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Antibacterial labels: How nano-technology can save your life

Abstract

The nano-technology makes it possible to produce antibacterial in-mould labels (IMLs) by applying a coat of colloidal nano-silver particles in the production process. IMLs have become an indispensable part of food packaging industry due to their aesthetic appearance and durable character. When combined with the antibacterial properties, they could become a solution of choice in situations when reducing the risk of bacteria contamination is a major concern (i.e., food or medical industries).

Key words: *In-mould label, IML, nano-technology, nano-silver particles, antibacterial properties, food packaging*

Introduction

According to the Department for Environment, Food and Rural Affairs (DEFRA), in the United Kingdom nearly one million of food-borne illness cases are reported each year. In about 20 thousand of them hospitalization is required, while 500 people will die of related complications (a). One of the key aspects of food quality preservation and contamination control is its proper storage (b). Due to the food safety concerns, and in reaction to the increased customer awareness and demands, food packaging industry is continuously searching for ground-breaking technologies that will help protect food from dangerous contamination and extend food's usable shelf life. (c). In addition, the ever-changing, tougher legislation forces food packaging producers to reach for the newest, safest materials available on the market[1].

Packaging food is the last step of food processing, which together with temperature control and enforcing time regimes concerning the 'best use before' along with rapid distribution, should guarantee, or at least significantly increase food safety.[2] However, a container, including its label, can be a source of significant microbiological hazard, dangerous to human health or, in severe cases, even life. Bacteria, yeast, fungi or must (mold) can find their way to the outside of the container and subsequently contaminate its content while unsealing or opening of the con-

[1] J. Brennan, G. Kelly, A. Martinez, *Tough choices for consumer-goods companies*, McKinsey Insights, December 2013; http://www.mckinsey.com/insights/consumer_and_retail/tough_choices_for_consumer_goods_companies

[2] I. Steinka, *Wpływ interakcji opakowanie–produkt na jakość mikrobiologiczną hermetycznie pakowanych serów twarogowych*, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2003.

tainer.[3] Recognizing the gravity of the situation, the field of nano-technology (the science dealing with the properties of materials with an extremely small particle sizes; smaller than 10–9 particles per meter, ppm) has recently entered the food packaging production industry. One of the early adopters of this promising new technology is a well established printing firm located in northern Poland, which is heavily vested in the development of the antibacterial labels.

Antibacterial properties of nano-silver particles

Silver (Ag) owes its valuable active properties to the interaction forces of its surface and is mostly used in the form of flakes. The bacteria fighting efficiency of silver is related to the value of the threshold surface, which indicates the concentration of the metal elements required to provide antibacterial protection. The dynamic developments in the nano-technology has introduced new and very promising application of nano-silver particles as the material that possesses antibacterial properties. Based on a number of tests performed by various laboratories, it was established, that applying nano-particles of silver in an amount of 10–50 ppm stops replication of bacteria from the group of Gram-positive as well as Gram-negative bacteria (Figure 1).[4]

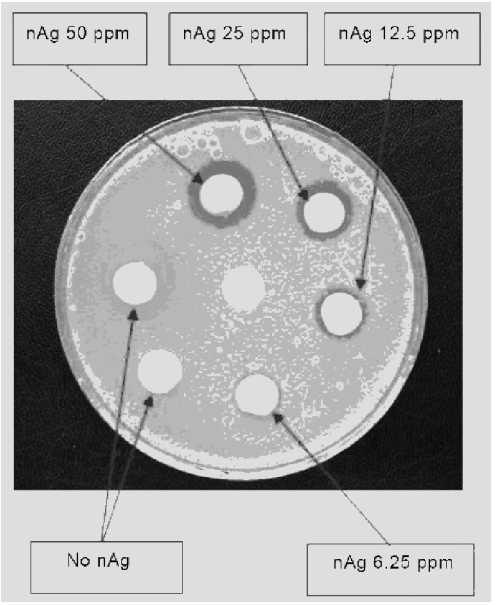

Figure 1.
Growth of Bacillus subtilis bacteria and its inhibition in presence of nano-silver

Making of antibacterial labels

The antibacterial label printing starts on a sheet-fed offset machine using special inks, cured in a dedicated, proprietary process. It allows for elimination of harmful photoinitiators that can be the source of bacteria migration (i.e., when traditional inks are cured with the ultra violet (UV) light); it also eradicates most of the harmful radiation.[5] The oxidative curing of the printed labels allows for maintaining print quality and preserving labels' protective properties. Good ventilation ensures equal access to every sheet of labels and makes their separation easier during the subsequent production stages. A critical part of antibacterial label making

[3] M. E. Doyle, C. E. Steinhart, B. A. Cochrane, Food safety, Marcel Dekker Inc., New York 1994.
[4] *Wykorzystanie lakieru dyspersyjnego z dodatkiem wodnego roztworu koloidalnego nanosrebra w procesie produkcji etykiet IML z odpowiednią grubością warstwy biobójczej – opinia techniczna*, Przedsiębiorstwo Amepox, Łódź 2013.
[5] The Swiss ordinance 817.023.21 on materials and articles intended to get into contact with food.

process is spraying them with the biocidal solution, which takes place on a separate, dedicated machine. The next stage involves precise die cutting, which will ensure labels' firm fuse with the containers. finished labels are then counted, checked for quality and packaged.

Multi-stage control of the production environmental parameters

A crucial element of the antibacterial label production is control of the environmental parameters, such as temperature and relative air humidity levels. Good ventilation of the production area should induce hyper pressure, which will keep the air impurities from this area. Air conditioning, ventilation, humidifying and heat disposal all help control the environmental parameters and make it possible to produce antibacterial labels under otherwise less than ideal conditions. A well designed, certified production environment parameters control system not only enables precise measurement of the external conditions, but also ensures protection from the electrostatics. Combined, these controls create optimal antibacterial label production conditions.[6]

Advantages of using the MILs with the bacteria control layer

Antibacterial labels can help protect container's content from microorganisms and extend food shelf life, even the container was opened, thanks to the integral biocidal and bacteriostatic properties gained by applying colloidal silver in the amount of 10–50 ppm to a varnish layer.[7] Added in a separate process, additionally varnish makes it compliant with the demands of the European Printing Ink Association (EuPIA) and the European Union's directives on specifications for materials that come in contact with food.[8] The unique structure of anilox, which is used to ensure even spread of the antibacterial layer, additionally provides protection from microbes on the entire surface of the label. It also improves label's resistance to mechanical damage.[9] Most importantly, adding the antibacterial layer is not detrimental to the remaining production stages (in-moulding). The antibacterial layer is resistant to high temperatures, which is vital since high temperature is an unwanted side effect of the in-moulding process. When properly stored and handled, the antibacterial labels are water-resistant and reasonably immune to the wide range of temperature and humidity changes. Exceptional dimension consistency combined with a long term life span (up to 1 year from the production date) are key advantages of using dedicated inks. These inks also provide high surface energy and preserve chemical neutrality of labels.

[6] *Ustalenie optymalnych parametrów środowiskowych produkcji etykiet antybakteryjnych: wilgotności oraz temperatury*, Raport wewnętrzny, 06.05.15.
[7] *Badanie aseptyczności etykiet IML z dodatkiem nanosrebra, otrzymanych na różnego rodzaju podłożach, w porównaniu do etykiet bez domieszki nanosrebra*, Raport wewnętrzny, 20.05.15.
[8] Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC.
[9] *Zakres prac badawczo rozwojowych przeprowadzonych z wykorzystaniem srebra koloidalnego,* Raport wewnętrzny, 15.10.2013.

Undoubtedly, material with such unique characteristics is of utmost interest of the food packaging industry. It is a response to the increased customer's demand for technologies that can help protect us from the food-borne illnesses.

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Streszczenie

Etykiety antybakteryjne: Jak nano-technologia może uratować życie

Nanotechnologia umożliwia wytworzenie bakteriobójczych etykiet IML (in-mould) dzięki nanoszeniu w procesie produkcji warstwy nanocząsteczek srebra koloidalnego. Etykiety IML stały się nieodzownym elementem opakowań dla przemysłu spożywczego z uwagi na swój estetyczny wygląd oraz trwałość. W połączeniu z właściwościami antybakteryjnymi mogą stanowić odpowiednie rozwiązanie w przypadku, gdy ograniczanie ryzyka skażeń bakteriologicznych jest bardzo ważnym problemem, np. w przemyśle spożywczym lub farmaceutycznym.