SiO_x layer as functional barrier for PET bottles towards potential contaminants from post-consumer recycled poly(ethylene terephthalate)

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Introduction

Post-consumer recycled polyethylene terephthalate (PCR PET) in softdrink bottles has been established in several countries. Typically the conventionally recycled post-consumer PET is further deep-cleansed using super-clean recycling processes. These super-clean recycling processes are able to remove compounds which are adsorbed into the bottle wall during the first use of the PET material. The PCR PET has then a migration potential, which is similar to virgin PET. Another possibility to minimize the possible migration of post-consumer compounds is the use of functional barriers, which reduces the migration from the bottle wall into the foodstuff.
Within this study the barrier effect of a silicon dioxide (SiO_x) coating on the inner surface of a PET bottle was investigated due to their ability to reduce the migration of post-consumer compounds from the PET bottle wall into the food simulants 3% acetic acid and 10% ethanol. The barrier effect was examined by artificially introduced model substances (toluene, chlorobenzene, phenyl cyclohexane and benzophenone) into the PET bottle wall at three contamination levels each. From the specific migration of the surrogates the maximum concentrations of the surrogates in the bottle wall corresponding with the general accepted migration limit of 10 ppb were determined. In order to investigate the coated bottles in a worse case scenario with an unfortunate surface/volume ratio small PET bottles of 0.3 l (24.5 g preform weight, estimated inner surface of 280 cm^2) were investigated.

Results

The concentration of the surrogates in the bottle wall was analysed for each concentration level after manufacturing of the spiked bottles as well as after coating. Subsequently the migration kinetics of the surrogates were determined into the food simulants up to storage for 30 d at 40 °C (Figure 1).

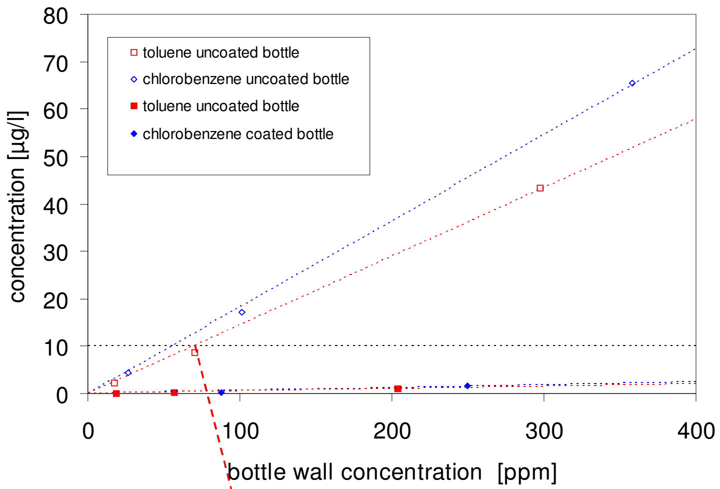

Figure 2: Correlation of the bottle wall concentration and the migration of toluene and chlorobenzene into 10% ethanol after 10 d at 40 °C

Table 1: Calculated maximum concentrations [ppm] of the investigated model compounds in the bottle wall of the test bottles corresponding to a migration of 10 µg l^{-1} in food simulant (contact conditions: 10 d at 40 °C)

Surrogate	Estimated maximum concentrations [ppm] in the bottle wall			
	non-coated bottle		SiO_x coated bottle	
	3% acetic acid	10% ethanol	3% acetic acid	10% ethanol
Toluene	204	67	>>204	>>204
Chlorobenzene	108	54	>>250	>>250
Phenyl cyclohexane	>782	>782	>>782	>>782
Benzophenone	>974	>974	>>974	>>974

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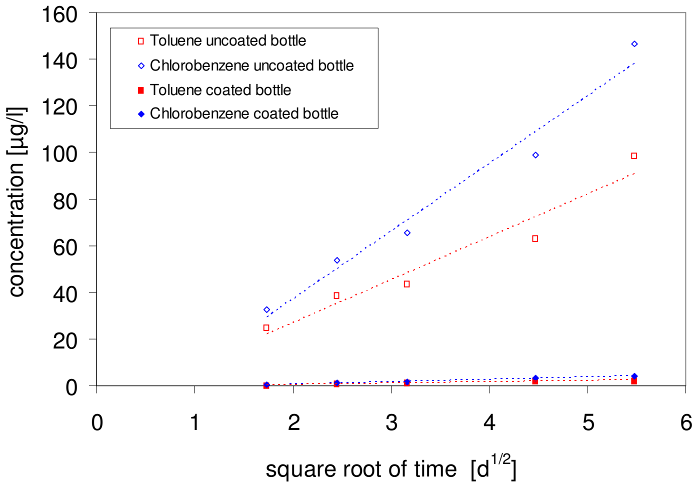

Figure 1: Migration kinetics of toluene and chlorobenzene into 10% ethanol at 40 °C (high level bottles)

The maximum acceptable concentrations of surrogates in the bottle wall, which corresponds to a 10 µg l^{-1} migration value in the investigated 300 ml bottle were calculated from the correlation between the bottle wall concentration and the resulting specific migration into the investigated food simulants due to the fact that according to migration theory the bottle wall concentration correlates linear with the concentration in food simulant for a specific migrant. Such a correlation after storage for 10 d at 40 °C was established for the surrogates toluene and chlorobenzene for the non-coated test bottles (Figure 2). For phenyl cyclohexane and benzophenone as well as for toluene and chlorobenzene in the SiO_x coated bottles, the concentrations in the migration solutions were below 10 µg l^{-1} even at the highest bottle wall concentrations. The estimated maximum acceptable concentrations in PET material which would correlate with a 10 µg l^{-1} migration limit in food simulants are summarized in Table 1. From the ratios of the slopes of the migration kinetics (concentration in food simulant versus square root of time) the barrier effect for the SiO_x coating layer for reducing the migration of toluene and chlorobenzene in 10% ethanol was determined to 37 and 29, respectively.

Conclusions

The results of the study demonstrate that the SiO_x coating layer is an efficient barrier towards post-consumer compounds. Consequently, this SiO_x coating layer would even allow the use of conventionally recycled post-consumer PET flakes without clean-up by super-clean recycling processes for packaging aqueous and low alcoholic foodstuffs under cold-fill conditions and prevent the food from migration of unwanted contaminants from post-consumer PET.

Reference

F. Welle, R. Franz, SiO_x Layer as a Functional Barrier of PET bottles towards Potential Contaminants from Post-consumer Recycled Poly(ethylene terephthalate), *Food Additives and Contaminants*, 2008, *25(6)*, 788-794.

Acknowledgements

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