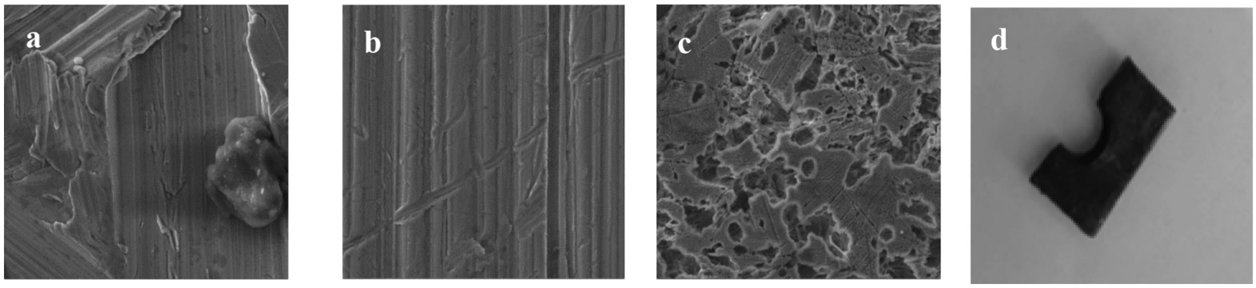

Fig. 1. Topographic images of SEM surfaces of steel substrates a) after polishing with sandpaper; b) after etching with organic solvents followed by treatment in an ultrasonic bath; c) and d) after etching with the "piranha" solution.

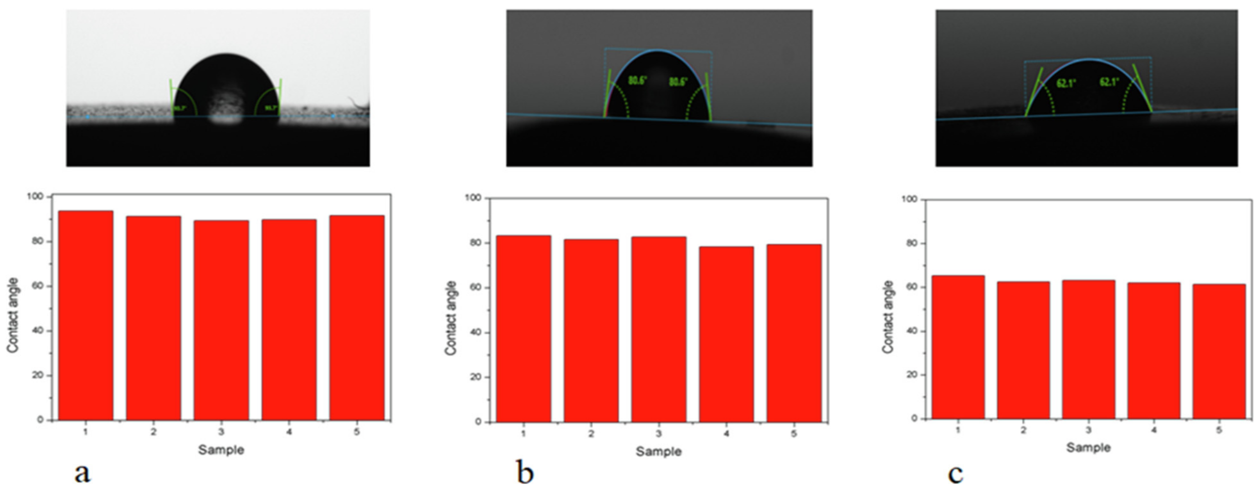

Fig. 2. Steel implant surface wetting angle a) surface of steel implants before treatment; b) surface after etching with organic solvents followed by treatment in an ultrasonic bath; c) surface after etching with 'piranha' solution.

Despite the simplicity of the LbL technology, the concentration of polyelectrolytes affects the assembly process. The effect of the initial polyelectrolyte concentration on the uniformity of the film distribution can be seen by varying the polyelectrolyte concentrations: 0.1 M, 0.01 M, and 0.001 M. The remaining parameters, such as pH, deposition method, the number of bilayers equal to ten, were identical in all experiments. The effect of concentration on surface parameter change is reflected in Table 1.

At high concentrations, a rapid, nonlinear increase in film thickness is observed that results in the formation of a rough surface, and the use of a lower concentration results in a decrease in the roughness of the multilayers. However, it should be noted that a high initial concentration of polyelectrolytes leads to the formation of viscous solutions and an increase in the wetting angle, which in turn leads to the flow of the solution over the surface. The use of a highly diluted solution of 0.001 M or more has a destructive effect on the integrity of the coating structure necessary to form an integrated solid film [10]. Glutaraldehyde crosslinking was used for strong adhesion to the substrate. Therefore, in the range of parameters studied, the optimal concentration of chitosan and CMC polyelectrolytes to obtain smooth and uniform films is 0.01 M polyelectrolyte solutions, Fig. 3.

Table 1
Roughness of films $(CS/CMC)_{10}$ of the polyelectrolytes collected at various concentration.

Polyelectrolyte concentration, M	0,1	0,01	0,001
Roughness, Ra, nm	15,24	9,4	3,2

For a more detailed understanding of the process of producing a multilayer film based on the above polyelectrolytes on steel implants, it was necessary to consider how the contact angle of the film surface with distilled water in each outer layer obtained by applying bilayer to the surface varies. Coatings were applied to the surface of steel implants, as steel substrates have poor adhesion, relatively to silicon and glass plates. As can be seen from Fig. 4, the wetting angle of the pure implant after surface activation is 62,1° and this value are reduced to 48,8° and 43° after application of chitosan and Na-CMC, respectively.

A sharp decrease in the wetting angle is observed at the first 2 to 10 monolayers, and a non-uniform coating is observed. After deposition of 12 monolayers, a zigzag, but the constant uniform change in the variation of this value is observed from 31, 2° to 24, 9°, resulting in a more uniform distribution of bilayers on the surface. The difference between wetting angle values observed after precipitation of CS and Na-CMC is caused by the difference of hydrophilicity of two polyelectrolytes [11]. These studies provide information on the minimum number of bilayers needed to completely coat the substrate surface. It follows that when producing thin nanofilms based on polyelectrolytes, it is necessary to take into account the number of bilayers from which there will be uniform surface coating and at the same time there will be a correct "architecture" of matrix layering on each other. From this point forward, it will be possible to use them as a'reservoir' for various bioactive reagents or nanoparticles. The resulting biofilms are biodegradable. With a change in pH, biodegradation of films occurs during long-term storage in physiological saline.