Functional design of porous systems by systematic patterning of flat knits

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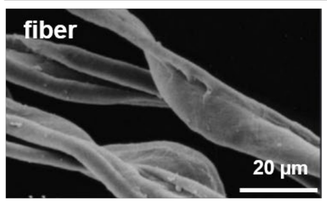
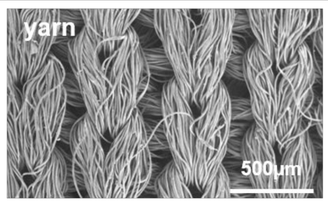
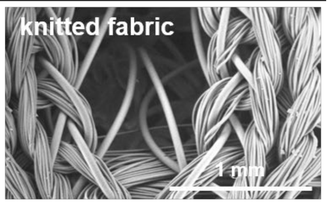
Introduction

The porous properties highly determine the physical properties of materials like density, stiffness and flow transport properties. This poster wants to contribute to the question whether knitted pore systems can be designed and optimized for highly functional garments like sportswear or be used as functional carriers in technical products or processes. In a new combined wicking and drying experiment, textile fabrics are investigated concerning their transport properties. The vision of this work is, that understanding of the porous properties of knitted fabrics by systematically changing the geometrical properties only by patterning deepens the understanding of the porous system and its transport characteristics.

Hierarchical Porous structure of textiles

- Textiles can be interpreted as porous systems consisting of fibers arranged in repeating patterns [1]
- In combination of different materials and textile production processes the structure of textile porous systems can be altered in a huge range.
- Pores in textiles can be systematically described on the scales fiber, yarn and fabric.
- Micropores occur on the fiber scale, Mesopores occur on the yarn scale and macropores on the fabric scale respectively. [2]

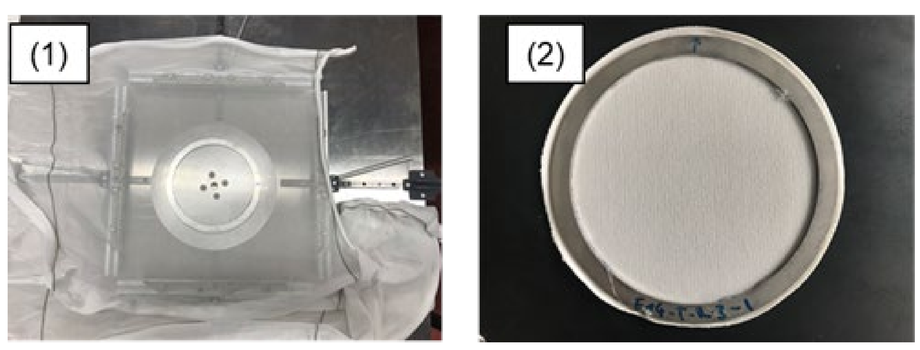
	micropores	mesopores	macropores
	< 1 µm	1 µm to 100 µm	> 100 µm
			
textile process chain	material, fiberform, fineness, avivages	yarn-fineness, yarn-forming process, twist, texturing, yarn strain	gauge, needle head, sinking depth, patterning, fabric strain
relevant transport processes	conduction, evaporation on fiber surface	wicking, evaporation on yarn surface	multiphase heat and mass transport, convection

Hierarchical porous system in knitted fabrics

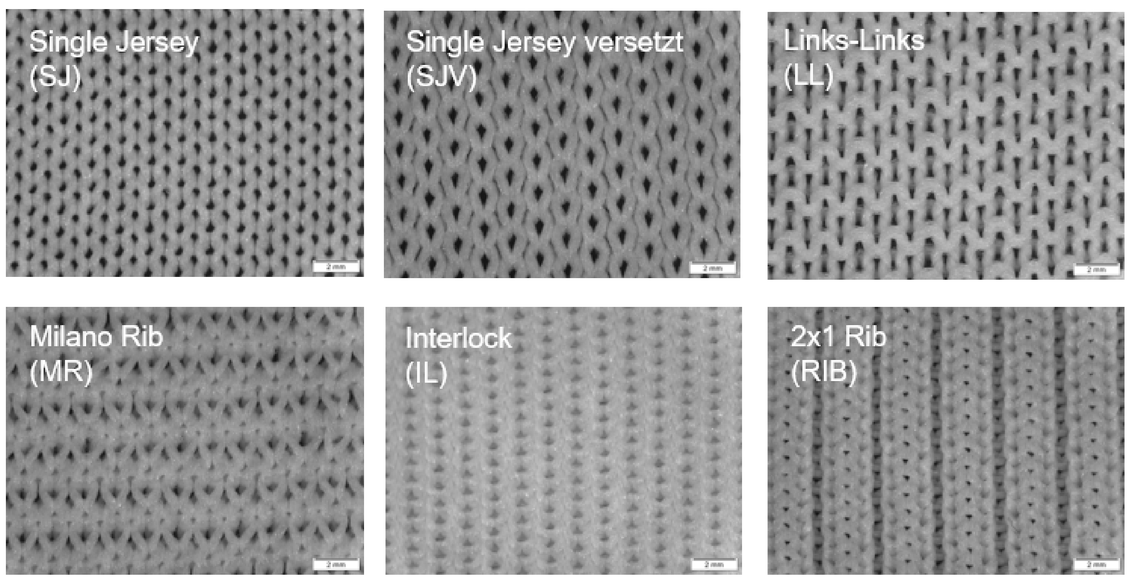
- For knitted fabrics, especially macropores with pore sizes of 100 µm and higher can be systematically altered by the patterning in the knitting process.

Specimen Production and Preperation

- Six different fabrics from Polyester Multifilic Yarns 167dtex f30/4
- E14 flatbed knitting machine Stoll CMS
- As knitted fabrics alter geometry with strain, a reproductive preparation of samples is necessary.
  1. Fabrics are put under constant strain.
  2. Fixation on specimen holder with hot glue.



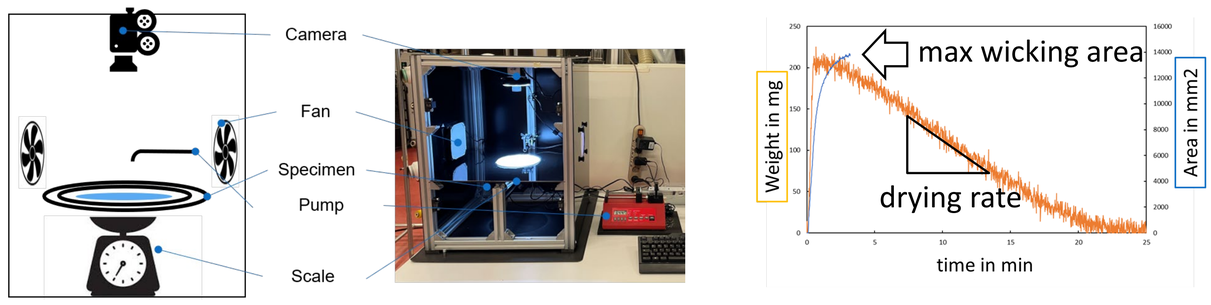
Preperation process of specimen.



Microscopic images of knitted fabric samples

Combined determination of drying rate and capillary transport

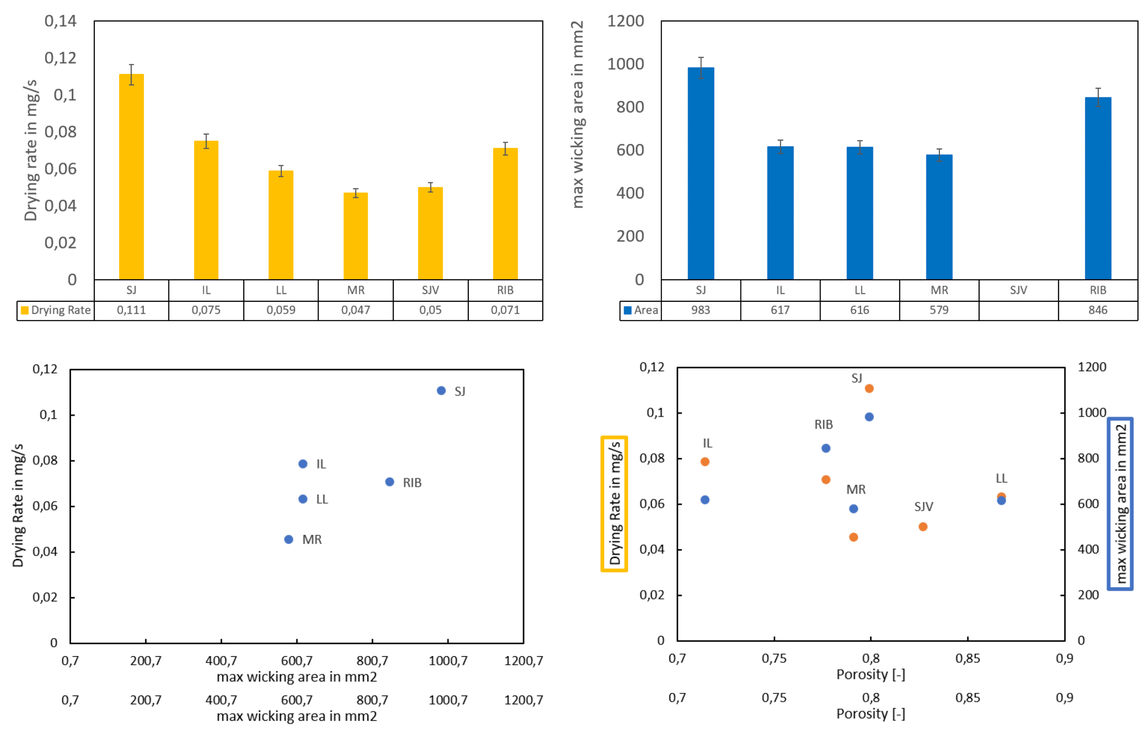
- Specimen is placed in a closed enviroment, water is dropvise applied with a needle, experimental time is reduced by fans
- Drying rate is determined by differencial measurement of specimen weight
- Capillary transport is determined by image analysis algorithm



Experimental setup for combined drying-rate and capillary flow measurement

- Drying rate can be calculated by gradient of the weight-curve
- Maximum wicking area is determinded by saturation of area curve
- Combined measurement shows that weight starts reducing significantally when wicking area is close to ist maximum

Results for different patterns



Results of combined measurement of drying rate and max. wicking area

- Drying rate differs by factor two for the investigated patterns
- Drying rate and max wicking area do correlate qualitatively
- No strong quantitative correlations of both with fabric porosity as known from permeability

Discussion and Outlook

- Method is suitable to correlate max wicking area with drying rate
- Actual setup is of limited usage for big pore diameters (SJV) .The experiment will be developed further as water drops through.
- For quantitative correlations poresize-distribution has to be taken into account.

Acknowledgement

Gefördert durch DFG Deutsche Forschungsgemeinschaft

The authors gratefully acknowledge the funding of the German Research Council (DFG) – Project Number 453311482.

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[1] A. Mark, B. Bauer, and G. Gresser, *Quantification of hierarchic multimodal pore structures in textiles by the example of knitted fabric structures*. 2015.

[2] A. Mark, A. Psikuta, B. Bauer, R. M. Rossi, and G. T. Gresser, "Artificial skin for sweating guarded hotplates and manikins based on weft knitted fabrics," *Textile Research Journal*, vol. 89, no. 4, pp. 657–672, Feb. 2019, doi: 10.1177/0040517517750646.