Assessment of activation energy of ice nucleation inside nano-pores through Positronium annihilation lifetime spectroscopy

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Positronium annihilation lifetime spectroscopy has been used to study the kinetics of ice nucleation inside TiO_2 nano-pores at three different levels of pore filling. Positronium annihilation lifetime profile with varying temperature indicates different freezing behavior at three different pore fillings. A model describing progressive trapping of positronium in ice nuclei during the phase transition while decreasing temperature has been employed to estimate the energy for ice nucleation in nano-pores. The estimated energy of ice nucleation inside nano-pores is observed to be less than that of bulk water. The reduction of activation energy is associated with the surface assisted nucleation phenomenon inside the pore. It is observed that degree of pore filling has a significant influence on the energetics of ice nucleation. The estimated energy for ice nucleation is seen to decrease with the decrease in pore filling. As the level of pore filling decreases, more and more fraction of water molecules get attached to the pore surface which indulges in incomplete freezing. This observation is pertinent to understand the ice nucleation through the pore condensation and freezing mechanism, which plays a key role for the formation of cirrus clouds in the upper atmosphere.