Preparation of macroporous hydrophobic flat-sheet PVDF membranes via vapor induced phase separation

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Introduction

Hydrophobic and highly porous **polyvinylidene difluoride (PVDF) membranes** with tunable and narrow barrier pore size distribution in the range from ~0.1 to ~1 µm are prepared using the water **vapor induced phase separation (VIPS)** technique. Additionally, the process is tuned to suit an industrial scale up, regarding hazardous chemicals and short production time, which is the topic of this poster. During the VIPS process the cast film of the membrane polymer solution is exposed to humid air prior to immersion in the coagulation bath. Thus the pore forming process is different from common industrial methods such as non-solvent induced phase separation (NIPS) or thermally induced phase separation (TIPS). Moreover, **VIPS provides** the possibility for the preparation of **membranes with high porosity, isotropic cross section and narrow barrier pore size distribution**. Factors like relative humidity, exposure time to humid air and airflow velocity influencing mass transfer can be used for tuning the VIPS conditions.

Method

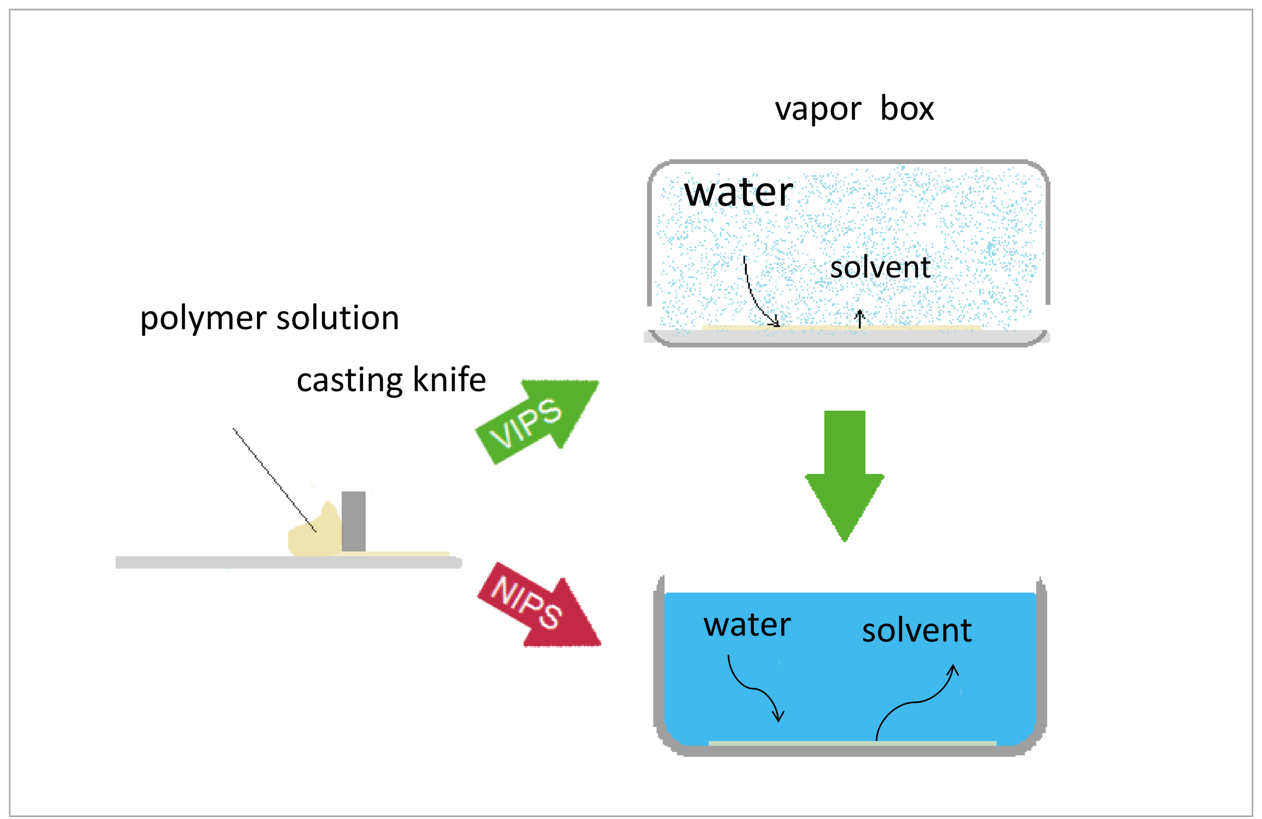

Fig. 1: **NIPS** (red) – the cast film is directly immersed into a coagulation bath; exchange of water and solvent is fast.
VIPS (green) – before immersion in the coagulation bath, the cast film is exposed to water vapor. Water uptake from the atmosphere into the cast film is slow.

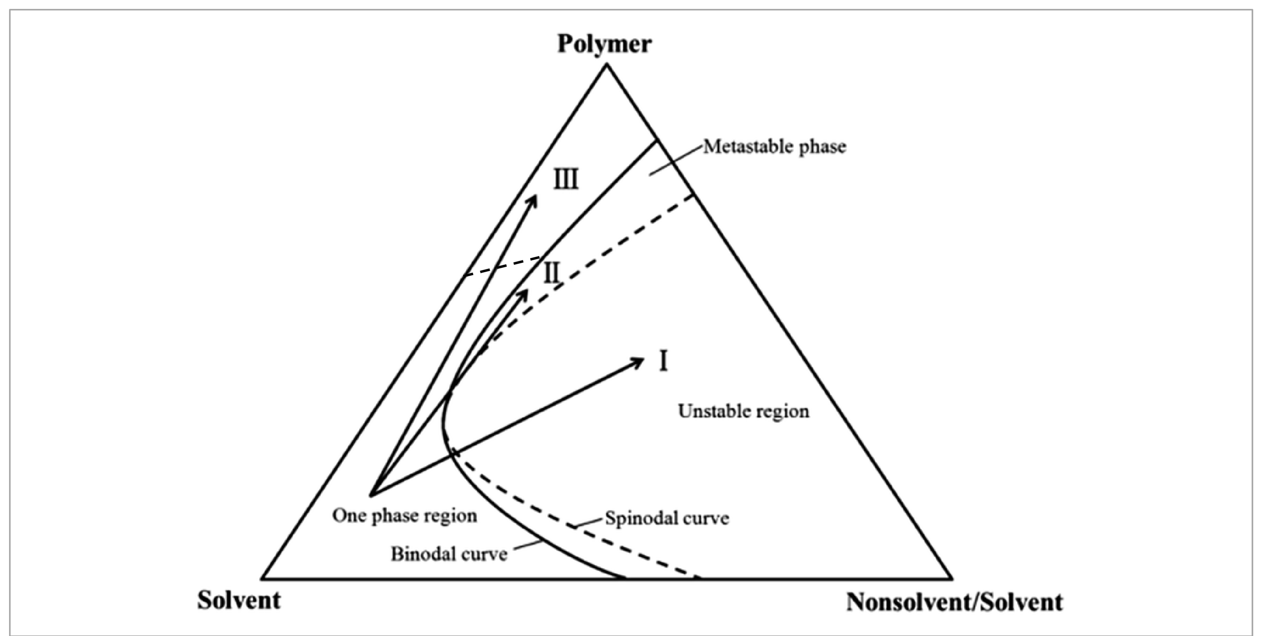

Fig. 2: Ternary phase diagram with different phase separation routes. I – spinodal decomposition, II – nucleation and growth, III – crystallization; [Li et al., RSC Advances, 2014]

Results

Laboratory scale

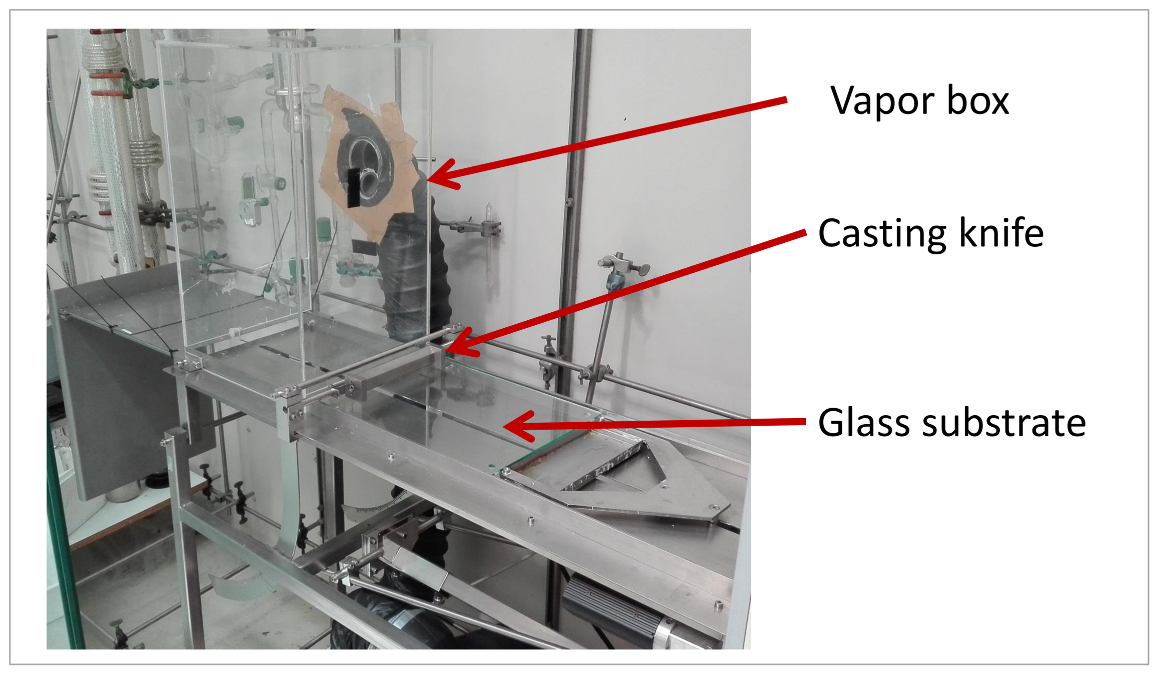

Fig. 3: Laboratory scale casting machine

Influence of relative humidity

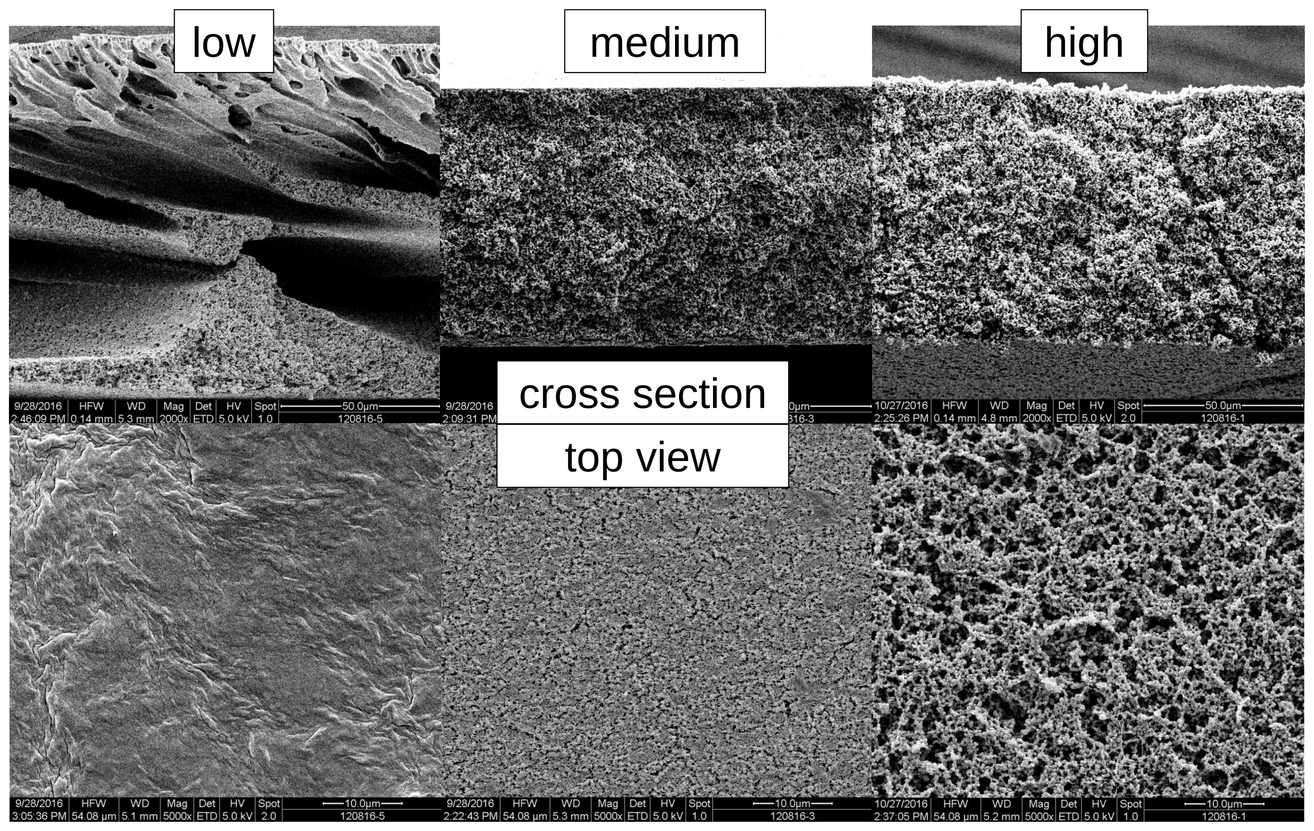

Fig. 4: The desired sponge like and porous structure is achieved by exposing the cast film to high humidity. Lower humidity values result in dense top layers and anisotropic cross sections.

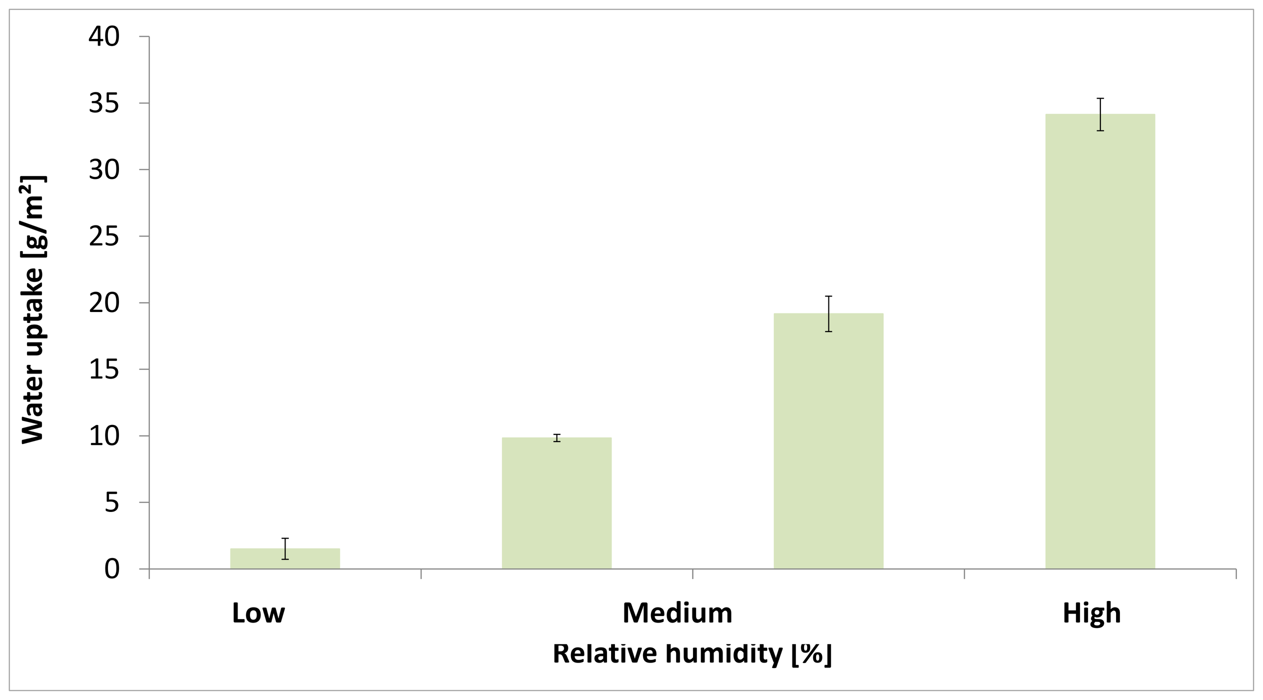

Fig. 5: Water uptake of cast film at various relative humidities.

Pilot scale

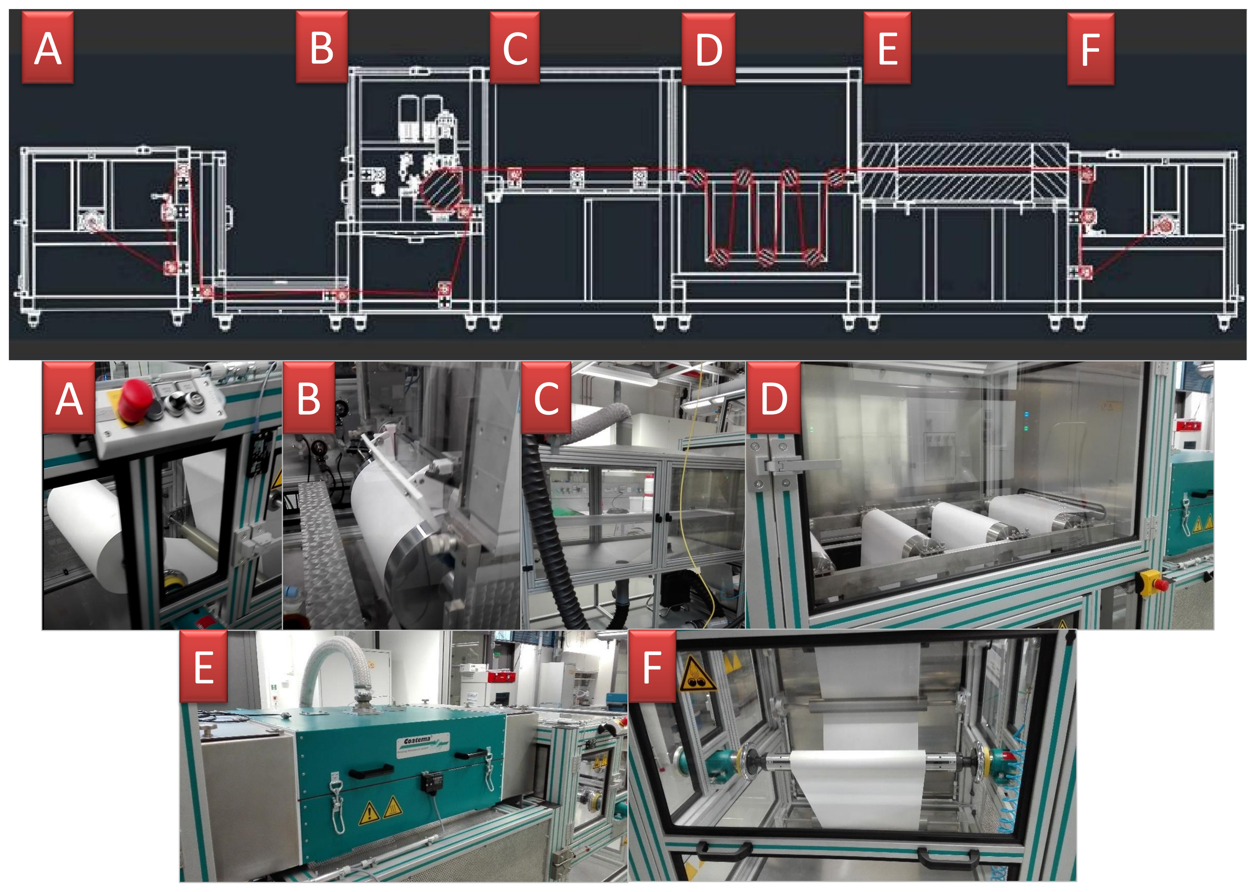

Fig. 6: Pilot scale casting machine: A – support stretching, B – casting, C – vapor box, D – coagulation bath, E – dryer, F – collector

Pilot scale membrane morphology

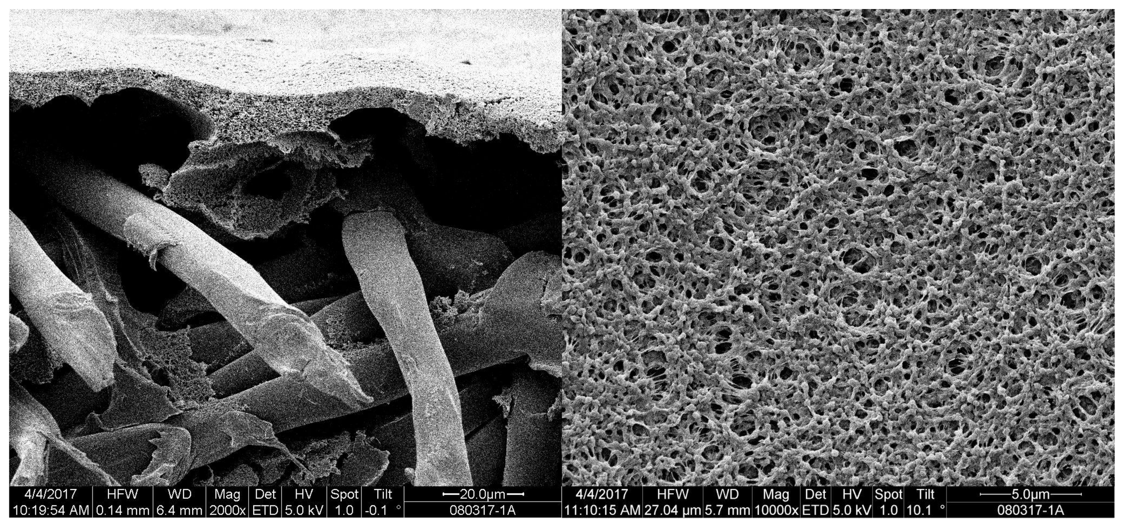

Fig. 7: SEM images of supported membranes, cross section (left) and top view (right)

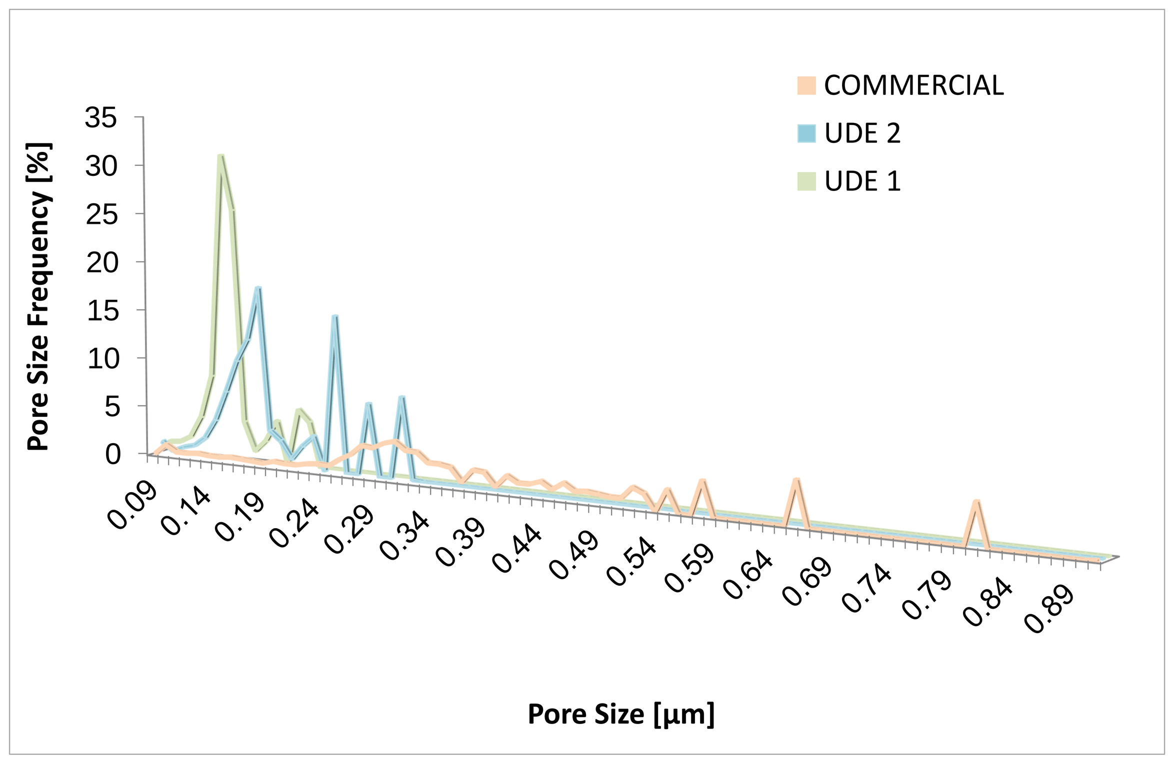

Fig. 8: Pore size frequency for commercial and self made supported PVDF membranes

Conclusions

Lab scale prepared membranes show the desired pore characteristics and performance parameters. Additionally the VIPS-based preparation process was successful in both, lab and pilot scales.

Acknowledgements

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