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Advances in Measuring Gas & Vapor Permeation Through Membranes & Barrier Polymers

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Measuring Gas and Vapor Permeation Through Membranes and Barrier Polymers

Dr. Sean McIntyre, *Surface Measurement Systems*

With the introduction of new bio-based polymers and functionalised Polymers of Intrinsic Microporosity (PIMs), new challenges arise in the form of contamination by fouling species such as humidity. Traditional petrochemical polymers are typically hydrophobic, but hydrophilic polymers can sorb water into the polymer free-volume dramatically changing the polymer properties. A new device for measuring multi-component permeation in humid streams, the MPA Horizon, will be revealed along with our latest insights in the field of multi-component permeation.

Gas and Vapor Diffusion and Solubility Data From Membrane Permeation Measurements

Dr. John M. Zielinski, *Intertek Chemicals & Pharmaceuticals, Allentown, USA*

Steady state permeation measurements are generally performed to gauge the barrier properties of polymer membranes and packages. While the transmission rates from these measurements are very valuable, evaluation of the diffusion and solubility coefficients from transient experiments can provide further insight into the interactions of the penetrant and the polymer. Interesting trends in gas transmission rates and how they are affected by diffusion and solubility will be discussed along with how experimentation may need to be modified for analysis of vapor penetrants. Both experimental and modeling results will be shown.

Temperature-dependent Crystallization Behavior of Poly(lactic acid) Films Induced by Ethanol

Prof. Rafael Auras, *Michigan State University*

Poly(lactic acid) – PLA – is a bio-based and bio-degradable polymer with a lower environmental footprint than fossil-based polymers. Its commercial application in the food packaging field provided many chances for PLA to contact organic compounds such as alcohol. Ethanol-aqueous solution with different concentrations is one of the normal food contact solutions and simulants used for certification. The diffusion of ethanol plays a vital

role in the property changes of PLA films due to the crystallization it induces. To understand the diffusion behavior of ethanol in PLA, the crystallinity evolution of amorphous PLA films immersed in pure ethanol below and above the in-situ glass transition temperature (Tg) was monitored by differential scanning calorimeter (DSC). The swelling degree of PLA films immersed in ethanol at 25 °C from 0 – 48 h was measured by an analytical balance. The sorption of ethanol in PLA films at 25 °C during 0 – 144 h was determined by quantitative proton nuclear magnetic resonance (1H - NMR). The sorption amount of ethanol in PLA films reached maximum value (c. 8 wt.%) at 4 h of immersion and entered a steady state at 24 h of immersion. The induced crystallinity (c. 25%) of PLA films immersed in ethanol at temperatures higher than the in-situ Tg (24.3°C/297.45 K) of PLA was greater than the induced crystallinity (<10%) of the films immersed at temperatures lower than the in-situ Tg. The $\alpha\alpha$ form crystal was detected by powder X-ray diffraction (PWXRD) in PLA films immersed in ethanol from 0 – 72 h immersion. The Avrami equation was used to explain the crystallinity changes. At the temperature above in-situ Tg, the chain mobility was enhanced, leading to more free volume and more sorption of ethanol in PLA films, which also caused the increase of crystallinity. This correlation between in-situ Tg and crystallinity evolution gives insights into the diffusion of organic compounds like alcohol in PLA.

Multi-lab Study on the Pure-gas Permeation of Commercial Polysulfone (PSf) Membranes: Measurement Standards and Best Practices

Sunshine Iguodala, *Imperial College London*

Over the past several decades, membrane gas separation has transitioned from a scientific curiosity to a commercial reality. However, conventional gas separation membranes are limited by the permeability-selectivity trade-off and typically show low gas permeability. Membrane materials with high gas permeability have attracted significant interest. Polymers of Intrinsic Microporosity (PIMs), recognized for their inherent porosity due to bulky, rigid contortion sites in their polymer backbone, have emerged as promising candidates for membrane-based gas separation. Despite this progress, the ongoing challenge lies in advancing PIMs for practical industrial applications. This talk will detail membrane fabrication practices and testing employed in our research labs, starting from polymer synthesis to membrane performance evaluation. Through these insights, we aim to outline future perspectives and research directions that could enhance the scalability and real-world applicability of PIMs in industrial contexts.

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