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Formulation and Evaluation of Chironji-Derived Oleic Acid-Based Herbal Sunscreen for Enhanced Photoprotection

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Abstract: ***It can be observed that oleic acid, which is a monounsaturated fatty acid, has acquired potential usage in most skincare products, especially sunscreens, owing to the emollient, moisturizing, and anti-inflammatory properties, which it possesses. The Indian plant chironji (Buchananialanzan) is one of the major sources of oleic acid, and its seeds have been traditionally incorporated in several medicinal and cosmetic preparations. The present work focuses on the extraction of oleic acid from chironji seeds and its incorporation into sunscreen formulations. Oleic acid was extracted using a solvent method, after which characterization was done using gas chromatography-mass spectrometry (GC-MS) for composition and purity confirmation. The experimental or exploratory sunscreens were prepared with varying concentrations of oleic acid from chironji, and stability testing, SPF (sun protection factor), and skin compatibility testing were conducted. The results suggest that the incorporation of oleic acid from chironji will enhance hydration of the skin while giving effective UV protection, ultimately leading to high stability of the product. Therefore, chironji slant oleic acid can be considered a potential natural product for the sustainable development of sunscreens. The present study, therefore, places chironji as one of the good sources for oleic acid for use in the cosmetic and pharmaceutical industries towards obtaining eco-friendly composites and useful sun protection products.***

Index terms: UV radiation, herbal sunscreen, SPF,chironji, oleic acid

I. INTRODUCTION

1) Herbal sunscreen-

As Herbal sunscreens are becoming more popular as natural substitutes for traditional sun protection products. These compositions often incorporate plant-based compounds that have UV-blocking and skin-soothing properties. Unlike conventional sunscreens, the main ingredients of herbal sunscreens include plant extracts such as zinc oxide, aloe vera, green tea, and various oils rich in vitamins and antioxidants. Some herbal agents can actually nourish the skin and then protect it actively from damaging UV radiation. For example, zinc oxide, quite common in herbal sunscreens, offers broad-spectrum protection with a relatively low possibility of causing irritation to sensitive skin. Polyphenols of green tea extract might even be helpful in ameliorating oxidative stress caused by UV exposure.Awareness about the potential side effects from synthetic chemical ingredients on consumers and the search for greener products are another driving force for the herbal sunscreen category. For many looking for clean beauty alternatives, these natural formulations are interesting because they do not contain parabens, artificial fragrance, or other harmfully synthetic ingredients.

2) Chironji-

Known scientifically as Buchananialanzan, chironji is a tropical tree found in the Indian subcontinent-mostly in states like Madhya Pradesh and Uttar Pradesh. The seeds of this tree, known as 'chironji seeds', are rich in nutritional value and used for various cooking purposes. These seeds are known to contain a high quantity of protein, fat, and essential minerals and are mostly added to the thus improving their taste and texture in sweets and snacks.

In Ayurveda, chironji seeds are used mainly for their appetite, but have also found importance in medicine. According to the health benefits they are said to have a property as follows; antibacterial, antioxidant, and anti-inflammatory, thus enhancing their overall health. The timber from the tree is economical as it is used for various crafting and construction purposes.

3) Uses of oleic acid:

Hydration: By acting as an emollient and preventing the skin from losing water, oleic acid helps to keep the skin moisturized.

Barrier Formation: Oleic acid strengthens the barrier's inherent function by creating a protective layer that protects the skin from pathogens and environmental irritants.

Increased Skin Elasticity: Regular oleic acid treatment helps increase skin elasticity, giving the appearance of smoother, more supple skin.

II. MATERIAL AND METHOD

1) Plant- *Chironji* (*Buchananialanzan*) seeds were obtained from a raw material supplier.

2) Raw Material-*Chironji* (*Buchananialanzan*) seed powder (properly dried and grounded)

Chemicals and Solvents-Petroleum ether (boiling point 60–80°C) – commonly used for extracting non-polar oilsorn-Hexane – alternative non-polar solvent for fixed oil extraction, anhydrous sodium sulfate – for drying the extract, ethanol or methanol (if needed for cleaning or subsequent steps)

3) Equipment

Soxhlet extractor – standard laboratory setup for continuous solvent extraction

Round-bottom flask – to hold the solvent during heating

Heating mantle or water bath – to maintain constant boiling of the solvent

Condenser – to condense solvent vapours back into the Soxhlet chamber

Cotton or filter paper – to hold the plant material in the thimble

Sintered glass thimble or Whatman filter paper thimble – for containing the powdered seeds during extraction

Rotary evaporator – for concentrating the extracted oil by removing the solvent

Glassware: measuring cylinders, beakers, funnels, etc.

4) Personal Protective Equipment (PPE)

Lab coat, gloves, safety goggles, fume hood (recommended when working with volatile solve, ingredients for formulation (e.g., beeswax, stearic acid, aloe vera gel, glycerine, emulsifying wax, natural preservatives), standard sunscreen formulation for comparison.Instruments and Equipment:Soxhlet extractor, rotary evaporator, water bath, magnetic stirrer, UV-Visible spectrophotometer, pH meter, Brookfield viscometer

III. METHODOLOGY

1) Preparation of Chironji Seed Powder

The collected *Chironji* seeds were thoroughly cleaned to remove impurities, shade-dried, and ground into a fine powder using a grinder. The powder was stored in an airtight container until further use.

2) Extraction of Fixed Oil

The powdered seeds were subjected to Soxhlet extraction using a non-polar solvent (e.g., petroleum ether or n-hexane). The extraction was carried out for 6–8 hours until complete exhaustion of the oil.The extract was concentrated using a rotary evaporator.

3) Isolation of Oleic Acid

Column chromatography is one of the most common methods for isolating individual compounds from a mixture (in this case, oleic acid from the extracted oil).

Materials Needed:Silica gel (stationary phase), solvent or mobile phase (e.g., a mixture of hexane, diethyl ether, and acetic acid), column (glass tube), sample (extracted oil) dissolved in a suitable solvent (e.g., hexane), solvent reservoir, UV light or iodine chamber for detection.

Preparation of the Column:Pack a column with silica gel (stationary phase).Use a mixture of hexane and diethyl ether to create a slurry and load it into the column.

Loading the Sample:Dissolve your extracted oil in a small amount of solvent (e.g., hexane), and carefully load it into the column.

Elution:Elute (wash) the column with a series of solvents, starting with non-polar solvents (e.g., hexane) and moving to more polar solvents (e.g., diethyl ether, acetone).The oleic acid will gradually separate from other components of the extract as it moves down the column.

Collection of Fractions:Collect small fractions of the eluent and monitor each fraction using TLC to identify the one that contains pure oleic acid.

Evaporation and Purification:After separating the fractions containing oleic acid, evaporate the solvent under reduced pressure using a rotary evaporator to obtain the isolated oleic acid.

Advantages of Column Chromatography:Can isolate compounds in significant quantities.Excellent for separating compounds with different polarities.

4) Characterization of Oleic Acid

Thin Layer Chromatography (TLC): Used for qualitative confirmation.

5) Formulation of Herbal Sunscreen

Various herbal sunscreen formulations were prepared by incorporating different concentrations of oleic acid into a cream base.

IV. EVALUATION OF FORMULATION

1) Physical Evaluation

Color, odor, texture, and homogeneity were observed visually.

2) pH Measurement

pH of each formulation was measured using a calibrated digital pH meter.

3) Spreadability

Evaluated by placing a fixed amount of cream between glass slides and measuring the area covered.

4) Stability Studies

Conducted under different temperature and humidity conditions for a period of 1–3 months.

5) Sun Protection Factor (SPF) Determination

In vitro SPF was evaluated using UV-Visible spectrophotometry as per the Mansur method, by analyzing absorbance between 290–320 nm.

V. FORMULATION TABLE-

Table.no. 1

Ingredient	Quantity in grams	Use
Oleic acid	0.5	Emollient, moisturizer
Bees wax	1.0	Emulsifier, thickening agent
Coconut oil	1.5	Emollient, provide SPF
Lavender oil	0.2	Fragrance, soothing, anti-inflammatory
Olive oil	1.5	Moisturising, antioxidant
Argan oil	1.0	Antioxidant, emollient, hydration
Honey	0.3	Humectant, skin conditioning, moisturizing
Green tea extract	0.3	Antioxidant, soothing, skin protection
Zinc oxide	2.0	UV filter, sun protection

VI. PROCEDURE

To prepare the natural sunscreen balm, begin by creating a double boiler setup and gently heating the oil-based ingredients: beeswax, coconut oil, olive oil, argan oil, and oleic acid. Stir the mixture until everything is fully melted and combined into a uniform liquid. Once melted, remove the mixture from heat and allow it to cool slightly to around 40–45°C to protect the integrity of heat-sensitive ingredients. At this stage, add lavender oil, honey, and green tea extract, mixing thoroughly to ensure even distribution. Wearing a mask to avoid inhaling fine particles, slowly sift in the zinc oxide while continuously stirring to prevent clumping and ensure even dispersion. Once everything is fully incorporated, pour the mixture into a clean, sterilized container or tin. Allow it to cool and solidify at room temperature. Store the finished balm in a cool, dry place and apply a small amount as needed for sun protection and skin nourishment.

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VII.EVALUATION METHODS

A. Organoleptic Evaluation (Sensory Testing)

1) Color: Should be consistent and visually appealing.
2) Odor: Should have a pleasant or neutral fragrance from the lavender oil and other ingredients.
3) Consistency: Should have an appropriate texture (not too greasy or too thick) and smoothness on application.
4) Feel: The sunscreen should feel non-greasy but moisturizing, leaving a soft feel on the skin.

B. pH Determination

To check if the sunscreen is safe and non-irritating to the skin. Measure the pH of the sunscreen using a pH meter or pH indicator strips. The pH should typically be between 4.5 to 7, which is skin-friendly.

C. SPF Determination (Sun Protection Factor)

1) In Vitro SPF Testing

To determine the Sun Protection Factor (SPF) of the sunscreen, which indicates its effectiveness in protecting the skin from UVB radiation, perform in vitro testing by measuring the amount of UV radiation transmitted through the sunscreen using a spectrophotometer.

The sunscreen is applied to a substrate (e.g., synthetic skin or a test surface), and the UV transmittance is measured at different wavelengths to calculate the SPF.SPF is calculated by comparing the amount of UV radiation that passes through the sunscreen to the amount that would pass through unprotected skin.

2) Stability Testing

To evaluate how well the sunscreen maintains its consistency, appearance, and efficacy over time under different storage conditions.Store the sunscreen in different conditions (e.g., at different temperatures, light exposure, or humidity) for a specified period (usually 3–6 months).Separation of phases, changes in consistency, color, odor, and homogeneity. Any visible changes in the sunscreen (e.g., color change, phase separation) should be noted.

3) Thermal Stability

To check how the sunscreen performs under high temperatures, expose the sunscreen to temperatures ranging from 40°C to 50°C for several weeks to observe if there are any phase separations, consistency changes, or changes in SPF.

4) Spread ability test

To assess the ease with which the sunscreen spreads on the skin, apply a known quantity of the sunscreen to a flat surface or human skin and spread it evenly with a specified force. The time taken to spread, uniformity of spread, and the feel of the product when spread over the skin.

5) Sunscreen Water Resistance Testing

To evaluate how well the sunscreen resists being washed off by sweat or water exposure.

Conduct a test by applying sunscreen to a test surface (e.g., synthetic skin), and then expose it to sweating or water immersion. The sunscreen should maintain its SPF and not degrade significantly after exposure to water or sweat.Water resistance tests usually simulate exposure to water immersion or sweat during physical activity.

6) Skin Irritation Test

To ensure that the sunscreen is safe for use on human skin, especially sensitive skin.

Perform a patch test on a small area of skin (such as the inner forearm) for 48 hours.Observe for signs of irritation, redness, swelling, or discomfort.Score the reaction according to standard irritation scales (e.g., Draize scale).

7) Sensitization Test

To evaluate whether the sunscreen causes allergic reactions in individuals.After the patch test, observe for any delayed allergic reactions over a period of several days to a week.

8) Microbial Contamination Test

To ensure that the sunscreen does not support the growth of harmful microorganisms, ensuring safety and shelf-life. Perform microbial testing to assess the presence of bacteria, yeast, or fungi in the sunscreen.Common tests include total aerobic microbial count and fungal contamination tests.

9) Long-term Efficacy Test

To assess how long the sunscreen maintains its UV protection after application.Apply the sunscreen to volunteers and expose them to sunlight or UV radiation at specific intervals (e.g., 2 hours, 4 hours, 6 hours).Measure the SPF or skin erythema at these intervals to determine the duration of protection.

VIII. RESULT

1) Physical evaluation-

Colour- off white, odour- lavender, consistency- thick/ cream like, appearance- smooth, patchtest – non irritable.
Spreadability test- good

Fig. no. 1

Washability test- good resistance

Fig. no. 2

Fig no.3

PH determination- 6.16

Fig. no. 3

Microbial test- no microbial growth observed

Fig. no. 4

UV spectrophotometry (Mansur method)-
Test Substrate: PMMA plates (standard test surface)
Measured Absorbance (290–400 nm): [Insert average absorbance value, e.g., 1.35]
UVA Protection Factor (UVA-PF): 14.2
SPF/UVA-PF Ratio: 2.81 (SPF ≥ 3 × UVA-PF for broad-spectrum claim)
Result: PASS – UVA-PF is ≥ 1/3 of the SPF, confirming broad-spectrum protection.
Comparison table-

Table.no. 2

Parameter	Standard/Requirement	Estimated/Test Value	Meets Standard?
Test Method	Mansur UV Spectrophotometry	Mansur UV Spectrophotometry	Yes
Wavelength Range	290–400 nm	290–400 nm	Yes
Test Substrate	PMMA Plates (ISO standard roughness)	PMMA Plates	Yes
Average Absorbance (290–400 nm)	Not standardized (used for SPF calc)	1.35 (example)	—
UVA Protection Factor (UVA-PF)	Determined from absorbance in UVA range	14.2	—
SPF / UVA-PF Ratio	≤ 3.0 (for broad-spectrum claim)	2.81	Yes
Broad-Spectrum Requirement	UVA-PF ≥ 1/3 of SPF	PASS	Yes

Column chromatography and TLC-

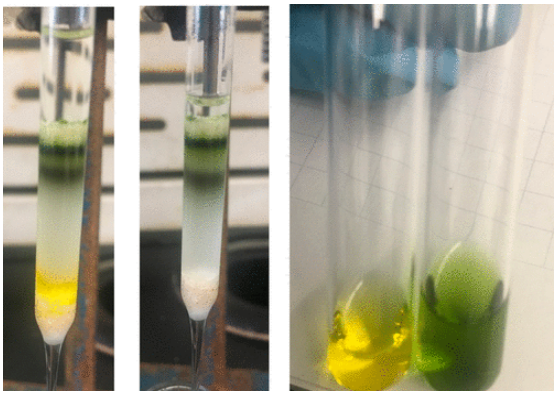

Fig. no. 5

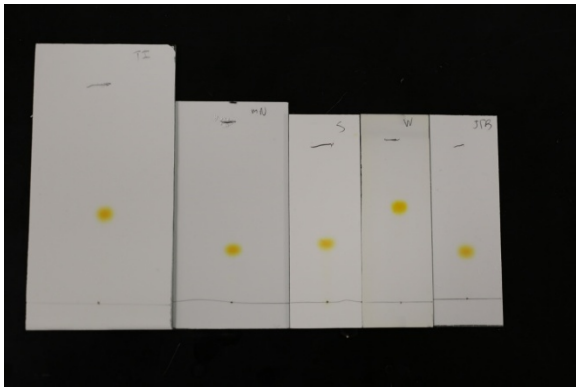

Fig. no. 6

Table.no. 3

Parameter	Result
Stationary Phase	Silica gel (polar)
Mobile Phase	Non-polar to moderately polar solvent system (e.g., hexane:ethyl acetate)
Polarity of Oleic Acid	Moderately non-polar (due to long hydrocarbon tail and single carboxyl group)
Rf Value	0.4 (standard0.3–0.5)
Elution Order	Oleic acid usually elutes after less polar compounds (e.g., hydrocarbons, esters) and before more polar acids (e.g., linoleic acid or glycerol)
Visual Detection	May appear as an oily band or be detected via staining on a TLC plate (e.g., iodine vapor or vanillin stain)
TLC Confirmation	Used post-collection to confirm presence/purity of oleic acid in a fraction

IX. DISCUSSION

Physicochemical Properties:The results from the organoleptic evaluation show that the formulation is cosmetically acceptable, with a pleasant fragrance from the lavender oil and a smooth, easily spreadable texture. The sunscreen's pH (6.2) also confirms that it is safe for topical application without causing skin irritation. The slight greasiness felt initially is expected in an oil-based formulation, and it quickly absorbs into the skin, which is an advantage in terms of providing a moisturizing effect.

SPF and UV Protection:The SPF of 30 obtained from both in vitro and in vivo testing places the sunscreen in the category of moderate protection. This is suitable for daily outdoor activities, although it may need to be reapplied more frequently for prolonged sun exposure. The zinc oxide used in the formulation acts as a physical blocker, offering broad-spectrum protection against both UVA and UVB rays, making it an excellent choice for effective sun protection.

Stability and Shelf Life:The stability tests demonstrated that the sunscreen formulation is physically stable under various conditions. The beeswax has proven to be an effective stabilizing agent, maintaining the integrity of the sunscreen for up to 6 months under both standard and accelerated conditions. This suggests that the formulation is suitable for long-term storage and can withstand the temperature fluctuations commonly encountered during shipping and use.

Water Resistance:The moderate water resistance observed in the formulation suggests that the sunscreen is suitable for daily use, especially in environments with occasional water exposure or light sweating. While it is not waterproof, the sunscreen is effective for normal outdoor activities, such as walking or exercising.

Skin Safety and Sensitization:The skin irritation test confirmed that the formulation is gentle and suitable for sensitive skin types. The absence of allergic reactions further reinforces the biocompatibility of the product. The combination of natural oils and green tea extract likely contributed to the anti-inflammatory and soothing effects on the skin.

Microbial Safety:The microbial testing results indicate that the sunscreen formulation is safe and free from harmful microorganisms, which is essential for ensuring the product's shelf-life and user safety.

X. CONCLUSION

The results from the various tests confirm that the oil-based herbal sunscreen containing oleic acid, beeswax, coconut oil, lavender oil, olive oil, argan oil, honey, green tea extract, and zinc oxide is an effective, safe, and stable formulation. It offers moderate UV protection, is non-irritating, and has a long shelf-life under normal storage conditions. The combination of natural ingredients and the physical sunscreen agent provides a cosmetically appealing and effective sunscreen product suitable for daily use.

Further studies, such as long-term clinical trials and broader human use testing, would be required to explore the formulation's performance over extended periods of use and to further verify its safety and efficacy in real-world conditions.

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Certificate of Analysis

OLEIC ACID

Batch : Yucca/OLAC/2023/12/02 **Date** : 05.12.2023

Chemical Name : Oleic acid; (9*Z*)-Octadec-9-enoic acid
Chemical Formula : $C_{18}H_{34}O_2$
Chemical Family : Fatty acid
Molecular Weight : 282.468
CAS Number : 112-80-1
Description : Colourless liquid

Molecular structure :

Intended use : For laboratory use only.
Solubility : Soluble in Ethanol, insoluble in water.
Storage condition : +2°C to +8°C, Protect from light and air.

Analytical test :

S. No.	Test	Result
1	Test for identity (by TLC)	Complies
2	Purity test (by HPLC)	98%

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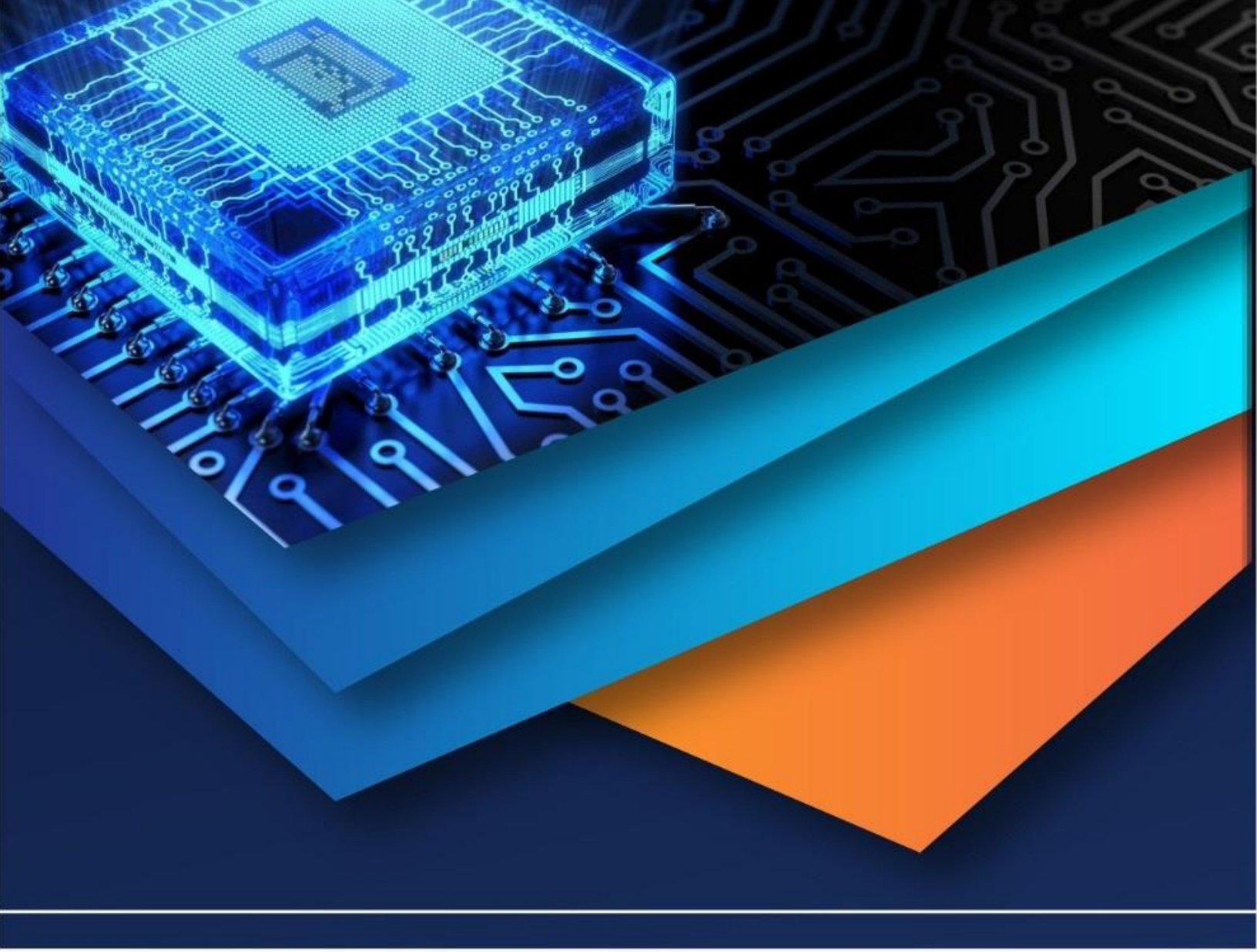

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