

Modern medicine, especially implantology creates a continuous development of material engineering because of high demands for materials, that are used for implants. The bone plates currently applied in the human body are used for bone reconstruction after serious injuries. Implanted plates have been made mainly from biomaterials such as titanium alloys or austenitic stainless steels yet. In case of short-term applications, where the implant is necessary only for the specific bone regeneration time, the patient must undergo an additional operation in order to remove the implant once the bones have knitted. It causes unnecessary stress and inconveniences for the patients. In order to improve quality of life materials that can both support regeneration of damaged tissue and biodegrade with implantation time in the human body without toxic reactions on corrosion products are still sought after. Polymeric materials, commonly used for this kind of application, are characterized by relatively low mechanical properties, especially insufficient strength, where the joined bones cannot be burdened. That is why the recent research tends to focus more on metals and their alloys. Some of them exhibit better durability and tendency to biodegradation in the biological environment what seems to be a reasonable alternative for polymeric materials.

Based on current knowledge, zinc-based alloys have become more and more popular for use as bioresorbable materials. Zinc is characterized by low melting temperature, good castability, and ease of machinability. From the medical point of view, zinc is essential microelement for the proper functioning of the human organism, and its controlled dissolution inside the body does not cause any side effects. The main application barrier of pure zinc is its low strength and plasticity. Modern materials engineering can deal with these problems. In theory, according to the Hall-Petch equation, it is possible to achieve improved strength through forming processes. Unfortunately, another problem is a tendency of pure zinc to recrystallization even at room temperature, what can lead to undesirable grain growth during hot forming processes. It is possible to resolve this issue by adding biocompatible elements that increase the temperature of recrystallization while causing a decrease in grain size. Based solely on current knowledge, it is not possible to state whether the investigated biocompatible zinc alloys will be characterized by sufficient mechanical properties until the bone has regenerated itself and regained its proper strength.

The aim of this project is to investigate the simultaneous effect of zirconium and silver additions in zinc and also extrusion process on grain refinement, microstructural stability, mechanical and biodegradation properties of ternary zinc alloys. Initial studies show that microaddition of zirconium creates with zinc the intermetallic phase in form of fine, dispersive particles in zinc matrix. They effectively hinder the grain growth after recrystallization during the hot plastic deformation process. It is expected that the addition of silver by solid solution strengthening effect will hinder recrystallization and grain growth phenomena and will contribute to the additional reduction of grain size. This will provide the basis for optimal Zn-Zr-Ag chemical composition, which would result in obtaining good mechanical properties, both strength, and plasticity, along with microstructural stability.

A series of ternary zinc alloys will be produced in order to confirm the hypothesis. The initial material will be annealed after casting and followed by indirect hot extrusion. Fluorescence and X-ray diffraction methods will be used to determine the chemical and phase compositions of the produced alloys. The material will be analyzed in each state via light and electron microscopy in order to receive as much microstructural information as possible. The mechanical properties of the extruded rods will be investigated by means of tensile and compression testing, and Vickers hardness measurements. Keeping in mind the material's target environment, corrosion testing will be carried out in an environment proximate to that of a human body.

The whole project will enable the characterization of synergetic element influence on microstructural stability after forming process and mechanical properties of zinc alloys at room temperature and conditions proximate to the human body. The achieved knowledge will provide the starting point for further investigations concerning the production of stable, bioresorbable zinc alloy implants.