Journal of Farayandno – Vol. 19 – No. 87 (2024): pp. 43-54

National Iranian Oil Refining and Distribution Company (NIORDC)

Journal of Farayandno

Research Paper

DOI: 10.22034/farayandno.2025.2045038.1975

Studying and Ranking Production Methods of 2, 5-Furandicarboxylic acid by Implementing the Analytical Hierarchy Process

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Received: 27 Aug 2024 **Accepted:** 20 Nov 2024

1. ABSTRACT

In recent years, the chemical industries have sought to identify biomass-derived sources in order to reduce dependence on fossil fuels, their associated emissions. The 2, 5-furandicarboxylic acid (FDCA) is one of the building blocks that connects biomass conversion to value added chemicals. The oxidation of 5-hydroxymethylfurfural produces FDCA, from which a valuable monomer, namely polyethylene furanoate can be synthesized which is an alternative to polyethylene terephthalate. In this study, the main goal is to select the best method for the producing of FDCA by implementing the Analytical Hierarchical Process (AHP). The AHP was performed by selecting economic, environmental, technical, social and reliability justification as criteria, and oxidation, catalytic and biological methods are considered as alternatives for these comparisons. In this study, comparisons were made between the criteria, sub-criteria and alternatives. Thus, the biological method was prioritized with 52% and the economic quality with 47.1%.

Keywords: Furan Dicarboxylic Acid, Analytical Hierarchy Process, 5-Hydroxy Methyl Furfural, Decision Making.

2. INTRODUCTION

Fossil fuels have been used as the main source of energy and chemicals since the last century. Utilization a considerable amount of fossil fuels has had negative impacts on the environment. In addition, it has not only polluted the air, water, and soil, but also caused severe weather conditions. Different sustainable resources such as solar and wind have been introduced as energy sources and alternatives to fossil fuel. However, only the biomass can be used as chemicals sources. Due to the fact that it contains carbon. In order to convert biomass to value added chemicals a multistep approach was suggested [1]. In the first step carbohydrates were released from the biomass structure, then those sugar monomers were converted into various building blocks. Finally, required chemicals were synthesized from the building blocks. Furan dicarboxylic acid (FDCA) is one of those building blocks that can be used to prepare polyesters, polyamides and other materials [2-3]. It has primarily been proposed as a substitute replacement for polyethylene terephthalate. FDCA can be synthesized by chemical or biological pathways [4-5]. The selection of the FDCA production method is a decision making process. Since there are different competing parameters that can affect the outcome. The Analytical Hierarchy Process

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Please Cite This Article Using:
Rajabi Aghbash, H., Karimi, A., Khalaj Karimi, E., Alipour, S., "Studying and Ranking Production Methods of 2,5-Furan dicarboxylic acid by Implementing the Analytical Hierarchy Process (AHP)", Journal of Farayandno – Vol. 19 – No. 87, pp. 43-54, In Persian, (2024).

(AHP) is one of the preferred decision making approaches [6] and has been reported as a useful method in this regard [7-8]. Therefore, AHP has been implemented to provide a viable choice for the FDCA production process.

3. MATERIALS AND METHODS

In order to conduct AHP method, critical criteria were determinted. Then, required data were obtained from a panel of experts and literature. Finally, criteria were assessed and compared to the goal. Pairwise calucalations were performed as described elsewhere [6].

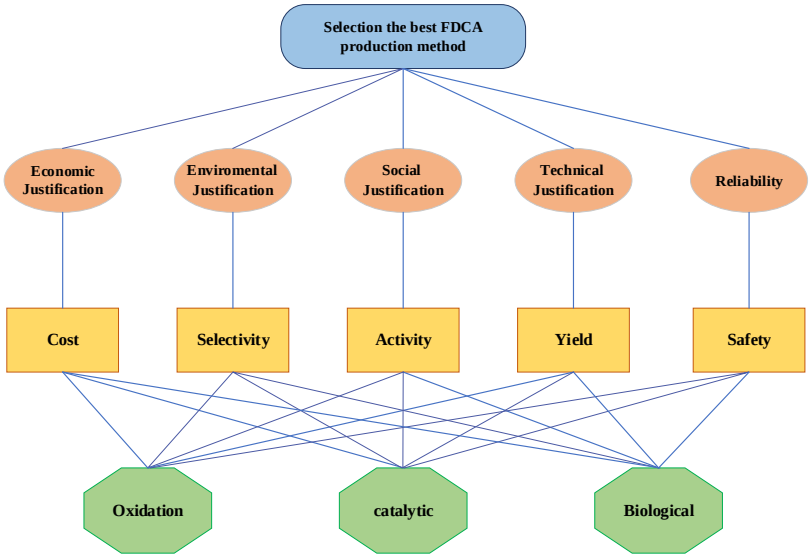

Figure 1. Hierarchical analysis process diagram for choosing the best method

4. RESULTS AND DISCUSSION

In this study, the AHP process was used to determine the best method for producing FDCA. Initially, by reviewing the articles, the existing methods were examined and selected. These methods include oxidation, catalytic conversion, and biological conversion. Based on the existing methods, the effective criteria for choosing the most appropriate method were identified and divided into sub-criteria. As shown in Figure 1, the first level is the goal, the second level consists of the paired comparison criteria (economic, environmental, social, technical and reliable) the third level shows the sub-criteria and the fourth level shows the selected production methods. Based on AHP computation [6], comparisons and compatibility rate calculations were performed. The AHP results demonstrate that the first rank among the criteria is economic justification with a score of 0.471. The next influential criteria are environmental, technical, social and reliability justifications, respectively. In addition, considering the data, the inconsistency value is less than 0.1, indicates reliable decision making.

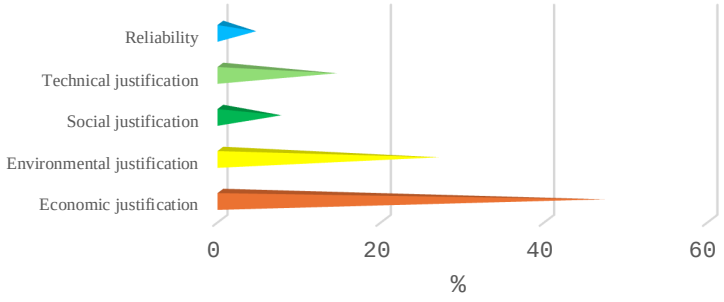

Figure 2. The results obtained from the binary comparison for the options in the software

The operating cost of FDCA production shows that the economic criterion with 47.1%, has the highest preference and superiority compared to other criteria. Then, in second place is the environmental criterion with 26.8%, which according to the analysis, shows that the difference in preference of this criterion with the technical criterion is small (i.e. less than 12%). After the mentioned criteria, the social and reliability criteria are ranked. These are not desirable due to the low percentages, which reach 4.4% for the reliability criterion. The result of this comparison is shown in Figure 2. In addition,

the inconsistency value is determined to be less than 0.1, which indicates the reliability of this analysis. Compared with other articles published in the field of economic analysis of the process (check [9-10]), it is clear that this finding agrees with reported analyses, where operational costs are often ranked at the top. Based on the scoring by implementing the AHP model, options are also ranked. Among the biological, catalytic and oxidation production methods, the biological method is ranked first. The calculations show the amount of inconsistency within the desired range (i.e. less than 0.1). A binary comparison between the options in relation to the target is performed, and results are illustrated in Figure 3. Data indicate the importance of the biological method with 52%, followed by the catalytic and oxidation methods with 35% percentages and 13% are preferred, respectively.

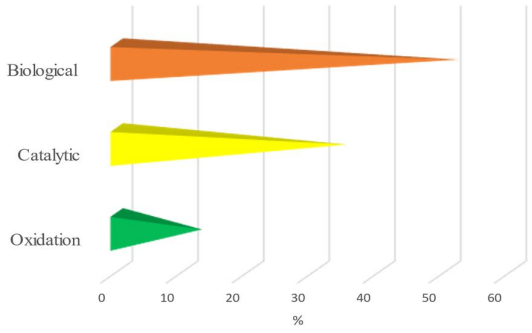

Figure 3. The results obtained from the pairwise comparison for the criteria in the software

5. CONCLUSION

In this study, the AHP method was used to select the most suitable method for FDCA production. To perform the comparisons and analysis by AHP method, economic justification, environmental justification, technical justification, social justification and reliability were measured as criteria. Besides, biological, catalytic and oxidation methods were proposed for making decisions about optimization. Based on the results, economic justification, with 0.47% was the main criterion, and biological conversion, with 0.52%, ranked first among the options. Furthermore, the inconsistency is significantly less than 0.1, which indicates the reasonableness of the pairwise comparison of the criteria.

6. REFERENCES

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