The main goal of the project is to study the influence of the ortho-positronium conversion process in para-positronium on the probability of para and ortho-positronium state formation in different molecular structures and under different chemical environments. The conversion process will be examined as a function of oxygen pressure in materials such as porous polymer (XAD4), aerogel (IC3100) or silica (SBA-15). Positronium is an atom, consisted of electron and its antiparticle – positron. It has a wide range of applications in the medical diagnosis, material studies and in the fundamental physics. It can exist in two states – para-positronium (p-Ps) and ortho-positronium (o-Ps). In the absence of the ortho-para conversion process which decreases probability of formation o-Ps, o-Ps state is formed three times more often than p-Ps state. Oxygen molecule may enhance the ortho-para conversion process and decrease number of formed positronia in the ortho- state. Positron Annihilation Lifetime Spectroscopy (PALS) or Doppler Broadening of Positron Annihilation Spectroscopy, are the techniques that allows to characterize structure of the samples, at the nanometer level, either by the time of the annihilation of positronium or energy of the photons coming from this annihilation. In addition, positronium is widely studied in the fundamental physics field. Better knowledge about the interactions between positronium and various molecules allow to develop new conclusions in the field of fundamental physics like studying rare decays of positronium.

Series of measurements with porous materials like silicas, aerogels and polymers will be conducted on the J-PET detector, to study ortho-para conversion process in different structures and chemical environment. The J-PET detector that is characterized by the very good timing properties and multiple detection modules (192), allows for comprehensive studies of different positronium decays. In addition to measuring the mean lifetime, the J-PET detector also allows the study of the fraction of three-photon to two-photon decays of positronium. Impact of the conversion process will be controlled by changing the oxygen pressure level in the system. Complex analysis by the dedicated software, based on the positronium lifetime and its correlation with the geometry of its annihilation and registered energy, will allow to accurately estimate the fraction of the ortho-para conversion process. Monte Carlo simulations will be performed for the measurement configuration to estimate the uncertainty of the final results.

Final results of the project, allow to more precisely estimate fraction of the ortho-para conversion process as a function of different chemical environment and nanostructure. Better understanding of the conversion process may improve the detection capabilities of the PALS systems. In addition, it can especially help in the studies of rare positronium decays, for which it is crucial to accurately estimate number of positronia formed in the experiment.