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Molecular mobility in glass forming matter – the role of free volume: positron annihilation perspectives for industrial applications

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Positron Annihilation based experimental techniques, in particular Lifetime Spectroscopy (PALS) is now a unique, versatile and well-established tool for direct evaluations of the local free volumes and associated physical/chemical phenomena in glassy matrices. The local free volume in glass forming matter, consists of a large number of sub-nanometre sized open volume "elements" (often referred to as "holes") which naturally exist in these materials due to their irregular molecular packing, density fluctuations and topological constraints [1]. The free volume plays a crucial role on molecular mobility and, thus, on related material properties such as diffusion (self or of 'ingressing molecules'), the glass transition, mechanical strength and a diverse range of other physical behaviour [2]. Over the past decade, we and many other groups have successfully used PALS, in conjunction with more traditional experimental techniques, to study a range of practical implications of the free volume in polymers and related materials for a wide range of industrial applications.

So far, much of the studies have concentrated on bulk properties using radio-isotope positron sources with considerable success. This will form the main basis of this presentation. However, there is ample room to investigate practical applications involving 'glass transition' behaviour in confined geometries such as in thin films, porous media or at surfaces and interfaces which will be touched upon in the presentation. We propose to give a 'selective' overview of the above activities in recent years. The talk would concentrate on relevant work of the Bristol positron group in this area [3] along with a brief sketch of other similar activities within the positron community. We shall also speculate about avenues of possible future direction(s).

[1] Y. C. Jean, P. E. Mallon and D. E. Schrader *Principles and Applications of Positron and Positronium Chemistry, World Scientific* (2003).
[2] G. Dlubek, in *Polymer Physics: From Suspensions to Nanocomposites and Beyond*, eds. L.A. Utracki and A.M. Jamieson, *John Wiley & Sons* (2011)
[3] Bristol Group and collaborators: *Biomacromolecules*, 11, 3237 (2010), *New J. Phys*. 14, 035016 (2012), *Energy & Env. Sci*, 5, 8359 (2012), *Polymer*, 55, 6827 (2014), *New J. Phys,* 16, 103030 (2014), Carbohydrate Pol., 102, 566 (2014), Biomacromolecules, 16, 1784 (2015), *Food Hydrocolloids*, 58, 75 (2016), *Food Hydrocolloids*, 58, 316 (2016).