Study on Element Migration from Plastic Food Packagings to Simulating Solutions

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Summary: In the present study a radiometric method was established for element migration determination from plastic food packagings to simulating solutions of 3% acetic acid solution and of water. This radiometric method consisted in irradiating plastics with neutrons, followed by exposition for migration and measurement the radioactivity in food-simulating solution. The experimental conditions used were 10 days of exposure at 40 °C. The migration was studied for packagings of water and dairy products. The results indicated the migration of Co, Cr and Sb to the simulating solutions. The advantages of this methodology are no necessity of blank analysis, as well as the use of high purity simulants. Moreover, it is possible to evaluate the migration to the food contents, instead of simulants. The detection limits of migration indicated the high sensitivity of the radiometric method.

Keywords: inorganic materials; irradiation; migration; packaging; radiometric method

Introduction

The plastic is one of the most used materials in the manufacture of packagings. The manufacture process involves catalytic processes and use of additives, which may cause contamination and possible migration to the food.[1]

The toxic element determinations in foods are of great interest and consequently the regulating agencies have established boundary-values of migrants and methodologies to evaluate the elements and substances migration from the plastic packagings to foods.

In the conventional methods of migration evaluation, the sample is immersed in a food simulating solution, and the element contaminants that migrate to the stimulant are, in general, measured by atomic absorption spectroscopy, inductively coupled plasma spectroscopy or colorimetric methods, according to the National Health Surveillance Agency (ANVISA) recommended procedures.[2]

In the present work the radiometric method was applied to the determination of elements that migrated from plastic packagings to simulating solutions. Packagings samples irradiated with neutrons of a nuclear reactor were submitted to the migration test and after, the gamma radioactivity of simulating solution was measure.

Methodology

Cleaning and Samples Preparation

The plastic packagings of water and dairy products were tested. First of all, these packagings were washed with domestic detergent and water, cut in approximately 15 cm × 10 cm pieces and then they were also, washed with deionized water, dried and next they were cleaned with hexane.

Elemental Synthetic Standards Preparation

Standard solutions of Cd, Co, Cr and Sb acquired from Spex Certiprep were used to

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prepare diluted multielemental standard solutions of these elements. 50 μL of these multielemental standard solutions were pipetted on Whatman filter paper sheets and dried at room temperature. These sheets were folded and placed in polyethylene involucres for irradiation.

Radiometric Procedure for Migration Evaluation

For this study, plastic packagings with regular surfaces and without risks were selected. The total area of each plastic sample submitted to the migration test was 0.405 dm^2. These samples placed in polyethylene involucres with the element synthetic standards were irradiated at the IEA-R1 nuclear reactor for 16 hours under a thermal neutron flux of 10^{12} n cm^{-2} s^{-1}.

After irradiation, the samples were immersed in 30 mL of simulating solution. The migration time was 10 days at temperature of 40 °C. The choice of the simulating solution was based on the ANVISA recommendation.[2] The water simulant was used for water packagings and 3% acetic acid solution (m/v) for dairy products packagings.

After the migration exposure time, the plastic samples were removed from the simulants and discarded. The simulant solution was transferred to a polypropylene bottle for gamma-ray measurement. The irradiated synthetic standards of elements were dissolved using nitric acid and with a carrier solution of the elements Cd, Cr, Co and Sb. The standard solutions were obtained in the same geometry of the simulants for the measurements.

The gamma-ray activities measurements were carried out using a hyperpure detector coupled in a gamma ray spectrometer. The gamma-spectra were obtained using S100 Canberra software and for data processing the VERSAO2 software was used.

The radioisotopes measured were identified according to their gamma ray energies and half-lives. The mass of the element that migrated from plastic to solution was calculated by comparative method. The migration detection limit of the elements was evaluated according to CURRIE.[3]

Table 1.
Elements migration from water packagings (ng dm^{-2} kg^{-1}) to water simulant.

Packagings	Elements			
	Cd	Co	Cr	Sb
AG1	<13055	<124	<852	480 ± 12[a]
AG2	ND[b]	ND	ND	774 ± 24
AG3	<517735	<250	<3842	<1686
AG4	ND	ND	<184	ND
AG5	ND	ND	ND	486 ± 13
AG6	<12098	<64	<565	423 ± 11

[a] The uncertainty was calculated using statistical countings errors of standard and of sample.
[b] Not detected.

Results and Discussion

Table 1 shows the results of element migration obtained for six samples of water plastic packagings and in Table 2 for five dairy product packagings.

The migration results are given in terms of element mass that migrated per mass of the simulant solution and area of plastic exposed to migration (ng dm^{-2} kg^{-1}). Four samples of water packagings presented Sb migration (Table 1) and two samples of dairy products packagings presented Co migration (Table 2) and one, Cr migration.

From the migration results, the total mass of each element that migrated to ''food'' was calculated. These values obtained for the elements Cr and Sb were lower than the maximum limit values established in the legislation.[4] These limits values are 0.1 mg kg^{-1} for Cr and 2.0 mg kg^{-1} for Sb.

Table 2.
Elements migration from dairy product packagings (ng dm^{-2} kg^{-1}) to 3% acetic acid simulant.

Packagings	Element			
	Cd	Co	Cr	Sb
L2	<57046	134 ± 9[a]	<886	<323
L3	<16296	<86	<702	<164
L4	<19516	<80	<625	<152
L5	<45398	107 ± 2	3064 ± 233	<252
L6	<56911	<76	<726	<287

[a] The uncertainty was calculated using statistical countings errors of standard and of sample.

Conclusions

Results obtained in this study indicated that the elements Co, Cr and Sb migrated from packagings to the simulating solutions. The migration detection limit values obtained for these elements indicated high sensitivity of the radiometric method. The advantage of this technique is no necessity of blank determination, as well as the use of high purity simulants and besides it is possible to evaluate the migration to the food, instead of simulating solution. Moreover, there are no contamination problems because the plastic to be exposed to the migration test is previously irradiated.

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