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PII: S0169-4332(17)31000-0
DOI: http://dx.doi.org/doi:10.1016/j.apsusc.2017.04.015
Reference: APSUSC 35687

To appear in: *APSUSC*

Received date: 28-10-2016
Revised date: 30-3-2017
Accepted date: 1-4-2017

Please cite this article as: Pieter Cools, Heidi Declercq, Nathalie De Geyter, Rino Morent, A stability study of plasma polymerized acrylic acid films, Applied Surface Sciencehttp://dx.doi.org/10.1016/j.apsusc.2017.04.015

A stability study of plasma polymerized acrylic acid films

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Highlights

- Plasma polymerization at medium pressure of acrylic acid based coatings on polymer surfaces
- Systematic study of the effect of plasma parameters on coating stability
- Full surface characterization using FT-IR, XPS and OPS
- Linear increase in deposition time.
- Visual tracking of coating dissolution through fluorescence staining
- Significant effects of coating instability on HFF in-vitro performance

Abstract
A medium pressure parallel-plate DBD set-up was used for the deposition of carboxylic acid-rich films using acrylic acid as precursor. A variety of discharge powers (21-33 W) and monomer flow rates (0.25-0.5 g/h) were applied to develop a range of coatings from highly unstable to completely stable in aqueous solutions. FT-IR and XPS were used to identify which coatings were stable under dynamic incubation conditions and what influence plasma operating parameters had on functional group preservation. White light interferometry was also used to calculate deposition rates (66-126 nm/min) and to determine the deposition regime (monomer deficient). Human foreskin fibroblasts were seeded onto the complete range of investigated samples and the effects of coating (in)stability on cell adhesion, viability and morphology were systematically studied. Results showed that the 27 W-0.25 g/h treatment conditions resulted in the most stable coatings. Although a concentration of only 0.7% of carboxylic acid groups was found under these experimental conditions, the positive effects of a highly acid-rich surface were still maintained as cell-material interactions were significantly enhanced.

Introduction
The development of plasma polymerized coatings at medium and atmospheric pressure has gained increasing interest in the last decade. Compared to low pressure plasma systems, it offers an economical advantage due to the absence of extensive vacuum equipment. Its lack of any solvents and its extremely low consumption of precursor make it also a more ecologically benign technique compared to traditional wet chemistry [1-7].
The deposition of carboxylic acid-rich coatings, using an acrylic acid precursor, has been studied extensively by the plasma community, as it is of high interest for biomedical applications [8-20]. The coatings are well-liked by a wide variety of cells and can thus strongly enhance cell adhesion, cell proliferation and differentiation [21, 22]. Furthermore, they can be used to immobilize a range of (bio)macromolecules such as collagen, gelatin, fibronectin, RGD peptides, ... with relative ease [15, 23-25]. The main issue concerning plasma polymerized acrylic acid coatings however is their stability in aqueous media. If deposited using improper plasma operating parameters, the coating will rapidly dissolve, not only nullifying the effect of the coating, but also significantly acidifying its immediate surroundings. This acidification is a major concern in biomedical applications as it is known to have detrimental effects on cells and tissues, similar to what is observed during infection [26, 27]. Several researchers have tried to increase the coating stability by applying very harsh plasma operating conditions (high discharge power per monomer molecule) to increase the cross-linking degree of the coatings, however, in that case, also extensive functional group fragmentation was observed [8, 17, 28-30]. This often results in coatings that do not contain any of the desired carboxylic acid groups