Funded by the Horizon 2020 Framework Programme of the European Union

CONFERENCE

Aerogel Industry-Academia Forum

Processes, products, applications & markets

July 13 – 15, 2021, Empa-Akademie and online

BOOK OF ABSTRACTS

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Tuesday, July 13th 2021

17^{00} - 19^{00} **Pre-conference networking**

Wednesday, July 14^{th} 2021

09^{00} - 09^{15} **Welcome**

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09^{15} - 10^{20} Production and processes

09^{15} - 09^{40} Irina Smirnova, TUHH, Germany - Production of aerogels in form of microparticles: an overview and latest developments

Irina Smirnova

Hamburg University of Technology

Abstract

Today, mostly aerogels are available in form of monoliths or small irregularly shaped particles. At the same time for many applications, including adsorption, personal care and food, aerogels in form of spherical particles of defined size are required. In the last 5 years different technologies for the aerogel particle production are rapidly developing.

In this talk an overview on technologies of aerogel production in form of spherical particles is given. Thereby the focus is on organic and hybrid aerogels with targeted particle and pore size distribution at the lab, bench and pilot scale.

Both the progress in the supercritical drying and solvent exchange of gel particles are discussed, especially concerning the process time. Further, the concepts of batch, semi-batch and continuous processes are compared. The experimental findings are supported by the detailed modelling of supercritical drying and solvent exchange steps including mass transfer phenomena and especially the solvent spillage out of the gel matrix.

Finally, the new concept being developed at TUH Hamburg for detailed evaluation of the kinetics of supercritical drying in batch and continuous processes ("Aerokinetics") is presented (Fig 1). Thereby the possibility to optimize the drying process for different aerogel types is given and the way to transfer the data between different apparatus in terms of upscale and size/form variation is discussed.

Fig 1. "Aerokinetics" apparatus at Hamburg University of Technology to determine the kinetics of supercritical drying

Acknowledgments

Part of this work was carried out in the frame of the COST-Action "Advanced Engineering of aeroGels for Environment and Life Sciences" (AERoGELS, ref. CA18125) funded by the European Commission." The work toward "Aerokinetics" was supported via PTJ within the program "6th Energy Research Programme of the Federal Government" of the German Federal Ministry of Economic Affairs and Energy (BMWi) based on a resolution of the German Parliament (Project 03EN2017).

09^{40} - 10^{00} Shanyu Zhao, Empa, Switzerland - 3D Printing of Aerogels

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Abstract

Aerogel is an ideal thermal superinsulator with great potential for multiple mass-market applications [1]. Although aerogels can have exceptionally high strength-to-weight ratios [1], silica aerogels are generally brittle and impossible to machine by subtractive processing. The viability of aerogel additive manufacturing has been demonstrated for graphene [2], graphene oxide [3], carbon nitride [4], gold [5], resorcinol-formaldehyde [6], and cellulose [7], but is quoted as "...not feasible for silica aerogels" [8]. With excellent replication fidelity at 10-1000 µm length scale, a printing capability for silica gels will create the possibility for spatially varying compositions and functions of the aerogels and enable a breakthrough in a technological adaptation of aerogels for miniaturization applications. Here, we present a direct ink writing protocol to print silica aerogel objects based on a custom-tailored silica precursor system. Functional (nano)particles or various polymers are easily incorporated. The method enables the production of miniaturized objects with outstanding shape fidelity. The printed aerogel can be pure silica without polymer additives, or hybrids with tailored compositions and functions, with typical properties for silica aerogel (S_{BET} 751 m^2/g, λ 15.9 $mW{\cdot}m^{-1}{\cdot}K^{-1}$). Furthermore, various aerogel materials (cellulose, RF silica composites and polyimide silica composites) can be printing based on developed methodology, which show good shape fidelity and comparable aerogel performance. We demonstrate a proof of concept of additive manufacturing silica-based aerogel materials and conclude with a perspective for the potential 3D printed aerogel materials and components in the targeted markets.

Fig 1 3D printing silica aerogel lotus flower

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Acknowledgments

We thank D. Rentsch for the support of NMR spectrometer, which is funded in part by grant 150638 from the Swiss National Science Foundation, F. Winnefeld for support with the rheometer, A. Braun for support with the photocatalytic setup, C. Stephan support with the infrared thermal imaging system.

10^{00} - 10^{20} Supan Yodyingyong, Thilium, Thailand - A Method for Producing a Micron-Size Spherical Silica Aerogel

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Abstract

Silica aerogel is the world's best insulating solid material. It is nanoporous silica with a sponge-like structure and has a wide range of industrial applications. Spherical silica aerogel is superior to powdery and granulate silica aerogel regarding uniformity, size control, handling, and purity. However, the existing production of high-quality of the controllable spherical silica aerogel is demanding and not sufficiently cost-effective, so they have yet to be widely implemented in the industry.

The present invention relates to a method of preparing the controllable micron-sized spherical silica aerogel using a low-cost water glass solution as the precursor at ambient conditions. The total processing time for the preparation of the spherical silica aerogel is about 3 hours. The aerogel has a bulk density of ~0.1 g/cm^3, the specific surface area of ~700 m^2/g, and the thermal conductivity of ~0.020 W/m.K. Difference types of drying methods have been explored to dry the aerogel. *Fig1.* shows the spring-back of the spherical silica aerogel during the drying. The drying of the spherical silica aerogel is fast (*Fig 1*). Our process can also use to produce silica aerogel powder and oil absorption material. The aerogel product can be used as an additive for the existing building, industrial, and coating products, and provide several advantages include; improved thermal insulation and acoustic insulation, moisture and corrosion resistance, and weight reduction. Examples of applications of our silica aerogel show in *Fig 2-3*.

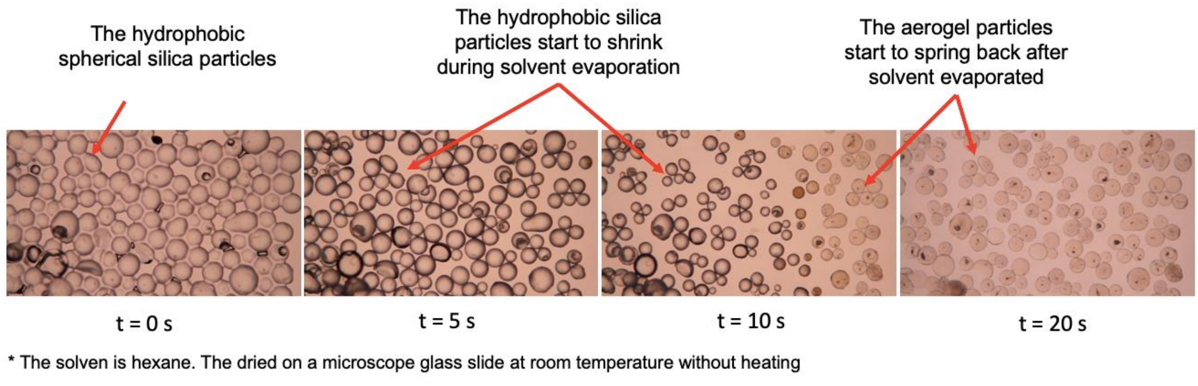

Fig 1. The spring-back of the spherical silica aerogel during drying, captured from an optical microscope

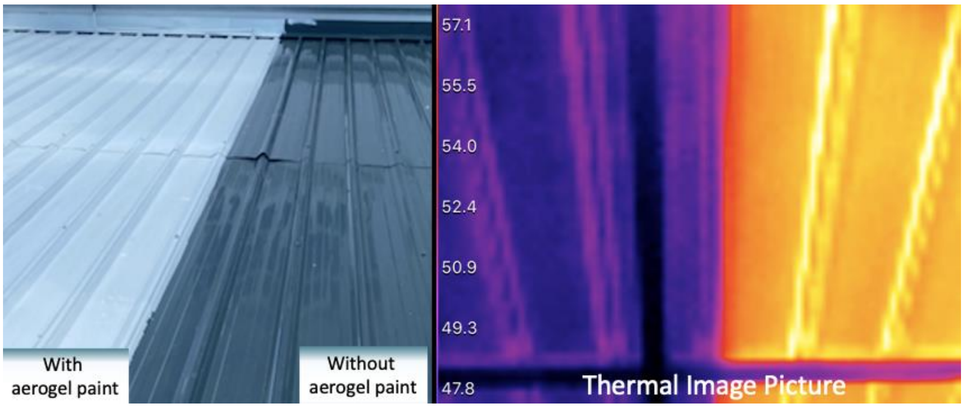

Fig 2. Effect of the aerogel insulation paint coated on a metal sheet roof

Fig 3. Others applications of aerogel

Acknowledgments

This work has been financially supported by Mahidol University and Thilium Co., Ltd.

"Work carried out in the frame of the COST-Action "Advanced Engineering of aeroGels for Environment and Life Sciences" (AERoGELS, ref. CA18125) funded by the European Commission."

10^{20} - 10^{40} Miguel Vazquez-Pufleau, IMDEA, Spain - Continuous Synthesis of 1-D Nanostructures via Floating Catalyst

Miguel Vazquez-Pufleau, Richard S. Schaeufele, Isabel Gómez-Palos, Luis Arevalo, Cristina Madrona, Anastasiia, Mikhalchan, Afshin Pendashteh, Moumita Rana and Juan José Vilatela*
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Abstract

In recent decades, the development of techniques to synthesize one-dimensional nanostructures (1-D NS) has been acquiring impetus. Such materials are very promising for the exploitation of quantum mechanical properties at a macroscopic level and provide the promise of improving significantly the macroscopic properties of classical materials. One of the main challenges of synthesizing 1-D nanomaterials remains to be able to synthesize in a determin-istic manner specific materials with controlled output features. Mastering such challenge will provide for control of specific material properties useful in the fields of chemistry, optoelec-tronics, mechanics, sensor technology, electrical and civil engineering among others.

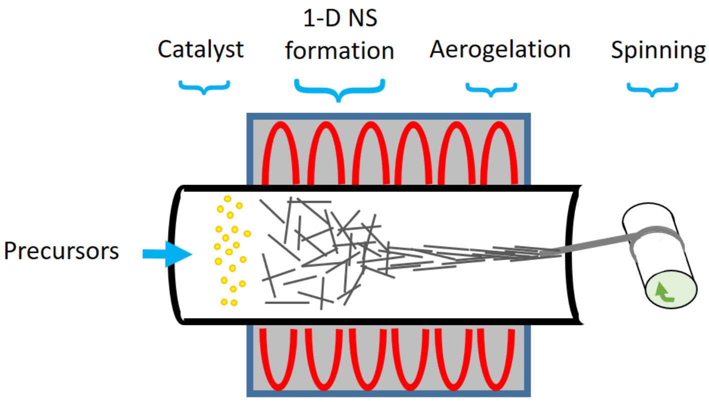

Figure I Schematic of critical steps for synthesis of 1-D nanostructures (1-D NS) spinnable as a macroscopic yarn

One of the key challenges is to gain a mechanistic understanding of the reaction pathways favoring and competing against the synthesis of 1D-Nanomaterials from the chemical as well as the transport phenomena perspective. For studying such effects, our group, is working with different synthesis routes for an array of nanomaterials including carbon nanotubes and silicon nanowires. We are utilizing different catalyst synthesis routes to obtain mechanistic information about the process, which will be useful for reactor design and selection of appropriate synthesis conditions, as well as for the development of successful routes for scaling up the processes.

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Acknowledgments

We are thankful to the European Union Seventh Framework Program under grant agreement 678565 (ERC-STEM) and by MINECO (RyC-2014-15115).

11^{00} - 12^{00} Product development and integration

11^{00} - 11^{20} Stephan Möller, Armacell, Germany - Unique technology opportunities utilizing ambient pressure dried aerogel materials

S. Moeller, P. Holub
Armacell, Muenster, Germany

Abstract

Armacell is the global leader in providing innovative, technical insulation solutions and components to conserve energy and make a difference around the world. As a multi-material and multi-product company, we apply world-class practices every day and expand into adjacent technical insulation end markets, continuously extending our temperature range and equipment verticals. We substitute the legacy materials of our competition with our innovative solutions and reinforce our premium brand position to create value for equipment owners, specifier engineers, contractors and investors.

Broad focus lies on the innovation of multi-material, high-tech products which help to manage energy efficiency, acoustic comfort, light weighting and the rising challenges of urbanization and globalization.

Looking for disruptive specialty materials Armacell entered into a JV – Armacell JIOS Aerogels (AJA) – in 2016. The innovative and patented technologies provided by the JV resulted in the launch of the first product based on aerogel technology, ArmaGel HT, in 2018 followed by ArmaGel DT in 2020. Armacell continues to invest in Innovation, resulting in significant progress in both product and process development. This opened up a wide design space for tailormade aerogel-based solutions which will materialize in further additions to the product line-up in the recent and upcoming years.

11^{20} - 11^{40} Jannis Wernery, Empa, Switzerland - Aerogel applications in the building sector

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Abstract

Silica aerogel insulation materials provide excellent thermal insulation combined with very good building physics properties (diffusion openness, fire protection, hydrophobicity). However, the costs of the available aerogel products are usually several times higher than conventional insulation materials for the same insulation performance. This particular set of characteristics defines a niche in the building sector where aerogel materials can provide outstanding performance or create financial opportunities.

We will give an overview on the common aerogel applications, i.e. retrofits, architectural details, new buildings and upward extensions. A brief analysis of the contexts where aerogel insulation can create economic benefit will be presented. New technical solutions for the implementation of aerogel insulation will be highlighted, in particular prefabricated aerogel wood elements.

Even though silica aerogels are a niche product and will not be cost competitive with conventional insulation materials due to higher raw material cost and more complex production processes, there is still significant potential for the use of these insulation materials in buildings that is not taken advantage of.

Acknowledgments

This work was supported in part by Innosuisse (project no. 25769.2), the Pilot and Demonstration Programme of the Swiss Federal Office of Energy (grant no. SI/501254-01) as well as by the AERoGELS COST action CA18125 of the EU Horizon 2020 Framework Programme.

11^{40} - 12^{00} Hasina Begum, U. Sheffield, UK - Acoustical properties of TEOS based granular silica aerogels

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Abstract

Available data suggests that granulated aerogels can be of interest in terms of their sound absorption performance in the audio frequency range. However, there is still no thorough understanding of the complex physical phenomena which are responsible for their observed acoustical properties. This work is an attempt to address this gap through advanced material characterization methods and mathematical modelling. Aerogel samples are produced through a two-step, acid-base sol-gel process, with sol silica concentration and density being the main variables. Their pore structure is carefully characterized by nitrogen sorption analysis and scanning electron microscopy. The acoustical properties of hard-backed granular silica aerogels are measured in an impedance tube and the results predicted accurately with the adopted theoretical model. Although silica aerogels have over 90% of open interconnected pores, this was neither reflected in the measured acoustical properties nor in the parameter values predicted with the model. Novel results show that only a proportion of the micro and mesopores in the direct vicinity of the grain surface influenced the acoustical properties of aerogels. Further work in the hierarchical pore structure of aerogels is required to understand better the roles of different pore scales on the measured acoustical properties of granulated aerogel.

In this extended abstract we focus on one type of silica aerogel prepared with variable PEDSP750 content in the sol to produce an aerogel named PEDS E30. Fig.1 shows that the particles are not spherical but angular with sharp edges. The complex reflection coefficient of these materials was measured in a specially developed impedance tube with 10 mm diameter in the frequency range of 300 – 3000 Hz.

Granular aerogels consist of highly porous particles with a large internal pore surface area. Modelling of their acoustical properties requires accounting for its multiscale nature and physical processes that occur at different scales. In this work, the model proposed by Venegas et al. [1] was applied. This upscaled analytical model has been developed for an array of spherical porous grains in which two inner-particle scales of porosity are considered. The model accounts for the viscosity and heat transfer effects in the voids formed between the particles, rarefied gas flow and heat transfer in the inner-particle transport pores, interscale (voids to/from inner-particle pores) pressure diffusion, interscale (transport- to/from mesopores) mass diffusion, and sorption in the micro- and mesopores.

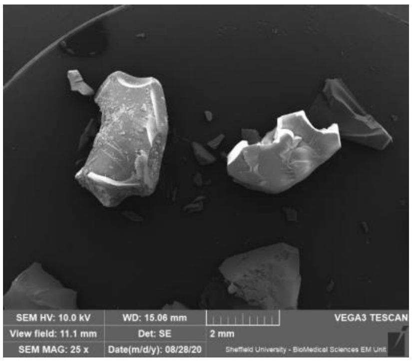

Figure. 1. SEM image of PEDS E30 showing micrometric grains of the 2-3 mm fraction.

After inserting the key experimental parameters obtained from this study into the model, Fig. 2 shows there is agreement between the measured and predicted acoustical surface impedance spectra. The relative mean error between the data and predictions was generally less than 3.1%, this suggests that the model captures the acoustical behaviour of aerogel PEDS E30 accurately.

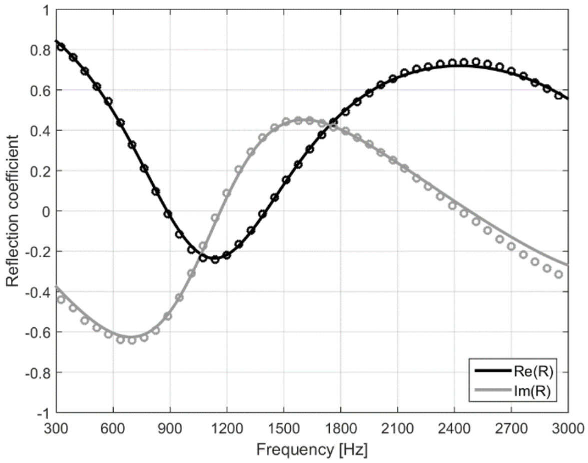

Figure 2. Measured and predicted reflection coefficient for a hard-backed layer of aerogel granulate PEDS E30.

The results found the values of the inverted parameters to make physical sense. Silica aerogels have close to 100% open porosity, however this is not reflected in the parameter values inverted using the proposed mathematical model. Our findings indicate that not all the aerogel's mesopores appear to contribute to the observed acoustical performance.

Table 1. Measured properties and inverted parameters of PEDS E30.

Properties of PEDS E30	Measured	Inverted
r_p [mm]	1.50	0.85
d [mm]	50	52.9
ϕ [%]	93.5	57.7
mesopore radius [nm]	22.7	17.7

The radius, rp of the macropores is in the order of 1 μm, which is a typical value for this type of transport pores (see ref. [2] for the case of activated carbon). The mesopore radius, measured from the SEM images, for PEDS E30 was 22.7 nm. Making use of the Knudsen diffusion coefficient, De the model inverts the nanopore radius parameter as 17.7 nm for PEDS E30. This value is close to those measured from the SEM images. The overall porosity, ϕ estimated from the porosity data is 57.7 whereas from the measured BET data was 93.5.

Aerogels usually consist of fully interconnected pores and this is not reflected in the pore parameter values inverted using the acoustical data and adopted sound propagation model. It is likely that only a proportion of the mesopore length which is in the direct vicinity of the transport pores or grain surface may influence the acoustical properties of the produced aerogels. This remains an open question and naturally suggests that more research is needed to understand better the relative roles of macro-, meso- and micropores on the acoustical properties of aerogels.

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Acknowledgements

The authors would like to thank the EPSRC-sponsored Centre for Doctoral Training in Polymers, Soft Matter and Colloids (EP/L016281/1) at The University of Sheffield for their financial support of this work. We would also like to thank our industry partner Armacell and Dr Mark Swift and Mr Pavel Holub for their continued support throughout this research study. Dr. Rodolfo Venegas acknowledges partial support from Corporación de Fomento de la Producción CORFO Chile (Production Development Corporation) through grant 16ENI2-66903 Innoving2030

13^{30} - 15^{00} Poster session

1. Raquel Barrulas - Poly(ionic liquid)-chitosan aerogels for CO_2 capture and conversion

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Abstract

CO_2 levels in the atmosphere are increasing exponentially, and for this reason CO_2 capture is a matter of global need.[1] Furthermore, the use of CO_2 as C1 building block to produce other chemical products is considered a clean and efficient approach for the reuse of this gas, since it can minimize the consumption of sensitive and toxic carbon sources.[2] So, heterogeneous catalyst that work at the same time as CO_2 sorbent and catalyst are extremely important in the context of CO_2 Capture and Utilization strategies.

In this work, we envisioned the ideal catalyst that combines porosity and high surface areas (S_{BET}) with CO_2 conversion capacity and that can be obtained through the combination of poly(ionic liquid)s (PILs) with aerogel structures.

PILs are obtained from ionic liquid (IL) monomers that are composed of organic cations combined with organic or inorganic anions, whose properties are tunable towards the final applications. PILs combine the unique characteristics of ILs with a macromolecular framework and have been on the spotlight for applications such as gas storage, separation, and catalysis.[3] Aerogels are light-weight nanostructured materials with high porosity and S_{BET}, that can be obtained from biopolymers such as chitosan that uses a biomass residue as starting material.[4,5] The combination of chitosan-based aerogels with PILs is expected to enhance CO_2 diffusion through the material, efficiency, and selectivity.[3] Promising PIL-chitosan composite aerogel beads (*AEROPILs*) for CO_2 capture and conversion are herein presented (Fig 1).

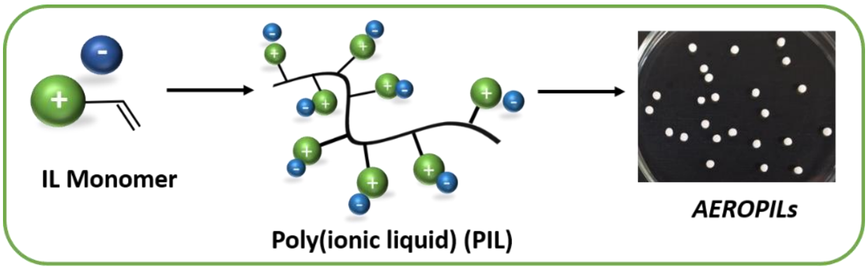

Fig 1. AEROPILs resulting from the combination of chitosan with PILs.

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Acknowledgments

This research was funded by National Funds through FCT – Portuguese Foundation for Science and Technology, through projects: UIDB/50025/2020-2023, UID/QUI/50006/2019, PTDC/QUI-QFI/31508/2017, PTNMR-ROTEIRO/0031/2013 and PINFRA/22161/2016, co-financed by ERDF through COMPETE 2020, PT2020, POCI and PORL and FCT through PIDDAC (POCI-01-0145-FEDER-007688, POCI-01-0145-FEDER-007265). Work supported by Xunta de Galicia [ED431C 2020/17], MCIUN [RTI2018-094131-A-I00], Agencia Estatal de Investigación [AEI] and FEDER funds. R.V.B. acknowledges FCT for the SFRH/BD/150662/2020 PhD fellowship. M.C. gratefully acknowledges PTNMR for the researcher contract. R.V.B. acknowledges the COST-Action "Advanced Engineering and Research of aeroGels for Environment and Life Sciences" (AERoGELS, ref. CA18125), funded by the European Commission, for the Short Term Scientific Mission grant to perform aerogels synthesis and processing at Universidade de Santiago de Compostela.

2. Sergejs Beļuns - Sustainable Ultralight Foams from Wood and Hemp Waste Cellulosic Nanomaterials for Thermal Insulation Applications

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Abstract

Nature is a source of inspiration for many material scientists to develop high-performance and functional materials and composites. Lignocellulose is one of the most common and prolific materials that attract scientists because of its properties and accessibility. Lignocellulose materials have significant advantages, such as abundancy, renewability, biodegradability, excellent rigidity, and new functionality. The preparation of wood imitating material based on lignocellulose gels has attracted high interest in scientific research over the last decade [1].

Transition to the circular economy requires the implementation of recycling and reuse routes for waste products. This research addresses one of the leading emerging areas, i.e., the development of sustainable materials and natural waste processing, namely wood and hemp byproducts. The cellulosic nanomaterials derived from these under-utilized waste residues and byproducts also serve as promising natural precursors for advanced applications, e.g., biomedical, pollution filtering, and thermal insulation. In this work nanocellulose was prepared from wood dust (birch) and hemp straws waste using minimal chemical treatment. The cellulose defibrillation was carried out with Microfluidizer®. Different concentrations such as 0.2, 0.5, 1.0, 3.0 wt% in water suspensions were adjusted to achieve several specific densities in subsequent freeze-drying. After freeze-drying, the resulting foam materials were characterized with a bulk density of 2-36 mg/cc. The foams prepared using the two distinct waste products were examined thoroughly for, mechanical properties, thermal properties, thermal conductivity, thermal degradation, chemical composition, and morphology. The thermal performance of obtained nanocellulose foams was in the range of 34 - 44 mW/m·K, which makes their application comparable to commonly used insulation materials and has a practical use potential.

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Acknowledgments

This research is funded by the Latvian Council of Science, project REALHLC, No. Z19/1-0390

3. Romain Civioc – SILICA-RMF COMPOSITE AEROGELS: CHEMISTRY, MICROSTRUCTURE, AND PERFORMANCE

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Abstract

Silica aerogels[1], thanks to their mesoporosity, are the best insulators in the world - but they are fragile, expensive, and display poor mechanical properties. RMF resins[2] (Resorcinol-Melamine-Formaldehyde) on the other hand are macroporous and robust materials. Based on our recent results on the transposition of RMF (Resorcinol-Melamine-Formaldehyde) resins to an ethanolic chemistry[3], composite aerogels of silica and RMF – ranging all the way from 100% silica to 100% RMF – were studied in this work. The samples were characterized with respect to their chemical identity, microstructural properties, and performance in terms of thermal conductivity. Some of the composites have a very low thermal conductivity even with a reduced silica concentration, due to chemical interactions between the two systems during the gelation phase of the composites; the consequences of this hybridization on primary particle size, gelation behavior, and consequently pore size distribution and porosity are discussed.

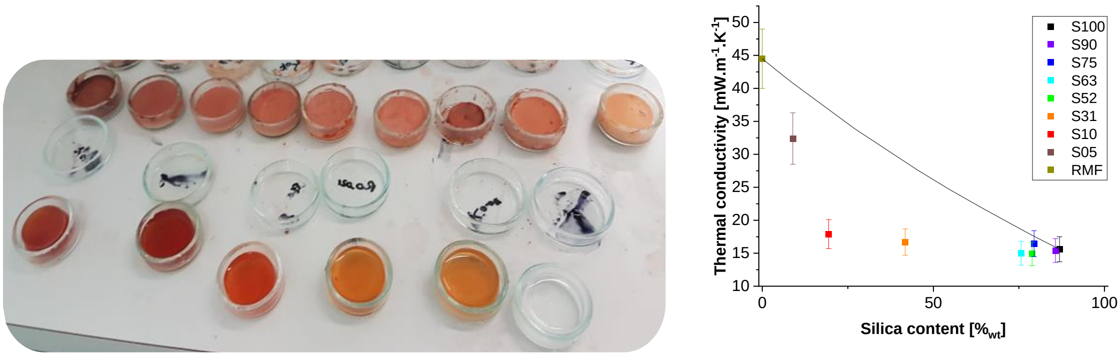

Figure 1: Silica-RMF composite alcogels and the thermal conductivity of their corresponding aerogels

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Acknowledgments

In case of work in the frame of AERoGELS Action, please add the following statement: "Work carried out in the frame of the COST-Action "Advanced Engineering of aeroGels for Environment and Life Sciences" (AERoGELS, ref. CA18125) funded by the European Commission

4. Lucia De La Cruz - Flame Retardant Crosslinked Aerogels based on Poly(vinyl alcohol) modified with Alginate and Tannic Acid

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Abstract

Among the ecofriendly aerogels, those based on polyvinyl alcohol (PVA) are among the most studied ones. PVA occupies a large part of the industrial production of water-soluble synthetic polymers. Also, this biodegradable polymer is non-toxic, oil/grease resistant, and possesses low surface tension. The latter favors the formation of colloid precursors and consequently the hydrogel and aerogel obtention. However, PVA shows some undesired properties such as high flammability and low compressive resistance, thus limiting its applications as a substitute for conventional petrol-based foams. In order to face these limitations, this study aimed to enhance the fire behavior resistance and mechanical properties of PVA by adding alginate and tannic acid (TA) as sustainable modifiers. Sodium hydroxide (NaOH) was used to decrease the blend viscosity. Aerogel samples were obtained by preparing gel precursors followed by freeze-drying and then post crosslinking with CaCl2 and H3BO3 in an ethanol solution. Fig. 1 (a) shows the proposed chemical modification and crosslinking mechanism. Morphology, flammability, mechanical and thermal degradation properties were analyzed.

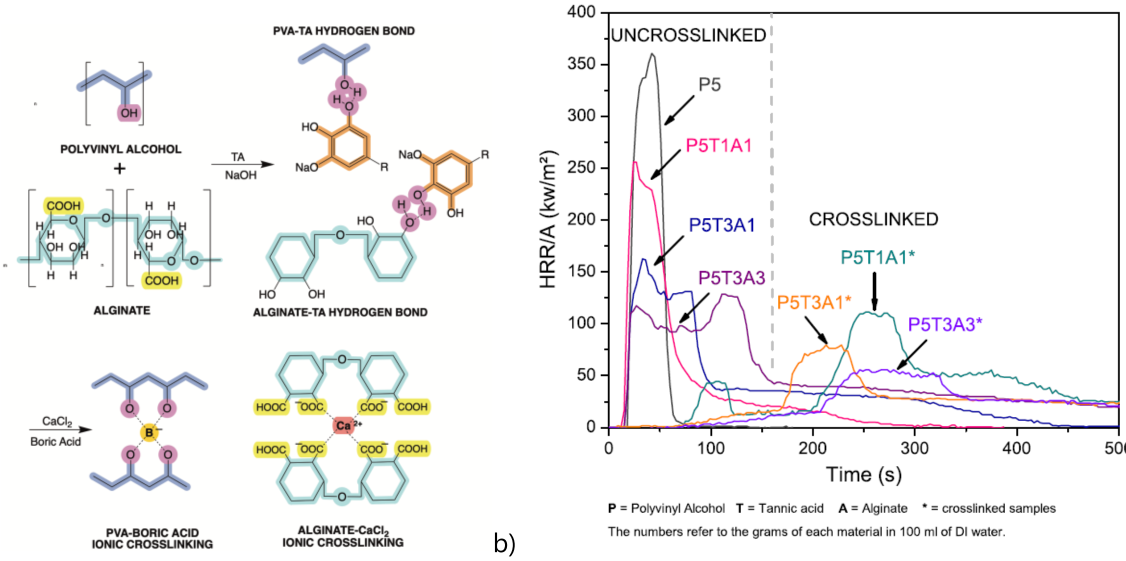

Fig 1. a) Proposed reaction mechanism of modification of PVA with alginate and tannic acid and ionic post crosslinking with CaCl2 and boric acid. b) Heat release rate (HRR) of uncrosslinked and crosslinked PVOH aerogels modified with alginate and TA under a heat flux of 50 kW/m2.

PVA aerogels modified with TA and alginate presented a ramified structure connected by thin fibrils oriented in direction of the ice crystal growth. The viscosity decrement by adjusting pH 9 favors the ice crystal growth rate and can endow a more ordered structure. As the alginate concentration increased, the physical entanglement increased too, leading to a honeycomblike structure.

The densities of pure PVA (P5), P5T1A1, and P5T3A3 aerogels were 0.07 g/cm3, 0.11 g/cm3, and 0.15 g/cm3, respectively. After crosslinking, the densities increased to 0.36 g/cm3 for P5T1A1 and 0.25 g/cm3 for P5T3A3. This increment was generated due to the incorporation of Ca^{+2} and B^{+} ions within the alginate and PVA chains.

Compressive properties increased as the amount of TA and alginate increased in the PVA matrix. Alginate not only raised the physical entanglement but might also increase the rigidity due to the restricted rotation of its sugar rings. The compressive moduli of PVA aerogels modified with TA and alginate exhibited a 5-fold increment for P5T1A1 and about 11-fold increase with 3g of alginate and 2 g of TA (P5T2A3) aerogels compared to the P5 aerogel. Once the aerogels were crosslinked, they were allowed to stabilize for two days, where an increase in density was observed due to the humidity absorption. As a consequence of the aforementioned, the uncrosslinked aerogels showed better specific compressive properties between 30MPa/g cm-3 to 68 MPa/g cm-3, as compared to crosslinked samples, namely between 8 to 40MPa/g cm-3. Nevertheless, in terms of absolute values, it is noteworthy to mention that the absolute compressive moduli of the crosslinked samples showed about a twofold increase of the PVA aerogels modified with the highest amount of TA and alginate.

The thermal degradation temperature of PVA-modified aerogels was accelerated due to the catalytic effect of NaOH, which on the one hand deprotonates the phenolic groups from TA and on the other hand possibly converted remaining polyvinyl acetate groups into polyvinyl alcohol. The thermal decomposition of the alginate was not affected by the content of TA or NaOH. NaOH and TA acted as inorganic and organic intumescent char-forming additives, respectively. In all cases, the formed char was higher than the theoretical one. The amount of char generated within the range of compositions tested was found to increase with increasing amount of TA.

Fig.1(b) illustrates the heat release rate (HRR) curves regarding the aerogel combustion behavior. The peak heat release rate (PHRR) of pure PVA aerogels was reduced by twofold when modifying with alginate and TA. After CaCl2/H3BO3 crosslinking, the PHRR of PVA modified aerogels further decreased, namely 4-fold. Additionally, the crosslinking significantly increased the time to ignition (TTI). Samples went from immediately burning (0 s) to retarding their ignition up to 180 s. The PHRR obtained by crosslinked samples further reduced threefold as compared to the uncrosslinked PVA-TA aerogels reported by Cheng et al. [1] and 33% less than the crosslinked PVA-Alginate-MMT aerogels reported by Wu et al. [2]. On this basis, the crosslinked aerogels with higher alginate and TA concentrations were considered the most promising compositions as flame retardant systems.

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Acknowledgments

Authors acknowledge the financial support to this work given by the Ministerio de Ciencia e Innovación for the project PID2019-106518RB-I00. L. G. De la Cruz thanks to CONACYT for the grant (num. 729201) received.

5. Thoa Duong - Alginate aerogel microspheres as bio-carriers in pulmonary drug delivery

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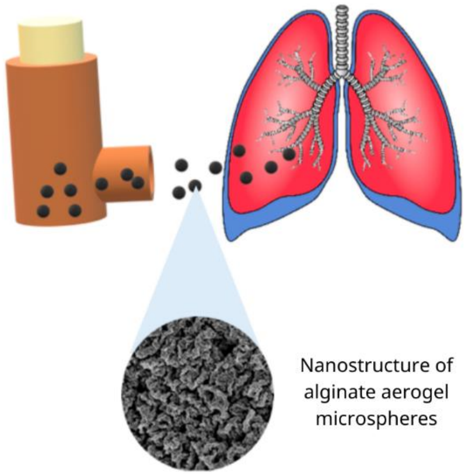
Abstract



Respiratory diseases are raising a huge challenge concerning the quality of life and sociosanitary costs. Under the outbreak situation, pulmonary drug delivery is highlighted as "an alternative route in the repositioning of drugs" contributing to the treatment of COVID-19 [1] and other local diseases. Dry powder inhalers (DPIs) highlight as convenient inhalation devices as they are easy-to-use, portable and friendly with the environment. However, current drug particles used in DPIs can easily be trapped in the oropharyngeal region or eliminated by the pulmonary barriers resulting in systemic adverse effects and in the reduction of therapeutic effect. Therefore, a great effort is devoted in the pharmaceutical research field to develop novel drug formulations for DPIs based on adequate particle designs.

As the lightest solid materials in the world, aerogels can be designed to obtain inhaled porous particles with excellent aerodynamic behavior [2,3]. Porous texture of aerogels also has a great significance for this use as it allows incorporating the drug into the aerogel structure, achieving the target deposition in the lungs and enhancing the dissolution rate of poorly-soluble water drugs. Namely, aerogels in the form of microspheres and from biocompatible sources like alginate, are distinctive drug carrier candidates for pulmonary delivery as inhaled particles. From an industrial point of view, aerogels with spherical shape are also favorable in terms of reproducible performance and cost of production compared to other shape formats.

In this work, a formulation based on aerogel microspheres was produced using a supercritical fluid (SCF) technological platform, and tested for inhalation therapy. The relevance of the processing parameters on the resulting aerogel performance in DPIs will be presented. Alginate aerogel microspheres loaded with beclomethasone dipropionate (BDP), an anti-inflammatory drug commonly prescribed for the treatment of asthma and usually administered by inhalation therapy, were obtained. This inhaled formulation was designed to enhance the dissolution rate of this low water-soluble drug as well as to minimize systemic side effects. Aerogel microspheres were prepared by the emulsion-gelation method followed by SCF drying. The prepared alginate aerogels were loaded with BDP by SCF post-impregnation. Nitrogen adsorption-desorption techniques (BET and BJH methods), SEM microscopy and helium pycnometry were used to evaluate the textural properties of the aerogels. The BDP release rate of the obtained drug-loaded aerogels was also evaluated and the aerodynamic properties tested in an *in-vitro* simulated lung deposition tests.

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Acknowledgments

Work carried out in the framework of the COST Action CA18125 "Advanced Engineering and Research of aeroGels for Environment and Life Sciences" (AERoGELS) and funded by the European Commission. This research was funded by Xunta de Galicia [ED431C 2020/17], MCIUN [RTI2018-094131-A-I00], Agencia Estatal de Investigación [AEI] and FEDER funds. C.A. García-González acknowledges to MINECO for a Ramón y Cajal Fellowship [RYC2014-15239].

6. Michal Ganobjak - Developing topology-optimized insulating facebrick with silica aerogel internal filling

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Abstract

Universal construction elements such a bricks have been invented and used independently in many cultures. Brick appearance and function have evolved over time and survived centuries. Bricks are still widely popular throughout the world and is a popular construction material many different places. However, the recent increase of standards in fire safety, sustainability, themal insulation properties, etc. have limited the use of the traditional brick as a load bearing construction element. Nowadays, bricks are used as cladding for their aesthetic appearance, historizing effect and low-maintenance demanding surface. However, if the thermal insulation properties of classical bricks are improved, bricks have the potential to become desirable structural elements again. This research presents the design of a new clay brick filled with sili-ca aerogel (Fig 1). The design has been performed using multi-objective topology optimiza-tion that considers both stiffness and thermal conductivity properties.

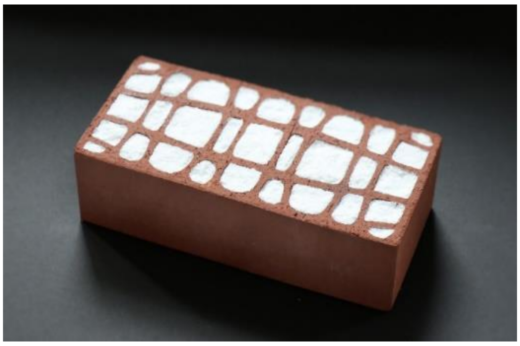

Fig 1. Topology-optimized face brick prototype with reduced U-value, filled with high performance thermal insulating silica aerogel.

In our contribution, the free-form design method of topology optimization is used with specified sets of boundary conditions for the design of the stiffness and thermal conductivity. The de-sign presents the internal void structure of a standard-sized brick which is filled with silica aerogel. The contribution offers numerical evaluations to compare the performance of the new optimized design to a standard full brick and bricks filled with air. The presented topology-optimized brick designs are shown to improve the thermal insulation characteristics significantly. For future research, it is suggested to perform experimental measurements and comparison these with simulations.

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Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and in-novation programme under the Marie Skłodowska-Curie Actions grant agreement No. 746992

Project supported by Fulbright scholar program at Massachusetts Institute of Technology

7. Ana Iglesias – A technological combination to obtain dual porous aerogels

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Abstract

3D printing is an emerging tool for tissue engineering that enables the obtaining of structures with complex architectures by depositting materials layer by layer (1). Bioprinting strategies have demonstrated their potential application in regenerative medicine by allowing the fabrication of 3D functional living tissues or artificial organs (2). Specifically, 3D-printing present an outstanding advantage for bone tissue engineering due to the biomimetic and controlled design of implants on the macro, micro, and nano-level that favor nutrient transport and cellmatrix interactions (3). Furthermore, the obtaining of biocompatible 3D-scaffolds with a welldefined and dual internal structure (mesoporous and macroporous) is crucial for tissue engineering and can be achieved by the novel combination of 3D-printing and supercritical fluid technology herein proposed. In the first step, a suitable ink must be printed to obtain a personalized shaped gel with attractive structural and biological properties. Then, the gel solvent is removed by a method that preserves the internal gel structure in terms of its textural properties, like the supercritical fluid technology. In this work, aerogel scaffolds were obtained by the 3D-printing of gels and its subsequently supercritical CO2 drying for bone tissue engineering applications aimed to personalized regenerative medicine and its textural properties were evaluated regarding this purpose.

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Acknowledgments

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8. Ann-Kathrin Koopmann - Sustainable, Tannin-based Carbon Spherogels as Electrodes for Electrochemical Application

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Abstract

Carbon aerogels, which are generated after pyrolysis of organic aerogels in inert atmosphere, are of increased interest for various applications, such as electrodes for supercapacitors or bat-teries, as well as in catalysis, due to their excellent material properties, namely low density, high surface area, good mechanical properties, well-adjustable porosity as well as high electrical conductivity. Furthermore, hollow carbon spheres provoked increased interest regarding their, compared to conventional carbon aerogels, additional characteristic properties such as a high surface-to-volume ratio, high structural stability as well as feasibility for encapsulation. How-ever, so far solely hollow carbon spheres powders have been prepared. Salihovic et al. [1] were the first to generate freestanding monolithic carbon sphere assemblies by templating with PS latexes, which they term carbon spherogels. Moreover, it has to be addressed that the polymer source for the preparation of carbon aerogels or hollow carbon spheres is often based on the organic precursors, e.g. resorcinol-formaldehyde (R/F), which are toxic and environmentally harmful. In order to produce hollow carbon spheres from sustainable carbon sources, research has been done to some extent, whereby the capability of monosaccharides as well as carbohydrates to function as organic precursor for hollow carbon spheres was verified. Furthermore, looking back at carbon aerogels, Celzard and Pizzi et al. [2] demonstrated the feasibility of replacing resorcinol-formaldehyde by tannin-formaldehyde, which is based on the natural, in-expensive tree extract tannin.

Within this work, we like to present a perspective route to generate freestanding, sustainable, monolithic carbon sphereogels, on the basis of the tree extract mimosa tannin and biomass-derived 5-(hydroxymethyl)furfural (5-HMF), as a crosslinker (Fig. 1). Highly porous, homoge-nous carbon spherogels based on these green organic precursors have been prepared and are investigated regarding their properties in comparison to previously prepared R/F-derived car-bon spherogels. Thus, the synthesised materials are thoroughly investigated for their chemical, physical as well as electrochemical properties.

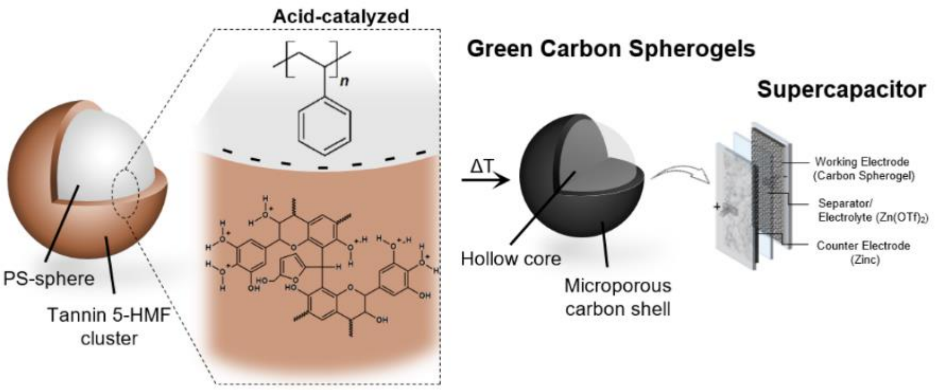

Fig 1. Schematic representation of the generation procedure of tannin-based carbon spherogels for their application as electrode material for zinc-based energy storage systems.

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9. Zahra Mazrouei-Sebdani Water repellent-Silica Aerogel Contained Coating of a woven Fabric

F. Shams-Ghahfarokhi[1], A. Khoddami[1], S. Salimian[1], Z. Mazrouei-Sebdani[1,2*]

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Abstract

The silica aerogels are the unique porous materials that have found increased attention in the various fields of application e.g. thermal and sound insulation due to their large surface area and very low density [1], but they are highly brittle due to their nano-porous nature [2]. One effective route, decreasing this fragile behavior, is to introduce fibers into the silica aerogels making fiber-reinforced aerogel composites [3], which must be still perfectly hydrophobic to water, leading to keep perfect performance even in the moist environment [4]. However, the excessive dusting of the aerogel particles from the fiber assemblies is of important drawbacks [5]. To solve these shortcomings, this paper aims to introduce a facile and feasible coating procedure on a PET woven fabric with the silica aerogel particles via a water repellent finishing, pad-dry-cure, process for engineering a flexible thermal/sound insulating material with the enhanced hydrophobic properties and low dust releasing.

To produce the aerogel-coated fabrics, polyester fabrics were impregnated in pre-mixed treatment baths containing 100 g/L RUCO-COAT FC 9000, from Rudolf, Germany, and 2 g/L thickening agent, and 0-6% (W/V) silica aerogels (made based on ref [5]). Amount of the coating material on the fabrics was controlled by passing through a two-roll padding system (Mathis, Switzerland), then drying at 100˚C, and curing at 170˚C, Fig. 1. The performance of the aerogel-fluorochemical-coated fabrics was studied by measuring air permeability (BS 9237-1995), water contact angle, water sliding angle [5], and SEM (Hitachi S-300 N).

The aerogel-coated samples showed low dust-releasing behavior, good insulation properties, and high hydrophobicity. An enhancement in the coated samples' hydrophobicity was observed due to both low surface energy (resulted from fluorochemical/aerogel) and generated proper surface topology (resulted from aerogel particles). Therefore, for the 6% aerogel-100 g/L fluorochemical coated sample, the values of water contact angle and sliding angle were found to be 152.8˚and 14.2˚, respectively. Also, fiber surface coating with a reduction in the gaps between the fibers and yarns resulted in the lower air permeability of the higher content aerogel coated sample with an air permeability of 8.8 mL/s.mm2 which is lower than those for the uncoated (24.8 mL/s.mm2) and only fluorochemical-coated samples (15.2 mL/s.mm2). These new-coated materials have a potential for applications in some fields of advanced materials, which need insulation properties, lightweight coating, and high hydrophobicity.

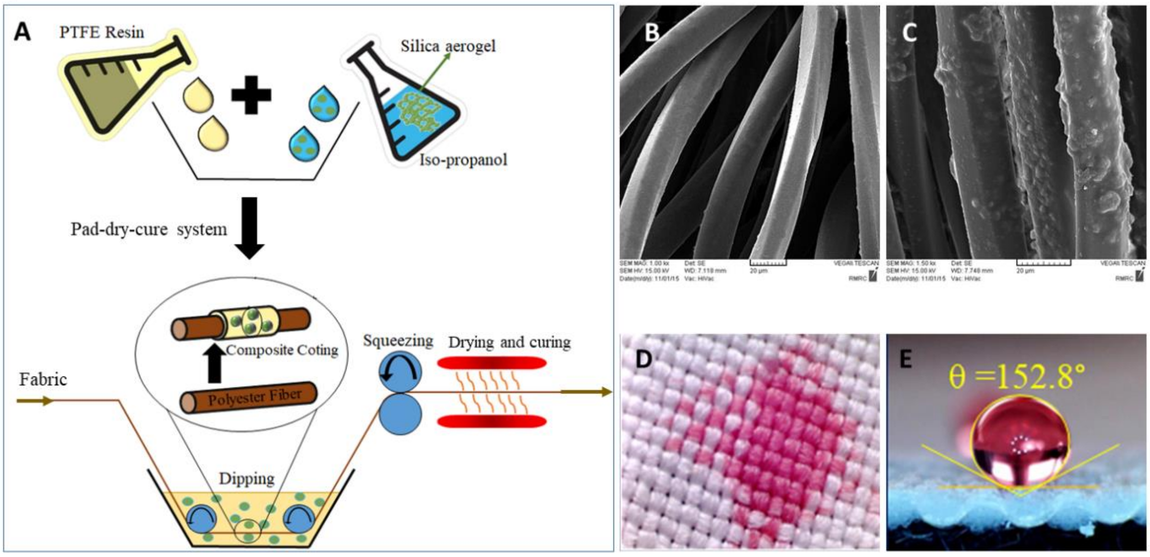

Fig 1. (A) Schematic of the aerogel-coated fabric preparation, (B) SEM photograph of the uncoated fabric, (C) SEM photograph of the aerogel-coated fabric, (D) a water droplet on the uncoated fabric, (E) a water droplet on the aerogel-coated fabric

Acknowledgments

Financial support of the Isfahan University of Technology (IUT) is gratefully appreciated.

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10. Mohammadreza Naeimirad - CNT/carbon aerogels: synthesis, characterization and application in polymer composites

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Abstract

In this work, carbon aerogel (CA), and CNT/carbon aerogel (CNT-CA) were synthesized. Aerogels were prepared using sol-gel conventional method and condensation polymerization of resorcinol and formaldehyde in CNT-surfactant stable suspension. The samples were dried with freeze dryer and carbonized in furnace under a nitrogen atmosphere. The aerogels were converted into powder form using a mortar grinder and were used in different weight ratios (0.1, 0.3 and 0.5 wt%) to reinforce epoxy (Ep) nanocomposites. The relationship between aerogels structure deformation such as the average diameter, the total volume of pores and specific surface area, and mechanical properties of nanocomposites were investigated. Mechanical investigations of nanocomposites showed 8-17% increment in young modulus, 39-52% tensile strength, 47-69% elongation at break compared to the neat epoxy matrix.

Experiments and results

By placing aerogels in the polymer substrate and trapping the chains in the pores, a high interaction between the polymer and the filler can be achieved [1]. Carbon aerogels have specific characteristics such as super light density, very high specific surface area and electric conductivity which make them suitable candidates for composite reinforcement [2].

CNT-CA was prepared by sol-gel conventional method. 1.3 wt% of purified CNTs were dispersed in surfactant aqueous solution containing NaDBS with NaDBS:CNT weight ratio of 5:1. Resorcinol and formaldehyde (RF solid) with R:F molar ratio of 0.5 were added to the solution. Sodium carbonate with a R:C molar ratio of 200 was used as catalyst. The sol-gel solution cured in the oven at 85 °C for 72 hours. Samples were dried by freeze dryer method. Then, those were pyrolyzed at 1050 °C for 3 h under nitrogen atmosphere. For comparison, the carbon aerogel (CA) was prepared using the above method without adding CNTs to the solution. The nanocomposites (Ep/CAx and Ep/CNT-CAx), where x represents the weight percentages of CA or CNT-CA were prepared by mixing aerogel powders with epoxy resin, then adding stoichiometric amounts of hardener and catalyst to the suspensions. The results of Nitrogen adsorption–desorption isotherms are shown in Figure 1. According to the IUPAC classification, in Figure 1a, the adsorption isotherms of the samples are type IV. The isotherms have a hysteresis loop indicating the presence of a mesoporous structure [3]. According to the pore size distribution diagram in Figure 1b, the pore size range is between 2-12 nm and confirms the mesoporous distribution. In both cases, the hysteresis loops are H3 type. Also adsorption isotherms show that the amount of nitrogen gas adsorbed on CNT-CA is higher than CA, which indicates a higher amount of specific surface area in CNT-CA. The pore size distribution diagrams determine that CA aerogel shows a broader pore size distribution compared to CNT-CA. The CNT-CA aerogel has a narrow and uniform pore size distribution which is due to the presence of MWCNTs [4]. Table 1 shows the structural characteristics of the aerogels.

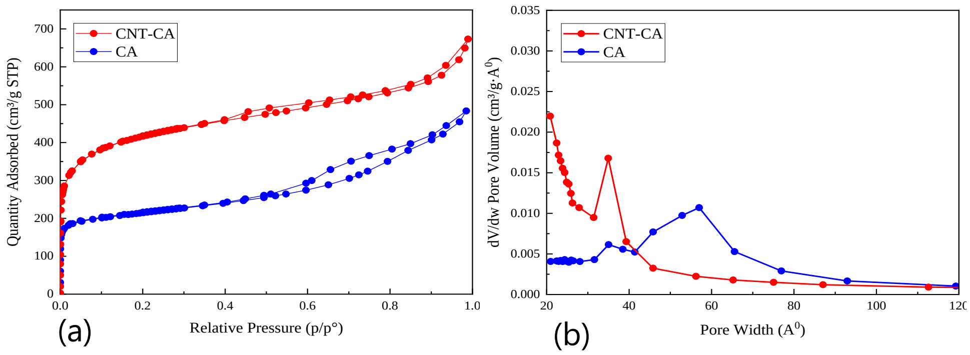

Fig 1. Illustration of (a) nitrogen adsorption–desorption isotherms and (b) pore size distributions of CA and CNT-CA.

Table 1. Structural properties of aerogels

Samples	ρ_a (g/cm^3)	D_{mean} (nm)	S_{BET} (m^2/g)	V_t (cm^3/g)
CA	0.16	4.80	797.96	0.73
CNT-CA	0.12	3.26	1507.47	0.99

The tensile test results are reported in Figure 2. According to the tensile test results, the tensile properties of all the composites are improved compared to the pure epoxy. The results indicate that young's modulus increases by adding the aerogel content, and the tensile strength and elongation at break show the maximum value in an optimum filler content [5].

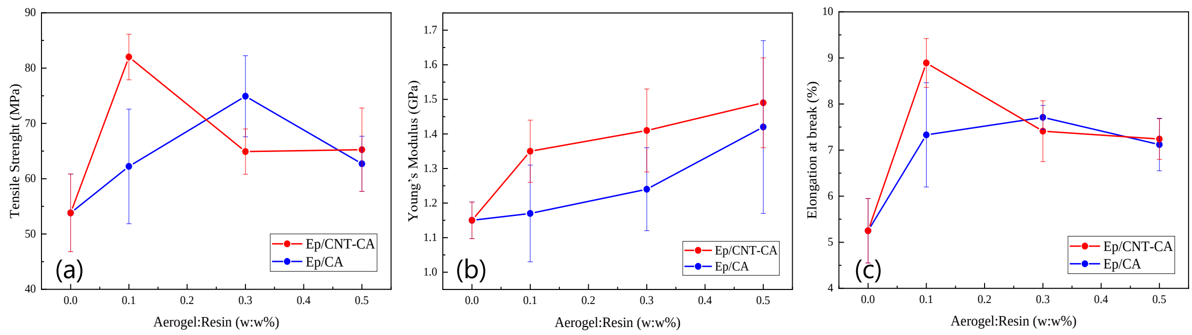

Fig 2. Illustration of comparison of (a) Tensile strength, (b) Young's modulus and (c) Elongation at break of Ep/CA and Ep/CNT-CA.

Epoxy resin was penetrated into the pores of the aerogel due to the specific surface area and an effective connection was created between the resin and the aerogels. It can be concluded that a very small amount of aerogel improved the tensile performance of epoxy dramatically. This achievement is due to effective interfacial interaction, and high contact surface area between the filler and the polymer chains.

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11. Marion Nègrier - Bio-aerogels

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Abstract
Bio-aerogels is a new generation of aerogels based on renewable matter, in particular, poly-saccharides. Today's interest in bio-aerogels is in part due to the desire to use sustainable resources instead of fossil-based ones in order to reduce the environmental impact of the pol-ymer industry and to realize a bio-based and sustainable society. In addition, bio-aerogels, as well synthetic polymer-based aerogels, possess much better mechanical properties than silica aerogels.
Due to their low density and high specific surface area, bio-aerogels can potentially be used in the same applications as classical aerogels such as for thermal (super)insulation, as catalysts and catalytic supports as well as absorbents and adsorbents. As no toxic compound is used in the preparation of bio-aerogels, their properties are highly beneficial from a biomedical point of view (for drug delivery, tissue engineering, wound dressings).
Our laboratory is developing bio-aerogels for various applications since the beginning of the 21st century (see, for example, refs. 1-5). Bio-aerogels are prepared by polymer dissolution, gelation (in certain cases this step can be omitted), solvent exchange and drying with super-critical CO2 (Fig 1). This is fundamentally different from the preparation process of classical aerogels, which starts with the polymerization of monomers. We will present some examples of aerogels based on cellulose, starch, chitosan and hyaluronic acid.

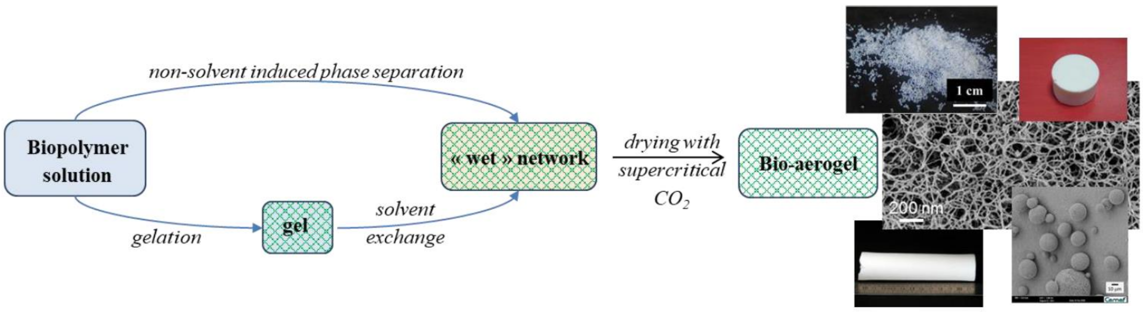

Fig 1. Schematic representation of bio-aerogel preparation

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Acknowledgments

We are grateful to Pierre Ilbizian (PERSEE) for the scCO2 drying, Suzanne Jacomet (CEMEF) for the SEM imaging and Romain Castellani (CEMEF) for the rheology expertize. Benjamin Nottelet and Hélène Van Den Berghe (IBMM, Montpellier), Elise El Ahmar (CTP, Mines ParisTech), Martial Sauceau and Romain Sescousse (RAPSODEE, IMT Mines Albi), Daniel Antonio Aguilera (CEMEF) for fruitful discussions, and CNRS, Institut Carnot M.I.N.E.S. and A.N.R. for fundings.

12. Abhijit Pisal - Synthesis of low density and high temperature resistant Y_2O_3 doped silica aerogels

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Abstract

Commercialization of aerogels has been slow down due to high cost and manufacturability issues [1]. Therefore, in the present paper, we manufactured silica aerogels at low cost and low risk. In this paper, we report the experimental results on the synthesis of low density and high temperature resistant Y2O3 doped silica aerogels. Silica sols were prepared by keeping the molar ratio of TEOS: ethanol (EtOH): water (0.01 M HCl as acid catalyst): Ammonium Flu-oride (0.5 M NH4F as base catalyst) was kept constant at 1:15:7:0.6 respectively, while the weight percent of Y2O3 powder was varied from 0.1 to 4%. The aerogels have been produced by two-stage sol-gel process followed by supercritical CO2 drying. The best quality silica aer-ogel in terms of low high-temperature thermal conductivity (0.097 W.mK-1 at 1000 ^{0}C), low density (26 mg/cc) and high optical transmission (about 87% in the red region) have been obtained with molar ratio of 1TEOS: 15EtOH:7water:0.6 NH4F and 3% of Y2O3 powder. The best quality Y2O3 doped silica aerogel is as shown in figure (Fig 1).

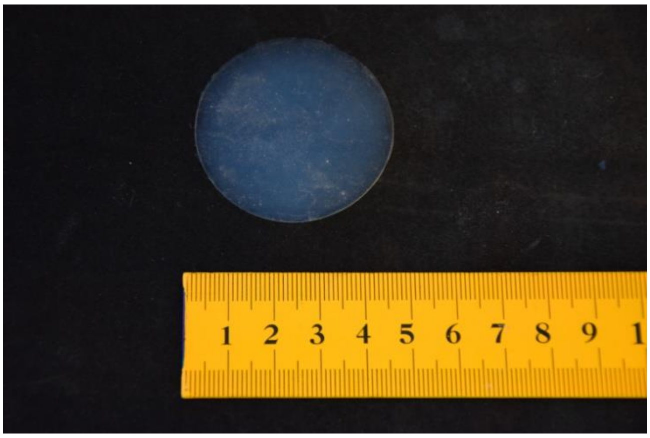

Fig 1. Y_2O_3 doped silica aerogel

The Y_2O_3 doped aerogels have been character-ized by SEM (Scanning Electron Microscopy), FTIR (Fourier Transform Infra-Red Spectros-copy), Optical transmittance, TG/DTA (Ther-mogra-vimetry/Differential Thermal Analysis, Thermal conductivity and BET (Brunauer-Em-mett-Teller) analysis. The experimental results on the physical and thermal properties of Y2O3 doped silica aerogels under normal and high temperature have been discussed by tak-ing into account the chemistry and porosity of aerogels.

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Acknowledgments

One of the author A. Pisal acknowledges the DLR-DAAD Research Fellowship Program 2018-2019, German Aerospace Center (DLR), Köln, Germany and Rayat Shikshan Sanstha, Satara, India."

13. Gudrun Reichenauer - Novel high performance thermal insulation panels for temperatures up to 2200 °C based on carbon xerogel composites

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Abstract

High temperature processes carried out under non-oxidizing atmosphere in industrial applica-tions well above 1000 °C, such as production of graphite, carbide or crystalline Si, are very energy demanding. To significantly reduce the energy consumption in these processes, themal insulations with largely improved performance are required.

State of the art carbon based thermal insulations are based on graphitized carbon fibers boards. These materials all show a strong increase in the thermal conductivity above 1000 °C that is characteristic for radiative heat transfer (dashed line in **Fehler! Verweisquelle konnte nicht gefunden werden.**).

To suppress this heat transfer path we applied sol-gel based carbons with pores well below 1µm. Mechanical reinforcement for processing and handling was provided by fibers embedded in the xerogel. The synthesis was designed such that the manufacturing process can be up scaled to provide insulation panels with a thickness of up to 4 cm via convectional drying of the gel. The resulting panels are machinable and allow lamination e.g. with a graphite foil where needed.

Fehler! Verweisquelle konnte nicht gefunden werden. compares the thermal conductivity of one of the newly developed composites as a function of the temperature compared to a state of the art commercial insulation panel (MFA by SGL Carbon). The novel insulation was also evaluated in a demonstrator furnace up to temperatures of 2200 °C. The investigations were accompanied by simulations to mimic various different application scenarios (tempera-ture ramps, dwell times) showing that up to 30 % energy can be preserved in typical applica-tions when using the new insulation component.

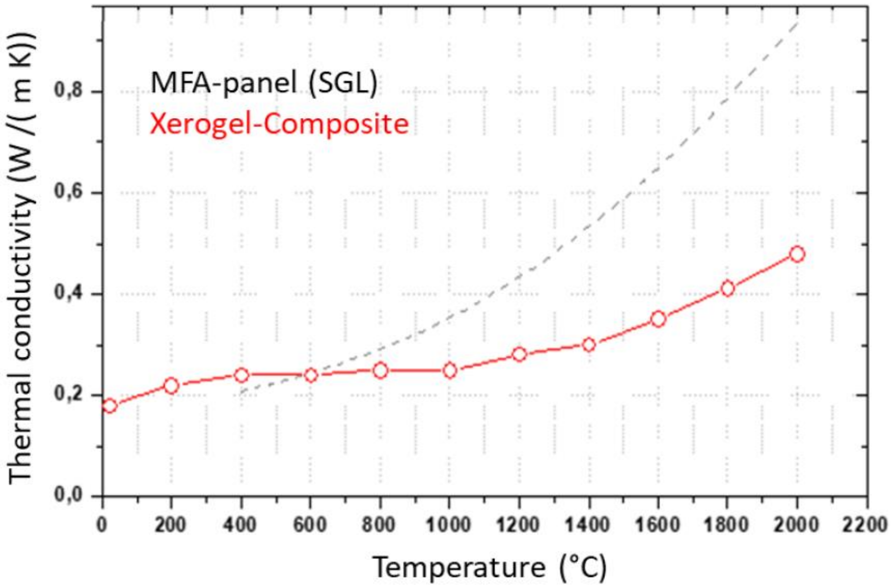

Fig 1. Thermal conductivity of one of the composites developed as a function of the temperature com-pared to a state of the art commercial insulation panel (MFA by SGL Carbon)

Acknowledgments

The project partners would like to thank the German Federal Ministry for Economic Affairs and Energy (BMWi) for the funding of the project "Optimization, Upscaling and Evaluation of Nanoporous Carbon Composites as Thermal Insulation in Process Furnaces for Application Temperatures above 1500 °C (AeroFurnace)" (funding code: 03ET1503A-C) based on a decision of the German Bundestag as well as the Project Management Jülich (PtJ) for the administrative support.

Gefördert durch:

Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

The responsibility for the content of this publication lies with the authors

14. Selay Sert - Facile Synthesis and Characterization of Multi-Purpose Organically-Functionalized Silica Aerogels

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Abstract

Silica aerogels are one of the most interesting sol-gel derived porous materials with many extraordinary properties such as very low density, high porosity, high specific surface area and low thermal conductivity. Although they are traditionally synthesized by supercritical drying, ambient pressure dried aerogels have also become popular in terms of cost and safety in recent years. Following an appropriate strategy, it is entirely possible to synthesize APD-dried aerogels with a morphology indistinguishable from that of supercritical dried analogs [1].

In the current study, silica aerogels were prepared under ambient conditions by following both in-situ and ex-situ hydrophobization approach. For this purpose, an organically modified silanes 3-methacrylopropyltriethoxysilane (MEMO) was served as a silylating agent in ex-situ hydrophobized aerogels and as a co-precursor along with tetraethylorthosilicate (TEOS) in in-situ hydrophobized aerogels. During the preparation of ex-situ hydrophobized aerogels (Ex-A), multiple solvent exchange and surface modification steps were carried out after gelation. For the samples obtained with in-situ hydrophobization (In-A) no post-gelation treatmeants were applied to the gels before drying. Therefore, comparing to ex-situ hydrophobization, the synthesis time needed to prepare the aerogels via co-gelation approach was much lower (only within 36 h). On the other hand, both samples have resulted in have low density (<0.13 g/cm^3) and high porosity (>94 %) after drying. They also possess high hydrophobicity (θ>130°), so that they can be well employed as adsorbents in environmental applications. Their flexible monolithical structures are also very advantageous in terms of handling and reusability (Fig 1). Besides their superhydrophobic nature, they are also good thermal insulators with thermal conductivity value lower than 45 mW/mK and possess high thermal stability up to 500°C.

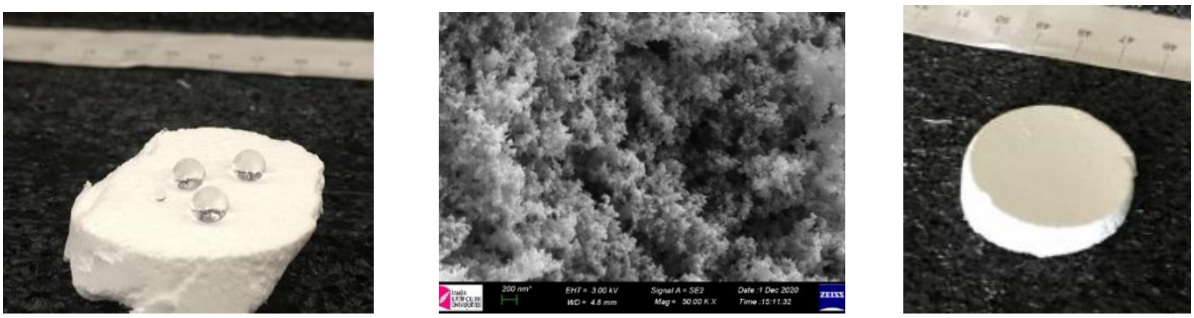

Fig 1. Hydrophobic, highly porous and monolithic organically modified silica aerogels

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15. Deeptanshu Sivaraman - Nano fibrillated cellulose aerogels: How density affects its properties

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Abstract

Aerogels have exceptional properties that open-up various application areas. Their largest field of application is in buildings as a thermal insulation material, owing to its ultra-low thermal conductivity (λ). For well-studied examples such as silica-based aerogels, λ is around 13 $mW.m^{-1}.K^{-1}$ at a density of ~0.110 g/cm^3 [1]. Biopolymers are potentially a more sustainable alternative to silica because of their renewable precursors and reduced costs. Cellulose is viable alternative as it is cheap, abundant and biodegradable. Kobayashi [2] reported using nano-fibrillated cellulose (NFC) aerogels having similar λ at 1/10th of silica (0.017 g/cm^3) whereas; Plappert [3] observed this λ at 0.087 g/cm^3, comparable to that of silica aerogel. Thus, the optimum density for cellulose aerogels remains controversial. We produce hydrogen-bonded hydrogels using a novel and scalable procedure, by gas-phase acid gelation of TEMPO-oxidized NFC suspensions in water, then solvent exchanged with ethanol and dried with supercritical CO_2. The aerogels are transparent with BET surface areas of ~450 m^2/g and mesopore volumes of ~2 cm^3/g. Their λ decreases monotonically with increasing density, from 37 to 28 $mW.m^{-1}.K^{-1}$ for densities from 0.005 g/cm^3 to 0.027 g/cm^3. This decrease was attributed to concentration of the NFC suspension, which indicates that the gas phase conduction is reduced as density increases, up to the limitation of suspension viscosity. This phenomenon was compared with densification by mechanical compression of produced aerogels. A more pronounced de-crease was seen; leading to a minimum at 18 $mW.m^{-1}.K^{-1}$ at a density of 0.065 $g.cm^{-3}$ and a traditional U-shaped curve seen for thermal insulation materials. This is inconsistent with Kobayashi et al., but more in line with the data from Plappert et al., albeit with lower λ values for a given density. Our present research focuses on hydrophobization of these aerogels to enable real-world applications.

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16. Elmira Soghrati, - Aerogel Composites, en route to becoming the new norm in industrial insulation applications

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Abstract

Aerogels provide many desirable properties required by the mass market, such as the cold chain packaging industry and construction industry. The cold chain packaging industry requires an affordable, yet safe and strong insulation material to reduce the high cost-to-payload ratio contributed by high refrigeration and transport energy costs. However, current solutions exhibit either poor thermal insulation or are highly expensive and non-durable, examples being Expanded Polystyrene and Vacuum Insulated Panels respectively. Aerogel composites, being both highly insulating and reusable, is an attractive solution for the needs required by the cold chain industry.

In the construction industry, 10% of the world's energy consumption is used for the heating and cooling of buildings. Rising energy costs, regulations, environmental concerns, coupled with rapid urbanization is driving demand for strong insulation within buildings. Yet, the construction industry suffers from a similar lack of suitable materials for insulation purposes. Relatively cheap insulation materials such as expanded polystyrene is combustible, and recent high-profile fires have discouraged the use of such combustible materials. Non-combustible materials such as mineral wool and fiberglass suffer from high thermal conductivity, and provide poor insulation. Inorganic Aerogel composites, being both highly insulating and non-combustible, is an attractive solution for the needs required by the construction industry.

It is well known that aerogel products suffer from several common drawbacks which prevent it from fulfilling the demands of the above industries, such as brittleness and cost. The development team at Krosslinker formulated a blend of silica-based aerogel composites (Fig 1) using a proprietary manufacturing process, with a turnaround time 3 times faster than conventional aerogel drying methods.

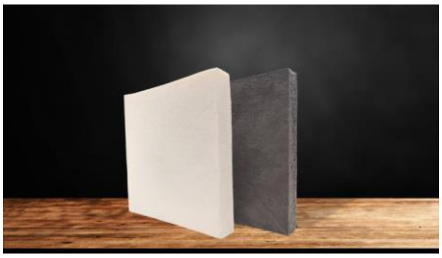

Fig 1. Krosslinker's aerogel composites products

The aerogel composites possess similar mechanical strength as foam-based materials, with ultra-low thermal conductivity (TC ~ 0.018 W/mK), and can be adapted for non-combustibility for required applications. The insulation properties come from the structure of the material created during the manufacturing process which does not degrade over time and the TC is maintained throughout the operational life of the final product. These materials are currently in pilot trails for use in cold-chain bio-pharmaceutical packaging and with education and awareness, the team is confident that the aerogel composites will be the choice insulation material in several industrial applications in the near future.

17. Miura Takaaki – Architectural Scope of Aerogel

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Abstract

Aerogel is concrete. The silica based PMSQ aerogel can be casted, laminated, and dried under ambient condition. In almost all of the conventional application to architectural openings are glazing into square frame. There remains much wider usage from the perspective considering them as a castable material. We propose three of those applications, based on the construction method of reinforced-concrete structure: On-site, Pre-cast, and digital fabrication (Fig 1).

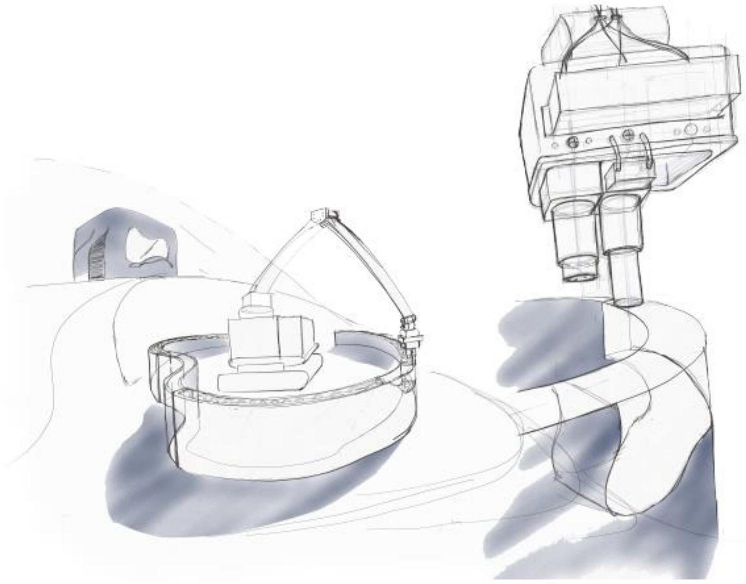

Fig.1 Digital fabrication of aerogel makes it possible to print windows

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Acknowledgments

This work could not have been completed without the advice of Dr. Takafumi Noguchi, Professor of Building Material Engineering, the University of Tokyo, on the board, and Dr. Kazuyoshi Kanamori, Assistant Professor of Organic-Inorganic Hybrid Materials, Kyoto University on how to dry and obtain decent PMSQ xerogel pieces.

18. M.E. Uslu - Aerogel Production by Using Cellulose Nanocrystal Hydrolyzed Extracted from Grape Pomace

E.R. Taymaz[1], M.E. Uslu[1*]

1 Department of Bioengineering, Faculty of Engineering, Manisa Celal Bayar University, Muradiye-Manisa, Turkey.

Abstract

For nearly 70 years, biocompatible materials made from polymers have revolutionized. New high-performance biocompatible and biodegradable polymers derived from fossil-based sources are produced to meet the functional performance demands of new applications. The key point for sustainable agriculture is the rational use of residues and by-products from agricultural processes. Viticulture produces nine million tons of pomace each year, about 20% (w/w) of the total grapes used for wine production. Thus, the development of new strategies for the use of grape pomace can minimize its environmental impact and at the same time add value to these wastes.

Cellulose is one of the most abundant organic polymers in grape pulp with highly reactive surface functional groups as well as attractive properties such as biodegradable, chemical resistance and thermal stability. Grape pomace mainly represents a source for producing cellulose nanocrystalline (CNC) materials. CNC is composed of polysaccharides from the plant cell wall, such as cellulose. CNCs are highly crystalline cellulosic nano-dimensional structures that offer properties such as low density and surface reactivity, high aspect ratio and surface area, high biocompatibility and biodegradable.

Cellulose aerogel (CA) to be produced from CNC has environmentally friendly, thermally stable and flame retardant properties. Figure 1 shows the method of obtaining cellulose raw materials from grape pomace, and then this cellulose is converted to CNC form by hydrolysis method. This high performance polymeric material is then converted into CA structure by freeze drying.

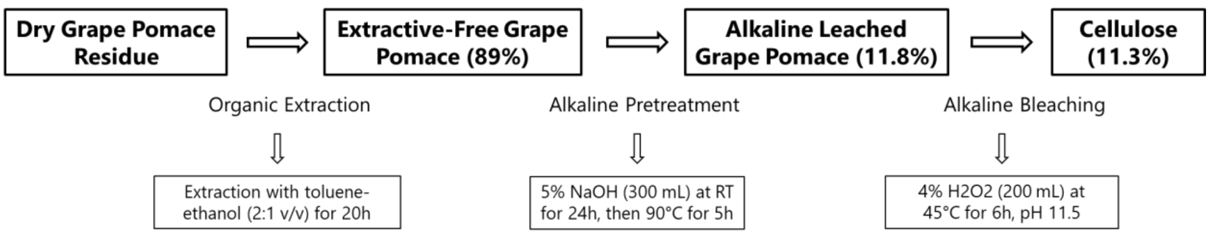

Fig 2. Scheme for cellulose isolation from grape pomace. All yield values were based on original grape pomace in %.

Consequently, the aim is to produce a high-performance polymer using recycling energy and to characterize the aerogel that will be produced with this polymer. However, the polymer produced needs to undergo a series of processes to transform into nanocrystalline form. The aim of this is to separate cellulose, which is the main material, from its unwanted by-products and to obtain purer. CNC can be used to produce materials such as aerogels. Currently, aerogels are the subject of research in several areas, such as medical, environmental and food packaging researches. The CA is commonly fabricated by sol-gel and drying process, in which each fabrication process may affect the porous properties. As a result of all these processes, the biopolymer aerogel will add innovations to the literature, as well as its detailed characterization will facilitate future studies.

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19. João P. Vareda - Cleaning of heavy metals-laden water by ORMOSIL aerogels ad-sor-bents

João P. Vareda[1]*, Artur J. M. Valente[2], Luisa Durães[1]

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2University of Coimbra, CQC, Department of Chemistry, Rua Larga, 3004-535 Coimbra, Portu-gal

Abstract

Contamination by heavy metals, the main pollutants in European soils and groundwater, is an issue of anthropogenic origin [1]. An accelerated release leads to the accumulation in the environment of these toxic substances. Copper, lead, cadmium and nickel are studied due to their high toxicity, human-made emissions, accumulation in the environment, and relevance in the majority of business sectors of contemporaneous societies [2-4].

The use of aerogels in environmental applications has been proposed due to their high specific surface area, low pore size, and ability to introduce specific functional groups via sol-gel chemistry. We report the development of tailored silica-based aerogels, for the decontamination of heavy metal polluted environments via adsorption. The adsorbents remove and immobilize the cationic heavy metals found in aqueous environments. Different matrices were synthesized, each featuring different surface chemical groups, either non-selective or selective. The importance of the functional group on the usability of silica-based aerogels as heavy metal adsorbents was studied. The adsorbents' properties were assessed, namely the structural effects of the modification of the silica. The adsorption process was studied in-depth through equilibrium, kinetic and thermodynamic tests using single-cation and binary solutions, showing promising results for the use of these ORMOSIL aerogels at larger scale [5, 6].

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20. Tingting Wu - Title: Attapulgite-reinforced polyimide composite aerogels with excellent thermal insulation properties and dimensional stabilities

T. Wu[1], Q. Zhang[2]

1 Building Energy Materials and Components Laboratory, Empa, CH-8600, Dübendorf, Switzerland;
2 State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials Science and Engineering, Donghua University, Shanghai 201620, PR China

Abstract

Strong low-density polyimide aerogels have received intensive attention as thermal insulators, filters, etc. However, dimensional instability has limited the applications of polyimide aerogels in high temperatures. Therefore, natural rod-like minerals, namely attapulgite (AT) nanorods, were introduced into polyimide aerogels to obtain reinforced polyimide/AT composite aerogels with improved dimensional stability, through the hydrogen-bonding interaction. In the composite aerogels, AT nanorods act as the rigid skeleton supporting the nanofiber-networks of polyimide aerogels, thus the resultant composite aerogels exhibit improved mechanical properties with the increased AT loadings (0-10 wt%). The Young's and specific Young's modulus increase by 100% and 105%, respectively, for the BPDA (biphenyltetracarboxylic dianhydride)-ODA (4, 4′-oxydianiline) aerogels containing 10 wt% AT compared to the pristine polyimide aerogels. Furthermore, the AT nanorods show strong supporting effects in maintaining the structural integrity of aerogels, which present a significant effect on reducing the shrinkage of composite aerogels at high temperatures (up to 200 °C) and retaining their excellent thermal insulation performance, especially for BPDA-ODA aerogels. Overall, AT is an effective and low-cost additive for preparing polyimide composite aerogels with improved mechanical properties and thermal dimensional stabilities.

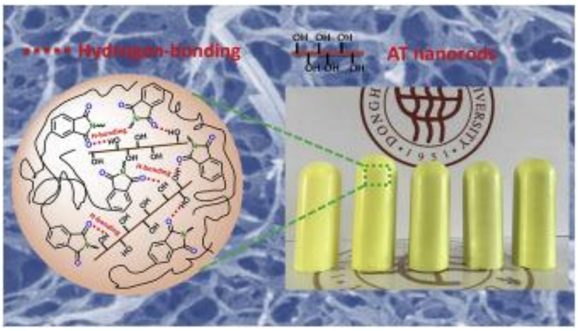

Figure 1. Schematic diagram of the interaction between AT and polyimide aerogels and the physical appearance of polyimide composite aerogels.[1]

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Acknowledgments

J.P. Vareda acknowledges the PhD grant SFRH/BD/131280/2017 by Fundação para a Ciência e Tecnologia (FCT, Portugal) funded by national funds from MCTES (Ministério da Ciência, Tecnologia e Ensino Superior) and, when appropriate, co-funded by the European Commis-sion through the European Social Fund. Consumables for the syntheses and characterizations performed at CIEPQPF and CQC research units were funded by national funds through the FCT and when appropriate co-funded by FEDER under the PT2020 Partnership Agreement under the projects POCI-01-0145-FEDER-006910 and POCI-01-0145-FEDER-007630 (FCT Refs. UIDB/EQU/00102/2020 and UIDB/QUI/00313/2020, respectively).

15^{00} - 15^{40} Processes and aerogel quality II/II

15^{00} - 15^{20} Gudrun Reichenauer, ZAE Bayern, Germany - Approaches to reliable measurement of thermal conductivities of aerogels

H.-P. Ebert[1] , F.Hemberger[1], J.Manara[1], G. Reichenauer[1]

1 ZAE Bayern, Magdalene-Schoch-Strasse 3, 97074 Würzburg, Germany

Abstract

Aerogels are the solids reaching the lowest thermal conductivities [1], both at ambient as well as at elevated temperatures. This is due to the fact that – at given porosity - their nanoporosity allows suppressing the heat transport along the gas phase at ambient conditions and above; in addition, if not consisting of an IR-transparent solid phase, the finely dispersed solid phase in aerogels effectively inhibits at temperatures above 1000 °C the contributions due to radiative heat transfer.

Thus, aerogels can be designed to show lowest thermal conductivities at defined application conditions by tuning the three major contributions, i.e. the heat transport along the solid phase (including coupling effects [2]), via the gas phase and radiative heat transport, respectively. Suitable instrumentation (as available at ZAE Bayern) and simulation tools that allows separating the contributions are hereby extremely valuable [3].

Finally, on their way to a product, reliable characterization of the aerogels supported by national and international standards are mandatory for market access.

Upon both, optimization and product development a reliable characterization is key. Unfortunately, there are still significant inaccuracies caused by inappropriate instrumentation, not well defined sample preparation and insufficiently controlled boundary conditions during the measurements.

In our presentation, we are giving approaches for thermal optimization of aerogels. In addition, we are presenting and discussing the measurement of the thermal conductivities of PU-aerogels [4] as a concrete example showing critical points in analysis that have to be addressed in future standards.

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15^{20} - 15^{40} Yannick Nagel, Empa, Switzerland - 3D printing of strong and thermally insulating nanocellulose aerogels

Yannick Nagel[1], Deeptanshu Sivaraman[2], Michael K. Hausmann[1], Antonia Neels[3], Tanja Zimmermann[1], Shanyu Zhao[2], , Gilberto Siqueira[1], Gustav Nyström[1]

[1] Cellulose and Wood Materials Laboratory, Swiss Federal Laboratories for Materials Science and Technology, Empa, Dübendorf, Switzerland.

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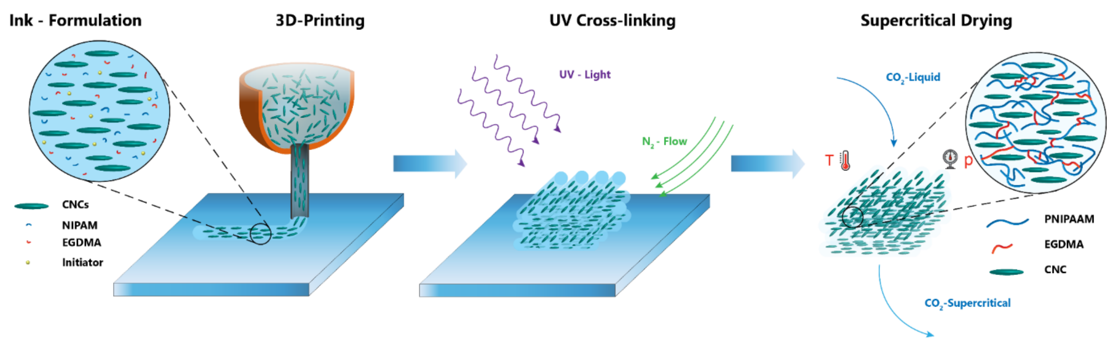
[3] Center for X-ray Analytics, Swiss Federal Laboratories for Materials Science and Technology, Empa, Dübendorf, Switzerland.

Abstract

The increasing costs of energy as well as the negative impact on the environment by energy production plants have created a great need to reduce energy consumption. Therefore, there has been a growing interest for thermal management materials that can fulfill the needs for thermal insulation over different length scales, from applications in the building sector to applications in the electronics industry. Additive Manufacturing (AM) has recently been exploited as a technique to produce multi-scale structures with aligned building blocks[1] that, due to anisotropic reinforcement, show multifunctionality and enhanced mechanical properties. Here, we describe how water-based inks loaded with renewable building blocks such as cellulose nanocrystals (CNC) and N-isopropyl acrylamide (P-NIPAAM) can be used to additively manufacture textured aerogels with exceptional mechanical and insulating properties. Our cellulose-based aerogel composites exhibit anisotropic thermal properties with very low thermal conductivity (down to 0.033 W/mK) perpendicular to the printing direction and a conductivity twice as high 0.061 W/mK along the printing direction. Moreover, our aerogels are mechanically robust, displaying a compression modulus of up to 87 MPa in the printing direction. The excellent mechanical and insulating properties, abundance, biodegradability and 3D-printability make cellulose-based aerogels a promising insulating material for many applications.



Illustrative scheme of the steps involved in the 3D printing of functional cellulose-based aerogels. a) Ink formulation and production b) Direct ink writing of cellulose-based polymer. c) Post-treatment to cure the printed structure into functional parts. d) super-critical drying of cellulosic gels to obtain cellulose-based aerogels

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16^{00} - 17^{00} Start-ups and emerging industries I/II

16^{00} - 16^{20} Francisco Ruiz, KEEY Aerogel, France - Lean Aerogel Manufacturing

F. Ruiz-González

Keey Aerogel S.A.S., Habsheim – FRANCE

Abstract

KEEY Aerogel proposes the creation of new value chains by expanding the size and attractiveness of silica-based tertiary sources by their transformation into highly added-value aerogel material: a nanoporous material with the best thermal insulation performance in ambient conditions. Keey's flagship product SICLA is made to significantly contribute to achieve the reduction of both energy consumption and CO_2 emission thanks to a significantly high share of C&DW recycled secondary raw materials.

With a disruptive continuous manufacturing technology called Lean Aerogel Manufacturing, KEEY Aerogel emphasizes the high interest and benefits of the manufacturing of affordable high-performance aerogels from construction waste or other kind of silica-rich source from industry.

16^{20} - 16^{40} Brice Fiorentino, Enersens, France - The Ultimate Thermal Management Solution To Optimise Battery Safety And Performance of Electric Vehicles

Abstract

Today we are witnessing an exponential increase in the electric vehicle market. A key requirement of the market is a great autonomy of EVs and of course, the assurance of their safety of use. To achieve these goals, all original equipment manufacturers (OEMs) and battery pack manufacturers are focusing on increasing the energy density of cells, increasing the number of cells in the modules, weight reduction, and more efficient thermal management[1]. At the same time, and due to the emergence of this new market, regulations are also evolving and regulatory requirements are becoming increasingly stringent in terms of battery safety imposed on manufacturers[2].

1 https://ec.europa.eu/energy/sites/default/files/documents/batteries_europe_strategic_research_agenda_december_2020__1.pdf
2 https://ec.europa.eu/environment/topics/waste-and-recycling/batteries-and-accumulators_en

Enersens now offers the solution for all these aspects and regulatory constraints: a super-insulating blanket (Figure 1), ultra-thin and light product, creating a real protective barrier to avoid all the safety problems linked to the increase in energy density. Designed to be placed between cells, the Skogar® UF is the key to prevent thermal runaway from cell to cell thanks to extreme insulation properties and high fire stability.

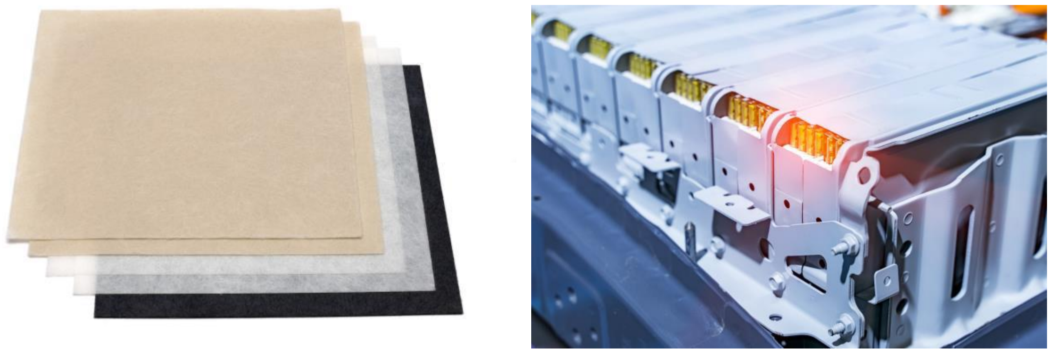

Fig 1. The super-insulating blankets Skogar® UF and their EV battery applications.

In addition and always in the search for maximum EV autonomy, the Skogar® UF is the solution to be used around modules and in battery packs to protect them from external conditions, i.e. from very low to very high temperatures. In this way, the Skogar® UF offers the battery the possibility of operating in the optimal and required conditions and thus significantly enables the autonomy of the EV by not over-consuming or overheating.

In this presentation, Enersens will first describe the process for obtaining this new super-insulating sheet, and then will focus on the key performance characteristics of this product. As well as, we will then describe all the added value of the Skogar® UF for the EV batteries.

References

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16^40 - 17^00 Raman Subrahmanyam, Aerogelex, Germany - Aerogelex

Raman Subrahmanyam, Pavel. Gurikov
Aerogelex UG, Barlachstr. 2, Hamburg, Germany

Abstract

Aerogelex UG is an ETPN (European Technology Platform on Nanomedicine) award winning startup founded in 2018 by Dr. Raman Subrahmanyam and Prof. Pavel Gurikov. With combined experience of more than two decades, Aerogelex focuses on enabling aerogel technology translation in both industry and academia. Aerogelex solves the most complex aerogel related problems related to material and process development assisting aerogel enthusiasts in their own vision of an aerogel.

Aerogelex presents its scope and project examples (Fig.1) in this forum.

Fig 1. World's lightest dessert: The aerogel meringue

Showcased in ITHRA museum by Bompas & Parr, Dhahran, Saudi Arabia

Thursday, July 15, 2021

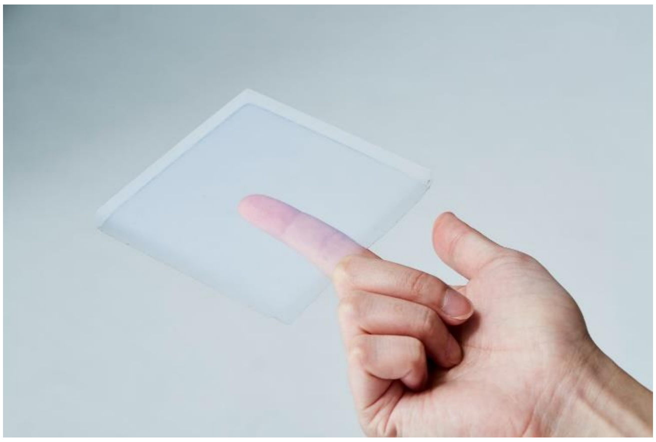
09^{00} - 10^{20} Start-ups and emerging industries II/II

09^{00} - 09^{20} Masa Yamaji, TIEM Factory, Japan - A Glimpse of the Future: Peeking through the Lens of "SUFA"

Masahiro Yamaji, tiem factory Inc., Japan

Abstract

Since the adoption of the Sustainable Development Goals (SDGs) in 2015, countries around the globe have become increasingly concerned about the efficient use of energy and the realization of a Carbon Neutral society. While new ideas and technologies have been introduced to the world, Aerogels: one of the highest performing insulators in existence, is also expected to play an immense role in reaching our goals. As the "D" in SDGs implies, the actions for an eco-friendly society should not become a hindrance for the development of the human race. At tiem factory we expect to contribute to this through what we call the SUFA (=Super Functional Air) monolith with high transparency, water repellency and improved flexibility.



As a material focused Startup based in Japan, tiem factory faces many challenges. One of the most substantial barriers is Japan's delayed enactment of building insulation regulations. In comparison to the European countries, Japan has long been ignorant of insulation efficiency, and have fallen behind in implementing a more sustainable system for buildings. We infer that this may be due to the latitude of the country's capital. Tokyo has a relatively warm and stable climate, which delayed the acknowledgement of the importance of efficient insulation. In order for SUFA to be accepted and be implemented into homes and facilities, our first challenge is to raise awareness for the need for stricter regulation on buildings.

In this talk we aim to give the audience an overview of SUFA's features, performances, history, its practicality advantages and possible implementation ideas. Furthermore, we would like to share an insight of the current Japanese market, the challenges we face, and the changes we seek to bring to the world.

09^{20} - 09^{40} **Sam Cryer, Thermulon, UK - How to start an aerogel company**

Dr. Samuel J. Cryer, Rozalie Ryclova, Alexander Murdock.
Thermulon Ltd., Netpark Thomas Wright Way, Sedgefield, Stockton-On-Tees, County Durham, United Kingdom, TS21 3FD

Abstract
Thermulon Ltd. is a UK based process chemistry start-up whose ultimate goal is the industrial production of super insulating aerogel powders for the built environment. The UK construction industry is currently facing increasing regulatory pressure from both an environmental perspective to meet Net Zero 2050 targets; as well as fire safety regulation after the tragic Grenfell fire tower block incident in 2017 that took 72 lives.
This regulatory change means that developers face a trade-off when using insulation materials between fire-safety, thermal performance and price. The banning of high-performance plastic materials (PIR / phenolics) in any building over 18m means developers are going back to A2 fire rated products like mineral wool. Although mineral wool satisfies the new fire regulation, its poorer thermal performance means developers are losing millions of dollars in lost floorspace due to thicker wall build-ups.
Thermulon is developing a fire-safe, low lambda aerogel insulation powder to be the first to beat this trade-off between thermal performance, fire-safety and price. Originating from the Deep Science Ventures start-up builder in London, Thermulon was started by Dr, Sam Cryer to directly meet this market need for new insulating materials. This talk will look into Thermulon's origins; the challenges of spinning out of an accelerator as opposed to an academic lab; the importance of commercial and fundraising strategy in building early stage tech start-ups; our current route to market via heritage homes plasters; and our growth trajectory and need for new chemists and engineers to join the team.

Acknowledgments
Thermulon Ltd. would like to acknowledge Innovate UK who have part funded their development so far.

09^{40} - 10^{00} Elmira Soghrati, Krosslinker, Singapore – QuintAero™: The Breakthrough Aerogel

E. Soghrati, M. Sachithanadam, M. Fearns
Krosslinker Pte Ltd., Singapore

Abstract
Though the number of development and publications on aerogel has increased significantly in recent years, few have managed to generate a product or production route which is both cost-competitive and yields a low thermal conductivity (≤18 mW/ mK) aerogel. Contrary to popular belief, the use of waterglass offers little in terms of reducing overall aerogel cost; with the primary costing factors being solvent consumption/extent of recycling, surface modifying agents and the opted for sol-gel drying method.

Krosslinker is commercialising a revolutionary new entrant to the aerogel market – an ultra low thermal conductivity, hydrophobic (though wettable), cost-competitive aerogel available as a finely dispersed powder and in granule form (Fig 1).

Fig 1. QuintAero™ aerogel powder and granules

QuintAero™'s exceptionally low thermal conductivity (12-16 mW/mK) is achieved through a novel formulation procedure, manufactured in a single-pot ambient pressure process.

Furthermore, whilst silica aerogel modified with trimethylsilyl groups is the most commonly implemented form of aerogel, there is significant opportunity for aerogel to undergo alternative surface modification to add functionality and market penetration. Traditional hydrophobic silica aerogels can be redesigned to possess monomeric character; then 'polymerised' to create an aerogel coating, laminate, composite or even concrete – imagine an aerogel with the versatility of a polymer.

Krosslinker is taking its first step to join the ranks of the major aerogel competitors, but our aim is to set a transcendental precedent which sets the new gold standard for aerogel solutions.

10^{00} - 10^{20} Ioannis Michaloudis - *U(rano)topia*: Spectral Skies and Rainbow Holograms for Silica Aerogel Artworks

I.Michaloudis[1], K. Kanamori[2], I. Pappa[3], N. Kehagias[1]

1 Institute of Nanoscience and Nanotechnology, NCSR Demokritos, Athens, Greece

2 Department of Chemistry, Graduate School of Science, Kyoto University, Japan

3 School of Engineering, Product Engineering Dpt., University of Aegean, Greece

Abstract

Development in high end products requests new technologies, novel functional materials and innovative manufacturing processes suitable for industrial production. Micro/nano structuring in distinct chemical compositions has demonstrated added values which could be utilized in various modern applications and products. Silica aerogel is a prominent example of such a nanostructure, with which we recently utilized to accommodate the unique design of high jewelry. Using its natural shades and transparent layers, silica aerogel can be described by the first author, a visual artist, as an extremely beautiful and ethereal material that closely resembles a piece of sky. Ultimately silica aerogel can be exploited as a sky-like material, and has been used in numerous collaborations amongst artists and scientists to bring to life concepts, like rainbow holograms on silica aerogel dried by high-temperature supercritical drying with methanol. In this presentation, we show how such collaborations the authors have been proceeding are evoking developments in science and technology as well as in jewellery design, fashion and art industries. Here we'll discuss the first author's recent collaboration with Maison Boucheron Paris for the creation of the *Skydrop,* (Fig 1)

Fig 1. "Skydrop", made of silica aerogel, quartz, diamonds and white gold, photo: courtesy Boucheron Paris

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10^{40} - 12^{05} Applications and markets I/III

10^{40} - 11^{05} Carlos García-González, U. Santiago, Spain - Biomedical Applications of Aerogels

Carlos A García-González

Department of Pharmacology, Pharmacy and Pharmaceutical Technology, I+D Farma group (GI4 1645), Faculty of Pharmacy, and Health Research Institute of Santiago de Compostela (IDIS), Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain

Email: carlos.garcia@usc.es

Abstract

Aerogels are nanostructured materials with attractive properties for biomedical applications, including drug delivery, wound treatments and regenerative medicine [1]. Aerogels are especially advantageous as carriers of bioactive compounds to increase the solubility and modify the release profiles of certain drugs, and physical properties of aerogels are particularly favorable for oral and mucosal administration routes [2]. Moreover, the aerogel production using supercritical CO_2 has a straightforward scaling-up and favours the manufacturing of drug products under good manufacturing practices. For wound treatments, the high and open porosity of aerogels and the excellent capacity to absorb exudate fluid assists in establishing haemostasis and promoting healing and regeneration at the wound. The customized and local release of bioactive compounds at the application site from aerogel carriers is of interest for the treatment of the different skin wound healing phases. Finally, the extracellular matrix-mimicking nanostructure of aerogels along with the biological implications of certain aerogel sources (e.g., polysaccharide and protein) to promote the attachment and growth of cells are especially attractive as scaffolds for regenerative medicine. In this work, the most recent developments on the state-of-the art of aerogels for biomedical applications are herein outlined.

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Acknowledgments

Work carried out in the framework of the COST Action CA18125 "Advanced Engineering and Research of aeroGels for Environment and Life Sciences" (AERoGELS) and funded by the European Commission. This research was funded by Xunta de Galicia [ED431C 2020/17], MCIUN [RTI2018-094131-A-I00], Agencia Estatal de Investigación [AEI] and FEDER funds

11^{05} - 11^{25} Charlotte Heinrich, DLR, Germany - How aerogel additives can significantly improve the casting process in foundry applications

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1 Deutsches Zentrum für Luft- und Raumfahrt (DLR), Köln (Germany)

2 Bosch Rexroth AG, Lohr am Main (Germany)

Abstract

Cavities in castings of metals and alloys are obtained by so-called cores, which are made of polymeric-bonded sands. Special additives are used to overcome negative effects that cause a lot of casting defects. Organic resorcinol-formaldehyde (RF) or inorganic carbon aerogel in granular form can replace conventional additives without any effort in the foundry process and offer a variety of advantages due to their nanostructure and composition.

We established a synthesis of these aerogel additives for iron casting, transferring the production from laboratory to pilot plant scale, elevating the level of development with respect to foundry needs. Our approach yields about 15 kilogram of RF aerogel in one batch. Further processing includes coarse milling, screening and carbonization of the organic aerogel to amorphous, nanostructured, highly porous carbon with special features. Practical applicability of the additives has been tested and examined in a demanding case of iron casting.

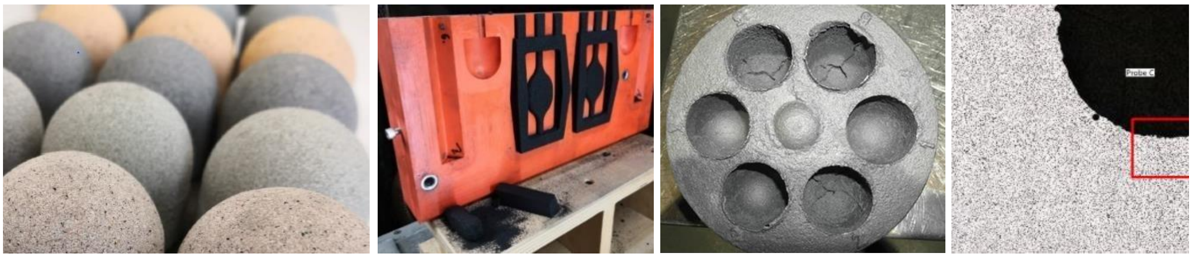

Fig 1. Impressions from the core molding and iron casting. (picture credits: Bosch Rexroth AG)

We were able to identify some very positive effects of the aerogel additive to the casting process compared to the regular used additive: higher core strength, delayed evolution of gas due to decomposition of the binder, significant reduction of gas emissions (BTXE, phenol, formaldehyde), smooth surface (Fig. 1). Additionally, the results show, that a considerable improvement of energy efficiency at different stages of the foundry process can be achieved by the application of aerogel additives.

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This work was done in the context of the project 03ET1527 supported by the German Federal Ministry for Economic Affairs and Energy (BMWi).

11^{25} - 11^{45} Lizeth Tinoco Navarro, Brno U.o.T, Czech Republic - Effects of Organic acid donors on the phase transition and the photocatalytic efficiency of TiO2 Xerogels

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Abstract

The present research of TiO_2 xerogels as photocatalyst had significant progress based on modifying their crystal structure and SSA, porosity, and particle size by using different donor agents. The synthesis was studied using titanium tetraisopropoxide (TTIP) in the presence of low molecular acids Monochloro acetic acid MCAA, Lactic Acid LA, Glycine GLY and, Glycolic acid GA in atmospheric conditions (25°C) and evaluated the dependence of the molar ratio (OAc) /Titania (Ti) (1/3- 1/30) on the structure of TiO_2 products and their photocatalytic activity. The xerogels were treated on ambient pressure drying, and four samples were selected for the application of an additional aerogel drying method as CPD-Critical point drying to compare the aerogel properties and to observe the effect of drying. SEM, XRD, XPS, and FTIR characterized the samples.

The obtained characterized products presented a biphasic composition with anatase, between 70-96 % w, and brookite 3-30% w for all the acids. The crystallite sizes are between 12-20 and 2-12 nm, respectively. The study reveals that higher concentrations of OAc lead to an increase in the brookite and amorphous phase, and lower concentrations formed the crystalline phases anatase and brookite. The use of Lactic Acid generates the highest composition of Brookite in comparison with the other acid (1/30, 80 w% A, 18 w% B; 1/3- 70 w% A and 30 w% B-Table 1) with d-spacing A(001), B(210) and (111) respectively. The phase rutile appears in a very low percentage by using low ratios of OAc: Ti.

BET Specific surface areas were in ranges of 200-600 m^2/g and 50-400 m^2/g for the OAc: Ti ratio 1/30 and 1/3 respectively. The heterophase TiO_2 xerogels presented nanoporosity; property observed in the samples offering the pore size diameter from 1.5 nm to 4 nm for all the OAc: Ti ratios. The sample with the best BJH-pore diameter distribution was GA: Ti 1/30, with a pore volume of 0.9 cm^3/g, the fact could influence to be the best xerogel in photodegrading of AO7 pollutant with a rate of activity of 0.00204 min^{-1} with about 60% of efficiency in 300 min. The combination of adequate specific surface area SSA of 200 m^2/g, pore size less than 2 nm, and BET constant of 150 were responsible to generate better photocatalytic performance, in addition to presenting one of the highest atomic concentration of bonded O 1s in the lowest acid titania ratio of 1/30.). In contrast, bounded atomic carbon increase as it is incorporated the organic donor source. High surface areas were obtained for the aerogels synthesized with LA: Ti ratio 1/10 and 1/5, of 622 and 1550 m^2/g. respectively, and low pore size less than 2nm.

11^{45} - 12^{05} Isaac Benito-González, IATA-CSIC, Spain - PLA coating improves the performance of renewable adsorbent pads based on cellulosic aerogels from aquatic waste biomass

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Abstract

Lightweight, hydrophobic, adsorbent aerogels from different cellulosic and nanocellulosic frac-tions from Posidonia oceanica waste biomass were developed by a simple freeze-drying and PLA dipping method. The pure (nano)cellulosic aerogels presented highly porous structures, capable of adsorbing large amounts of oil (up to ~34 g oil/g aerogel) but lost their integrity when soaked in water. The incorporation of PLA hydrophobized the aerogels and improved significantly their mechanical performance (up to 10-fold increase in the compression stress) (Fig. 1). The most porous aerogels, obtained with the less purified fractions, incorporated greater amounts of PLA, which was mostly distributed filling in the pores. All the PLA-coated (nano)cellulosic aerogels presented a hydrophobic behavior, with contact angles of 95-130º and selectively adsorbing greater amounts of oil (5.9-9.2 g oil/g aerogel) than water (2.8-6.7 g H2O/g aerogel). These materials present a great potential for oil spill cleaning and food pack-aging applications.

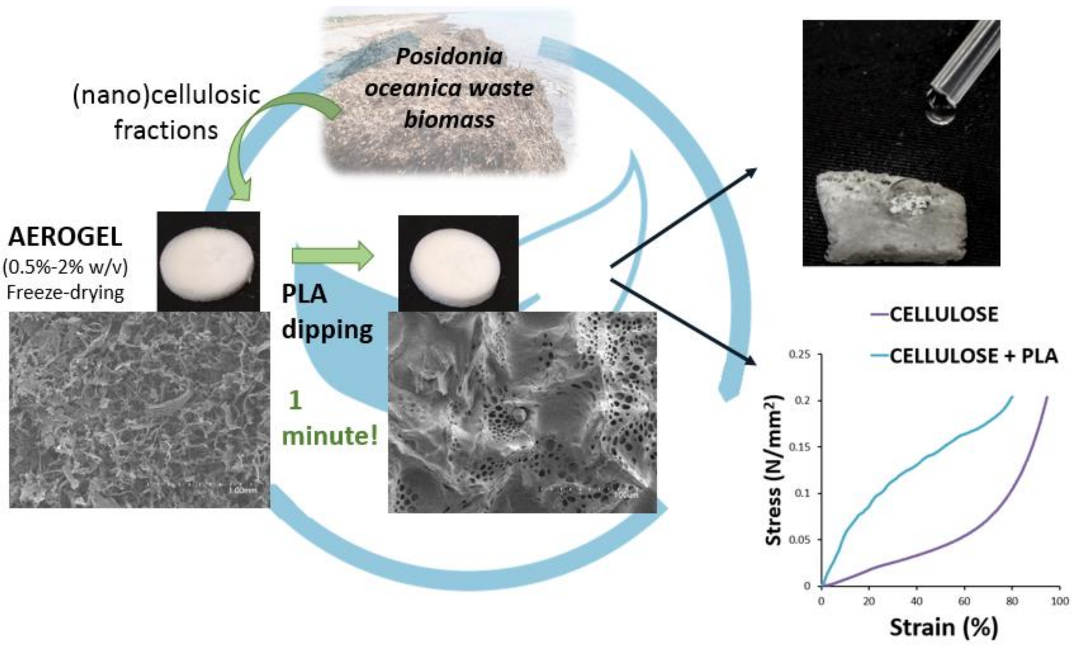

Figure 1. Schematic representation of the dipping process with some of their most relevant outcomes.

Acknowledgments

This work was financially supported by the project RTI2018-094408-J-I00 from the Spanish Mi-nistry of Science, Innovation and Universities, the "Agencia Estatal de Investigación" and co-funded by the European Union's Horizon 2020 research and innovation programme (ERA-Net SUSFOOD2). Isaac Benito-Gonzalez was recipient of an Erasmus Plus grant (European pro-gramme) from the Polytechnic University of Valencia (UPV) in order to carry out part of the experimental work at Teagasc (Fermoy, Ireland).

13^{30} - 14^{10} Applications and markets II/III

13^{30} - 13^{50} Rémy Poupot, INSERM, France - Rehabilitating the immune system with multivalent macromolecules to resolve inflammation

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2 Laboratoire de Chimie de Coordination, 205 route de Narbonne, BP44099, 31077 Toulouse Cedex4, FRANCE

3 Toulouse Institute for Infectious and Inflammatory Diseases (INFINITy), CHU Purpan, BP3028, 31024 Toulouse Cedex3, FRANCE

Abstract

IMD-Pharma is a French spin-off company from the National Centre for Scientific Research (CNRS), the National Institute for Health and Medical Research (Inserm), and the University of Toulouse. It was launched in July 2016.

It is specialized in the development of innovative compounds dedicated to the treatment of Chronic Inflammatory Diseases (CIDs). The R&D pipeline priority aims at Rheumatoid Arthritis [1], and at Psoriasis [2] as a pivotal indication. Other indications of interest include neuro-inflammation (eg, Multiple Sclerosis [3]).

We design and synthesize the most well-defined and adaptable multivalent macromolecules [4] able to provide multivalent interactions with pools of cellular receptors according to a paradigm-breaking mode of action. This disruptive mode of action improves both the overall outcomes and the benefit/risk ratio in comparison with available therapy, such as monoclonal antibody that target one single molecular actor of the inflammatory network. Our second generation drug candidates are ready to enter the regulatory preclinical phase.

With its immuno-regulatory, and anti-inflammatory effects on monocytes/macrophages, and CD4+ T cells, IMD-Pharma's innovation represents a promising breakthrough for the treatment of CIDs where no therapeutic option exists that is capable of specifically modulating inflammatory monocyte-derived effector cells [5].

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13:50 - 14:10 Tony Eisenhut, Novasterilis, USA - Supercritical Carbon Dioxide: A Terminal Sterilization Solution for Hydrolytically and Thermally Sensitive Materials

Tony Eisenhut, CEO and Co-founder, NovaSterilis Inc, Lansing, NY U.S.A.

Abstract

Supercritical carbon dioxide ($scCO_2$) processes have been used for decades in multiple industries across a wide range of applications, including caffeine extraction, chromatography and critical point drying. In the late 90's, seeking to find an effective sterilization method for hydrolytically and thermally sensitive drug delivery devices, Dr. Robert Langer's team demonstrated inactivation of vegetative cells using $scCO_2$[i]. NovaSterilis was founded to build upon this work and address the emerging market need for sterilization of sensitive materials.

Using CO_2, process-specific additives, and instrumentation, NovaSterilis has successfully developed a $scCO_2$ technology solution capable of inactivating a wide variety of microbiological contaminants (fungi, viruses, and bacteria) on medical devices and/or materials across several physical states including lyophilized, hydrated, submerged or liquid. The ability to achieve terminal sterilization at Sterility Assurance Level (SAL) 10^{-6} has been publicly demonstrated by regulatory clearances in the U.S.A. and Australia, as well as registrations in Europe.

NovaSterilis' $scCO_2$ sterilization mechanism of kill was researched by Setlow *et. al.* in 2016[ii] who showed that highly resistant bacterial endospores (e.g., *B. atrophaeus*) are susceptible to $scCO_2$ sterilization. When exposed to relatively low pressure and temperature, CO_2 transitions to a supercritical state, which allows for deep and uniform penetration. This diffusivity coupled with liquid-like density makes $scCO_2$ the most penetrating sterilization modality when compared to other solutions.

NovaSterilis' $scCO_2$ platform achieves SAL 10^{-6} at 35C, with complete penetration in a non-destructive manner in as little as one hour, which is unachievable with current sterilization methods. As the capabilities of scCO2 sterilization are further researched, novel uses are being discovered. In 2020, Dr. Frederic Zenhausern and his team demonstrated using the NovaGenesis platform the ability to both decellularize and sterilize spinach leaves, which were used as templates for the growth of vascular mats[iii].

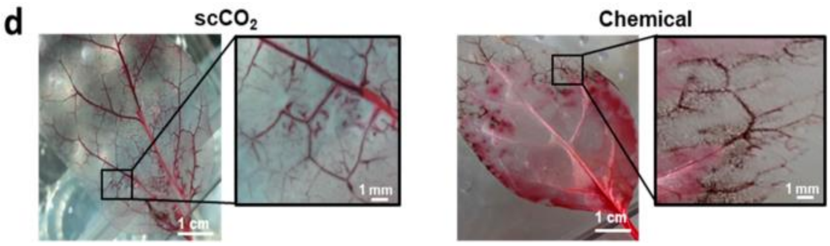

Fig. 1 *Comparison of spinach leaves decellularized and sterilized using scCO2 versus decellularized and decontaminated using chemical washes.*

Their work demonstrated the gentle nature of the $scCO_2$ process through the preservation of the macro and micro substructure of the spinach leave. These results stand in stark contrast to their then current chemical decellularization and aseptic process.

All sterilization methods (including NovaSterilis') have limitations. Novel technologies like NovaSterilis' are needed to meet the demands of emerging medical devices and therapies as well as address the environmental and human safety issues associated with the most widely used modalities. Historically, ethylene oxide (EtO) and gamma radiation have been the most utilized methods, together accounting for over 90% of the industrial sterilization market. However, both methods have their shortcomings. With EtO, residual gas can cause hemolysis and other toxic and chemical reactions including molecular weight changes of biomaterials. Gamma radiation causes damage to polymers, such as changes in shear and tensile strength, elastic modulus, and transparency. If incorporated for drug delivery, both of these methods reduce drug activity due to cross-linking or degradation. When developing novel materials, sterilization compatibility should be considered a critical aspect of research and development.

This talk will focus on the breadth of material compatibility with $scCO_2$ sterilization, as well as its ability to preserve the activity of many biotherapeutics.

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Funding for the research related to protein activity was provided by NIH grants 1R43AI120282-01 and 2R44AI120282-02 from the National Institute of Allergy and Infectious Diseases.

15^{20} - 16^{20} Applications and markets III/III

15^{20} - 15^{40} Ákos Lakatos, U. Debrecen, Hungary - Systematic research results of fibrous aerogel insulation

Á. Lakatos[1]

1 University of Debrecen, Faculty of Engineering, Hungary-4028, Debrecen Ótemető u. 2-4.

Abstract

Decreasing the energy loss both by buildings and by vehicles perhaps one of the most important efforts to protect our environment and energy resources. An option to achieve this is to apply thermal insulations moreover, of super insulation materials (such as aerogel) are becoming increasingly justified. However, these are relatively new materials. The main aim of the presentation is to present research results based on case studies of a spaceloft type aerogel. During the presentation we will present measurement results reached on fibre-reinforced aerogel insulation. We will present experimental results on a thoroughly and systematically examined aerogel. Its thermal conductivity, moisture absorption and thermal insulation ability, will be showed, moreover results applied to masonry with mechanical fixings, too. New material constants, such as moisture uptake and temperature conversion coefficients, have been determined for the aerogel, which are well applicable in practice. In the short paper a model for heat transfer through insulating materials to both the steady state and the effect of moisture will be highlighted. I investigated the thermal conductivity of the masonry and their heat retention. I have given new contexts that can be applied well in practice. I revealed a degradation process in connection with the aging and combustion of the fibrous aeorgel, thus determining the thermal stability of the material, the process of which I followed with several devices, as well as the specific heat of the material. [1-7]

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Acknowledgments

This paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences, grant number: Ákos Lakatos - BO/269/20. Supported by the ÚNKP-20-5-DE-46 New National Excellence Program of the Ministry for Innovation and Technology from the source of the National Research, Development and Innovation Fund.”

15^{40} - 16^{00} Mike O'Connor, Orlanna, France - Introduction to ADVAPOR association

Michael O'Connor
Orlanna Associates, Dundrum, Ireland.

Abstract

Brief introduction to the nanoporous materials association ADVAPOR. ADVAPOR was initiated in 2017 in response to the Global IEA working group on Super Insulation materials to create a single voice representing aerogels. Our goal is to support the many growth challenges facing our fledgling industry.

16^{00} - 16^{20} Sebastian von Stauffenberg, AGI, Switzerland - Innovation projects with aerogel in Switzerland

Sebastian von Stauffenberg
AGITEC AG, Dällikon, Switzerland

Abstract

AGITEC AG is one of the leading European aerogel distributers with headquarters in Zürich (Switzerland). We have more than 12 years aerogel application experience in building and construction, industry, housing and leisure. During this time, AGITEC has repeatedly succeeded in opening up new application areas for aerogel. From the first building facade completely renovated and plastered with aerogel to the subsequent core insulation of double-shell masonry with aerogel granules, AGITEC has repeatedly broken new ground - most recently in the co-development of ultra-slim wood facade elements with aerogel. Thanks to the space saved compared to conventional construction methods, aerogel has also become an interesting alternative in new buildings. S. von Stauffenberg will present the current innovation projects. Furthermore, we will present the latest aerogel product developed by AGITEC, PUREFLEX (Fig. 1).

Fig 1. New Aerogel product of AGITEC: PUREFLEX

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