The effect of hot-pressing on performance of MEA using acid-doped bacterial cellulose as proton exchange membranes

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Series of proton-conducting polymer electrolyte membranes have been prepared from bacterial cellulose by incorporation of phosphoric acid (H_3PO_4/BC) and phytic acid (PA/BC).[1] Although the power density was higher than other membranes based on BC,[2,3] the cell performance still needed to be improved. The methodologies for performance enhancement include modifying membranes,[4] changing catalyst loading[5] and the dosage of Nafion, [6] alternating fabrication methods of catalyst layer[7] and optimizing hotpressing conditions[8] and so on.

Specifically, in theory, different membranes hot-pressed under different conditions should be tested in PEMFCs. However, hundreds of optimal experiments will cost quantities of noble metal catalysts and carbon papers as well as test duration. Considering that the water uptake of acid-doped BC membranes was not low and the conductivity was sharply decreased after hot-pressing, we chose the residual conductivity ratio (r) as the measuring protocol to process the single factor tests, which was defined as the percentage of conductivity after hotpressing (σ_2) to that before hotpressing (σ_1).

These handy materials in the lab such as PTFE sheets, parafilms, weighing papers, aluminum foils, printer papers, filter papers were obtained as supporting materials sandwiching and immobilizing the MEA. Proton conductivities of acid-doped BC membranes before and after hot-pressing were measured by electrochemical impedance spectroscopy. Then the optimal hot-pressing condition needed to be testified by PEMFC performance. The catalyst layers with a Pt loading of 0.5 mg cm^{-2} sprayed on carbon papers for both cathode and anode were used in all the MEAs. Besides, the effect of the hydrogen and oxygen fluxes and the operating temperature were also obtained from single cell tests.

Figure 1 displays the optimization of hot-pressing conditions including the supporting materials of MEA and the temperature, pressure and time of hot-pressing with acid-doped BC membranes' conductivity ratio as the evaluation factor. The single factor test results reveal that in comparison with other factors, the supporting materials have more remarkable effects on the conductivity changes during hot-pressing. Those hydrophobic dense supporting materials such as PTFE sheets are much easier to lessen the decrease of conductivity of both two kinds of membranes. Given that high hot-pressing temperature and pressure could reduce the contact resistance and combining with the efficiency principle, 80 ^oC, 10MPa, 6 min and 80 ^oC, 6MPa, 3 min are chosen as the optimal condition for 8 M H_3PO_4/BC and 1.6 M PA/BC respectively.

Figure 2 shows the PEMFC performance of acid-doped BC membranes under the initial and optimized hot-pressing conditions. Compared to the former results, the power densities of both 8M H_3PO_4/BC and 1.6M PA/BC remarkably increased from 17.9 mW cm^{-2} and 23.0 mW cm^{-2} to 25.0 mW cm^{-2} and 26.1 mW cm^{-2}, respectively. Also, the results testify the feasibility of the optimization method for MEA.

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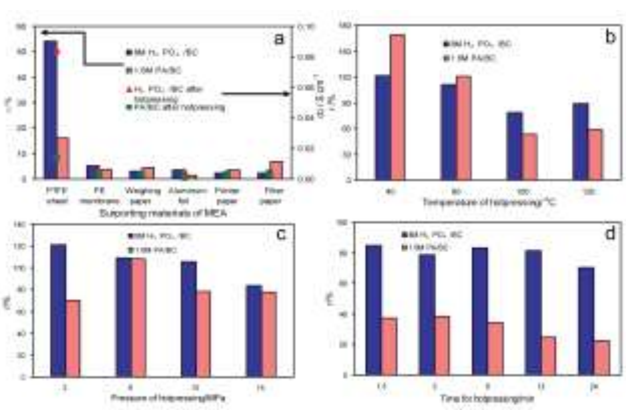

Figure 1: Optimization of hot-pressing conditions: (a) supporting materials of MEA, (b) temperature of hot-pressing, (c) pressure of hot-pressing and (d) time for hot-

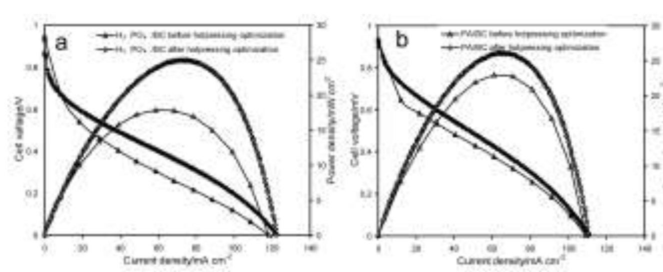

Figure 2: Comparison of PEMFC performance of (a) 8M H_3PO_4/BC and (b) 1.6M PA/BC before and after hot-pressing optimization. The fluxes of hydrogen and oxygen were 100mL min^{-1} and 200mL min^{-1} respectively. The single cell tests were operated at ambient temperature