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Highly proton conductive nitro-oxidized cellulose nanopaper for polymer electrolyte membrane (PEM) fuel cell

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Polymer electrolyte membrane (PEM) fuel cells have attracted tremendous attention over the past decades because of the promising and environmental friendly alternative power source, but the major challenge is high cost which provokes it from commercialization. The fuel cell membrane (e.g. Nafion) contributes significantly to this cost, and therefore, novel and green alternative substrates are required. To solve this issue, we have developed a simple and cost-efficient Nitro-oxidation approach to produce carboxycellulose nanofibers (NOCNF) from untreated/raw biomass. Cellulose nanopaper fabricated from NOCNF possessed high mechanical strength having tensile stress of 108±2 MPa. The initial studies on testing these membrane were done separately on ionic (COO-Na+) and acid (COOH) forms of NOCNF which were tested in polymer electrolyte membrane (PEM) fuel cell set up. The two-fold increase in current density was observed in NOCNF-COOH as compared to NOCNF-COO-Na+. Hence, NOCNF-COOH was further used to prepare composite membrane separately with different concentration of Nafion (5, 25, 50 wt %). The initial studies on composite nanopaper/ membrane prepared from NOCNF and Nafion (5 wt %) showed drastic increase in current density from 70-130 mA/cm2 at 20 psi, when tested at 80°C and 95% relative humidity using hydrogen fuel in polymer electrolyte membrane (PEM) fuel cell set up. The performance shown by NOCNF-COOH-Nafion (5 wt %) was significantly higher than the CNF and its derivate membranes reported till now in the literature. Furthermore, NOCNF and NOCNF composite membranes were characterize by NMR, WAXD, FTIR, SEM, TEM, BET, TGA, proton conductivity and gas permeability studies.

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