Positron annihilation in functional soft materials: Recent studies and opportunities

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Microstructural alterations during functional tasks are known to have a profound impact on the performance of soft materials. Consequently, the development of advanced materials by constructing predetermined microstructures has been a focus of the recent global research, putting the precise monitoring of the microstructure at the centre stage. The free-volume, in particular, is considered as a critical parameter which should be closely monitored. In the past few years we have carried out extensive and systematic studies on a variety of polymeric materials having diverse applications such as polymer-based electrolytes for Li-ion batteries, piezo-resistive sensors, actuators and shape recovery polymers. Our main objective has been to establish a correlation between microstructure and properties in these multi-component soft materials.

In this regard, we have extensively used positron annihilation spectroscopy (PAS) to probe molecular structure in polymers and its nanocomposites. We have carried out systematic studies using PAS complemented with other techniques in order to correlate microstructural characteristics with the properties of nanocomposites. In the case of polymer nanocomposites-based electrolytes, our results indicate that in addition to amorphous fraction, interphase structure of PEO nanocomposites plays crucial role for the enhancement in Li ion conductivity. We could achieve room temperature ionic conductivity ~ 10^{-4} $S.cm^{-1}$ in a PEO based quasi solid-state electrolyte filled with ZIF-8. In addition to the role of nanofillers, we have also investigated radiation induced modification of microstructure leading to significant change in the properties in polymeric materials with diverse range of applications. A careful monitoring of free volumes in these diverse matrices would be helpful in deciphering the role of free volumes in dictating properties of these materials. The talk will discuss our recent results and exciting opportunities PAS provides in understanding functional soft materials.