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Antimicrobial Modification of LDPE Using Non-thermal Plasma

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Low-density polyethylene (LDPE) represents polymer having good chemical and physical characteristics for which it is widely used in many applications, such as biomedical and food packaging industry. This polymer excels by good transparency, flexibility, low weight and cost which makes it suitable material compared to non-polymer packaging materials. However, its hydrophobicity cause many limitations for antimicrobial activity which can result in absence of some characteristics required in food packaging applications. For that purpose, some researches have done experiments to modify the polymer surface to increase the surface free energy (hydrophilicity). This can be done by introducing some polar functional groups into the LDPE surface which will permit an increment of its surface free energy and so its wettability or adhesion without any disruption in its bulk properties [1]. One of the most preferable modification techniques is known as non-thermal radio-frequency discharge plasma, and it is preferred technique due to the ability to modify only thin surface layer leading to noticable improvement of the surface properties [2]. Moreover, it represents environmentally friendly technique since it does not require the use of any hazardous chemicals or dangerous radiations and therefore non-thermal plasma is highly recommended for food packaging applications [1]. In addition, the surface modification of LDPE can lead to the enhancement of the antimicrobial activity, which was the main purpose of this research. Food packaging materials requires preventing any growth of bacteria, fungal, or any other microbial organisms for health and food safety. Some approved preservatives are commonly used directly in foods to preserve them form microorganisms growth and spoilage. Nowadays, some innovative ways are applied to graft acrylic acid on polymers surfaces [3] for biomedical applications to create an effective layer for an immobilization of antibacterial agents and this results in bacteria prevention on the LDPE surface. In this research, we focused on grafting of sorbic acid as one of the most commonly used preservatives in food and beverage for being safe, and effective in bacteria inhibition (whether pathogenic strains or spoilage kinds), molds, and yeasts [4]. It is also used in cosmetic industries since it has good compatibility with skin and it is easily usable [5]. For the potential enhancement of the antimicrobial efficiency, chitosan representing antimicrobial agent

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was used for the immobilization on sorbic acid created layer. Chitosan (a derivative of chitin polysaccharide) was chosen as a natural occurring antimicrobial agent (from crabs shrimps, and other sea shells [5]) that has strong and effective antimicrobial activity along with its nontoxicity, biofunctionality, biodegradability, and biocompatibility [6]. In this study, the LDPE surface was modified by several modification steps. The first step involved the modification of the LDPE surface by non-thermal radio-frequency discharge plasma as a radical graft initiator for the subsequently polymerization of sorbic acid containing double bonds. In the next step, grafting of sorbic acid was carried out immediately after plasma treatment allowing the interaction of plasma created radicals on LDPE surface with sorbic acid. Final step was focused on the immobilization of chitosan on grafted sorbic acid platform. Each modification step was analyzed by different analytical techniques and methods to obtain detailed information about the modification process. The surface parameters changes after modification of the LDPE surface, such as surface free energy (contact angles measurements), graft yield (gravimetric measurements) surface morphology (scanning electron microscopy and atomic force microscopy) and chemistry (Fourier transform infrared spectroscopy with attenuated total reflectance) were obtained allowing understanding the modification process.

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