Surface modification of biodegradable polymers by low temperature plasma for improving their performances as food packaging

Matteo Pedroni 1, Espedito Vassallo 1, Marco Aloisi 1, Milena Brasca 2, Pierfrancesco Cerruti 3, Hao Chen 4,5, Riccardo Donnini 6, Giuseppe Ghezzi 2, Francesco Ghezzi 2, Stefano Morandi 2, Silvia Maria Pietralunga 5,8, Tiziana Silvetti 2 and Teresa Virgili 8.

1 CNR - Institute for Plasma Science and Technology (Istp), Via R. Cozzi 53, 20125 Milan, Italy; 2 CNR - Institute of Sciences of Food Production (ISPA), Via G. Celoria 7, 20133 Milan, Italy; 3 CNR - Institute of Polymers, Composites and Biomaterials ( IPCB), Via G. Previati 1/C, 23900 Lecco, Italy; 4 Politecnico di Milano - Department of Physics, Piazza Leonardo da Vinci 32, 20133 Milan, Italy; 5 CNR - Institute of Condensed Matter Chemistry and Technologies for Energy (ICMATE), Via R. Cozzi 53, 20125 Milan, Italy; 6 University of Genoa - Department of Physics, Via Dodecaneso 33, 16145 Genova, Italy; 7 CNR - Institute for Photonics and Nanotechnologies (IFN), Piazza Leonardo da Vinci 32, 20133 Milan, Italy.

Biodegradable polymers are viewed as a promising eco-friendly solution to replace conventional plastic polymers as packaging materials, reducing the enormous environmental impact that the latter involve [1]. However, biodegradable plastics still occupy a rather restricted section of the plastic food packaging market due some limitations including their poor gas barrier and UV protection properties [2]. In fact, both oxygen and UV light lead to oxidation processes which affect food quality and produce toxic compounds [3,4]. In this regard, low temperature plasma technique can be exploited to fabricate multifunctional polymeric surfaces with significant enhanced performances. This approach is completely environmentally friendly avoiding the use of toxic solvents or high temperatures that could damage the polymer structure [5,6] and it is crucial to extend the use of biodegradable packaging and preserve the food quality. In this work we report on surfaces modifications of two commercial biodegradable polymers by low temperature plasma processes. In particular, tungsten oxide (WOx) thin films were deposited by plasma magnetron sputtering on poly(lactic acid) (PLA) in order to enhance its performances in terms of barrier to oxygen and UV light protection. The coated samples are characterized by an oxygen permeability and light transmittance in the UV-B region reduced of ≈ 90% compared to pristine PLA. Finally, plasma etching was employed to tailor the surface morphology of poly(butylene succinate) (PBS) resulting in a packaging with antimicrobial effect due to the nature inspired contact-killing mechanism. The treated samples showed excellent antimicrobial activity against 4 different types of bacteria, i.e., Escherichia coli, Pseudomonas fluorescens, Listeria innocua and Staphylococcus aureus, with a reduction greater than 5 log_{10} CFU cm^{-2} after 24 h.