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New porosimetric method based on 3g/2g annihilation. Applications to material science and medical imaging

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The 3γ fraction determination in positron annihilation is one of the most common analysis of the porous materials. It was successfully applied many times to search materials for experiments containing high porosity targets.

However in the case of the materials containing small free volumes like polymers, annihilation into 3γ is usually neglected, for example in PALS measurements. The attention is paid mainly on the o-Ps lifetime value while the component intensity is less used and rarely interpreted. It is known that in the dense matter, 30-40% of positrons create positronium which can be trapped in free spaces between molecules. There exists correlation between the o-Ps lifetime value $\tau_{o\text{-}Ps}$ and the free volume size; the larger is volume the longer is the lifetime value. On the other hand it is known that the longer is the lifetime value the larger fraction of ortho-positronium annihilate with emission of three gamma quanta. One can state the fraction of three gamma annihilation reflects free volumes size (lifetime value) and their concentration (intensity value).

The idea of determination of the relative change of the 3γ fraction in the investigated material in comparison to the reference material is proposed. It can be used to follow changes in the porosity of the investigated materials depending on the preparation conditions or measurements temperature, for example.

The proposed idea can be also treated as a keystone to preparation new imaging method during positron emission tomography. PET is a commonly recognized diagnostic method enabling imaging of the metabolism of chosen substances in the living organism. The PET imaging is based on an annihilation of the positron emitted by radiofarmaceutical with an electron from the body of the patient into two gamma quanta with energy of 511 keV each. One of the most important applications is imaging of patients tumour location and size and aiming at the search for the possible metastases as metabolism rate rises significantly in theese places and in effect the number of annihilating positrons.

Method proposed here is based on a ratio of three gamma annihilation (from trapped ortho-positronium decay) and two gamma (produced in other processes).

The $f_{3\gamma 2\gamma} = N_{3\gamma}/N_{2\gamma}$ can be determined experimentally as a ratio of the number of 3γ and 2γ events emitted from the patient during PET investigation. It may be used as a measure (morphometric indicator) of the degree of the tissue modification in the investigated organism.