Universitatea *Transilvania* din Braşov

HABILITATION THESIS

SUMMARY

Title: COMPOSITES MADE FROM RECYCLED AGRICULTURAL AND INDUSTRIAL WASTES

Domain: FORESTRY ENGINEERING

Author: Ass.Prof.Dr.Eng. Camelia COŞEREANU

University *Transilvania* of Braşov

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Summary

During the last years it got obvious that many toxic substances have become so widely distributed in the natural environment as to cause significant effects on the people's health. It is the case of formaldehyde and of polystyrene, which are considered to be probable human carcinogens. Formaldehyde is used mainly to produce resins used in particleboard products and particleboards are the main raw materials for furniture manufacturing, polystyrene is the common material used for thermal insulating of the buildings, both of them affecting day by day our health. On the other hand, due to the shortage of forest resources, new strategies for the sustainable use of other lignocellulosic materials must be implemented. The new strategies require research work focused on new engineered materials with low ecological impact, addressing societal challenges and technological needs with an interdisciplinary approach. Materials science has become one of the most dynamic engineering disciplines, due to significant efforts made to ensure industry can meet the challenges it currently faces, in terms of the new materials being introduced and the stronger integration of products and processes required. The habilitation thesis entitled "*Composites made from recycled agricultural and industrial wastes*" aims at promoting alternative composite materials to particleboards, green products with low ecological impact in terms of ultra-low formaldehyde emission and use of agro-waste and by-products not valorized yet and at substituting wood and save forests.

The scientific research presented herein after was performed between 2006 and 2015, after obtaining the doctoral degree in „*Industrial Engineering*" in May 2006, and is a part of the personal original contribution to the biocomposites field in the conditions when resources continue to decrease, and it becomes necessary to develop wood adhesives based on renewable resources, as alternative materials to the most common resins used in the production of wood-based panels, as formaldehyde-based resins and isocyanate. The results of the research were published in *Thomson ISI Journals* and journals indexed in international databases, and a part of them are the object of patent proposals.

The habilitation thesis is structured on three main directions of composites research, each one being presented in a separate Chapter.

Chapter 1, entitled „*Study of using agricultural wastes in classical structures of lignocellulosic composites"* presents the experimental work of manufacturing and testing in the laboratory conditions of structures similar to particleboard, replacing totally or partialy the wood particles with other lignocellulosic resources obtained as waste from the agricultural sector, as the sunflower seed husks and rape stalks are. The research work in this field is new in Europe and a starting point in Romania, focused on finding alternative materials to the classical raw

materials in buildings and furniture manufacturing sector, for providing a long-term sustainable development of these industries, even in the conditions of wood resources shortage.

This type of research requires imagination and creativity, in order to make the proper combinations and find the most suitable solutions for getting the performance. It usualy ends with „it's possible" or not. It needs small steps first, followed by accurate conclusions that open new sequential directions in research. This is the case of the research work presented in Chapter 1. First, sunflower seed husks were investigated as alternative materials for wood in the structure of single-layer and three-layer particleboard, as fine and coarse particles, using the classical UF (urea-formaldehyde) resin as a binder. The biocomposites were manufactured in the laboratory conditions and tested for density, internal bond, bending strength and MOE and screw withdrawal. The results have shown that only the fine particles of this resource met the standard SR EN 312 requirements, except the bending strength. The next step was to investigate other classical resins for these structures and in this case good results were obtained for the coarse particles of sunflower seed husks glued with polyurethane resin. Rape straws were also investigated as potential raw materials for particleboards, using UF resin. The same protocol of manufacturing and testing the biocomposites was followed. The results have shown that the rape straw particles increase the bending strength of the biocomposites, but have a negative influence on the results of the internal bond of the panels.

Chapter 2 entitled „*Research on obtaining biocomposites without resins"* presents the investigations on the possibility of producing particleboards without resins. Based on the previous researchers' results, the adhesives were replaced by lignin PROTOBIND 1000, a powder lignin which substitues 15% of the phenolic resins in various applications. The lignin was used in its original state, not modified as found in the literature for increasing its reactivity. It was mixed with wood particles and then with sunflower seed husks and rape straws, separately. The structures could not met the SREN 312 requirements, but close values were obtained for structures made from lignin and fine particles of sunflower seed husks. Promissing results obtained for lignin based structures so far, encouraged the next step in research, namely to use lignin and pulp extracted from wheat straws, rape stalks and recycled paper in manufacturing new biocomposites. Good results were obtained by mixing lignin with pulp extracted from wheat straws and with recycled paper.

In *Chapter 3* entitled „*Study of new thermal- and soundproofing panels made from industrial waste",* new composites made from ABS waste and planner shavings were studied. Experimental determinations of thermal conductivity coefficient and sound absorption coefficient were performed. Attempts of designing and testing new composites with similar applications, using industrial textile wastes (wool fibers) and different binders, were performed in the frame of the *Contract no. 72-200/2008, Programme no. 4 - Partnerships in The Prioritary Fields,* coordonated by the author of the present habilitation thesis between 2008 and 2011. The theme and results of the contract entitled „*(Bio)Degradable Composites with Textile Inserts for*

Ecological Environemtal Products", BIOCOMPTEX acronyme, were disseminated in a book, three scientific papers were published in ISI journals and three were published in a journal indexed in *CABI, DOAJ, DRJI, EBSCO Publishing Ltd. Academic Search Complete, INDEX COPERNICUS.*

Chapter 4 entitled „*Final conclusions and personal original contributions*" is a synthesis of the results of the research work developed in the last ten years by the author of the present habilitation thesis, comparing the properties and prices of the new proposed products with those already existed on the market.

Since 2006, the research and proffessional activities of the author of the present habilitation thesis are prooved by the following publications: 10 books, 1 international book chapter, 2 support courses, 2 book chapters containing the dissemination of the research activity in the frame of the *BIOCOMPTEX* project, 8 papers published in *ISI Thomson* indexed journal, from which **4 papers** with an **impact factor >1,00** (2 papers in *Environmental Engineering and Management Journal* with an **impact factor of 1.004**, 1 paper in *European Journal of Wood and Wood Products* with an **impact factor of *1.105***, 1 paper in *BioResources* with an **impact factor of *1.549***) , 6 papers published in *ISI Proceedings*, 36 papers published in other international data basis (*CABI, DOAJ, DRJI, EBSCO Publishing Ltd. Academic Search Complete, INDEX COPERNICUS, Google Scholar)* and 43 papers presented at the international conferences in Romania and abroad, **a total of 108 publications**. The author of the present habilitation thesis has also coordinated 1 national grant and 1 research project, being member in other 6 grants. The international visibility is proved by the 23 citations, 7 of them in ISI Thomson indexed journals and by 7 patents applications, 6 abstracts being already published, 1 of them being prepared for issuing the *Patent Certficate*, related to the research work presented in *Chapter 3* of the present habilitation thesis .

The future scientific and academic career will be focused on two directions:

- to continue the investigations on biocomposites and to disseminate the results in *ISI Thomson* indexed journals, trying to finance the research work by national and international grants and use the results to improve the courses in the academic activity.
- to develop the research and academic activities on furniture manufacturing technologies, testing alternative technologies and spreading the knowledge in this direction by creating internet accesses databasis in the frame of future projects (*Erasmus*$^{+}$ project proposal ERGOSIGN entitled *„Novel learning approach for ERGOnomic principles for deSIGNers working in the upholstery and sleep sectors by using Virtual Reality"*, submitted March 2015), as coordinator.