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Treatment of Food Waste for Bioethanol Production Using Pervaporation Separation Technology

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Abstract*: The development of alternatives to fossil fuels like Bio-fuel is becoming increasingly urgent with the depletion of resources of fossil fuels and the steadily worsening state of our atmosphere and natural environment. The usage of bio-fuels is one possibility to decrease greenhouse gas emissions in the nearer future. Bioethanol can be used in fuels for vehicles without any modifications of the engines in concentrations up to 5 percent and even 10 percent in newer engines. Different possible raw materials for the production of bioethanol have been studied during the last few decades. Food waste from restaurants and hotels in India are increasing environmental problem, particularly in tourist areas. Food waste can be defined as any edible waste from food production and consumption. Food waste generated in India is rich in carbohydrate, as high as 65% of total solids due to its high proportion of cooked rice and cereals. With the use of fermentation & pervaporation technology this waste can be converted in to useful byproduct like bioethanol. Thus, utilization of hotel & restaurant food waste for bioethanol production can positively influence both the energy and environmental sustainability.

Keywords*: Fossil fuels, Biofuels, Food waste, Bioethanol, Pervaporation Technology.

I. INTRODUCTION

Food waste is one of the major waste issues in India. This food waste can be classified as a bio-degradable waste. There are various methods for waste disposal one of land filling. This land filling of waste food produces a methane gas which is 20% more heavily than CO_2 gas. Therefore with the help of promising and environmental friendly technology this food waste is converted in to useful byproduct like biofuels. Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn, sugarcane, or sweet sorghum. Cellulosic biomass, derived from non-food sources, such as trees and grasses, is also being developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a petrol additive to increase octane and improve vehicle emissions. Ethanol is used as an automotive fuel by itself and can be mixed with petrol to form what has been called "petrohol" fuel. Ethanol the most common blends contain 10% ethanol and 85% ethanol mixed with petrol. Over 1 billion gallons of ethanol are blended with petrol every year in the United States. Because the ethanol molecule contains oxygen, it allows the engine to more completely combust the fuel, resulting in fewer emissions. Since ethanol is produced from plants that harness the power of the sun, ethanol is also considered a renewable fuel. Therefore, ethanol has many advantages as an automotive fuel. Most industrial ethanol is denatured to prevent its use as a beverage. Denatured ethanol contains small amounts, 1 or 2 percent each, of several different unpleasant or poisonous substances.

Food waste from restaurants and hotels is an increasing environmental problem, particularly in tourist areas. Restaurant waste consists of restaurant discards, waste from food preparation, large amounts of oils and fats. Food waste can be defined as any edible waste from food production, transportation, distribution and consumption. Under the Waste Disposal and Public Cleansing Law the food waste is classified into industrial waste and municipal waste: waste from food manufacturers are classified as the former and waste from food distributers and restaurants are classified in the latter category along with household waste. In India restaurants generated approximately 60 percent of municipal food with only 5-10% of household kitchen waste. Food waste is a complex biomass containing various components such as starchy, fatty, and cellulosic materials.

Without some sort of processing, these organic polymer materials may be difficult for ethanol production. Food waste generated in India is rich in carbohydrate, as high as 65% of total solids due to its high proportion of cooked rice and cereals. Food waste is difficult to dispose of by incineration. Most food waste has been land filled together with other wastes. Food waste is the major component of organic matter in garbage and so when it is disposed of in landfills it is the major source of methane gas produced in the landfills.

TABLE I- Composition in waste food

Fraction	% w/w
Soluble	33.81
Glucose	4.39
Fructose	3.47
Sucrose	4.38
Total reducing sugars	12.54
Protein	0.54
Fats	11.91
Cellulose	18.30

A. Objective of Work

1) To find alternative source for the production of bioethanol.
2) To produce bioethanol from food waste, without interfering with food security.
3) To find alternative to traditional technology for recovery of bioethanol from fermentation broth by using pervaporation.
4) To study Effect of optimized operating conditions on performing parameters of pervaporation.
5) To study the effect of temperature, feed composition & pressure on membrane flux.
6) To purify the bioethanol by using pervaporation.

II. MATERIAL AND METHODS

A. Raw Material

Food waste use in this study was collecting from stalls, trolleys, restaurants, and canteens. We have to remove First plastic, chopsticks and toothpicks and paper were removed and then the samples were homogenized in a blender and then stored.

Figure 1- land filling of waste food

B. Enzymes

Enzymes used in this project are α-Amylase and Gluco-amylase.

1) *A-Amylase:* α-Amylase is a bacterial α-amylase preparation produced by submerged fermentation of a selected strain of Bacillus licheniformis. It is a thermo stable amylase that can randomly hydrolyze α-1.4 glycosidic bonds of starch and starch derivatives into soluble dextrin and oligosaccharides. Application pH range 5.5 to 6.5.Optimum 5.8 Application Temperature Range 50-100 °C**.**

2) *Gluco-amylase:* Glucoamylase is an enzyme which decomposes starch into glucose by tearing-off glucose units from the non-reduced end of the polysaccharide chain. It is derived by submerged fermentation of a specially selected producer strain of Asp. niger. Enzyme activity is expressed in glucoamylase units, representing the amount of enzyme which catalyses liberates 1 µmol of glucose from 1% of starch solution in 1 min, at PH 4- 4.5, and at Temperature 30-40^{0}C.

3) *Yeast:* Dry active yeast (Saccharomyces cerevisiae) also called as baker's yeast brought from local market and is rehydrated in water bath at 40°C, by using clean water and allowed taking to room temperature before for Fermentation.

4) *Membrane:* Hydrophobic Polytetrafluoroethylene (PTEF) Membrane is used of pore size 0.2µm.

Figure 2- Polytetrafluoroethylene (PTEF) Membrane

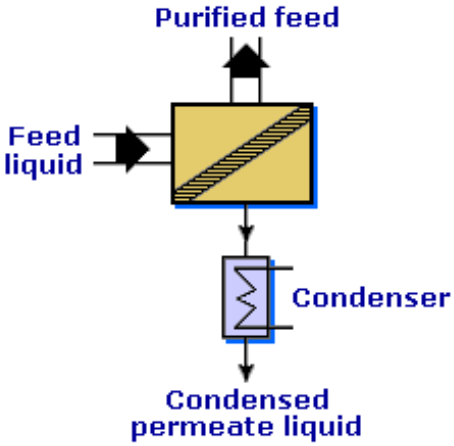


Figure 3- Mechanism of PTFE membrane for pervaporation

III.EXPERIMENTAL PROCEDURE

The food waste is collected from canteens and boys hostel mess. Initially 200gms of food waste was taken. And then crushed in a mixer and collected in beakers, 50% distilled water was added into the mash. The pretreatment is usually followed by enzymatic hydrolysis to convert the Starch to fermentable sugars. It was treated with α-Amylase at 90^0C, PH 5.5 for 2hrs.and then hydrolysed by gluco-amylase at 85^0 C, pH 4.8 for 2hrs. Autoclave for 15 min at 121 °C and 15 PSI.

A. Enzymatic hydrolysis of waste food

1. Alpha-Amylase hydrolysis

a) A 125 ml Erlenmeyer flask was used with a stopper and aluminum foil for digestions.

b) Totally, 100 ml of sample was added to the flask followed by 1 to 2 drops of Alpha-Amylase.

c) The experiments were performed for 2 h in a water bath maintained at 85^0C for the first digestion.

d) The bath was covered with aluminum foil to keep the temperature constant.

e) After 2 h, the samples were removed and cooled with running water.

B. Gluco-Amylase hydrolysis

1) Once the samples were cooled to 40^0C.

2) 2 to 4 drops of gluco-amylase was added and the flasks were incubated for 2 h at 100 rpm.

3) Again, the bath was covered with aluminum foil to maintain constant temperature.

C. Fermentation

1) After the two-part enzyme digestion, the samples were inoculated with Saccharomyces cerevisiae (Baker yeast) inoculums.

2) The broth was prepared by adding about 0.8 g dry yeast to 10 ml distilled water.

3) The samples had been sterilized for 15 min at 110^0C in the autoclave.

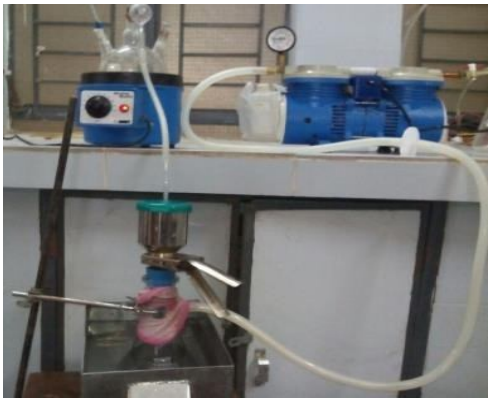


Figure 4- small pervaporation setup in lab

D. Analysis

1) Glucose Estimation: Glucose content was determined according to the method of Miller. The reducing sugars liberated by these reactions were measured using the 3, 5-dinitrosalicylic acid (DNS) method, with glucose as standard. 3 ml of DNS reagent is added to 3 ml of glucose sample in a lightly capped test tube. The absorbance values of the reducing sugar were measured using spectrophotometer at 575 nm.

2) Ethanol Estimation: Ethanol concentration is determined according to the method of Williams and Darwin. The 100 ml of potassium dichromate reagent solution is prepared. Saturated S-Diphenylcarbazide solution is prepared by dissolving 1 g of S-Diphenylcarbazide to 1 ml of 95% ethanol. The mixture is then added with 1 ml of a 40% potassium sodium tartrate (Rochelle salt) solution to stabilize the color. The ethanol absorbance values were measured at 575 nm.

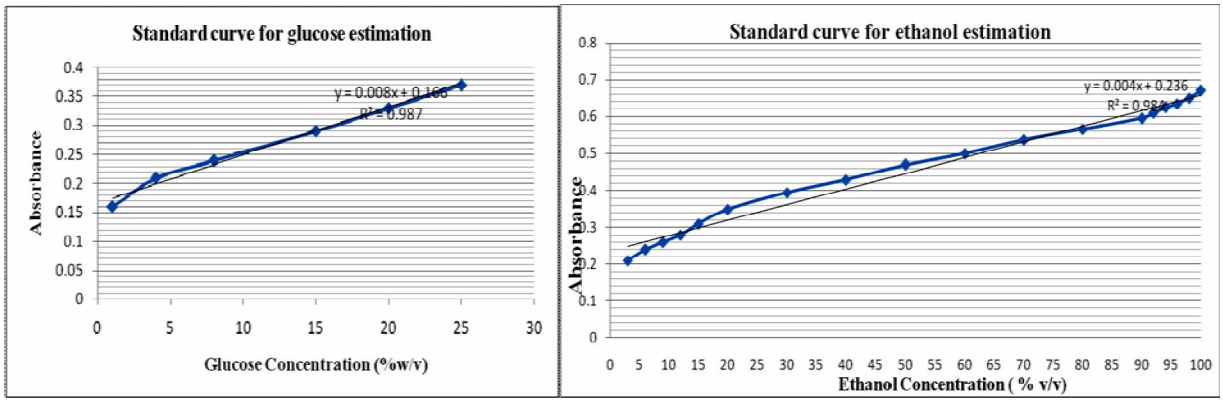


Figure 5- Graph shows the standard concentration of Glucose and Ethanol

IV. RESULT & DISCUSSION

A. Glucose concentration: (Enzymatic Hydrolysis of food waste)

TABLE III-The glucose concentration is measured at different time interval of fermentation broth.

Glucose Concentration w/v%	Fermentation Time(hr)				
	0	24	48	72	90
First run	12.0	6.05	3.5	0.8	0.4
Second Run	13.2	5.6	3.1	0.6	0.2
Third Run	13.1	5.30	2.8	0.45	0.21

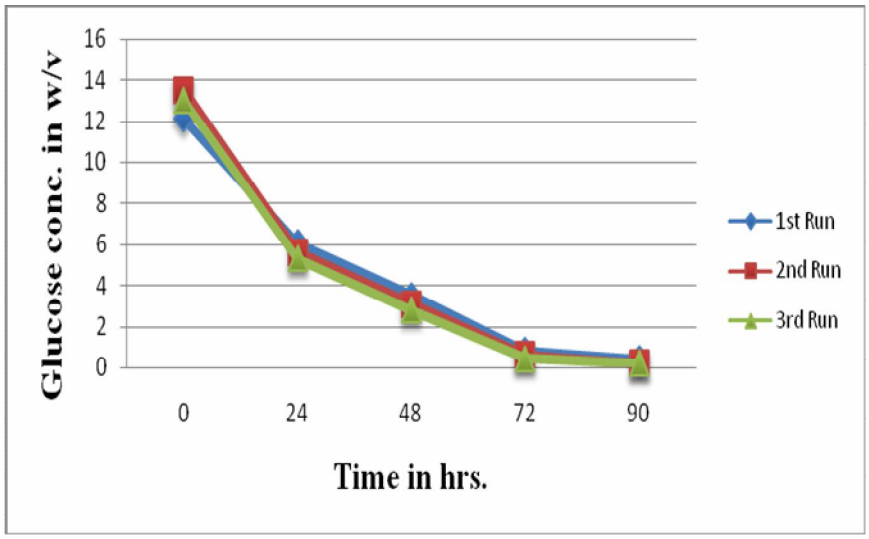


Figure 6- The glucose concentration is measured at different time interval of fermentation broth

B. Bioethanol Concentration

TABLE IIIII- The ethanol concentration is measured at different time interval of fermentation broth.

Ethanol Concentration v/v%	Fermentation Time(hr)				
	0	24	48	72	90
First run	0	3.3	5.45	6.1	6.8
Second Run	0	3.8	6.2	6.8	7.04
Third Run	0	3.7	6.5	6.85	7.1

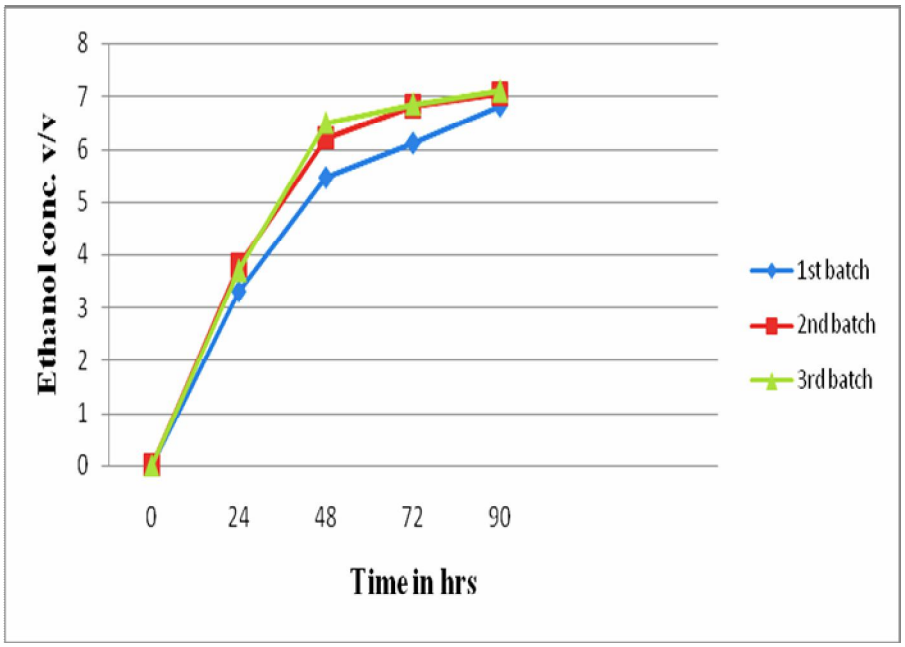
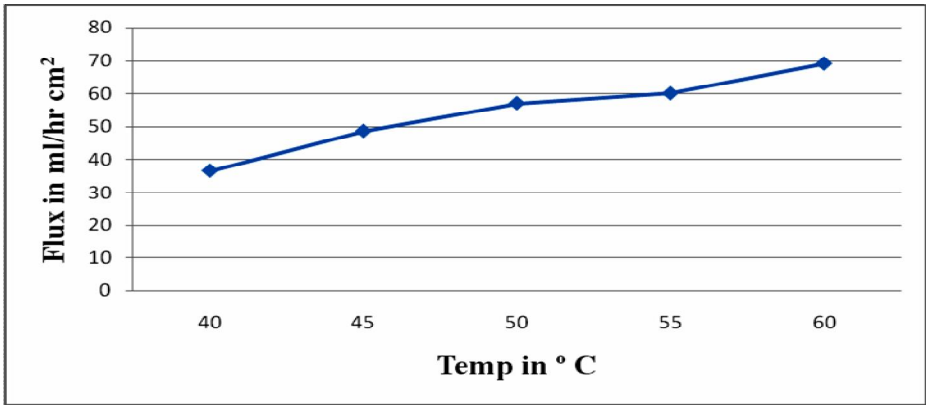


Figure 7- Graph shows concentration of Glucose and Ethanol at different time interval of fermentation broth.

C. Pervaporation of Fermented Broth

We studied pervaporation at different concentration and temperature.



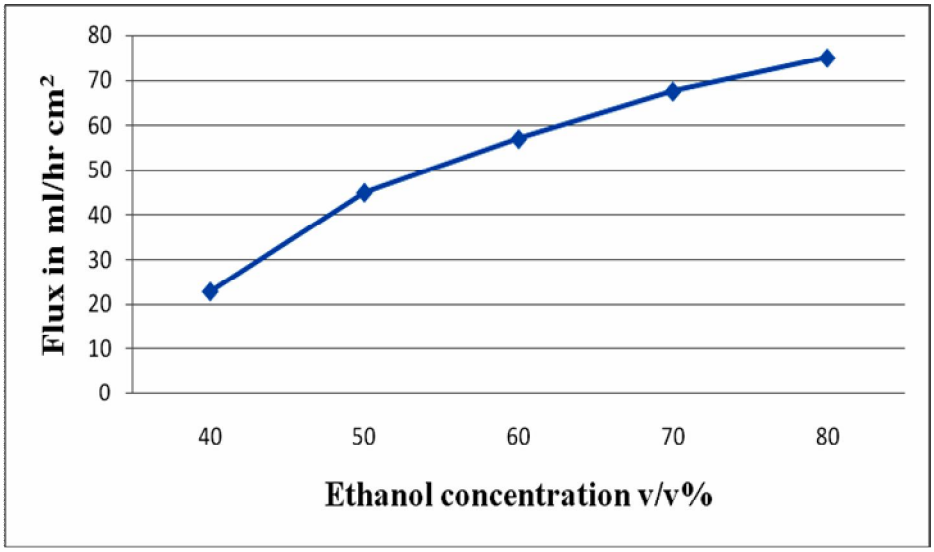


Figure 8- Graph Shows Permeate flux at constant concentration (60%) and at different temperature

Figure 9- Permeate Flux at constant temperature and different concentration

V. CONCLUSION

A. Bioethanol produced from waste food up to 7.1% v/v by anaerobic fermentation using Saccharomyces cerevisiae.

B. Concentration increases of bioethanol from fermentation broth from 7.1 % to 99.50% v/v using pervaporation.

C. To separate bioethanol from fermented broth and concentrate it to 99.50% from 7.1% Optimum conditions found are, temperature between 50^0-60^0C, vacuum 650mmHg.

D. The membrane separation processes have many advantages that are used to improve the total efficiency of biofuel production process.

E. Bioethanol production from food waste does not only solve environmental issues but also provides renewable biofuels.

F. This fuel contributing to the reduction of the global warming effect and negative environmental impact generated by the worldwide utilization of fossil fuels.

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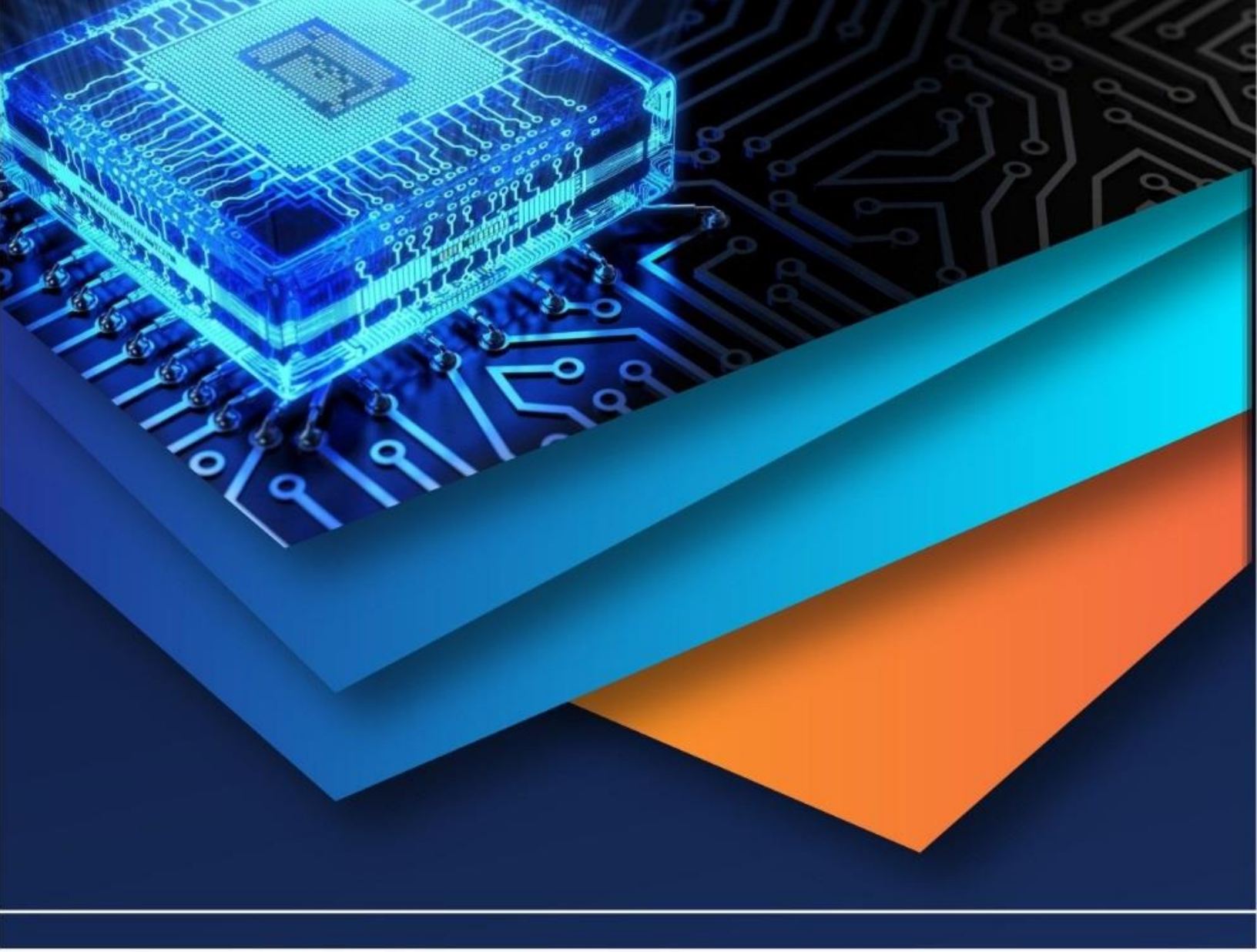

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