Period Report WOODLIFE Month 18

Publishable summary

1. <u>A summary description of the project context and the main objectives. The length of this part cannot exceed 4000 characters</u>

The long term objective of the WOODLIFE project is to provide coated and glued wood products with substantially improved durability for a more sustainable society. The project aims to develop new water-based clear coating systems for wood with improved UV-absorbing properties, and to develop new water-based thermoplastic wood adhesives with improved mechanical properties. The new coating and adhesive systems will be designed through molecular manufacturing of inorganic nanoparticles, nanoclays and composite organic-inorganic binders with predictable and controllable properties.

Wood is an excellent building material with a high strength/density ratio and it is a renewable resource. For outdoor use it is, however, necessary to enhance the durability of wood materials due to the high sensitivity for UV degradation. Traditionally, organic UV-absorbers are used in clear coatings for wood, however these substances degrade upon outdoor weathering. New UV-absorbing systems for clear coats will be developed in the project based on nanoparticles of mainly CeO_2 and ZnO. With these new systems the service-life of the coated wood will be extended and the cost for maintenance and wood replacement will be decreased.

If the mechanical properties of water-based thermoplastic wood adhesives such as polyvinyl acetate (PVAc) can be improved it would be possible to use the wood products based on these systems for a longer time, leading to a more sustainable society. It would also be possible to use PVAc adhesives instead of the more expensive MUF/PRF adhesives in some load-bearing applications. Engineered nanoparticles will be developed in the project and will be introduced into wood adhesives in order to improve the properties of wood-adhesive joints.

The nanoparticles and nanoclays that will be developed in the project will either be added directly to water-based systems or incorporated in hybrid binders in order to improve the dispersion of the nanoparticles and to improve storage stability.

The following tasks will be performed in the project to reach the main objectives:

- Development of metal oxide nanoparticles by molecular manufacturing that have an absorption in the range 250 - 440 nm and that are well-dispersed in water-based clear coating formulation, and thus give a transparent coating film in the visible part of the UV-VIS spectrum.
- Development of metal oxide nanoparticles by molecular manufacturing that have an absorption in the range 250 - 440 nm and that are suitable to incorporate in polymeric binders for clear coating application in order to get a well-dispersed system, and thus give a transparent coating film in the visible part of the UV-VIS spectrum.
- Surface modification of nanoclays and nanosilica particles in order to incorporate them in a water-based adhesive or in the binder particles of a water-based adhesive.

- Development of composite binders containing well-dispersed metal oxide nanoparticles for water-based clear coating applications.
- Development of composite binders containing well-dispersed nanoclay particles or nanosilica particles for water-based adhesive applications.
- Formulation of clear coating systems and adhesive systems with suitable wet state properties (rheology and wetting of wood for example) and dry state properties (film formation and adhesion to wood for example).
- Production of a water-based clear coat prototype with the following properties: UV-absorption 250 - 440 nm, high transparency, 2-5 times longer service-life of coated wood panels compared to the reference systems used today (estimated from accelerated weathering test).
- Production of a water-based wood adhesive prototype with the following properties: low cold creep of corresponding wood joints, temperature resistance of corresponding wood joints, low formaldehyde content.

2. *A description of the work performed since the beginning of the project and the main results achieved so far. The length of this part cannot exceed 4000 characters.*

The following work has been performed since the start of the project:

- To start with, the relevant state-of-the-art of UV-absorbing nanoparticle dispersions, nanoclay systems and hybrid binders was summarized in literature, patent and market surveys of the three areas.
- In the development of UV-absorbing nanoparticles YKI, Energenics, SIRRIS and BYK have produced a series of nanoparticle dispersions. Both water-based dispersions and solvent-based dispersions have been developed. YKI has focused on CeO_2 nanoparticle dispersions and liquid-phase methods have been used to produce the dispersions. Energenics has worked at the development of CeO_2 and modified CeO_2 systems with liquid-phase methods. SIRRIS has developed ZnO systems using liquid-phase methods and plasma methods. BYK has tested different dispersing agents and optimized the dispersion of some of the metal oxide nanoparticle systems. UV-Vis spectra of the nanoparticle dispersions have been obtained and the systems were evaluated based on absorption in the UV-range and transparency in the visible part of the spectra. A couple of nanoparticle systems with the best optical properties were selected and used in new clear coatings.
- Eka has evaluated a number of different colloidal silica samples in adhesive formulations with PVAc (polyvinyl acetate). Both commercial samples were tested and new samples were synthesized for the WOODLIFE project.
- Nanoclay systems have been developed at Laviosa and UPV/EHU. Laviosa has supplied a range of nanoclay products with different properties and UPV/EHU has developed a new surface modification of nanoclays that is suitable for the incorporation of nanoclays in hybrid adhesive binders.
- UPV/EHU has developed hybrid binders, both acrylate-based binders for clear coatings and PVAc-based binders for adhesives. Stable hybrid latex acrylic binders with UV-absorbing nanoparticles from batch and semi-batch polymerizations were

obtained. Microscopic observations of the latexes show that the nanoparticles are uniformly dispersed in the latex, either on the surface or inside the latex particles.

- New clear coating formulations have been developed by PRA, using the hybrid binders from UPV/EHU. Formulation of adhesives has been performed by Casco and Eka.
- Testing of nanoparticles and nanoclay systems has been performed by SP, YKI, PRA, AkzoNobel and Energenics through for example UV-Vis measurements, TEM analysis and particle size measurements.
- Testing of clear coatings has been performed by SP and PRA. Wood panels have been coated with new clear coating formulations and natural exposure field tests have been started with exposure sites in Sweden and UK. Protocols for accelerated ageing have been set up. Haze and colouring effects of the new clear coatings have been evaluated by AkzoNobel.
- In the testing of wood adhesives Casco has tested systems with colloidal silica or nanoclays, according to the tests EN 204 (wet strength) and Watt 91 (heat strength).
- The initial sustainability assessment of the new coating and adhesive systems that will be developed in WOODLIFE has been performed by SP in collaboration with the other project partners. This work has resulted in a literature survey of potential toxicological effects of nanoparticles (including genotoxicity), setting up ecotoxicological test and initial life cycle assessment of clear coating systems.
- The dissemination of results from the project so far has been achieved by; creating a web-site, setting up a plan for protection of IPR, presentations at conferences.
- The consortium management of the project has consisted of the following tasks; risk log management, creating and submitting deliverables and reports, following costs in the project in 6-month periods, organization of management board meetings and exploitation board meetings.

3. <u>Description of the expected final results and their potential impacts and use (includind socio-economic impact and the wider societal implications of the project so far). The length of this part cannot exceed 4000 characters</u>

The expected final results from the WOODLIFE project include:

- A novel water-based clear coating to be used for wood applications with the following properties: UV-absorption 250 - 440 nm, high transparency, 2-5 times longer service-life of coated wood panels compared to the reference systems used today (estimated from accelerated weathering test).
- A novel water-based wood adhesive (PVAc) with the following properties: low cold creep of corresponding wood joints, temperature resistance of corresponding wood joints, low formaldehyde content.

The potential impact and use of the new clear coating and adhesive systems can be summarized in terms of environmental impact and economic/social impact:

The global warming is one of the biggest environmental issues facing mankind today. There are strong indications that the emission of CO_2 is the main cause for this. The CO_2 in the atmosphere can be reduced by reducing emission or by removing partly the CO_2 already present in the atmosphere, by reducing carbon sources or by increasing carbon sinks. Wood can do both. Thus, wood products can help to reduce the climate change. Furthermore, the carbon storage can be extended by increasing the lifespan of wood products. Thus, it is desirable to increase the use of wood materials in buildings for example by using wood instead of plastics or aluminium in window frames and other exterior building components. However, since clear coated wood products have a high need of maintenance today, they are often rejected as a building material. Thus, there is a need for new clear coatings for wood with increased service life. The negative environmental impact of degradation products with traditional organic UV-absorbers in clear coatings is also a problem that can be avoided using the new clear coating systems that will be developed in WOODLIFE.

The new PVAc adhesives that will be developed in WOODLIFE with improved mechanical properties may compete with the traditional formaldehyde-based system for some wood applications. The use of more durable wood adhesives will extend the service life of glued wood products and this will also contribute to a reduction of CO_2 in the atmosphere.

The wood working industry is a very important industrial sector for Europe. With the development of improved clear coatings and adhesives systems we can foresee a positive development of this sector.

AkzoNobel Nobel Deco GmbH has calculated the possible savings over 10 years using a maintenance free coating compared to the clear coatings used today. For example, for a wood window area of 22.000m^2 for the object “Campeon” in Germany it is possible to save 589.5 k€ for this object only, using new clear coatings from WOODLIFE.

The market for wood adhesives is estimated to be 4 million tons per year worldwide of which 600.000 tons are produced in Europe. If the creep and thermosensitivity of the PVAc adhesives are sufficiently reduced it is expected that part of the more expensive MUF adhesives can be replaced by PVAc adhesives. It is also likely that an increased technology gap between Europe and the rest of the world will increase the amount of adhesives produced in Europe securing more jobs in Europe.

The use of adhesive chemicals only makes 3 % of the worlds fastening market. There is an increasing demand from the construction and assembly industries for adhesives that can replace mechanical fixing industries. Thus, the potential for growth of the adhesive market at the expense of the traditional mechanical fixing technologies is enormous, but this growth can only be realized if adhesive technologies can be enhanced so that they achieve the necessary performance for replacing existing technologies. The new WOODLIFE adhesive systems can contribute to this development.