Final Report

Project acronym: *Bio4Cryo*

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M-ERA.NET Call 2017

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2. Publishable project summary

Focus on methodology, results and conclusions (max. 1 page).
Please note: The publishable summary will be used for dissemination by M-ERA.NET and the EC.

The Latvian State Institute of Wood Chemistry, Cracow University of Technology, Warsaw University of Technology and the Polish company Damiton FW were consortium partners in the international M-Era.Net activity project "Development of Cryogenic Insulation Modified with Nanocrystalline Cellulose from Renewable Resources" (acronym Bio4Cryo). The implementation of the project took place from 2018 to 2021. The Bio4Cryo project was structured in 7 work packages.

The project as a whole was a complex study, where the partners' knowledge in chemical synthesis, nanotechnology and materials science was used, which resulted in a real multi-layer cryogenic insulation material. Cryogenic insulation is not only important for space technologies, but it is also needed wherever very low temperatures occur, such as the transport of liquefied natural gas and the increasingly widespread use of zero-emission hydrogen technologies. The polyurethane (PU) industry is also following the European Green Deal and is interested in producing materials from renewable feedstock equivalent to or better than those currently available on the market from petroleum raw materials.

As the most promising raw material for bio-polyol synthesis was defined rapeseed oil. The batch parties of two different bio-polyols with low and high functionality were synthesized. Both polyols were combined in different ratios to develop polyol component for cryogenic insulation.

Nanocellyulose (NC) was obtained using wood dust from local wood processing plants. It was recognized that the ammonium persulphate method was the most efficient and less harmful, and obtained NC was with higher crystallinity (70%).

Thermo-reflective coatings based on acrylic dispersion, glass microspheres, rheology modifiers and anti-corrosion and flame-retardant substances were developed. The material had good adhesion to PU foam. Total Solar Reflectance of coatings was >98%.

Spray applied PU composition was developed with optimum content (1.5%) of dispersed cellulose. Higher amounts of NC drastically increased polyol viscosity. The most feasible method for dispersing cellulose in polyols was using a mechanical stirrer followed by subjection to a calender.

Basic characteristics of the rigid PU foams, such as compression strength, tensile strength, Young's modulus at room and cryogenic temperatures, Poisson's ratio at room temperature, cell size, closed-cell content and apparent density, were tested. More than 40 series of PU foams with different low functional and high functional polyol ratios, different types of blowing agents, and different types of micro-nano cellulose and their concentration were tested, and optimum concentration was selected for up-scaling.

A pilot-scale liquified gas storage container was developed using a spray-applied rigid PU system. The optimal PU composition withstood thermal stains at cryogenic temperatures, and the achieved safety coefficient of the composition was > 2.5, which is very important for cryogenic insulation.

Life Cycle Assessment of two rapeseed oil-based bio-polyols produced at a pilot-scale reactor was performed. The bio-polyols showed a lower environmental footprint when compared to petrochemical polyol. Moreover, a detailed inventory of rapeseed and its oil production in Northern Europe was built and can be used in other studies.

The scientific output of Bio4Cryo is – 13 scientific articles, 5 of them joint research publications and 1 national patent application. The developed multi-layer cryogenic insulation has the potential for commercialization, which could benefit the industry of both partner countries. The publication of the project results will ensure the visibility of the institute and universities in the international scientific area.