INFLUENCE OF SURFACE MODIFICATION OF 316L MEDICAL STEEL ON MICROBIAL ADHESION

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Introduction

316L steel is a material that is often used in the production of medical instruments. When examining the microbiological properties of such materials, efforts are made to reduce the adhesion of bacteria to their surface in order to avoid negative reactions in contact with the human body. One way to achieve the reduction of microbial adhesion to the surface is to reduce the contact area between pathogens and material using various methods of surface topography modification. The investigations presented in the article are a part of this trend of research on the impact of surface modification of 316L steel on microbial adhesion [1].

Materials and Methods

The test samples were divided into three groups depending on the method of surface preparation. The first one was 316L steel (reference test). The second group was subjected to the electro-etching process in an aqueous solution containing 100 g/l H_2SO_4, more than 15 g/l Fe3+, 25 g/l HF and about 1 g/l of additives (emulsifiers, wetting agents, corrosion inhibitors) [2]. The third group was mechanically processed on rotary grinders. All samples before etching were cleaned and washed in 98% acetone in an ultrasonic cleaner. The etching of 316L steel surface was performed with a mixture of nitric and hydrofluoric acids (10% HNO_3 and HF 5%). The etching temperature was 50°C with continuous mixing for 5, 10, 15 minutes consecutively.
The bacteria used in the study came from the American Type Cultures Collection: *Staphylococcus aureus* ATCC 25922, *Escherichia* coli *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853. The contact angle was measured using a goniometer with DROPimage Advanced software. The antimicrobial activity of the coatings was assessed by a direct method based on the criteria in ASTM E2922. The susceptibility of the coating surface to microbial adhesion was assessed in accordance with the procedures contained in the ISO 22196: 2011 standard with modifications related to the assessment of microbial viability.

Results and Discussion

The assessment of the contact angle of the tested samples showed their hydrophilic character. The contact angles range from about 50 degrees (49.1) to over 80 degrees (80.8). Samples whose surface was not pre-treated (reference) and mechanically ground show the same tendency. The contact angle increases with increasing chemical etching time. The trend is reversed for samples subjected to the electro-polishing process - the contact angle decreases with increasing etching time.
The assessment of bacterial adhesion to the surface of 316L steel (FIG. 1, TABLE. 1) showed the highest adhesion to the surface of unmodified (reference) samples, and to samples after a treatment time of 5 minutes, for both surface preparation methods, ie. electro -polishing and mechanical grinding. Of the tested bacteria, Escherichia coli was found to be the most numerous on the tested samples.

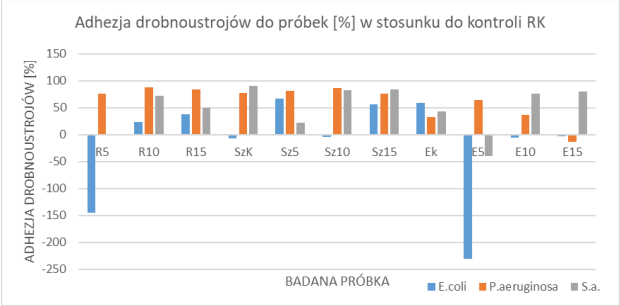
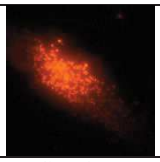
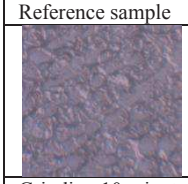
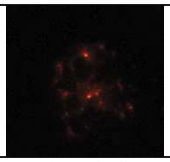
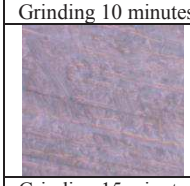
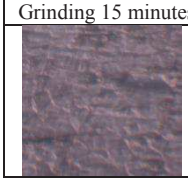


FIG. 1. Microbial adhesion to samples.

TABLE 1. Microbial adhesion to samples.

Sample images	
Optical microscope magnification 400x	Fluorescence microscope magnification 400x
Electro -polishing 5minutes	*E.coli* Electro -polishing 5minutes
	
Reference sample	E.coli Reference sample
	
Grinding 10 minutes	*E. colic* Grinding 10 minutes
	
Grinding 15 minutes	*E.coli* Grinding 15 minutes
	

Conclusions

The presented research makes it possible to indicate both the etching and the processing method of 316L steel for further surface modification in terms of its microbiological properties.

References

[1] K. Mydłowska, E. Czerwińska, A. Gilewicz, E. Dobruchowska, E. Jakubczyk, Ł. Szparaga, P. Ceynowa, J. Ratajski: Evolution of Phase Composition and Antibacterial Activity of Zr–C Thin Films. Processes 8(3) (2020) 260. doi:10.3390/pr8030260/
[2] C. Pedrazzini, P. Giordani: „Patent US5843240A”, 1998.