Nanoscale Insights into Helium Diffusion and Permeation in Polymer Bottles

[1,2]Sefer Avdiaj
[1]Lyra Hoxha
[1]University of Prishtina, Department of Physics, Mother Teresa av 3, Prishtina, Kosova
[2]Nanophysics, outgassing and diffusion Research Group, NanoAlb-Unit of Albanian Nanoscience and Nanotechnology, 1000 Tirana, Albania
sefer.avdiaj@uni-pr.edu

Abstract

This work investigates the diffusion and permeation of helium in various plastic bottles through a nanoscience lens, using both Steady State and Time Lag methods. Helium, with its small atomic size, serves as an ideal probe for studying gas transport at the nanoscale within polymers. The nano-structured characteristics of polymers, such as chain density, free volume, and molecular interactions, significantly influence gas diffusion and permeation behaviours. By applying the Steady State method for equilibrium transport and the Time Lag method for transient behaviour, we extract key diffusion and permeation coefficients that reveal how nano-structural features of the polymer affect gas transport. These findings contribute to a deeper understanding of how nanoscale properties of materials govern macroscopic behaviours, which has implications for industries like packaging, pharmaceuticals, and materials design, where precise control of gas barriers is critical. Our study underscores the importance of integrating nanoscience concepts into the analysis of gas diffusion, demonstrating the potential for enhanced material performance through targeted nano-engineering.

References

[1] Firpo et al. Vacuum, 191 (2021), 110368
[2] Kurtishaj et al, Acta IMEKO, 11 (2022) 1-4