LDPE)). Both types of CB have similar external dimensions, but differ in the level of branching. 95 % Ethanol was used as dispersant to produce carbon black dispersions for AF4/MALLS method development which covered:

- separation of CB particles from other matrix components
- quantification of CB particles by the correlation of light scattering intensities with the injected mass of particles
- Determination of stability/recovery of CB particles when dispersed in food simulants under migration test conditions

Plaques (1 dm^2 of nanocomposites and polymer blanks) were stored for 10 d at 60 °C in 95 % ethanol and 3 % acetic acid and 24 h at 40 °C in isooctane. At the end of storage the simulants were evaporated to dryness, picked up with 95 % ethanol and analyzed by AF4/MALLS.

Results

Pre-tests

- Fractionation of both CB types was possible with specific elution times from t = 15 – 27 min for both types of CB. Thereby, the more branched CB type caused slightly higher signal intensities.
- Linear correlation of injected mass of CB with light scattering (LS) signals was possible. Limit of Detection (LOD) for both CB types: 10 ng/ml (in 95 % ethanol).
- Storage of the CB dispersions under test conditions (time / temperature / simulant) caused loss of sample. However, with recovery rates ranging from 49 to 61 % a part of CB remained dispersed, wherefore detection of CB as particles in the respective simulants was still possible. The recovery rates were respected to determine the overall LOD of the method.

Migration measurements

- Interactions of the polymer matrix with more aggressive simulants (95 % ethanol and isooctane) led to extraction of oligomers, whereby polymer blanks and nanocomposites caused identical signals.
- In none of the migration samples a signal at elution times relevant for CB could be detected
- Fortification of migration samples with CB dispersions to 25 ng/ml CB showed that separation and detection of CB would have been possible in case of migration (Figure 2).

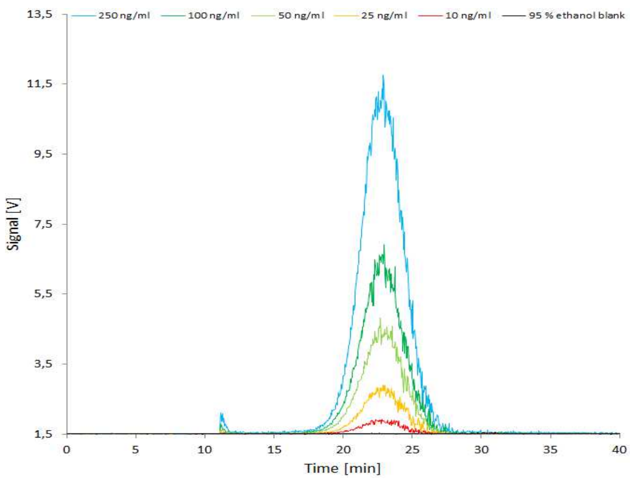

Figure 1: AF4 fractograms of a Printex® 80 serial dilution in 95 % ethanol.

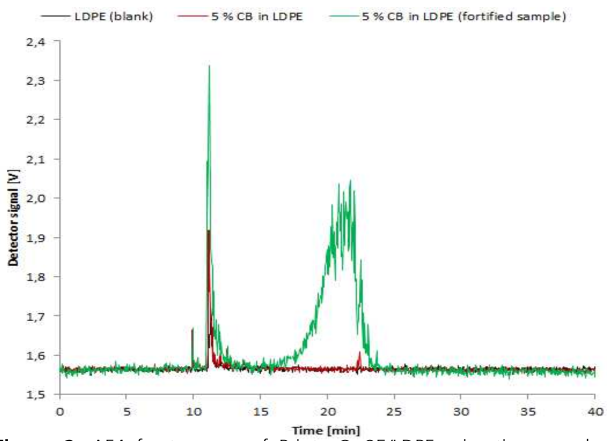

Figure 2: AF4 fractograms of Printex® 85/LDPE migration samples stored for 10 d at 60 °C in 95 % ethanol.

Conclusion

- The AF4/MALLS method was successful in separation and detection of different types of CB in migration samples.
- The chosen types of CB and polymers, as well as the migration test conditions represented a worst case scenario regarding the migration potential of CB particles.
- With detection limits from 12-14 µg CB per kg food (simulant) no migration of CB was detected.
- It can be concluded that CB is immobilized when it is incorporated into a polymer matrix and therefore does not lead to exposure.

Results published in:

Bott et al. (2014), Food Additives & Contaminants Part A 31:10, 1769-1782

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