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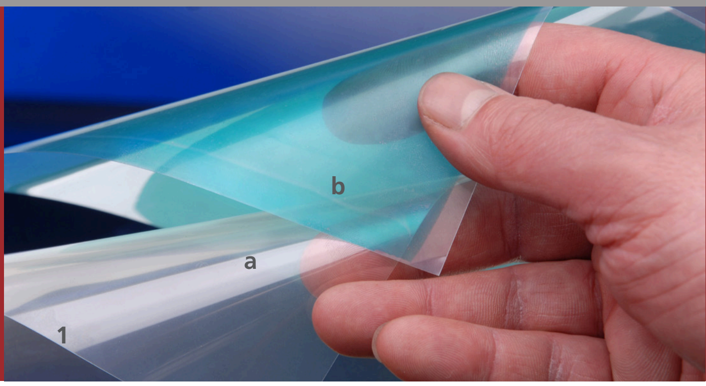


1 Colors of the indicator layer a: after UV activation, b: after reaction with oxygen

2 A possible active packaging concept containing an oxygen indicator as visible quality control for the consumer

Fraunhofer Institute for Silicate Research ISC

Neunerplatz 2
97082 Würzburg, Germany

Contact
Competence team
Hybrid Polymer Coating Materials

Dr. Sabine Amberg-Schwab
Phone +49 931 4100-620
sabine.amberg-schwab@isc.fraunhofer.de

www.isc.fraunhofer.de

OXYGEN SCAVENGER AND INDICATOR SYSTEMS FOR FOOD PACKAGING

The food packaging industry has an increasing demand for flexible and transparent polymeric materials due to their light weight, easy-to-handle properties and, most important, low cost. Our present lifestyle – and more so in future – demands a high diversity of convenience food products which should nevertheless be healthy, fresh and nutritious.

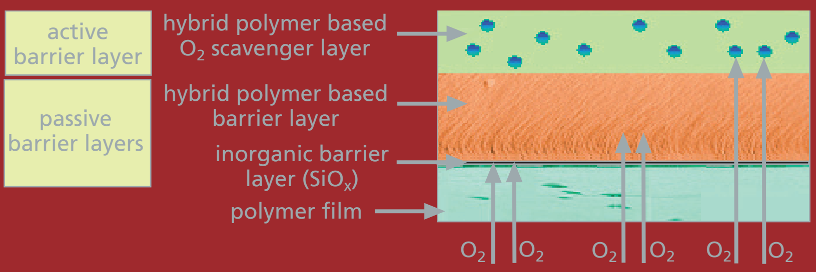
Oxygen, an essential part of the air surrounding us, reduces the quality and shelf-life of food products. Generally nutrient and flavor loss, browning or bleaching are observed. More typical for fatty foods is the development of rancidity and aerobic microbial growth can be a problem in meat, prepared dishes and juices.

Even very small amounts of oxygen, i.e. in the range of 1 – 200 ppm (mg/kg) may cause a substantial loss in food quality. In most packaging systems the level of residual oxygen lies between 0.1 % (1 000 ppm) in vacuum and 2 % (20 000 ppm) in gas flushed packs. Therefore, not only avoiding the access of oxygen to the filled goods is an important task, but also the reduction of levels already present at the time of packing.

The new approach

Oxygen penetrates the packaging via defects but also due to the inherent permeability of the packaging material. Suitable materials which can be used to solve these problems in food packaging combine passive barriers with active oxygen absorbers.

At present, these so called oxygen scavengers are incorporated in the packaging, by adding sachets or tablets. As these methods are not allowed in all countries and may also bother the consumers, a different concept is required.



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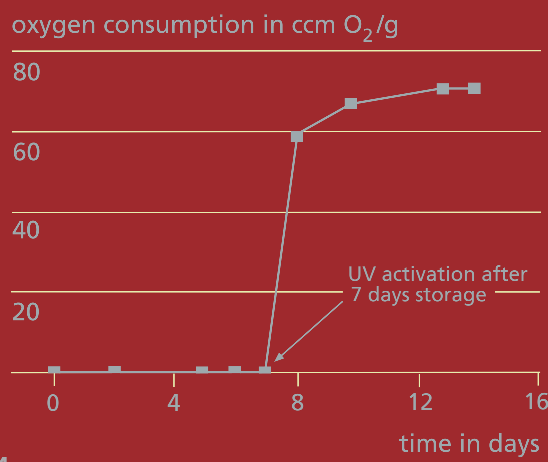

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The task is to ensure significantly higher barrier properties and to incorporate the oxygen scavengers homogeneously into the whole surface area of the packaging films.

A new combined oxygen indicator/-scavenger system for integration into packaging film materials should remove oxygen by means of the oxygen scavenger component and, simultaneously, monitor the functionality of the oxygen absorber and the integrity of the packaging by the oxygen indicator dye.

Active oxygen barrier layers

The functional principle of the newly developed oxygen scavenger system is based on a photo-initiated, metal catalyzed oxidation of a cyclo-olefin bonded chemically to a silicate backbone. This concept permits the activation of the scavenging process by UV light and prevents the formation of low-molecular weight oxidation products which may decrease the quality of the packaged goods or may even be toxic.

The coating material is formed in a one-step synthesis by hydrolysis of the corresponding alkoxysilanes. In addition, the resulting sol can be applied to any suitable film substrate by common coating techniques.

The evaluation of the coated, cured and then UV-activated films show an oxygen consumption of 77 ccm O_2/g layer (Figure 3). This value corresponds approximately to a 100 per cent theoretical oxidation rate.

To ensure sufficient shelf-life under air the coated samples were stored a couple of days and then activated. Their evaluation confirms oxygen consumptions comparable to non-stored ones. Keeping the coated films under daylight also has no influence on their oxygen uptake. Upon UV activation, these layers act as oxygen scavengers and provide both high oxygen uptake and fast oxidation kinetics.

Oxygen indicator layers

First a polymer matrix for incorporating the indicator dye – which changes its color in the presence of oxygen – had to be developed. The matrix must have a high oxygen permeability with an oxygen concentration threshold not higher than 2 %. The indicator dye used for the active layers was Methylene Blue (MB), the only redox dye for which genotoxic risks could be excluded by in vivo experiments at low dose levels.

Incorporated into a polymer coating matrix, the MB indicator dye can be applied on packaging films. After activation by UV light, the indicator layer is able to detect the presence of oxygen within the package (Figure 1).

Combining the two

The two active layers were combined within one laminate and were activated at the same time. The evaluations confirm that after UV-activation with an intensity of 6 - 7 J/cm^2 both layers were working.

Customer benefit

At a glance, consumers can judge the quality of packaged foods from the point of purchase to the point of consumption (Figure 2). Both shelf-life and quality of foods can be improved.

The developed coating materials can be integrated into packaging processes, so that the new active oxygen barrier layers are particularly suitable for food packaging.

By combining the passive barrier layers based on hybrid polymers with newly developed active oxygen barrier layers it may also be possible to make these barrier films available for new fields of applications. A future target is to create a new »zero transmission«" laminate, e.g. for flexible OLEDs and organic solar cells.

3 Schema: Combination of passive barrier layers with an active oxygen barrier layer to create »zero oxygen transmission« laminates

4 Scavenging activity of the scavenger system after seven days of storage under air and subsequent UV activation. Not activated coated samples stored for 2, 5 and 6 days show no oxygen consumption. Usual coating thickness: 3 – 4 µm