Ion exchange membrane resistance from cm to µm scale: is the power per unit area a good indicator?

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Since the beginning of blue-energy harvesting researches, a lot of work and advances have been made about membrane design and nanofluidic diffusio-osmotic transport, but the efficiency gap of several orders of magnitude between micro-scale designs and industrial power plants remains unsolved.[1]

The output power is usually calculated based on the membrane conductance per unit area, and the measured Donnan potential. This measurement method of power per unit area based on membrane conductance is therefore a key point to be able to compare several devices and their efficiency.

Our experimental work shows that on the contrary to the common belief, the device conductance is not proportional to the membrane area. Indeed, at small scale, the conductance is limited by the resistance of the junction between the membrane and the reservoir.

We made measurements with masking windows on the membrane varying from 25 square microns to square centimeters. We measure the conductance as a function of the masking but also as a function of the salt concentration solution in presence or not of salt gradient concentration.

These measurements imply that the power densities recovered in the presence of salt gradients grow by orders of magnitude as the membrane surfaces decrease.

The consequence is that the power per unit area obtained at the micro scale cannot be extrapolated to larger membranes. It follows that the comparison is biased between large scale commercially available membranes, and nano-engineered microscale membranes. This raises the urgent need for new indicators different from power per unit area, or standard measurement protocols allowing meaningful quantitative comparison between the different membranes.

References

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