Task 39 - Polymeric Materials for Solar Thermal Applications

In this newsletter:

Materials

Collectors & systems

Recent meeting

The 11th Experts Meeting took place at the Grand hotel Union conference centre in Ljubljana, Slovenia from May 19-20, 2011. The meeting was hosted by the National Institute of Chemistry in Ljubljana. 32 experts participated in the meeting, among them experts from two new industrial companies from Canada and Israel. Most of the presentations are summarised in the present newsletter.

Left: During the Task 39 experts meeting in May 2011 in Ljubljana;
Right: Excursion to the National Institute of Chemistry, Ljubljana;

Next meetings

Aveiro, Portugal, September 18-21, 2011

Berlin, Germany, May 2012

Recent graduations

Angelika Hagauer: *Aging behavior of novel polyolefin compounds for heat stores.* Master thesis, 2011, University of Leoben in co-operation with the PCCL and the Institute of Polymeric Materials and Testing at the Johannes Kepler University Linz.

All graduations on Task 39 related topics: www.iea-shc.org/task39/gradstudents

Expertise in Handy Size: The Task 39 Handbook

In the past four years, the Task 39 experts have broken new grounds in the research on polymeric materials for solar thermal applications. The Task 39 handbook "Polymeric Materials for Solar Thermal Applications" gathers this knowledge in a comprehensive way and makes it accessible to the world wide public. Informative, compact and to the point, the handbook deals with the requirements, conditions and potentials of polymeric materials in solar thermal applications and it does so in a format that is still to be missed among other publications in the field.

According to the two major fields of research of Task 39, the handbook is specifically designed to appeal to two expert groups. Part one explains the subject "solar thermal energy" for representatives of the plastics industry and research. The second part, in turn, provides information about polymeric materials and processing for solar thermal experts - a know-how which is fused in part three of the publication. The expertise in handy size will be available in 2012.

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New Insulations for Solar Thermal Components

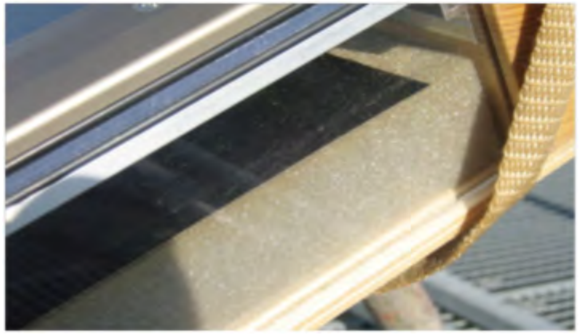

Fig.1: Polyurethane foam tested in a solar collector

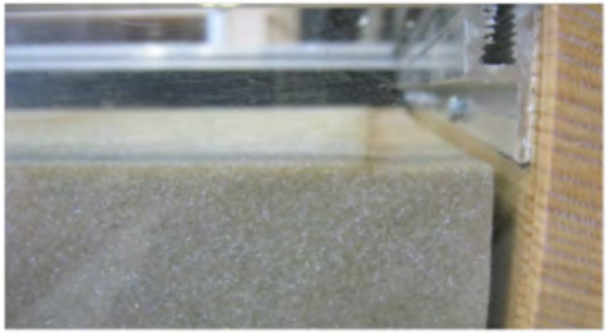

Fig.2: Visible degradation of a polyurethane foam after outdoor exposure in a collector.

Within a 3 year research project, the Austrian Institute of Technology evaluates the potential of new insulations for solar thermal collectors and storages.

A thorough screening of existing and new materials is the basis for a detailed analysis of the behavior of insulations in real components. Thermogravimetry in combination with FTIR and Mass Spectrometry is employed to evaluate the potential for solar thermal applications with special emphasis on thermal stability (Fig. 3.) and outgassing (Fig. 4).

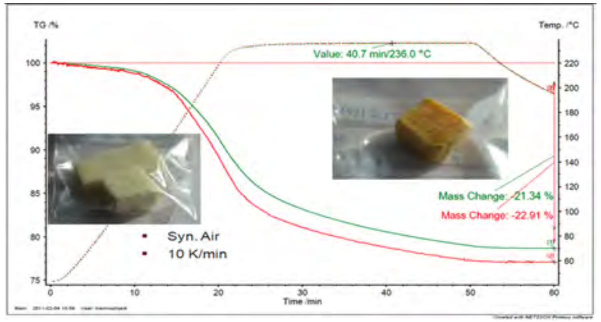

Fig.3: Thermogravimetric analysis of polyurethane foam

A set of particularly interesting candidates will then be selected for assembly of real collectors (Fig. 1) and storages at the project partner TiSUN. This allows to investigate production related issues such as processability and automatization. A special focus is put on polymeric foam materials of various kinds as they pose an interesting potential also in solar thermal collectors if thermal stability in the long-run be ensured (Fig. 2). The latter point is investigated via outdoor exposure and accelerated aging in climate chambers and ovens.

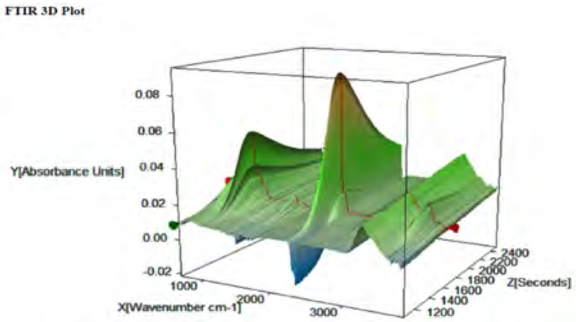

Fig. 4: FTIR analysis of outgassing products of mineral wool

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Architecturally appealing solar thermal systems as a marketing tool

– new database online

A new - first version - database consisting of showcases where solar thermal energy systems have been successfully integrated into the architecture is now online: http://www.iea-shc.org/

The appearance of a product certainly counts in making a first impression on a customer and often plays a decisive role in the final decision to buy or not. Effective use of design and high visual quality adds value to the product and builds trust and confidence. When it comes to solar thermal systems, the collector design is only one part of the final product. Placement of the collector field and good architectural integration is more important for the final result that will be judged by the public. To focus on showing really good examples of harmonic and well designed solar thermal systems can be a important parameter for market development, and help to re-define solar thermal to the public as something that can be high-tech, good looking and sustainable, giving an added value to each building.

To secure that the database will be extended with more showcases over time, that new project presentations will be regularly added to the collection, we have appointed responsible national contacts from Austria, Canada, France, Germany, Israel, Norway, Portugal, Slovenia, Sweden and Switzerland.

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Environmental costs of different solar heating systems can be compared

Analysis of LCA data for two solar heating systems specified in the Ecoinvent data base shows that the total cost methodology would be a suitable tool to compare performance of different solar heating systems not only in terms of direct costs but also in terms of the indirect costs that can be attributed to the environmental impact the processes of the life cycles of the solar systems are causing.

The analysis has also shown that to make an adequate comparison between two solar systems with respect to environmental performance or environmental cost, the two systems have to be analysed when operating under the same external conditions with respect to outdoor climate and heat demand. The yearly amount of solar heat utilized by the systems must be the same which means that only the design and the size of the two systems are different.

In the comparison it is important to take into consideration effect of recycling on the environmental performance. Making use of those findings life cycle analysis is now under way to compare environmental performance of solar heating systems equipped with traditional collectors with those where polymeric solar collectors are used.

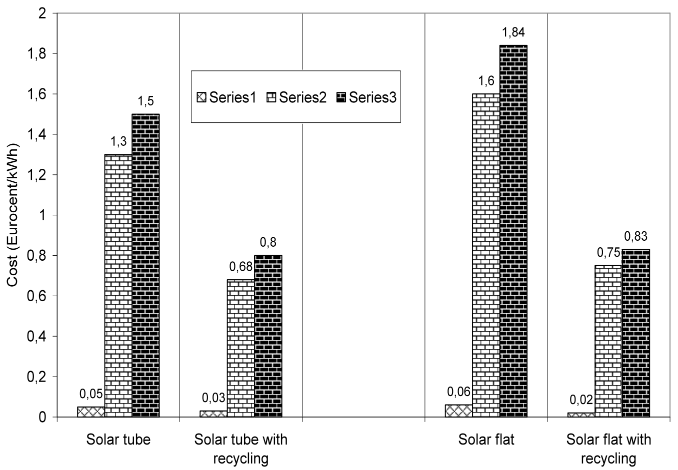

Figure above: The effect of recycling on the environ-mental costs for two traditional solar heating systems - one with flat plate solar collectors and one with evacuated tube solar collectors

Series 1: Costs for carbon dioxide emission according to the rate 20 € /tonne CO2;
Series 2: Total environmental costs based on the modified Ecoindicator 99(H/A);
Series 3: Corresponding total environment-tal costs based on the modified Ecoindi-cator 99 and with additional costs for car-bon dioxide emission according to the rate 100 € /tonne CO2.;

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High-performance plastics on the test-bench

Polymers already facilitate our lives in various areas – but are they also the key to a green energy supply, easily accessible for everyone? Solarthermal systems made of polymers would offer low production costs as well as an unlimited scope of design options. In order to ensure long lifetimes, the reliability of potential polymers is of great importance. Therefore, several kinds of high-performance polymers were aged indoors and outdoors at the Fraunhofer ISE and characterized in terms of physical and chemical stability. AFM measurements revealed essential information about changes in surface properties of the polymers. Also Raman microscopic analysis of changes within the chemical composition was carried out.

Especially aging procedures containing UV irradatiation emerged to be very demanding for the polymers investigated as can be seen in Fig. 1. and 2. Already after less than one week of UV/DH exposure (85°C, 85% r.h., 15 kWh/m²), strong fluorescence became observeable in the Raman spectra. Visible aging effects could not be found before 500 h of UV/DH aging. Raman Spectroscopy can be used as a sensitive method for early-stage qualification of polymers.

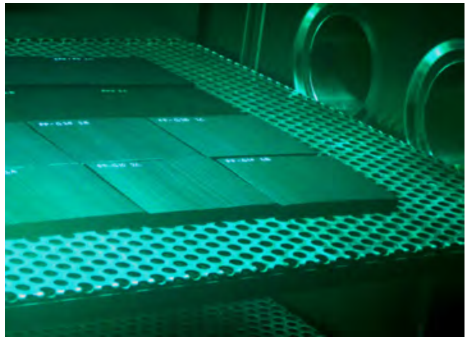

Fig.1. Climatic cabinet for UV/DH aging.

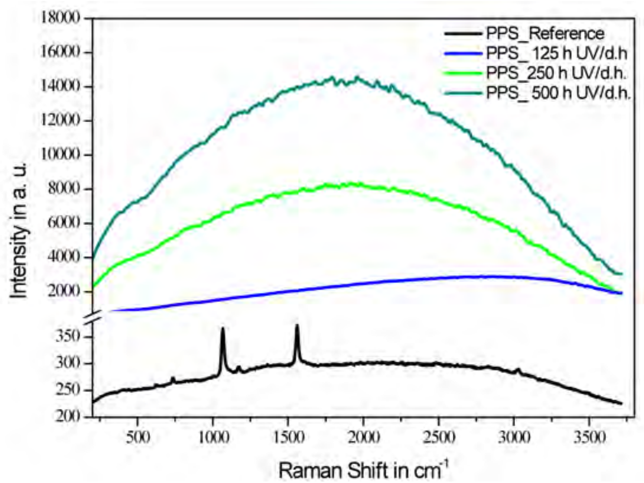

Fig.2 Raman spectra of PPS before and after UV/DH aging.

K.-A. Weiß, M. Falk, C. Stöver, C. Peike, Fraunhofer ISE Germany, karl-anders.weiss@ise.fraunhofer.de

Electrochromic plastic devices

In modern architecture, large glass facades are being built in increasing numbers. This allows the use of solar radiation for heating in winter, but in summer, protection against overheating is needed. Literatures have described potentials of Electrochromic device (ECD) as glare/ heat control for arhitectural and automotive applications. High efficient roof or façade solar collectors suffer stability problems when high temperatures are reached due to the low hot water consumption or at stagnation conditions easily exceeding 200 °C. Two methods cope with the overheating problems: either one uses expensive materials that can withstand high temperatures which are not easy to get and are not cheap or one can simply dumps the excess of hot water. ECD open a number of technologically interesting possibilities because of their ability to modulate their optical transmittance, reflectance, the solar spectrum and providing control of the incoming radiation.

It is reasonably to expect that when the low-cost ECD (i.e. smart windows) on flexible plastic foils will be made they will provide very effective shading and overheating protection of solar absorbers made of polymeric materials.

One of the important steps toward flexible ECD systems is the roll-to-roll processing of EC materials on polymeric substrates enabling simple gluing of EC foils together and formation of EC stack with the electrolyte in between. We succeeded to deposit on plastic foils (Solaronix ITO PET 175-60) at low temperature processing (150°C, 30 min) electrochromic TiO2 and NiOx pigment dispersions with small haze (~ 2.5% haze) that are suitable for making ECD with transmittance modulation. The preparation of low temperature ECD pigmented coatings is based on paint technology and opens a new very exciting field of electrochromic paints.

Figure: Low cost polymeric electrochromic devices can be used as shading devices and overheating protection for solar absorbers.

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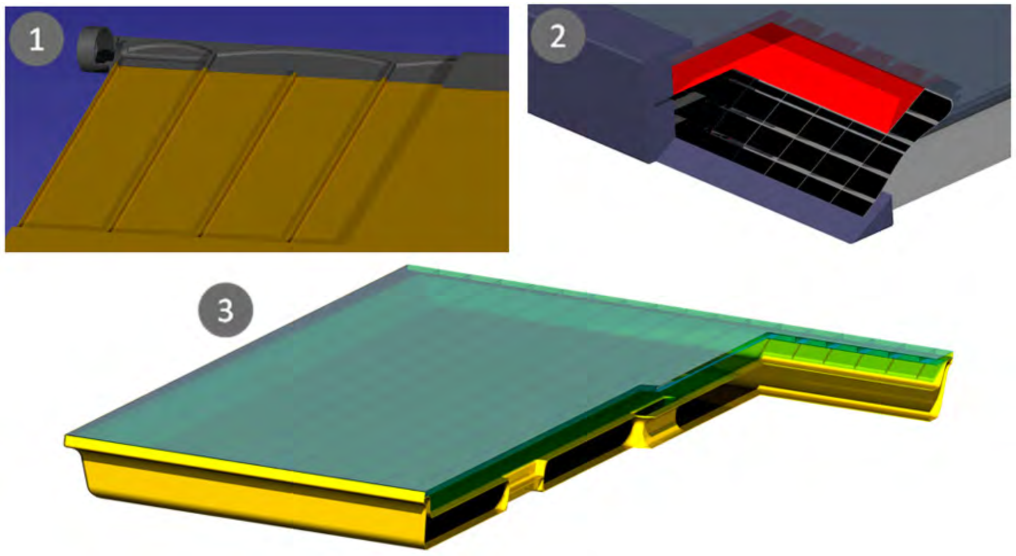
National Institute of Chemistry, Slovenia.

Design concepts and suitable production processes for a new generation of polymeric collectors

The design of solar collectors made of polymeric materials fundamentally depends on available production processes. Hence, several design concepts have been developed at *Ingolstadt University (Germany)*, aiming at light-weight structure, short cycle times and few production steps. Suitable production processes to achieve these attributes were found to be extrusion and twin-sheet thermoforming for either single parts of the collector or the whole product. Extrusion for example can be used for production of the absorber (1) or the glazing as a single part.

Another concept is producing absorber, insulation and housing as one part (2). The structure consists of a multi-wall sheet with encapsulated air layers for insulation and channels for the heat carrier. The very stiff and light-weight construction causes little material consumption and short production times. Finally, twin-sheet thermoforming promises the production of collector parts with complex enclosed cavities for insulating air layers in innovative casings (3) or for absorbers with special geometries for homogenous volumetric flow.



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Subtask C: Materials

As shown in Phase 1 of IEA SHC Task 39 polymer engineering and science offer great potential for new products in solar thermal systems, which simultaneously fulfill technological and environmental objectives as well as social needs. Based on the major achievements and experiences in Phase 1 the project structure of Subtask C for phase 2 was adapted. The following three projects were defined in the work programme for phase 2:

1) Multi-Functional Polymeric Materials
2) Processing and Evaluation of Components
3) Methods for Testing and Characterization of Polymeric Materials

In Project C1 multi-functional polymeric materials for different components in polymeric solar thermal systems will be assessed and evaluated. Special attention will be given to absorber materials for various stagnation temperature ranges, switchable glazing materials or absorber coatings, polymeric foams or polymeric liner materials for storage tanks.

Project C2 aims at the evaluation of polymer processing methods for the production of parts and components in solar thermal systems (e.g., extruded films and sheets with functional coatings; injection or compression molded plaques and components; welded, bonded or laminated components).

The properties and performance of polymeric materials and components are determined by their material structure and formulation, the processing routes and the loading conditions in the use phase. For the assessment of the material quality and performance in solar thermal applications adapted and novel methods for quality assurance testing and long-term performance and durability testing will be developed and evaluated in Project C3.

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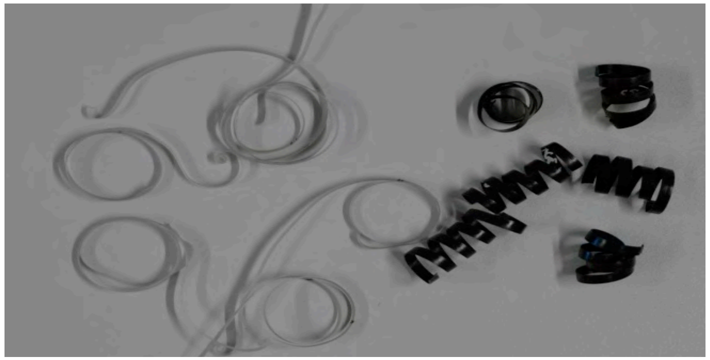
Accelerated aging of liner materials for storage tanks

Polyolefin based liner materials are used in large or modular storage tanks. To enhance the long-term service temperature up to 95°C novel formulations are developed and characterized as to their aging behavior. Due to the fact that the mechanical loads are low, conventional time/temperature-limit methods can be applied to predict the lifetime. In a previous study it was shown that the determination of time/temperature-limits for polyolefin specimen with an application-relevant thickness of 2 mm requires long testing times of more than 1 year at significantly enhanced testing temperatures.

In the collaborative, basic research project *SolPol-1* novel accelerated test methods that make use of a combination of a polymer physics based approach to accelerate the aging process and advanced analytical and mechanical test methods are under development. An approach currently examined is based on micro-sized specimen with significantly reduced thickness and the exposure in heat carrier fluids and air at application-relevant temperatures of 95°C or slightly enhanced.

More information: www.solpol.at



Klemens Grabmayer and Gernot M. Wallner, University of Linz, gernot.wallner@jku.at

eco-FLARE™

Patented full Polymeric flat plate collector as a solution for the increasing demands in emerging markets

eco-FLARE™ is a full polymeric flat plate collector developed and manufactured by Magen eco-Energy. Magen eco-Energy also known for manufacturing Heliocol™ - unglazed solar collector (absorber) dedicated and designed especially for pool heating at low to medium temperatures as well as pre-heating of large volumes of water.

The engineering and marketing philosophy behind eco-FLARE™ is directed to emerging markets at geographical sunny environments such as the Mediterranean, Middle-East, Latin America, Southern-Africa, Australia and the US-Sunbelt.

Main assets of the eco-Flare™ unique design – Lightweight, easy to install, resistant to corrosion, low lime-scale buildup, resistant to occasional night-frost. Glazing is shatterproof and resistant to vandalism. eco-FLARE™ can be installed as a closed loop system or open loop with city water pressure (Thermosiphon or Circulated) and is suitable for a large range of applications, from heating water for a single house or apartment to heating large quantities of water for hotels and industrial facilities.

Main engineering features are:

- Patented venting system for overheating protection.
- Long term heat and creep resistance of the Polyolefin absorber.
- High pressure resistant manifold and absorber's pipe connections (Patent-Pending)
- Specially developed polyolefin compound with improved Thermo-oxidative and pressure resistant.

Magen eco-Energy is putting future R&D efforts in development of 2 new all polymer flat plate models which are designed to have the best "Cost to Efficiency" in the solar thermal market.

For more information:
www.magen-ecoenergy.com
Magen eco-Energy
info@magen-ecoenergy.com

New designed solar air collector with polymer absorber and casing

Based on collaboration within IEA-SHC Task 39 the German company Söhner Kunststofftechnik GmbH, Schwaigern together with Dr. Axel Müller – HTCO, Freiburg have developed a new generation of solar air collector. The absorber and the casing of the collector are made from polymers. To enhance the performance the heat transfer between the absorber and the airflow and the distribution of the flow within the absorber have been optimized by computational fluid dynamics (CFD) calculations. The collector has been tested successfully archiving promising results. A prototype of the new designed air collector with a size of 1.6 m x 1.0 m will be shown at the Intersolar Munich, June 2011 for the first time.

Markus Peter, based on information by T. Doll and A. Müller

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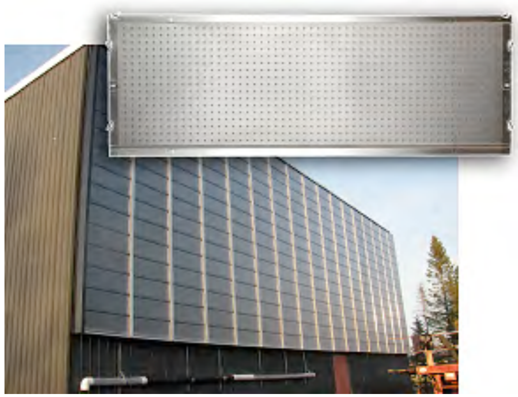
The development of the new designed air collector has been supported by the German Federal Ministry of Economics and Technology in the framework of the Central Innovation Programme (ZIM)

Polycarbonate solar air collector breaks efficiency record



Enerconcept Technologies, a Canadian company located in Quebec, Canada, developed and patented a technology based on perforated transparent glazing to minimize heat losses in solar thermal collectors and to recover heat in a very effective way.

As a first application of its technology, Enerconcept offers the Lubi™ collector, a wall-mounted solar air heater which is entirely made of polycarbonate, deemed so far the best material to withstand impacts from the environment and for wind load resistance. All other parts of the collector, including the structural components and the frames, are made of aluminum.

It is often claimed that the adoption of polymeric materials for solar thermal collectors entails a drop in efficiency when compared to metal, but this time this was not the case.

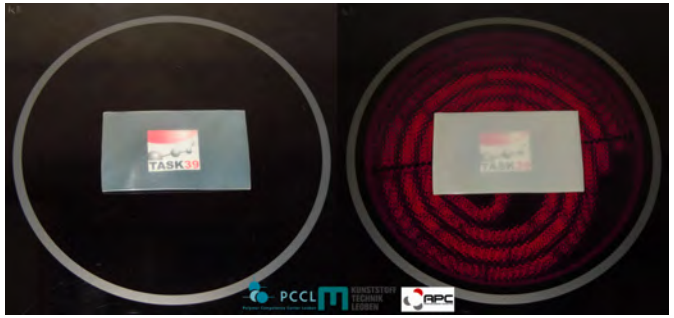
The Lubi™ solar air heater was tested in 2010 at the National Solar Test Facility of Toronto after about three years of development, and the efficiency test results showed a 20% increase in efficiency for preheating outside air over any of its metal counterparts, including Enerconcept's own Unitair™ metal collector.

The principle of the collector is simple: to perforate the transparent front glazing in order to let the light through the glazing to the absorber, and then to minimize heat losses by allowing the cool outside air through the glazed surface, thereby reducing the glazed surface temperature. Further development now focuses on the characterization of collector performance over the expected lifetime of 20 years.

More information: www.enerconcept.com

Smart Materials: Thermotropic glazings for overheating protection

In a recent joint research project performed at the Polymer Competence Center Leoben and the Department Polymer Engineering and Science at the University of Leoben, which has 40 years in depth experience in chemistry, characterization and processing of polymeric materials, the development of smart glazings for overheating protection applications is intended. Such thermotropic glazings change their light transmittance upon reaching a certain threshold temperature reversibly by switching from a highly transparent to a light reflecting state. This reduction in optical gain yields a reduction of stagnation temperatures in solar thermal collectors and would thus enable the use of cost-efficient plastics as absorber materials. Besides numerical studies concerning material design, within the research project a novel systematic approach for material formulation was established (formulation roadmap), which is based on sound principles of polymer physics. Specific focus was given to systematic material selection and characterization in order to meet the requirements for solar thermal applications. The novel produced material formulations yield promising results for efficient overheating protection of solar thermal collectors. In the cold state the layers exhibit a solar hemispheric transmittance between 39 to 84%. Above the switching threshold, which was adjusted between 50 and 75°C, the transmittance changed by -31 to +34% to values ranging between 53 and 85%. Currently, further materials are formulated. In a next step the long-term stability of the light-shielding performance of the layer will be evaluated.



Optical appearance of a representative thermotropic layer in the cold (left) and hot (right) state.

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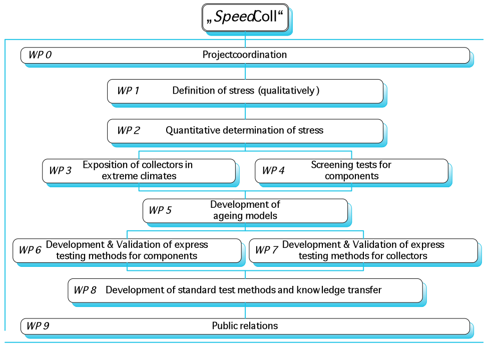
Katharina Resch, Department Polymer Engineering and Science, University of Leoben, Austria, katharina.resch@unileoben.ac.at

Project *Speed*Coll:
Development of accelerated ageing test procedures for solar thermal collectors and their components

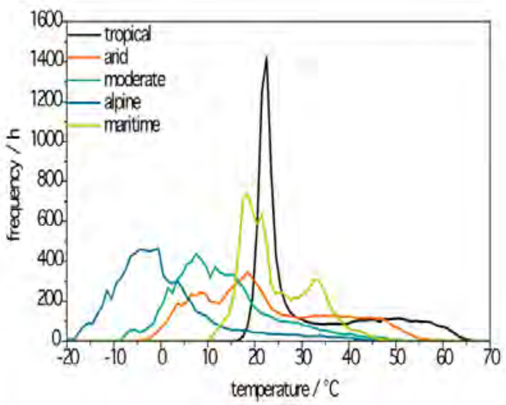


*Structure of the project Speed*Coll.

The aim of the research project "*Speed*-Coll" is to develop accelerated ageing test procedures for solar thermal collectors and their components as well as the verification of these proceedings. The work packages include the determination of loads, the definition of typical operational conditions, screening tests for components, the exposition of collectors and components in extreme climates, the development of ageing models and the development and validation of test sequences for collectors and components. For this purpose, the data collected from the different accelerated ageing tests concerning temperature, UV irradiation, salinity, humidity and condensation are compared with the data received from the 6 outdoor test sites.

At the end of the project, innovative and concrete proposals for test sequences, specifications and international standards shall be prepared.

The project is funded by the German Ministry for the Environment, Nature Conservation and Nuclear Safety and industrial partners like collector manufacturers and suppliers of solar thermal materials and components. *Speed*Coll is a collaborative project of the Fraunhofer Institute of Solar Energy Systems and the Institute of Thermodynamics and Thermal Engineering (ITW) of the University of Stuttgart. The project was launched in April 2011 and runs for four years.



Frequency distribution of module temperatures measured on the different outdoor tests sites during one year.

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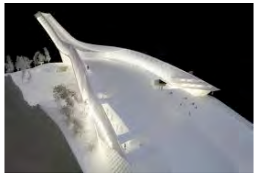
Architecture meets sustainability

Aventa's polymeric collector is presented at The National Museum – Architecture May 6th – August 21st 2011, as part of the exhibition "SPOR Norwegian architecture 2005-2010". The aim of the exhibition is to communicate developing architectural qualities in Norway today, and to point out new trends of architecture making social impact.
The AventaSolar collector is part of the "Bjørnveien 119 Dahle/Dahle/Breitenstein" presentation, a residence with solar collectors integrated into the façade.

The exhibition is the seventh in a series of presentations devoted to contemporary Norwegian architecture from 1968 until today, and shows examples from small private houses to complex infrastructure and recent city developments, which were elected by a jury.



The election of the project Bjørnveien with Aventa's solar collectors demonstrates that sustainability is becoming increasingly important also for house builders and architects. Hopefully the exhibition will encourage even more architects to look for energy efficient solutions in their future projects.

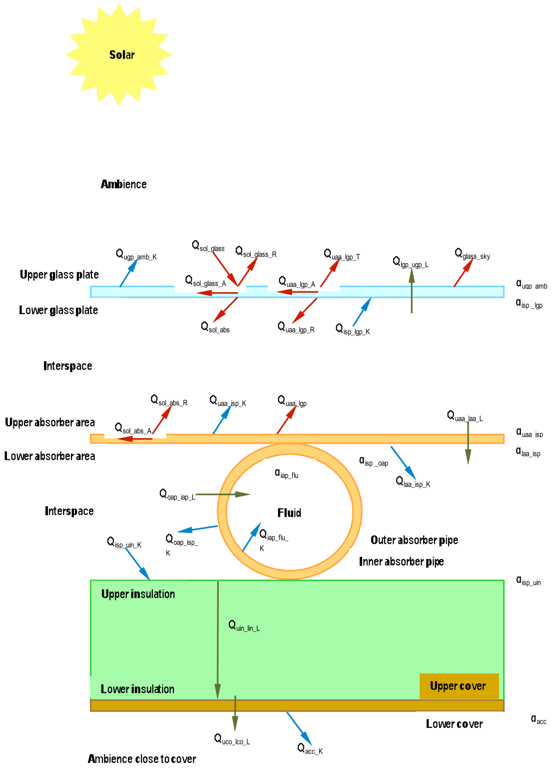
The exhibition is part of the Year of Architecture 2011.
http://www.nasjonalmuseet.no
www.aventa.no

Collector with Internal Overheating Control

The national Austrian research project SolPol 1 and SolPol2 lead by Linz University, comprises several approaches for polymer based solar thermal collectors.

Within work Package 1 of SolPol2 a concept of reducing the maximum collector temperature at stagnation with high collector efficiency during operation will be developed. The following tasks will be performed in the project:

- Definition of basic requirements of solar thermal collectors
- Screening of possible materials and semi-finished parts
- Construction and optimization of different polymer based collector concepts using
    - Set up of simulation tools (collector modeling),
    - Detailed studies with CFD/heat transfer
- Laboratory tests with prototype collectors and collector parts
- System Simulations (SHWwin, TRNSYS)



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Black absorber materials based on polypropylene

Polypropylene (PP) is a cost-efficient polymer type used in various fields of application (e.g., automotive, buildings or packaging industry). In the solar thermal industry polypropylene grades have gained commercial importance especially for absorbers of swimming pool collectors, expanded foams for thermal insulation or liners for storage tanks. In glazed solar collectors with appropriate overheating protection polypropylene could become an alternative material for metals or high-performance polymer types.

Currently only few black-pigmented polypropylene grades are commercially available. The main aim of this study was to provide a basic characterization of the LyondellBasell PP grade PP H4122, which is used by various manufacturers for swimming pool collectors.

PP H4122 is based on a PP block copolymer modified with about 2 m% of carbon black and various additives. The PP grade exhibits a high degree of solar absorbance (~ 96%), a glass transition region below ambient temperature, a melting peak temperature at 169°C and an oxidation temperature at 275°C. In designing with polypropylene the change in elastic modulus by a factor of about 3 to 4 between ambient temperature and 100°C has to be considered.

solpol

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