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Jensen, Annemette Hindhede; Prag, Carsten Brorson; Li, Qingfeng; Christensen, Erik; Bjerrum, Niels J.

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Fabrication and characterizations of materials and components for intermediate temperature fuel cells and water electrolysers

Authors: A. H. Jensen*, C. B. Prag, Q. Li, E. Christensen, N. J. Bjerrum

Email: *ahije@dtu.dk

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Outline: The worldwide development of fuel cells and electrolysers has so far almost exclusively addressed either the low temperature window (20 - 200 °C) or the high temperature window (600 - 1000 °C). This work concerns the development of key materials and components of new generation of fuel cells and electrolysers for operation in the intermediate temperature range from 200 to 400 °C. The intermediate temperature interval is of importance for the use of renewable fuels. Furthermore electrode kinetics are significantly enhanced compared to when operating at low temperature. Thus non-noble metal catalysts might be used.

One of the key materials in the fuel cell and electrolyser systems is the electrolyte. Solid acid materials such as cesium hydrogen phosphates, zirconium hydrogen phosphates and tin pyrophosphates have been investigated by others and have shown interesting potential as proton conductors in the intermediate temperature range. [1-3]

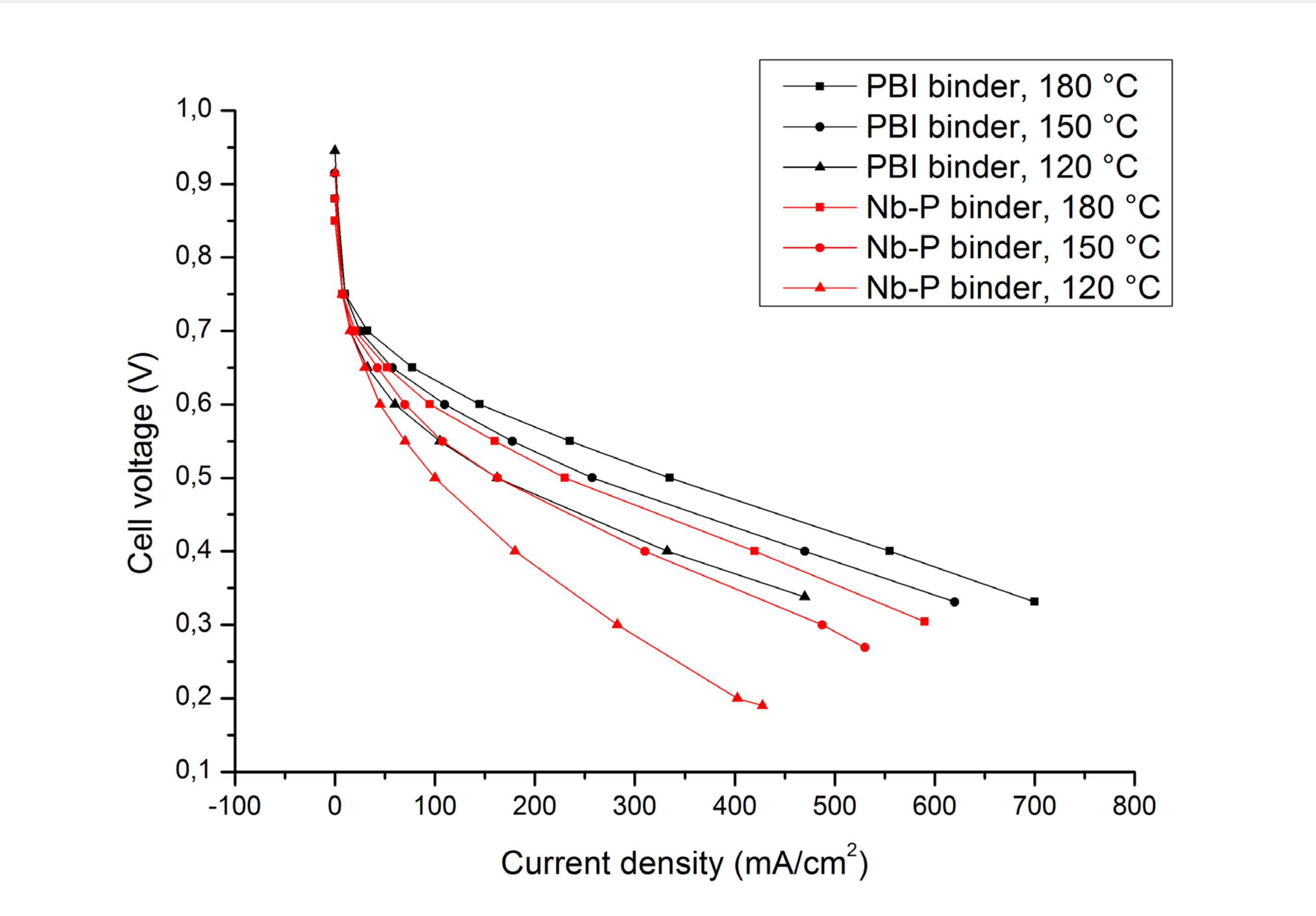

Figure 1: Polarisation curve for electrodes. Both electrodes had a Pt loading of 0.7 mg/cm². One electrode had a Nb-P loading of 1.2 mg/cm² and the other had a PBI loading of 0.14 mg/cm².

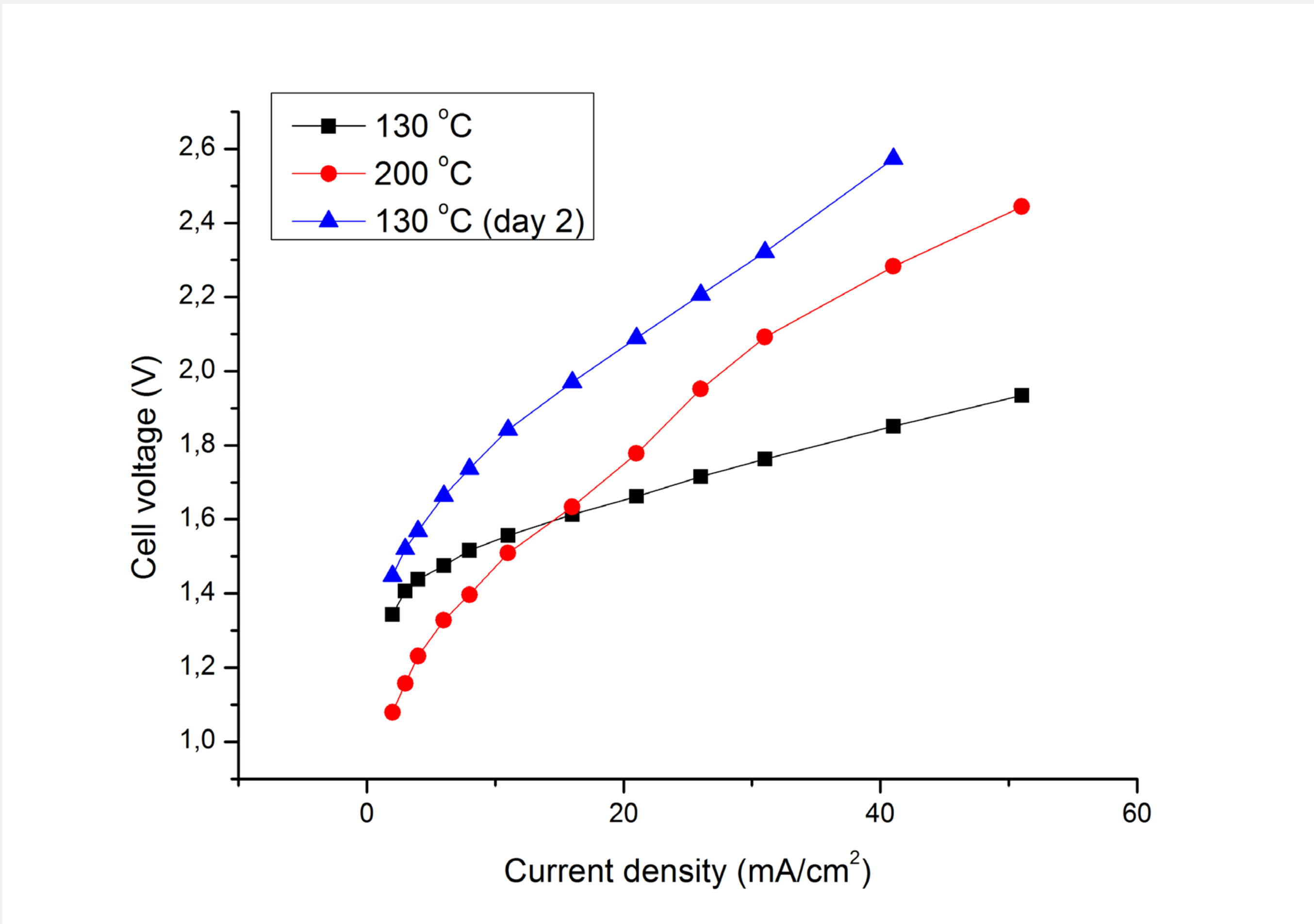

Figure 2: Polarisation curve for electrolysis mode. The cathode had a Pt loading of 0.7 mg/cm² and a Nb-P loading of1.2 mg/cm². The anode had a IrO_2 loading of 2.1 mg/cm² and a Nb-P loading of 2.1 mg/cm².

Experimental: A new type of fuel cell and electrolyser based on solid acid electrolytes suited for the intermediate temperature interval is in the design phase.
So far fuel cell and water electrolysis tests have been performed for technical demonstration using phosphates as electrolyte material.

Initial tests with Nb-P as proton conducting electrolyte in electrolysis mode have been conducted. Results with a 1 mm thick electrolyte, Pt/C cathode and IrO_2 + Nb-P anode are shown in Figure 2. The best results were obtained at 200 °C and low current densities, whereas higher current densities resulted in high polarisation resistance of the cell. Upon cooling to 130 °C decrease in performance at all current densities indicated a non-reversible degradation of the cell.

Comparison of Pt based electrodes with respectively Polybenzimidazole (PBI) and Niobium Phosphate (Nb-P) binders/proton conductors at temperatures up to 180 °C has shown that Nb-P containing electrodes have a greater gain in performance when temperature is increased (Figure 1). Here the electrodes were utilised in fuel cell mode with a PBI electrolyte.

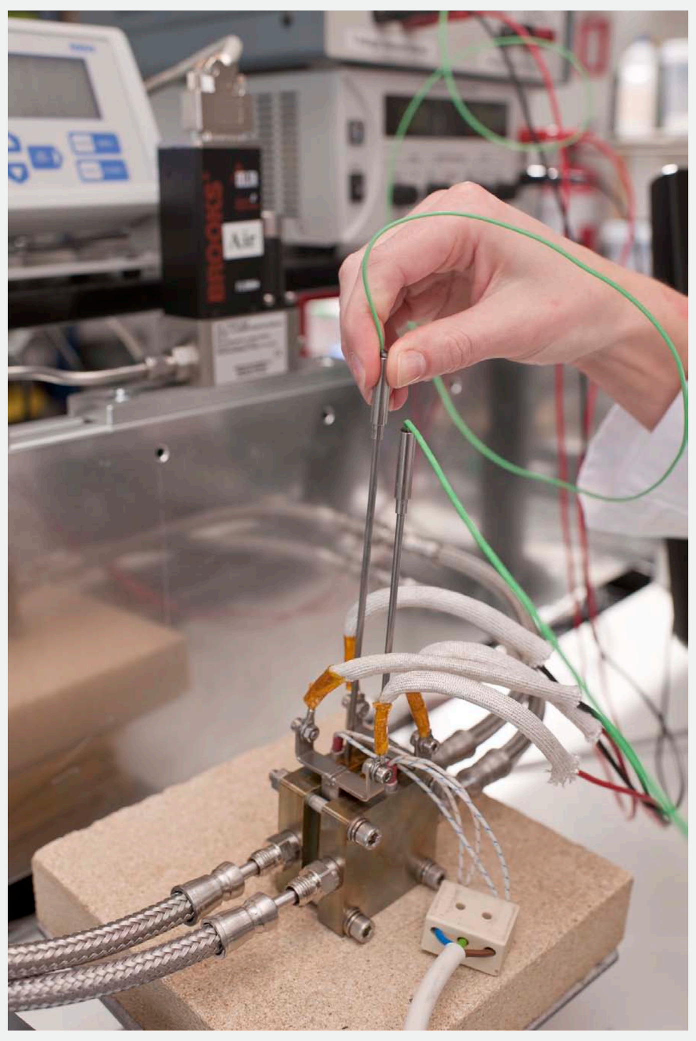

Figure 3: Experimental setup.

Further work: Bismuth Phosphate (Bi-P) has shown stability as electrolyte in preliminary fuel cell tests at 200 °C. Work is continued to ensure gas-tight electrolysis tests of Bi-P electrolytes with the goal of thin electrolyte layers. Cell tests will be performed at 300 – 400 °C.

References:

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[3] K. Kwon, M. Yano, H. Sun and J. Park, 2005, US Patent Specification Appl. Publ. 2005221143 A1 200051006

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