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הפקולטה להנדסה כימית
ע״ש וולפסון
The Wolfson Department of Chemical Engineering


**Wolfson Department of Chemical Engineering Seminar**

**Monday, February 24th, 2025, at 13:30**
**Room 6**

# Anisotropic proton-exchange membrane with enhanced through-plane conductivity


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**Ph.D. Seminar**

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Fuel cells and water electrolyzes are to play key roles in future hydrogen economy, yet these technologies still face challenges. Specifically, currently used proton-exchange membranes (PEMs) show insufficient ion conductance and water permeance, which also sharply drop at low humidity and limit the size, cost, and efficiency of these electrochemical energy devices. Unfortunately, a long and extensive effort has not yielded a viable remedy to this problem, inherent to all common PEM materials, including Nafion, the established benchmark. Recently, anisotropic materials possessing through-plane (TP) aligned nanochannels showed some promise of boosting PEM conductivity, however, reported realizations are complex and the materials are challenging to synthesize and upscale.

Nafion, the current state-of-the-art PEM, offers good stability and conductivity, but its limitations originate in randomly aligned channels embedded within the hydrophobic matrix, which becomes disconnected at low relative humidity (RH). Achieving stable through plane (TP) alignment of nanochannels is a promising approach to such next-generation PEMs.

The anisotropic TP-aligned Nafion/PVDF composite membranes were fabricated by in-plane (IP) compression of dual mats of co-electrospun Nafion and PVDF nanofibers. We demonstrated that Nafion and PVDF are uniformly mixed in the dual mats at ratios that can be varied from 50:50 to 90:10 using SEM and FTIR. The consolidated membranes obtained after IP compressions display a structure with both macro- and nanoscale alignment, where TP-aligned conductive nanochannels of Nafion are co-aligned with TP-oriented PVDF microfibers, as observed by TEM and confirmed by SAXS. With the well-defined composite structure, the resulting membrane displays twice the proton conductivity and ten-fold water permeability of Nafion. Most remarkably, it was discovered that high conductance of the new membranes unprecedently sustains at low humidity and thus exceeds that of Nafion 13 times in these conditions. The mechanism behind this effect was also confirmed and elucidated by molecular dynamics simulations.

**Refreshments will be served at 13:15**