SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY
NEWSLETTER 6 - June 2010
TASK39

Task 39: Polymeric Materials for Solar Thermal Applications

CONTENTS

MEETINGS

8th Experts meeting, April 15-16, 2010

The 8th IEA-SHC Task 39 Experts meeting was hosted by Institut National de l'Énergie Solaire (CEA-INES, http://www.ines-solaire.com/) in Aix Les Bains, France from April 15-16, 2009. Due to volcanic activity in Iceland and air traffic stop only 12 experts could join the meeting. Some experts participated in the discussions via SKYPE.

9th Experts meeting, June 10, 2010

The additional, 9th Task 39 Experts meeting took place at the INTERSOLAR Europe Fair 2010 in Munich on June 10, 2010 and was hosted by Fraunhofer ISE, Freiburg (http://www.ise.fraunhofer.de/). 24 experts took part in the meeting, among them 7 from industry.

Most of the presentations and the results from group work at both experts meetings are summarised in this newsletter.

Task 39 meetings in Aix Les Bains and in Munich: (a) Group picture during the 8th Experts meeting in Aix Les Bains; (b) during the 9th Experts meeting at the Intersolar 2010 in Munich; (c) Excursion to the laboratories of INES : Silicon for PV Lab and (d) demonstration passive houses (France).

10th Experts meeting, September 27-28, 2010

The 10th Task 39 experts meeting will take place in Blumau, Austria from Sept. 27-28, 2010. The meeting will be prior to the EuroSun 2010 conference (see below).

EuroSun 2010 conference, Sept. 29 - Oct. 01, 2010

The EuroSun 2010 conference will be arranged in Graz, Austria, from Sept. 29 - Oct. 01, 2010. EuroSun is Europe's largest conference on solar thermal energy and focus on solar heating, cooling and buildings. Registration, booking and conference program: http://www.eurosun2010.org/

Eight contributions related to Task 39 will be presented at the EuroSun 2010 conference, further one Keynote lecture on Friday morning Oct. 1, 2010 on "Polymeric Materials for Solar Thermal Applications".

Task 39 Active Supporters:

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Determination of temperature loads by means of system simulation

A simulation study was carried out to assess the temperature loads on the different parts of a solar thermal system. The simulation was carried out for 7 different system configurations (2 systems for domestic hot water preparation and five so called combi systems which provide solar domestic hot water and hot water for space heating systems). The study included 3 different locations: Stockholm (Sweden) to represent Nordic climate, Würzburg (Germany) to represent central European climate and Athens (Greece) to represent southern European climate.

In a solar thermal system the collector is subject of the highest loads. To assess the temperatures of the different collector parts a four node model was implemented taking into account the absorber, heat transfer fluid, transparent cover and backside insulation.

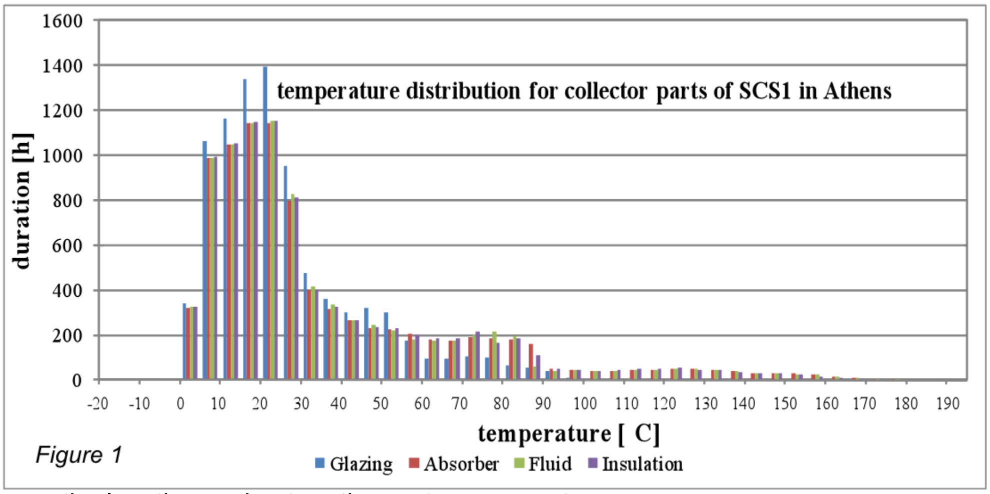

Figure 1

Figure 1 shows a temperature histogram for one selected combi system at the location of Athens and a tilt angle of 45° for the 4 collector components. For the absorber, fluid and insulation maximum temperature of 180 °C to 190 °C are reached. The transparent cover reaches temperatures up to 90 °C. In case of lower tilt angles high temperature can be expected due to smaller incident angles. The study showed that the collector temperatures are mainly depending on the location and not on the system concept.

Stephan Fischer, ITW, University of Stuttgart, fischer@itw.uni-stuttgart.de

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Annual Load Profiles and Overheating Protection of Flat-Plate Solar Collectors

In a field test of a solar heating system for hot water and space heating, the temperature loads of a flat-plate solar collector's components have been analysed. Additionally, a stagnating, dry collector as a reference was investigated. After a one-year measurement period, annual load profiles regarding the occurring temperatures of the collectors' components could be evaluated. The analyses showed moderate temperature loads for cover and frame, so that the use of polymeric materials seems to be highly feasible for these components. As was anticipated, considerable temperature loads were identified at the absorber, up to 140°C in operation and 208°C in stagnation state, which prove the need for effective overheating protection measures for polymeric absorbers (*Fig. 2*). Hence, in a methodological process a functional analysis for the collector and the solar-thermal system was carried out, where overheating protection methods could be traced back to two different basic principles. One option is to affect the collector's optical efficiency, whereas the second principle is to actively remove surplus thermal energy. The optical efficiency can for example be controlled by varying transmission properties at the front side or by varying absorption properties at the absorber surface. The removal of thermal energy can be realised by raising the collector's thermal losses or by active cooling of critical components. Further analyses as well as an identification and evaluation of suitable technical approaches are carried out in a subsequent project phase.

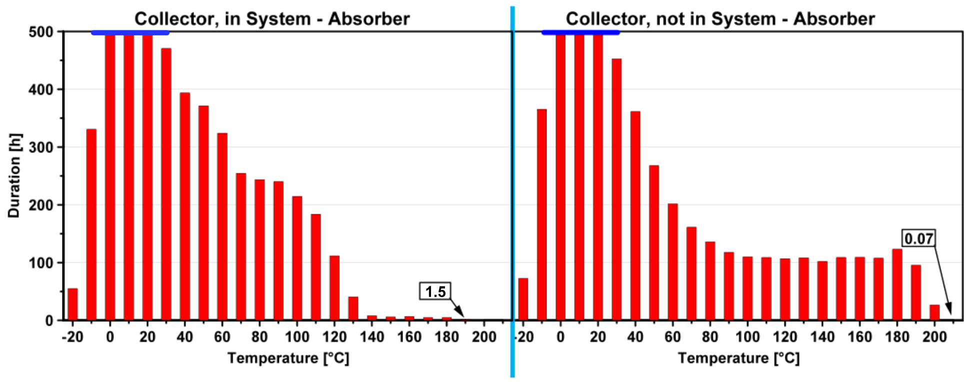


Fig. 2. Distribution of the annual temperature loads on the absorber in the system (left) and not in the system (right)

Christoph Reiter, Dr. Christoph Trinkl, Centre of Excellence for Renewable Energy Research, Ingolstadt University of Applied Sciences, Germany, christoph.reiter@haw-ingolstadt.de

Architecturally appealing solar thermal systems as a marketing tool

Although mature technologies at competitive prices are largely available, solar thermal is not yet playing the important role it deserves in the reduction of buildings fossil energy consumption. There has been a rapid market growth over the latest years, but the spread of solar thermal installations are still very modest taking into account that the technology is highly efficient and proven with a payback time much shorter than lifetime and a cost per kWh of 6 to 10 times cheaper than photovoltaic.

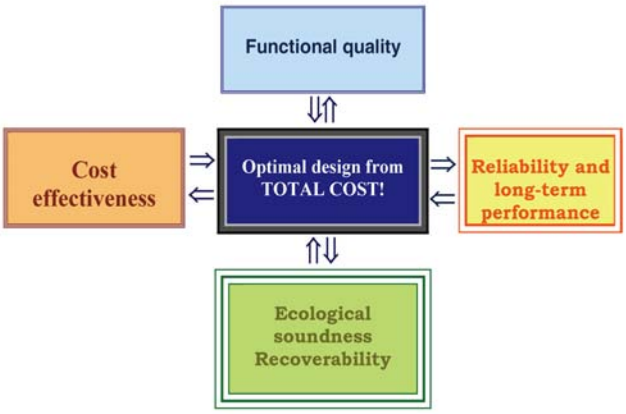
As a contribution from IEA-SHC Task39 to the challenge of making solar thermal systems more desirable a database consisting of showcases where solar thermal energy systems have been successfully integrated into the architecture have been established. The idea is to increase interest by showing visually appealing solar systems – something people really would want to put on their houses and something architects would want to implement in their design of new buildings.

We received 21 proposals as a result of our first call for projects. A group of experts has been evaluating the projects (both technical and architectural evaluation). The database will be published this autumn (2010) and IEA-SHCP will host the site. Our intention is that the database shall be extended with more showcases over time, that new excellent project presentations will be regularly added and help spreading the use of these technologies by making them appealing to both users and building designers.

Ingvild Skjelland, Aventa AS, Norway, is@aventa.no

Total cost accounting for material selection in product design

To meet the requirements on sufficient functional capability, service reliability and minimum environmental impact and cost in design of a functional unit of a product, a total cost accounting approach may favourably be adopted. Most appropriate product design alternative is the one with lowest total cost, the latter determined by the sum of production cost, cost associated with initial non-ideal function or performance during service, operation and maintenance cost, probable cost of failures and damage during use, end of life cost, and probable cost associated with ecological damage.



The total cost accounting approach has successfully been adopted for material selection in many areas of application, such as in design of solar absorber coatings, use of lightweight materials in automotives, and in design of more sustainable product element life cycles related to materials for windings in electric transformers. By adopting a total cost accounting approach to solar collector design within the framework of some selected case studies, the suitability of using polymeric materials relative to more traditional materials would be possible to assess in an illustrative way. The main advantage of the total cost accounting approach is the holistic view point taking into account not only functional quality, cost effectiveness, reliability, and long-term performance of a particular design alternative of a functional unit but also its environmental performance aspect related to ecological soundness and recoverability.

Bo Carlsson, Linnaeus University, Sweden, bo.carlsson@lnu.se

IEA-SHC Task 41 “Solar Energy and Architecture”

This new IEA SHCP Task, the first of the Program to explicitly mention “architecture” in its title, concentrate on promoting solar energy use in buildings by architects, not only installers, and on increasing the architectural quality of the systems (*http://www.iea-shc.org/task41/*).

The Task is organized into three subtasks:

Subtask A : Criteria for Architectural Integration

Subtask B : Methods and tools

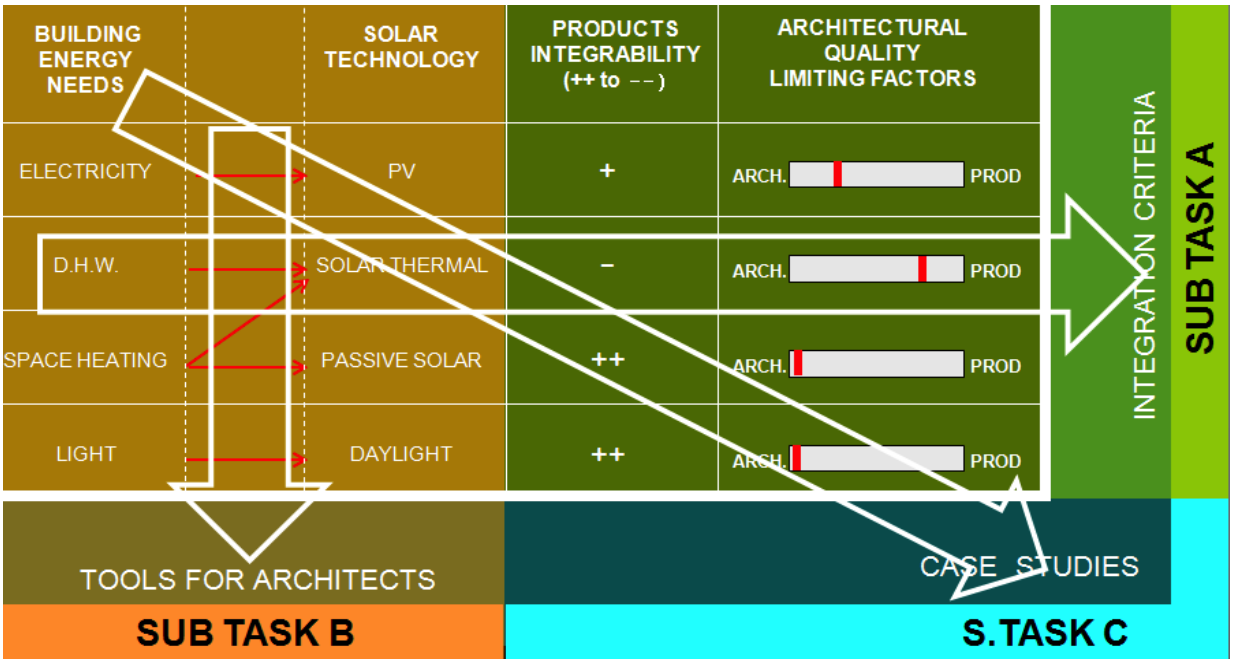
Subtask C : Concepts, Case Studies and Guidelines

The main goals are:

- Disseminate specific knowledge of active solar technologies integration to practicing architects through booklets, seminars and a collection of good examples
- Helping develop new products for architectural integration
- Propose/recommend tools and methods to integrate active solar systems, if possible in the early design stage

Solar Energy AND Architecture!

A clear synergy could exist with the Task 39 activity aiming at removing non technical barriers through diffusion of good architectural examples, as started within Task 39's Subtask A, and the Task 41 Subtask's A and C.



IEA-SHC Task 41 “Solar Energy and Architecture”

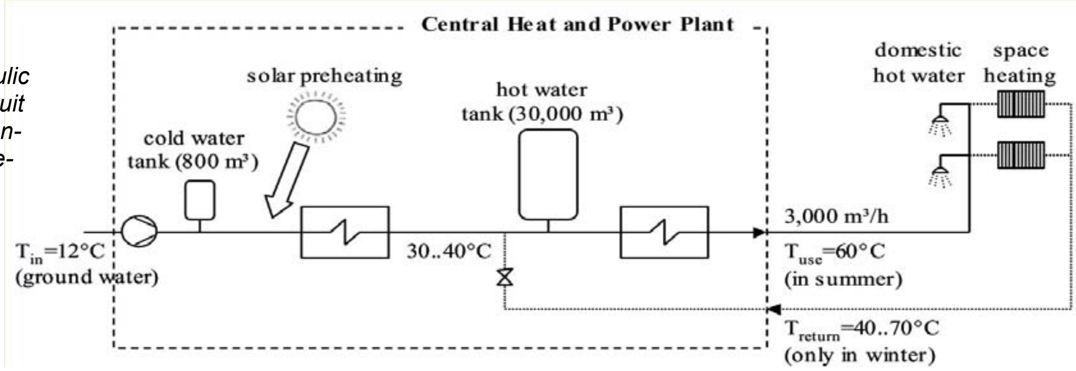
Christian Roecker, EPFL-LESO, Switzerland, mailto:christian.roecker@epfl.ch

Solar Water Preheating for Open District Heating Nets

In heat and power plants with so-called open district heating nets, large quantities of cold water (e.g. 12 °C) are heated up to supply temperatures (e.g. 60 °C) using fossil fuels. This water, however, can be effectively preheated by uncovered collectors before heating up conventionally to the supply temperature. Due to high basic load, low inlet temperature and good climatic conditions in most parts of the Commonwealth of Independent States (CIS), extraordinary solar gains and very low solar heat costs can be achieved during the frost-free season.

An uncovered collector that work at temperatures around 20..40 °C is an excellent application for a wide range of polymeric materials. EPDM, PE-X as well as commodity plastics like PE or PP can be easily used. It was found that 38 out of 197 heat and power plants in the CIS countries are in principle appropriate for this kind of solar thermal technology. In addition, this study includes an economic analysis of the technology based on previous experimental and theoretical results. Solar heat costs of less than 0.01 €/kWh$_{th}$ and a payback time of about 9 years are expected.

Figure right: Simplified hydraulic scheme of a typical open-circuit district heating net in CIS countries (usually without solar preheating)



Contact: Kassel University, Institute of Thermal Energy Engineering, Kassel (Germany)

Analysis of climatic impacts on polymeric materials

Researchers at the Fraunhofer ISE analyse the impacts of degradation factors like UV irradiation, temperature and humidity since durability and weatherability of polymers are very important for solar thermal systems. The polymeric materials PPS, PPE/PS, and PP with graphite are analysed using Raman Microscopy and Atomic Force Microscopy (AFM). Micrographs showing the surface of PPS after 0 h and 500 h UV irradiation are shown in Fig. 3.

All analysed polymers show strong fluorescence in their Raman spectra after exposure to UV irradiation at 85 °C. The fluorescence is increasing with exposure time. The changes of the Raman-spectra of PPS (Fig. 4) can be explained with photodegradation effects.

AFM-measurements show surface properties like adhesion, stiffness and topography. The latter is shown in Fig. 5 for unaged PPS and after 500 h UV irradiation or 500 h at 85 °C, 85% r.h.

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

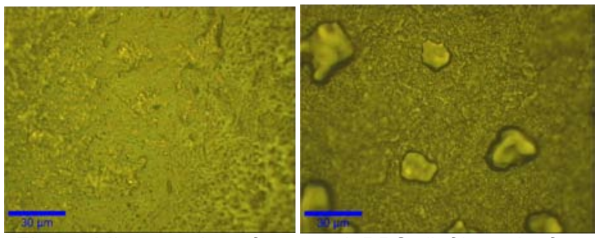


Fig 3: Micrographs of unaged PPS (left) and after 500 h UV irradiation (right).

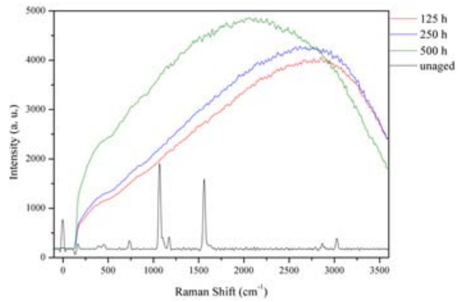


Fig. 4: Raman-spectra of PPS, after different times of exposure to UV irradiation.

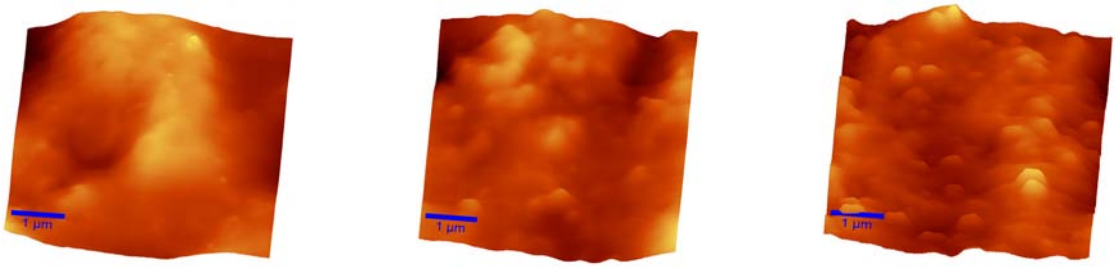


Fig. 5: Topography of unaged PPS (left), after 500 h UV irradiation (middle) and 500 h at 85 °C, 85% r.h. (right).

Novel Material Formulations for Thermotropic Glazings

Novel material formulations were investigated for the preparation of thermotropic glazings for overheating protection applications. Specific focus was given to the preparation of thermotropic systems with fixed domains, which consist of an additive with specific thermo-functional properties that is dispersed within a matrix material. Numerous non-polar and polar waxes as well as block copolymers and terpolymers were selected as additive types. As matrix materials, both, thermoplastic and resin materials were investigated. Layers exhibiting the strongest light shielding efficiency so far were obtained by combining a UV curing resin with a specific polar wax type. The best thermotropic layer showed a hemispheric solar transmittance of 78% in the clear state and of 62% above its switching temperature of 75 °C. Its overheating protection performance for solar collectors was studied by theoretical modeling of an all-polymeric solar collector with twin-wall sheet glazing and black absorber (done by Robert Hausner, AEE-Institute for Sustainable Technologies, Gleisdorf, Austria). Compared to the collector without thermotropic overheating protection the investigated thermotropic layer yields a reduction of the maximum absorber temperature by 29 °C (Fig. 2), as stagnation temperatures of 129°C were obtained. A maximum operating temperature of 130°C would already allow for the application of cost-effective plastics as absorber materials.

Nevertheless, further material development should focus on an increase of the collector efficiency in clear state and thus of the hemispheric solar transmittance of the thermotropic layer. Furthermore the long-term stability of the layer has to be assured.

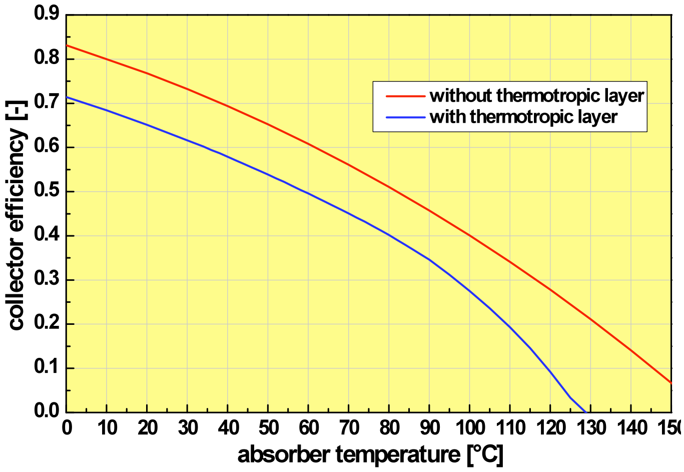


Fig. 2. Effect of thermotropic layer on collector efficiency and maximum absorber temperature of an all-polymeric solar collector with twin-wall sheet glazing and black absorber (α=0.95, ε=0.90) at a solar irradiation of 1000 W/m² and an ambient temperature of 20 °C.

Katharina Resch, Institute of Materials Science and Testings of Plastics, University of Leoben, Austria; katharina.resch@unileoben.ac.at

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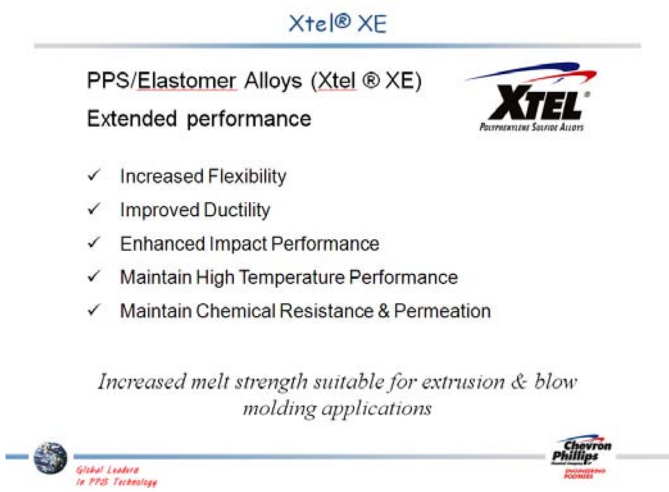
Xtel®XE: PPS/elastomer alloys

PPS, poly-(p-phenylene sulfide), is a semi-crystalline, aromatic polymer. It is a highly stable polymer with a remarkable degree of molecular stability toward both thermal degradation and chemical reactivity.

To extend the performance of Ryton®PPS, Chevron Phillips Chemicals has introduced Xtel®XE, a series of PPS/elastomer alloys. Xtel®XE alloys retain many of the good properties of Ryton®PPS and offer an increased flexibility and ductility and enhanced impact resistance. Another key advantage of the introduction of the elastomer phase is the increased melt strength, which allows the use of Xtel®XE in extrusion and blow molding applications.

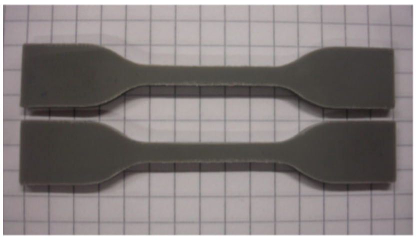
Grades with different levels of flexibility and glass fiber loadings are available to serve a wide variety of applications.



By working closely with Aventa to understand their needs for the polymeric solar collector, we have been able to develop XE4500BL for the absorber sheet, which has an excellent process ability, hydrolytic stability and temperature resistance.

Els De Meersman, CHEVRON PHILLIPS CHEMICALS INT., Belgium; demeee@cpchem.com

Novel Polyolefin Formulations for Heat Stores



Polypropylene (PP) is already in use for various components of solar thermal systems with a special relevance in polymer based heat storage tanks. For large or seasonal storage tanks an enhanced service temperature up to 95 °C is required. Hence, the main objective was to develop novel polypropylene compounds and to characterize their aging behavior in hot water and air environment.
A reference and twelve novel compounds were prepared and exposed in hot water or hot air at 115, 125 and 135 °C at specimen level (s. Fig.). To describe the aging behavior thermoanalytical and ultimate mechanical values were determined and evaluated.
Especially for the novel grade No. 8 a significantly improved aging behavior was deduced for both environmental conditions hot water and hot air. Further work will focus on the continuation of the exposure tests and on the deduction of endurance limits under maximum operating temperature (95 °C).

K. Schnetzinger, M. Haager, A. Hagauer, G.M. Wallner, Austria; karl.schnetzinger@a-p-c.at, hm@agru.at, gernot.wallner@jku.at

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Polyolefins for heat storage tanks

Polyolefins are already used for various solar thermal applications. Heat storage tanks is one of the most promising application with a growing demand in the future. For several projects polyethylene (PE) as well as polypropylene (PP) has already been selected to be used for the inner lining of large and medium sized seasonal heat storage tanks. The advantage of the polymer lining is the good weldability which leads to an absolutely water tight tank and the excellent corrosion resistance.

Several projects have already proven the feasibility to use PE and PP in this application. However, an enhanced long-term service temperature of up to 95 °C is required in order to increase the efficiency. Currently novel polyolefin formulations are being developed especially for the application in heat storage tanks.

M. Haager, AGRU Kunststofftechnik GmbH, Austria; hm@agru.at

Figure right: Mid sized heat storage tank with PP lining on the inside (© FSAFE Solartechnik GmbH)

Modular Solar Heat Storage with Polymeric Liner

Within a German research project financed by the Ministry of Environment (BMU), a new concept for storing solar energy in residential buildings has been investigated. Since 2009, a product is commercially available by FSAVE Solartechnik GmbH, a spin-off of Kassel University. The so-called FLEXSAVE VARIO is a heat storage that can be easily installed into existing buildings. An inner polymeric liner that is welded on-site of PP-H is used. Storage volumes from 2 to 100 m³ are available. Since „Each cellar is different“ (FSAVE), these storages are fully customized. At the INTERSOLAR exhibition in Munich this year, FSAVE Solartechnik won the INTERSOLAR AWARD 2010 in the category „solar thermal technology“.

More information: www.fsave.de or via e-mail: info@fsave.de

Figure, left: FLEXSAVE VARIO: Modular Buffer Storage with polymeric liner for residential buildings

Polymer collector ready for market introduction

The development of a solar collector with transparent cover and absorber both made in plastics, started as a result of the excellent scientific and industrial network created by the IEA-SHC, Task 39.
The product, which will be launched by the Norwegian solar energy company Aventa Solar, is now in the final phase of testing and certification.
The main barrier for using plastics is the unavoidable high temperature of the absorber when the storage is charged and there is no need for heat from solar collector (stagnation). The main challenge has been to find a material that is suitable for processing into an appropriate design, and be sufficiently high temperature resistant in order to sustain the stagnation temperatures over a reasonable life span.
The present solution has been enabled through a collaboration between Chevron Phillips Chemicals and Aventa Solar, based on further modifications of the high performance PPS-elastomer (XTEL) materials from Chevron Phillips Chemicals. Essential contributions to the development have been given by Fraunhofer ISE, UiO, NIC, AIT, AEE-INTEC, EPFL and Prirev, all participants in Task 39.

J. Rekstad and M. Meir, Department of Physics, University of Oslo, Norway, john.rekstad@fys.uio.no

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Air solar collectors for building facades in Slovenia

Air-based collectors are type of solar collectors in which air is used as the medium for heat transfer instead of a liquid. The collected energy can be used for ventilation air heating, space heating or crop drying. Air collector offers numerous advantages: weight less than water collectors, no freezing or boiling problems, less problems with corrosion and they are suitable as buildings envelope for building façades. The main disadvantage is low heat storage capacity of air, but air is fast-reacting heat transfer medium and with a satisfactory regulation we achieve high efficiency.

Solar Thermo Systems – STS Inc. company is aware of the developing trends oriented towards the use of solar building for harvesting the solar radiation. In order to make solar air collectors the space between the outer and inner PC wall should be filled with solar absorbing material. When air is heat-carrying medium, metallic or plastic absorbers could be inserted into the wall segment. The critical parameter is the ratio between the insolated area and the heat exchange area. Absorbing material colored with Thickness Insensitive Spectrally Selective paint coatings (NIC) represent new way of harvesting the renewable energy.

The most critical step important for optical properties and for our development of TISS paint coatings is the painting procedure. The metal strip, which is prefabricated, is in next step coated with the spraying guns with different speed. Thickness of coating plays an important role by achieving high absorptance and low thermal emittance. Thermal curing is also needed after spray coating.

Represented were ways of production, experimental results of continuous spray coatings and efficiency experimental results of the existing façade made of black TISS paint coated stripes, mounted into the twin PC sheet linked side- by- side together and mounted on the façade of the building (Figure, right).

Fig: Tehnopolis building, Celje, Slovenia.

J. Felicijan, Solar Thermo Systems, Obrtniška cesta 3, SI-3220 Štore, Slovenia; http://www.sts-inc.eu/index.php?lang=en
I. Jerman, B. Orel, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia; e-mail: boris.orel@ki.si

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The contributions of this newsletter were presented at the 8th and 9th IEA-SHC Task 39 experts meetings in Aix Les Bains, France and in Munich, Germany. The authors are responsible for the content of their contributions. The newsletter is available as PDF-file at: http://www.iea-shc.org/task39/newsletters/. For more information on Task 39 visit the official website http://www.iea-shc.org/task39.