Orientated Co-deposition of Polydopamine/Polyethylenimine via Electric Field for Surface Modification of PVDF Membranes

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An electric field-accelerating and -directing co-deposition process is proposed to fabricate polydopamine-based coatings from polydopamine with charged polymers such as polyethylenimine. Vertically orientated coatings with uniform surfaces can be obtained on various membranes, especially on those adhesion-resistant materials.

Introduction

Mussel-inspired multifunctional polydopamine (PDA) coatings has spotlighted much interesting in the field of surface modification. However, the deficiencies of the PDA deposition process on membranes, such as tedious deposition time, low deposition efficiency, and non-directional diffusion, are obstructing the expansion of its applications. Herein, a rapid, efficient and orientated co-deposition process of PDA/polyethylenimine (PEI) has been achieved on poly(vinylidene fluoride) (PVDF) membranes via a novel electric field accelerated approach.

Mechanism

PDA is weakly negatively charged while PEI is positively charged, thus the electropositive PDA/PEI aggregates could move from the anode to the cathode in the electric field, which promotes the fabrication of PDA/PEI coatings on membrane surfaces located at the cathode with higher PDA/PEI aggregates concentration. Meanwhile, as the voltage of the electric field in our case is higher than that for water electrolysis, the membranes at the anode could also be co-deposited rapidly due to the higher oxygen concentration.

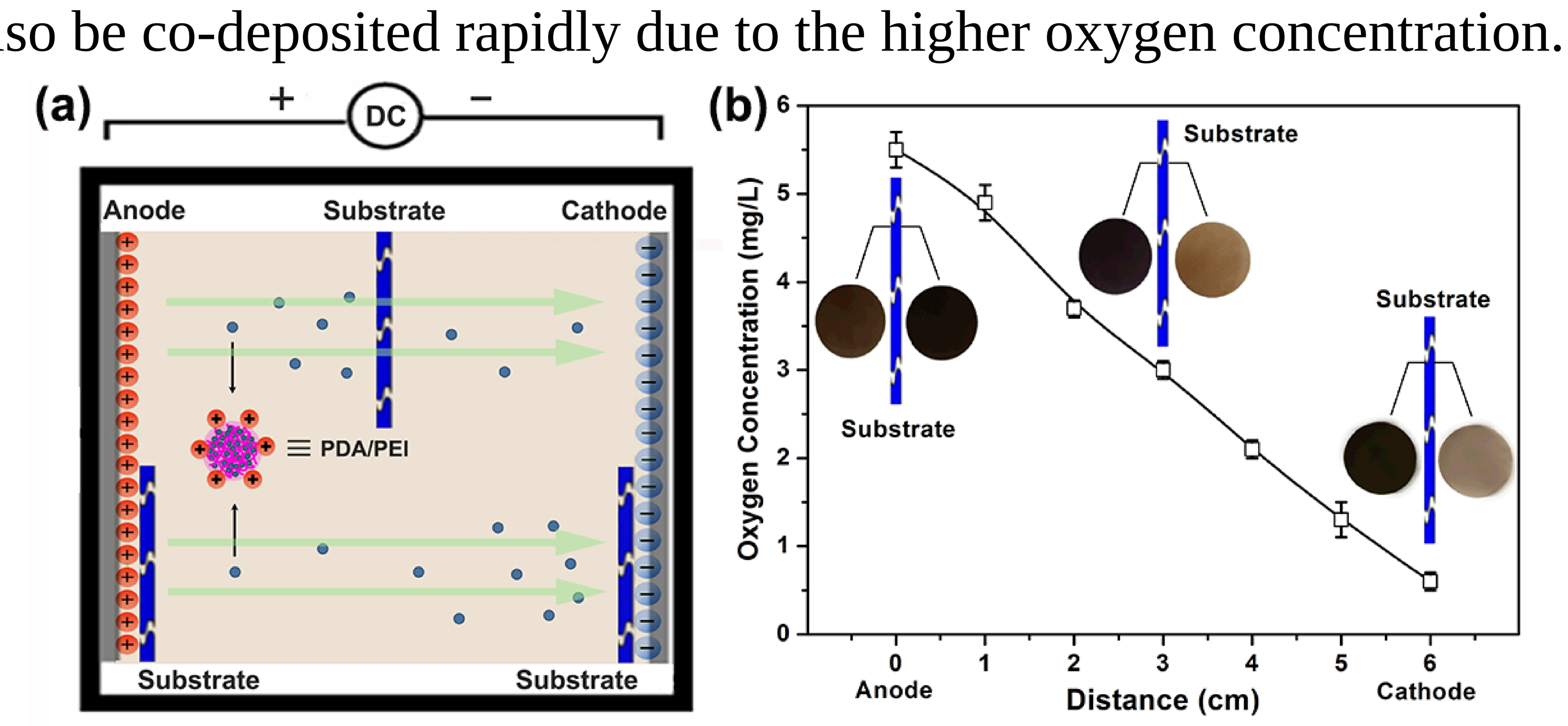

Figure 1. (a) Schematic diagram for PDA/PEI co-deposition in an electric field. (b) Oxygen concentration in the electric field and digital photographs of the co-deposited PVDFMMs.

The PDA/PEI coatings are selectively co-deposited on silicon wafer at the cathode, which is vertical to the electric field direction. However, silicon wafer at the profile plane of the container exhibits a much thinner coating after co-deposition in the parallel direction of the electric field.

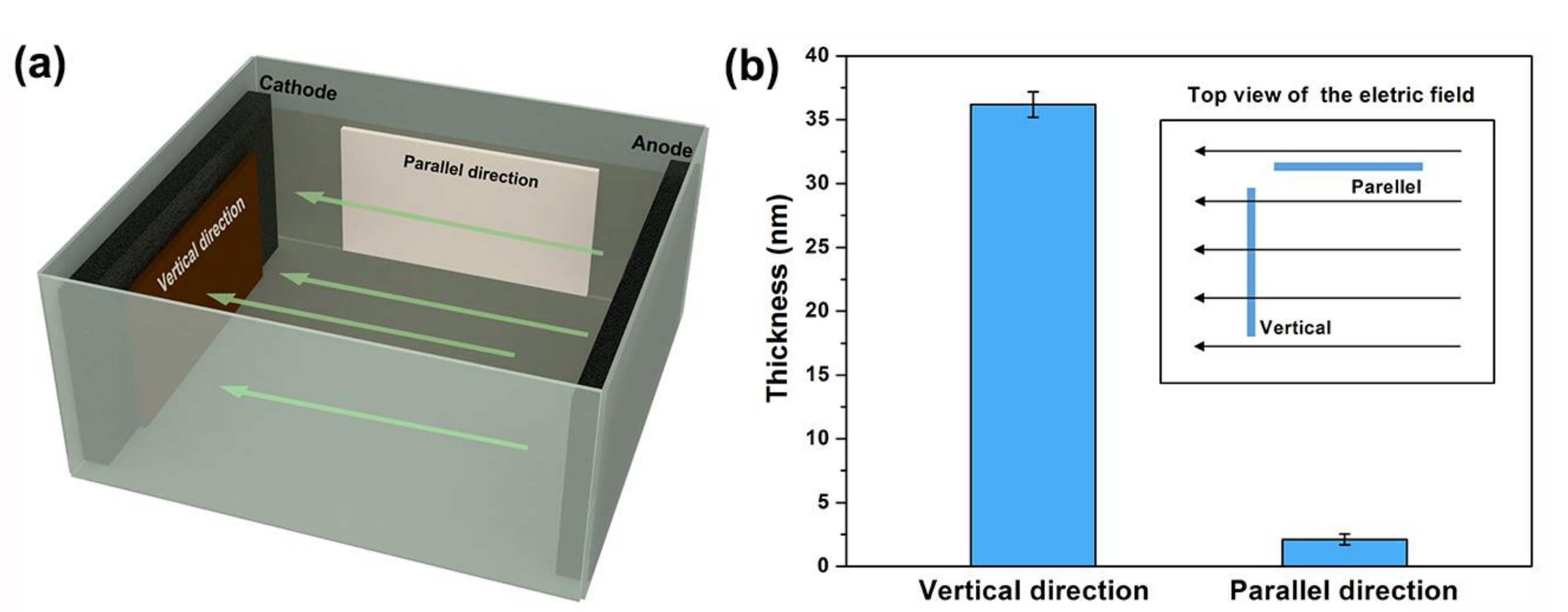

Figure 2. (a) Schematic diagram for orientated co-deposition in the electric field. (b) Thickness of the PDA/PEI coatings co-deposited on silicon wafer at vertical direction and parallel direction, respectively. And top view (insert) for the stress state of the silicon wafers in the electric field.

Performance

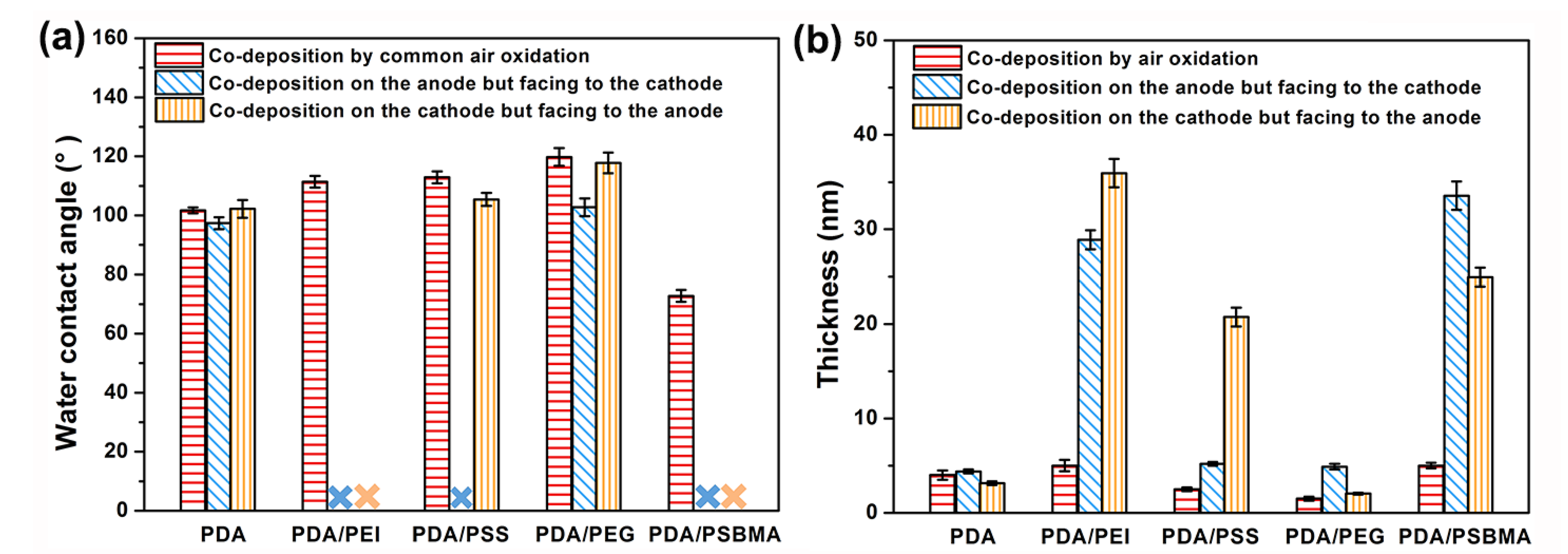

Figure 3. (a) Water contact angles of PVDFMM surfaces co-deposited with different charged polymers. The symbol "×" stands for the membranes which can be permeated by the water drop at once. (b) Coating thickness co-deposited on silicon wafers with different charged polymers.

The modified membranes show superhydrophilicity with a more uniform and smoother coating layer, whose thickness could increase to 36.3 nm with only 2 h rapid co-deposition. Our process can also be applied to fabricate mussel-inspired coatings from PDA with other polyelectrolytes including anionic poly(sodium p-styrenesulfonate) (PSS) and zwitterionic poly(sulfobetaine methacrylate) (PSBMA).

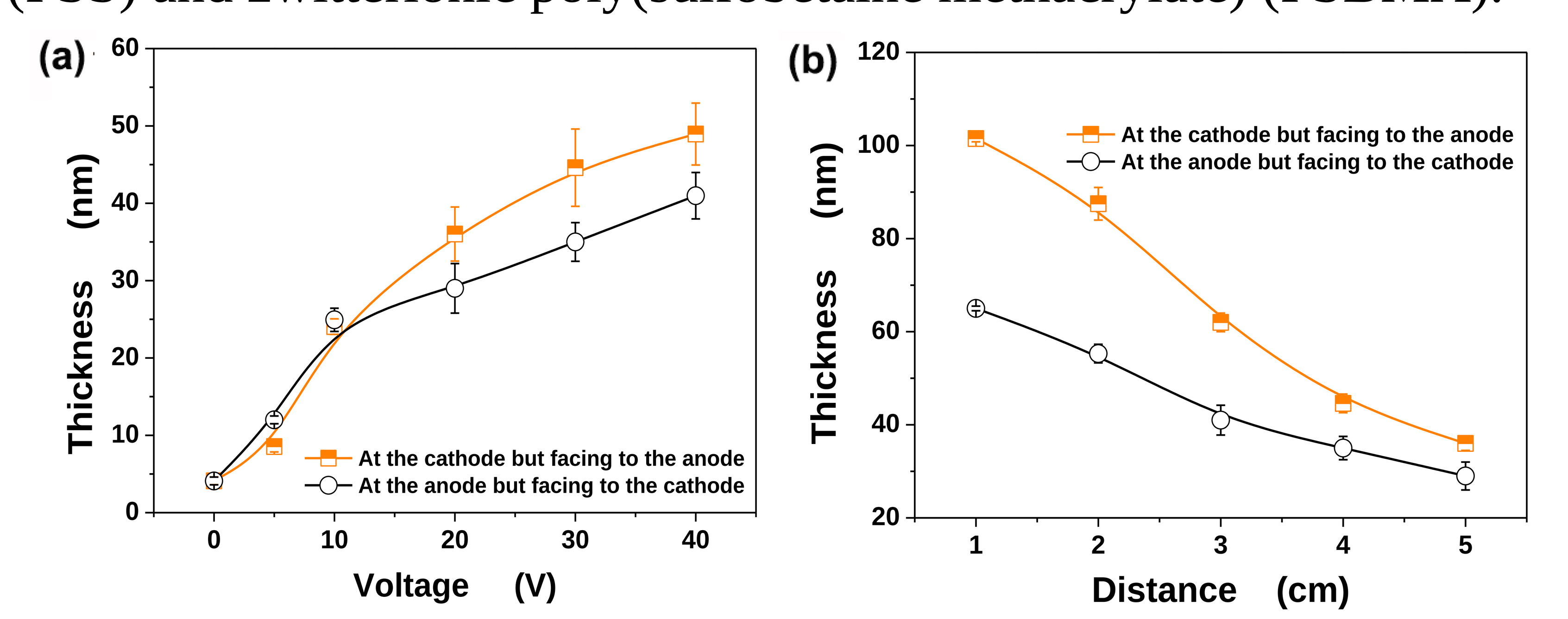

Figure 4. Effects of applied voltage and distance between the two electrodes on the coating thickness of PDA/PEI co-deposited on silicon wafers in the electric field.

Conclusion

Mussel-inspired coatings have been successfully fabricated via an electric field-directing/-accelerating method for the first time. Being more environmentally friendly, this facile method can reduce the deposition time and lead to vertically orientated co-deposition with less wasted polydopamine-based aggregates. The fabricated PDA-based coatings are uniform and exhibit asymmetric chemistry and wettability, which is promising for preparing Janus membranes.

References

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