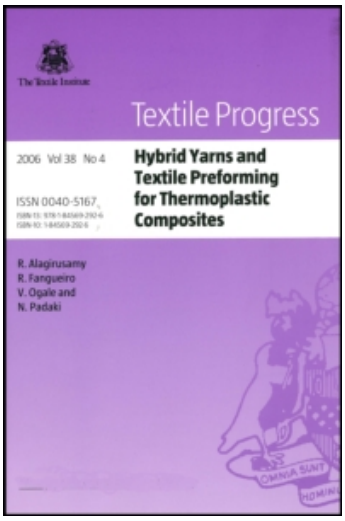

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FLUID TRANSPORT PHENOMENA IN FIBROUS MATERIALS

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Abstract: Fluid transport is one of the most frequently observed phenomena in the processing and end uses of fibrous materials. Fibrous materials have a unique structure of complex geometry, characterized by system anisotropy and heterogeneity. The characterization of fibrous materials, therefore, is critical in the understanding of transport behavior through fibrous structures, and is discussed after an introductory section. Subsequent sections cover topics of various transport processes through fibrous structures, including wicking and wetting, resin impregnation in liquid composite molding, filtration and separation in geotextiles, aerosol filtration in fibrous filters, micro/nano scale transport phenomena, and biomedical applications. The fibrous structure is also known for its multi-scale pore distribution from intra-fiber to inter-fiber spaces. This multi-scale effect is even more prominent when micro or nano fibrous materials are concerned, and so multi-scale approaches to address the scale effects of transport behavior in fibrous materials are discussed. Finally, the Ising model of statistical mechanics, a robust computer-simulation tool dealing with the fluid transport problems in fibrous materials, is introduced.

Key words: Transport, fibrous materials, structure characterization, wetting, multi-scale, Ising model.

1. INTRODUCTION

Transport study had its origin from astrophysics which, in the late 19th century dealt with light diffusion by the atmosphere [1, 2]. The work expanded into the larger scope of radiation transfer from a star through the atmosphere, formulated into what is known as the transport equation of Boltzmann in the early part of 20th century [3]. Transport phenomena were defined in [3] as the interactions and changes in the properties and states of a particle when it is passing through a medium. By substituting the particle with any concrete object concerned in practical problems, one can enable the theory to be applicable in tackling such issues as diffusion, permeation, and spreading widely existed in biology, chemistry, physics and engineering processes, as documented in numerous books [3–12].

When a fibrous material serves as the medium, and air, moisture, physical or biological entities or heat and even various rays (in a quantum sense) [13, 14] as the particle moving through the fibrous medium, the significance of the transport theories in understanding these fundamental issues becomes instantly self-evident.

In general, study of liquid transport phenomenon in fibrous materials deals with a wide array of issues; most of them are complex and intricate and still inadequately