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Bio-Inspired Selective Ion Transport Membranes

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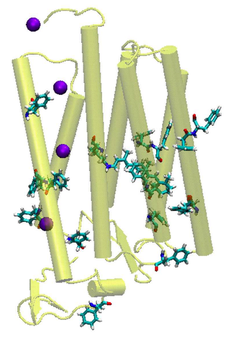
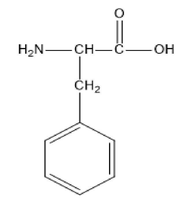
Background and Motivation

- Ion Exchange Membranes (IEMs) selectively transport ions of a certain species while barring transport of other ions in solution.
- Ionic selectivity is one of the most important factors affecting IEM performance.
- Layer-by-Layer (LbL) deposition of polyelectrolyte (PE) coatings is a low cost method to apply functional composite thin films with fine control over film thickness and composition.
- Phenylalanine is an amino acid with a phenyl-functionalized side chain that is believed to be a key component of the cation transport channel in channelrhodopsin.

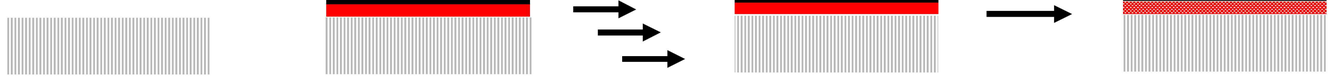


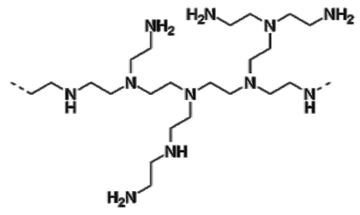
Na^+ (purple) transport in biological ion channels is facilitated by phenylalanine (blue) in channelrhodopsin chimera C1C2.



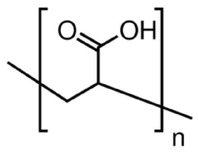
Phenylalanine (Phe)

Layer-by-Layer (LbL) Deposition of Polyelectrolytes





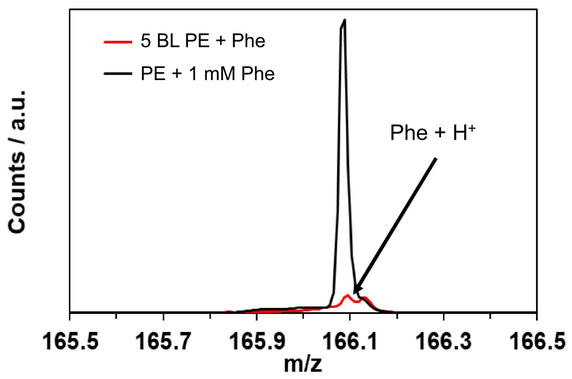
Branched PEI



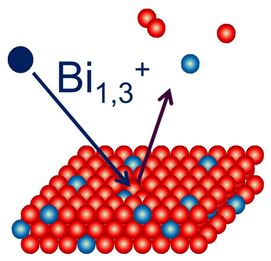
PAA

Percival, S.J., et al. *RSC Advances, (*2018), ***8,*** 32992-32999.

Phenylalanine Integration in PE films

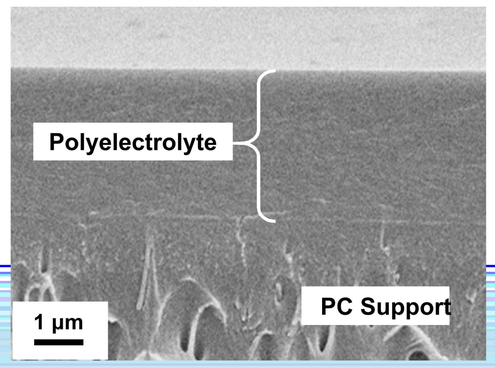


ToF-SIMS

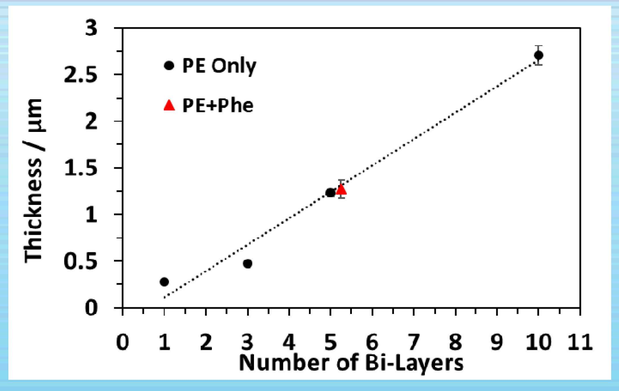


Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS) wss used to analyze the composition of the polyelectrolyte and confirm the presence of phenylalanine in the film

PE-Phe Coating Thickness

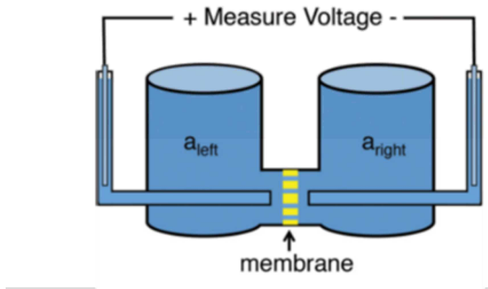


- Cross-sectional scanning electron microscopy (SEM) was used to determine the thickness of the PE coating.
- Coating thickness increases linearly with each additional bilayer.



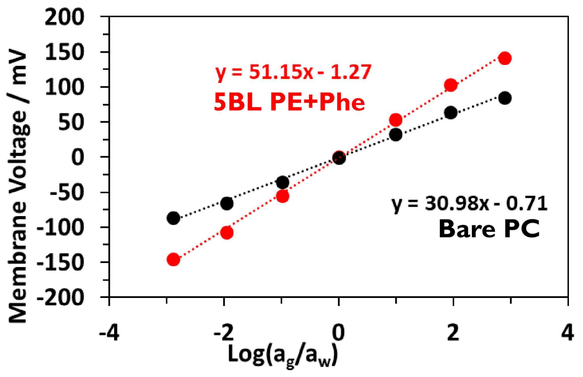
- Increasing polyelectrolyte thickness decreases other physical properties, such as ionic conductivity, important for the functionality of the ion exchange membrane.
- Incorporation of Phe into PE films did not change coating thickness.

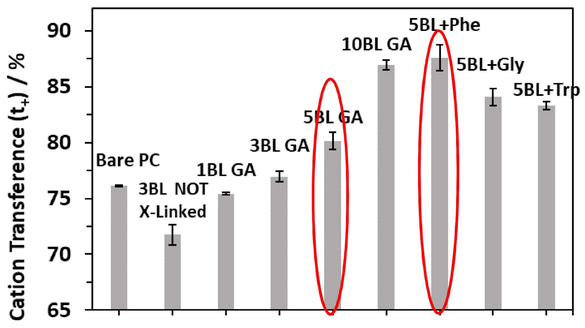
Ionic Selectivity of PE-Phe Coatings



$$V_m = 0.059 \cdot (t_+ - t_-) \cdot \log \frac{a_{right}}{a_{left}}$$

- A transmembrane potential was created by varying salt concentrations across the membrane.
- A cationic transference number (t_+) was calculated using the Nernst equation and the measured transmembrane potential.





- A large, positive slope indicates good cationic selectivity
- Addition of phenylalanine to polyelectrolyte films increases selectivity when compared to polyelectrolyte alone as well as other amino acid additives.

Conclusions and Path Forward

- Phenylalanine can be introduced to LbL-assembled polyelectrolyte thin films coatings on nanoporous substrates.
- Adding phenylalanine to a polyelectrolyte coating causes the same increase in selectivity as doubling the number of bilayers without increasing the thickness of the film.
- Future work will investigate the relationship between Phe concentration or the addition of other amino acids (or combinations of amino acids) impact ionic selectivity.

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