Tools for the design and uses of materials

PO-057 - (26) - ECOPACKLAB: A NEW LABORATORY FOR THE DEVELOPMENT OF NEW ACTIVE FOOD PACKAGING

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Introduction

The substitution of synthetic materials with eco-friendly products (derived from renewable resources, biodegradable, compostable) is attracting much interest in the food packaging industry, a field characterized by high production volumes. Beyond the ecological aspect, an innovative improvement for the new generation of food packaging is the possibility of enhancing the product shelf-life without adding any or lower conservative agents in the food's formulations. One of the main factors responsible of food degradation is oxygen, and usually the bio-compostable packaging material doesn't have a high barrier against it.
In order to produce/obtain an eco-friendly and active packaging with high oxygen barrier properties, we developed EcoPackLab, a Laboratory dedicated to the design and production of new food packaging, by exploiting the surface enzyme immobilization technique, an approach which is used in many field to prolong enzyme stability, increasing their efficiency. The main facility that we are implementing is an industrial machine able to produce a multilayer film, which consists of two layers of a biodegradable polymer with in between a thin active gel able to catalyse the absorbed oxygen. The machine is set up with an in-line cold plasma source, pivotal for the realization of homogeneous coating and multilayer coupling. Moreover, in order to monitoring the efficiency of the coating layer, we developed a sensor based on a conductive polymer that can be easily printed on the film and used as in-line characterization.

Materials and Methods

The multilayer is composed of two films of Polylactic acid (PLA) with a thickness of 30 um. The active gel coating consists of glucosidase and glucose dissolved in a matrix based on 10% v/v of Polyvinyl alcohol in distilled water. Different concentrations of glucose and glucosidase dissolved in PVOH were opportunely chosen to fulfill specific food product requirements to maintain high quality levels during shelf-life. In order to homogenously distribute the film coating, the PLA is treated by means of a non-equilibrium ("cold") atmospheric pressure plasma that increases the contact angle of the surface allowing the deposition of a water based gel. The sensor used for the in-line characterization is based on a conductive polymer Poly(3,4-ethylenedioxythiophene) – poly(styrenesulfonate) (PEDOT : PSS) purchased by Cleviou Hareous. PEDOT:PSS is dispersed in water, and can be deposited as an ink on hydrophilic surfaces such as plasma treated PLA.

Results and Discussion

In the EcoPackLab laboratory we developed a prototype film- forming machine for a new active and eco-friendly packaging endowed with high barrier oxygen proprieties. The oxygen barrier is obtained by including in the multilayer film system a gel layer containing glucose and glucosidases, an enzyme that catalyzes the oxygen consumption. Both glucose and enzyme are dissolved in a polymer matrix based on PVOH 10 % v/v dissolved in water. This matrix in a gel form preserves the activity of the enzyme and at the same time can be easily deposited by a roll two roll technique. To guarantee an uniform coating, the hydrophobic PLA film has been treated by means of cold plasma. The treatment is performed in air with an in-line plasma source included in the film-forming machine. The main effect of the plasma treatment is to increase the number of alcohol and methyl groups, enhancing the contact angle and guaranteeing a perfect coating with the active gel solution. After the active gel coating step, the second layer of PLA is used to close the multilayer. This procedure has been designed to guarantee no contact between food product and the active gel. This is

crucial for two main reasons: first, any products resulting from the catalyzed glucose oxidation might enter in the packed food, altering its composition and sensorial characteristics. Secondly, different foods to pack can have pH value not suitable for the specific enzymatic reaction or compounds/ingredients that can interfere affecting its efficiency in catalyzing and consume the oxygen excess. Therefore, the incorporation of the enzyme and the glucose in the PVOH matrix keeps a perfectly closed environment preserving the food with very high efficiency. Finally, in order to *in situ* characterize the efficiency of the oxygen barrier a sensor was easily inserted inside the multilayer by means of a simple fabrication process, included in the film-forming machine. To do that, we developed a sensor based on a conductive polymer PEDOT:PSS , used as a water based ink, that can be printed on the PLA film, previously treated with cold plasma to increase its hydrophilicity. The PEDOT:PSS is sensitive to the charge exchanged during the catalyzed reaction of glucose with oxygens and can be fast detected measuring a variation on the current flowing in the sensor

Conclusion

The EcoPackLab is an innovative laboratory where new biodegradable and biocompostable films for active food packaging can be developed. We demonstrated the possibility to produce eco-friendly multilayer films able to prolong the shelf-life of food products, acting as oxygen scavenger. The new active packaging consists of two layer of biodegradable PLA films coupled by means of a cold plasma treatment with an active coating based on glucose and glucosidase enzyme dispersed in PVOH matrix. The final multilayer of PLA, with high oxygen barrier, being totally biodegradable, can perfectly implement a “green” food packaging.

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