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Article

Analysis and Characterization of Organic Materials for Abrasive Sand-Blasting Process

Estudio y Caracterización de Polvos Abrasivos Orgánicos para Proceso de Sand-Blast

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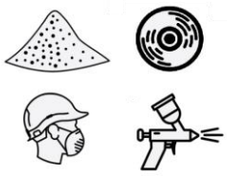
Abstract

This article presents the results of research conducted at the Polytechnic University of Otzolotepec, focused on characterizing organic materials for abrasive applications. The study involved producing powders from walnut shells and orange peels, aiming to develop an organic abrasive for cleaning and material removal. The project successfully resulted in an environmentally friendly abrasive compatible with abrasive discs. The sandblasting process, using pressurized air and the organic abrasive, effectively cleans and removes impurities from various materials, including deep craters, with minimal material wear. Conducted in the Manufacturing Technology Engineering laboratory, the research emphasized identifying and processing locally available organic materials to minimize environmental impact and health risks for students and faculty. This article outlines the project's methodology, findings, and the critical factors contributing to its success, while highlighting the practical experiences and outcomes achieved during its implementation.

Objectives	Methodology	Contribution
Walnut and orange peels as eco-friendly abrasives, reducing synthetic waste and health risks. 	Walnut and orange peels were processed and sieved to optimize flow through a 3/8" nozzle. Orange peel removed paint in 2.5 min at 100 psi, while walnut was unsuitable. Organic abrasive powder was tested for sandblasting and discs. 	• Organic alternative to silica sand in sandblasting • Abrasives for manufacturing industry • Production of organic abrasive discs • University-driven innovation • Safer, sustainable practices 

Sand-blast, Organic, Dust, Abrasive

Resumen

Este artículo presenta los resultados de una investigación realizada en la Universidad Politécnica de Otzolotepec, centrada en la caracterización de materiales orgánicos para aplicaciones abrasivas. El estudio involucró la producción de polvos a partir de cáscaras de nuez y cáscaras de naranja, con el objetivo de desarrollar un abrasivo orgánico para limpieza y remoción de materiales. El proyecto logró producir un abrasivo ecológico compatible con discos abrasivos. El proceso de arenado, utilizando aire a presión y el abrasivo orgánico, limpia eficazmente y elimina impurezas de diversos materiales, incluso en cráteres profundos, con un desgaste mínimo del material. Realizada en el laboratorio de Ingeniería en Tecnología de Manufactura, la investigación enfatizó la identificación y procesamiento de materiales orgánicos locales para minimizar el impacto ambiental y los riesgos para la salud de estudiantes y docentes. Este artículo detalla la metodología, los hallazgos y los factores críticos que contribuyeron al éxito del proyecto.

Objetivos	Metodología	Contribución
Cáscaras de nuez y naranja como abrasivos ecológicos, reduciendo residuos sintéticos y riesgos para la salud. 	Las cáscaras de nuez y naranja fueron procesadas y tamizadas para optimizar el flujo en una boquilla de 3/8". La cáscara de naranja eliminó pintura en 2.5 min a 100 psi, mientras que la de nuez fue inadecuada. Se probó polvo abrasivo orgánico para arenado y discos. 	• Alternativa orgánica a la arena de sílice en arenado • Abrasivos para la industria manufacturera • Producción de discos abrasivos orgánicos • Innovación impulsada por la universidad • Prácticas más seguras y sostenibles. 

Polvos orgánicos, Abrasivos, Arenado

Area: Development of strategic leading-edge technologies and open innovation for social transformation

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Introduction

This article presents a study on the application of walnut and orange peels as organic abrasives, an alternative to reduce the use of synthetic abrasives, conducted at the Polytechnic University of Otzolotepec. Students carry out cleaning processes on corroded metal structures and etching on glass pieces using the sandblasting process and/or abrasive discs, within a commercial cabin and equipment. The process is conducted in the Manufacturing laboratory. When working with sand in the cabin, dust clouds form during cleaning or etching, causing visibility issues and posing environmental and health risks to the students.

The main objective is to characterize walnut and orange peels as organic materials that can be used as natural abrasives for the sandblasting process, as inorganic abrasives pose health risks to the students and have a significant environmental impact. As a sustainable university, efforts are made to reuse cutting discs by incorporating organic materials in their manufacture.

Set of issues

The development of this research is based on the problems caused by silica sand when it comes into contact with the respiratory tract and its environmental impact. Silica sand has been affecting health for several years, and the study

aims to determine which organic product could potentially be used for this application. A natural abrasive is required to support the process in order to avoid environmental and health issues, benefiting the students of the Polytechnic University of Otzolotepec and improving the process by testing derivatives that can be adapted as abrasives.

For years, sand has been the only abrasive used for engraving or cleaning in the University's laboratory. So far, students have not encountered risks during the process; however, the effects become evident over the years [1].

Previous Work

The first known instance of sandblasting took place in England, United Kingdom, in August 1870, when Benjamin

C. Tilghman invented a machine that he patented under the number 2147. This machine has been modified over time to fulfill different purposes, but the operating principle has always remained the same [2].

The term "sandblast" comes from the English words "sand," meaning sand, and "blast," meaning pressure, thus referring to the technique known as "sand under pressure." However, this system does not necessarily use sand for its operation and can employ various pressure abrasives [3].

Vegetable abrasives are those derived from living plants. The most commonly used ones are obtained from corn cobs, walnut shells, fruit pits, and rice husks.

Vegetable abrasives are mainly used to clean valves, turbine rotor blades, to remove grease from engines, and to remove sludge or other deposits from a layer of paint. They are also used to remove scale or pieces of paint, especially when repainting, whether on wood, fiberglass, or aluminium. Vegetable abrasives do not generate sparks, which is why they are used in hazardous areas where all parts to be cleaned are adequately placed on the ground and ventilated [4].

Some shells, such as walnut shells, contain oil or colouring substances that may not be suitable for some surfaces, especially when repainting. Within the university, sandblasting tests have been conducted using only silica sand, yielding satisfactory results, as sand is one of the best inorganic abrasives that can be used to clean corrosion from metallic materials [5].

Sand-Blast

The primary objective of this process is to safely perform maintenance and/or cleaning of equipment using organic sand-blasting on surfaces such as tanks, pipes, production vessels, sheets, compressors, and machinery that require this procedure for their presentation and preservation. This procedure is executed to remove rust, existing corrosion, metal impurities, and to achieve a surface with an anchor profile that meets the requirements for coating applications. It also applies to maintenance operations and surface preparation to achieve the necessary conditions and requirements in coating, finishing, and painting processes.

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Organic sandblasting is an advanced technique that uses eco-friendly and biodegradable materials, minimizing environmental impact compared to traditional sandblasting methods. This method is not only effective in removing contaminants but also safer for operators, reducing exposure to toxic sub- stances and decreasing the risk of health issues associated with hazardous dust particles [4].

During the execution of the process, specialized equipment is used to project the organic abrasive at high speed onto the surfaces to be treated. This controlled impact ensures thorough and uniform cleaning, completely removing dirt and oxidation layers without damaging the integrity of the base material.

Proper surface preparation through this method is crucial to ensuring the optimal adhesion of subsequent coatings. An ad- equate anchor profile enhances the durability and performance of the coating, extending the lifespan of the treated equipment and structures.

This process is essential in various industries, including petrochemical, maritime, construction, and manufacturing, where corrosion protection and surface preparation are vital for maintaining and efficiently operating equipment. Implementing this method significantly contributes to reducing long-term maintenance costs and increasing the reliability and safety of industrial operations.

This method is considered one of the best in the industry for removing any type of impurity and preparing surfaces for any final finishing process [6].

Sand-Blast Equipment

The sandblasting equipment generally consists of a com- pressor that reaches a minimum pressure of 100 psi [pounds per square inch]. In addition to having air and sandblasting ducts, it also has a sand tank where pressurized air is injected, producing the air-sand mixture. Finally, there is a nozzle that directs the flow toward the surface.

Air Compressor

A necessary part of the equipment for abrasive blasting is an air compressor.

The compressors regularly used are portable units without a storage tank; they are essentially the same equipment used for pneumatic breakers. These units differ in the air supply capacity and the pressure they can withstand. Occasionally, stationary units can be used, but this depends on their capacity since only a few can meet the required air demand. The air compressor used at the Polytechnic University in Otzolotepec as shown in Figure 1, it has a capacity of 20 litres, which is sufficient for conducting sandblasting tests at the laboratory level.

Box 1

Figure 1
Compressor 150lt-10 Bar
Image by author

Abrasive Container

All sandblasting containers serve the same essential function, which is to provide an amount of abrasive to a high- pressure stream; the difference between one setup and another lies in the abrasive storage capacity. The tanks range from 50 to 400 or more liters of storage [Figure 2]; sometimes they are classified by the kilograms of abrasive they can store, but this can be relative due to differences in volumetric weights. Therefore, classification by volume may be more accurate [2]. The issue is that only a medium capacity of the container can be added, although it may not seem so, but it is very useful for students, which is why it is necessary to find the correct organic abrasive so they don't have problems with the amount of abrasive.

Nozzle

Nozzle tips for blowtorching are manufactured in various materials, of which the most common are: ceramic, cast iron, and tungsten carbide.

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The first two are more economical but have a lifespan of approximately 2 to 4 hours of continuous service. Our nozzle is shown in Figure 3. The sandblasting gun is commonly used; its size is 3/8", which allows us to work in the process without complications.

Sand blasting hoses

The hoses used in the process are reinforced with multiple layers of natural rubber without wires or reinforcements, usually prioritizing the prevention of electrostatic charges that could create sparks in potentially explosive environments. They are approximately 15m long with inner diameters of 1" or 1 ¼", suitable for 3/8" nozzles. Using smaller diameters may result in pressure losses in the line unless smaller diameter nozzles are used. The inner diameter of the hose should be 3 to 4 times larger than the inner diameter of the nozzle.

Sand blasting cabin

The cabin was created within the University to mitigate the impact of the environment and potential illnesses caused by using any type of inorganic abrasive. The cabin prevents students from direct contact with the dust generated by sand or organic abrasive materials.

Box 2

Figure 2
Abrasive Container

Image by author

Box 3

Figure 3
Connection nozzle

Image by author

Types of Sandblasting

Wet blasting

Wet abrasive blasting [also known as vapor abrasive blast- ing] removes coatings, contaminants, corrosion, and residues

From hard surfaces. The main advantage of wet abrasive blasting over dry blasting is that it reduces dust. It provides a cleaner surface with a more uniform finish, ready for coating, without embedded particles or adhered dust [6].

For this, we need a compressor that, instead of assisting the abrasive with air pressure, does so with water. There are several types of commercial compressors that can be used in the process. This process is not viable for organic materials since moisture reduces the hardness of the dust, thus eliminating its removal capacity.

Dry blasting

This technique involves cleaning or removing materials from a surface by the action of granular abrasive material expelled by a compressed air machine through a nozzle. Sandblasting is used to remove rust or any type of coating on surfaces and prepare them for coating, but that's not its sole function; there are many more functions of sandblasting besides the aforementioned [7].

Abrasives

Abrasives are tools used for polishing, grinding, and smoothing surfaces.

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They are widely employed across various industries to work on other materials. The use of abrasives involves the removal of material through the action of hard abrasive particles that are typically bonded. Grinding is the most significant abrasive process. Other traditional abrasive processes include honing, lapping, superfinishing, polishing, and buffing. Generally, abrasive machining processes are used as finishing operations [8].

Organic abrasives

These abrasives are composed of materials found in nature, such as walnut shells and corn residues. Because they are softer than other common materials, they are useful for delicate applications like polishing or cleaning, leaving surfaces largely intact. A significant advantage of this medium, besides being natural and non-toxic, is its reusability due to its resistance to decomposition [4].

Corundum: It is the most common abrasive in the metal industry. It is a fused aluminum oxide with an alpha aluminum structure and a Knoop hardness of between 2000- 2100 Kg/mm2. There is white corundum [harder and purer] and brown corundum, with a chemical composition including small percentages of titanium oxide and iron. Corundum is primarily used for shot blasting [removal of rust and scale on metal surfaces, discoloration, and material removal cleaning of surfaces], surface finishing, improvement of metal surface adhesion, deburring, glass matting, and treatment of highly hardened workpieces.

Quartz: Widely used and inexpensive, also known as silica sand. It is used in the manufacture of sandpapers, blocks, or discs, and primarily in abrasive blasting systems through pressure sandblasting.

Garnet: It is a mixture of various hard alkaline earth silicates. The purest variety is used in jewelry, while the smaller,more impure fragments are used as abrasives, especially for woodworking, water jet cutting, and sandblasting.

Corn Residues: Another sandblasting abrasive is corn residues. Since it is not very hard, it is mainly used for delicate surfaces like wood and glass, or to remove soft layers like grease or debris.

It is a biodegradable abrasive made from corn, its major advantages being completely safe for operators and resistant to breakage, making it reusable. It only comes in extra coarse size.

Walnut Shell: Walnuts are an organic and biodegradable abrasive. Because it is a soft abrasive, it is widely used for cleaning, polishing, or preparing wood and stripping car coatings. Some of the most important advantages of walnut shells are that they are non-toxic, pose no health risks, and are recyclable, making them a healthy and economical medium.

Synthetic Abrasives

Steel Grit: Another widely used sandblasting abrasive is steel. Steel shots are rounded, and steel grits are angular, but they are made of the same material: carbon steel.

They are mainly used for heavy-duty sandblasting tasks, such as epoxy coating preparation, hard coating removal, deburring, etc. Among the main advantages of this medium are high quality and the resulting smooth surface it produces. Additionally, there is a wide variety of sizes and hardness levels for this medium [9].

Plastics: Plastic abrasives are an excellent choice for strip- ping and cleaning applications involving aluminum compounds and other delicate materials.

If you need to remove organic coatings without damaging the underlying component surface, this is the sandblasting abrasive to choose. Some of the main advantages of plastic abrasives are that they are available in all standard sizes, hardness, shape, and density, and can even be manufactured to meet different needs.

Parameters for abrasives

Shape: Different shapes in abrasives will offer different profiles on the surface, with the two main abrasive configurations being angular and spherical. Angular abrasives work best when dealing with heavy layers of paint and corrosion. They are classified into four possible shapes: angular, sub-angular, round, and sub-rounded. As the designation describes, angular media have sharper edges than sub-angular ones, but both are used for aggressive abrasive blasting.

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Hardness: The hardness of the abrasive will determine its effect on the surface being cleaned or etched. Abrasive hardness is measured on the Mohs scale, with 1 being as soft as talc and 15 as hard as diamond. Abrasives such as boron carbide, silicon carbide, and aluminum oxide fall within the range of 10 to 13. Size: The size of abrasive particles is extremely important for achieving a consistent texture pattern when applying the abrasive blast on the surface. Abrasive manufacturers use various nomenclatures and numbering systems to define the size of their products [10].

Main benefits of sandblasting

Sandblasting offers numerous benefits beyond corrosion removal in metals. It has many advantages within the industry, improving cleanliness in materials such as glass, marble, slate, ceramic, tile, stainless steel, acrylic, concrete, wood, iron, aluminum, bronze, among others [2]. Removing impurities and leaving surfaces exactly as desired is one of the main functions that sandblasting benefits industries, helping to:

- Reduce labor costs.
- Improve part maintenance.
- Enhance the appearance of finished parts.
- Achieve efficient results with less effort.
- Optimize work time.
- Increase adhesion for coatings.
- Highlight material priorities.

Methodology

The current situation at the laboratory of the Polytechnic University of Otzolotepec is limited for research development due to equipment constraints. However, with support from COMECYT, equipment has been acquired to characterize the abrasives being developed. Considering relevant background and investigating key aspects related to health and the environment, it is known that silica sand causes significant pollution, and frequent inhalation can lead to silicosis.

Preparation of organic products

The products suitable for obtaining the abrasive underwent a series of processes before being ground, with the purpose of finding the shape, hardness, and size. The first step was cleaning, followed by drying, and finally grinding.

The initial option was corn husks. After consulting with individuals engaged in agriculture near the University's location, it was decided to primarily work with walnut and orange peels, as they are used as feed for livestock, as shown in Figures 4, 5 and 6.

Box 4

Figure 4
Harvested corn husk
Image by author

Box 5

Figure 5
Cleaned pecan shell
Image by author

Use and Integration of an Electric Mill into the Procedure

An electric mill is acquired to process seeds and dry products. Figure 7 shows a capacity of 2hp Electric Mill, resulting in the material having the grain size characteristics as shown in Figure 8 and 9.

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The resulting product is presented below.

Results

The results obtained after using the electric mill to reduce the size of the shells of three different types of natural products showed that the achieved fineness, measured with various instruments, allowed us to reach a valid conclusion.

Results of Sieving Test

A sieve was used to observe and analyze the particle size obtained for both walnut shells and orange peels. It was carefully observed that the grain size of each raw material achieved the necessary fineness to carry out the tests, thus demonstrating that any type of grain met the characteristics typical of sand. Subsequently, sandblasting tests were conducted using a 3/8" nozzle without encountering flow problems and maintaining a constant output, as with sand.

To evaluate the feasibility of using walnut shells and orange peels as abrasive materials in sandblasting processes, a detailed particle size analysis was conducted using a sieve. This procedure allowed for the determination that both types of shells broke down into grains fine enough to meet the necessary requirements for sandblasting tests. Observations showed that the grain size of each raw material met the granulometric characteristics typical of conventional sand used in these processes.

Box 6

Figure 6
Orange Peel Drying Process
Image by author

Once the adequacy of the particle size was confirmed, sandblasting tests were performed. For these tests, a standard 3/8" nozzle was used. During the sandblasting process, it was observed that there were no flow issues and that the output of the abrasive material remained constant, similar to what is experienced when using conventional sand. This suggests that both walnut shells and orange peels can be viable alternatives to traditional sand in sandblasting applications, potentially offering additional benefits such as waste reduction and the utilization of recycled organic materials.

Moreover, these alternative abrasive materials may present significant ecological advantages since they are biodegradable and do not produce the silica dust associated with sand, which can be harmful to health. This property makes them a safer option for operators and more environmentally friendly. In summary, the tests indicated that walnut shells and orange peels not only meet the necessary physical characteristics for sandblasting but also offer additional benefits, positioning them as promising alternatives in the surface cleaning and finishing industry.

Measurements were made using the sieving process, with the largest sieve being 2 mm and the smallest 250 microns. These tests concluded that, in terms of grain size, the materials met the standards compared to silica sand. The results obtained with the different materials are shown in Figure 10.

Box 7

Figure 7
Electric Mill
Image by author

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We started with an initial weight of 145 g for the three types of husks, in order to conduct the necessary measurements. Each sample undergoes a weight reduction with each subsequent sieving; for instance, after the first sieving, the weight decreases to 138 g, and so on.

These initial weights are crucial for subsequent calculations. On average, we observe a loss of 7 grams per product, which can be recycled to achieve a minimum size of 1 mm and fully utilize the material. The sieves used are standardized, ensuring precise results essential for accurate tabulation and obtaining concrete outcomes. Figure 11 depicts an image of the sieves with the sieved materials. The three types of husks were measured using six different mesh sizes, each with a different mesh opening. Measurements were conducted on the three types of powders obtained after grinding. Mesh sizes of 2mm, 1mm, 710 microns, 500 microns, 355 microns, and 250 microns were used. As mentioned previously, the weights decreased as the material passed through each sieve.

Referring to Table 2, which provides granulometric classification, we can compare the results obtained. The fineness of the silica sand ranges from 600 microns to 2mm in the table.

The highest final weight was obtained with the 500-micron mesh, indicating that the particle size of each husk is slightly finer than that of silica sand. Thus, the results obtained were as expected. Dividing the total weight by the three types of husks yields an 85% effectiveness rate for any powder as an abrasive. Tables 1, 2 and 3 present the results of the measurements conducted with the sieves for each of the powders derived from different husks.

Box 8

Figure 8
Sifted walnut shell

Image by author

Box 9

Figure 9
Dry orange peel

Image by author

After sieving the three types of grains used throughout the project and analyzing the results in a standardized manner, we conclude that none of the powders clog the sandblasting gun nozzle. This is because their fineness is finer than that of sand, making them ideal for the process. Taking into account the statistics from the tables and the measurements of silica sand grains, which theoretically range from 0.625 microns to up to 2 millimeters for compressor work, we can draw conclusions without conducting direct tests.

The final results regarding the weight of the different powders are as follows: orange peel weighed 4g, walnut shell weighed 2g, and pecan shell weighed 5g, all with a minimum grain size [less than 250 microns].

Box 10

Figure 10
Sieve used to measure grain size

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Box 11

Table 1

Orange Peel Measurements

Num	Opening	Initial weight	Sample Weight	Final weight
1	2.00mm	145g	145g	10g
2	1.00mm	138g	138g	10g
3	710mic	132g	133g	1g
4	500mic	127g	131g	4g
5	355mic	124g	127g	3g
6	250mic	122g	124g	2g
TOTAL		89g	91g	2g

Source by author

This indicates that both orange peel and pecan shell meet the grain size requirement. With the acquired mill, it is possible to obtain organic abrasive powder according to desired characteristics, adjusting analytically through trial and error.

For the Sand Blast process, orange peel, pecan shell, and walnut shell were used, all with a grain size of 1mm, compressor pressure set at 100 psi, and a time of 2.5 minutes. Orange peel efficiently cleaned an area of 3.5x3.5 cm. It was observed that both types of walnut shell presented flow difficulties and lacked hardness.

The results obtained with orange peel are shown in Figure 12.

Conclusions

Through thorough analysis and following the project's objectives step by step, we can confidently conclude that it has been completed satisfactorily. The material generated has exceeded expectations, meeting the granulometry specifications and exhibiting the characteristic properties of an abrasive material.

Box 12

Table 2

Measurements of the Shell of the Castilian Walnut

Num	Opening	Initial weight	Sample Weight	Final weight
1	2.00mm	145g	145g	0.0417g
2	1.00mm	138g	138g	0.0010g
3	710mic	132g	133g	1g
4	500mic	127g	129g	2g
5	355mic	124g	127g	3g
6	250mic	122g	124g	2g
TOTAL		89g	93g	4g

Source by author

Box 13

Table 3

Measurements of Pecan Nutshell

Num	Opening	Initial weight	Sample Weight	Final weight
1	2.00mm	145g	145g	1.3438g
2	1.00mm	138g	138.5g	0.5g
3	710mic	132g	136g	4g
4	500mic	127g	132g	5g
5	355mic	124g	126g	2g
6	250mic	122g	123g	1g
TOTAL		89g	91g	2g

Source by author

This achievement brings positive benefits to the students of the Polytechnic University of Otzolotepec, who are the primary users of the material during their laboratory hours. It also significantly contributes to reducing environmental pollution and helps prevent respiratory problems that may arise from long-term exposure to silica sand.

In conclusion, this project was successfully concluded, the development of an organic abrasive powder for the Sand Blast process is fully usable, meeting the established objectives and making a positive impact on both the student community and the environment.

Box 14

Figure 11

Measurement of Pecan Shell Granules Using Seven Different Sieves

Image by author

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Box 15

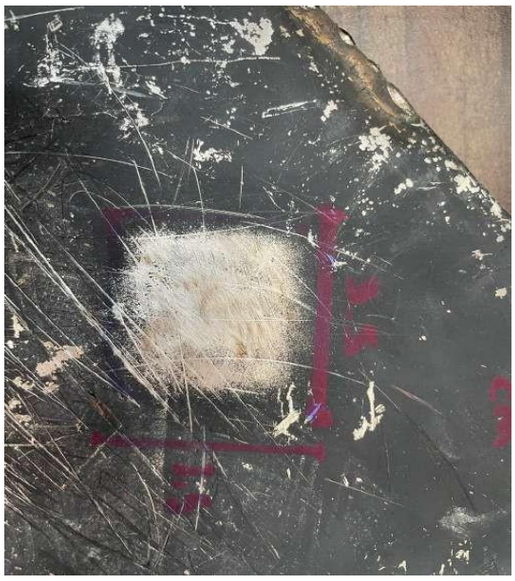

Figure 12
Sand-Blasting Results
Image by author

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

García-Medina, Daniela: Contributed to the project idea, research method and technique.

Montúfar, Jesús: Contributed to experimentation and writing.

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