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Osteoconstructive nanocomposite based on polyurethane with additives of polysaccharides of various origin

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Abstract

The basics of chemistry and manufacturing techniques of medical bone glue based on a polymer-polyurethane matrix, in which natural polysaccharides are additionally introduced, are described. The physicomechanical characteristics of the reconstructed bones (on the model of pork ribs) are given in comparison with polyurethane without additives (kryptonite). We measured the force necessary for a longitudinal fracture of the bone at the junction, the impact force leading to the destruction of the polymer. The tests were carried out on a universal machine for tensile testing IR 5047-50, the tensile strength of which reaches 50×103 N. It is shown that, compared with the mechanical strength of kryptonite (0.85 kPa), most polysaccharide composites are stronger from 1.2 to 2,3 times. Additives of sodium alginate and hyaluronic acid contribute to the formation of the most stable structures (2.00 MPa and 1.60 MPa, respectively). The strength of the glue with the inclusion of chitin is 1.05 MPa. The least tear resistant is the polyurethane-pectin copolymer (0.140 MPa). The low strength of glue with pectin is explained by the features of its chemical structure, a high degree of esterification of polygalacturonic acid (84%). Impact destruction of the material was recorded at 200 MPa, while the composite crack did not break up into fragments. Thus, the strength of new biopolymer composites is determined by the structure of polysaccharides, which increase the adhesive properties of potential medical adhesives.

Using a *JSM-6510 LA* scanning electron microscope from *JEOL* (Japan), it was shown that the composite is a cellular structure along the entire depth of the material, 70% of the polymer has pores with a size (55-160) microns. The resulting glue may be compatible with bone tissue. Osteoblasts with a size of 20-30 μm can grow into the cellular structure of new materials and further increase their strength by osseointegration with the host bone. It was found that complete curing of kryptonite occurs in 75 minutes. Materials with additives of other polysaccharides can be cured in much less time (hyaluronic acid, xanthan, pectin in 15 minutes, sodium alginate in 50 minutes. The exception was chitin, which hardens in 200 minutes. During curing, the volume of all polymers increased and amounted to pectin, hyaluronic acid, xanthan gum, sodium alginate, chitin (32; 50; 62; 110, 250)% of the initial value, respectively. Kryptonite was characterized by a 130% increase in volume. Studying the interaction of polymers with water in an isotonic solution of sodium chlorine, imitating the internal environment of the body, showed that kryptonite does not absorb water within 40 days of observation, the mass of pectin increased by 2% in 2 days, xanthan – by 5%, sodium alginate – by 12%, and in 40 days the mass of xanthan gum and sodium alginate increased by 12 and 24%, respectively. The polyurethane composite with pectin lost 10% of its mass in the first 2 days and 35% in the next 40 days, which indicates hydrolysis of ester bonds in polygalacturonic acid. A composite with hyaluronic acid quickly absorbed water (30% in the first 6 hours), turned into a gel and lost its adhesive properties. In air, this polymer hardens quite quickly. It is obvious that composites with hyaluronic acid can only be used in an anhydrous environment. The most promising as medical bone glue is a polyurethane-xanthan copolymer, the physicochemical properties of which (curing time 15 minutes, an increase in volume by 62%) allow the formation of a bone bonding area and also regulate its surface during surgery. There is a direct relationship between the physicochemical properties of the new composites, the features of the primary structure, and the spatial organization of carbohydrate macromolecules. A methodological approach to the development of adhesives promising for reconstructive medicine of mineralized tissues is proposed.

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