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## **How to transfer the scientific knowledge from research to industry in the field of the recovered wood?**

A. JMAL<sup>1,\*</sup>, A. NDIAYE<sup>2</sup>, F. MICHAUD<sup>1</sup> and M. IRLE<sup>1</sup>

<sup>1</sup>LUNAM université, Laboratoire Matériaux Composites Bois, Ecole Supérieure du Bois  
Nantes, France.

<sup>2</sup>INRA, UMR927, I2M, Université de Bordeaux/CNRS/INRA, Talence, France.

\*Corresponding author: aymen.jmal@ecoledubois.fr, +33240181222.

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### **Abstract**

The creation and the use of scientific knowledge on recovered wood allow industry to refine their skills on recovered wood management and to propose an ecologically responsible choice as the future of this waste respecting the environment. Nowadays, numerous scientific results are generated and published by university but little quantities are translated to the practice. This limitation is due to the difficulty to transfer this knowledge in its typical format i.e. scientific papers. In this paper, a new channel transfer in the form of the electronic knowledge book (k-book) on the recovered wood is proposed which facilitate the transfer of scientific knowledge from research to industry. It contains a new approach for representing scientific knowledge adapted to the industrial word. The declarative scientific knowledge has been represented by concepts maps and the procedural scientific knowledge has been represented by a knowledge-sheets.

The tests realized have demonstrated that the user of the k-book experiences has a low disorientation and a cognitive load level, which promotes the absorption and the use of the transferred scientific knowledge.

## 1- INTRODUCTION

Knowledge transfer here is the process where scientific knowledge (SK) is transmitted across a transmission channel so that it might be absorbed and used by the receiver (industrialists) [1]. The absorptive capacity of industry is its ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends [2]. It is dependent on a person's prior knowledge and also on the format of the knowledge.

The transfer of SK generated by universities on recovered wood to industry will help the sector to develop [3, 4] and encourage the responsible recycling of waste wood. The European commission has highlighted the importance of improving knowledge transfer between public research and industry [5].

In its typical format, i.e. scientific papers, SK is not readily accessible nor easily understood by industrialists, partly due to the fact that the scientific language can be very specific and then difficult to comprehend without specific training. Knowledge transfer to industrialists can be facilitated by the existence of dedicated structures e.g. R&D departments, within the company [6], employee training and/or using Industry Mediators [7]. These structures require a large investment and so are largely inappropriate to the wood sector, which consists mainly of small or medium-sized enterprises that cannot afford such investment. This study is therefore looking for alternative ways of transferring SK on recovered wood to the industry. For a successful transfer, SK must be acquired and represented into a formalism adapted to the knowledge domain of the industrialist. The representation depends on the nature of the knowledge. The SK on recovered wood is an explicit knowledge, and by the way can be acquired, represented and transferred through an electronic medium. It consists of both declarative and procedural knowledge. The declarative knowledge corresponds to the theoretical knowledge such as facts, rules and laws. The procedural knowledge corresponds to necessary knowledge for the achievement of tasks, e.g. sub-tasks, parameters and conditions etc. The SK on recovered wood also is granular and fragmented. The relevant SK includes the technical, environmental and economic data associated to the two broad types of use: recycling into new materials or energy production.

In this paper, a new transfer channel of SK on the recovered wood from research to industry is developed in the form of an electronic knowledge book (k-book). Below is a description of the proposed framework for the SK acquisition and representation and its application to recovered wood. This is followed by an evaluation of the absorptive capacity from the k-book as assessed by the disorientation and cognitive load when exploring the k-book.

## 2- MATERIALS AND METHODS

The knowledge book (k-book) is a web-based medium dedicated to the transfer of knowledge, here SK about recovered wood. Its development started with the acquisition of SK. Firstly, the recovered wood valorisation process was identified and modelled. The model of the valorisation process (Figure 1) is a succession of unit operations and it corresponds to the industrial process of recovered wood valorisation. This model defines the scope of the knowledge domain (necessary and sufficient knowledge to determine the optimal use of the recovered wood). Then, the second step consists in collecting the available SK for each process unit operation. In order to do this, individual unstructured and semi-structured interviews were organized with a set of researchers who had complementary skills covering the knowledge domain. An adapted knowledge models (trees, semantic network etc.) [8] has been used to model each collected knowledge; and then propkindsosed to the knowledge

provider for the validation of its accuracy. Thereafter, the collected data were structured and represented.

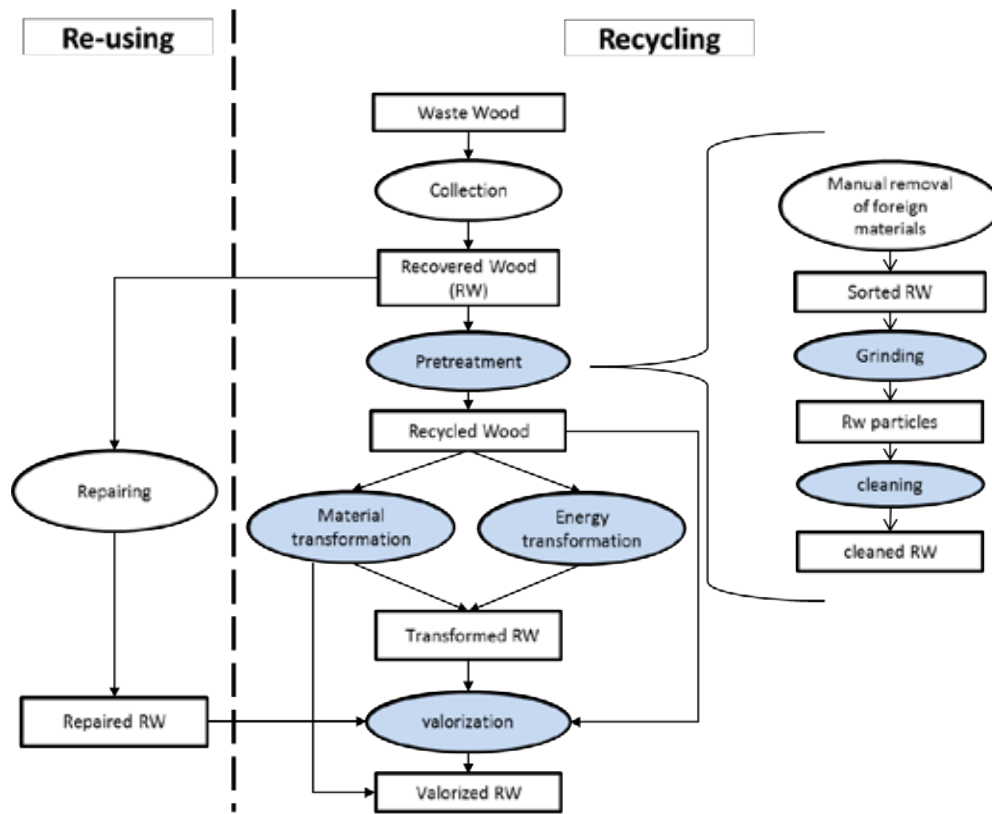


Figure 1 : Representation of a valorization recovered wood process

The declarative scientific knowledge has been represented using the concept maps formalism [9]. The nodes represent the scientific concepts and the links the relationships existing between them. Only taxonomical, meronymical and domain relationships have been used in the representation of declarative knowledge according to a specific canonical form of concept maps [10]. The canonical form is a tree which declares at a sufficient level a concept (the root) through three ontological axes: 1) a taxonomic axis to declare what is the principal concept across the generalization/specialization relationship “is-a”, 2) a meronymic axis to enumerate the parts of the principal concept across the part-whole relationship “has-parts” and 3) a SK domain axis to declare how the concept is observed, measured, characterised or studied across the relationships “is-observed-by”, “is-measured-by”, “is characterised-by” or “is-studied-by”.

The procedural scientific knowledge has been represented through knowledge sheets (k-sheet). A k-sheet is composed of several information fields including: title, illustration, explanation of the illustration, author of the k-sheet, keywords, related k-sheets and references (see Figure 3). The set of concept maps and k-sheets has been proposed to the knowledge providers during interviews for the validation of the correctness of the knowledge representation.

In the k-book, the network of concept maps and k-sheets, a hypertext, has been implemented. Three kinds of hyperlinks are used: concept to concept-map (the declaration of the concept), concept to k-sheet (a procedural knowledge associated to the concept) and k-sheet to k-sheet (a related k-sheet). The model of the valorization process (Figure 1) which is the industrial recovered wood valorization process is used as transfer structure in the k-book in the form of a clickable menu. To each unit operation is associated a concept map, through a hyperlink,

that declare what is the operation. The associated concept map will provide access to more detailed information (more specific concept maps and k-sheets) through the hyperlinks contained within.

The ease of absorbing knowledge from the k-book was evaluated using 45 under-graduates from the Ecole Supérieure du Bois. The evaluation was based on the disorientation and the cognitive load required whilst exploring the k-book. The cognitive load was measured with the 7-points rating scale of mental effort [11]. The disorientation was measured using the disorientation scale method [12]. The participants were divided into 2 groups: the first group was informed of the canonical form of the k-book prior to navigation and the second was not informed about the form. An assessment of mental effort and disorientation was performed after 2 navigation tasks of 25 minutes using a questionnaire with a response scale of 1 (extremely low) to 7 (extremely high) to a set of questions.

### 3- RESULTS AND DISCUSSION

The k-sheets have been created using a specific computer program developed to facilitate the creation of k-sheets. So far, 39 concepts maps and 100 k-sheets have been created. An illustration of a concept map representing the relevant declarative knowledge related to the concept of “recovered wood” is shown in Figure 2. An example of a k-sheet is shown in Figure 3. The results of mental effort and disorientation tests are presented in Table 1 and show that the use of k-book generates a low level of disorientation ( $M = 3.4$ ,  $SD = 1.27$ ) and requires low level of mental effort ( $M = 3.8$ ,  $SD = 1.49$ ) while exploring the k-book. The disorientation and cognitive load observed are mainly due to the use of the network of concepts maps and k-sheets. This network and its main menu, the k-book main page, promote knowledge transfer because it offers to user the possibility to explore the k-book from multiple perspectives and navigate freely in the k-book content [13].

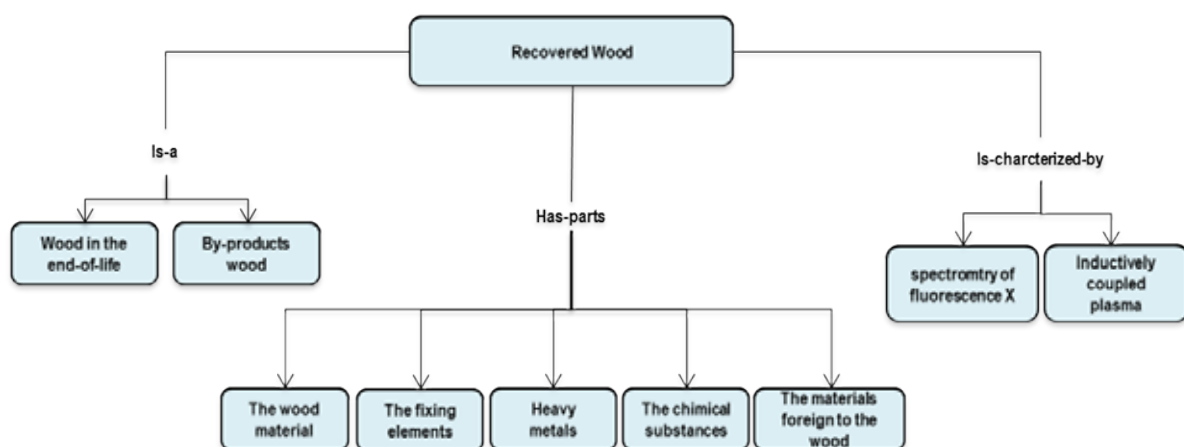


Figure 2 : Concept map of the recovered wood

The representation of the information space using concept maps and hypertext minimize the disorientation and cognitive load of users of the k-book. The use of concept map with hierarchical structure creates a favorable situation to absorb external SK [14]. Therefore, it allows the creation of a mental representation which reduces disorientation and cognitive load [14]. The recovered wood valorization process used as a transfer structure should reduce the disorientation and cognitive load of the industrialists who has some knowledge of recovered wood because he will navigate the k-book according to his prior knowledge. At the same time, he will be acquiring new SK related to each operation in the process.

A one factor ANOVA indicated no significant effect (all  $p > 0.05$ ) between the average mental effort rating for the first group of participants who had the canonical form (PCF) compared to those without the canonical form (PWCF). This implies that the two kinds of participants are investing the same effort mental. Another ANOVA applied on disorientation scores of two kinds of participants also indicates no significant effect (all  $p > 0.05$ ) which means that all participants (PCF and PWCF) had the same disorientation level. According to these results, we can conclude that the canonical form of concept map is intuitive. During navigation, the participants (PWCF) rapidly understood the form. In fact, it offers a standardized, simplified and uniform reading for the set of maps and a direct access to the relevant information.

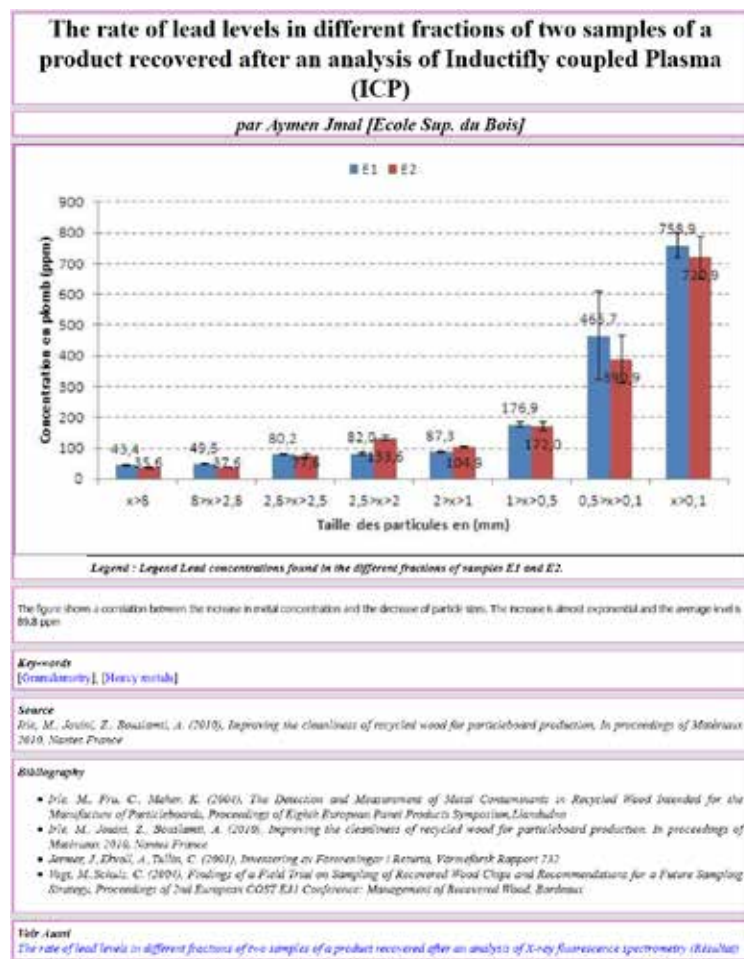


Figure 3 : Example of a k-sheet

	Group1 (PCF)		Group2 (PWCF)	
	Test 1 M(SD)	Test 2 M(SD)	Test 1 M(SD)	Test 2 M(SD)
Mental effort	3.75(0.91)	3.59(1.31)	4.29(1.03)	3.59(1.26)
Disorientation	3.75(1.13)	3.89(1.13)	3.62(0.95)	3.09(1.18)

Table 1 : Means (M) and standard deviations (SD) of the mental effort and disorientation rating

## 4- CONCLUSIONS

A new transmission medium in the form of the electronic knowledge book on the recovered wood is proposed. The first results tend to show that it will facilitate the transfer of scientific knowledge from university to industry. It contains a new approach for representing scientific knowledge adapted to the industrial word. The tests realized have demonstrated that the user of the k-book experiences low disorientation and cognitive load level, which promotes the absorption of the transferred scientific knowledge. In addition, the developed k-book provides a review on scientific knowledge generated in the domain of recovered wood, which helps users of recovered wood to find answers to their technical problems. In addition, the k-book provides an opportunity to identify knowledge gaps and therefore aids researchers in the development of new, relevant research projects. The next aim of this study is to enrich the k-book with industry knowledge (know-how) and determine its better representation in order to develop a decision support tool for industrialists when deciding on the optimal solutions for their recovered wood streams.

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