

Supporting information: Reinforced Saloplastic Anion Exchange Membranes: Balancing Ionic Transport and Mechanical Stability

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1. Membrane preparation and characterisation

Figure S1 illustrates the hot-pressing mould configurations used to control the thickness of saloplastic membranes. For non-reinforced membranes, PTFE-coated fiberglass spacers were fixed to the bottom Delrin plate to define the final membrane thickness during hot pressing (**Figure S1a**). For reinforced membranes, no spacers were used, and thickness control was achieved by placing the hydrated PEC directly onto a reinforcement fabric positioned on the bottom Delrin plate (**Figure S1b**). In this configuration, the reinforcement layer, together with the plasticised PEC apparent viscosity, defines its thickness.

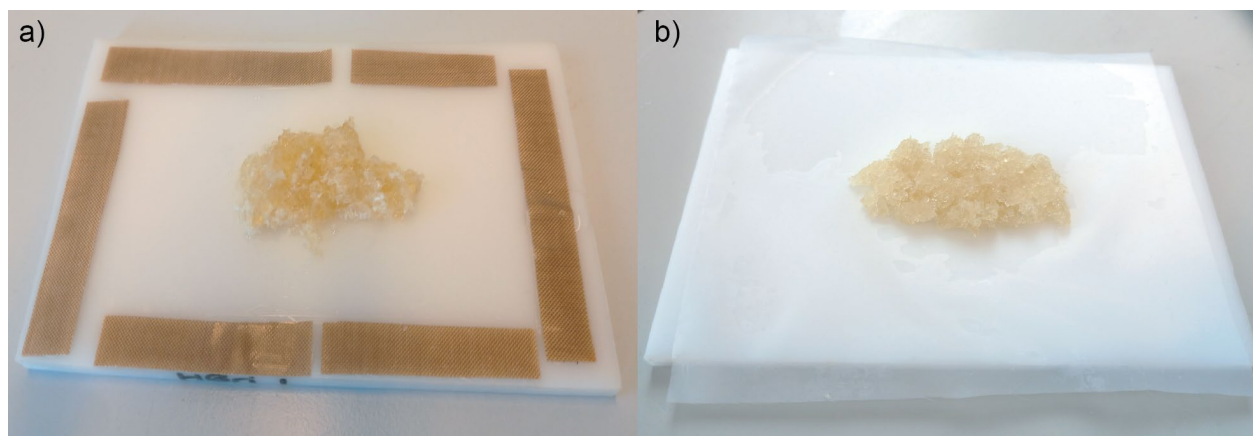


Figure S1: Schematic of the hot-pressing mould configurations used for saloplastic membrane fabrication. (a) Delrin plates with PTFE-coated fiberglass spacers used to control the thickness and size (5.5 x 8.5 cm²) of non-reinforced saloplastic membranes. (b) Spacer-free configuration for reinforced membranes, where hydrated PEC is placed on top of a reinforcement fabric positioned on the bottom Delrin plate to control membrane thickness.

2. Mechanical stability: Load-strain curves

Figure S2a shows the stress-strain curves of the three reinforcement fabrics used in **Section 3.1**, which have similar open areas but different thicknesses (60, 80 and 95 μm). **Figure S2b** shows the load-strain curves without thickness normalisation of membranes produced with the thinnest reinforcement (PA, 60 μm , 50%).

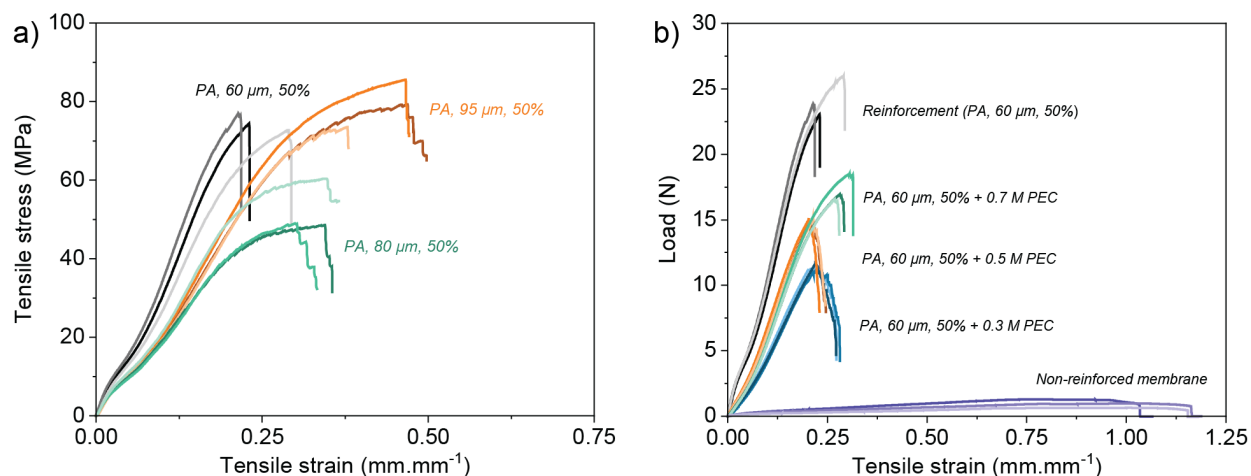


Figure S2: (a) Stress-strain curves of woven polyamide reinforcement meshes with identical open area (50%) but different thicknesses. (b) Load-strain curves of reinforced saloplastic AEMs prepared using the same polyamide (PA) woven reinforcement (60 μm fabric thickness, 50% open area) and different PEC layer thicknesses, obtained by equilibrating the PEC in 0.3, 0.5, and 0.7 M KBr prior to hot-pressing. The response of the reinforcement fabric alone and of a non-reinforced membrane (PEC only) is shown for comparison. Three repeat measurements are shown for each sample.

3. Swelling results of complete membrane as a function of membrane thickness

Figure S3 shows the swelling behaviour of the overall reinforced membranes (PEC + reinforcement) as a function of wet membrane thickness. In these membranes, the observed thickness dependence mainly reflects differences in the polymer-to-reinforcement ratio rather than specific interactions between the PEC and the reinforcement.

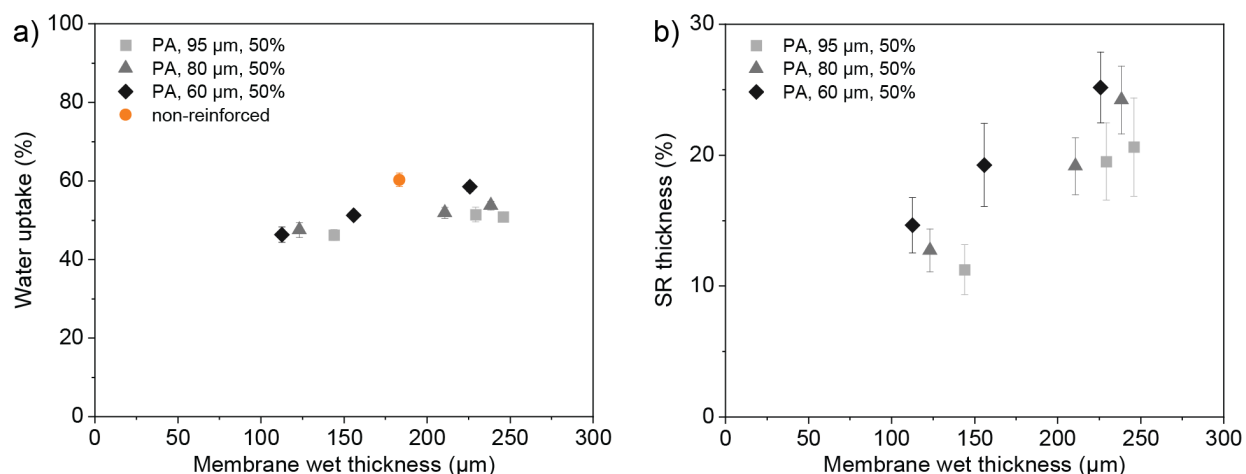


Figure S3: (a) Water uptake and (b) through-plane swelling (SR thickness) of reinforced saloplastic membranes (PEC + reinforcement) as a function of wet membrane thickness for reinforced saloplastic AEMs with systematically varied thicknesses. Data for a non-reinforced membrane (PEC only) are included for comparison. Legend entries are given as (reinforcement material, fabric thickness, open area). Error bars represent the 95% confidence interval (n = 5).

4. Dimensional stability of freestanding and reinforced membranes

Figure S4 shows photographs of membranes taken immediately after permselectivity testing. The non-reinforced membrane (**Figure S4a**) deforms during testing and adopts a curved shape, indicating poor mechanical stability and high elasticity of the PEC. This deformation can promote the formation of small defects, which may reduce permselectivity and increase variability between samples. In contrast, the reinforced membrane (**Figure S4b**) remains flat, demonstrating that reinforcement effectively mitigate this limitation.

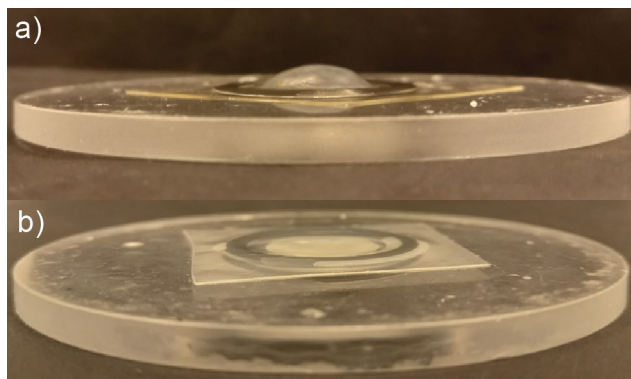


Figure S4: Photographs of membranes taken immediately after permselectivity testing: (a) non-reinforced membrane and (b) reinforced membrane. Samples are shown mounted on the plastic support disk used in the test setup. The non-reinforced membrane undergoes noticeable deformation during testing, while the reinforced membrane maintains a flat and stable shape.

5. Estimation of resistance contribution of two transport regions

To examine the hypothesis that ion transport in reinforced saloplastic membranes occurs through two distinct regions, a simple series resistance model was used to estimate the relative contributions of the dense PEC layer and the PEC-reinforcement composite region to the total membrane resistance.

In this model, the total membrane area resistance (R_{total}) is approximated as the sum of the resistances of the two transport regions:

$$R_{total} = R_{PEC} + R_{PEC+Reinf}$$

Where R_{PEC} represents the resistance of the dense PEC layer and $R_{PEC+Reinf}$ corresponds to the resistance of the PEC-reinforcement composite region.

The thickness of the PEC-reinforcement region was assumed to be equal to the thickness of the reinforcement fabric, obtained from supplier specification sheets and verified using a micrometer. The remaining membrane thickness was therefore attributed to the dense PEC layer. Resistance data obtained from non-reinforced membranes (PEC-only) were used to estimate the resistance per unit thickness of the dense PEC layer. This allowed the resistance contribution of the dense PEC region to be estimated based on its calculated thickness.

The resistance contribution of the PEC-reinforcement composite region was subsequently determined by subtracting the calculated dense PEC resistance from the experimentally measured total area resistance. Error propagation was used to estimate the uncertainty in both resistance contributions, which are reported as 95% confidence intervals.

Using this approach, the model can be evaluated by comparing membranes fabricated with the same reinforcement but pressed using different KBr concentrations. In this case, the PEC-reinforcement region should remain the same for all membranes, while only the thickness of the dense PEC layer changes. If the model is valid, the resistance of the PEC-reinforcement region should remain approximately constant, whereas the resistance of the dense PEC layer should increase with its thickness. This behaviour was observed experimentally, indicating that the model provides a reasonable approximation of the two transport regions in the reinforced membranes.

6. SEM images of reinforced membranes in Section 3.4

Figure S5 shows scanning electron microscopy images of reinforced saloplastic membranes fabricated discussed in Section 3.4.

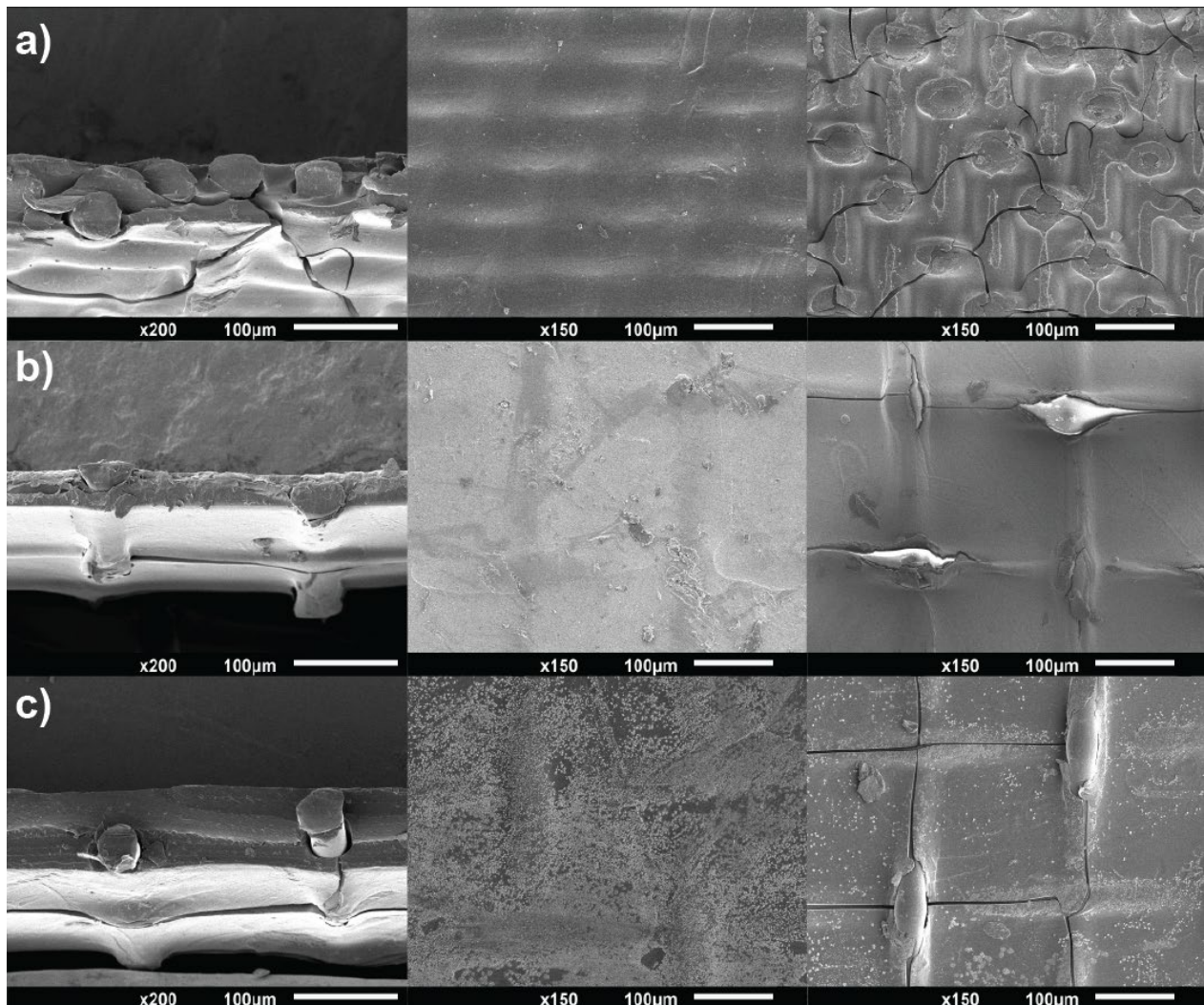


Figure S5: Scanning electron microscopy images of reinforced saloplastic membranes fabricated using optimised reinforcements and PEC equilibrated in 0.7 M KBr. For each membrane, cross-sectional (left), top-surface (middle), and bottom-surface (right) images are shown. From top to bottom: (a) PEEK reinforcement (71 μm thickness, 22% open area), (b) PEEK reinforcement (40 μm thickness, 70% open area), and (c) PPS reinforcement (40 μm thickness, 70% open area).