Bioplastics for solar collector components

INFO Sheet C5

Description:	*Novel materials* *Green systems*
Date:	May 2015
Authors:	Katharina Resch, Montanuniversitaet Leoben Andrea Klein, Montanuniversitaet Leoben Gernot Oreski, Polymer Competence Center Leoben
Download at:	http://task39.iea-shc.org/publications

Introduction and scope

Numerous research and development activities carried out by renowned research facilities and the global players in the polymer and solar industry – presented and discussed also within the framework of IEA SHC Task 39 – demonstrate that polymers are the materials of choice for next generation solar thermal systems [1]. In addition to classical polymers made from petrochemical resources bioplastics (i.e. polymers based on renewable resources and/or biodegradable polymers) have been introduced as a sustainable and seminal alternative [2,3]. Bioplastics are already successfully used in the automotive and electronic industry [3]. Therefore, bioplastics are expected to have a high potential in the solar industry as well, yielding further greening of solar thermal systems. However, so far no systematic and comprehensive investigation of bioplastics for solar applications has been carried out. Hence, in scientific literature there are almost no data on relevant properties regarding solar applications (optical, mechanical, and thermal properties). Also the material characteristics after exposure to application relevant external stress factors such as ultraviolet (UV) radiation, humidity and temperature have not been investigated extensively so far. Therefore, within the project "Bio4Sun – Bioplastics for solar applications" (funded by the Klima- und Energiefonds (Austrian Climate and Energy Funds) and carried out within the framework of the e!mission program) the principle potential and applicability of bioplastics in solar thermal devices (absorbers, glazings, framing for various collector types) was evaluated and tested.

Material selection, processing and characterization

In total 38 materials were selected following extensive literature research and market survey. Elected biopolymers include cellulose derivatives (CA, CAB), thermoplastic elastomers (TPU, TPE, TPA), poly lactic acid (PLA) and blends thereof, poly hydroxy alcanoates (PHA, PHB), poly trimethylene terephthalate (PTT), bio polyethylene (PE), poly butylene succinate (PBS) and blends thereof, bio polyamide (PA) as well as starch blends. Bioplastics were extruded into films with a thickness between 200 and 500µm on a Dr. Collin Laboratory extruder. Following a basic characterization after extrusion into films, several of the biopolymers were nominated for further investigation regarding their ageing behavior. Depending on the specific application (collector glazing, absorber, swimming pool absorber, air collector etc.) accelerated ageing was done on film specimens in air, in air including UV radiation (Xenontester), and in water at various temperatures ranging from 35°C up to 80°C. Specimens were tested after 250, 500 and 1000h of exposure. Moreover, outdoor exposure is conducted for 2.5 years with specimens being tested after 3, 6, 12, 18, 24 and 30 months. Characterization of as-produced and aged samples focused on thermal, thermo-mechanical, mechanical and optical properties. Differential Scanning Calorimetry (DSC), Dynamic Mechanical Analysis (DMA), tensile testing, UV/Vis/NIR spectroscopy and IR spectroscopy were applied.

Performance characteristics and applicability

The generated polymer physical property profiles of as-produced samples indicated that bioplastics in general possess a high potential for application in solar thermal devices. However, long-term service temperatures are limited. Thus bioplastics available so far are mainly suitable for low-temperature components (glazings, swimming pool absorbers, air collector absorbers) or for components with integrated overheating protection (e.g. flat-plate collectors with thermotropic glazing or integrated venting mechanisms). Most promising candidate materials are CA, CAB, PA, Bio-PE, PTT, PLA and blends of it, PHA, and PBS. Several biopolymers came into consideration for more than one component type. Ageing tests emphasized the potential of bioplastics for application in solar thermal technology. However, also high potential and necessity for further optimizing performance properties by using specific or functional (bio-) additives to enhance long-term service temperatures and thermo-mechanical characteristics as well as long-term stability were revealed. Especially after exposure to UV radiation or storage in water at elevated temperatures deterioration in mechanical performance characteristics was determined. Details are found in:

Resch, K., Klein, A., Oreski, G. (2014). Bioplastics in solar thermal applications: opportunities and limits, manuscript in preparation.

Klein, A., Oreski, G., Resch, K. (2014). Ageing characteristics of bioplastics, manuscript in preparation.

References

[1] Meir M et al. Polymeric Materials for Solar Thermal Applications. 1st ed. Weinheim: Wiley VCH; 2012.

[2] Endres H, Siebert-Raths A. Technische Biopolymere. Rahmenbedingungen, Marktsituation, Herstellung, Aufbau und Eigenschaften. 1st ed. München: Hanser; 2009.

[3] www.european-bioplastics.org