INTELLIGENT PACKAGING

INDUSTRY LEAFLET

ActinPak

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PACKAGING WITH ADDED VALUE

Traditional packaging functions: protection, communication, convenience and containment, enriched by a variety of new possibilities are representing a new era of food packaging. By monitoring the environmental conditions in the packed food the quality of product and its shelf life can be estimated and decisions made for optimizing the information flow within the food supply chain more efficiently.

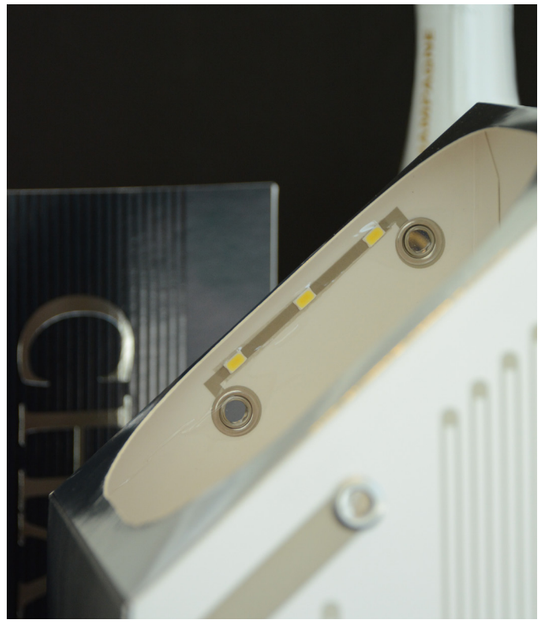
By the definition of EC 'Intelligent materials and articles' means materials and articles which monitor the condition of packaged food or the environment surrounding the food (EC, 2009). Intelligent packaging, with its ability to detect, sense and record the changes in the products environment, is an extension of the communication function of traditional packaging.

The purpose of intelligent food packaging is to monitor and give indication of the quality of the packaged food and thus guarantee its safety.

Intelligent packaging is the component responsible for sensing the environment inside packaging or in the vicinity of packaging, while active packaging gives enhanced protection to the packed food. Smart packaging, i.e., a total packaging concept combines the benefits arising from active and intelligent technology. It is designed to increase the quality of food, product safety, shelf life and to provide more information.

TYPES OF INTELLIGENT PACKAGING

Intelligent packaging does not refer to a single technology, but to a variety of technologies that together are able to perform specific functions and thus inform the consumer about the food product. In general, three types of intelligent packaging are presented, that are differentiated according to their main function. These technologies differ from each other not only in composition (physical and chemical), the way that they inform about a detected change, but also in the amount and type of data that can be carried and how the data are captured and distributed.



Interactive packaging refers to data carrier devices, able to store information regarding storage, distribution and traceability of the foods. They are also known as automatic identification devices making the information flow more efficiently within the food supply chain. Interactive packaging are intends to guarantee traceability, theft prevention, or counterfeit protection. Most used are barcode labels, such as 2D codes and RFID tags, which belong to the main category of convenience-enhancing intelligent systems. Nowadays it is also possible to use RFID technology to monitor storage conditions (e.g. temperature, humidity and light) and food quality through the entire supply chain, using sensor-enabled RFID tags.

Sensors are used in packaging to collect information of the package and its content. Sensors can collect information of the changes in the environment, the condition or the operating history of the packed material. The sensors monitor specific functionalities, e.g. pH, time and temperature, hydrogen sulphide or carbon dioxide. In food packaging, the quality and safety of food is monitored with the sensors attached to the package.

A sensor is defined as a device used to detect, locate or quantify energy or matter, responding to a measured signal of a chemical or physical property. A sensor must provide a continuous signal and it usually contains two functional units: a receptor and a transducer. Several types of sensors can be found for different types of applications.

Indicators cannot, in contrast with sensors, provide quantitative information (e.g. concentrations) and are not able to store the data of measurement and time. Indicators can provide visual, qualitative (or semi-quantitative) information about the packaged food by means of a colour change. An indicator leads to a colour change (e.g. different colour intensities or irreversible diffusion). They can be used to provide information regarding temperature, gas and volatiles presence, pH change and microbiological contamination.

THE RIGHT TECHNOLOGY FOR EACH APPLICATION

Intelligent packaging technologies can be integrated in the packaging material in several ways. They can be placed onto secondary and tertiary packaging if the main idea is to have information about shipping or storage conditions (normally using interactive packaging), or can be included in the primary packaging if the information is related with the food characteristics (e.g. release of ethylene or bacteria presence) or storage conditions (e.g. temperature).

The right selection of an intelligent packaging technology for a specific food product will depend on the information sought. Nowadays, it is possible to find several solutions according to the applications and the required information. According to the information wanted it is important to know the main characteristics of the food products, the main factors affecting the food quality loss and the supply chain and storage conditions, from the production to the final consumer, as these will be factors that will strongly influence the intelligent materials behaviour. If the aim is to have the storage information, distribution and traceability the interactive packaging should be selected. In this case the data is stored and then read through an electronic device. Nowadays, it is also possible to have RIFD systems that give information of the storage conditions (temperature and relative humidity) and information regarding food quality (e.g. able to detect and measure a metabolite through a sensor and store the information that afterwards is read). If the main interest of the intelligent packaging is to have information about the shelf life parameters of the food product (mainly for the consumers) a sensor or an indicator should be used.

Nevertheless, also retailers can use this kind of intelligent packaging to obtain information about the quality of the food product and packaging and thus guarantee safety to the consumers. It is possible to have information regarding temperature, headspace composition, pH and spoilage indicator metabolites. These factors will determine the chemical, biochemical, physical and microbiological characteristics of the foods products, and thus also the shelf-life or lifespan of the product. Depending on the spoilage mechanism(s) of the product, a specific type of intelligent packaging technology can be selected. Therefore, it is important to know exactly how much of a substance should be detected in which timeframe, in order to determine the type of indicator and sensor that should be used.

EXAMPLES

Tables on the next pages provide an overview of the different intelligent packaging technologies. The technical composition and action mode, the application areas and the commercial products are presented. Here, some visual examples of intelligent packaging are presented.

"Campania" Champagne box is created to demonstrate luxurious and functional features in intelligent packaging for high end products like champagne bottles.

Time Temperature Indicator (Keep-it)for salmon. // On the market (Trondheim, Norway).

Functional printing with thermochromic inks on Coca-Cola cans. // On the market (Netherlands).

Time Temperature Monitoring (OnVuTM) grilled chicken. // On the market (Zurich, Switzerland).

	TECHNOLOGY	TECHNICAL COMPOSITION	APPLICATION AREAS	COMMERCIAL PRODUCTS / EXAMPLES
INTERACTIVE PACKAGING	2D barcodes	A 2D barcode is a graphical image that stores information about product both horizontally and vertically. Information can be read with a suitable optical scanning device or camera-based reader.	All packaged foods. Used in product identification, traceability and livestock management.	The generation and the reading of a code can be free and developed online, being then printed. Some examples are: - http://barcode.tec-it.com/en - http://www.onlinebarcodereader.com
	RFID tags	The RFID tag is a data-carrying device that is composed of a microchip attached to an antenna. A RFID system presents a reader (i.e., a read/write device composed of a transmitter and/or a receiver) and uses electromagnetic (EM) waves to communicate with an RFID tag through antennas.	All packaged foods. Used in product identification, traceability and livestock management. Product identification and traceability, cold chain monitoring, livestock management and shelf life prediction.	CAEN RFID easy2logTM RT0005ET (CAEN RFID, Italy)
	Sensor-enabled RFID tags	RFID tag connected to sensor ensuring energy supply of the sensors and storage of the data measured. The sensor should be able to measure one or more properties (e.g. temperature, relative humidity, pH, pressure, light exposure, volatile compounds and gas molecules concentrations).	Meat, fruits and vegetables. Used in cold chain monitoring, livestock management and shelf life prediction. Measures temperature, relative humidity, pH and shock.	TempTRIP® (TemTRIP, UK) Easy2log© (CAEN RFID, Italy)
SENSORS	Oxygen sensors	Made of a material able to change their color in the presence of oxygen. Can be made, for instance, of a redox dye, methylene blue, combined with photocatalytic titanium dioxide. Fluorescence-based oxygen sensor consists of a fluorescent or phosphorescent dye in a polymer matrix. Molecular oxygen penetrates the dye-polymer film and extinguishes luminescence.	All package foods. Used for the detection of oxygen inside the package, e.g. to detect oxygen in MAP and vacuum packaged foods.	OxySense® (OxySense, USA)
	Temperature sensors	Integrated circuit with an electrical communication with the temperature sensor and the antenna or battery, and is configured to process a signal from the temperature sensor.	Meat, fish and dairy products, especially in refrigerated and frozen products.	ThinFilm (Thin Film Electronics ASA, Norway)
	Biosensors	The sensor is based on antibody-antigen reactions, that indicate the presence of a pathogenic bacteria. In the presence of a pathogenic bacteria, the bacterial toxin is bound to the antibodies and immobilized on a thin layer of film, resulting in a visual signal.	Meat and fish products.	Toxin GuardTM (Toxin Alert Inc., Canada) [abandoned] Food Sentinel System® (SIRA Technologies, USA) [abandoned]
INDICATORS	Time-temperature indicators	Time-temperature indicators can be divided in diffusion-based, photochromic, microbial, enzymatic and polymer-based TTIs. The response can be caused by a chemical reaction, physical change or a change in biological activity. Time-temperature indicator can be a thermochromic ink that indicates the temperature of the packed product.	Meat and fish products, especially in refrigerated and frozen products. They are also used in refrigerated beverages bottles to give an indication of the temperature.	MonitorMark (3M, USA) OnVuTM (BASF, Germany) VITSAB (Vitsab International, Sweden)
	Gas indicators	Gas indicators provide information about the presence or absence of particular gas or altered gas concentration. They change colour due to the chemical or enzymatic reactions (e.g. a redox reaction).	All packaged foods. They can be used to reminding consumers exactly how long it has been since the product was opened and therefore, for how long it can still be used, via a simple and intuitive visual cue.	Ageless Eye® (Mitsubishi Gas Chemical Company, Inc, Japan) Shelf Life Guard (UPM) [abandoned]
	Freshness indicators	They can be used for O_2, CO_2, ethylene, amines, ammonia, ethanol or H_2S detection. The indicator (e.g. pH sensitive dye) detects the production and accumulation of gaseous substances by ripening and microbiological spoilage.	Can be used to meat and fish products, vegetables and fruits such as pears, kiwi, melon, mango and avocado.	Freshpoint (Freshpoint Quality Assurance Ltd, Israel) Ripesense® (Ripesense, New Zealand) FreshTag® (FreshTag, Netherlands)

ADVANTAGES

Intelligent packaging systems have become more popular because of the growing usage of active components in food packaging, which requires a means of monitoring both the active device's performance and the overall packaging conditions.

Intelligent packaging system can help in reducing the food waste, achieving higher food safety, consumer convenience and management along the food supply chain. Demand for this kind of packaging is raised because of demographic and economic changes, changing lifestyle, demand for processed food and the need to have longer life of packed products, and most of all food safety issues and increasing health awareness. Apart from aspects such as quality, safety, and distribution, intelligent packaging offers considerable potential as a marketing tool and the establishment of brand differentiation.

Intelligent packaging involves a switching function on the package in response to changing external/internal stimuli, in order to communicate the product's status to the stakeholders of the food supply chains. An intelligent packaging system can show when the packaged food is fresh or whether its shelf life has expired; it can show the food's temperature; it can display the food's temperature history; it can be used to check the effectiveness or integrity of active packaging systems.

One of the innovation drivers of the intelligent packaging are the manufactures and the retailers that want to have information about the food products during storage and shipping. Also consumers have given especially attention to this kind of applications, not only to ensure that the quality of the product is good but also to obtain information of the food product (e.g. country of origin, month of harvest).

Some forecasts predict that intelligent packaging will be the fastest growing segment of smart packaging, mostly because of increasing use of indicators, especially time-temperature indicators, and by intelligent systems offering product differentiation, traceability and other interactive features at more affordable prices.

FUTURE DEVELOPMENT

The enhancement of the known systems using nanotechnology, printed electronics and photonics that will lead to cheap materials with high capacity to detect and measure changes on food products. Intelligent packaging won't be used only to control the effectiveness of active packaging systems but also to trigger a desired function of the active packaging, and to release the active compound only if needed.

The integration of several functions within only one device and the development of new functions, e.g., systems able to communicate the presence of potential allergens, warnings related to diet management, and error prevention alerts.

Internet of everything (IoE) (new concept that aims at a world-wide network of interconnected objects provided with sensors and RFID tags), resulting in an advanced food safety management system (e.g. HACCP) that will be able to monitor food loss and food waste, identify potential hazards and conduct biohazard analysis and recommend controls, critical limits, and appropriate corrective actions when a deviation occurs.

INTELLIGENT PACKAGING LEAFETS

A series of short-text leaflets on the topic of intellignet packaging has been published.

On the right, there are clickable links to web versions of the ActInPak's Intelligent packaging leaflets in various languages named after their country of origin.

English

Bulgaria

Croatia

Netherland

Slovakia

Slovenia

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More information on this topic can also be found in the book:

Cerqueira, M.A., Lagaron, J.M., Pastrana, L.M., Martins De Oliveira Soares Vicente, A.A. (2018). Nanomaterials for Food Packaging: materials, processing technologies and safety issues. Micro & Nano Technology Books. Elsevier.
Web: https://www.elsevier.com/books/nanomaterials-for-food-packaging/cerqueira/978-0-323-51271-8

COST FP1405 ActInPak aims to identify and overcome the key technical, social, economic and legislative barriers to a successful deployment of renewable fibre-based functional packaging solutions such as active and intelligent packaging. Currently, 43 countries are involved in the network, with participants representing 209 academic institutions, 35 technical centers, and 83 industrial partners.

For more information, please visit the ActInPak website:

www.actinpak.eu

COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

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