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Modification of the bacterial adhesion of *Staphylococcus aureus* by antioxidant blooming on polyurethane films

Johanna Saunier [a,*], Jean-Marie Herry [b,c], Christian Marlière [d], Margareth Renault [b,c], Marie-Noëlle Bellon-Fontaine [c,b], Najet Yagoubi [a]

[a] IFR 141, EA 401, UFR de Pharmacie, Université Paris Sud, 92290 Chatenay Malabry, France
[b] INRA AgroParisTech, UMR 1319 MICALIS, équipe B2HM, 91300 Massy, France
[c] AgroParisTech INRA, Institut MICALIS, équipe B2HM 91300 Massy, France
[d] ISMO, UMR CNRS 8214, Université Paris Sud, 91405 Orsay Cedex, France

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ABSTRACT

Medical device-related infections are a major problem in hospital. The risk of developing an infection is linked to the bacterial adhesion ability of pathogen strains on the device and their ability to form a biofilm. Here we focused on polymer surfaces exhibiting a blooming of antioxidant (Irganox 3114® and Irganox 1076®) on their surface. We tried to put into evidence the effect of such a phenomenon on the bacterial adhesion in terms of number of viable cultivable bacteria and bacteria localization on the surface. We showed that the blooming has a tendency to increase the *Staphylococcus aureus* adhesion phenomenon in part for topographic reasons.

1. Introduction

The nosocomial diseases are an important health concern having a lot of human, social and economic consequences. A great part of these infections results from the catheter use. Catheters are for most of them made of polymers such as polyvinylchloride (PVC), polyurethane (PU) or polysiloxane. They can moreover contain additives such as antioxidants (AOs) or lubricants. The ratios of these additives in the polymer bulk are very low (commonly less than 0.5%). However, as these additives are generally not soluble in the polymer matrix at the ambient temperature, they can diffuse through the polymer matrix after catheter processing, bloom onto the surface [1] and be present at very high concentration on the surface. As a consequence, the surface can be richer in additives than the bulk. This blooming can thus impact the material surface properties such as roughness, chemical composition, hydrophobicity, charge and stiffness. These surface properties are known to impact the bacterial adhesion [2–4]. The blooming of Irganox 1076® (antioxidant) has for instance been observed on the surface of Pellethane® catheters after a long cold storage [5] and was implicated in the modification of some properties of the medical device [6,7]; modification of Biomer® catheter surface composition because of antioxidant blooming has also been put into evidence by Tyler et al. [8]. Moreover, an exudation of a bis amide lubricant and its effect on platelet adhesion and thrombi [9–12] have been observed for Pellethane® catheters. However, although this blooming phenomenon on polymer is known, there are only few studies on its impact on biocompatibility and bacterial adhesion.

In this study we focused on a Pellethane® polymer, a poly(ether urethane) used in catheters and on the impact of blooming of two antioxidants on the bacterial adhesion of a pathogen bacterium. We worked on *Staphylococcus aureus* because it is often implicated in nosocomial diseases and is one of the most healthcare concerns in the clinic. This gram + coccus is a versatile and virulent pathogen that is very dangerous for human. It can cause a wide range of infections from moderate to highly severe ones and has a great ability to become resistant to antibacterial agents.

We worked on spincoated films of polymer in order to better control the surface state. To promote the blooming of antioxidant on our samples and to obtain different surface coverages of the PU films by the AO, several very high antioxidant ratios were used. Bacterial adhesion was studied by counting viable adherent bacteria and by

* Corresponding author at: Faculté de pharmacie, 5, Rue Jean Baptiste Clément, 92290 Chatenay Malabry France.
E-mail addresses: johanna.saunier@u-psud.fr (J. Saunier), jean-marie.herry@jouy.inra.fr (J.-M. Herry), Christian.marliere@u-psud.fr (C. Marlière), margareth.renault@jouy.inra.fr (M. Renault), marie-noelle.bellon-fontaine@agroparistech.fr (M.-N. Bellon-Fontaine), najet.yagoubi@u-psud.fr (N. Yagoubi).

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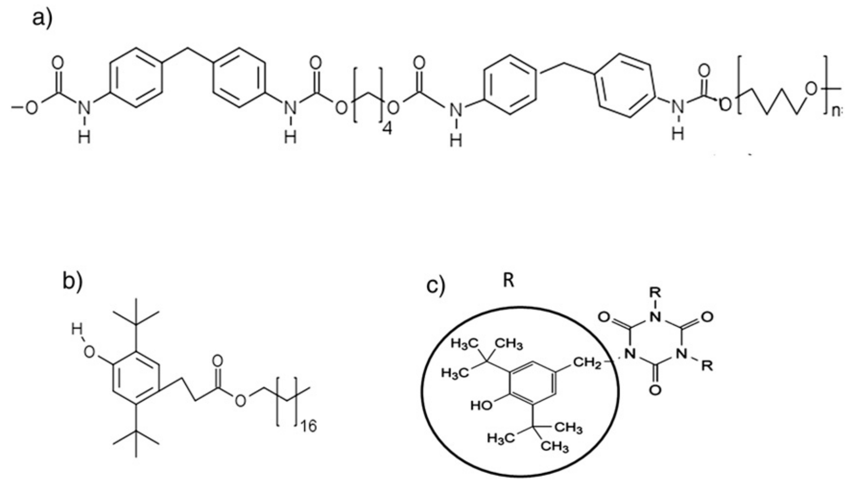

Fig. 1. Formula of a) polyurethane used b) Irganox 1076® and c) Irganox 3114®.

epifluorescence microscopy. Moreover the sample roughness, stiffness and adhesion were characterized by Atomic Force Microscopy (AFM). Contact angle measurements were realized at different scales to study the hydrophobicity of the surface. The aim of this study was to see whether adhesion was promoted by blooming, whether the nature of antioxidant was important in the adhesion phenomenon and what kind of parameters (topography, hydrophobicity…) had a major effect on the adhesion in the case of a surface with blooming.

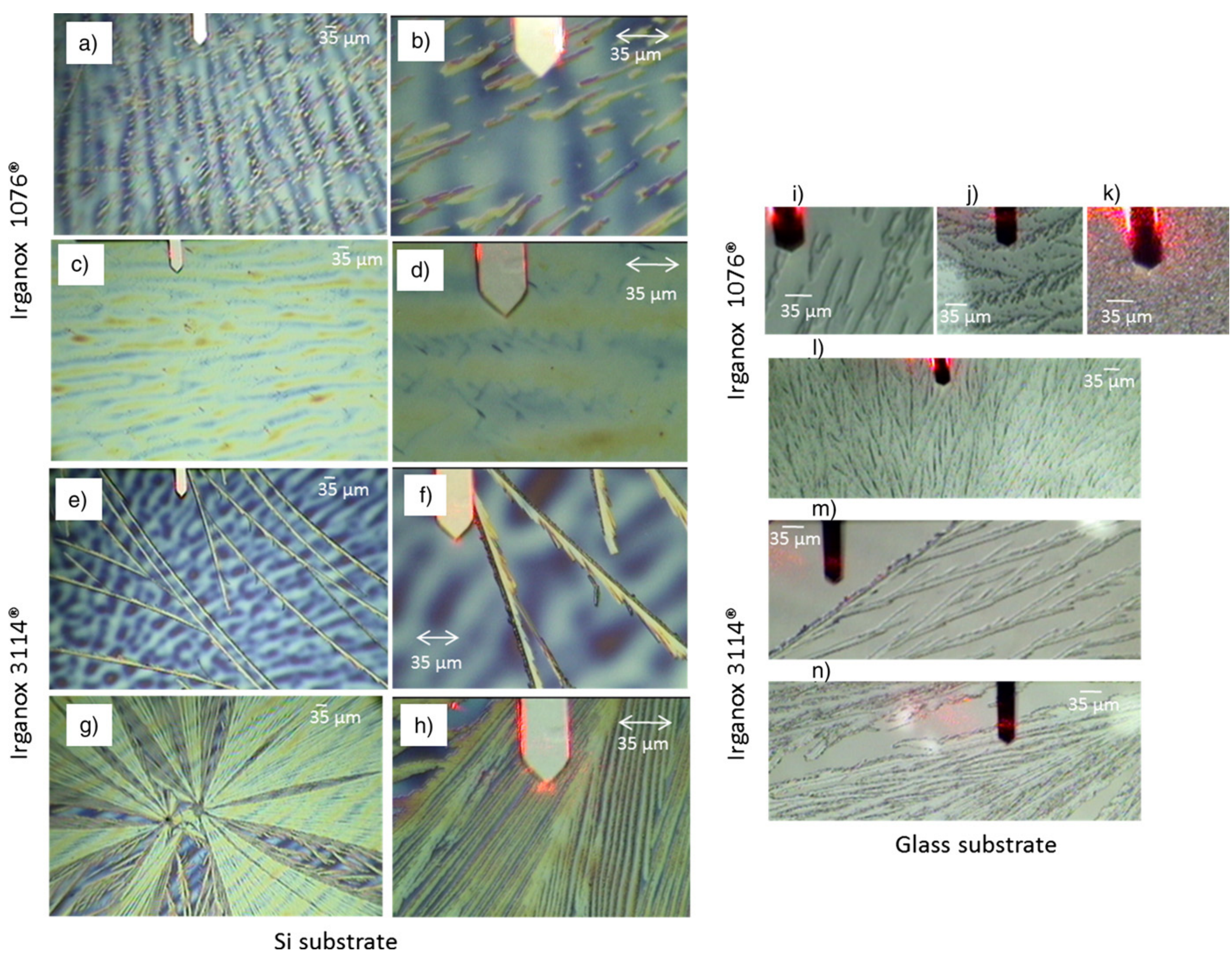

Fig. 2. Optical images of the spincoated films with AO blooming. a, b) PU film with Irganox 1076® ($q = 0.2$) spincoated on Si, c, d) PU film with Irganox 1076® ($q = 0.5$) spincoated on Si, e, f) PU film with Irganox 3114® ($q = 0.2$) spincoated on Si, g, h) PU film with Irganox 3114® ($q = 0.5$) spincoated on Si, i) j, k) PU film with Irganox 1076® ($q = 0.2$) spincoated on glass showing the blooming heterogeneity for this sample, l) PU film with Irganox 1076® ($q = 0.5$) spincoated on glass, m) PU film with Irganox 3114® ($q = 0.2$) spincoated on glass, n) PU film with Irganox 3114® ($q = 0.5$) spincoated on glass.