

3rd International Conference and Exhibition on Materials Science & Engineering

October 06-08, 2014 Hilton San Antonio Airport, USA

Biocompatible polymer composites based on ultrahigh molecular weight polyethylene

V D Danilov², F S Senatov¹, S D Kaloshkin¹ and V V Tcherdyntsev¹

¹National University of Science and Technology «MISIS», Russia

²A. A. Blagonravov Institute of Machine Science Russian Academy of Science, Moscow

Modern constructional materials must have high impact strength, wear-resistance and corrosion resistance. UHMWPE has required physical-mechanical and tribological behavior. For better properties polymer materials can be filled by inorganic particles. According to this fact ultrafine and nanopowders are of special interest.

UHMWPE powder (2 million g/mol) was used as a polymer matrix. As a reinforcing phase was used alumina Al₂O₃ of 2 types: ultrafine powder with 200 nm particles and microspheres of alumina with size 1000 nm. The first stage of the process of polymer composite obtaining was mechanoactivation of UHMWPE powder and alumina in different ratios. Optimal milling time was defined according to required morphology of alumina particles. The next stage was thermo-pressing of obtained mixed powder. Obtained composites were investigated using scanning electron microscopy, X-ray diffraction analysis and IR-spectroscopy analysis. Influence of concentration and form of alumina on physical-mechanical and tribological properties of compacted samples were investigated. After milling ultrafine alumina powder consists of particles with irregular shape and size 200 nm, so it can increase adhesion to UHMWPE matrix by increasing contact area. It was demonstrated that increasing of adhesion leads to increasing of modulus of elongation and impact strength.

There is a corundum peak on diffractogram of mechanoactivated mixture of UHMWPE and ultrafine alumina powder and there are crystal peaks with orthorhombic lattice (110)_o and (200)_o, and peaks under $2\Theta = 19.5^\circ$ and 23.1° , referred to (010)_M and (200)_M of monoclinic lattice. In IR-spectrum of pure UHMWPE main lines of C-H bonds in the range 2850-2910 cm⁻¹ and in crystallinity band 1450-1471 cm⁻¹, 717-730 cm⁻¹ were observed.

In IR-spectrum of mechanoactivated powders there is a line of valence C-O bond with wavenumber 1050 cm⁻¹, and there are also lines with wavenumbers 570 cm⁻¹ and 830 cm⁻¹, referred to stretching vibrations of Al-O bonds. Increasing of line's intensity of C-O bonds vibrations in mechanoactivated UHMWPE powder is due to release of C-H bonds and subsequent cross-linking because of additional deformation by Al₂O₃ microspheres. Also this fact can be explained by appearance of monoclinic phase.

Increasing of ultimate stress limit and modulus of elongation was achieved by filling UHMWPE with alumina particles. Ultimate stress limit increases on 38 % and modulus of elongation increases in 2,9 times. Reinforcing of the alumina-filled composite after mechanical activation is due to bonding on UHMWPE-alumina particles interface. Destruction of UHMWPE and other amorphous-crystalline polymers is realized by spreading microcracks. Ceramic particles stop this spreading, that brings about increasing extension strain. Due to this fact impact elasticity increases in 1.7 times. Friction coefficient decrease in 1.7 times.

As a result, UHMWPE-based composites filled with ceramic particles with better physical-mechanical and tribological properties can be obtained by mechanical activation and thermo-pressing, and can be used as a constructional material.