Study of a Laser Method to Control the Condition of Coatings of Titanium and Magnesium Alloys for Medical Cryo Instruments

T Yu Mogilnaya[1], L L Pagava[1], N A Petelin[1], V N Medvetskova[1], E A Sagitova[1], and B L Krit[1]

[1]*Institute No. 12 "Aerospace Science-intensive Technologies and Production", Moscow Aviation Institute (National Research University) , 4 Volokolamskoe sh., 125993, Moscow, Russia. Contact Phone: +79161903465*
Contact Email: mogilnay@mail.ru

Currently, cryomedicine (cryotherapy and cryosurgery) is actively used, in particular, in the Russian Medical Academy of Postgraduate Education, the 1st City Clinical Hospital named after N.I. Pirogov, the Clinic of Pediatric Surgery of the Sechenov Russian State Medical University. Applicable cryoapplicators are usually made from copper alloys with titanium nickelide coatings for anti-corrosive properties and biocompatibility. Such materials do not provide optimal conditions for heat removal. It increases the duration of exposure to the tissue in the operation area since the thermal conductivity of TiNi is extremely small and amounts to 1 W/(m K). The lack of thermal-physical properties is exacerbated by the porosity of the TiNi coating, which is necessary for the evaporation of the cryoagent. In several cases, coating rupture and delamination during evaporation of liquid nitrogen were observed. Besides, the toxicological and biotolerance characteristics of copper alloys cannot be considered optimal: according to SanPiN 2.1.4.1074-01, the maximum permissible concentration for Cun+ cations is 1.0 mg/m3. The need for sterilization complicates the procedure of their application. The application of nano-coatings from ultralight magnesium alloys creates an opportunity to improve cryoapplicator characteristics. In addition to a significant reduction of gravimetric indicators, the formation of highly adhesive and cohesive ceramic-like nanostructured oxide layers based on MgO is possible on the surface of magnesium alloys. The thermal conductivity of magnesium oxide at a porosity of 3-8% exceeds 30 W/(m K) and tends to increase with decreasing temperature. The biocompatibility of Mg (MAC 50 mg/m^3) is the highest for metals.

Our studies have shown that nano-structured coatings have bactericidal properties, presumably due to the effect of local surface plasmon resonance. To determine the conditions of realization of this effect, we developed a laser method. A model was built to determine the requirements for laser radiation. A number of experiments were carried out to create an installation for control.