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Analytical and Measuring Instruments

How Safe Are Your Snacks? Depends on the Packaging!

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■ Introduction

As you read this article, chances are you're snacking on one of the snacks in Figure 1. With our busy lives, many of us skip at least one of the traditional meals of breakfast, lunch, or dinner. In many cases, we choose fast food restaurants as our backup source for nutrition. Even if we want to choose something healthy, the salad doesn't work very well when driving to that next appointment. Thus, the snack food industry has grown by developing healthy snacks to be consumed as we drive, work at our desks, or just watch television.

The packaging protects the food from physical, chemical or biological issues … and can be in the form of bags, boxes, cans, cartons, pallets, trays, wrappers, etc.

Figure 1: Snacks in a vending machine

How healthy your food is depends on a number of factors, such as food type, food additives, contaminants, such as pesticides, microorganisms, veterinary pharmaceuticals, and toxic metals, as well as the packaging. This article focuses on the last step of the food chain, which involves the packaging.

The packaging protects the food from physical, chemical or biological issues. Packaging can be in the form of bags, boxes, cans, cartons, pallets, trays, wrappers, etc. A recent article in "*Food and Beverage Packaging*" magazine stated the hottest trends in packaging include re-sealability, single-service packaging, eco-friendly materials and uniqueness because they make our lives a little easier and more enjoyable. The single-service packaging is reminiscent of the movie *Fight Club* where the Ed Norton character says to Brad Pitt's character: "Tyler, you are by far the most interesting single-serving friend I have ever met."

■ Packaging Strength

These single-serving meals must be packaged properly as with any food product such that the package is strong enough to protect the contents, but weak enough to be easily accessed by the consumer. A wide range of materials is used in packaging, including aluminum and other metals, and non-metals such as paper and plastic. According to their application, these materials must meet certain tensile, compression and bending strength requirements, and if an adhesive is used, adhesive strength requirements must also be met.

Figure 2 shows results of adhesive strength testing of liquid-filled pouches and dry snack packages as performed by a Shimadzu EZ-X Universal Testing Machine (shown in Figure 3). All passed the requirements.

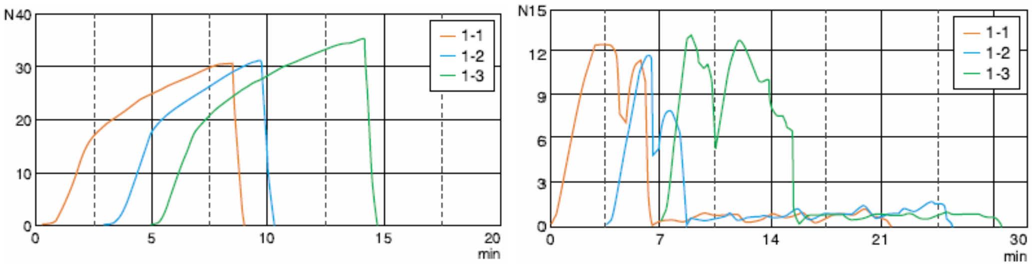

Figure 2: Analysis of adhesive strength of liquid-filled pouches and dry snack packages

Figure 3: Shimadzu EZ-X Universal Testing Machine

■ Packaging Material

The packaging materials for these snacks are much more complex than you might imagine. At minimum, these packages must be able to protect against oxygen, water vapor, dust and microorganisms. Figure 4 shows the differential interference contrast (DIC) image of a thin packaging film such as that used for a single serving food like potato chips, but magnified 200x. The thin film of the packaging shows seven distinct layers. The inner five layers were alternating polypropylene (PP), nylon, polypropylene, nylon, and polypropylene at different thicknesses as determined by Shimadzu's IRTracer-100 FTIR spectrophotometer and AIM-8800 microscope.

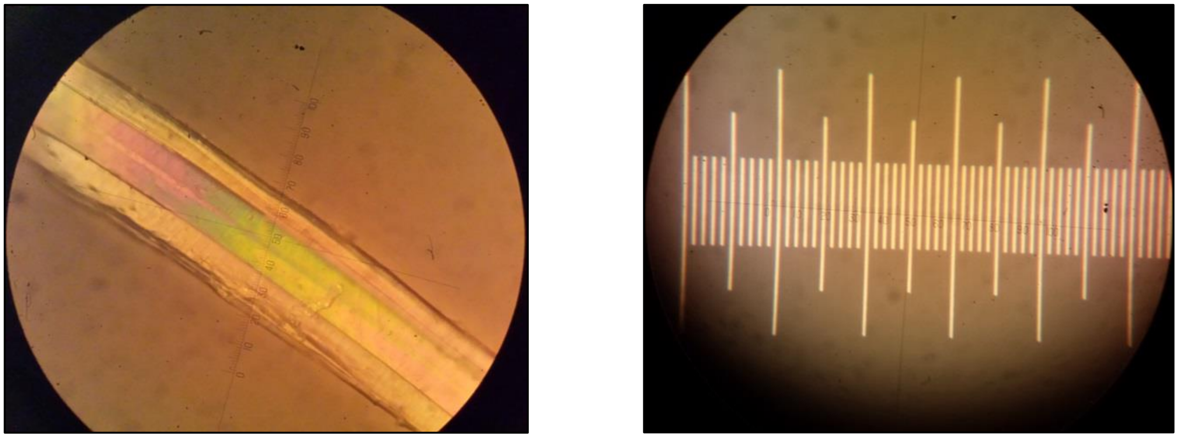

Figure 4a): DIC image of thin section of film (~200X); **4b)** Image of stage micrometer used to calibrate the reticle
Seven layers are present, and from the above images, they were estimated to be 9 um (outer), 36 um (PP), 25 um (nylon), 6 um (PP), 25 um (nylon), 36 um (PP), and 9 um (outer).

Shown in Figure 5 is a 3-dimensional (3D) plot of FTIR scans of wavenumber (400-4000 cm^{-1}) across the thin film in 5 micron (um) increments for a total 30 scans covering the cross-sectional area of the 150 um layers. FTIR instruments provide the functional groups that can help identify the material and thickness of each layer. The absorption at 1475 cm^{-1} appeared to be the better identifier of the polypropylene instead of the 2850-2980 cm^{-1}. This is because both nylon and polypropylene have absorption bands that occur in the same region due to symmetric and asymmetric stretching of the $-CH_2$ and $-CH_3$.

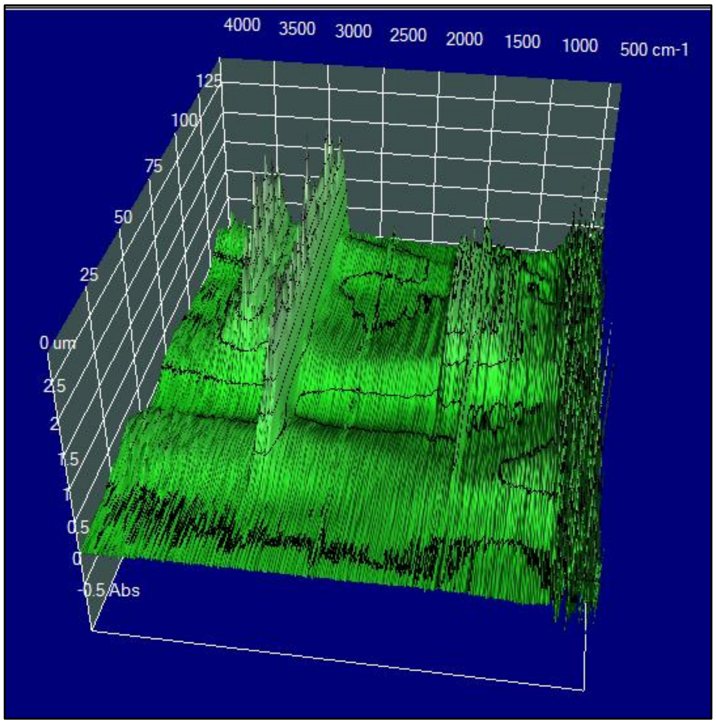

Figure 5: 3D Map of 5 um incremental FTIR scans across the 150 um thin film

■ Packaging Printing

Paperboard food packaging contains many different color inks (Figure 6) to help promote the product. The inks in the food packaging materials and containers involve the use of organic solvents. These solvents can leave residues, which can be analyzed by a technique called headspace gas chromatography (GC), as shown in the chromatograph of Figure 7.

Figure 6: Various inks used on food packaging

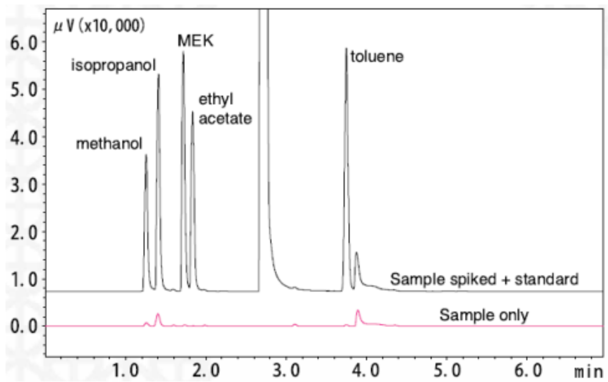

Figure 7: Headspace GC analysis of residual organic solvent dry snack packaging

Often, these inks are dissolved in mineral oil that can migrate into the foods. Food package printing does not always contain these mineral oils as the printing may use vegetable oil; however, the mineral oil may still be present from other sources such as recycled paper. The mineral oils contain a portion of mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH). According to the Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives (JECFA 2002, 2012), MOSH can impair organ functioning and lead to chronic disease, while MOAH contains known mutagenic and carcinogenic compounds.

Dr. Luigi Mondello, University of Messina, Italy, developed Shimadzu's Technical Note (C146-E239) and discusses these mineral oils that are derived from crude oil. The note describes the analysis of pasta (Figure 8 and Table 1), icing sugar, and rice for MOSH, MOAH, and DIPN or 2,6-Diisopropylnaphthalene by GCxGC-MS/FID to obtain qualitative and quantitative information. Utilizing the comprehensive 2D GC method reveals additional compounds that could not be separated by a single GC column technique.

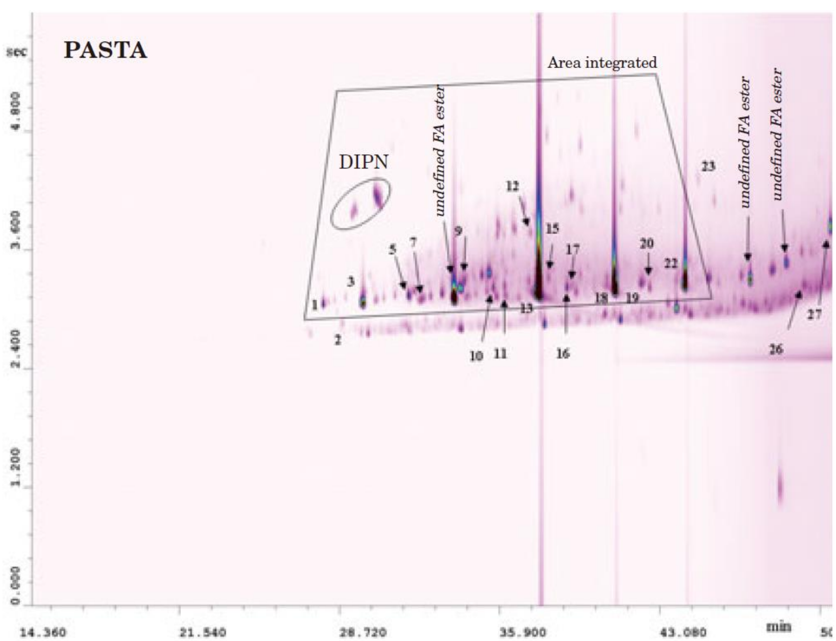

Figure 8: Identification of MOAH in pasta by GCxGC-MS

No	Compound	No	Compound	No	Compound
1	Isopropyldodecanoate	2	Dioctylether	3	2-Ethylhexyl octanoate
5	Isopropyltetradecanoate	9	Methylhexadecanoate	10	Ethylhexadecanoate
11	Isopropylhexadecanoate	12	Abietatriene	13	Octyldodecanoate
15	Methyloctadecanoate	16	Dodecyloctanoate	17	n-Butylhexadecanoate
18	Octyltetradecanoate	19	Tetradecyloctanoate	20	n-Butyloctadecanoate
22	Octylhexadecanoate	23	Di(ethylhexyl) phthalate	25	Squalene
26	1-Hexacosanol	27	Tetradecyltetradecanoate	@	@

Table 1: MOAH compounds identification by GCxGC-MS

■ Packaging Labels

Many of us read the food labels to be sure the food is healthy. Food labels contain nutritional facts such as calories, fat, cholesterol, sodium, carbohydrate, protein, and vitamin values. Reporting these values requires analytical instruments for testing. Others read food labels to see if they are allergic to one of the ingredients. A listing of allergens on the labels is very important since the best medicine to prevent an allergic reaction is avoidance. The big eight allergens responsible for 90% of reactions involve milk, soy, egg, wheat, peanut, tree nut, fish, and shellfish. LC-MS/MS is the analytical instrument typically used for the measurement of these allergen proteins.

The typical packaging food label contains many food additives. One can see a list of allowable food additives by country by visiting the "Food Additive Database" by Christie Bryant, Inc. (http://www.foodadditivedatabase.com/index.cfm). The website was compiled in cooperation with the United States Department of Agriculture (USDA) as well as other organizations.

■ What Isn't Listed On Labels

In some cases, additives are included in the food despite not being permitted by a regulatory committee and are therefore not listed on the label. This is referred to as adulteration and the motive is economic gain. For example, the nitrogen-rich adulterant melamine was added to pet food and infant formula, which resulted in a number of deaths. This section is a brief overview of what is not on the label. For a more complete guide on food safety issues and analytical instruments, request the brochure "Shimadzu's Total Support for Food Safety" (P/N C10G-E020B).

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What's not on the labels and hopefully not in your foods are over 1000 types of pesticides commercially available throughout the world. These pesticides are generally analyzed by gas chromatography-mass spectrometry/mass spectrometry (GC-MS/MS) and liquid chromatography-mass spectrometry/mass spectrometry (LC-MS/MS). The United States Environmental Protection Agency (EPA) sets the tolerance levels (http://www.epa.gov/pesticides/regulating/tolerances.htm), but it is the responsibility of the Food and Drug Administration (FDA) and United States Department of Agriculture (USDA) to ensure these levels are below the tolerance levels. The European Union has their own set of levels, which are referred to as Maximum Residue Levels (MRL).

Other contaminants not listed on food labels are mycotoxins, toxic chemicals produced by fungi and analyzed by LC-MS/MS. Alfatoxins, which are naturally occurring mycotoxins, can be analyzed by Ultra High Performance Liquid Chromatography (UHPLC). These mycotoxins can produce disease or death so one can see the importance of not consuming them. In fact, the FDA Regulatory Guidance for aflatoxins is 20 parts per billion (ppb) for corn-based foods used for human consumption.

Microorganisms can be identified by a Shimadzu MALDI-TOF-MS (Matrix Assisted Laser Desorption Ionization-Time of Flight-Mass Spectrometer). The platform used is called the "iDPlus Microorganism Identification System." The system can classify and identify over a thousand microorganisms for family, genus, species, and subspecies for pennies a sample in two minutes using a database that prevents false positive and false negatives from being reported.

Veterinary pharmaceuticals are also not reported on packaging labels. These drugs can include classes of compounds such as anabolic hormones, anthelmintics, antibiotics, beta-agonists, coccidiostats, corticosteroids, nonsteroidal anti-inflammatory drugs (NSAIDs), and sedatives, which are analyzed by LCMS or LC-MS/MS.

Heavy metals, such as Arsenic (As), Cadmium (Cd), Lead (Pb) and Mercury (Hg), can be tested by atomic absorption (AA), inductively coupled plasma (ICP), or ICP-MS, which is an ICP with a mass spectrometer for detection, and X-ray fluorescence (XRF). The specific techniques used will depend on sample matrix, sample preparation, and samples concentration. XRF and FTIR are used for inspection of foreign matter for metals and organic material, respectively, and require little sample preparation.

■ Conclusion

When it comes to foods, the packaging strength, material, printing, and labeling all require high-precision analytical instruments and physical testing machines so that we may enjoy a healthy (or not so healthy) snack.

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