

Task 39: Polymeric Materials for Solar Thermal Applications

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NEWS

■ October 6-8, 2009

The 7th IEA-SHC Task 39 experts Meeting was hosted by the National Renewable Energy Laboratory (NREL) in Golden, Colorado, USA from October 6-8, 2009. 26 experts were present at the meeting. 10 participants were industry partners. Most of the presentations and the results from group work at the experts meeting are summarised in this newsletter.

The experts meeting included two half-day excursions to NREL professionally guided by Tim Bosch from NREL: The Mountain top facilities, Biofuels Facility, Outdoor Test Facility, FTLB labs, SERF and S&TF (see: <http://www.nrel.gov>). The diner and excursion on October 7 to The Fort Restaurant in Morrison were sponsored by FAFCO Inc.



Excursion to NREL's Mountain top facilities in Golden: (a) Group picture of Task 39 experts in front of solar spectrophotometer; (b) Solar furnace primary reflectors, concentrating up to 50,000X; (c) Gary Jorgensen explaining the ultra-accelerated natural-light UV concentrator (50X); (d) Attendees in front of the trough optical efficiency test rig; (e) Tom Stoffel discussing measurement of solar irradiance.

■ April 15-16, 2010

The 8th Task 39 experts meeting is planned to take place in Chambéry, France from April 15-16, 2009. CEA-INES will host the meeting. <http://www.iea-shc.org/task39/meetings>

■ September 27-28, 2010

The 9th 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 (Sept. 29 - Oct. 01, 2010) in Graz, Austria: <http://www.eurosun2010.org/>.

■ Task 39-related graduation

Very central contributions to the work in Task 39 were made in the frame of PhD- and master projects, in collaboration with our Task 39 research- and industry partners. Since April 2009 two graduations took place:



Susanne Kahlen

Aging behavior of polymeric absorber materials for solar thermal collectors, University of Leoben, Leoben, Austria, Mai 2009 (in co-operation with PCCL).



Ivan Jerman

Multifunctional polyhedral oligomeric silsesquioxanes as metal, textile and polymeric resin binder modifiers. PhD thesis. National Institute of Chemistry, Ljubljana, Slovenia, June 2009 (in co-operation with COLOR).

More, see: <http://www.iea-shc.org/task39/graduations/index.html>

Task 39 Active Supporters:



Temperature monitoring of different parts inside two prototype collectors produced by Söhner Kunststofftechnik, Germany

To examine temperature loads on different components and areas within a collector housing, two prototype flat plate collectors had been produced by Söhner Kunststofftechnik, Germany. The casings of both collectors were identically built from ABS by thermoforming. One collector was prepared with a selective coated absorber ($\alpha \approx 0.95$; $\varepsilon \approx 0.05 - 0.1$), the other with an absorber made from HDPE (modified) produce as a twin-sheet (α and $\varepsilon > 0.9$). The backside of the casings were insulated with approx. 6 cm mineral wool, no insulation was mounted at the sides. To maximize the thermal load on the collector casings, both collectors were equipped with transparent covers of anti-reflex glass with low content of iron oxide ($\tau \approx 0.95$).

Outdoor measurements of the irradiance on collector plane, the surrounding air temperature of the collectors and the respective surface temperatures of components inside the collectors took place in August 2009. From the measured data for both collectors the stagnation temperature was calculated according EN 12975-2:2006, Annex C. At a total solar irradiance on collector plane of 1000 W/m^2 and a surrounding air temperature of $30 \text{ }^\circ\text{C}$ the stagnation temperature of the collector with the selective absorber is approx. $175 \text{ }^\circ\text{C}$.

The project is funded by Deutsche Bundesstiftung Umwelt, Germany

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For the collector with the HDPE (modified) absorber it is calculated to be $135 \text{ }^\circ\text{C}$, respectively.

Even though the results reflect measurements of prototypes, in general the findings document that the temperatures of the inside surface of a transparent cover of a flat plate collector with a non-selective, black absorber are only marginal lower than of those equipped with absorbers with selective coating. To protect (polymere) casings of closed collector housings against harmful temperatures, independently of the kind of absorber, sufficient insulation of the backside **and** of the sides of the framing is mandatory.

Estimated temperatures at stagnation conditions

	absorber copper, selective coated	absorber HDPE, modified
backside side ¹⁾	70 – 75 °C	55 – 65 °C
transp. cover	100 – 110 °C	60 – 75 °C
	$\approx 105 \text{ }^\circ\text{C}$	$\approx 95 \text{ }^\circ\text{C}$

¹⁾no therm. insulation

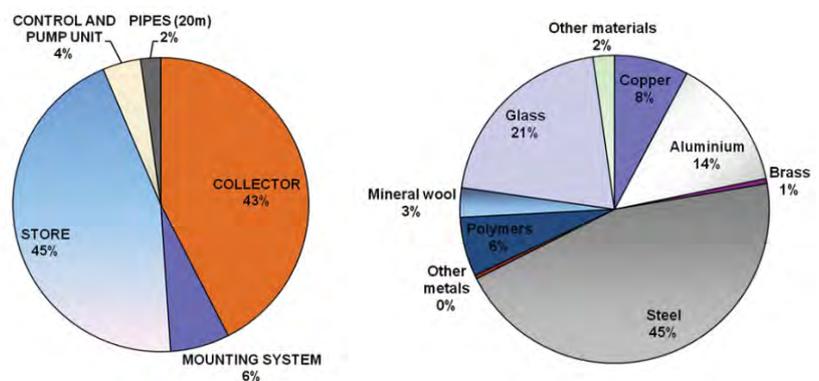
Materials used in conventional German combi systems

So called combi systems provide solar domestic hot water and hot water for space heating. A study was carried out to assess the materials used for the combi systems. Altogether 14 conventional German combi systems were investigated, 11 of them used flat plate collectors and 3 evacuated tubular collectors. The range of the collector area was between 7.3 and 14.3 m^2 and the store volume reached from 620 to 960 liters.

The average weight of the combi systems was found to be 517 kg, where the portion of the collector field (43%) and the heat store (45%) are almost identical. The remaining 12% are shared by the mounting system, the pump and control unit and the piping.

Steel is the material used most (45%) mainly used for the heat stores followed by glass (21%) for the glazing of the collectors. Aluminium (14%) is used for the collector casing and mounting systems but also more and more as absorber material.

The 8% copper are used for the absorber and pipes of the combi systems. The remaining materials (12%) comprise polymers (6%), mineral wool (3%) and other materials (3%).



Average fraction of the components (left) and average fraction of material (right) in Combi systems (2008).

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

■ **An Update on Work at the National Renewable Energy Laboratory**

Previous work at the National Renewable Energy Laboratory (NREL) has supported the development of low-cost SWH based upon polymer materials and manufacturing. Two low-cost SWHs have now entered the U.S. marketplace: i) an unglazed drainback system from FAFCO, and ii) a glazed integral-collector-storage system from Harpiris Energy. The FAFCO system consists of a PP/PE copolymer unglazed pool collector configured in a drainback configuration. The fluids enter/leave the pressurized storage tanks through a bottom connection at the drain valve location, enabling use of conventional electric storage tanks. The system (minus the storage tank) comes in a small box, enabling unconventional marketing channels like the shelves of big-box hardware stores and plumbing trucks. The Harpiris system consists of a PE rotomolded tank under an acrylic glazing containing solar-heated water. The heat is extracted from the (stagnant) water by a copper tube heat exchanger carrying the potable water. System hardware cost in both cases is less than 50% of the cost of similar-area conventional systems. Due to uncertainty in what solar thermal projects from industry and universities have been funded by the 2009 Recovery Act and what projects proposed by the laboratory will be funded, it is not certain what projects NREL will be supporting in the near future.

Jay Burch, National Renewable Energy Laboratory; jay.burch@nrel.gov

Harpiris Energy:



FAFCO Inc.



■ **Visually appealing solar heating systems**

One of the outcomes of Task 39 is a database, which includes projects where -not only function- but also aesthetics and architectural integration is focused. A small group of 3-4 experts (architects and solar thermal engineers) is proposed to evaluate the incoming projects for the database. The plan is that the database is hosted by IEA-SHC. Presently a questionnaire has been elaborated for the collection of projects for the database.

If you know of a project that could be of inspiration – please contact:

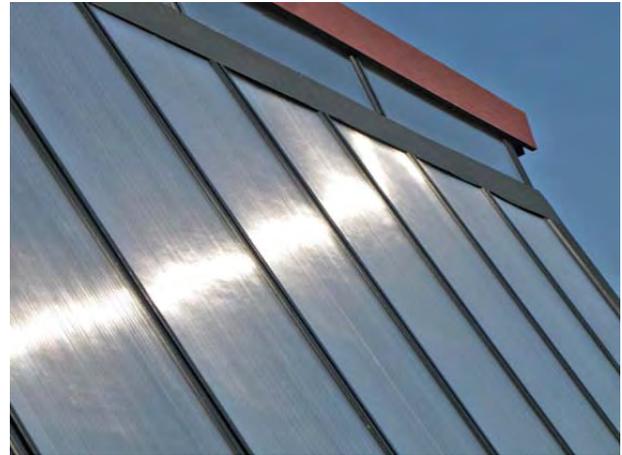
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■ **Challenges on the way from laboratory to practice**

High temperature performance (HTP) polymeric materials can withstand the thermal loads and hence substitute metals in glazed solar collectors. Numerous challenges on the way from laboratory to practice have to be solved, starting as in the present example with the extrusion of polymeric sheets and the injection molding of end caps. Strong, experienced and innovative industrial partners have to be part of the team during this process. Expertise with regard to the assembly of components (gluing, welding) has to be acquired, especially if the challenge is to use new materials in new shapes and applications.

But also questions related to inter-connection between modules, the drain back properties and balanced flow in complete array need to be addressed.



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■ **EMS-GRIVORY Introduction**

Christian Rytka, former representative of EMS-GRIVORY, had worked on Solar panel projects for the Task 39. His projects will be taken over by Mr. Michael Pabst, Application Development, and Dr. Botho Hoffmann, Research & Development, of EMS-GRIVORY. Due to this personnel change, Ms. Sabine Bertram, Application Development Engineer, of EMS-CHEMIE (North America) Inc., participated in the Task 39 meeting in Denver, CO in order to transfer the meeting information to Mr. Rytka's successors. Ms. Bertram introduced the company EMS-GRIVORY and the companies' specialty Nylon products that could be of interest for the solar panel development to the participants of this Task 39 meeting at NREL in the US.

EMS CONTACTS T39

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Fig. 1. Contact persons EMS-GRIVORY

Overview of EMS-GRIVORY

Product Range

<p>GRIVORY[®] </p> <ul style="list-style-type: none"> • Partially aromatic polyamide • (PPA) <p>Grivory GV Grivory HT Grivory G Grivory HB</p>	<p>Grilamid[®] </p> <p>Polyamide 12 Transparent polyamide</p> <p>Grilamid L Grilamid TR</p>	<p>GRILON[®] </p> <p>Polyamide 6 Polyamide 66 Polyamide 66/6 Co-polyamide</p> <p>Grilon B Grilon A Grilon TS Grilon C</p>
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Fig. 2 EMS-GRIVORY Products

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■ Overview of application methods for Thickness Insensitive Spectrally Selective paint coatings

There are dozens of ways to apply liquid Thickness Insensitive Spectrally Selective (TISS) paint coatings on metallic or polymeric substrates. Paint application techniques can be divided into two basic types, spray application method and bulk (dip, roll and coil coating) application method. Spray coating is an application of paint on one part at a time and is most common application used across many industries. It is also suitable for TISS paint coatings especially because in case of the finished absorber we have to apply spectrally selective coating just on one defined side. On the contrary, bulk techniques imply coating on many parts at one time or coating continuously. Coil-coating technique as example enables continuous production of flat substrate. The coated sheet can be cut up and post-formed by bending, folding, or pressing into the needed shapes. In the case of coil-coating process TISS paints should have determined rheological behavior. They have to be thixotropic yield-stress fluids, which exhibit viscosity change with, shear. Viscosity drop consecutively enable fast levelling of ribbing surface before hardening in oven. Steady-state rheology of TISS paints predicts the applicability for deposition on various substrates. The quality of the final TISS coating is in our case determined by optical properties (high absorption, low emittance), and self-cleaning surface property.



Fig. 3. Water drops on surface of the TISS paint coating.

Without optimization of different application methods we did not find out any difference in solar absorptance for the same TISS paint coating, but the emittance increased which shows necessity of the optimization of particular technique. Self-cleaning property was achieved by addition of the low surface energy polyhedral oligomeric silsesquioxane additive.

Ivan Jerman, Lidija Slemenik-Perše, Boris Orel, NIC – National Institute of Chemistry, Slovenia, Ivan.Jerman@ki.si

■ Degradation analysis of new polymeric absorber materials and selective coatings

Durability and weatherability of polymeric materials are essential preconditions for the use of these materials in solar energy systems. Fraunhofer ISE therefore analyzes the durability of different types of polymers with different stabilization systems and coatings. Non-destructive optical methods like Fourier Spectroscopy and Raman Microscopy with high lateral resolution are used for the characterization of materials.

While there are significant changes after exposure to high temperatures and high humidity (damp-heat testing), it turns out that Polyamide (PA) samples with an optical selective AZO-coating as well as Polycarbonate (PC) samples with a visually transparent coating do not even show changes in the optical parameters after UV ageing (see Fig. 5).

Raman Microscopy shows strong fluorescence due to photo-degradation both after UV- or damp-heat-exposure (Fig. 6). This shows that the stability of both coatings and materials has to be improved further. In this respect, coating of the materials with a barrier layer seems to be one possibility.

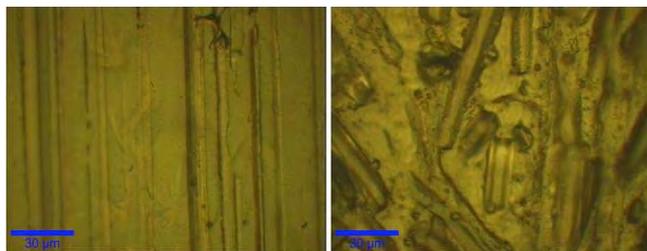


Fig. 5 Micrograph of uncoated PA-sample with 0,5% CNT before (left) and after 600h UV-exposure (right graph).

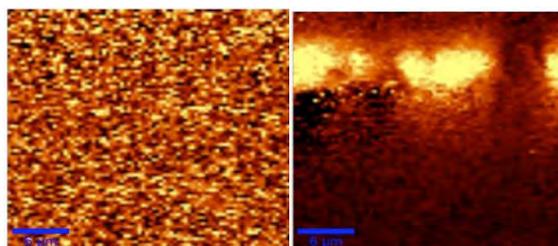


Fig. 6 Raman depth-scan before (left) and after 600h combined damp-heat and UV-exposure (right graph) of AZO-coated PA-samples with 1% CNT.

Karl-Anders Weiß, Fraunhofer ISE, Germany; karl-anders.weiss@ise.fraunhofer.de

■ Sulfone Polymers for Plumbing Systems

Sulfone polymers from Solvay Advanced Polymers have successfully replaced brass in pressurized hot water applications for over 20 years. The tough, heat resistant plastics can be molded to tight tolerances and exhibit low creep under a sustained load at elevated temperatures. This, combined with their excellent oxidative resistance, has made sulfone polymers a reliable choice for applications that require continuous exposure to hot chlorinated water. Key Features include excellent compressive strength, low tensile and compressive creep, outstanding long-term hydrostatic strength and the ability to withstand continuous exposure to hot chlorinated water. <http://www.solvayplumbing.com>



UDEL® polysulfone was chosen for dip tubes in APCOM's self-cleaning commercial water heaters because of its ability to withstand long-term exposure to hot chlorinated water.

Fig. 4. Udel® Polysulfone

Pat Neel, Solvay Advanced Polymers, pat.neel@solvay.com

■ Application of Polymer Materials to Solar Thermal Systems

Researchers at the University of Minnesota are investigating the use of polymers for solar thermal systems. The focus of this research includes: prediction of lifetime for polyolefins exposed to hot potable (chlorinated) water, evaluation of CaCO₃ scale formation and removal on polymer tubes, and investigation of overheat protection for glazed polymeric collectors. To predict the lifetime of polyolefins, a model for antioxidant loss was developed. This model includes diffusion of antioxidant and chlorine in the polymer and chemical reaction of chlorine ions and antioxidant. An experimental study, in which polymer samples were exposed to either reverse osmosis water or chlorinated water (5 ppm), showed that the time scale for diffusion of the antioxidant out of the polymer is much slower than the chlorine diffusion or reaction time scales. There is good agreement between model predictions of antioxidant depletion and the experimental data, as measured by oxidation induction time (Figure 7). An experimental study of scale formation on polypropylene (PP) and copper tubes (Cu) with exposure to mildly supersaturated potable water (typical of municipal water supplies) was conducted. Scale accumulates on both materials at the same order of magnitude, but phosphate ions and other species in the water impact the effect of substrate material on scale formation. In Minneapolis city water, in which phosphate ions are present, the amount of scale as represented by its calcium ion content is slightly higher on copper than on polypropylene (Figure 8). Measurement of removal of scale by fluid shearing forces indicates scale is more easily removed from PP, and by inference other polymeric materials, than copper by flushing with water.

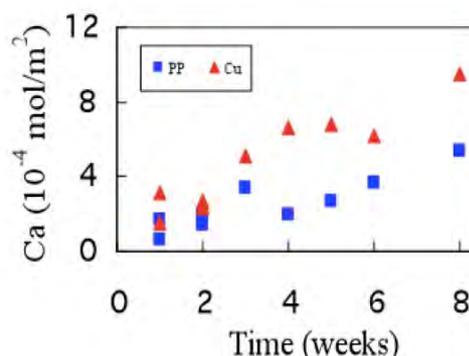


Fig. 8. Ca formation on PP and Cu surfaces exposed to mildly supersaturated water ($S=4$, $pH=8$, $T=40^\circ C$).

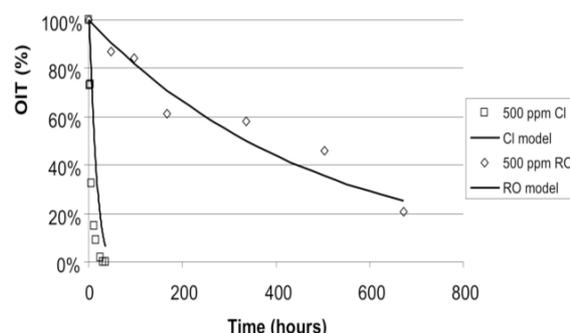


Fig. 7. Antioxidant depletion in PE samples (300 microns thick) exposed to 80 °C chlorinated (5ppm, 7 pH) water or reverse osmosis water.

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