ZUKUNFT BAU

SHORT VERSION "Aerogels and advanced porous materials in building practice"

Title

Long version of title: "Program for scientific monitoring of product development and market introduction of insulating materials based on aerogels and advanced porous materials (APM)"

Occasion / initial situation

In order to comply with the requirements for thermal insulation of the building envelope in the scope of the energy-saving regulation (EnEV) many different insulating products are available on the market. In addition to conventional and well-established products the development of new and innovative products takes place. Within the last years especially micro- and nanoporous materials were in the focus of development processes due to their outstandingly low thermal conductivity. While the construction of walls with conventional insulation products requires high layer thicknesses, many advantages arise from the new products for high energetic quality in lower thicknesses. In many renovation cases, only limited space is available which should be made use of in the most optimal manner. In such cases, solutions with space-saving products such as APMs and aerogels are of big interest. The amount of available data is still low for these new materials. It is important to establish a basis of available information to support the trust in those materials and to pave the way for a widespread use.

Subject of the research project

For many industrial applications innovative and efficient solutions were found with nanotechnology and nano-structured materials. The most significant development for the construction sector is mainly about micro- and nanoporous insulation materials (advanced porous materials) which represent an alternative among the insulation products in the future because of their highly insulating properties.
The aim of this research project was to find scientifically reliable statements about the investigation of durability aspects of aerogels and APMs for different types of applications. Moreover, the elaboration of trust of potential users into the newly developed products and the investigation of possible methods for recycling through research in literature and basic laboratory trials can induce an increasing market share and also support future standardization activities.

The following methods were applied:

- Modelling of boundary conditions for different applications (variations in types of construction depending on the type of APM product, exposure and climates)
- Selection of suitable artificial accelerated aging methods depending on boundary conditions
- Laboratory trials to investigate the influence of temperature, relative humidity, etc. on important building physics properties

- Documentation of the degradation of important properties due to the aging conditions
- Investigation of the service-life-time
- Trials for crushing and separation of raw materials

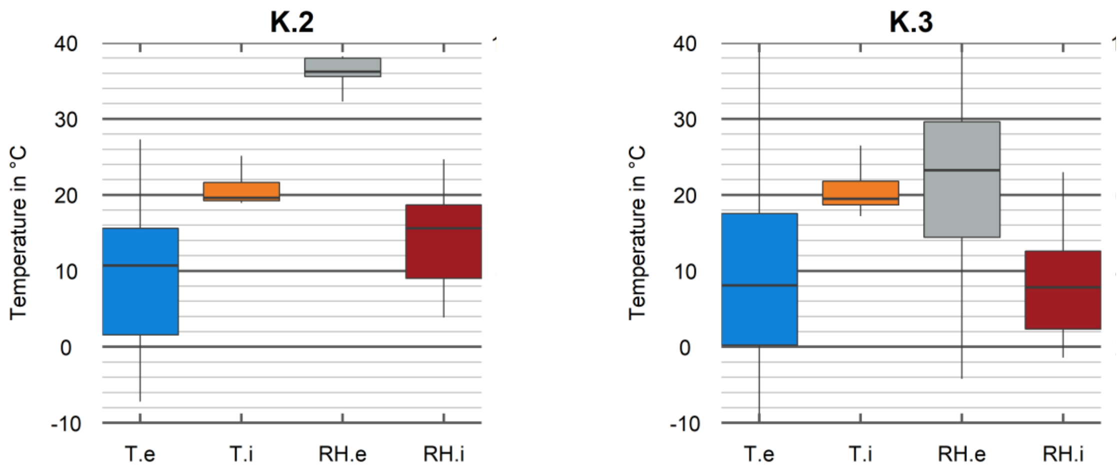

Figure 1 Distribution of temperature and humidity on outside and inside of insulation layer at a construction with internal insulation (left) and pitched roof (right) for the exposition case south, location Holzkirchen.

On the basis of a market research about available products and their typical fields of application, four aerogel-based products and one based on fumed silica have been selected for further investigations. The selection covers the bandwidth of currently available products. For the examination of the boundary conditions, the temperature and humidity distribution on the surfaces of the insulation layer occurring in the typical application cases for the different products have been outlined by simulation (examples for internal insulation and pitched roof in Figure 1). Different locations (climates) and exposures were included and the typical mean temperatures on the outer surface are 10 °C, on the inside 20 °C. The relative humidity covers the range between 65 % and 95 % on the outside and 35 % and 55 % on the inside surface. From these results, a sufficiently critical combined temperature and moisture condition for hygrothermal aging could be identified at 50 °C and 70 % relative humidity. The mechanical properties, thermal conductivity and the fire behaviour were determined in cycles of 90 days over a total time span of 9 months. The mechanical properties comprise the compressive strength, tensile resistance, dimensional stability and dynamic stiffness. Moreover, samples of the products were exposed to a freeze-thaw aging mechanism consisting of 400 cycles to test the effects on the thermal conductivity and behaviour under pressure in dry and wet condition. The loose aerogel granules, which can be applied as translucent insulation also, were exposed to UV-aging. In addition, structural analyses such as SEM, sorption analysis and pycnometry were conducted to examine changes in the particles and pores.

The combination of aging methods and tests performed can be taken from the matrix in Figure 2.

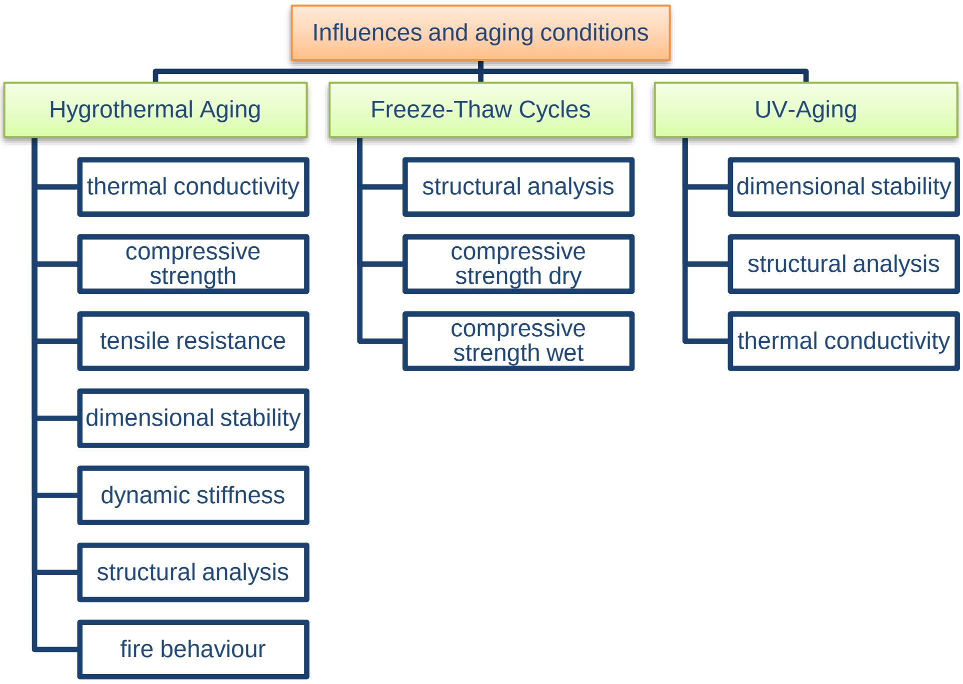

Figure 2 Aging methods and tests performed

Due to the fact that aerogel and APM products are available in very diverse types of delivery forms, there are big differences in how the products are assembled in different constructions. This influences the way of how to deconstruct, separate and recycle the single products. Starting from an enquiry of manufacturer specifications in e.g. environmental product declarations to get an overview about their end-of-life recommendations, different trials on separation and sorting of material components were conducted. Wall elements have been erected and boards of insulating material have been applied to demonstrate the deconstruction layer by layer. The deconstructed material consisting of mortar and insulating material was shredded and due to the difference in raw density and hydrophobic behaviour, the components could be separated by sedimentation. Products with fibre fractions were shredded and classified by a sieve vibrating machine. Thereby, a separation of fibres and nanoparticles could be achieved successfully.

Conclusion

Each of the investigated products showed an individual behaviour at the different characterization tests but none of the products revealed a clear tendency when it comes to degradation of product properties over the investigated period of 9 months. All products show a very stable behaviour throughout the aging period. The thermal conductivity measurement results after the artificial aging showed slightly worse values for four of the five tested products but deviations were only at minimum extent. The increase during the test duration is in the range of 0.0006 W/m·K and 0.0002 W/m·K as can be taken from Figure 3. For product S.1, the raw density slightly decreased during aging, what may lead to the decreasing thermal conductivity towards the end of the aging period. Only the evaluation of the SEM images allows to detect some influences caused by the different aging methods. The counter-check by calculating the U-values of the typical application cases with the aged values leads to a degradation of performance of only 1-3 % and therefore, the thermal performance of constructions will only decrease slightly over decades.

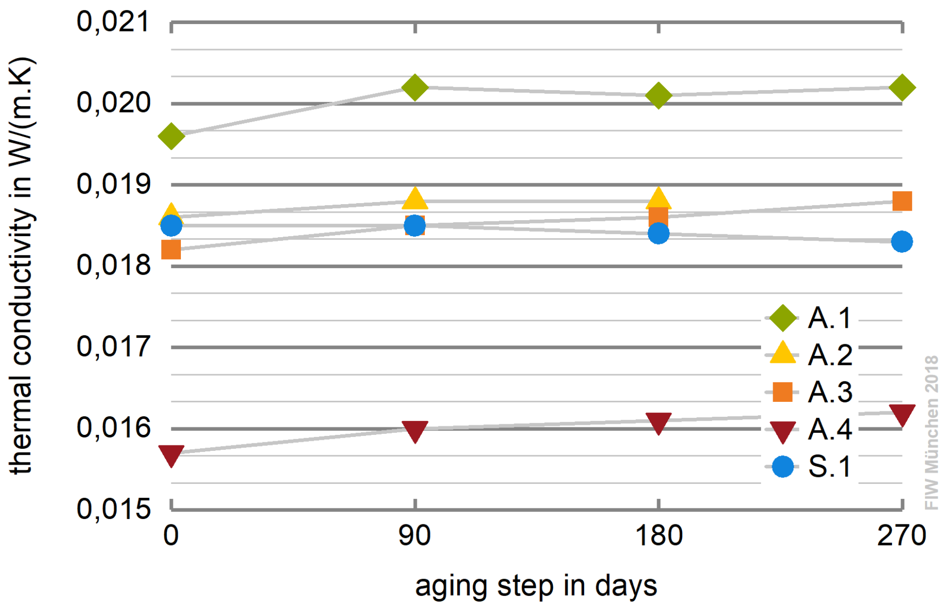

Figure 3 Evolution of thermal conductivity during hygrothermal aging

In addition to the comprehensive characterization of the products, the boundary conditions for future product developments can be derived from the investigations conducted in the scope of this project. Furthermore, a large amount of information about the products has been gathered for later standardization activities.

Key facts

Short title: Aerogels and APM in building practice

Researcher / project management:

Dr.-Ing. Sebastian Treml (project management)
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Carolin Kokolsky M.Sc.
Susanne Regauer M.Sc.

Total cost:	120,008.67 €
Share of federal subsidy:	72,000.00 €
Project term:	24 months

<u>Pictures/ Figures</u>

Figure 1: File name: Fig1left_Temperature humidity internal insulation
Fig1right_Temperature humidity pitched roof

Caption: *Distribution of temperature and humidity on outside and inside of insulation layer at a construction with internal insulation (left) and pitched roof (right) for the exposition case south*

Figure 2:

Caption: *Aging methods and tests performed*

Figure 3: File name: Fig3_thermal conductivity

Caption: *Evolution of thermal conductivity during hygrothermal aging*

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