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Smart and Active Package Integrating Printed Electronics

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Abstract : In this paper, the results of R&D on an innovative food package for increased shelf-life are presented. SAP4MA aims at the development of a printed active device that enables smart packaging solutions for food preservation, targeting the extension of the shelf-life of the packed food through the controlled release of active natural antioxidant agents at the onset of the food degradation process. To do so, SAP4MA focuses on the development of active devices such as printed heaters and batteries/supercapacitors in a label format to be integrated on packaging lids during its injection molding process, promoting the passive release of natural antioxidants after the product is packed, during transportation and in the shelves, and actively when the end-user activates the package, just prior to consuming the product at home. When the active device present on the lid is activated, the release of the natural antioxidants embedded in the inner layer of the packaging lid in direct contact with the headspace atmosphere of the food package starts. This approach is based on the use of active functional coatings composed of nano encapsulated active agents (natural antioxidants species) in the prevention of the oxidation of lipid compounds in food by agents such as oxygen. Thus keeping the product quality during the shelf-life, not only when the user opens the packaging, but also during the period from food packaging up until the purchase by the consumer. The active systems that make up the printed smart label, heating circuit, and battery were developed using screen-printing technology. These systems must operate under the working conditions associated with this application. The printed heating circuit was studied using three different substrates and two different conductive inks. Inks were selected, taking into consideration that the printed circuits will be subjected to high pressures and temperatures during the injection molding process. The circuit must reach a homogeneous temperature of 40ºC in the entire area of the lid of the food tub, promoting a gradual and controlled release of the antioxidant agents. In addition, the circuit design involves a high level of study in order to guarantee maximum performance after the injection process and meet the specifications required by the control electronics component. Furthermore, to characterize the different heating circuits, the electrical resistance promoted by the conductive ink and the circuit design, as well as the thermal behavior of printed circuits on different substrates, were evaluated. In the injection molding process, the serpentine-shaped design developed for the heating circuit was able to resolve the issues connected to the injection point; in addition, the materials used in the support and printing had high mechanical resistance against the pressure and temperature inherent to the injection process. Acknowledgment: This research has been carried out within the Project “Smart and Active Packing for Margarine Product” (SAP4MA) running under the EURIPIDES Program being co-financed by COMPETE 2020 – the Operational Programme for Competitiveness and Internationalization and under Portugal 2020 through the European Regional Development Fund (ERDF).

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