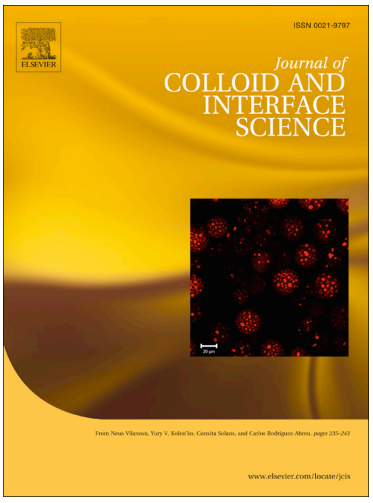

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Modeling of the capillary wicking of flax fibers by considering the effects of fiber swelling and liquid absorption

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Abstract

We propose a new model for the capillary rise of liquid in flax fibers whose diameter is changed by liquid absorption. Liquid absorption into the flax fibers is taken into account in a new modified Washburn equation by considering the mass of the liquid absorbed inside the fibers as well as that imbibed between the fibers. The change of permeability and hydraulic radius of pores in a fibrous medium due to the fiber swelling is modeled by a statistical approach considering a non-uniform distribution of flax fiber diameter. By comparisons between capillary rise test results and modeling results, we prove the validity of the proposed modified Washburn model to take into account the effects from fiber swelling and liquid absorption on the decrease of capillary rise velocity. The experimental observation of long-term capillary rise tests show that the swelling behavior of the fibers highly packed in a closed volume and its influence on the capillary wicking are different from those of an individual single fiber in a free space. The current approach was useful to characterize the swelling of fibers highly packed in a closed volume and its influence of the long-term behavior of capillary wicking.

Keywords: Capillary rise; Washburn equation; Flax fiber; Fiber swelling; Liquid absorption

Introduction

The use of natural fibers as composite reinforcements has steadily increased in some industrial applications such as building and automotive products, during the past several decades. In particular, this trend is being expanded into many other industrial sectors owing to the European environmental regulations that recommend the use of more sustainable materials, either bio-sourced or recyclable. It is well known that natural fibers such as flax and hemp, exhibit some interesting properties as