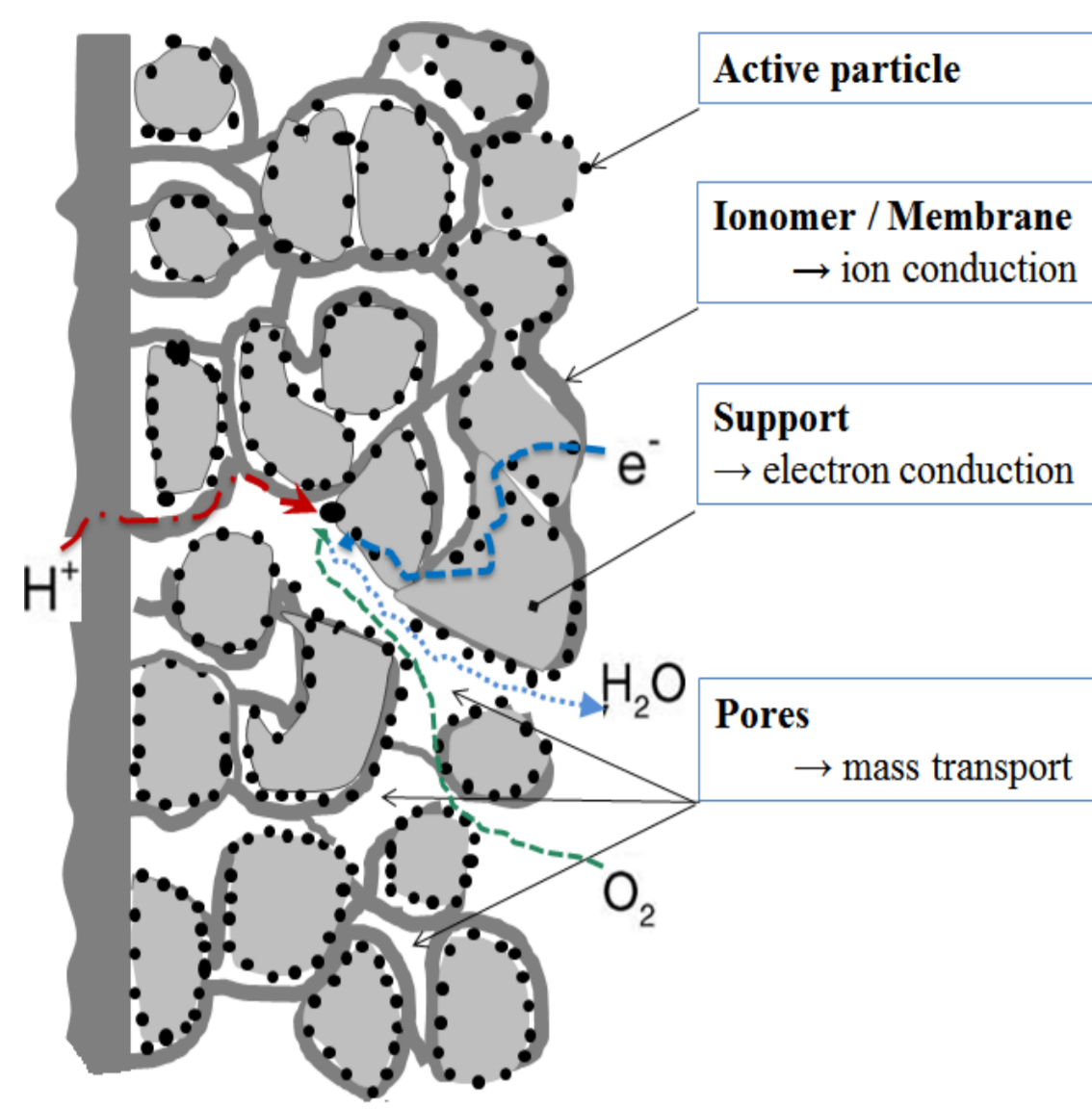


3D structuring of electrodes for fuel cells and batteries with polyaniline (PANI)

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Transport of gases, protons, and electrons in a PEM fuel cell electrode.[1]

Introduction
Electrodes for electrochemical devices have to fulfill several functions. First of all, they provide matrices for the active species, like platinum for fuel cells or lithium for Li-ion batteries. Secondly, they conduct electrons as well as reaction species allowing the access of reactants and the exit of products [1]. The material, which has been successfully applied as the support material in fuel cells [2] and Li-ion batteries [3] is the electroconducting polymer PANI. However, the effect of support morphology - leaving the chemistry unchanged - on the electrochemical performance has not been much investigated so far. Below, two different synthesis pathways for PANI fibers are presented.

Experimental: Wet chemical PANI synthesis

0.45 ml aniline and 1.428 g ammoniumperoxodisulfate (APS) were dissolved in 50 ml acid each. Under vigorous stirring the APS solution was poured into the aniline solution. The resulting mixture was kept untouched for 24 hours. As acid 0.4 M acetic acid, 1 M and 0.1 M H₂SO₄ were chosen. The obtained PANI was carbonized under nitrogen flow at 700 °C for two hours with a heating rate of 1°C/min.

Results: Wet chemical synthesis

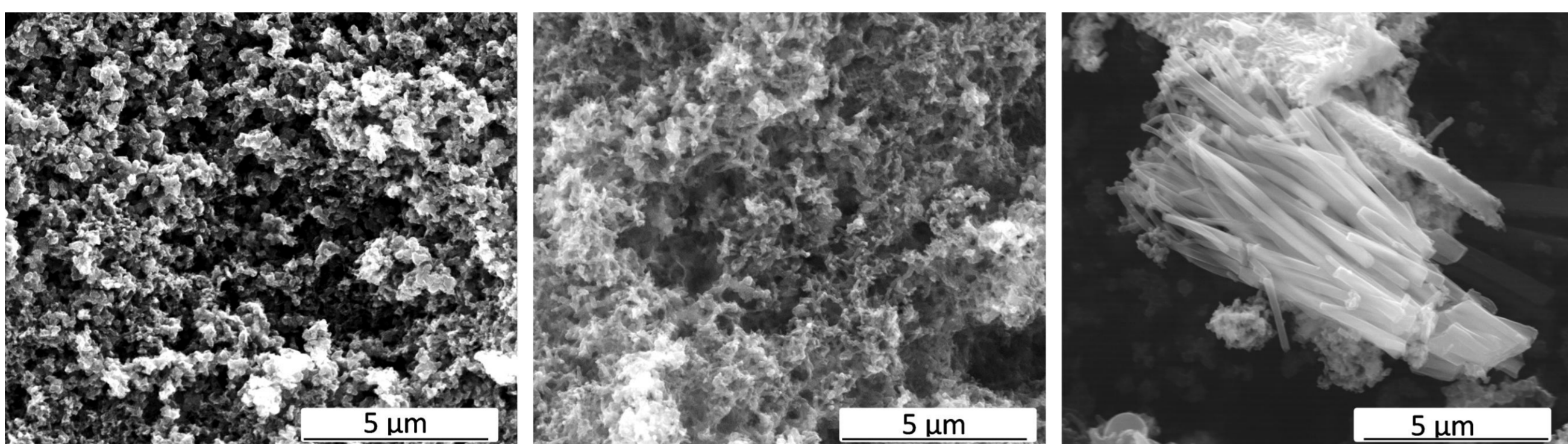


Figure 1: SEM images of as prepared PANI: a) in 0.1 M H₂SO₄, b) in 1 M H₂SO₄, c) in 0.4 M HAC. Small changes in the synthesis parameters result in remarkable changes in the morphology.

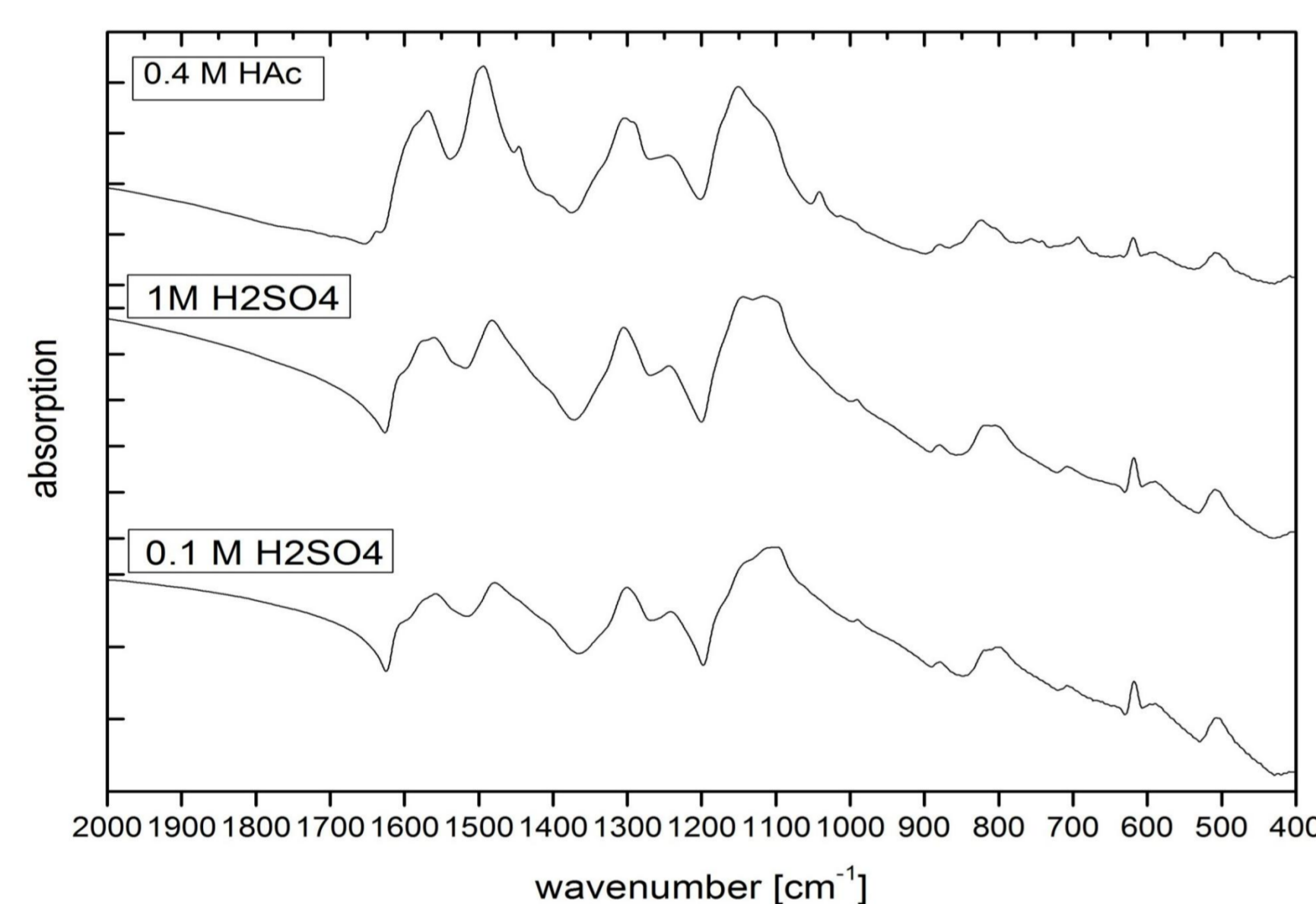


Figure 2: IR measurements demonstrate the chemical identity of the three differently synthesized PANI materials.

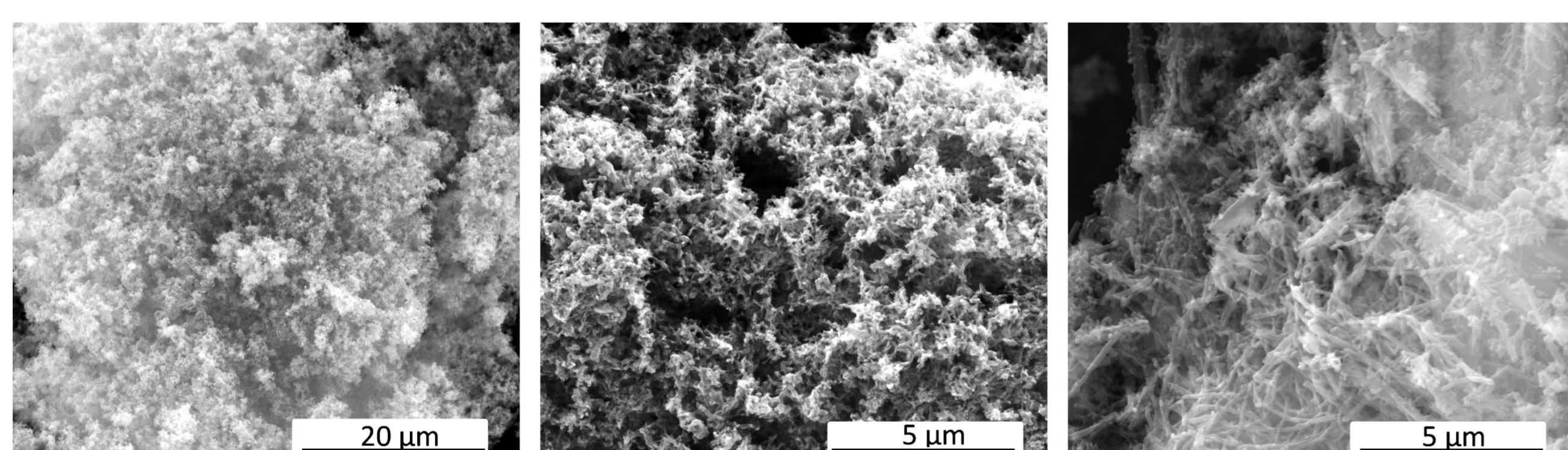


Figure 3: SEM images of PANI after carbonization, synthesized in a) 0.1 M H₂SO₄, b) 1 M H₂SO₄, c) 0.4 M HAC no significant changes in the morphology are observed.

Experimental: Electrospinning

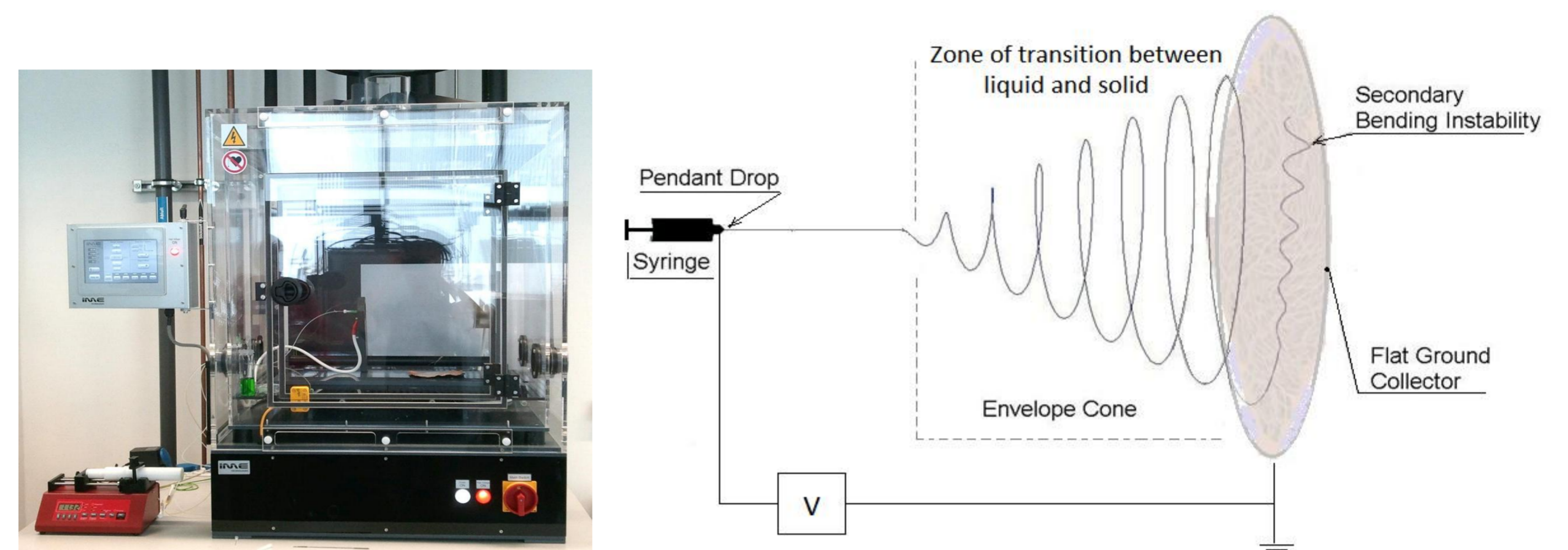


Figure 4: Electrospinning apparatus and its working principle.

The electrospinning solution was made of 10% PANI dissolved in DMF, blended with a supporting polymer. The viscosity of the solution, as well as the applied voltage, the distance between the electrodes, the temperature and the humidity have crucial influence on the morphology of the electrospun material.

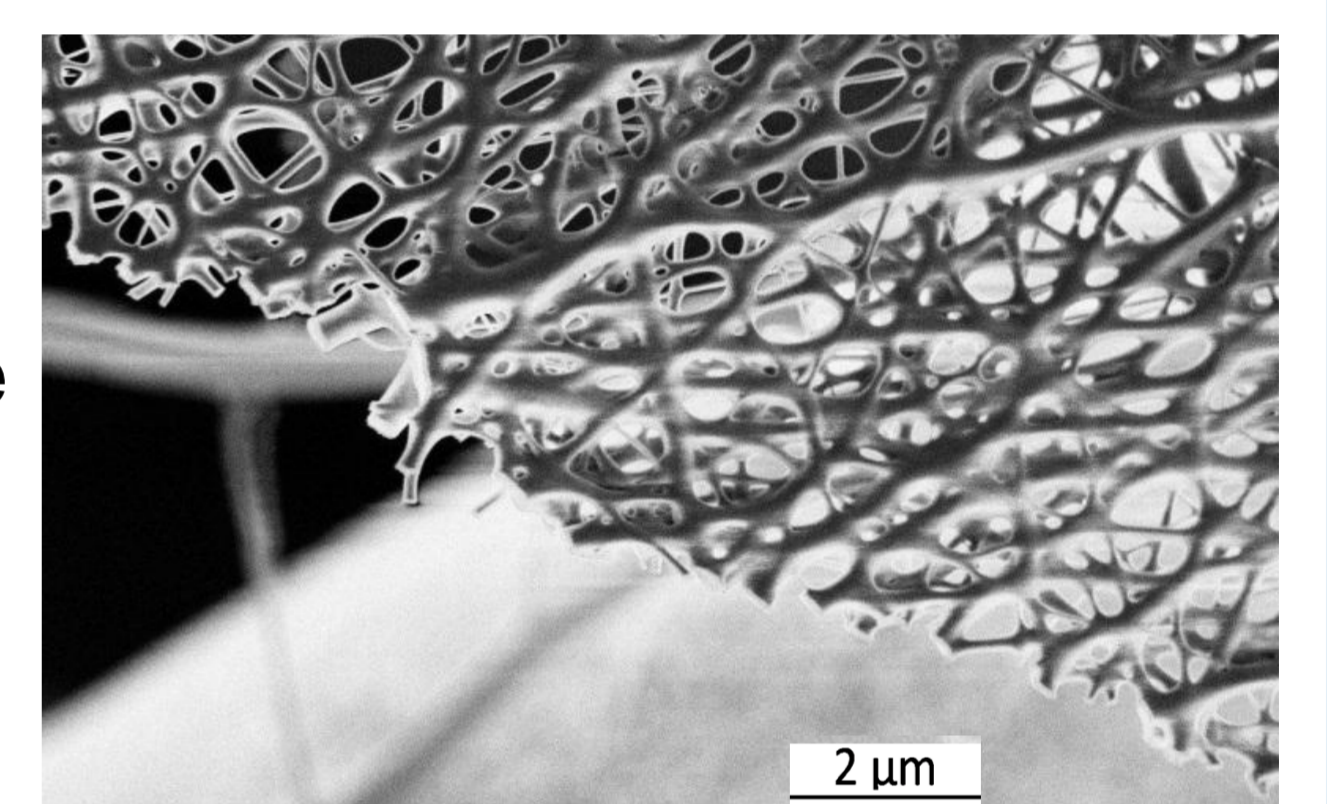


Figure 5: An example of electrospun nanofiber network

Results: Electrospinning

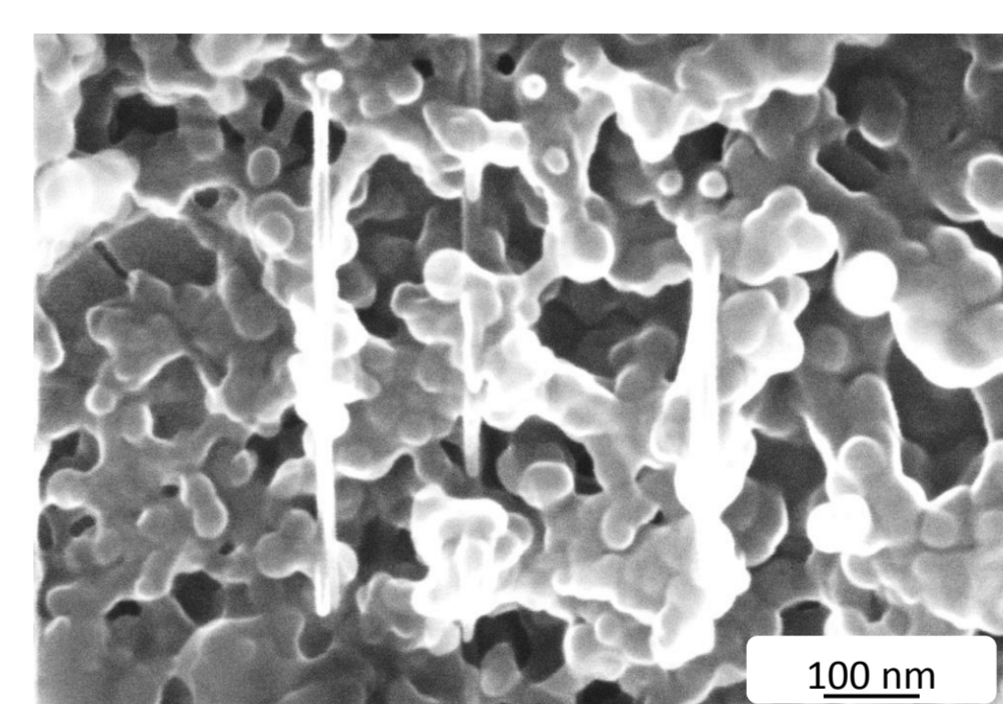


Figure 6: SEM image of PANI electrospun structure made out from a solution with low viscosity. The small viscosity together with relatively low temperature (25°C) enable to obtain very thin although short fibers together with the porosity in nanometer range.

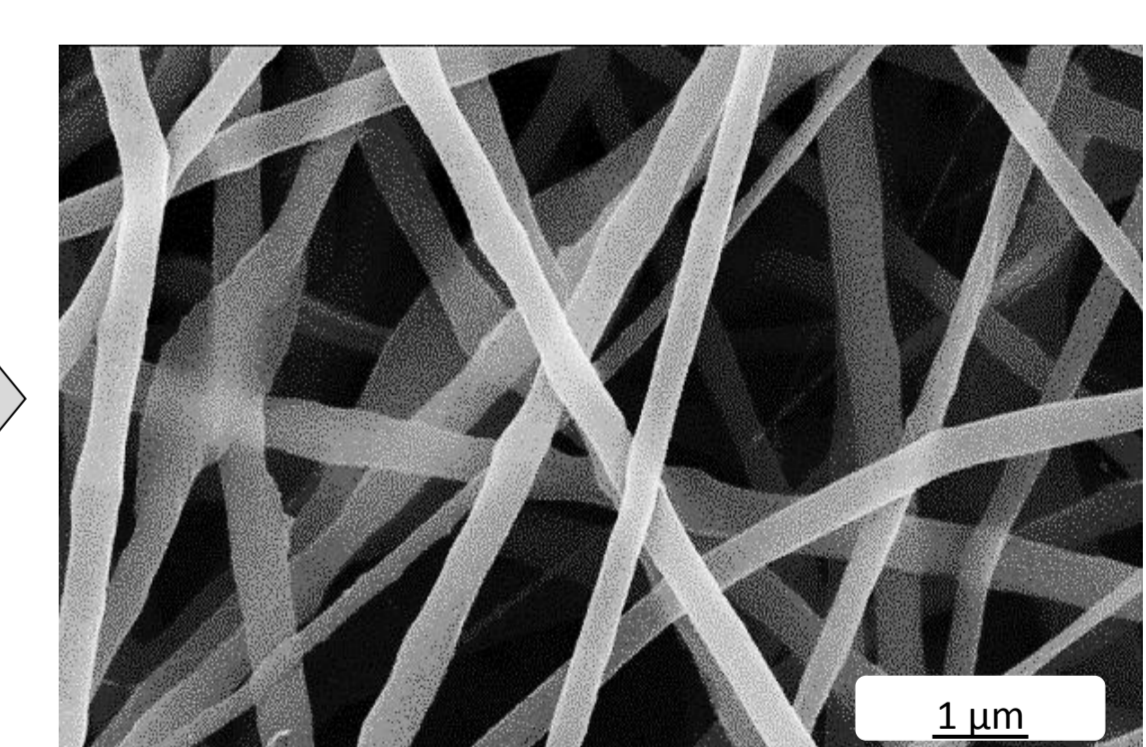
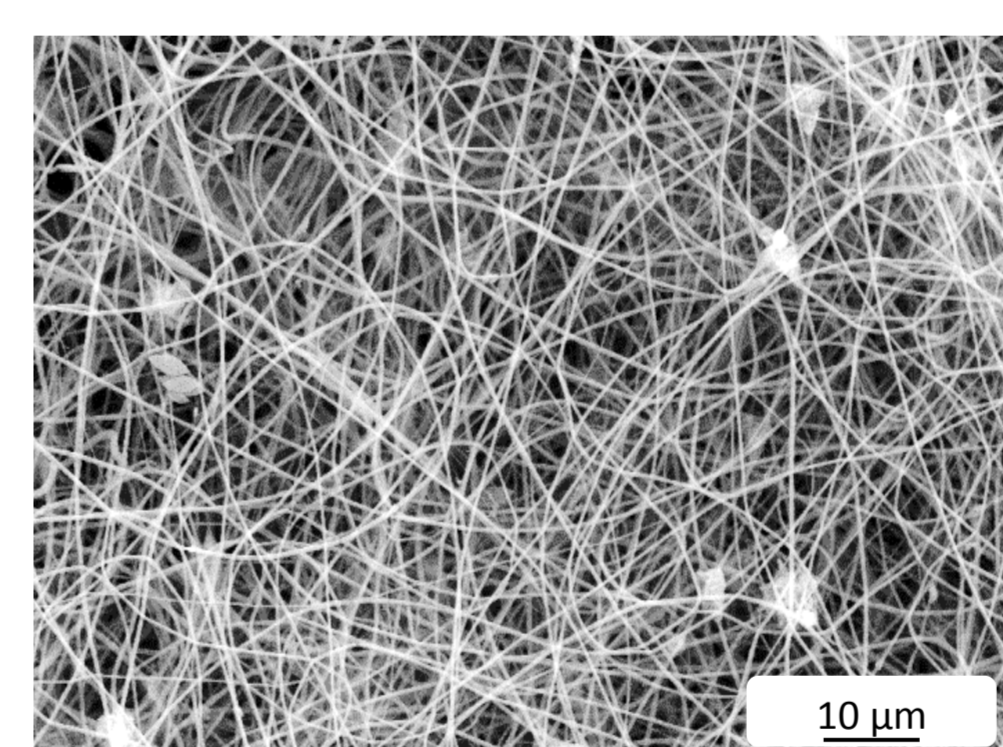


Figure 7: SEM images of electrospun material made from PANI/PEO polymer blend at 35°C. The elevated temperature together with higher viscosity results in relatively thick continuous fibers and the structure porosity in micrometric range.

Discussion and Conclusion

Chemically identical PANI materials can be produced with significantly different morphology using wet chemical synthesis in the respective conditions. In addition, electrospinning can be used to build up a continuous 3D sponge-like network of these materials. It has been shown that carbonization of PANI is possible without a significant change in its morphology. Thus, nitrogen-doped carbon materials can be obtained and further decorated with catalytically active Pt for fuel cell applications or with intercalation materials for lithium ion batteries.

Up to date there has been little attempt to investigate the influence of the supports structure on the performance of electrochemical devices. There have been studies on the application of different kinds of carbon support materials in fuel cells [4]. However, different functional surface groups and different amount of graphitization did not allow for a direct comparison. The use of our chemically identical material will enable us to investigate the pure influence of their morphology on their performance in the future.

References

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