STICK: modeling textile using FiPy and SciPy

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Textile is a complicated material to model: it is typically thin, while still containing 3 relevant scales: fibers, threads, and fabric. Most practical textile models are based on two scales: a 1D fiber model and a fabric model, see [1]. The yarn scale is neglected in this setup. For densely woven fabrics this seems appropriate as the yarns connect everywhere, but for loose fabrics or nets this approach cannot be kept. Specifically when one is interested in tracking an active component released by the fibers, the yarn level plays an important role. This is because the saturation vapor pressure will influence the release rate from the fibers, and its value will vary over the yarn cross-section.

Therefore, a 3 step multi-scale model is applied in this work: The active component is tracked in the fiber, the yarn, and finally at the fabric level. At the fiber level a 1D reduction to a non-linear diffusion equation is performed, and solved on a as needed basis, see Fig. 1(a). At the yarn level a 2D cross-section (see Fig. 1(b)), or a 1D model is applied, and finally the yarn result is up-scaled to the fabric level.

![Figure 1: Typical release concentration with fiber model (a) and typical yarn model cross-section result.](image)

In creating the STICK toolbox (http://gitorious.org/stickproject) useful for SME’s to model textile, python was chosen as a language, as it is ideal to bridge the different models needed, and has a low learning curve and allows for fast adaptation (different solvers, different workflow, ...). For the fiber model an ODE solver is used, while for the yarn model the finite volume solver FiPy is applied. Python also allows ready use of ini files to expose to experimenters for their modelling, while SciPy can be used to create a fiber-yarn layout construction based on virtual locations, as well as for the validation that this layout satisfies given distribution functions.

The toolbox is applied first on the release of active components from textile fibers (eg odors, repellants). Validation is possible with a series of Gas-Chromatograpy experiments that determine the release rate of a piece of textile, which the model matches based on the multi-scale approach.

References


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