Xenon diffusion through Acrylic Xenon vessel

From <u>Diffusion Coefficients of Xenon in Polystyrene determined by Xe-129 NMR Spectroscopy</u>, Inglefield, et. al (1996) <u>Macromolecules</u>, diffusion coefficient for Xe in polystyrene (similar to acrylic, much more so than polypropylene quoted earlier) is:

$$D_{Xe\_PS} := 1.9 \cdot 10^{-9} \frac{cm^2}{s}$$ (at 25C, 10-15 atm Xe pressure)

Xe concentration in Xe vessel

$$C_i := \frac{1}{v} \qquad v := \frac{RT}{P} \qquad C_i := \frac{P_{MOPa}}{R \cdot 293K} \qquad C_i = 624.094 \frac{mol}{m^3}$$

Flux through walls, from Fick's Law (assume vessel walls and ends = 0.5 cm thick)

$$Q_{Xe} := \frac{C_i}{0.5cm} \cdot D_{Xe\_PS} \cdot A_{Xe\_v} \qquad Q_{Xe} = 1.407 \times 10^{-7} \frac{mol}{s}$$

In mass terms: $\qquad M_{a\_Xe} \cdot Q_{Xe} = 0.019 \frac{mg}{s} \qquad M_{a\_Xe} \cdot Q_{Xe} = 0.604 \frac{kg}{yr}$

This does not include leaks, which will likely double the flux into N2. There will need to be cryopumping of the N2 to reclaim Xe, it is not clear whether circulation will also be needed; Xe will likely find its way to cryopanels outside. Assuming a Xe partial pressure of 10^-8 torr at a cryopanel surface combined with a pumping speed 10% of that for the Xe vessel, we find an Xe partial pressure and mass in the N2 buffer region:

$$P_{Xe\_buf} := 10^{-8} torr + \frac{2Q_{Xe} \cdot (R \cdot 293K)}{0.1 C_{m\_tot}} \qquad P_{Xe\_buf} = 0.017 \, torr$$

$$M_{Xe\_buf} := \frac{1m^3 \cdot P_{Xe\_buf} \cdot M_{a\_Xe}}{R \cdot 293K} \qquad M_{Xe\_buf} = 0.129 \, gm \quad Cost_{Xe} := \frac{10^6 euro}{100kg} \quad Cost_{Xe} = 10 \frac{euro}{gm}$$

This is an inconsequential amount of Xe in the buffer region, regarding dielectric strength and cost, so it does not appear that N2 gas circulation is needed to reduce this to a lower concentration. N2 buffer gas circulation might be desirable for other reasons, however.