Integration of layered double hydroxide nanosheets and nanoparticles for high-performance anion exchange membrane

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Layered double hydroxides (LDH) nanosheets exhibit high OH^- conductivity approaching 10^{-1} S cm^{-1} along in-plane direction, promising for the fabrication of anion exchange membranes.[1] However, 2D anisotropic conduction of the nanosheets results in the substantially low conductivity of 10^{-6} S cm^{-1} along cross-plane direction, posing a great hurdle to achieve ultrafast ion pathways along cross-membrane direction.[1] Herein, inspired by formation of effective electron-conducting channels within the electrode materials of lithium batteries,[2,3] a composite membrane was prepared based on mixing/assembling of LDH nanosheets with nano-sized LDH platelets (nanoparticles) via a filtration process. The results revealed that the incorporation of nanoparticles reduced the parallel restacking of nanosheets. Nanosheets surrounded by nanoparticles could form effective ion conducting paths and networks in the membrane, which could help to reduce the high anisotropy of LDH nanosheets and therefore greatly improve the cross-membrane conductivity. As a result, ion conductivity of the composite membrane was measured to be in a range between 10^{-3}~10^{-2} S cm^{-1}, in both in-plane and cross-membrane directions. The cross-membrane conductivity of the composite membrane was significantly increased by 2-3 magnitudes of order compared with that of membrane composed of pure nanosheets (10^{-6} S cm^{-1}).

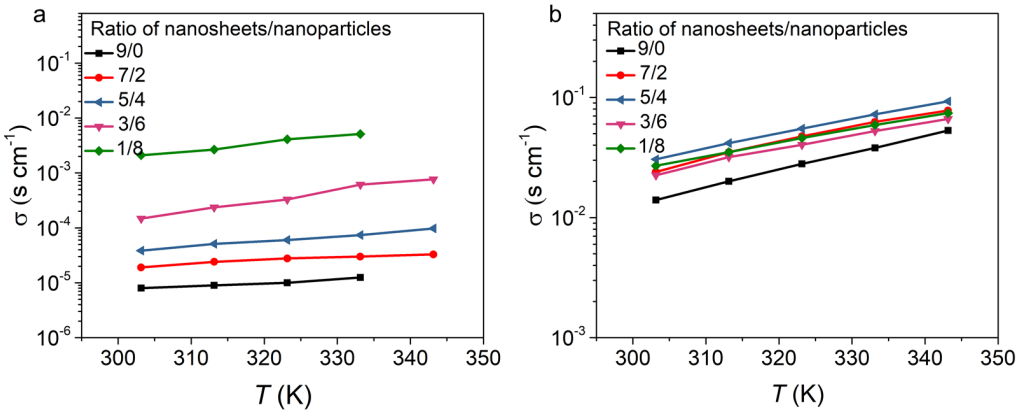

Fig. 1. Temperature-dependent ion conductivity for (a) cross-plane and (b) in-plane direction of different membranes with different mixing ratio of nanosheets to nanoparticles under 80% RH.

1) P. Sun, R. Ma, T. Sasaki, *Sci. Adv*. **2017**, 3: e1602629. 2) a) F.-Y. F. Kang, *Nano Energy* **2012**, 1, 429. b) H. Wang, Y. Cui, H. Dai, *Angew. Chem., Int. Ed*. **2011**, 50, 7364.

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