Wettability of Stainless Steel Processed Titanium and Molybdenum Ions

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Abstract – Purpose of work is study of wettability of samples processed by ionic implantation. In the paper wettability was determined by optical method. Wetting angles was determined by using the camera for three types of fluids: water distilled, ordinary tap water and mineral sparkling water. Due to the research it was found that the contact angle of droplets of distilled water for implants less than for steel. This is consistent with theoretical predictions, because roughness increases during implantation. In the case of tap water difference between contact angles decrease. Taking mineral sparkling water wettability of implants compared to untreated samples deteriorates.

Key words – wettability, ionic implantation, implants, contact angle, titanium ions, molybdenum ions.

I. Introduction

The phenomena of wetting plays an important role in everyday life and technology. Many mechanisms come into contact with liquids. Good wetting is required during dyeing, washing, brazing, enrichment of ores of valuable species and other technical processes [1]. Poor wetting can be used in many industries in the manufacture of mixtures or for production of hydrophobic surfaces [2]. Icing depends on wetting [3].

Wettability is very important in the interaction surfaces between them. Wettability can be changed from changing the physical properties and chemical composition of the surface and fluid [4, 5].

When the properties of the surface change its roughness (a set of surface irregularities) also changes [6].

Ion-plasma technologies is included to the modern technologies, which directly affect the microgeometry solid surface [7, 8]. Recently, ionic implantation increasingly gain popularity among effective electric vacuum technologies based on ion fluxes [7-8].

II. Experimental part

Samples was synthesized in a vacuum chamber. The process taked place at a voltage of 20 kV in source of ions and 300B on the target. Due to this magnetic field was formed and ions of the target (Ti, Mo) are knocked by nitrogen ions. The energy produced in the transformer.

Samples were treated by titanium and molybdenum ions to a dose $4 \div 5 \times 10^{17}$ ions / sm^2. The depth of the modified layer is less than 1 micron, ie weight of implants almost isn't changed.

Then experimental studies taked place.

Liquid (water) was dropped on implant in volume of 0.1 ml. White screen was placed perpendicular to the sample and behind it (Fig. 1).

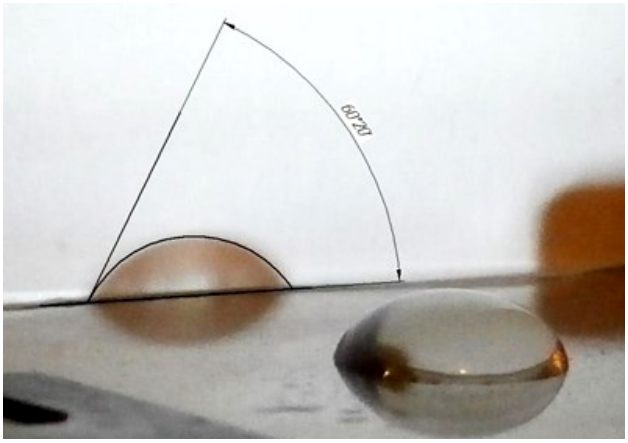

Fig. 1. The scheme of contact angle measurement

The results were recorded by the camera Olimpus VG-170. The experiment was performed for the original steel and implant. Used three types of water: tap water, distilled and mineralized.

Processing of results was carried out on a computer using the "КОМПАС-3D LT" [9]. Contact angle θ, diameter d and height h drops were measured. The drop was measured using a shadow that appeared on the screen (Fig. 1).

Analytical verification of the results was carried out using the formula of Young-Laplace (Eq. 1):

$$\cos\theta = \frac{(d/2)^2 - h^2}{(d/2)^2 + h^2} \quad (1)$$

To detect correlation between wetting and roughness analysis of surface characteristics was carried out through software «Gwyddion» [10]. This program makes it possible to calculate the roughness and create a 3D model of the surface. The surface was studied with a microscope "MIM-7", equipped with a camera.

III. Results and discussion

In the experiments it was found that the wetting angle depends on the nature of the ion and fluid. In the case of tap and distilled water contact angle decreased to implant with titanium and increased for the implant with molybdenum. That is the first sample wettability increased, the second - reduced. At change of temperature angles values change, but accordance remains (Fig. 2, 3).

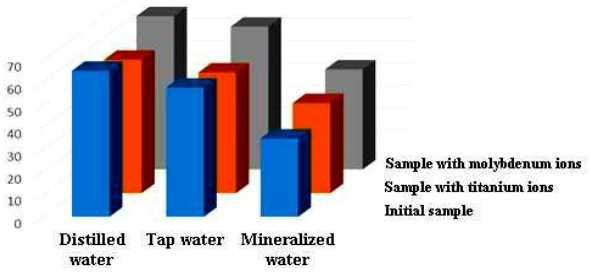

Fig. 2. Contact angles at 28 °C

As seen with graphs (Fig. 2, 3), the properties of the impurities hardly affect the wettability of steel. More significant influence is observed depending on the type of ions, by which samples are processed.

To determine what more affects the wettability - surface roughness or chemical properties of ions surface characteristics were investigated at the above method.

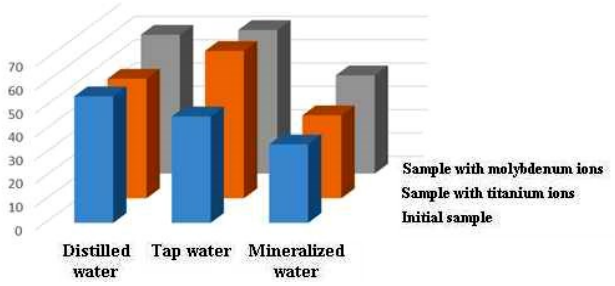

Fig. 3. Contact angles at 11 °C

Fig. 4 shows the surface of samples. Clearly can be see the changes in the geometry of the surface after treatment with ions.

a b c

Fig. 4. Photomicrography of: a) untreated sample; b) the implant with titanium ions; c) the implant with molybdenum ions

Quantification characteristic defined by using the program «Gwyddion» shows that indeed roughness of samples increases after ion treatment (Table 1).

TABLE 1

THE SURFACE CHARACTERISTICS OF SAMPLES

Sample	Initial	The implant with Ti ions	The implant with Mo ions
The coefficient of roughness	42,3	53,2	53,8
The average roughness, micron	72,0	69,8	73,7

Roughness coefficient, which is a common characteristic and determined as the ratio of full surface area to projective, demonstrates significant changes of relief for implants.

So, if to take that surface roughness is the most powerful factor can be expected reduction of contact angle for all implants at different temperatures for all liquids. But in reality this is not observed in some cases samples of titanium and molybdenum for all. It can be concluded that the physical and chemical interactions have greater impact on wettability. The nature of the ions that penetrated the steel base have impact on wettability too.

Conclusion

Implants with titanium and molybdenum ions based steel were synthesized.

It was established that at low concentrations of contaminants in water wettability after treatment improved for samples with titanium ions. This is due to the growth of surface roughness and can be used to intensification of heterogeneous processes.

It is shown that the surface wettability by water in which a greater range and number of substances (mineral water) is dissolved, more affects on physical and chemical interaction between the surface and the liquid. As a result wettability deteriorates that can be used to obtain hydrophobic surfaces, to prevent icing of buildings and vehicles, for the manufacture of medical instruments and so on.

It was established that at any concentration of impurities in water wettability after processing for samples with molybdenum ions deteriorates, that can be used for anticorrosive and lyophobic surfaces.

It is shown that wettability changes are observed at different temperatures and almost the same.

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