R&D of polymer composite materials based on natural fibres - BL/01/V10

Context and objectives

This project fits very well with the second theme of the collaboration framework between Belgium and Vietnam, which focuses on "sustainable development": Biodiversity and agro-biotechnology as source of new materials, renewable energy and medicine.

This project aims at valorising agriculturally obtained fibres into higher added value products, more specifically into new structural materials. These new materials are moreover environmentally friendly.

Natural fibre composites fit into the framework of sustainable development and more specifically sustainable materials on various fronts: natural fibres are a CO2 neutral and renewable material source, have a low energy utilisation, are lighter again than traditional composite materials and have high specific mechanical properties. They can be recycled if combined with thermoplastic matrix; combined with biodegradable matrices, truly biodegradable composites can be made; on the points of health and safety, natural fibres are less abrasive and more pleasant to handle and last but not least natural fibres are typically low cost, affordable materials, allowing wide-spread use in less developed areas.

This project should result in new extraction techniques for Vietnam-grown natural fibres, specifically bamboo, coconut and water hyacinth, into yarns or other forms ready for composite processing. Fibres will be treated based on a scientific approach of matching surface chemistry and surface tension. Environmentally sound treatments will be chosen to compatibilise fibres and polymer matrices. An economically viable route will be investigated to process the fibres into composites, for both thermoplastic and thermoset matrices. Composite mechanical performance will be characterised and benchmarked against synthetic fibre composites, with the expectation that competitive natural fibre composites can be developed.

Methodology

WP1: Survey of natural fibre sources. A survey of availability and available qualities of specifically bamboo, coconut and water hyacinth fibres in Vietnam.

WP2: Technology of extraction and characterisation of fibres. New extraction methods will be evaluated, particularly a new process for the extraction of bamboo fibres developed in Columbia. Characterisation of single fibre mechanical properties, geometry and microstructure.

WP3: Treatment and modification of fibres. Characterisation of fibre surface chemical composition. Development of methodology to measure fibre and matrix surface tension. Chemical fibre treatments and measurement of interfacial adhesion strength.

WP4: Processing technology: Preparation of both thermoplastic composites by injection moulding, extrusion and compression moulding and thermoset processing by RTM and compression moulding.

WP5: Characterisation and testing of composites: Static mechanical testing, durability testing, moisture absorption and biodegradability.

WP6: Dissemination of knowledge: Training and exchange of specialists, workshop and seminars and employment of Vietnamese PhD students in Leuven on separate grants.

Results

WP1 Survey of natural fibre sources: our Vietnamese partners have conducted a survey of the availability of the various natural fibres in Vietnam.

WP2 Technology of extraction and characterisation of fibres: HUT has made progress in the steam explosion method of extracting bamboo fibres; CTU has developed their so-called "bristle-fibre" method for the extraction of coconut fibre, allowing extraction of significantly longer and straighter fibres. The Columbian people who are now working again at KU Leuven in the framework of this project, have made good progress with their mechanical rolling process, allowing very low damage levels in technical bamboo fibre. A working prototype machine is now available.

There is however still a lot of work necessary in the subsequent handling of discontinuous and rather thick coconut and bamboo fibres. Normal spinning of yarns is not possible due to the nature of these fibres.

WP3 Treatment and modification of fibres: This is an important part of the project and still ongoing. Focus has in first instance been on developing methods to determine fibre surface energies and to characterise the fibre-matrix interfacial wetting and adhesion. This work will be expanded upon by the current PhD student who recently came over from Vietnam (2008-2012).

WP4 Processing Technology: Conventional composite manufacturing processes for thermoplastics and thermosets have been and are being employed without major problems.

WP5 Characterisation and testing of composites: Work here is still ongoing. Especially bamboo-epoxy composites show good performance due to the good interfacial adhesion.

WP6 Dissemination of knowledge: Workshops/seminars are still being planned. The project coordinator presented first project results on the ISUP-2008 conference on sustainability in Bruges. Visits to Vietnam were paid by the project supervisor (Prof. Verpoest) and the chief composites technician from MTM for technical support. A visit of the project coordinator to Vietnam is planned for early 2009. As mentioned, a first PhD student from CTU has now started a 4 year PhD track in Leuven.

Products and services

International conference proceedings:
1) van Vuure, A.W., Verpoest, I., Natural Fibre Composites; recent developments; Proceedings of i-SUP 2008, Bruges, 22-25 April 2008

Journal paper in preparation:
1) Nele Defoirdt, Aart van Vuure, Ignaas Verpoest, Measuring tensile properties of tropical plant fibres for composites, to be published in probably Composites, part A.

Execution

Period: November 2006 – October 2009

Laboratory/network :

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Discipline

Chemistry
Forest & natural vegetation
Agriculture Environment
Materials (bio- etc.)