HUMIDITY TRANSFER MEASUREMENT ON SPECIAL TEXTILES AND MEMBRANES FOR GAS SENSORS

Petr Exnar [1], Pavla Těšinová [2] & Ivan Doležal[3]

Abstract: Various special textiles (nomex, goretex based, polypropylene nonwovens) and semi-permeable membranes from company Zibai were measured for the humidity transfer in the vapour state. Time behavior monitoring of sensor response was used for this measurement on the humidity sensor SHT15 made by company Sensirion. Sensor was covered by measured textiles. Response of the sensor transferred from low humidity atmosphere to high humidity atmosphere was measured. The results are usable for selection of the proper textile for covering gas sensors (including vapour humidity) in intelligent textiles. Polypropylene nonwovens with hydrophobic treatment appear to be the best material in this stage of research because sensors have to be protected against the liquid humidity.

1 INTRODUCTION

The gas sensors have to be covered by a proper textile layer in intelligent textiles for protection against pollution and mechanical damage. It is also necessary to protect sensor surface against the liquid humidity together with retain of ability to transfer of the vapour humidity. Set of the measurements was done to make decision about covering textile. The time behaviour of the sensor response on a step change of the humidity was measured for various textile materials and semi-permeable membranes.

2 METHOD

The tests were run on the apparatus developed for dynamical measurements of gas sensors according to modified methodology [1]. Time response of the gas sensor SHT15 made by company Sensirion [2] was experimentally measured. The sensor was covered by measured textiles and tested in the step change of the humidity. Low humidity atmosphere was realized by Erlenmeyer flask filled with saturated water solution of lithium chloride containing undissolved lithium chloride. Material with sensor was stabilized for duration of 20 minutes. Tested system was transferred as fast as possible to the 3-neck glass flask with continual flow of humid air after stabilization. Temperature of both spaces was (20.0 ±1.3) °C. Temperature and humidity recording was started in the low humidity atmosphere and finished after 930 s in the flow of humid air. Result value was converted to the water vapour concentration in $g.m^{-3}$. This conversion eliminates temperature variation during measurement and also hydration heat of the sensor layer of the sensor SHT15 [2].

The time, which is necessary to reach 63% of output signal change to steady-state after input step change of the humidity (Response Time 1/e, next only RS), was computed numerically for comparison. Free sensor exhibits RS = (11.7 ±0.7) s.

[1] Doc. Ing. Petr Exnar, CSc.; Technical University of Liberec, Department of Chemistry; Studentská 2, Liberec 46117, Czech Republic, petr.exnar@tul.cz.
[2] Ing. Pavla Těšinová, Ph.D.; Technical University of Liberec, Department of Textile Evaluation; Studentská 2, Liberec 46117, Czech Republic, pavla.tesinova@tul.cz.
[3] Doc. Ing. Ivan Doležal, CSc.; Technical University of Liberec, Institute of Mechatronics and Computer Engineering; Studentská 2, Liberec 46117, Czech Republic, ivan.dolezal@tul.cz

3 RESULTS

Two sets of material were used for measurement. Special semi-permeable membranes from company Zibai (Hong Kong, China) at first and goretex, nomex and treated nonwovens from various productions represent the second group.

Semi-permeable membranes from company Zibai (11 samples, thickness from 0.012 to 0.025 mm) were medium or lower permeable and RS values match in 53.5 - 436 s. All tested membranes retain liquid water but some of them swelled. Figure 1 shows examples of the reached time/concentration dependencies for chosen membrane samples. Some membranes embodied a delay effect of the response beginning after insertion to the wet atmosphere (effect is highly evident on the blue curve on figure 1).

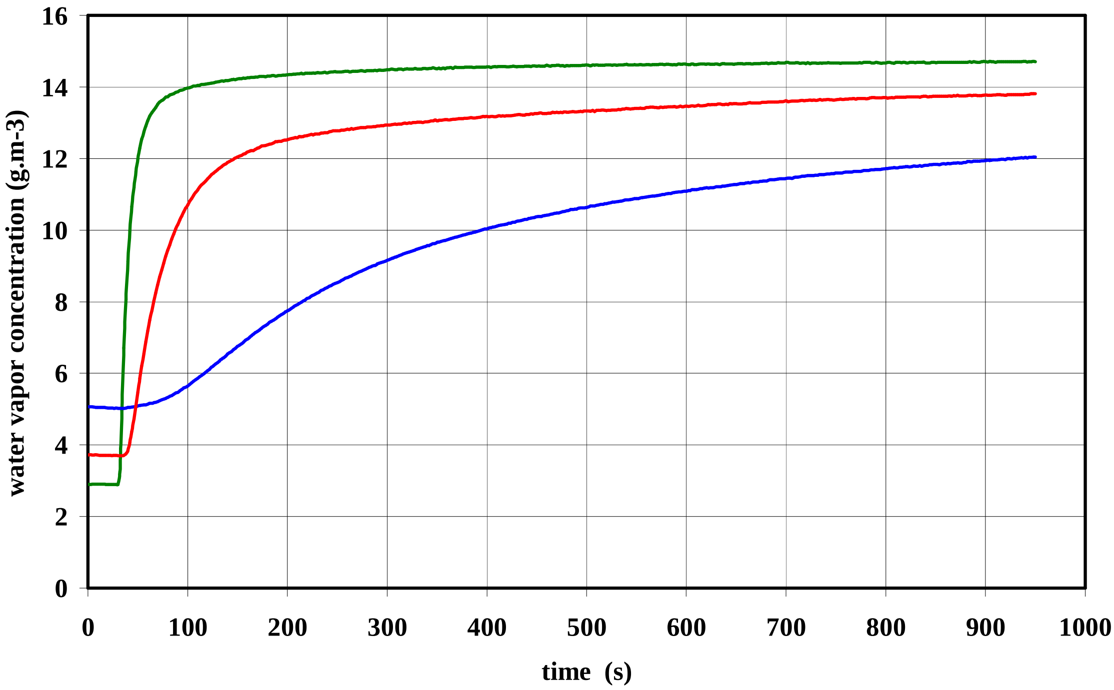

Figure 1: Dependence of the water vapour concentration computed from sensor SHT15 on time of free sensor SHT15 (green curve, RS = 12.3 s), the most permeable (red curve, RS = 53.5 s) and the least (blue curve, RS = 436 s) membranes from Zibai. Samples transferred in time 30 s from atmosphere RH = (15.5 ±1.5) % to the atmosphere RH = (84.0 ±1.5) %.

Nomex textiles (3 samples, labelling N1-N3, table 1) showed medium permeability. Obtained curves are depicted on Figure 2. Two from nomex fabrics leaked liquid humidity or absorb it. Only one sample (N1) prevents liquid humidity transfer but its RS value was too high.

Permeability of goretex textiles (3 samples, labelling G1-G3, table 1) was lower. Obtained curves are shown on Figure 3. All three textiles prevented liquid humidity transfer otherwise their RS values were too high.

Polypropylene based materials (4 samples, labelling P1-P4, table 1) were very good permeable except the nonwoven with PU membrane (P4) however pure polypropylene was not enough hydrophobic to prevent liquid humidity transfer. It is necessary for polypropylene materials to be modified by hydrophobic treatment then. It is very important recognition that the treatment did not affect vapour transfer negatively (sample P2).

Table 1: Description and specification of the textiles samples and detected properties.

labelling	specification of textile	RS (s)	protection against water
	free SHT15	11.9	
N1	Nomex surface material 215 g.m^{-2}	122	+
N2	Nomex lining with hydrophilic treatment, 200 g.m^{-2}	114	-
N3	Nomex lining 140 g.m^{-2}	73.5	-
G1	Goretex Flameliner A 175 g.m^{-2}	360	+
G2	Goretex Airlock 200 g.m^{-2}, nonwoven base nomex	150	+
G3	GoreTex Fireblocker N - 140 g.m^{-2}	184	+
P1	PP fabric comparative	17.2	-
P2	PP hydrofobic nonwoven	16.6	+
P3	PP hydrophilic nonwoven with PU membrane	17.8	-
P4	PU membrane on PP 825 - 130 g.m^{-2}	525	(+)

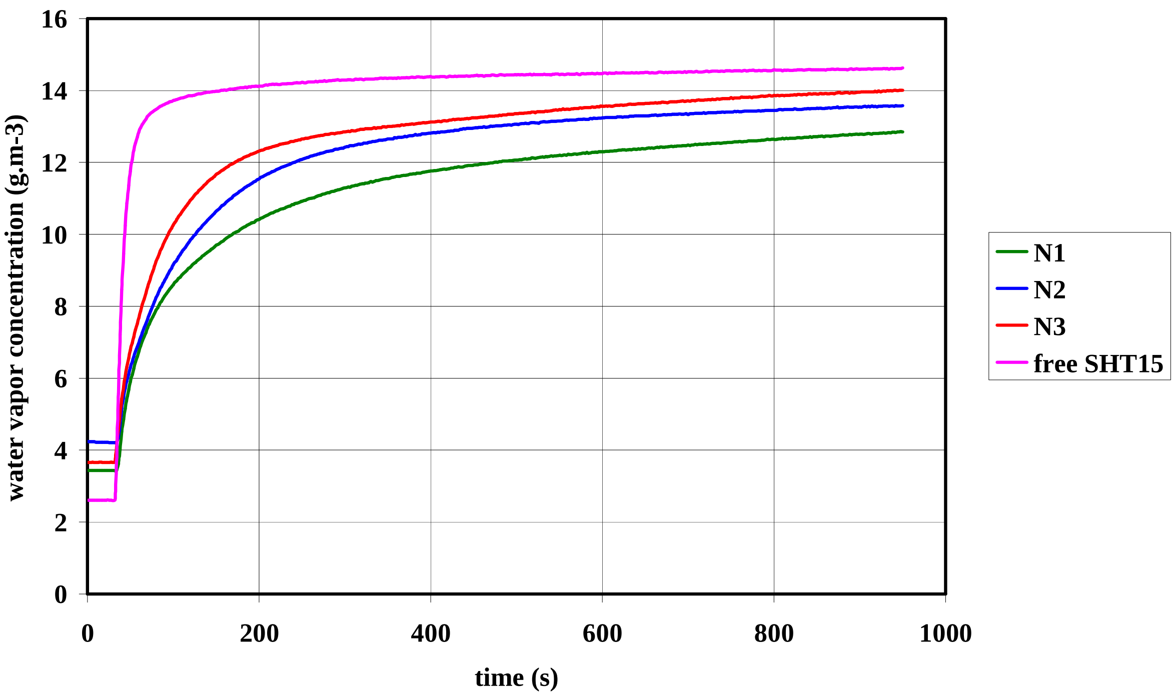

Figure 2: Dependence of the water vapour concentration computed from sensor SHT15 on time for nomex textiles (table 1). Samples transferred in time 30 s from atmosphere RH = (15.5 ±1.5) % to the atmosphere RH = (84.0 ±1.5) %.

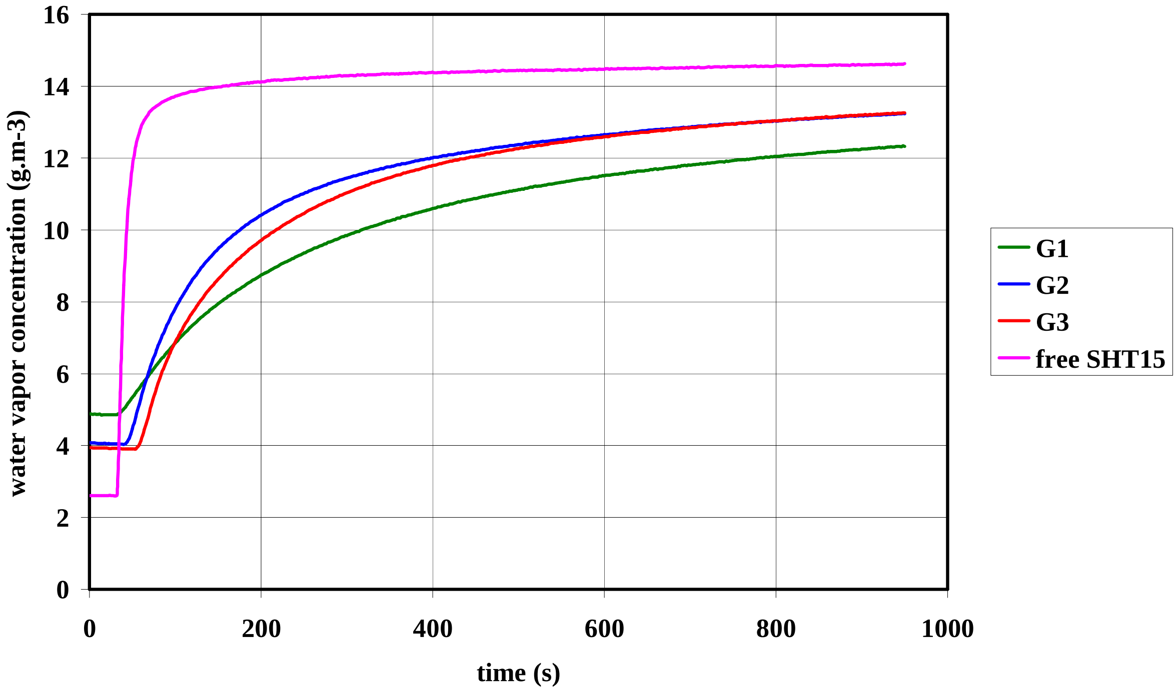

Figure 3: Dependence of the water vapour concentration computed from sensor SHT15 on time for Goretex textiles (table 1). Samples transferred in time 30 s from atmosphere RH = (15.5 ±1.5) % to the atmosphere RH = (84.0 ±1.5) %.

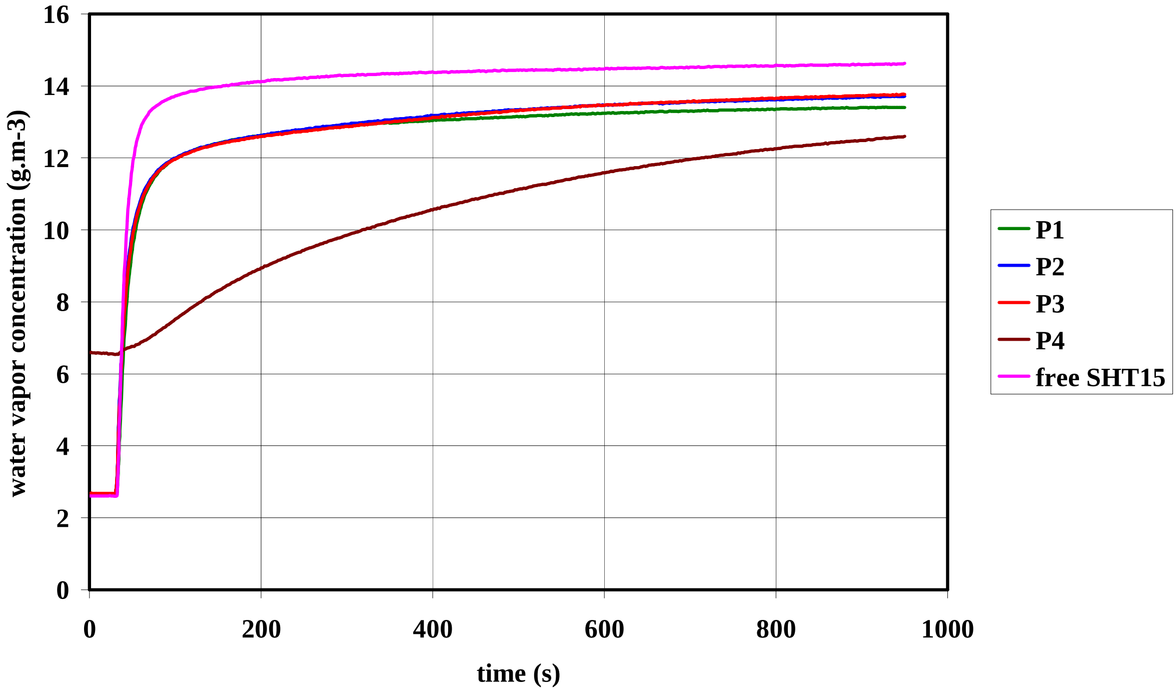

Figure 4: Dependence of the water vapour concentration computed from sensor SHT15 on time for polypropylene based materials (table 1). Samples transferred in time 30 s from atmosphere RH = (15.5 ±1.5) % to the atmosphere RH = (84.0 ±1.5) %. Curves P2 and P3 are nearly similar.

4 CONCLUSION

The best material from the viewpoint of transfer of the humidity in the vapour state that appeared is created on polypropylene base. The hydrophobic treatment is necessary in addition to protect transfer of the liquid humidity. This treatment on the tested nonwovens did not affect vapour humidity flow negatively.

Semi-permeable membranes from company Zibai and nomex textiles were insufficiently permeable for the studied purpose. Goretex materials were even worse permeable.

References

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[2] SHT1x/SHT7x Humidity & Temperature Sensor, Available from http://www.sensirion.com/en/01_humidity_sensors/03_humidity_sensor_sht15.htm Accessed: 2010-09-16.

Acknowledgement

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