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Analysis and application of natural wax extracted from *Colocasia esculenta* leaves

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Article

ABSTRACT

The epicuticular wax on the leaves of the edible aroid Colocasia esculenta produces contact angles of more than 150 degrees and confers super hydrophobic characteristics. By use of the maceration procedure, this wax is extracted utilizing polar and non-polar solvents. Polar solvents like ethanol and ethyl acetate are unable to remove the hydrophobic wax as successfully as non-polar solvents like toluene, xylene, di-ethyl ether, and petroleum ether. Thin Layer Chromatography (TLC) is used to extract the characters of the obtained wax in various steps. Later to detect functional groups, Fourier Transform Infrared (FTIR) analysis is done using acid and base properties. The natural non-polar wax can only be dissolved in non-polar solvents, and thus results in an extraction rate that is typically between 3 to 4 percent, with SPF variables playing a significant role. Application of the obtained wax is examined.

Keywords: Colocasia esculenta, Polar solvents, non-polar solvents, FTIR analysis, Thin layer Chromatography, super hydrophobic

INTRODUCTION

The protective waxy layer found on leaves plays a vital role in preventing excessive moisture loss, ensuring their hydration is maintained. Primarily it is observed that from the leaf surface two varieties of wax are found. A visible layer on the outer surface of the cuticle membrane which is noticed is called Epicuticular waxes and which are incorporated within the cutin polymer is called Intracuticular waxes. Epicuticular waxes make the plant more essential by minimizing water loss, mitigating harm from UV radiation, and discouraging pests. A three-dimensional wax with crystal structure is formed by the Epicuticular waxes for the plant's self-cleaning mechanism known as the lotus effect. Intracuticular waxes help the plant from other environmental stress.

Colocasia esculenta, often recognized as taro or elephant ear, is a tropical plant belonging to the Araceae family which is mostly grown in South East Asia regions. It is extensively grown for its starchy corms[1] and sizable, heart-shaped foliage. As it is a fundamental source of food over tropical areas, it is cooked in a perfect condition and then it is taken. These are widely grown in wet, water staging and flowing areas. Polymorphic content is highly observed in the leaves. Since it is grown in high water content area, it is rich in aquaphobic property. Vitamin A and C are found in them. Calcium Oxalate [CaC_2O_4] is present naturally in plants which is harmful when consumed without proper cooking. Surfaces which are coated with wax can display a phenomenon referred to as super hydrophobic or ultra-hydrophobic behaviour. The surface containing exceeds a contact angle higher with regarding to the water basically more than 150 degrees. This is generally formed in between the droplets of the liquid and the air present around them where they are joined. The structures of micro hydrophobic found in the waxes of those leaves are taken and applied with different materials to bring hydrophobic properties. This process has a rough end surface which behaves as natural microstructures mostly seen in super hydrophobic surfaces.

Taro plant juice offers various medicinal benefits[2] like stimulation and skin relief. It can treat internal issues like gland inflammation. Taro corm juice works as a laxative and soothes irritation. Taro leaves, high in fiber, aid digestion and regulates

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bowel movements while also offering health benefits like managing diabetes and mood, and fighting parasites.[3] In Nagaland, Colocasia is grown as both a summer and Kharif crop. Planting usually occurs from March to April, with harvesting taking place between November and December.[4] Enzymatic isolation is widely used to remove the cuticular membrane, employing a solution of pectinase and cellulase. Pectinase targets the pectin layer between the cuticle and cellulose cell wall, while cellulase digests cellulose in cell walls.[5] The superhydrophobic surface, characterized by a contact angle exceeding 150º, on the cuticular wax layer of select plant species offers self-cleaning capabilities. This unique property endows cuticular wax with significant potential across various fields. Studies have shown the hydrophobic nature of epicuticular wax extracted from plants like Calotropis procera and Alstonia scholaris.[6] Sorghum typically boasts higher levels of epicuticular wax on its leaves and culms compared to rice and maize. This wax starts appearing during the seedling stage and becomes most abundant as the plant progresses through the pre-flowering and maturity stages.[7] The wax layer found on C. bipinnatus petals contains relatively high concentrations of fatty acids and primary alcohols, which are notably shorter compared to those found in leaves. As a result, the transpiration barrier properties of the petal cuticle are weaker when compared to leaf cuticles.[8] Senecio jacobaea have a small portion of wax, in layer of leaves that typically composed of apolar components, in thrips resistance is relatively unclear.[9] A wild plant of Cissus rotundifolia, commonly known as Arabian wax Cissus, is used for cooking and in various medicinal purposes.[10] The level of wax concentration present in the leaves will change from one plant to another; similarly its thickness will also be changed accordingly. Methanol (MeOH) and dichloromethane (DCM) are the two main components generally used for the extraction process.[11] Repulsion in water is greatly found in the lotus leaves, having a familiar contact angles on superhydrophobic surfaces that produces wax in its topmost layer of epidermis.[12] So here using Colocasia esculenta leaves analysis is performed to find the presence of wax.

Related work

Some of the recent related works are mentioned below

Nelumbo nucifera, often recognized as the lotus plant or sacred lotus is an aquatic botanical specimen. The self-cleaning process of the plant is done with the help of super hydrophobic wax layer which protect the plant from all environment issues. Srivastav, et al.[12] detailed the study based on the features, composition present in the raw natural wax extracted from the lotus plant. Polar solvents are those have significant polarities like water, ethanol, methanol, and acetone. Non-polar solvents do not have significant polarities like hexane, diethyl ether, and chloroform. These two solvents are used in lotus plant to extract wax with various methods. The significant polarities present in the polar could not give the best result but with non-polar solvents mainly with xylene exacted super hydrophobic with higher percentage. But in toluene shown similarity feature with lotus leaf surface. The extraction process is done in Soxhlet and Maceration of two different methods. A special analysis of FTIR is done to find out the process flow. Maceration showed the best extraction than the Soxhlet extraction method.

Plants generally suffer from environmental factors which cause them to degrade their growth. The presence of cuticular wax in few plants helps themselves to clean and promote its growth. Shepherd, et al.[13] have proposed a study on abiotic stress faced by the plants and how few plants overcome them using cuticular wax. Through this it was observed that it combines few molecules as a battery to protect themselves and store required amount of water in it. It is becoming increasingly evident that the CER6 gene in Arabidopsis likely plays a pivotal role in the plant's reaction to various environmental stressors. The connection between the biosynthesis, structure, composition, and utilization of cuticular waxes, alongside the effects of stress, as well as recent research shedding light on these impacts and their role in the regulation of wax biosynthesis, is elaborated upon.

Guo, et al[14] developed a process suitable for industrial scaling to create a copper super hydrophobic surface, characterized by a substantial contact angle and minimal sliding angle, has been established through surface oxidation. The super hydrophobic behaviour was credited to the formation of CuO crystals resembling those found on lotus leaves, which occurred due to surface oxidation and subsequent chemical modification involving low-surface-energy compounds. This shows a straightforward and cost-effective approach for producing super hydrophobic surfaces on metal substrates, featuring biomimetic structures reminiscent of lotus leaves. It also proves an efficient and affordable method to create super hydrophobic surfaces on metal substrates, mimicking the bionic structures seen in lotus leaves.

Torpedograss, a perennial grass species, is regarded as a weed across numerous areas and American black nightshade is a plant in the Solanum genus used in traditional medicine in certain cultures. The utilization of chloroform to extract compounds from these plant leaves implies an emphasis on isolating lipophilic substances like lipids, waxes, or other non-polar compounds. Bewick, et al.[15] used these components to serve diverse functions within plants, encompassing roles such as energy storage, safeguarding against environmental stressors, and engagement in biochemical processes. From these plants maximum amount of material is taken over a time, which is calculated through quadratic model with a plateau. The extraction weight for American black nightshade is 82 h and for Torpedograss is 123 h. The quantity of chlorophyll detected in each extract displayed variability. This could be attributed to the fact that chlorophyll is not effectively extracted using chloroform from fresh plant tissue, owing to its hydrophilic properties. Acetone is the recommended solvent for chlorophyll extraction.

Colocasia Esculenta leaves are very famous for its water consistency and acts as shield to protect itself from environmental factors. Kumar et.al.16 proved his studies with Colocasia Esculenta leaves to create a surface coating with water on particular substances. Qualitative tests like adhesion and abrasion resistivity were taken on the created surface and needed density, pH and microbial growth tests for its supporters are also considered. A poor uniform in the made to develop formulated paint with unity. To achieve the formulated paint the combination of both slurry and paint is mixed together. Adhesion test is performed at the end of the process to show the layer is formed in a perfect way.

Organic solvents are carbon-based compounds that have the ability to dissolve other substances, has a crucial role in processes such as extraction, purification, synthesis, and analysis of different compounds. The exchange of water vapour and gasses between the plants and surrounded environment is taken place with help of the transpiration barrier. Zeisler-Diehl, et al[17] taken the drawback of Prunus laurocerasus for the transpiration barrier formation and applied to various species. Epicuticular wax removed using collodion from isolated cuticular membranes or intact leaf discs of ten diverse plant species. Scanning electron microscopy verified wax removal with two collodion treatments, yielding smooth surfaces. Total wax removal and residual amounts quantified via gas chromatography and mass spectrometry. It is shown that Epicuticular wax does not contribute to leaf transpiration barrier.

Hydrophobic substances repel or strongly avoid interacting with water molecules. Such substances are typically non-polar or have low polarity, lacking the positive and negative charges found in polar molecules. Hydrophobic properties find use in raincoats, water-resistant fabrics, non-stick cookware, waterproof electronics, and other applications. Super hydrophobic surfaces repel water, boasting high contact angles (>150 degrees) that cause droplets to roll off. Inspired by nature, like lotus leaves, they are used for self-cleaning coatings, anti-icing, and efficient water management. Gobalakrishnan, et al.[18] explained in detail the super hydrophobic nature of some leaves. These leaves contain micro-structured wax.

Around 20 years of struggle on plant surfaces to scan electrons over microscope was succeeded. The functions of epidermal surfaces based on taxonomic were investigated. Besides all, water repellent gave a good move on rough surface. Neinhuis, et al.[19] detailed on Plant surfaces feature unique microstructures deterring the adhesion of particles, pathogens, and organisms, promoting self-cleaning. Leaves with lasting water repellency have prominent convex to papillose epidermal cells and dense waxes; temporary repellency features slightly convex cells and less dense wax. This trait is prevalent in herbaceous plants, notably in subtropical areas, wetlands, and disturbed sites, while being uncommon in trees; the focus is on their importance for self-cleaning and anti-adhesive attributes.

The escalating threat of environmental pollution stemming from oil spills has been driven by expanding oil exploration, maritime activities, and industrial development. These incidents profoundly impact ecosystems and human well-being, necessitating urgent attention to oil spill treatment and recovery. Porous materials have emerged as promising absorbents, offering rapid oil absorption, high adsorption capacity, selectivity, and reusability within the spectrum of oil spill recovery methods. Hoang, et al[20] two polymer-based porous absorbents with modified surfaces and structures were introduced for oil-polluted water treatment. Furthermore, the absorption mechanism and factors impacting adsorption capacity for oils and organic solvents were comprehensively examined. Notably, the attributes of polymer-based porous materials were extensively discussed, encompassing microstructure analysis, absorption efficiency, and reusability considerations.

Liu, et al.[21] introduced a novel approach involving an emulsion-mediated sol-gel process for the synthesis of composite particles with micro-nanoscale binary structures. This method offers a simple coating technique to create super-hydrophobic surfaces on different substrates, making it practical for both civil and industrial uses. Through an emulsion-mediated sol-gel process, micro-nanoscale binary structured composite particles comprised of silica and fluoropolymer were synthesized. These particles were then applied to various substrates to replicate the microstructures found on lotus leaves. The resulting super-hydrophobic surfaces exhibit water contact angles exceeding 150°, suggesting potential applications in rust prevention, anti-fog solutions, and self-cleaning treatments.

The key concept of the model is given below.

- Polar and non-polar solvents are used to extract natural hydrophobic wax from leaves of Colocasia esculenta plant.
- Acid and base tests are done to the obtained wax to find out the stability.
- Thin layer chromatography is implemented along with the FT-IR spectroscopy to find its characters.

Methodology

Maceration extraction, a time-tested method, involves submerging plant materials in either polar solvents like water or alcohol, or non-polar solvents like oils, allowing for gradual dissolution of targeted compounds. This technique is known for its simplicity and effectiveness in drawing out active ingredients and flavours.

Figure 1: Plant of Colocasia esculenta (Giant Taro)

A well-known plant Colocasia esculenta is used for the study. Colocasia esculenta, known as taro, is a tropical plant with edible starchy corms[1] and large elephant ear-shaped leaves. The leaves of the plant are used in multiple purposes. The plant leaves were introduced into a securely sealed iodine flask and subjected to a 48-hour isolation process within a solvent blend comprising both polar and non-polar solvents. This is as shown in the below figure 2.

Figure 2: Dry leaves stored in flask

Ethanol and ethyl acetate combine to form a versatile mixture used in solvents, coatings, fragrances, and food flavourings, spanning industries from pharmaceuticals to culinary arts. Combining xylene, toluene, diethyl ether, and petroleum ether yields versatile solvents for industries like coatings and labs, with petroleum ether favoured in extractions. Because of the feature of all these polar and non-polar solvents, are applied in the study. Whatmann filter paper is used for filtration, separation, and purification. So, the filtration process to the isolated samples was taken place. This is shown in below figure 3.

Figure 3: Filtering the solution after 48hrs.

A laboratory device of heating mantle is used for distillation. To separate nature wax from the obtained solution petroleum ether solvent is used. It is shown in below figure 4. Petroleum ether can be used to extract wax from a material by dissolving it in the solvent. Waxes separate from the solution using separation techniques like filtering. Waxes can be processed further after recovery.

Figure 4: Wax from petroleum ether solvent

Xylene is used as a solvent and dissolved in the solution to obtain the nature wax. The obtained nature wax is kept in Petri dish or watch glass and desiccator is used to store the natural wax. A suitable wax solubilize is aromatic hydrocarbon solvent xylene. Due to their decreased solubility, the waxes precipitate or separate from the solution when the combination is subsequently exposed to separation processes like filtering or centrifugation.

Figure 5: Nature wax from Xylene solvent.

Utilizing petroleum ether as a solvent, hydrophobic wax is extracted from substances, yielding water-repellent wax used for waterproofing, coatings, and related industries. This is shown in figure 6.

Figure 6: Hydrophobic wax from petroleum ether.

The wax extracted using xylene solvent exhibits hydrophobic properties, making it repel water. This is shown in below figure 7.

Figure 7: hydrophobic wax from Xylene.

The obtained solution is dried completely and it is seen that petroleum ether solvent is not water repellent. This is shown in below figure 8.

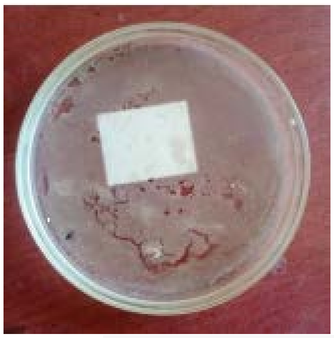

Figure 8: Dried wax from petroleum ether solvent

Thin Layer Chromatography (TLC) is a method for separating and analysing mixtures by placing them on a thin adsorbent layer, revealing component differences through migration. It's used in various fields for qualitative analysis and compound identification. Chloroform was utilized as the mobile phase in conjunction with silica gel, a porous solid substance, acting as the stationary phase in chromatography. This combination serves to separate and analyse compounds within mixtures, leveraging their distinct interactions with the phases for various applications in fields like chemistry and pharmaceutical studies. Here three process of extraction is used wax from xylene, wax from Di-ethyl ether solvent, and wax from petroleum ether solvents. Then RF values regarding the three processes were noted. Finally stability is tested with help of concentrated H_2SO_4 and NaOH for the extracted natural wax.

CALCULATIONS

Based on the collected masses of the initial samples M_i from the obtained hydrophobic wax M_o. The percentage of water-repellent wax WRW extracted from the initial sample, using their masses as a basis is calculated as shown in below equation 1.

$$WRW = \frac{M_o}{M_i} \times 100 \qquad (1)$$

Analysis on Thin Layer Chromatography (TLC)

A small sample of a mixture to a thin layer of adsorbent material on a plate. The plate is then placed in a developing chamber with a solvent, allowing compounds to migrate based on their affinities for the stationary and mobile phases. As the solvent moves up the plate, it separates the mixture into distinct spots. After visualization using methods like UV light or staining reagents, RF values are calculated for each compound's migration distance. These values aid in identifying compounds by comparing them with known standards or reference compounds. TLC is a versatile technique for quick compound separation and analysis.

Characteristics of TLC are as shown below.

Stationary Phase

In chromatography, the stationary phase, usually a solid or liquid substrate, remains fixed, causing compounds in the sample to separate due to their distinct interactions with it. To construct the stationary phase, a mixture of silica and chloroform slurry was prepared and applied onto the chromatography plate. Because of its non-polar properties, wax migrates upwards on the plate with any of the three mobile phases, indicating a strong attraction to the non-polar stationary phase. This phenomenon underscores a fundamental principle in chromatographic separation.

Mobile Phase

The mobile phase is the fluid that transports sample components through the stationary phase in chromatography, leading to their separation based on interactions.

Extracting wax using Di-ethyl ether solvent.

I. 10ml of Di-ethyl ether solvent is taken for the process.
II. Then it is combined with ethyl acetate in 5: 5 ratios.
III. Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

RF Calculation: In chromatography, the retention factor (RF) is a metric used to measure how well components within a mixture separate during a separation procedure. RF values for wax extraction with Diethyl ether depend on the experiment and compound composition. They indicate compound migration on a TLC plate relative to the solvent front, aiding identification. Reference compounds with known RF values are crucial for accurate analysis.

Table 1: RF values for Extracting wax using Di-ethyl ether solvent.

Spots	a	b	C
Yellow Spot	0.5555	0.405	0.837
Green Spot	0.694	0.608	0.878

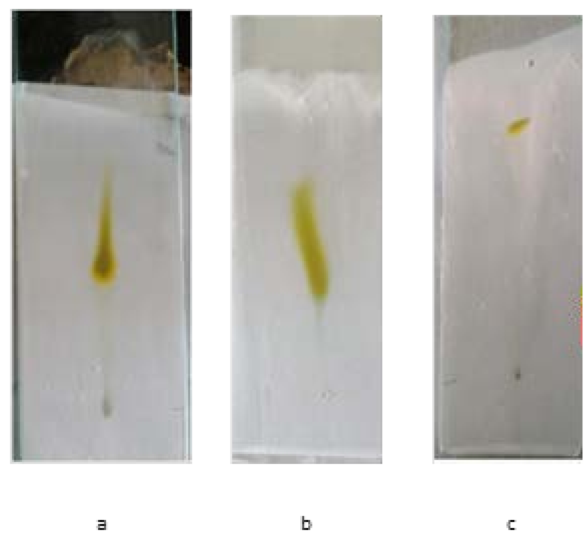

Figure 9: Extracting wax using Di-ethyl ether solvent

*Extracting wax using Petroleum ether solvent***.**

I. 10ml of petroleum ether solvent is taken for the process.
II. Then it is combined with ethyl acetate in 5: 5 ratios.
III. Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

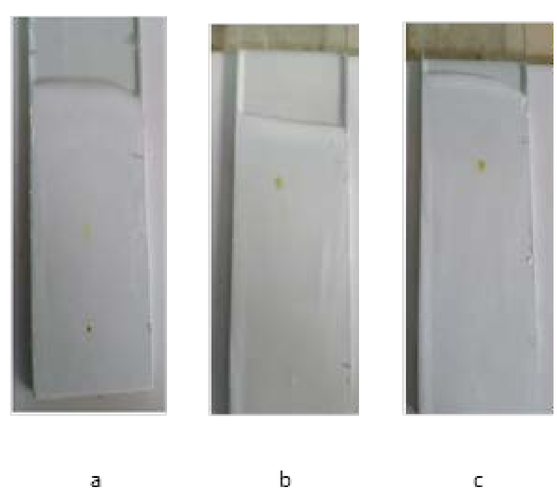

Figure 10: Extracting wax using petroleum ether solvent

RF Calculation: RF values for wax extraction using Petroleum ether as solvent vary based on compound composition and TLC conditions. They indicate compound migration relative to solvent front, aiding identification with reference compounds.

Table 2: RF values for Extracting wax using petroleum ether solvent.

Spots	**a**	**b**	**C**
Yellow Spot	0.6	0.866	0.9
Green Spot	0.0	0.88	0.928

Extracting wax using xylene solvent.

I. 10ml of xylene solvent is taken for the process.
II. Then it is combined with ethyl acetate in 5: 5 ratios.
Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

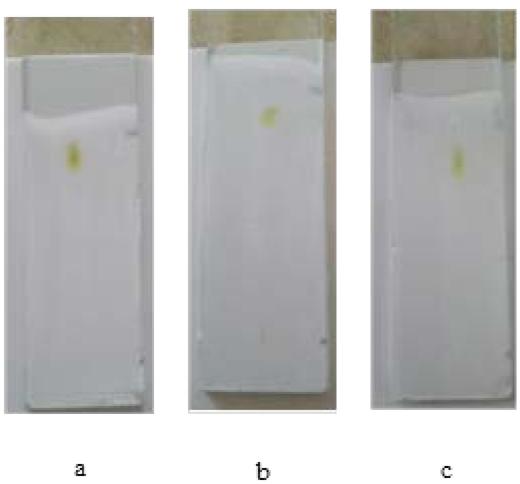

Figure 11: Extracting wax using xylene solvent

RF calculation: RF values when extracting wax with Xylene as solvent depend on compound composition and TLC conditions. They reflect compound migration relative to solvent front, aiding identification with known references.

Table 3: RF values for Extracting wax using xylene solvent.

Spots	**a**	**b**	**C**
Yellow Spot	0.855	0.755	0.833
Green Spot	0.922	0.822	0.888

Extracting wax using Toluene solvent.

I. 10ml of toluene solvent is taken for the process.
II. Then it is combined with ethyl acetate in 5: 5 ratios.
Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

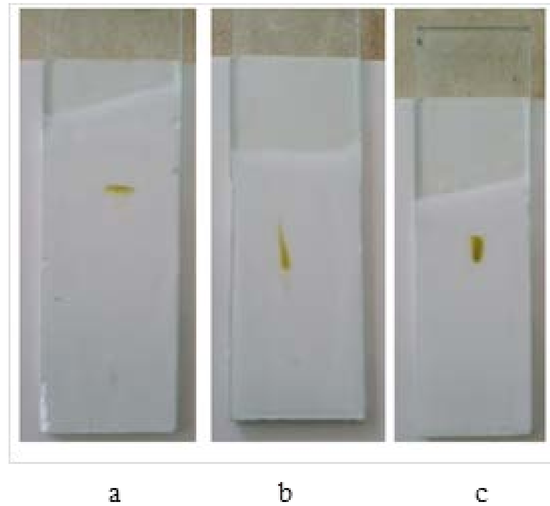

Figure 12: Extracting wax using Toluene solvent.

RF calculation: RF values for wax extraction using Toluene as solvent vary with compound composition and TLC setup. They signify compound migration relative to solvent front, assisting in identification with reference compounds.

Table 4: RF values for Extracting wax using toluene solvent.

Spots	**a**	**b**	**C**
Yellow Spot	0.909	0.564	0.736
Green Spot	0.922	0.677	0.828

Extracting wax using ethyl acetate solvent.

I.
II. 10ml of ethyl acetate solvent is taken for the process.
III. Then it is combined with ethyl acetate in 5: 5 ratios.
Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

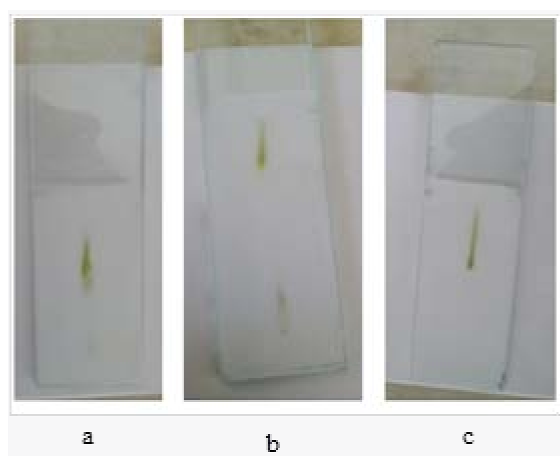

Figure 13: Extracting wax using ethyl acetate solvent.

RF calculation: RF values for wax extraction using Ethyl acetate as solvent differ with compound composition and TLC conditions. They indicate compound migration compared to solvent front, aiding identification alongside known references.

Table 5: RF values for Extracting wax using ethyl acetate solvent.

Spots	A	B	C
Yellow Spot	0.714	0.882	0.867
Green Spot (Dark)	0.574	0.764	0.722
Green Spot (light)	0.476	0.129	0.602

Extracting wax using ethanol solvent.

I. 10ml of ethanol solvent is taken for the process.
II. Then it is combined with ethyl acetate in 5: 5 ratios.
III. Lastly it these are combined with glacial acetic acid in 5:5:1 ratio.

RF calculation: Extracting wax using Ethanol as the solvent involves determining RF values through thin-layer chromatography (TLC). The process entails applying the wax extract in Ethanol to a TLC plate, followed by development in an Ethanol-based solvent system. After visualization, RF values are calculated by measuring compound and solvent front distances.

Table 5: RF values for Extracting wax using ethanol solvent.

Spots	A	B	C
Yellow Spot	0.597	0.814	0.747
Green Spot	0.552	0.928	0.827

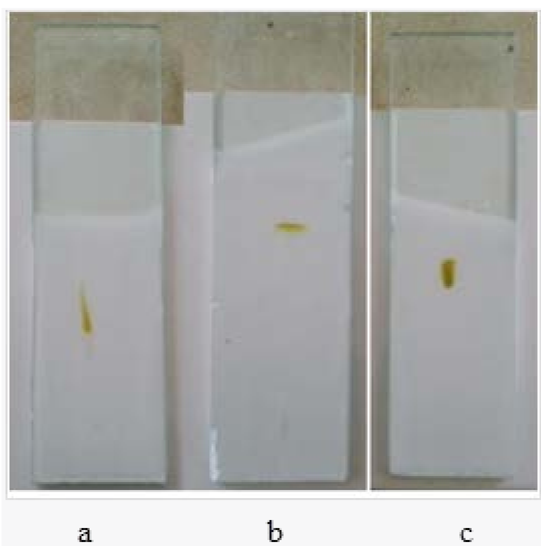

Figure 14: Extracting wax using ethanol solvent

FTIR Analysis:

Alkanes are hydrocarbons comprising solely carbon-carbon (C-C) and carbon-hydrogen (C-H) single bonds. FTIR analysis stands as a suitable technique for detecting the existence of these functional groups, given the distinctive infrared absorption bands linked with these bonds. Analysis for toluene to extract wax was shown below.

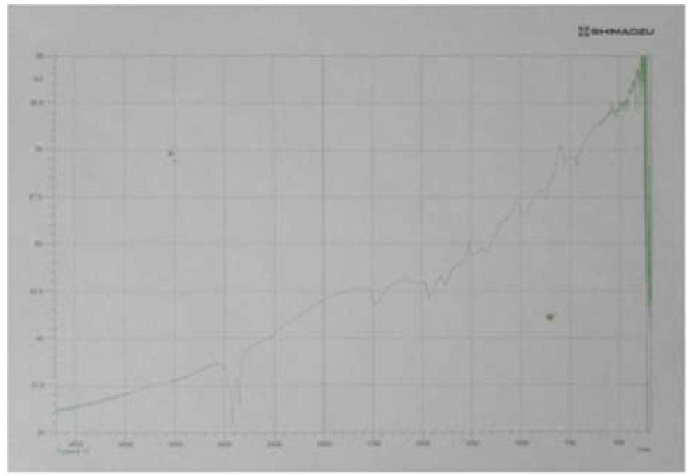

Figure 15: Wax extracted using toluene.

The peaks at 2910 cm-1 and 2845 cm^{-1} correspond to the stretching vibrations of carbon-hydrogen (C-H) bonds in alkanes, providing evidence of their presence. The peak at 1725 cm^{-1} signifies the stretching vibration of the carbonyl (C=O) bond, characteristic of carboxylic acids. This peak suggests the existence of acid functional groups. Furthermore, the peak at 1470 cm^{-1} points to the vibrations of aromatic C=C bonds present in compounds with aromatic structures.

Analysis for xylene to extract wax was shown below.

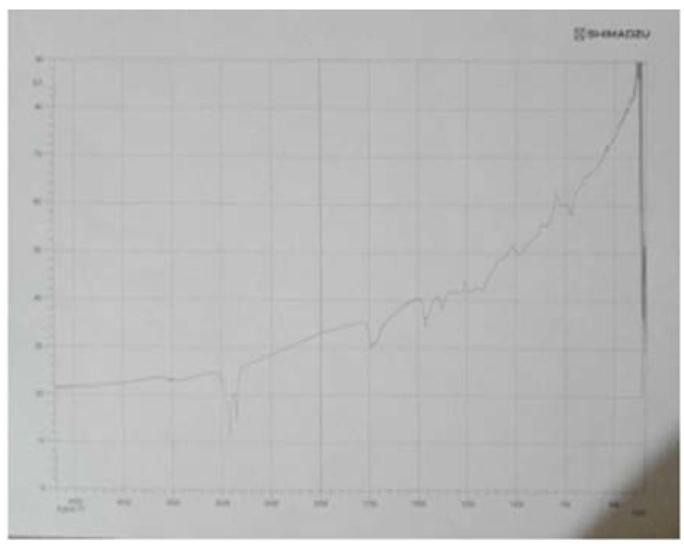

Figure 16: Wax extracted using xylene

The peaks noticed at 2910 cm^{-1} and 2840 cm^{-1} signify the presence of aliphatic hydrocarbons' C-H bonds, a distinctive marker for alkanes. The data also reveals informative peaks at 1740 cm^{-1} and 1705 cm^{-1}, denoting the stretching vibrations of carbonyl (C=O) groups - common traits in acid compounds. Additionally, the peak observed at 1470 cm^{-1} is attributed to aromatic C=C bonds' vibrational patterns, characteristic of molecules featuring aromatic structures. Analysis for Di-ethyl ether to extract wax was shown below.

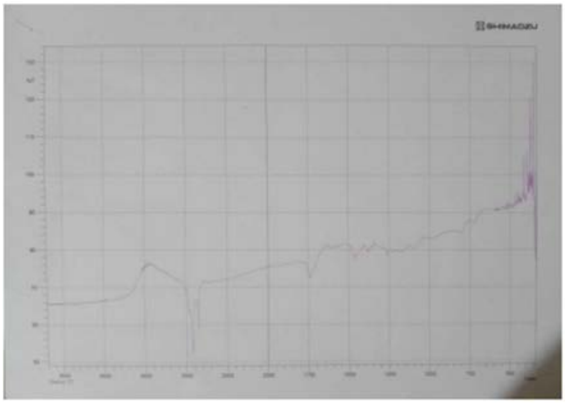

Figure 17: Wax extract using Di-ethyl ether

The range between 1740 cm^{-1} and 1745 cm^{-1} indicates the presence of (C=O) carbonyl groups, commonly associated with acids. Simultaneously, the peaks at 2910 cm-1 and 2850 cm-1 are indicative of alkanes' C-H bonds, elucidating the hydrocarbon structure. Furthermore, the observed signal at 1450 cm^{-1} corresponds to the vibrations of aromatic C=C bonds, which suggest the presence of aromatic compounds.

Analysis for petroleum ether to extract wax is shown below.

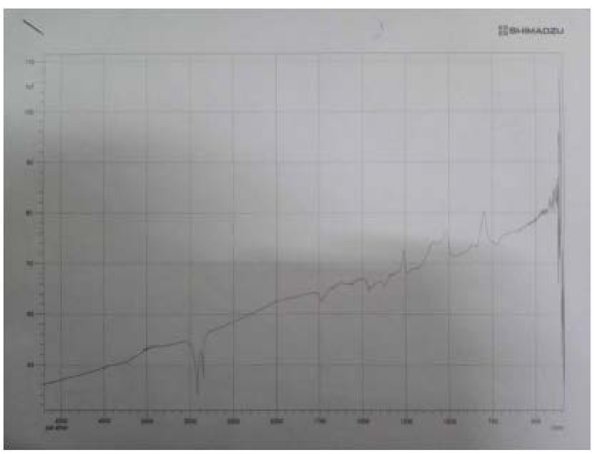

Figure 18: Wax extracted using petroleum ether

The appearance of peaks at 2910 cm^{-1} and 2850 cm^{-1} signifies the presence of alkanes' C-H bonds, offering insights into the hydrocarbon structure. Conversely, the peak spanning from 1740 cm^{-1} to 1745 cm^{-1} arises due to carbonyl (C=O) groups, a hallmark of acids. Additionally, the observed signal at 1460 cm^{-1} corresponds to vibrations related to aromatic C=C bonds, indicative of aromatic compounds.

Stability Test

Stability Test for Giant Taro Wax

Reacting wax with concentrated H_2SO_4 yields shorter hydrocarbons through dehydration. This process, catalysed by sulphuric acid, is used to produce valuable compounds like gasoline. Caution is essential due to the hazardous nature of concentrated sulphuric acid. By the action of H_2SO_4 acid the wax obtained was melted and it is shown in figure 19 and 20 respectively.

Figure 19. Wax as obtained **Figure 20**. On reaction with H_2SO_4

Figure 21. Wax as obtained **Figure 22**. On reaction with NaOH

Wax is reacted with Base NaOH.

When wax interacts with NaOH (sodium hydroxide), it undergoes saponification, leading to the formation of soap and glycerol. The reaction involves breaking down ester bonds in wax into fatty acid salts, a key step in soap production.

On combining both NaOH and the collected wax, it was noted that nothing was changed.

Applications

When wax is applied to wood, it acts as a polish, improving the appearance while creating a barrier against dust and moisture. This procedure highlights the wood's natural characteristics and has long been used to repair and enhance wooden products.

On the wooden block, wax mixed with a solvent such as pet ether, diethyl ether, xylene, toluene, or turpentine is brushed. In addition to improving the appearance of the wood and shielding it from the elements, the wax produces a protective coating when the solvent evaporates. The wood becomes polished when it has dried.

Figure 23. Wooden block original **Figure 24**. Wooden block on application of wax

Iron materials are taken in two sets where each contains a washer and two nails. Next it is dipped into the wax as shown in figure 25.

Figure 25: Iron material dipped in wax.

Applying a layer on iron to reduce friction and stop rust and corrosion is known as wax coating. In order to improve lifespan, the surface of the molten wax hardens, forming a shield. The dipped wax is removed and made to dry as shown in figure 26 B.

Figure 26. (A) Without coating of wax. (B). With wax coated

The iron material coated with wax and without coated with wax is then dipped in normal water. This is as shown in figure 27.

Figure 27: Iron materials dipped in water.

This is allowed to dip for a month to see the changes in the iron materials. This is as shown in below figure 28.

Figure 28: After a month of dipped iron materials in water.

Iron materials are removed from water after 30 days trail and it was seen as shown in figure 29.

Figure 29. (A) Without wax (B) With wax coated

It was clear that the iron material without coated started rusting from 2nd day and became totally rusted after a month. At the same time the iron material coated with wax remained constant.[22]

Conclusion

The study was taken on the leaves of Colocasia esculenta plant. The natural hydrophobic wax was obtained from polar and non-polar solvents. The stability of the obtained wax was tested on acidic and basic stability tests. FT-IR spectroscopy is used to characterize the nature of hydrophobic wax. It is noticed that Ethyl acetate and ethanol did not show super hydrophobic wax property from the wax obtained from Giant Taro and Taro. The extracted wax from petroleum ethyl is less but showed super hydrophobic wax. The obtained wax from xylene is ranging over toluene and di ethyl ether. Toluene shows a super hydrophobic wax property ranging over Diethyl ether and Xylene. The highest range of extraction is seen from Diethyl ether solvent and also shown repellent in water.

Furthermore, reducing isolation time (to 48 hours) resulted in decreased wax production with weakened hydrophobic characteristics. Extending isolation time (>48 hours) occasionally led to wax degradation and reduced water resistance. The produced wax begins melting at 70°C to 75°C, displaying hydrophobic traits when wet, but losing both hydrophobic features and colour upon complete drying. The drawback of this approach is that it takes a long time, but the wax it produces has a very broad range of uses. The wax was discovered to melt when acid (H_2SO_4) was added to it. It was discovered that adding NaOH did not alter the wax's composition.

Conflict of Interest Statement

Authors do not have any conflict of interest.

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