



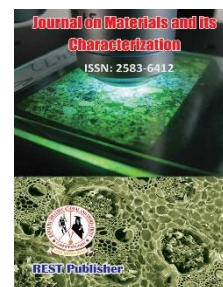
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Biomedical Applications of Polymer-Composite Materials using Fuzzy ARAS Method

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Abstract: Polymer composites typically two primary components Contains: A polymer matrix and a Reinforcement phase. Polymer matrix, serving as the continuous phase, provides cohesion, shape, and protection to the composite. Various thermoset and thermoplastic polymers, such as epoxies, polyesters, polyamides, and polypropylene, are chosen as matrix materials based on their processing characteristics and desired properties. Meanwhile, the reinforcement phase enhances the matrix, boosting Mechanical of mixing, Thermal and Electrical properties. Reinforcements come in forms like fibers, particles, or additives, each offering unique advantages. Common fiber reinforcements include glass, carbon, aramid, and natural fibers like hemp and flax, known for their high strength-to-weight ratios and tailored mechanical properties. In materials science and engineering, polymer composites are recognized as versatile and innovative solutions with applications across various industries. These materials, characterized by a combination of distinct constituents with complementary properties, have seen significant advancements over time. The history of polymer composites dates back centuries, with early instances of rudimentary composite materials found in ancient civilizations. For instance, ancient Egyptians used straw-reinforced clay for constructing bricks, showing early experimentation with composites. However, substantial progress in polymer composites occurred in the 20th century, driven by advancements in polymer science, manufacturing technologies, and the pursuit of materials with superior properties. The mid-20th century marked a pivotal moment with the introduction of fiberglass-reinforced polymers (FRPs) pioneered by Owens Corning. This innovation revolutionized industries like aerospace, automotive, and construction. The development of synthetic polymers such as epoxy, polyester, and vinyl ester further propelled the growth of polymer composites, allowing for tailored formulations to meet specific performance requirements. Bio-based Polymer Composites, Recycled Polymer Composites and Nanostructured Polymer Composites. Mechanical Properties, Thermal Properties, Electrical Properties and Chemical Resistance. The FUZZY ARAS ranking of Polymer Composite Materials indicates the highest value for Recycled Polymer Composites and the lowest value for Bio-based Polymer Composites.

Keywords: Mechanical Properties, Thermal Properties, Electrical Properties and Chemical Resistance.

1. INTRODUCTION

A composite material for two or more of more elements can be described as mixed each contributing distinct attributes, resulting in a final assembly with enhanced properties surpassing those of individual components. This amalgamation involves reinforcement elements, commonly referred to as fillers, which are strategically arranged to reinforce the composite structure. Effective team coordination ensures proper orientation of these reinforcements to withstand loads and pressures exerted on the composite. The composition of such products is highly adaptable and typically exhibits anisotropic characteristics, meaning its properties vary based on direction. Nature of matrix, type, of form and reinforcements arrangement, between elements the quality of the interface and including parameters Due to various factors of composite material properties are affected involved in the manufacturing process [1]. Advanced composite materials have seen widespread adoption in industries such as Aerospace, Marine, and Automobile over the past several decades, beginning around 1960. Their appeal lies in their high specific strength and stiffness, low density, excellent fatigue tolerance, and ability to provide enhanced cushioning, among other engineering properties. Additionally, their low thermal coefficient, particularly in the fiber direction, adds to their appeal. In more recent years, there has been a noticeable trend in the construction industry, with civil engineers increasingly recognizing the strengthening capabilities of composites. This shift has

been driven by the deterioration of infrastructure and a host of related concerns. Over the past decade, Fiber-reinforced of polymer composites (FRPCs). Remarkable in use Progress has been made. Construction projects. This surge can be attributed to the favorable engineering characteristics of these materials [2]. Biomaterials encompass both natural and synthetic substances that interact with living tissues in the human body, serving various purposes such as tissue regeneration, augmentation, or substitution. Historical evidence, such as Egyptian mummies and traditional Chinese and Indian practices, illustrates the early use of natural materials like waxes, glues, and tissues from different organisms to repair or replace missing or damaged body parts. Over centuries, significant advancements have been made in the development various in clinical applications Biomaterials Enables use in contemporary clinical practice, a wide array of devices and implants derived from biomaterials are routinely employed. Many more this includes medical treatments. Needs and conditions [3]. Various types of fibrous composite structures, known as hybrid compounds, are created through methods that involve the arrangement of fibers and filaments. These methods include layering, convergence into a single layer, blending different types of fibers, and strategically placing fibers according to specific orientations to achieve optimal performance. Hybridization is particularly effective in situations where specific forces are anticipated, allowing the preferred positioning of fibers to enhance performance. However, achieving the desired results can be complex, as stacking fibers is relatively straightforward while blending them may introduce challenges and inconsistencies. Researchers have focused on identifying the most suitable composition of fibers, considering factors such as content, orientation, size, and manufacturing processes, to optimize performance for specific applications. Success in this endeavor varies depending on the particular requirements and the properties of the fibrous composite [4]. Various types of graphene-polymer composites have been studied extensively, incorporating graphene fillers of different forms. Literature reports indicate that these composites offer significantly enhanced as well Improved electrical and Tensile strength and elastic modulus thermal conductivity, making them promising candidates for multifunctional applications. Despite encountering certain challenges, such as those encountered with carbon nanotube-polymer composites, graphene-polymer composites often outperform their counterparts. This superiority can be attributed to the exceptional properties of graphene, including its high strength and conductivity [5]. Different techniques were employed to characterize polymer composites, encompassing initiation, propagation, branching, and other aspects like finishing and material deterioration. Among these techniques, epoxy resins stand out for their widespread application due to their notable chemical and corrosion resistance, along with their low abstract in healing capabilities. Despite their versatility in processing under different conditions and cross-linking within networks, epoxy resins often exhibit high brittleness, leading to substance vulnerability. In addressing this issue, it becomes crucial to focus on the energy dissipation of composite mixtures, especially when they are subjected to vibrational environments [6]. Polymer composites incorporating micro or nano materials for radiation shielding purposes are under scrutiny. A comprehensive examination of their fundamental interactions with incident radiation and target objects is outlined, defining their role as shields. These polymer composites, distinguished by their micro or nano structures, are broadly classified, with a literature review shedding light on the utilization of nano materials. Additionally, the discussion encompasses the emerging trend of employing polymer-based protective materials [7]. Polymer composites, typically, benefit from chemically modified compounds, especially nanotubes, which exhibit superior mechanical properties. Widely employed methods such as chemical functionalization and/or ultrasound treatment facilitate the dispersion of nanotubes in solvents, particularly enhancing their integration into polymer composites. The solution casting technique effectively addresses challenges related to integrating nanotubes into the composites [8]. Polymer composites, particularly those designed for thermal conductivity, often overlook the importance of the polymer matrix. Prior research indicates that despite using fillers with similar thermal conductivity, are significantly different. In comparison, high temp with conductive polymer Polymer composites matrix exhibit considerably higher thermal conductivity values than those with a low thermal conductivity polymer matrix [9]. Polymer composites are effectively utilized in neuroscientific designs to train networks with specific datasets, requiring a certain level of test results. Addressing material issues within the network post-learning aids in predicting new outcomes within the same domain without extensive experimental durations. The application of Artificial Neural Networks (ANNs) aims at conducting formal parametric studies, leveraging this tool for optimizing composite material designs tailored to specific applications. This review delves into the utilization of various ANN strategies for predicting properties of certain polymer composite materials [10]. Nanocarbon polymer composites involve the incorporation of nanoscale materials, which amalgamate with stable substances like polymers, forming a unified matrix. This integration leads to significant enhancements in mechanical strength, durability, as well as electrical and thermal conductivity—a comprehensive improvement in properties. The addition of nanoparticles, typically ranging from 0.5% to 5.0% by weight, brings forth superior characteristics. These composites exhibit attributes distinct from conventional microscale composites, yet they can be manufactured using straightforward, cost-effective techniques [11]. In the early 1990s, reports surfaced indicating Toyota's experimentation with mica addition to enhance the properties of materials. Researchers observed a fivefold increase in nylon yield and a subsequent boost in material tensile strength. This success

spurred interest in polymer-nanoparticle blends, leading to developments aimed at further enhancing their properties. The emergence of nanoparticles like inorganic nanoparticles, dendrimers fullerenes, Carbon nanotubes, and bio particles, offered precise control over composition at smaller instrumentation became pivotal in analyzing particle size and form influence on nanoparticle-polymer composite properties [12]. Polymer compounds involve the blending of two specific components in a solvent, which subsequently evaporates to yield the compound. Various methods exist for processing such solutions, with a common protocol involving fluid handling, including dispersion of CNT powder. Achieving efficient dispersion typically requires vigorous agitation or sonication to ensure uniform distribution throughout the polymer solution. Control over evaporation conditions is crucial, often accomplished through techniques such as bath or nozzle ringing [13].

2. MATERIALS AND METHOD

Bio-based Polymer Composites: Bio-based polymer composites consist of polymer matrices sourced from renewable origins like plants, animals, or microorganisms. These alternatives offer environmental benefits compared to traditional petroleum-based polymers by lessening reliance on fossil fuels and being biodegradable or compostable. Examples include cellulose, starch, soy protein, or polylactic acid (PLA), and they serve various sectors such as packaging, automotive, construction, and consumer goods.

Recycled Polymer Composites: Recycled polymer composites are crafted from polymers sourced from post-consumer or post-industrial waste. Through processing, these materials are salvaged and refined for reuse in composite production. By diverting plastics from landfills and diminishing the need for new materials, recycled polymer composites aid in addressing environmental concerns associated with plastic waste accumulation. Their applications span similar fields as conventional polymer composites, while additionally lessening environmental impact.

Nanostructured Polymer Composites: Nanostructured polymer composites integrate nanoscale additives like nanoparticles, nanofibers, or nanotubes into the polymer matrix. These additives imbue the composite with distinctive properties such as improved mechanical, thermal, electrical, or barrier characteristics. Carbon nanotubes, graphene, clay nanoparticles, and metal nanoparticles are common additives. With their enhanced performance attributes, nanostructured polymer composites find utility across

Mechanical Properties: These characteristics include strength, stiffness, hardness, toughness, ductility, and elasticity, among others. Hardness signifies a material's ability to resist indentation or scratching, and toughness indicates its capability to absorb energy before fracturing. Ductility describes the extent to which a material can deform before breaking, while elasticity pertains to its ability to revert to its original shape after deformation.

Thermal Properties: Thermal properties are essential factors governing how materials react to temperature variations, holding significant importance across industrial and scientific domains. These properties influence the transmission, storage, and dissipation of heat within a material. Key thermal attributes include thermal conductivity, which gauges a material's heat-conducting ability; thermal expansion, revealing its dimensional changes with temperature shifts; specific heat capacity, and thermal diffusivity, indicating the speed at which heat propagates through a material.

Electrical Properties: Electrical properties describe how materials respond to electric fields and currents, playing a vital role in various applications from electronics to power distribution systems. Fundamental among these properties is electrical conductivity, indicating a material's ability to conduct electric current, while resistivity measures its resistance to the flow of electric charge. Dielectric constant and permittivity assess a material's capability to store electrical energy under an electric field.

Chemical Resistance: Chemical resistance underscores a material's aptitude to endure exposure to diverse chemicals or environmental conditions without deteriorating. Factors such as corrosion resistance, solvent resistance, acid/base resistance, and oxidation resistance collectively shape a material's overall chemical resilience. Each of these categories of properties plays a pivotal role in evaluating the suitability of materials for specific applications across various industries.

Method: The application of Ambiguous ARAS involves assessing and selecting maintenance strategies, aiming to enhance operational processes and support managerial decision-making. It seeks to assist managers by integrating suitable tools and strategies into their decision-making framework. In this context, a systematic system is provided, drawing insights from relevant literature and optimizing the utilization of maintenance strategies

through sub-criteria evaluation [14]. The results obtained from implementing repair and maintenance strategies are analysed using FUZZY ARAS, which involves a comprehensive examination and final ranking of options. The study discusses the application of FUZZY ARAS in various scenarios and acknowledges its limitations. Fuzzy ARAS proves beneficial in project management, enabling project managers to prioritize projects based on various criteria including cost, schedule, and risk. Its ability to incorporate both qualitative and quantitative factors facilitates a comprehensive assessment of project alternatives, aiding in the selection of projects aligned with organizational objectives [15]. Similarly, in product design, Fuzzy ARAS assists designers in evaluating design alternatives considering factors like performance, cost, and environmental impact. By leveraging fuzzy logic and AHP-based criteria weighting, Fuzzy ARAS supports the identification of optimal design configurations that balance customer requirements with technical constraints [16]. Fuzzy ARAS designed to tackle the complexities and uncertainties inherent in decision making situations. Fuzzy logic techniques With Fuzzy-like methods by integrating ARAS offers a structured approach to classify and solve decision-making problems characterized by uncertainty, ambiguity, and multiple criteria. It allows decision-makers to analyse alternatives effectively and select the most suitable option [17]. The power of fuzzy logic within Fuzzy ARAS enables the handling of imprecise data and subjective judgments, while AHP facilitates the structuring of decision hierarchies and pairwise comparisons to determine criteria importance. Additionally, in ranking alternatives based on their proximity to ideal and anti-ideal solutions. This methodology finds applications across various domains and provides decision-makers with a robust framework for making informed choices amidst complex decision landscapes [18]. One notable application of Fuzzy ARAS is in supplier selection processes, where it assists in evaluating and ranking potential suppliers based on criteria such as quality, price, and reliability. Despite its strengths, Fuzzy ARAS may face limitations such as reliance on expert opinions and the need for validation through larger sample sizes in research settings. Future studies could focus on addressing these limitations by increasing the number of respondents and refining weighting methods to better reflect the expertise and experiences of decision-makers. Moreover, researchers may explore the use of Fuzzy ARAS in other domains, such as green supplier selection, by leveraging advanced modelling techniques like ANFIS (Adaptive Neuro-Fuzzy Inference Systems) [19]. At the core of Fuzzy ARAS lies Fuzzy logic, this imprecise and of uncertain data representation and allows handling, Thus the decision will be made about contexts Subtle understanding provides Traditional binary Unlike logic, Fuzzy logic accommodates degrees truth, making it suitable for modelling subjective judgments and vague criteria prevalent in decision-making scenarios [20]. Additionally, Fuzzy ARAS employs a structured approach to decision-making, enhancing transparency and consistency by organizing decision criteria and eliciting preferences from decision-makers. Fuzzy ARAS offers benefits such as simplicity and faster calculations, it may encounter limitations related to the of evaluation criteria interdependence, especially real life criteria in problem settings often exhibit strong interconnections [21]. To address this, researchers have developed various models that consider the complex relationships between decision elements for instance, in evaluating e-courses, researchers have proposed methods like the PIPRECIA (For enrichment assessment Priority ranking system method) method and the Interval-Valued Triangular Fuzzy ARAS method [22]. These methods utilize criteria definition weights and alternative ranking techniques to assess the quality and effectiveness of e-learning courses. However, it's crucial to pay special attention to the specific challenges inherent in e-learning environments, focusing on aspects like content quality, teaching processes, and technical implementation to ensure effective decision-making using Fuzzy ARAS methodologies [23]. Fuzzy ARAS has found successful application across diverse sectors including transportation, economics, technology, sustainable development, and construction. Its versatility is exemplified by numerous significant applications, such as estimating the performance of Iranian companies for Chief Accountant Officer Selection, creating brand inventories for farm vendors, and selecting in the eastern Baltic Sea deep sea ports [24]. These applications demonstrate the effectiveness of Fuzzy ARAS in providing structured assessments and aiding decision-making processes. Additionally, it has been in order to improve the assessment several criteria are used to make the decision (MCDM) framework integrated and selection of conveyors, showcasing its adaptability and utility in various contexts [25].

3. RESULTS AND DICUSSION

TABLE 1. Criterion Weights

Criterion Weights	
Medium	(0.1,0.3,0.5)
High	(0.5,0.7,1.0)
Very High	(0.7,1.0,1.0)

Table 1 uses fuzzy numerical ranges to represent linguistic importance levels using scale weights. "Medium" importance is defined as between 0.1 and 0.5, "high" ranges from 0.5 to 1.0, and "very high" emphasizes strong

importance between 0.7 and 1.0. These ranges allow for flexible assessment while effectively capturing uncertainty in decision-making processes.

TABLE 2. Cultural Considerations in Assessment and Monitoring

	C1	C2	C3	C4
A1	M	H	H	M
A2	M	H	H	H
A3	Vh	M	Vh	H

Table 2 the provided code pertains to Polymer Composite Materials, encompassing Bio-based, Recycled, and Nanostructured variants. Each criterion index, including Mechanical, Thermal, Electrical properties, and Chemical Resistance, is adjusted to reflect corresponding values.

TABLE 3. Analysis in Fuzzy

	l	l'	m	u'	u
0.1	0.191293	0.44814	0.629961	1	
0.1	0.292402	0.527763	0.793701	1	
0.5	0.559344	0.788374	1	1	
0.1	0.292402	0.527763	0.793701	1	

Table 3 Table 2, the values from Table 1 are substituted. The "l" column represents the minimum value among all criterion weights in Table 1, which is then replaced in Table 2. Likewise, "l'" represents the cube root of the product of the first substituted value in Table 2. "m" indicates the cube root of the product of the second substituted value, and "u'" denotes the cube root of the product of the third substituted value.

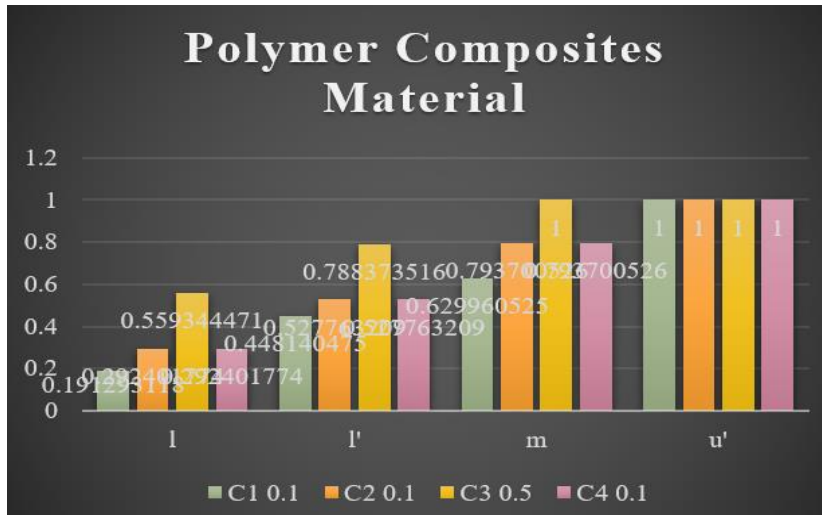


FIGURE 1. Polymer Composites Material

Figure 1 Table 3 illustrates the Criterion Weights for Polymer Composite Materials. It reveals that all criteria, including Mechanical Properties (C1), Thermal Properties (C2), Electrical Properties (C3), and Chemical Resistance (C4), hold equal significance, with Chemical Resistance emerging as the predominant criterion in comparison to the rest.

TABLE 4. Performance Rating

MG	0.5,0.7,0.9
G	0.7,0.7,1.0
VG	0.9,1.0,1.0
F	0.3,0.5,0.7

Table 4 shows the values representing the fuzzy linguistic ratings used for performance evaluation. MG (moderately good) ranges from 0.5 to 0.9, G (good) from 0.7 to 1.0, VG (very good) from 0.9 to 1.0, and F (fair) from 0.3 to 0.7. These ranges capture the uncertainty in expressing varying levels of quality.

TABLE 5. Polymer Composites Material

	w1	w2	w3	w4
	C1	C2	C3	C4
Optimal				
A1	1,1	1,2	1,3	1,4
A2	2,1	2,2	2,3	2,4
A3	3,1	3,2	3,3	3,4

Table 5 illustrates the location of Polymer Composite Materials, outlining the columns and rows within the aforementioned table.

TABLE 6. Formula to Calculate the Performance Rating

	C1	C2	C3	C4
A1	G,F,MG	F,MG,G	VG,MG,G	VG,F,MG
A2	MG,G,VG	VG,F,MG	G,MG,VG	G,MG,F
A3	F,MG,G	MG,G,VG	F,G,MG	MG,G,VG

Table 6 the process entails utilizing the performance rating formula on each cell within the table, substituting the Table 5 value with the corresponding Table 6 value. Through iteratively repeating this process for each row and column, subsequent values can be calculated.

TABLE 7. Solved value of L, l', m, u'

	l	l'	m	u'	u
0.3	0.471769	0.625732	0.857262	1	
0.3	0.471769	0.625732	0.857262	1	
0.5	0.680409	0.788374	0.965489	1	
0.3	0.512993	0.70473	0.857262	1	
0.5	0.680409	0.788374	0.965489	1	
0.3	0.512993	0.70473	0.857262	1	
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0.3	0.471769	0.625732	0.857262	1	
0.5	0.680409	0.788374	0.965489	1	

Table 7 Table 5 furnishes the established values for Solved, L, l', m, and u', which are subsequently incorporated into Table 6. Within the l column, the minimum value of the initial criterion weight is specified, subsequently replaced in Table 6. Similarly, l' represents the cube root of the product derived from the first value substituted into Table 6. The value m signifies the cube root of the product resulting from the second value substituted in Table 6, while u' denotes the cube root of the product originating from the third value

TABLE 8. Maximum Calculated the Value

A0	0.5	0.680409	0.788374	0.965489	1
A1	0.3	0.512993	0.70473	0.857262	1
A2	0.3	0.471769	0.625732	0.857262	1
A3	0.5	0.680409	0.788374	0.965489	1
					4

Table 8 the maximum value within each box is displayed, taking into account Table 5. This involves identifying the highest value across all rows and columns within the respective box.

TABLE 9. Normalized Matrix

	Normalized Matrix				
A0	0.125	0.170102	0.197093	0.241372	0.25
A1	0.075	0.128248	0.176182	0.214315	0.25
A2	0.075	0.117942	0.156433	0.214315	0.25
A3	0.125	0.170102	0.197093	0.241372	0.25

Table 9 displays the normalized matrix for Polymer Composite Materials, encompassing Bio-based Polymer Composites, Recycled Polymer Composites, and Nanostructured Polymer Composites. It includes normalized values for Mechanical Properties, Thermal Properties, Electrical Properties, and Chemical Resistance.

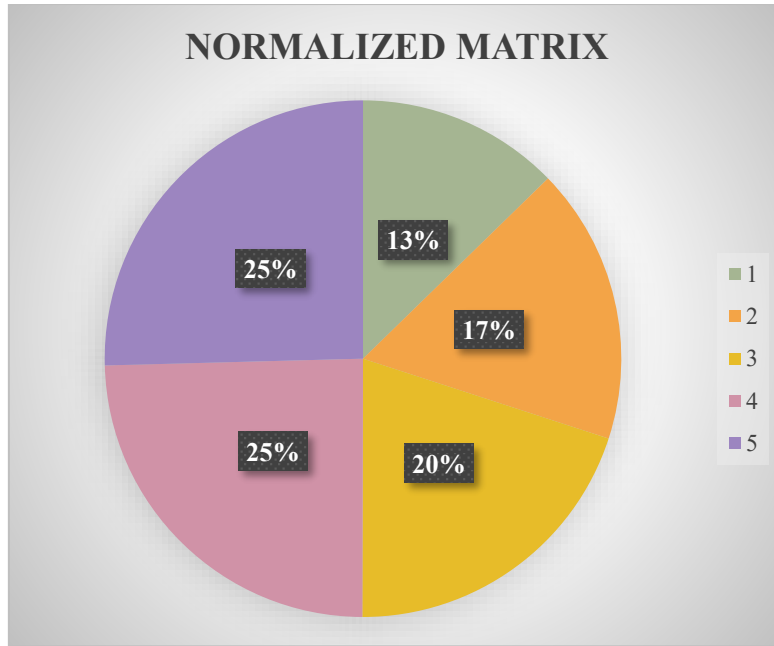


FIGURE 2. Normalized Matrix

Figure 2 displays the normalized matrix for Polymer Composite Materials, encompassing Bio-based Polymer Composites, Recycled Polymer Composites, and Nanostructured Polymer Composites. It includes normalized values for Mechanical Properties, Thermal Properties, Electrical Properties, and Chemical Resistance.

TABLE 10. Weighted Normalized Matrix

	Weighted Normalized Matrix				
	0.1	0.292402	0.527763	0.793701	1
A0	0.0125	0.049738	0.104019	0.191577	0.25
A1	0.0075	0.0375	0.092983	0.170102	0.25
A2	0.0075	0.034487	0.08256	0.170102	0.25
A3	0.0125	0.049738	0.104019	0.191577	0.25

Table 10 Illustrates the Weighted Normalized Matrix for Polymer Composite Materials, indicating the maximum and minimum values.

TABLE 11. Weighted Normalized Matrix C1

	Weighted Normalized Matrix				
	0.1	0.191293	0.44814	0.629961	1
A0	0.0125	0.032539	0.088326	0.152055	0.25
A1	0.0075	0.022562	0.070104	0.13501	0.25
A2	0.0125	0.032539	0.088326	0.152055	0.25
A3	0.0075	0.022562	0.070104	0.13501	0.25

Table 11 the Weighted Normalized Matrix for Mechanical Properties C1, this analysis stands out among other calculations conducted. It specifically illustrates the weighted normalized matrix for Mechanical Properties C1, emphasizing its representation and importance in the overall context.

TABLE 12. Weighted Normalized Matrix C2

	Weighted Normalized Matrix				
	0.1	0.292402	0.527763	0.793701	1
A0	0	0	0	0	0
A1	0.01	0.055934	0.236512	0.5	1
A2	0.00125	0.009515	0.046615	0.120686	0.25
A3	0.00075	0.006597	0.036998	0.107158	0.25

Table 12 Displaying the Weighted Normalized Matrix for Thermal Properties C2, this representation underscores the value calculation concerning inclusivity. Among the various calculations conducted, it highlights the weighted normalized matrix that reflects a higher value, indicating its importance in the assessment process.

TABLE 13. Weighted Normalized Matrix C3

Weighted Normalized Matrix					
	0.5	0.559344	0.788374	1	1
A0	0.0625	0.095146	0.155383	0.241372	0.25
A1	0.0625	0.095146	0.155383	0.241372	0.25
A2	0.0625	0.095146	0.155383	0.241372	0.25
A3	0.0375	0.06597	0.123328	0.214315	0.25

Table 13 the Weighted Normalized Matrix for Electrical Properties C3, this calculation highlights the cost-effectiveness aspect compared to other computations. It focuses on the Polymer Composites Materials, where the weighted normalized matrix reflects a superior value.

TABLE 14. Weighted Normalized Matrix C4

Weighted Normalized Matrix					
	0.1	0.292402	0.527763	0.793701	1
A0	0.0125	0.049738	0.104019	0.191577	0.25
A1	0.0075	0.0375	0.092983	0.170102	0.25
A2	0.0075	0.034487	0.08256	0.170102	0.25
A3	0.0125	0.049738	0.104019	0.191577	0.25

Table 14 the calculation of the Weighted Normalized Matrix for Chemical Resistance (C4) stands out from other calculations by showcasing its specific relevance to Polymer Composite Materials, thereby highlighting its heightened importance.

TABLE 15. Calculated in using Maximum Value.

Si Calculated in using Maximum Value.					
A0	0.8	1.335441	2.29204	3.217362	4
A1	0.0875	0.177423	0.347727	0.585005	0.75
A2	0.0875	0.211142	0.554982	1.046485	1.75
A3	0.08375	0.171686	0.372883	0.684216	1

Table 15 Demonstrating the utilization of maximum value in Polymer Composites Materials, Bio-based Polymer Composites, Recycled Polymer Composites and Nanostructured Polymer Composites show both the highest and lowest values.

TABLE 16. Final Result of Polymer Composites Materials

	Si	Qi	Rank
	2.328969	1	
A1	0.389531	0.167255	3
A2	0.730022	0.313453	1
A3	0.462507	0.198589	2

Table 16 the culmination of FUZZY ARAS's Polymer Composites Materials indicates that the final Recycled Polymer Composites result displays the highest value for Si, while Bio-based Polymer Composites the lowest value. Additionally, Recycled Polymer Composites result displays the highest value for Qi, while Bio-based Polymer Composites is showing the lowest value.

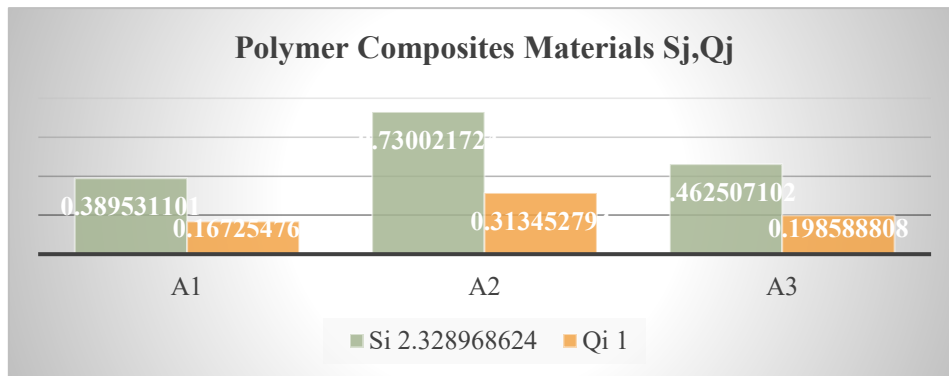


FIGURE 3. Final Result of Polymer Composites Materials

Figure 3 the culmination of FUZZY ARAS's Polymer Composites Materials indicates that the final Recycled Polymer Composites result displays the highest value for Si, while Bio-based Polymer Composites the lowest value. Additionally, Recycled Polymer Composites result displays the highest value for Qi, while Bio-based Polymer Composites is showing the lowest value

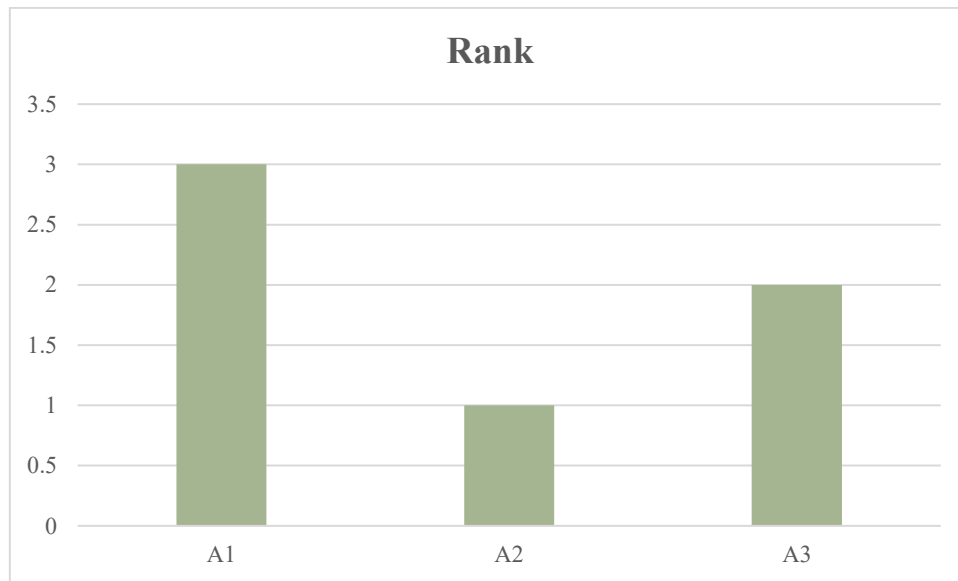


FIGURE 4. Shown the Rank

Figure 4 The FUZZY ARAS ranking of Polymer Composite Materials indicates the highest value for Recycled Polymer Composites and the lowest value for Bio-based Polymer Composites.

4. CONCLUSION

Polymer composites typically two primary components Contains: A polymer matrix and a Reinforcement phase. Polymer matrix, serving as the continuous phase, provides cohesion, shape, and protection to the composite. Various thermoset and thermoplastic polymers, such as epoxies, polyesters, polyamides, and polypropylene, are chosen as matrix materials based on their processing characteristics and desired properties. Meanwhile, the reinforcement phase enhances the matrix, boosting Mechanical of mixing, Thermal and Electrical properties. Reinforcements come in forms like fibers, particles, or additives, each offering unique advantages. Common fiber reinforcements include glass, carbon, aramid, and natural fibers like hemp and flax, known for their high strength-to-weight ratios and tailored mechanical properties. In materials science and engineering, polymer composites are recognized as versatile and innovative solutions with applications across various industries. These materials, characterized by a combination of distinct constituents with complementary properties, have seen significant advancements over time. The history of polymer composites dates back centuries, with early instances of rudimentary composite materials found in ancient civilizations. For instance, ancient Egyptians used straw-reinforced clay for constructing bricks, showing early experimentation with composites. A composite material for two or more of more elements can be described as mixed each contributing distinct attributes, resulting in a final assembly with enhanced properties surpassing those of individual components. This amalgamation involves reinforcement elements, commonly referred to as fillers, which are strategically arranged to reinforce the composite structure. Effective team coordination ensures proper orientation of these reinforcements to withstand loads and pressures exerted on the composite. The development of synthetic polymers such as epoxy, polyester, and vinyl ester further propelled the growth of polymer composites, allowing for tailored formulations to meet specific performance requirements. Bio-based Polymer Composites, Recycled Polymer Composites and Nanostructured Polymer Composites. Mechanical Properties, Thermal Properties, Electrical Properties and Chemical Resistance. The FUZZY ARAS ranking of Polymer Composite Materials indicates the highest value for Recycled Polymer Composites and the lowest value for Bio-based Polymer Composites.

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