Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Liquid flow through paper with the consideration of swelling and intra-fiber pores[1] WONJUNG KIM, SOOYOUNG CHANG, Sogang University — Paper is one of the most widely used porous media for absorbing liquid, and accurate control of water imbibition in paper is crucial in developing paper-based microfluidic devices. Washburn equation is usually used to describe the dynamics of the liquid flow through the cellulose matrix of paper. However, it is well known that this equation has limitations in predicting water flow in paper. We report that swelling and intra-fiber pores that have not been considered in developing Washburn equation are mainly responsible for the limited accuracy when predicting imbibition length of water. We demonstrate that cellulose fibers have significant internal voids that absorb water. In addition, we quantify water induced swelling that leads to the expansion of inter-fiber space. We develop a hydrodynamic model of water imbibition with the consideration of intra-fiber voids and cellulose fiber swelling that well explain experimental observations. Our study provides a new insight into not only porous media flow with intra-void structure and swelling effects, but also a theoretical background to design μPADs.

[1]This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (grant no 2017R1E1A1A01073599)

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Date submitted: 29 Jul 2019 Electronic form version 1.4