Aminophosphonates and aminophosphonic acids are phosphorus analogues of naturally occurring amino acids. These compounds exhibit a variety of interesting and useful properties. They found a wide range of applications in biochemistry and medicine due to their biological activities.

Significant progresses have been made in the organic chemistry up to the concerning the synthesis, characterization, and application of the metal complexes in medical science for the last decade.

The conjugation of aminophosphonates or bisphosphonates with organometallic complex may lead to important changes in the physicochemical and biological properties of the parent molecules.

Taking into consideration all aspects described above, the first aim of the doctoral dissertation was the synthesis and structural characterization of molecules containing metallocarbonyl fragments and organophosphorus groups, as potential inhibitors of acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE). Several new metallocarbonyl complexes containing phosphonate groups were synthesized. The structural studies were performed using spectroscopic methods (^{1}H NMR, ^{31}P NMR, ^{13}C NMR, IR) and mass analysis. Biological tests have been carried out for inhibition of the enzymes: AChE and BuChE, moreover anti-tumor properties and normal cell toxicity were examined.

The second aim of the doctoral dissertation was the synthesis of new nanomaterials – magnetic nanoparticles with metallocarbonyl fragments on the surface. Metallocarbonyl complexes were immobilized on nanoparticles using two methods. In method I $CpM(CO)_2(\eta^1$-*N*-maleimidato) (M=Fe, Ru) complexes reacted with thiol and amine groups on the surface of nanoparticles. Method II was based on the reaction of $CpFe(CO)_2I$ complexes with thiol groups on the surface of magnetic nanoparticles. Nanomaterials prepared by method I were characterized by IR spectroscopy, electron microscopy and thermogravimetric analysis. The metallocarbonyl complexes and complexes immobilized on magnetic particles were studied and compared in terms of their photostability. In addition, antibacterial activity against *Pseudomonas aeruginosa* and antifungal activity against *Candida albicans* were examined.

During research on the synthesis of metallocarbonyl complexes containing an organophosphorus fragment, a side product of oxa-Michael addition was obtained. Further oxa-Michael reactions were carried out and the crystallographic structures of the products were determined.