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STUDY ON THE INTERACTION BETWEEN THE FOOD MATRIX AND THE METAL FOOD CANS

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Abstract

The metal cans are used to preserve food and beverages for long periods of time, proving to be one of the most versatile packaging materials nowadays. Some of their vital functionalities are represented by ensuring that foods are not contaminated, providing physical protection and extending the shelf life of it.
Metal cans are protected on the inside by a thin coating layer, which can be affected by stroke. Thus, the canned food or beverage comes in direct contact with packaging metal. The coating is an epoxy lacquer that separates the liquid from the packaging material. Normally, the metal cans are affected by corrosion (primary, secondary or stress corrosion). However there are several factors which can accelerate the corrosion processes.
This study is conducted to determine the degree in which the damages caused by hitting causes the existence of substance traces in canned food or beverages (product contamination). While the final product is stored, the coating is damaged and the intensity and the type of damages are depending on the products characteristics, e.g. acidity, resulting higher pore-gaps in coating surface, which allow direct contact between the food and the metal from which the can is actually made (e.g. aluminium alloys, iron etc.) and also between the food and the coating epoxy resin.
In this paper were summarized the literature scientific approaches which revealed until now the chemical contamination occurring in canned food considering the packaging materials. This information have been completed by various tests carried out in specialized laboratories in order to determine aspects like: which type of mechanical actions generate damages to the cans coating integrity, the remanence of metals or other chemical substances within the product, the optimal variances of the internal coating, considering the various types of can strokes and other research evidence which may be needed. The measurement results are compared considering the food matrix remanence revealed through other researches (local, international). All in all, the study aims to offer a better approach regarding handling canned food and beverages without or with minimum damaging of their coating, in order to maximize the product′s safety and guarantee its long shelf life.

Keywords: *canned food, corrosion, packaging materials, food matrix, chemical contamination.*

INTRODUCTION

The damages made through the operations carried out on the production line or during the final storage phase, like transport, handling, bottling and can filling may alter the internal coating quality of the packaging cans. While the final product is stored, the coating is damaged due to the products characteristics, e.g. acidity, resulting higher pore-gaps in coating surface, which allow direct contact between the food and the metal from which the can is actually made (e.g. aluminum alloys, iron etc.) and also between the food and the coating epoxy resin.
These residual BPA and BADGE can be a potential contaminant to the food that is packed. When the cans are heated at high temperature as in case of commercial canning, BPA may leach out of can coating.
Bisphenol A (BPA) and its condensation product with epichlorohydrin, bisphenol A-diglycidyl ether (BADGE) may remain unreacted if the curing process of lacquer coated can is insufficient (Mungia Lopez and Sato-Valdez, 2001).
Recent studies discovered many aspects regarding the connections between the materials from which the metal cans are made of and the food matrix. Thus were revealed a series of chemical changes that occur in canned food considering the packaging materials, such as the influence of aluminum particles which are migrating into the packed product or the Bisphenol A (BPA) toxic traces in food (a product found in the epoxy resins most commonly used as a protective lining in canned food and beverages). Some studies revealed that Bisphenol A diglycidyl ether traces were

discovered in fish tins. The Community legislation takes account of the new toxicological results (Regulation 1895/2005/EC) and sets a new, higher migration limit for BADGE and its hydrolysis products at 9 mg/kg/food, but for BADGE chlorohydrins it maintains a limit of 1 mg/kg/food (Barnes, K.A., et al., 2011). According to FERA's research, the limit of dietary exposure of Melamine is 0.013 mg/kg body weight per day, and their highest recorded level of melamine was 0.33 mg/kg found in the coatings for can and jar lids for food packaging (Stollenwerk, J.D., 2012).

Metal can be considered to be a specific type of packaging-derived contaminant. Although there is no evidence that excess tin intake has any long-term health effects, some studies have shown that intake of high concentrations (more than 150 mg/kg in canned beverages; more than 250 mg/kg in canned fruit and vegetables) may cause short-term gastrointestinal problems. For most foods, this is of no significance, but for foods packed in cans with some unlacquered tinplate, high levels can sometimes occur. Tin dissolution in unlacquered tinplate cans is essential in that it confers electrochemical protection to the iron, which makes up the structural component of the can and so maintains the can's integrity. Without it, the can would quickly become corroded by its contents; this could cause serious discoloration, off-flavors in the product and swelling of the can.

Given all the factors mentioned above, were conducted three types of analyses aiming to establish the integrity level of lacquer.

MATERIALS AND METHODS

In order to reveal the interaction between the food matrix and the metal cans were used special analyses tools and methods, including:

- Cans made of aluminum alloy or galvanized tray;
- Can lids;
- Chemical solutions, juices, beer, canned food, honey etc.;
- Liding machine (Seamer);
- Coating measuring device (Sencon);
- Induction meter (Sencon);
- Microscope with camera;
- Axial force measuring machine;

-ISM – Automatic spraying can machine (varnished); -gloves, protective glasses, scissors.

Batches of 2x10 boxes each have been analyzed. Using a special equipment, called Secon, they were classified in the proper coating category (1,2,3,4). The boxes have been filled with water or viscous solutions (food or chemicals) with different pH/acidity levels (according to the coating categories). Also, they were filled with corrosive chemical solutions (various concentrations of NaOH, CuSo4). The witness water-based solution should have a pH close to 7. Previously, the cans were marked and sealed with a lid (seaming), using the manual electrical-device from the laboratory.

After the storage period, the cans have been drained. In the laboratory have been measured, using the camera microscope, the internal size of the damage, the pores, in order to observe how the different solutions altered the coating and to conduct other relevant aspects (measurements of the coating integrity after storage).

Another Sencon device will quantify the electricity inductance through the damaged can and will generate reports that will help in determining what type of mechanical actions generate damages to the cans coating integrity.

Following the cans opening, samples have been analyzed by the chemical laboratory in order to measure the remanence within the product, for aluminum or other metals/chemical substances.

Also have been conducted tests in order to determine the optimal variances of the internal coating, considering the various types of can strokes.

These were made using the Sencon device, which determines the distribution of the interior lacquer over the can's inner surface, returning the results in g/m2.

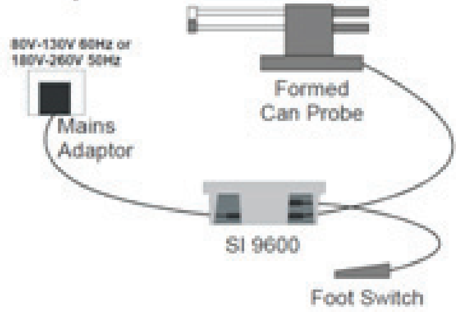

Figure 1. Lacquer measuring Sencon system

Considering A the capacitance between the probe tip and the metal of the can or sheet, which are separated by the lacquer, acting as the dielectric. The capacitance is given by the formula $C = (\varepsilon \times A) / d$ where ε is the dielectric constant of the lacquer, A is the probe surface area, and d is the lacquer thickness. By using the gauge as a comparator to a known calibration standard sample, both ε and A become constant. So variation in capacitance is due to the difference in d, which can thus be used to determine the lacquer thickness.

1) Determining the weight of the interior lacquer, using the analytical balance, by weighting the can before and after the lacquer operation.

Figure 2. Can measurements on the analytical balance

2) Measuring the integrity of the cans interior coating by measuring the conductivity using a saline solution (5%NaCl) and a measuring device (Auto EnamelRater).

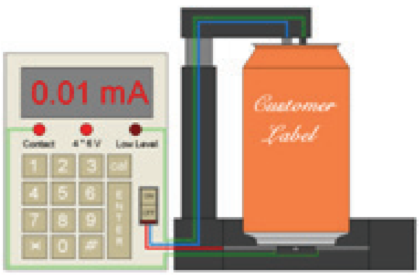

Figure 3 Auto EnamelRater – measuring the cans conductivity

Simultaneously have been analyzed the empty cans, without any lid or product inside, in order to see how the hits influence the axial endurance – respectively the cans resistance at these force actions. This parameter will also be monitored also by microscopic observation of the cans in order to see any damage over the cans (the aim is to obtain information regarding the behavior of the pallet stored can).

The measurement results have been compared considering the food matrix remanence revealed through other previous researches (local, international).

All measuring machines (except the manual ones) can generate reports, graphs, statistical data, regarding the measured product type, category, etc (having more options from which to select which are taken into the analysis).

3) Measuring the interior lacquer in 4 areas of the can (up, middle, base, bottom).The data obtain after the measurement are automatically stored within a server database. Thus, it can be obtained customized reports (e.g. daily, weekly, by type, by measurement area etc.).

RESULTS AND DISCUSSIONS

The importance of measuring the integrity of the cans interior coating analysis is given by the fact that a can with high integrity of the interior coating represents a safe packaging material (the result should be close to zero).

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Batch 3          13:04   02-Apr-01          Line 1
SODA POP         Lacquer 1 Epoxy 2603ST
==========================================================
Machine 1                Gun 1                   Can 1

                 Top of can          | Average
         8.6*    8.3     8.3         |   8.4
         8.4     8.2     8.2         |   8.3
         8.4     8.3     8.1*        |   8.3
-----------------------------------------
Average  8.5     8.3     8.2         |   8.3
Dome     8.1
```

Figure 4. Measurement results and mean values

Regarding the experiments the minimum values (near to zero at Auto Enamelrater) are the normal ones and the exponential increasing of values is directly linked to the deficiencies of the internal varnish (being the first part of experiment). The second method of testing shows values like eight (at Auto Enamelrater) are represented by small interior dots that could be provided by dust particle, undried water drops from process washer etc. Almost 90% of this process can imperfections are sorted by necking phase camera (Optic sorting). The most considerable defects that could bring such values as eight are physical damages like those that are made from handling and presentation racks in stores. These are the precursors of corosivity and most of the damaged cans measured (shown in the third part of the research) are with values above two and the normal one between zero point one and two value.

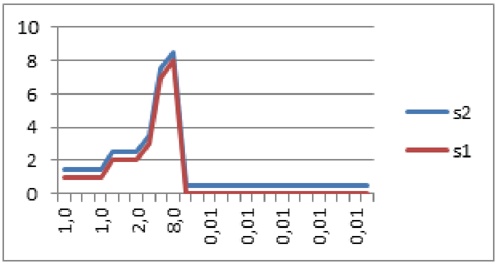

Figure 5. Conductivity results for 2 batches of tested cans, s1 and s2, including maximum and minimum values as per results (where 2 is the maximum value admitted)

CONCLUSIONS

Most food products rely on their particular packaging to achieve their expected shelf life.

In some circumstances the desired shelf life can be a major factor in the selection of a packaging material.

Nowadays, in the EU there is a general requirement that food packaging components must not migrate into food during its normal shelf-life to the detriment of the food (i.e. to pose a health risk, or to adversely affect the quality of the food, its flavor, texture or appearance).

Most canned foods are now processed in lacquered cans which are one of the best solutions, but also but all these cans are susceptible to residual chemicals migration in food.

Test results of the present study indicate that in 90% of damaged cans, scratched or hitted, have lost their laquer integrity in a certain degree.

According to the test, weak results of the axial force determine changes within the cans structure (affecting the pressure rezistance) and is correlated with the measurings indicating that the laquer integrity is also damaged.

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