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Potentials and challenges in jetting microdroplets onto nonwoven fabrics

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Abstract: Nonwoven fabrics are very diverse in their structural properties. This paper discusses potential opportunities and challenges involved in jetting and depositing microdroplets on such materials. This study reports on the interaction of controlled droplets with the nonwoven substrates. Droplets used had velocities of about 1.8 m/s and diameters of about 90 μm and were produced by using a drop-on-demand (DOD) inkjet printhead. Nonwovens used consisted of two groups of high and low solid volume fraction (SVF) substrates. The results indicate that in the case of low-SVF nonwovens, the local spacing and orientation of the fibres plays a significant role in determining the outcomes of the jetting process. Drops were seen to penetrate deep into a low-SVF nonwoven and deposit on a single fibre or bundle of fibres. Low-SVF nonwovens, therefore, can hold the fluid within their structures—a case of interest in printing electric circuits. The case of jetting on high-SVF nonwovens was found to be primarily dependent on the fibres' surface properties. The drops were found to stay above the surface in the case of hydrophobic fibres and below the surface in the case hydrophilic ones.

Key words: Inkjet, nonwovens, droplet, drop-on-demand.

INTRODUCTION

In this study, we investigate the possibilities and challenges in jetting and spraying microdroplets on nonwovens. Nonwovens can be soft, flexible, conformable, and durable as compared with paper. They can also be produced more cost effectively than their woven or knitted counterparts. The new generations of micro-denier nonwovens are found to be very absorbent and facilitate wicking easily. Moreover, nonwovens are very diverse in their structural properties, such as solid volume fraction (SVF), specific surface area, surface properties, and polymer composition. They are finding new applications in different industries such as inkjet printing, printing electric circuits (RFID tags), and some biomedical applications. In addition, many nonwovens are functionalized by spraying a liquid on the structure during or after the manufacturing of the material. The spray solutions will form droplets that will impinge the structure at some velocity. The final properties will naturally depend on how well the structure interacts with the spray particles. The discussion presented here is concerned with and limited to applications wherein a liquid is sprayed or jetted onto a nonwoven substrate in the form of microdroplets.

In jetting microdroplets onto a nonwoven substrate, it is important to know to what depth the drops penetrate and how far they spread in-plane. For instance, in printing applications, many microdroplets are required to form a continuous printed line on a substrate. Depth penetration and spreading will control the line thickness beyond the intended thickness and the visibility of the line. In the case of printing electric circuits, the depth in which the line is formed is important as it is directly proportional to the durability of the circuits when exposed to washing cycles (Karaguzel, 2006). Note that printing on regular papers is typically a surface-driven phenomenon while printing on nonwovens, depending on their SVFs, can be a surface- or structure-driven problem as will be discussed in this paper.

Below, we investigate the spreading and penetration of microdroplets in nonwoven substrates using a drop-on-demand (DOD) inkjet printhead manufactured by MicroFab (Plano, TX 75074, USA). A DOD inkjet printer is the most accurate and repeatable device available for generating microdroplets with diameters (diameters in a range of 40–100 μm) close to those formed by sprayers or, of course, inkjet printers and is therefore used here for

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