Solvent composition (isopropyl alcohol/water) effect on self-assembled Nafion films

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The conventional catalyst layer (CL) of polymer electrolyte fuel cells (PEFC) is made from catalyst ink of Pt/C and ionomer suspended in a liquid medium. The liquid is often a hydro-alcoholic mixture. It has been considered that a building block structure, i.e. the agglomerate, of the CL is essentially the structure that resulting from self-assembly of ionomer upon aggregated Pt/C particles. Even in the absence of Pt/C, the structure of ionomer in a suspension media/solvent depends on the ionomer concentration and suspension media composition/type. Many challenges exist in probing the effect of large number of factors influencing the structure/property of ionomers in the CL, not the least being difficulty in directly probing the system of ill-defined structure.

To deconstruct the system, we have employed a model substrate (SiO_2), with well-defined physical structure and wettability. Previously, we reported one of the thinnest, continuous film of Nafion (4nm thin) generated from self-assembly from 0.1 wt% Nafion solution prepared by dilution of 5 wt% stock solution by isopropyl alcohol [1]. In this work, we report the effect of IPA/water composition on self-assembly of films on different substrate like SiO_2, carbon and Pt. The solution/dispersion was characterized by Dynamic Light Scattering (DLS) method.

The surface of the substrate after self-assembly was probed by atomic force microscopy (AFM) in tapping mode at ambient laboratory condition. The morphology was examined from height and phase images. AFM was also employed to scan the particle size of Nafion after spraying different Nafion solution in different solvent composition. Dynamic light scattering (DLS) measurement was conducted to measure Nafion solution state.

Fig. 1 shows AFM image of self-assembled Nafion ionomer structure from 80% and 50% IPA solution on SiO_2 substrate. Underneath of each image, section analysis of each image has been presented. It was found that Nafion non-continuously deposited on the substrate from different solvent composition where agglomeration features were different. Nafion from 80% IPA exist as fibril structure with 20 to 50 nm width whereas ribbon like aggregates from 50% IPA. However, the corresponding height of feature was ~3 nm regardless of solvent composition. These features are remarkably comparable to the results obtained from small angle x-ray scattering (SAXS) study [2] of Nafion in solution, wherein a rod-like structure with a 2 to 2.5 nm radii was deduced.

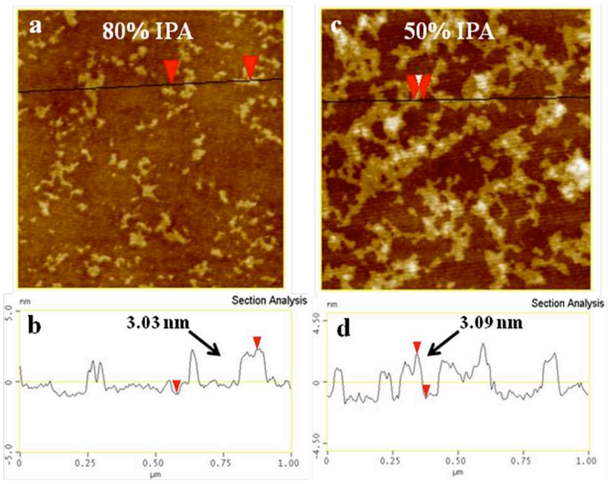

Fig.1: AFM image and section analysis of self-assembled Nafion from 80% IPA (a&b) and 50% IPA (c&d)

It indicates that solution state of Nafion, interaction media and behavior might have significant influence on Nafion agglomeration and structural behavior on the substrate surface. To investigate the aforementioned issues, we also investigated Nafion solution state by DLS. It showed very comparable particle size mostly distributed in between 100 to 500 nm where Nafion in 50% IPA solution is non-homogenously distributed. With increasing water content, the distribution became more homogeneous. Particle size measurement by spray technique also supported this observation.

The presentation will discuss these findings and report the results for other substrates

Acknowledgements
Financial Early Researcher Awards (Ontario Ministry of Research and Innovation) and Natural Sciences and Engineering Research Council of Canada (NSERC).

References

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