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Research Article

Green Chemistry and Sustainability Aspects of Ionic Liquids For Bamboo Preservatives: A Didactical Content Analysis Study

Anita Damayanti*, Hernani, and Ahmad Mudzakir

Department of Chemistry Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi No. 229 Bandung, West Java 40154, Indonesia

ORCID
Anita Damayanti: https://orcid.org/0000-0002-9048-4533
Hernani: https://orcid.org/0000-0002-3724-5955
Ahmad Mudzakir: https://orcid.org/0000-0002-9048-4533

Abstract.
Bamboo has many benefits; it can be used as a construction material and multiple products. However, bamboo has low durability and is easily attacked by fungi and termites. One way to overcome the disadvantages of bamboo is by using environmentally friendly preservatives. Engineering done with ionic liquids can be made into a bamboo preservative that is environmentally friendly and sustainable. This feature of ionic liquids can be integrated into teaching and learning on the concepts of green chemistry and sustainability. This study aimed to produce a concept map and teaching-learning sequences from scientists' conceptions of green chemistry and sustainability on the topic of ionic liquids. The method used in this study was qualitative content analysis. The research instrument was content analysis. The content analysis processes included literature collection, descriptive analysis, category selection, and material evaluation by didactic aspects. The results of this study are in the form of a concept map, and TLS illustrate the potential consequences of bamboo. Concept map and TLS that connects the relationship between science, technology, and engineering. The results of this study can be used as a basis for designing teaching materials and didactical sequences.Keywords: bamboo, green chemistry, sustainability, ionic liquids.

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Corresponding Author: Anita Damayanti; email: anitadamayanti@upi.edu

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1. INTRODUCTION

In 2015 the United Nations held a session to discuss 17 sustainable development goals [1]. Education is one of the factors in realizing the goals of sustainable development, because through education can determine the quality of life of the community [2]. Learning who are integrated in green chemistry and sustainability can provide content and pedagogical knowledge so that it can raise awareness of the environment, have a positive attitude in solving environmental problems and motivate behavior change in a sustainable direction [3]. However, only a few teaching methods in higher education promote continuing education [4]. In addition, learning that integrates green chemistry

and sustainability can create a sense of responsibility for social, economic and environmental problems in the form of human life [5]. One of the environmental problems is the excessive use of natural resources, especially in development. One way that can be done is through the use of environmentally friendly materials. The material that can be used is the use of bamboo media as part of sustainable construction [5]. Bamboo as a natural, versatile and renewable material is known as one of the materials for sustainable building, however their modern use for sustainable buildings is still very few [6, 7]. One of the weaknesses of bamboo as a structure is the durability of bamboo which is not too long, because bamboo is susceptible to insects, fungal attack, and the tendency for cracks to occur in joints/connections [8]. To overcome the weakness of bamboo so that it can be used as a durable building construction, namely using bamboo preservatives [9]. Preservatives for bamboo can be used as a solution to increase the durability of bamboo use [9]. The preservatives used are environmentally friendly preservatives as a way to reduce problems that exist in the environment and can realize sustainable development. The use of preservatives that are environmentally friendly and in accordance with the green chemistry and sustainability aspects can use ionic liquids [10]. Ionic liquids have received attention as a solvent which is advantageous in terms of green chemistry, with a low environmental impact [11]. This environmentally friendly and sustainable ionic liquid can be integrated with the teaching and learning process on the concept of green chemistry and sustainability. Implementation of topics such as ionic liquids as a preservative bamboo in everyday life can help address environmental concerns. This concept can be integrated in learning through the design of learning stages from the results of the analysis of ionic liquids as a bamboo preservative in accordance with the aspects of green chemistry and sustainability.

2. RESEARCH METHOD

The method used in this research is content analysis [12]. The content analysis used was qualitative content analysis, literature analysis type [13]. The content analysis process is carried out as shown in Figure 1.

Figure 1: The Process of analyzing the qualitative content of literature type.

Figure 1 describes the qualitative content analysis process in general, for the structured content analysis process is shown in Figure 2 [13].

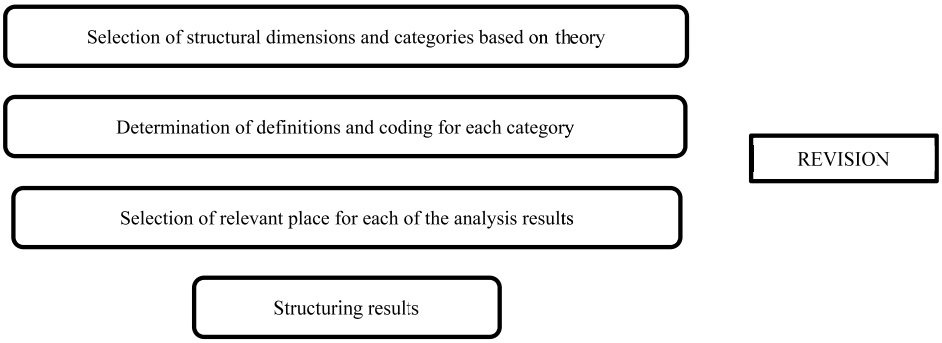

Figure 2: Structure process of content analysis results.

The first stage carried out is material collection. In the process of collecting literature that things are done collecting the sources used such as textbooks, monographs, articles of its review and research articles. The instruments used in the first stage are as in table 1. The second stage is descriptive analysis, at this stage the sources that have been collected in the first stage are then analyzed and described. The instruments used in the second stage are as in table 2. The third stage is the selection of categories, in the third stage the results of the analysis that have been carried out in the second stage are grouped based on pedagogic and service categories. The fourth stage is material evaluation, in this last stage, the categorized analysis results are made into a concept map and TLS in order to make it easier to read the results of the analysis and can be used as a stage in understanding the content.

TABLE 1: Literature collection instrument format.

Author	Title	Year	Code
.....	.....	.....	....

TABLE 2: Descriptive analysis instrument format.

Content	Analysis Result
.....	.....

3. RESULTS AND DISCUSSION

3.1. Material Collection

The first stage carried out is material collection. The sources used in the material collection process were textbooks, monographs, review articles and research articles.

These sources are used as reference material in preparing content analysis. The sources used in content analysis are shown in table 3.

TABLE 3: The sources of material analyzed.

Author	Tittle	Year	Code
Tamo, *et al.*	*Enantioselective 29 allylic substitution catalyzed by Pd0-ferrocenylphosphine complexes in [bmim,PF6] ionic liquid*	2000	A
Shaoqin han, *et al.*	*Potential application of ionic liquids in wood related industries*	2009	B
Hisashi Miyafuji	*Application of ionic liquids for effective use of woody biomass*	2015	C
Peter Wasserscheid and Tom Welton	*Ionic Liquids in Synthesis*	2008	D
Monika Stasiewicz, *et al.*	*1-Alkoxymethyl-X-dimethylaminopyridinium-base ionic liquids in wood preservation.*	2008	E
Michael Freementle	*An Introduction to Ionic Liquids*	2010	F
Pereira Marco Antonio Dos Reis & Barata Tomas Queiroz Ferreira	*Bambu As Sustainable Material Used In Design And Civil Construction: Species, Management, Characterization And Applications*	2015	G
Benedikt Neyses, *et al.*	*Pre-treatment with sodium silicate, sodium hydroxide, ionic liquids or methacrylate resin to reduce the set-recovery and increase the hardness of surface-densified Scots pine.*	2017	H

3.2. Descriptive Analysis

The second stage is descriptive analysis, at this stage the sources that have been collected in the first stage are then analyzed and described. The results of the descriptive analysis are in table 4. Table 4 describes the results of the analysis that has been carried out from several sources. The results of the analysis are in the form of an explanation of several contents such as bamboo, bamboo properties, bamboo weaknesses, advantages of bamboo, bamboo preservatives, ionic liquids, characteristics of ionic liquids, benefits, properties and synthesis processes. Green chemistry aspects are included in the characteristics of ionic liquids is the design of chemical products safe, minimize the potential for accidents and safe solvents and additives. These three aspects are appropriate because ionic liquids do not have toxic materials so that they do not have a negative impact, the potential for accidents to the surrounding environment. The sustainability aspect that is suitable for ionic liquids is the environmental aspect because the use of ionic liquids can protect the ecosystem.

Table 4: Qualitative content analysis ionic liquids.

Content	Analysis Results
Characteristics of Ionic Liquids	Ionic Liquids have different characteristics from molten salts which have a high melting point and viscosity (A). Ionic liquids are generally liquid at room temperature, this is due to the mismatch in the size of the anions and cations, which makes the crystal structure of the ionic liquid asymmetrical (F). The large ionic liquid structure causes the bonds between the ions to be not too strong and the energy to release the bonds is lower (B). The solubilization ability and hydrophobic / hydrophilic character of ionic liquids can be adjusted by modifying cations and anions (E). Ionic liquids have a relatively lower viscosity and are not corrosive. Ionic liquids are non-volatile and non-flammable. The damage caused by ionic liquids is lower than that of other volatile organic compounds (E). Ionic liquid can be said to be a green preservative because of its environmentally friendly nature, so that the use of ionic liquids as a preservative for bamboo does not damage the environment and can reduce waste and reduce harmful chemicals/raw materials (B). In addition, ionic liquids are said to be green solvents that are environmentally friendly because ionic liquids have non-volatile and non-flammable properties, so that the ionic liquid is used as a solvent that can replace volatile organic solvents and flammable (H). Ionic liquids are also used as a protective agent for wood against fungus (C).

3.3. Category Collection

In the third stage, namely categorizing the results of the analysis that has been done. From the results of the analysis are categorized into 3 parts, namely science, engineering and technology so that there is a relationship between each other. Topics that fall into the science category are in the form of composition of bamboo, parts of bamboo, advantages of bamboo, deficiency of bamboo, nature of bamboo, bamboo preservative means ionic liquid, and the characteristics of ionic liquids which are marked in pink. Topics included in the engineering category are in the form of how to preserve bamboo using chemicals, botanic materials, ionic liquids and samples of ionic liquids marked in blue. Topics included in the technology category are bamboo applications, ionic liquid applications and bamboo manufacturing processes which are marked in green. Apart from categorizing it into 3 sections, The analysis results are also categorized back into some system [14]. The analysis results are categorized based system, there are several parts, namely the sub-system socio-economic-environmental, sub-system core, sub-system desired, sub-system unwanted, sub-system of chemical composition of bamboo, sub-system of the part of bamboo that is utilized, sub-system of types of bamboo preservatives, sub-system of ionic liquids, sub-system of definition of ionic liquids, sub-system of ionic liquid properties, sub-system of ionic liquid applications, and sub-system of liquid manufacturing ionic.

3.4. Material Evaluation

In the fourth stage, the results of the analysis from several sources were categorized and then made into a concept map and TLS. On the concept map that has been made, there are several parts marked by different colors as shown in Figure 3.

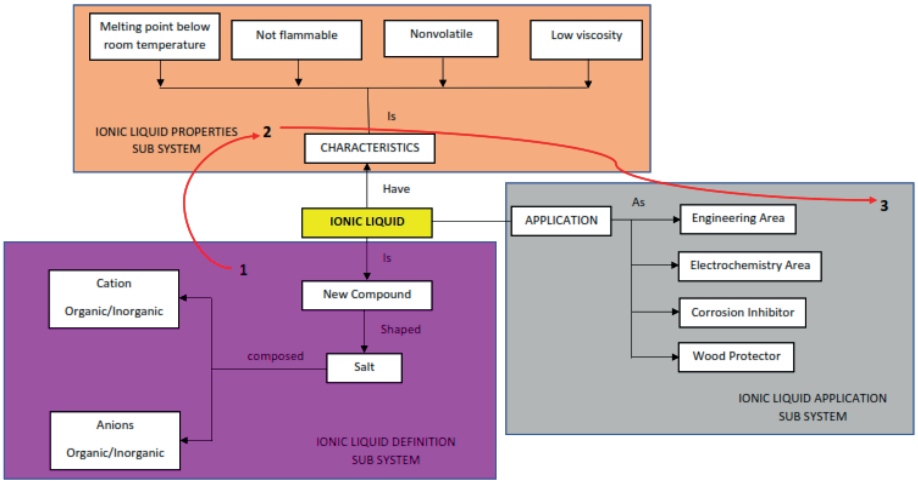

Figure 3: Concept map and tls.

Figure 3 is a concept map of the analysis results. In the concept map, it can be seen the connection of each stage which is connected with several questions. Figure 3 is an example of a concept map that discusses ionic liquids. The first stage discusses the definition of ionic liquids. In the first stage, it is included in the definition of ionic liquid sub-system which is marked in purple. From stage 1 to stage 2, it is connected with questions “Mention the characteristics of ionic liquids so that they are included in the green chemistry and sustainability aspects!”. In the second stage discusses the characteristics of ionic liquids. The 2nd stage is included in the nature of the ionic liquid subsystem which is marked by a light brown color. From the 2nd stage to the 3rd stage it is connected with questions “Based on the characteristics of ionic liquids, state the application of ionic liquids in daily life!”. The 3rd Stage discusses the application of ionic liquids in daily life. The 3rd stage is included in the ionic liquid application subsystem which is marked in gray.

From the concept map and qualitative analysis, the content of the ionic liquid analysis relates to the green chemistry and sustainability aspects. The relationship between green chemistry and sustainability aspects can be seen from the nature of ionic liquids which are environmentally friendly and non-flammable. In addition, ionic liquids can be used as green solvents that can replace volatile and flammable organic solvents. From the characteristics of ionic liquids, ionic liquids are included in 3 aspects of

green chemistry, namely: 1) safe chemical product design, 2) minimize the potential for accidents, 3) safe solvents and additives, and 3 aspects of sustainability, namely: 1) environmental aspects, 2) social aspects, 3) economic aspects.

4. CONCLUSION

The conclusion in this study is that ionic liquids can be used as examples in contextual learning processes that involve aspects of green chemistry and aspects of sustainability, because ionic liquids have characteristics that contain both aspects.

Concept maps and TLS are designed through qualitative results of content analysis from several sources and are linked to several questions at each stage so that they are interconnected from one stage to another.

The concept of ionic liquids as a bamboo preservative can be integrated in learning through the design of the learning stages. Another result of this study is a concept map and TLS that can be used as a basis for making teaching materials and design stages of learning.

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