Investigation into the migration potential of colloidal silica from food packaging plastics into food

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Introduction

Synthetic amorphous silica (SAS) is used as a polymer additive in food packaging. Typically SAS structures consist of primary particles in the 1-100 nm size range wherefore SAS is a nanomaterial and needs to be subjected to risk assessments. For this, special analytical techniques for the detection, characterisation and quantification of nanomaterials are required. In this study asymmetric flow field-flow fractionation (AF4) and multi-angle laser light scattering (MALLS) were used to investigate into the migration potential of colloidal silica particles out of a low density polyethylene (LDPE) film.

Materials and Methods

Colloidal silica with particles of 20 nm in diameter was provided in form of a LDPE-nanocomposite film (9000 mg/kg silica, 30 µm thickness) and as a stock dispersion with a content of 30 % silica. The stock dispersion was diluted using an aqueous 500 mg/l sodium dodecyl sulphate (SDS) surfactant solution. Diluted dispersions were used for AF4/MALLS pretests which covered:

- separation of silica particles from other matrix components
- quantification of silica particles by the correlation of light scattering intensities with the injected mass of particles.
- Determination of stability of silica particles when stored under migration test conditions

Cutouts of the nanocomposite (1 dm^2) were stored for 10 d at 60 °C in the 500 mg/l SDS solution, which was used as an alternative food simulant. The simulant was then analysed by AF4/MALLS on the presence of colloidal silica particles.

Results

Pretests

- Fractionation of colloidal silica particles was possible with specific elution times from t = 43 – 52 min
- Measurement of a standard series of diluted silica dispersions showed that the light scattering signal can be correlated with the injected mass (Figure 1). A dispersion with 75 ng/ml silica still delivered an evaluable signal.
- Colloidal silica particles dispersed in the surfactant solution remained stable when stored for 10 d at 60 °C. At the end of storage 87,5 % of the original silica content could be recovered as particles.
- The SDS solution (blank) itself did not cause any interfering signals in the AF4 fractogram. Therefore, 500 mg/l SDS solution can be considered as a suitable alternative food simulant regarding the potential to disperse migrated colloidal silica particles.

Migration measurements

- LDPE blanks and SAS-nanocomposites caused identical signals at the end of the fractogram, which might be caused by extracted oligomers.
- AF4 fractograms of migration samples did not show any signal at elution times relevant for colloidal silica.
- Fortification of migration samples to 250 ng/ml silica showed that separation and detection of the particles would have been possible (Figure 2).

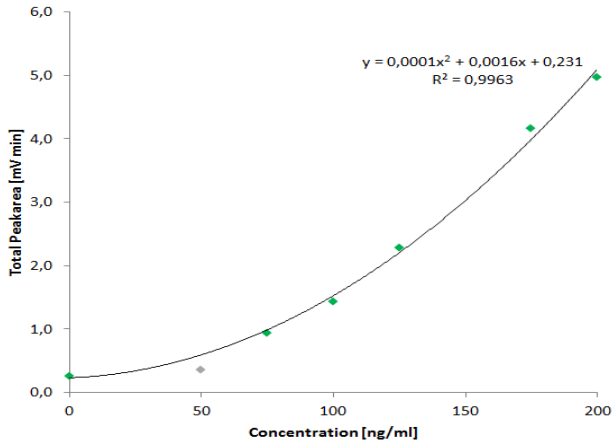

Figure 1: Sum of all MALLS detector outputs (i.e. total peak area) of the colloidal silica peaks versus the concentration.

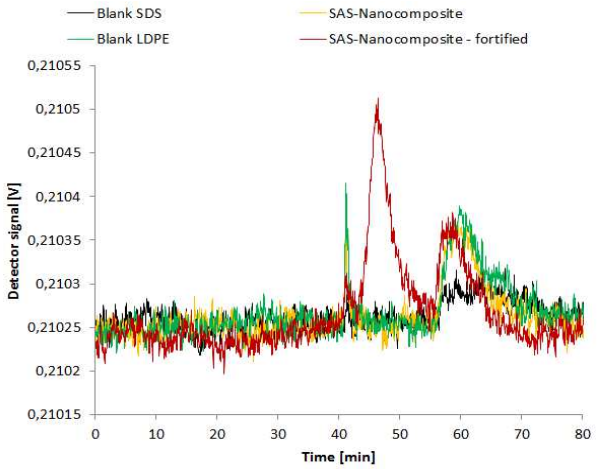

Figure 2: AF4 fractograms of migration samples stored for 10 d at 60 °C in a 500 mg/l SDS solution.

Conclusion

- The AF4/MALLS method was successful in separation and detection of colloidal SAS particles
- With LDPE as a polymer matrix and silica particles with 20 nm in diameter only, the setup of this migration experiment can be considered as a worst-case regarding the potential of silica particles to migrate out of the polymer into food.
- At a detection limit of 0,1 mg silica per kg food (simulant) no migration of colloidal silica was detected.
- From the findings it can be concluded that nano-particulate SAS in general would not migrate into food when it is incorporated into a polymer matrix.

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