General Strategy for Synthesis of Morphology-Tunable Layered Double Hydroxide on Arbitrary Substrates with a Mussel-Inspired Intermediate Layer: from Nanosheets to Nanoscrolls

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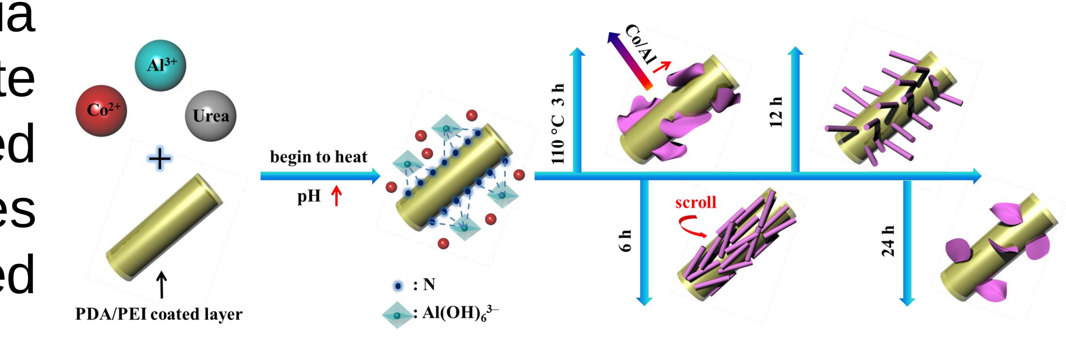
Abstract: Layered double hydroxides (LDH) with different morphologies were fabricated via hydrothermal treatment on various polydopamine/polyethylenimine (PDA/PEI) modified substrate surfaces. The morphology of the LDH nanostructures from ultrathin nanosheets, parallel aligned nanoscrolls and vertically aligned nanoscrolls could be tuned facilely by reaction times, temperatures and metal-salt concentrations. The investigation confirmed that amino group and positively charged surface play key roles in the formation of well-defined LDH nanoscrolls.



Introduction

Synthesis of morphology-controlled nanocrystals on target substrates presents an enticing prospect for fabricating multifunctional devices.[1-3] Herein, PDA-based coating was introduced as a reagent for the growth of LDHs and also as the adhesive component in the intermediate layer. PEI was codeposited onto the target substrate surfaces to increase the stability and surface hydrophilicity of the modified substrate. Then, in situ growth of LDHs on the modified surfaces was performed in a homogeneous aqueous solution.

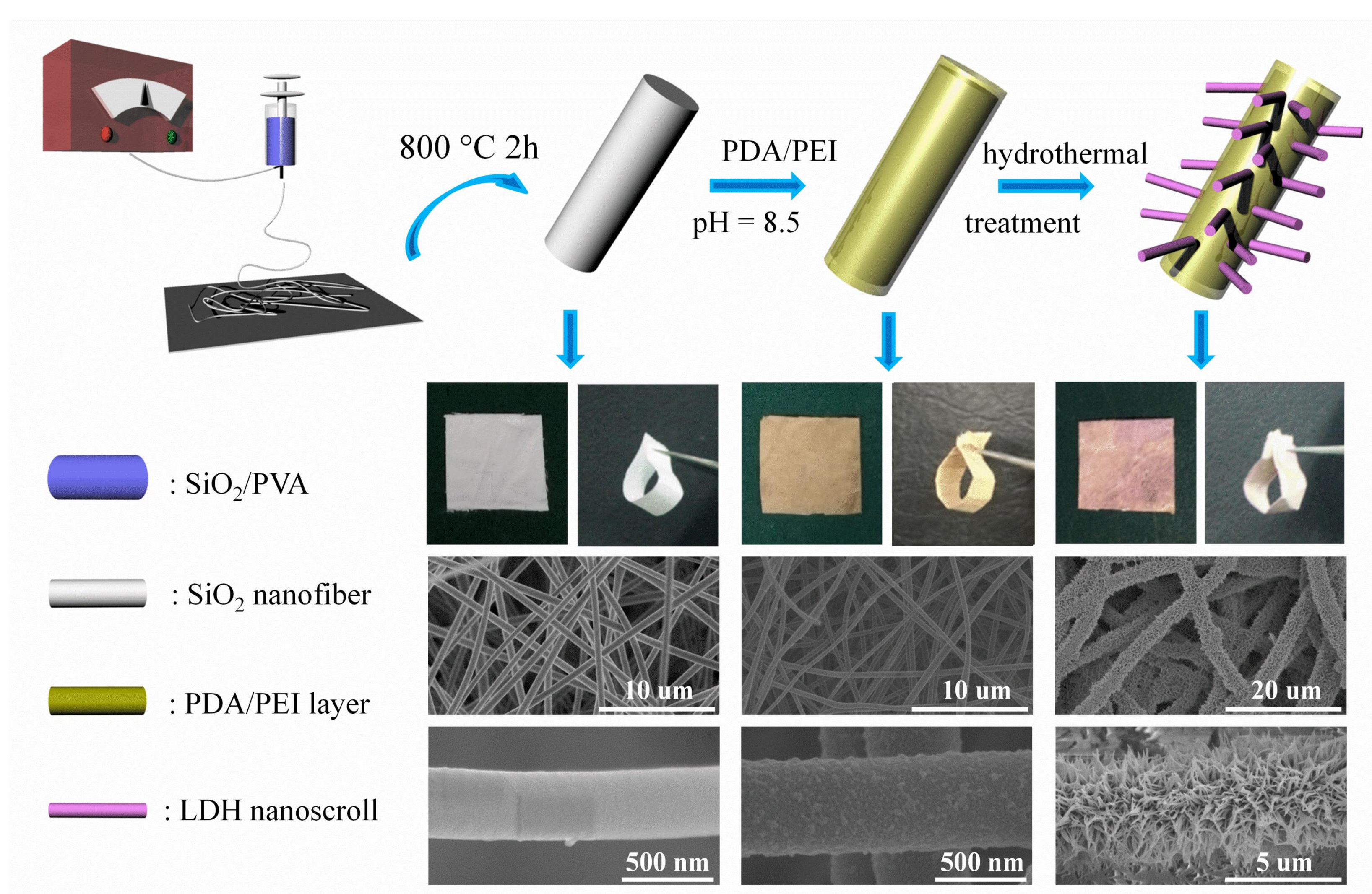


Fig. 1. Schematic illustration of the preparation steps of LDH coated hybrid nanofiber membranes and their corresponding optical and SEM images.

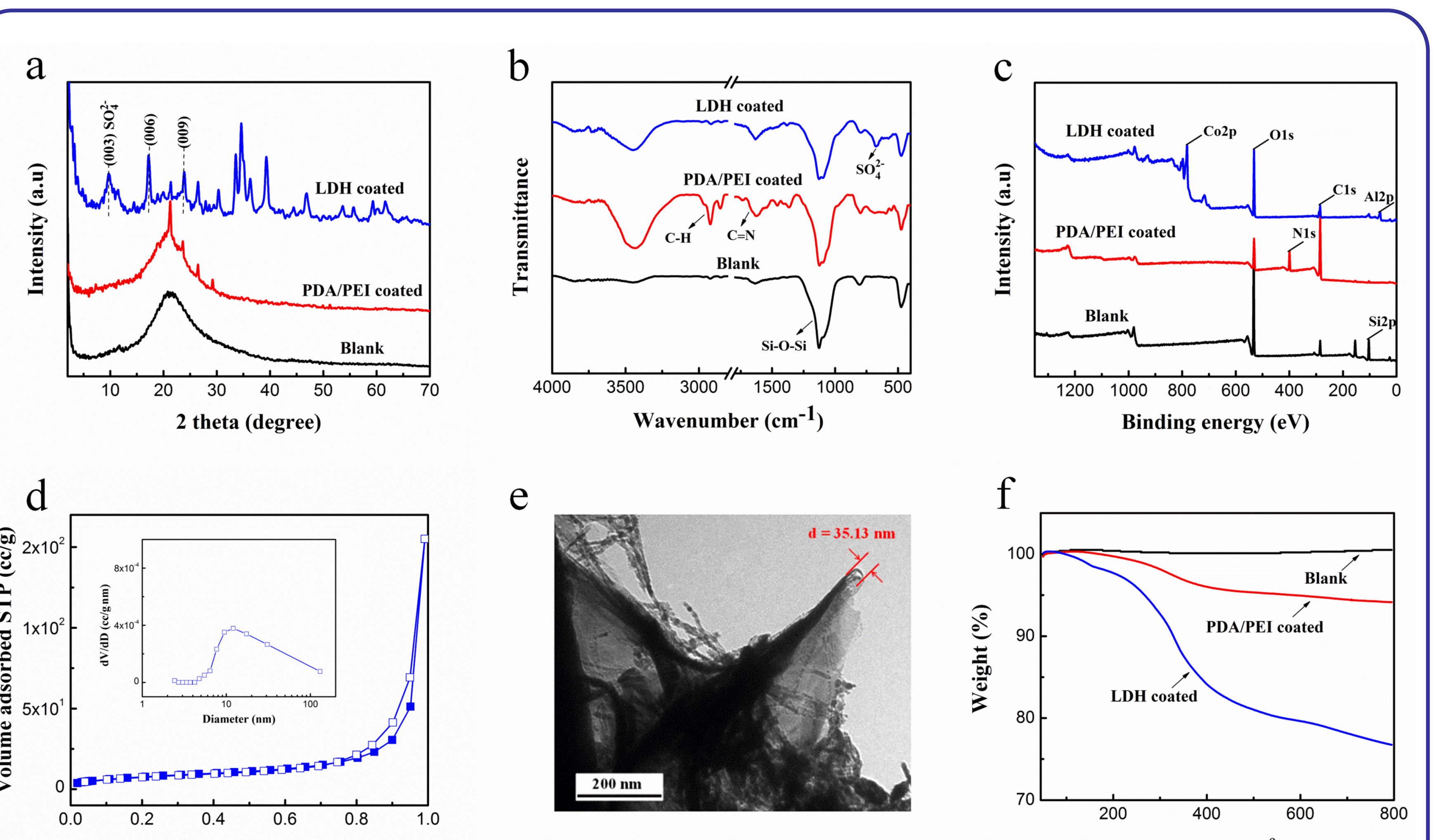


Fig. 2. Characterization of structure properties of the prepared membranes. (a) XRD patterns, (b) FT-IR spectra, (c) XPS spectra, (d) N_2 adsorption-desorption isotherm of the LDH coated nanofiber membranes, (e) TEM image showing the LDH nanoscrolls on SiO_2 nanofiber, and (f) TGA curves. The insert in (d) is the pore size distribution of the LDH coated membranes.

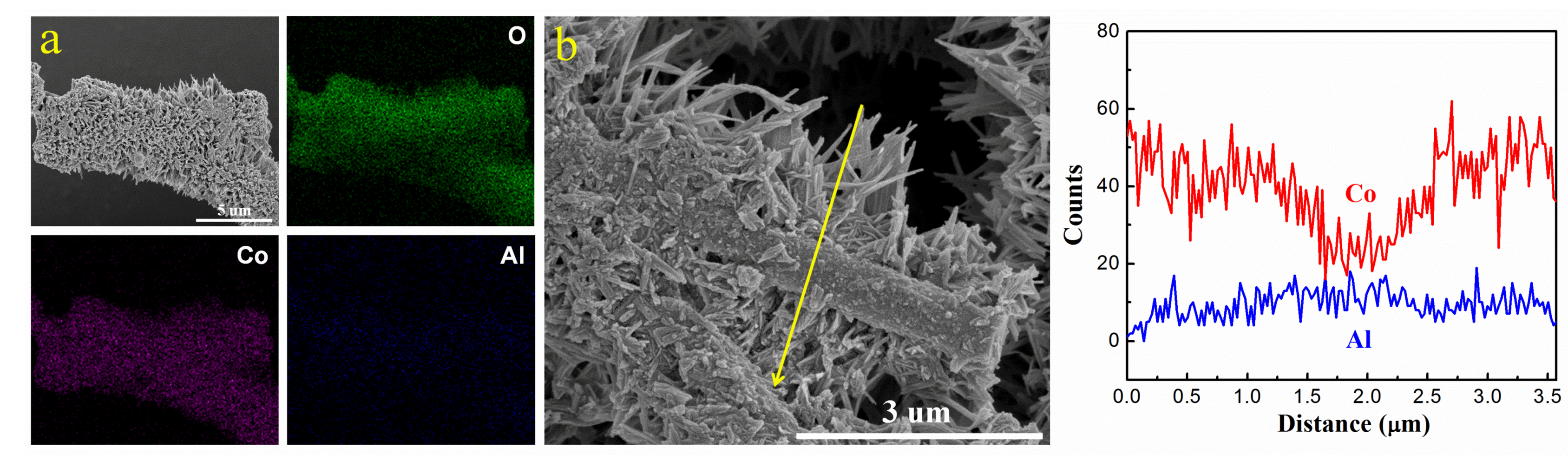


Fig. 3. (a) EDX element mapping of LDH coated nanofiber. (b) SEM image and the corresponding energy dispersive X-ray line scan of the LDH coated nanofiber where half of the LDHs was wiped out.

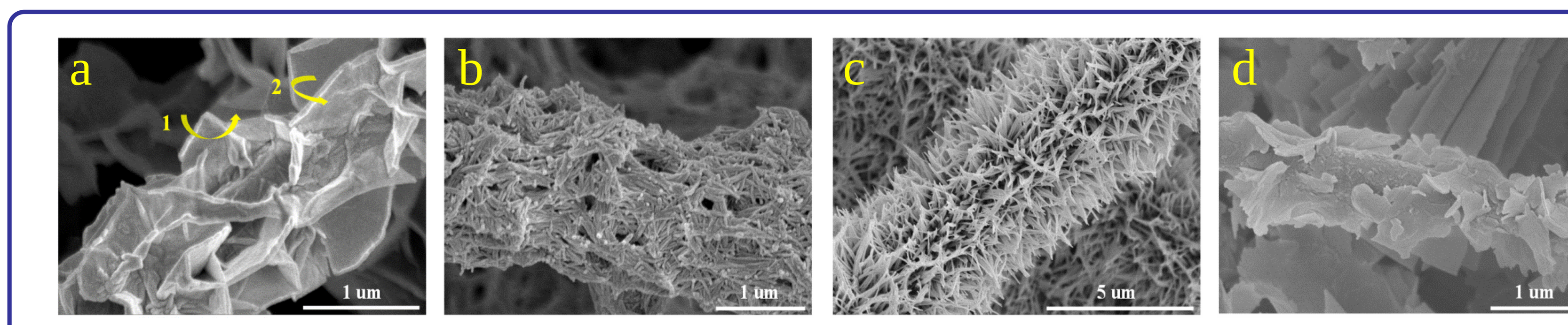


Fig. 4. SEM micrographs of the LDHs grown on the nanofibers at different times (at 110 ℃ and the total metal concentration of 96 mmol/L): (a) 3 h, (b) 6 h, (c) 12 h and (d) 24 h.

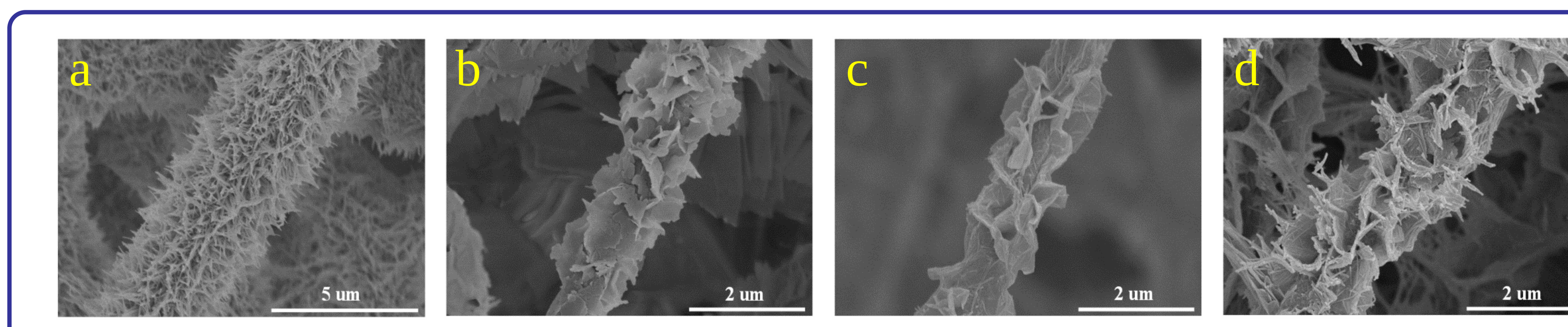


Fig. 5. SEM micrographs of the LDHs grown on the nanofibers at different temperatures with the total metal concentration of 96 mmol/L: (a) 100 ℃ and (b) 120 ℃. SEM micrographs of the LDHs grown on the nanofibers at 110 ℃ with different metal concentrations: (c) 12 mmol/L and (d) 48 mol/L. The reaction time of all experiments was 12 h.

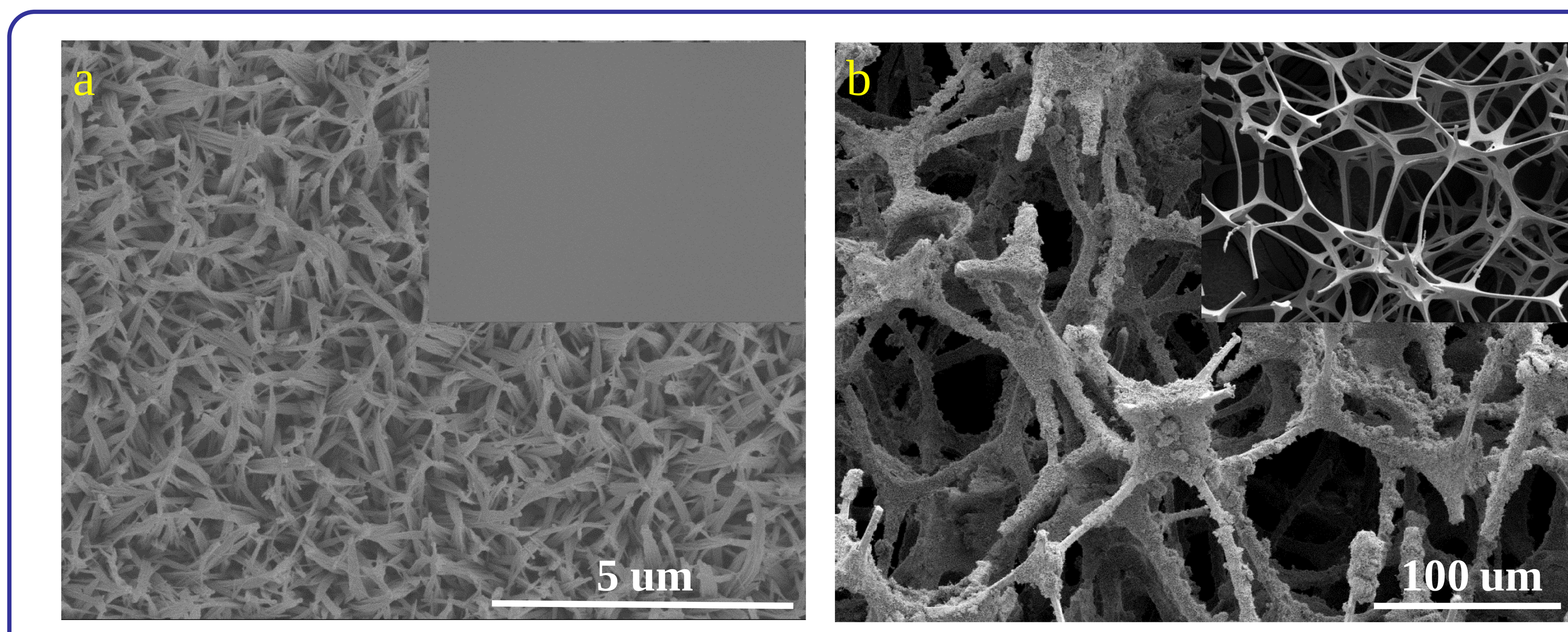


Fig. 6. SEM images of the LDHs grown on (a) the aluminum foil and (b) the melamine sponge. The inserts in (a) and (b) are the blank substrates.

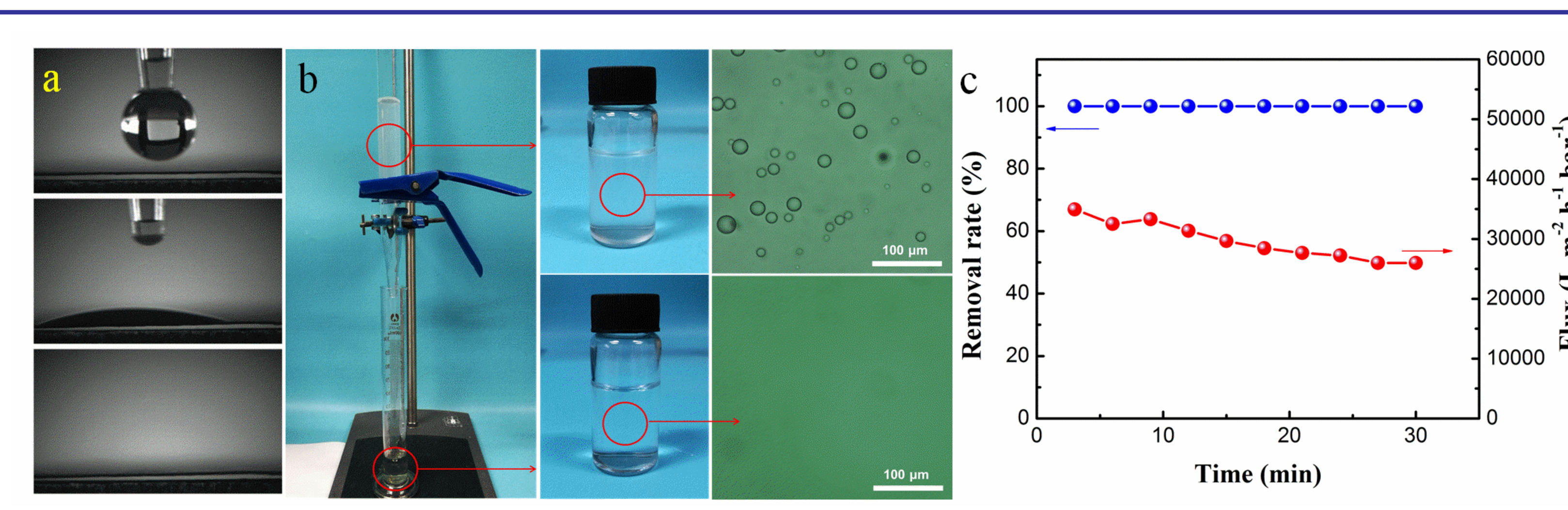


Fig. 7. (a) Optical profiles of the water contact angle on the surface of LDH coated membranes. (b) Home-made filtration unit showing the facile separation of oil-in-water emulsion. (c) Removal efficiency and permeation flux of oil-in-water emulsion by the LDH coated membranes.

Conclusions

1. LDHs with ultrathin nanosheets, parallel aligned nanoscrolls and vertically aligned nanoscrolls on arbitrary substrates were successfully prepared by combining polydopamine /polyethylenimine (PDA/PEI) modified layer and the hydrothermal treatment.
2. The LDH coated membranes could effectively separate the surfactant stabilized oil-in-water emulsion with high flux and oil rejection.

Acknowledgement

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References

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