Investigation of Mechanical Properties of Composites Filled with Modified Hydroxyapatite

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Abstract* − *The purpose of this work was to increase the compatibility of composite components by modifying the surface of hydroxyapatite particles. Oleic acid and peroxide copolymer VEP-MA were used as modifiers. It was shown that modified composites have higher impact viscosity and tensile strengths.

Keywords – modification, hydroxyapatite, composite.

In our days, the orthopedics and dentistry industry is interested in finding new biocompatible materials with high mechanical properties, which capable of interacting with bone tissues. Dispersed hydroxyapatite (HA) has a very high biocompatibility, but is not characterized by high mechanical strength [1]. The great solution to this problem is use polymer composite materials based on HA. However, this is complicated because of the significant difference in surface energy, and hence the poor compatibility of the components. One of the ways to improve the compatibility of composite components is modify the surface of the filler particles.

To solve this problem, we used next modifier: oleic acid (OA) and peroxide copolymer VEP-MA to modify the surface of hydroxyapatite. Synthesis of hydroxyapatite passed through the reaction:

$$10CaCl_2 + 6\ (NH_4)_3PO_4 + 2NH_4OH = Ca_{10}(PO_4)_6(OH)_2 + 20NH_4Cl$$

Synthesis of peroxide HA was performed according to next method. A sample of the peroxide modifier was pre-dissolved in a solution of triammonium phosphate. To a solution of $CaCl_2$ at 60 °C with vigorous stirring, was added dropwise a solution of $(NH4)_3PO_4$ and VEP-MA, after the reaction mixture was thermostated with stirring for 7 hours. At the end, the reaction mixture was filtered and washed three times with distilled water. The resulting precipitate was dried at room temperature to constant weight.

Modification of mineral filler modifiers was carried out in a solution of organic solvent (ethyl acetate), within 2 hours. Upon completion of the modification, the filler was filtered and dried at room temperature to constant weight. The polyacrylamide-based composite was prepared as follows: an aqueous solution of acrylamide was prepared, dispersed HA added to the solution, polymerized acrylamide at 60 °C in the presence of HA and initiator of potassium peroxide sulfate, the resulting composite was dried to constant mass. The polyethylene composite was prepared as follows: a mechanical mixture of crushed polyethylene and disperse

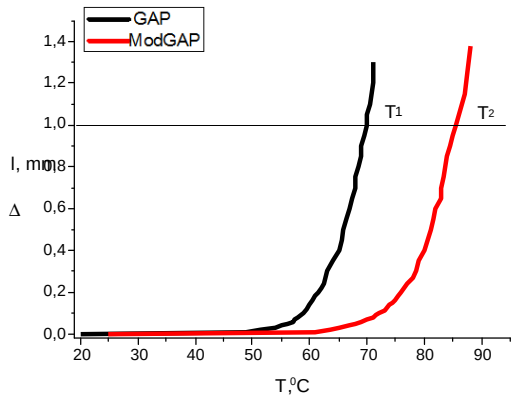

Fig.1. Thermomechanical curves of composites based on polyacrylamide filled with HA (degree of filling = 40% by mass) and HA (degree of filling = 40% by mass) modified with

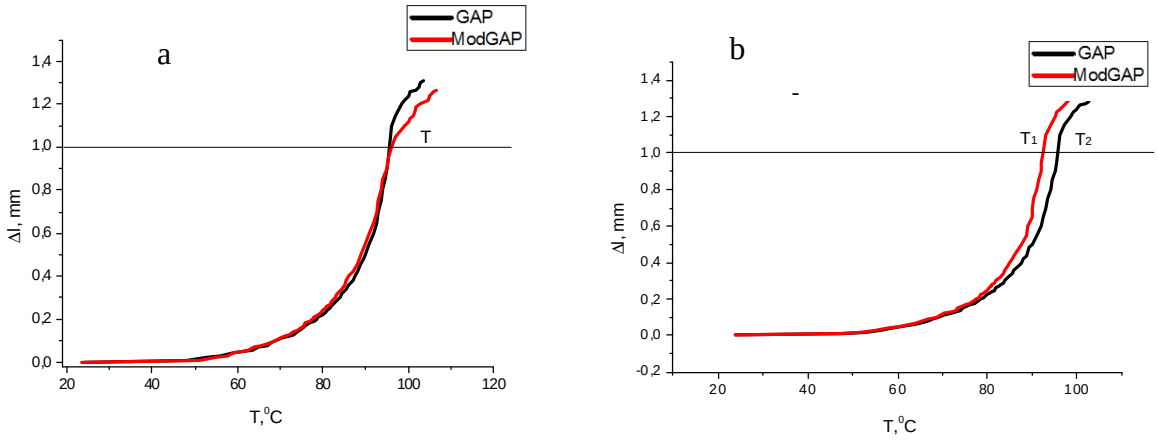

Fig.2. Thermomechanical curves of composite polyethylene filled with HA ((degree of filling = 40% by mass): a) HA which modified oleic acid (degree of modification = 2% by mass) T = 97 °C; b) VEP-MA (degree of modification = 2% by mass) T1 = 92^{0}C, T2 = 96^{0}C

hydroxyapatite was made, the mixture was filled into a mold and sintered at 180 °C for 4 hours and then remained pressed to a constant temperature. To characterize the composites obtained, studies were carried out on thermomechanical properties, shock viscosity and tensile strength.

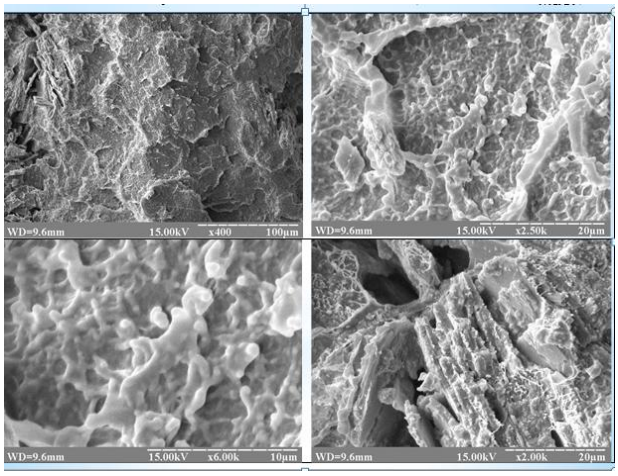

Fig.3. Microphotographs of the fracture surface of a HA-filled polyethylene composite (degree of filling = 20% by mass) which modified with oleic acid (degree of modification = 2% by mass).

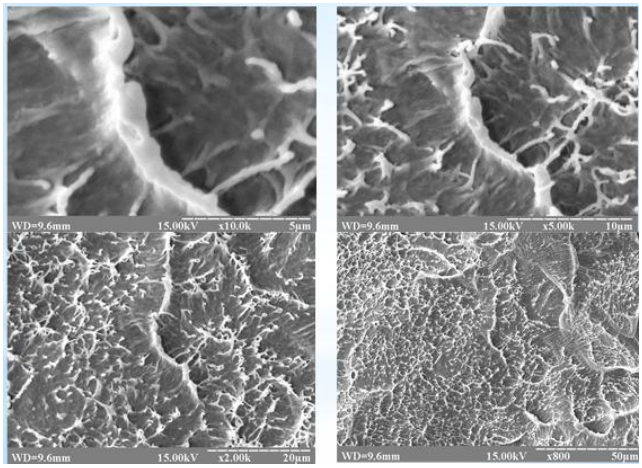

Fig. 4. Microphotographs of the fracture surface of a HA-filled polyethylene composite (degree of filling = 20% by mass) which modified VEP-MA (degree of modification = 2% by mass)

As a result of the conducted studies it was shown that the modification of hydroxyapatite with oleic acid and peroxide modifier increases the mechanical properties of the composites obtained. Composites based on polyacrylamide filled with HA (modified with oleic acid) have an increase of 30% impact strength and an increase in temperature of 20 °C. Polyethylene samples filled modified HA (OA and VEP-MA) showed no significant changes in thermo-mechanical properties. At the same time, they demonstrated a significant increase (> 50%) of the tensile strength.

References

[1] K. R.St. John, L. D. Zardiackas, R. C. Terry. “Histological and electron microscopic analysis of tissue response to synthetic composite bone graft in the canine”. *Journal of Applied Biomaterials*, vol.6, pp.89—97, 1995.