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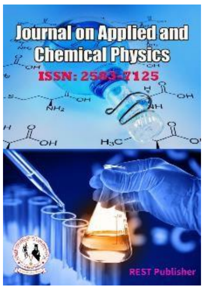

The Selection of Suitable Biomass Materials for the Maximum Bio-oil Yield During Pyrolysis Using the TOPSIS Method *

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Abstract: *The intent of this research is to discover as well as evaluate optimal biomass materials for pyrolysis in order to enhance bio-oil generation. Introduction: Choosing the right biomass material is critical for maximizing bio-oil production during pyrolysis. This includes assessing aspects such as the chemical makeup, amount of moisture, and structural qualities of the biomass. The bio-oil output is greatly influenced by key components such as lignin, cellulose, and hemicellulose. It is feasible to increase the effectiveness of the method of pyrolysis and generate a better yield of bio-oil by selecting biomass sources with greater amounts of these parts and lower moisture levels. Research Significance: As a consequence, the ideal biomass for the best bio-oil yield throughout the pyrolysis procedure should have a significant cellulose and hemicellulose amount as well as a low lignin quantity. The existence of volatile matter, carbon-fixed moisture, and ash level in extracts of biomass are crucial variables for pyrolysis output amount as well as quality. Method: TOPSIS method- It estimates the degree to which accessibility of possibilities to the ideal option by contrasting them against a set of requirements, requesting an insightful assessment for making choices. Alternate parameters: Rice straw, sunflower shell, hardwood, wheat straw, Sugarcane Bagasse, corn crop, and Palm shell. Evaluation Parameters: Cellulose, Hemicellulose, Volatile matter, Moisture content, Ash content and Lignin. Result: The sugarcane bagasse is in the 1st Rank, Sunflower shell in the 2nd Rank, Hardwood in the 3rd Rank, Corn crop in the 4rth Rank, Rice Straw in the 5fth Rank, Wheat Straw in the 6th Rank, and Palm shell in the 7th Rank. Conclusion: For the selection of suitable biomass materials for the maximum bio-oil yield during pyrolysis: The sugarcane bagasse is in the 1st Rank, Sunflower shell in the 2nd Rank, Hardwood in the 3rd Rank, Corn crop in the 4rth Rank, Rice Straw in the 5fth Rank, Wheat Straw in the 6th Rank, and Palm shell in the 7th Rank.*

Key words: *Sugarcane Bagasse, Corn crop and Palm shell.*

1. INTRODUCTION

Higher levels of lignin in the sample slow down pyrolysis, while higher levels of cellulosic material have a beneficial impact on it. As a result, the output of bio-oil is going to be significantly reduced. Therefore, the ideal biomass for pyrolysis should have a high concentration of cellulose and hemicellulose and a low concentration of lignin in order to produce the most bio-oil. The amount and the calibre of the by products of pyrolysis depend on the quantity of volatile matter, carbon fixed to the substrate, moisture, and ash concentration in the biomass samples[1].Each and every bio-oil yield was delivered on a water-free basis. All of the weight reductions of the reactor were used to calculate the char yield. A funnel for separation was used to identify the water. Material balance in its whole was used to calculate gas yield[2].A solid bed pyrolytic reactor was used to produce the biooil. It is made up of a condenser, a heating and control system, and a reactor. A 16 channels copper condensate kept in a water bath was used to condense the reactor's vapour. Weighing was done for the char (reacted solid residual) and biooil quantities[3].The product distribution was examined when the weight ratio of sepiolite to biomass varied between 3:1 to 1:6 (always maintaining the weight proportion of sand + catalysts to biomass at 3:1). This was done in an effort to determine an optimum catalyst to biomass relation that would enable boosting the production of bio-oil. Gas yield increased marginally with catalyst dilution, as shown in Fig. 1b. When the biomass to sepiolite weight ratio was decreased to 1:3, the solid production showed a substantial reduction but the liquid yield increased noticeably (by around 30%).Sepiolite was added at a weight ratio of 1:6, which resulted in stable product yields that were remarkably similar to those seen when the catalyst was absent. Consequently, it was possible to draw the inference that boosting the amount of catalyst hadn't been appropriate[4].The study introduced a new approach to extract heat from BF waste in order to produce bio-oil and combustible gas. A conventional pyrolysis reactor was designed to evaluate its practicality and investigate the impact of heat and BF sludge size on biomass pyrolysis. The main objective was to explore the viability of bio-oil and combustible gas production through biofuel pyrolysis, leveraging hot BF sludge as a heat carrier [5].Maximum biochar is produced, and the degree of carbon conversion is boosted by the combination of more fixed carbon, which yields pyrolysis products with the highest heating potential. The level of moisture in the waste product restricts heat transfer and has an impact on the efficacy and circulation of the resulting products [6].The goal of this study is to perform a complete evaluation of the body of literature because pyrolysis studies have extensively explored a variety of biomasses and operating circumstances[7].The most practical approach, however, is still conventional pyrolysis when thinking of process costs. As a result, maximizing the required product fraction and producing remarkable commodities in terms of their energy contents and characteristics are possible when using an appropriate pyrolysis technique and sufficient feedstock [8].The lignocellulosic component of biomass affects bio-oil output and chemical composition. The principal components of bio-oils produced under perfect circumstances are being identified as "phenols and methoxyphenols" caused by lignin degradation [9].Proteins can be repurposed both an essential form of power for the manufacturing of bio-oil along with for use in upgrading, thus could improve the process's feasibility[10].A highly challenging combination of bio chemicals and water is the biological oil produced by thermochemical transformation methods like pyrolysis and HTL. Finding ways that will boost its commercial worth has always been of the utmost importance[11].Batch, semicontinuous, as well as continuous biomass pyrolysis techniques were frequently used for bio-oil production. Because of their ease of in-situ product removal during pyrolysis, semi-continuous and ongoing pyrolysis processes clearly outperform the beforehand[12].Although pore size is vital for zeolite shape selection and has a substantial impact on bio-oil output, it would make logical sense to devote greater focus on it in the coming work, although zeolite choosing is a direct result of power. The relationship involving zeolite exterior and carbonium ion absorption [13].Since bio-oil includes a greater percentage of oxygen than diesel fuel, it is more susceptible to reaction and less stable than diesel fuel, and its chemical characteristics change fast during condensation and storage. To increase the stability of storage and heating value, they must be upgraded before they may be used as biofuels or providers of chemical feed stock.Ultimately, by employing different upgrading methods, bio-oil properties can be improved, and the oil created by rapid pyrolysis of safflower seeds beneath those circumstances can be used directly or mixed with other conventional fuels[14].The current research focuses on the removal of phenolic chemicals from bio-oil produced by the pyrolysis of agro-industrial residues. Two alternative extraction procedures were utilised to improve the phenol content of bio-oil: liquid-liquid separation and dynamic extractor [15].

2. MATERIALS AND METHOD

Employing a simulation-based tool, this paper investigates the traditional TOPSIS procedure and empirically illustrates the underlying reasons for the method's shortcomings[16].Consequently, the paper's fundamental contributions are as follows: (i) an in-depth review of the TOPSIS tactics as it relates to the RRP, grabbing into account every one of the cases of RR offered in the writing; in fact, (ii) example of the RRP's roots in the methodology; (iii) proof as to the effect of regularization processes in the RRP; (iv) presenting a novel alteration for the classic TOPSIS method, deemed immune to the RRP; and (v) establishing the structure required to assess cases of RR[17].A thorough investigation of currently available approaches to the temporal extension of the TOPSIS method is made available. It indicates that these extensions are based on various heuristic techniques to defining both positive and negative optimal outcomes. Real quantities or periods, which are not reachable in a decision matrix, are adopted to represent these ideal knowledge[18].TOPSIS constitutes an effective procedure for solving difficulties related to multi-attribute decision-making with finite options in the future. The basic idea underpinning the above approach is to organize all the options by computing the distance they are from the ideal response and the undesirable option for decision-making difficulties, and then determining the most effective alternative[19].The field experimentation showed how every single definition of IVFS distances have an important effect on the final conclusions associated with the interval valued TOPSIS fuzzy proximity. The findings from the comparison assigned in our experiments show disparities in a number of key regions[20].A newly developed standardised approach and risk mindset for analysing the TOPSIS given interval data is put forward in the present article. The findings suggested that a variety of decision makers with varying risk attitudes made significant decisions. Both the illustrated scenario and the in-depth examination demonstrate the novel approach's potential benefits regarding the use of TOPSIS analysis. Most importantly, the shown scenario is recorded with three types of risk attitudes: risky-averse, risk-neutral, and risk-seeking in order to choose the optimum solution. Ultimately, such an approach will be advantageous when a decision-maker seeks to circumvent any type of decision-making risk and decide on the most successful alternative [21].The research paper describes the TOPSIS-DoE implementation for deciding on CIM innovations in the manufacturing business. Four scenarios were studied to demonstrate the method's applicability; the selection matrices employed in the preliminary stage of the TOPSIS-DoE applications were derived from widely recognised papers in the scientific community in each of them. The top-ranked alternatives are clearly equivalent to others set from prior studies in the obtainable literature [22].For delivering ratings for numeric qualities such as accuracy and degree of roughness combined with conjoint evaluation illustrative of what users want, a new test element that assesses the functionalities that presently present RP platforms has been created [23].In short, one of the paper's elementary advances is the inclusion of an methodology for selecting the best correct partner for logistics service outsourcing. This structure would work well using the most common MCGDM approaches, which include linear weighting systems and AHP. Nonetheless, for the reasons stated above, fuzzy TOPSIS seems to be the most rational and straightforward choice. TOPSIS allows you to quantify the applicant's separation from the optimum solution's beneficial and detrimental features, whilst fuzzy logic is utilized to address contradiction. Plus, international levels and ratings have been established in a straightforward manner

[24]. The fundamental difference between the TOPSIS technique and the PB technique is the fact that there is no goal of finding the optimal response between the greatest and lowest feasible parameters for the standard. Consequently, the intimate option is the perfect answer for the decision maker, but the smallest preferred choice is the perhaps unusual alternative [25].

3. ALTERNATE PARAMETERS

1.Rice Straw (RS): Rice straw is the stalks that remain after rice grains have been harvested. It is a plentiful agricultural residue with numerous applications. Rice straw can be used by farmers as feed for livestock, housing subject matter, or even as a form of energy from renewable sources using techniques such as burning biomass or biofuel every generation.

2.Sunflower Shell (SS): The rigid appearance encompasses of sunflower seeds are referred to as sunflower shells or sunflower hulls. They are an inevitable outcome of the making of sunflower oil. Sunflower shells have many kinds of usages, namely combustibility from biomass, feed for livestock, and as an ingredient for the creation of biodegradable goods that include bioplastics.

3.Hardwood (HW): Hardwood is the wood obtained from angiosperm trees that can be recognized by its thick texture and changeable habit. Because of its strength and aesthetically pleasing characteristics, it is used extensively for a range of applications. Hardwood is popular for flooring, household items, cupboards, and even performing arts equipment because it mixes power, beauty, and resilience.

4. wheat straw (WS): Wheat straw, also known as straw, is the stalks or stem of a wheat crop that persists after the grain was harvested. It constitutes a agricultural residue with many possible uses. Wheat straw is suitable for use as livestock bedding, composting material or an unprocessed product for the manufacture of sustainable goods such as paper, packaging materials and even construction supplies.

5. Sugarcane bagasse (SB): It describes the fibrous squander left over upon obtaining sugarcane juice. It is a residue of sugar production that has an extensive number of practical applications. Sugarcane bagasse has the potential to be altered into recyclable products such as paper, wrapping, and even throwaway utensils, and it can be used as an environmentally friendly form of energy via operations such as burn or biofuel every generation.

6. Corn Crop (CC): Corn, typically referred to as maize, serves as a frequently grown grain plant with numerous uses. It is an essential food source in a lot of globes and is a key component in many different kinds of food items. Moreover, the maize crop is extensively utilised in areas such as livestock nutrition, the manufacturing of biofuel, and the generation of the starch, oil, as well as ethanol.

7.Palm Shell (PS): The tough outermost coating of palm fruit seeds is sometimes referred to as palm shell (PS). It is a farm-waste product with many kinds of uses in practice. Palm shells are versatile as a biomass fuel source, in particular for businesses such as electricity generation and warmth. They can also be converted into carbon dioxide for use in applications such as purification of water and air purification.

4. EVALUATION PARAMETERS

1.Cellulose: Cellulose is an intricate carbohydrate found inside plant cell walls that acts as support for structure. It is the most commonly found organic compound on our planet and serves a purpose in a wide range of sectors including paper and clothing production, as well as the growth of environmentally friendly biofuels and bioplastics.

2.Hemicellulose: Hemicellulose is an example of a polysaccharide that inhabits the walls of plants with cellulose. It is crucial to the malleability and binding durability of the cell wall organization, which contributes to the general equilibrium and hardness of plant tissue. It may also be broken into smaller sugar and processed to generate biofuels or utilized to produce renewable substances.

3.Volatilematter: The expression "volatile matter" refers to the explosive elements in solid fuels, which are substances that can vaporize or dissipate at lower temperatures. It comprises humidity, reactive hydrocarbons, and various other organic chemicals which contribute to the fuel's combustibility and amount of energy. A volatile matter analysis gives beneficial data to comprehend the combustion factors and the possible energy discharge from solid fuels.

4.Moisture Content: The quantity of water that is found in an item or substance is commonly referred to as its level of moisture. It usually appears as an amount and plays an important role in a number of sectors, including farming, building, and manufacturing since excessive moisture can affect the durability, stability, and efficiency of products.

5.Ash Content: The artificial remnant left behind after an item has been entirely burned is referred to as ash content. It is frequently reported as a percentage that reflects the mineral content and non-combustible components included in a sample.

6.Lignin: Lignin is a complicated polymer found in plant wall cells that provides them toughness and rigidity. It functions as a glue-like stuff that bonds cellulose fibers shared, therefore helping to the general firmness of tissue from plants. Moreover, lignin offers uses across a number of sectors, especially the manufacture of biofuel, since it may be converted into useful substances by procedures including breakdown and pyrolysis.

5. ANALYSIS AND DISSECTION

TABLE 1. The selection of a suitable biomass material for maximum bio-oil yield during pyrolysis

Materials	Cellulose	Hemicellulose	Volatilematter	Moisturecontent	Ashcontent	Lignin
rice straw (RS)	32.1	24	79	6	4.3	18
sunflower shell (SS)	48.4	34.6	73.7	3.5	4	17
hardwood (HW)	47.5	25	79.2	3.6	2.2	27.5
wheat straw (WS)	37	22.5	58.8	16.1	4.1	17.5
sugarcane bagasse (SB)	39	47.6	80.2	5.4	3.1	13.4
corn crop (CC)	52.5	32.5	78.39	12.77	2.3	15
palm shell (PS)	27.7	21.6	67.2	11	2.1	44

Table 1 shows the selection of a suitable biomass material for maximum bio-oil yield during pyrolysis for the alternatives: “Rice straw, sunflower shell, hardwood, Wheat straw, sugarcane bagasse, corn crop and Palm shell”.

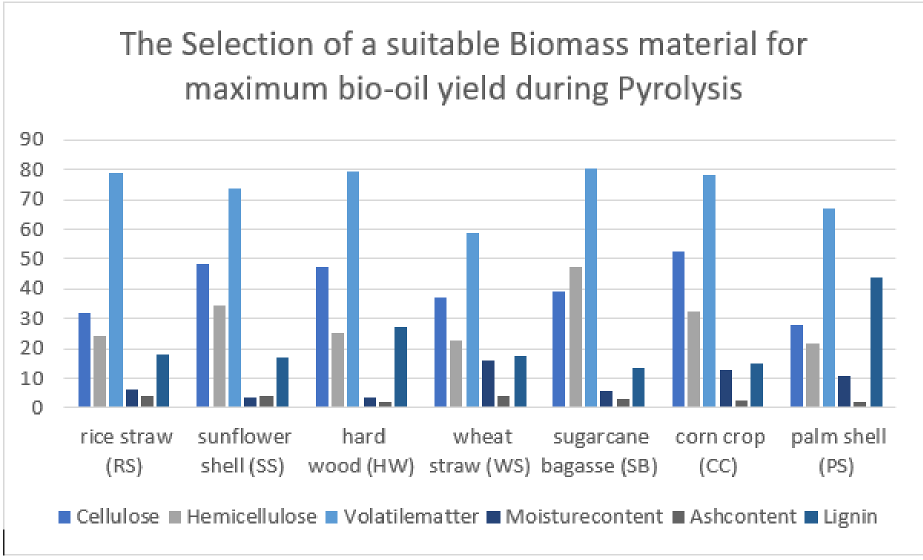

FIGURE 1. The selection of suitable Biomass material for maximum bio-oil yield during pyrolysis.

Figure 1 illustrates how the selection of an appropriate biomass matter for greater biological oil turn over throughout pyrolysis.

TABLE 2. Normalized Matrix

Material	Normalized Matrix					
rice straw (RS)	0.292511	0.29336	0.402644	0.238356	0.495038	0.284035
sunflower shell (SS)	0.441044	0.422928	0.375631	0.139041	0.460501	0.268256
hardwood (HW)	0.432843	0.305584	0.403663	0.143013	0.253275	0.433943
wheat straw (WS)	0.337162	0.275025	0.29969	0.639588	0.472013	0.276145
Sugarcane bagasse (SB)	0.355387	0.581831	0.40876	0.21452	0.356888	0.211449
corn crop (CC)	0.478406	0.397259	0.399535	0.5073	0.264788	0.236696
palm shell (PS)	0.252416	0.264024	0.342502	0.436985	0.241763	0.694309

Table 2 shows the Normalized matrix for the various alternatives such as Rice straw, sunflower shell, and many more. Here the Evaluation parameters include cellulose, hemicellulose, Ash content and two others.

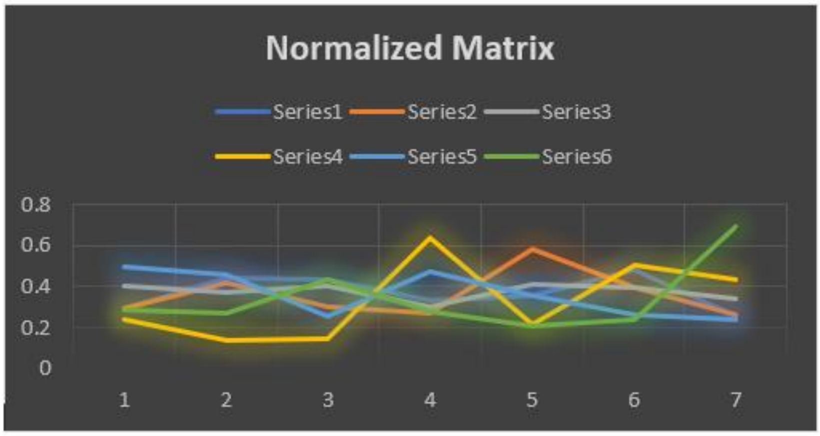

FIGURE 2. Normalized Matrix

Figure 2 illustrates the normalized matrix for the various alternatives and Evaluation parameters such as hardwood, corn crop, lignin and ash content, moisture content respectively.

TABLE 3. Weight matrix

Material	Weight Matrix					
rice straw (RS)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
sunflower shell (SS)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
hardwood (HW)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
wheat straw (WS)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
sugarcane bagasse(SB)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
corn crop (CC)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
palm shell (PS)	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667

Table 3 shows the weight matrix which is taken same for all.

TABLE 4. Weighed Normalized Matrix

Material	Weighed Normalized Matrix					
rice straw (RS)	0.048752	0.048893	0.067107	0.039726	0.082506	0.047339
sunflower shell (SS)	0.073507	0.070488	0.062605	0.023173	0.07675	0.044709
hardwood (HW)	0.072141	0.050931	0.067277	0.023836	0.042213	0.072324
wheat straw (WS)	0.056194	0.045838	0.049948	0.106598	0.078669	0.046024
sugarcane bagasse (SB)	0.059231	0.096972	0.068127	0.035753	0.059481	0.035241
corn crop (CC)	0.079734	0.06621	0.066589	0.08455	0.044131	0.039449
palm shell (PS)	0.042069	0.044004	0.057084	0.072831	0.040294	0.115718

Table 4 shows the weighed Normalized matrix for All the Alternatives mentioned above.

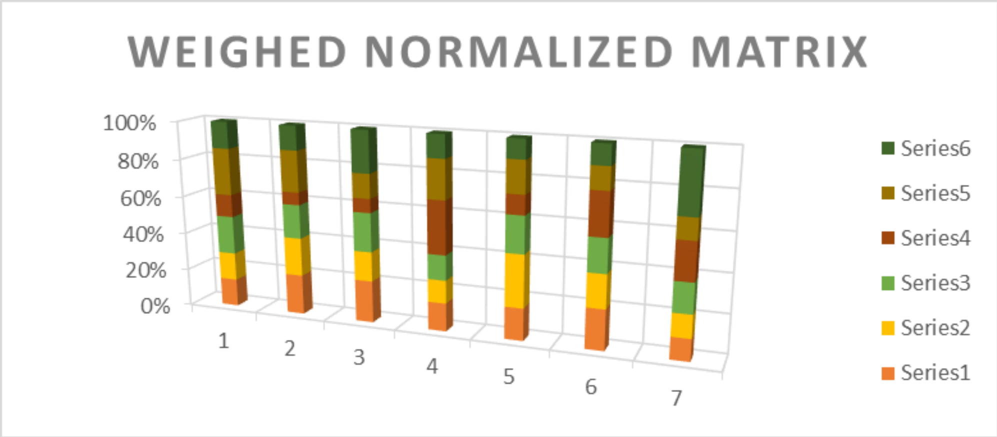

FIGURE 3. Weighed Normalized Matrix

Figure 3 illustrates the Weighed Normalized matrix for the alternatives and evaluation parameters that includes rice straw, sunflower shell and ash matter and moisture matter respectively.

TABLE 5. Positive Matrix

Materials	Positive Matrix					
rice straw (RS)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
sunflower shell (SS)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
hardwood (HW)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
wheat straw (WS)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
sugarcane bagasse(SB)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
corn crop (CC)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241
palm shell (PS)	0.079734	0.096972	0.068127	0.023173	0.040294	0.035241

Table 5 shows the Positive Matrix.

TABLE 6. Negative Matrix

Materials	Negative Matrix					
rice straw (RS)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
sunflower shell (SS)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
hardwood (HW)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
wheat straw (WS)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
sugarcane bagasse (SB)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
corn crop (CC)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718
palm shell (PS)	0.042069	0.044004	0.049948	0.106598	0.082506	0.115718

Table 6 shows the Negative Matrix.

TABLE 7. Si plus, Si negative ,Ci and Rank.

Material	Si+	Si-	Ci	RANK
rice straw (RS)	0.073991	0.097522	0.568597	5
sunflower shell (SS)	0.046791	0.117835	0.715775	2
hardwood (HW)	0.059644	0.107744	0.643679	3
wheat straw (WS)	0.109763	0.071238	0.393577	6
sugarcane bagasse(SB)	0.03077	0.124323	0.801603	1
corn crop (CC)	0.068907	0.099822	0.59161	4
palm shell (PS)	0.115276	0.054526	0.321113	7

Table 7 shows the Si plus, Si negative and Ci value for all the alternatives. For “Rice straw, the Si plus value is0.073991 and Si negative value is 0.097522.

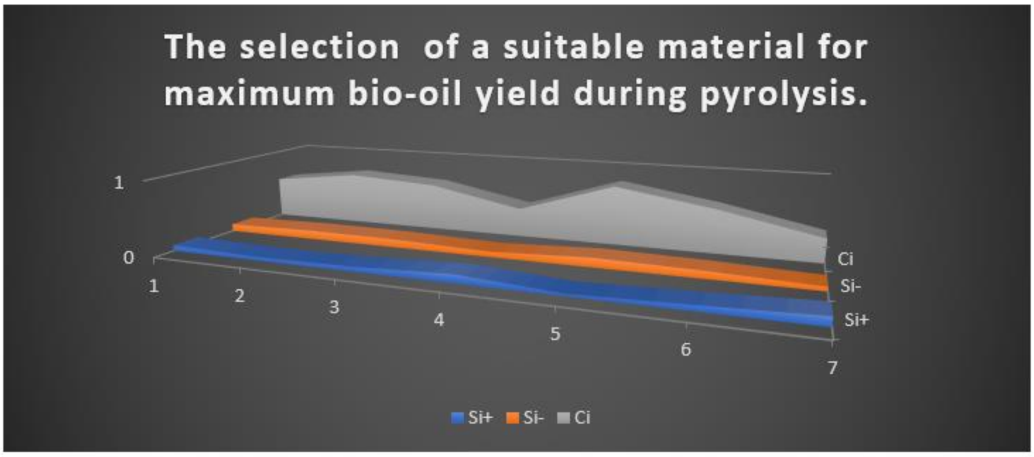

FIGURE 4. Si plus, Si negative and Ci.

Figure 4 shows the Si plus, Si negative and Ci.

TABLE 8. Rank

Materials	RANK
rice straw (RS)	5
sunflower shell (SS)	2
hardwood (HW)	3
wheat straw (WS)	6
sugarcane bagasse (SB)	1
corn crop (CC)	4
palm shell (PS)	7

Table 8 shows the Final Result of the Rank for the Alternative : "Rice straw, sunflower oil. Hardwood and four more".

FIGURE 5. Final Result of the Rank.

Figure 5 illustrates the Rank for the Alternatives. “Sugarcane Bagasse” is in the 1st Rank. “Sunflower shell” is in the 2nd Rank and others are mentioned in the Table 8.

6. CONCLUSION

The intent of this research is to discover as well as evaluate optimal biomass materials for pyrolysis in order to enhance bio-oil generation. The bio-oil output is greatly influenced by key components such as lignin, cellulose, and hemicellulose. It is feasible to increase the effectiveness of the method of pyrolysis and generate a better yield of bio-oil by selecting biomass sources with greater amounts of these parts and lower moisture levels. Each and every bio-oil yield was delivered on a water-free basis. All of the weight reductions of the reactor were used to calculate the char yield. A funnel for separation was used to identify the water. Material balance in its whole was used to calculate gas yield.

Employing a simulation-based tool, this paper investigates the traditional TOPSIS procedure and empirically illustrates the underlying reasons for the method's shortcomings.

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