

**PRODUCTION OF SILICA NANOPARTICLES FOR LATENT  
FINGERPRINT DEVELOPMENT USING BAMBOO LEAVES**

**BY**

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## CERTIFICATION

We the designated certify that this project work was carried out and presented by Evelyn Ehinosen ADOGA in partial fulfillment of the requirement for the award of Bachelor of Science degree (B.Sc.) Chemistry, in the Department of Chemistry, University of Benin, Benin City, Edo State.

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## **DEDICATION**

This work is dedicated to God Almighty who has been my guide, help, support, strength, since the beginning of this journey till this very moment.

To my irreplaceable and supporting family who have been encouraging and supporting me in all areas and to my amazing friends who have contributed in one way or the other to the success of this work. I also dedicate this work to you.

## ACKNOWLEDGEMENT

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## ABSTRACT

This paper focuses on the application of forensic science in latent fingerprint detection by the usage of distinct nanomaterials and their benefit with respect to the quality of fingerprint images. Nanotechnology is involved with the study of nanoscale materials, it is having a substantial impact in every industry. It is a widely used technique because of its ability to change and characterize matter down to individual and tiny atoms. Nanoparticles have recently showed considerable potential in the production of nano-fingerprints i.e. the next generation of fingerprint development procedures. Silica nanoparticles were produced to detect invisible finger impressions on non-absorbent surfaces. Silicon usually has been obtained from mineral in rock and sand, however, silicon also can be obtained in organic material such as risk husk, bamboo leaf, wheat husk and another agricultural waste. Bamboo is a source of organic silica (bio-silica). The bamboo absorbs silicic acid from the water and then convert it into  $\text{SiO}_2$  hydrate in the root branches and leaves.

## CHAPTER ONE

### 1.1 INTRODUCTION

#### 1.1.1 BACKGROUND OF STUDY

Criminals normally take great care to avoid leaving any evidence at the crime scene and when handling objects. But the majority of crime scenes have latent fingerprints. A fingerprint is an impression left by the friction ridges of a human finger. Moisture and grease on a finger result in fingerprints on surfaces such as glass or metals. The creation of fingerprints is a potent instrument in forensic science and is recognized as a reliable technique of identifying a person. The characteristics, size, texture, and color of the surface where the latent fingerprints are left behind all play a part in determining the procedures for producing the latent fingerprints. Human fingerprints are detailed, nearly unique, difficult to alter, and durable over the life of an individual, making them suitable as long-term markers of human identity. The surface that a fingerprint is left on is frequently the main determinant of the enhancement technique chosen. Specific enhancement procedures are chosen based on the surface type and porosity, the condition of latent marks, and the degree of contamination that has occurred. There are a wide variety of porous and non-porous surfaces.

Research, evaluation, and identification of evidence at crime scenes that can be used to easily apprehend suspects are all considered to be part of forensic technology. Prior to making a decision in court, forensic evidence is an essential tool for identifying culprits through examinations at crime scenes. It is also a useful tool for gathering credible records of evidence against the accused [B. Telles *et al.*, 2016]. Fingerprints have been used by criminal justice to

identify individuals for over 100 years. It is one of the most important evidence due to their uniqueness and immutability for personal identification [Thomas GL 1975].

Nearly every department of science is enthralled by nanotechnology, a branch of science that is growing rapidly. As nanotechnology has advanced, it has been discovered that criminological sciences frequently use nanomaterials for research and testing. With the development of emerging methods of nanoparticles being combined with latent fingerprinting, nanotechnology is the field of forensic science that is currently undergoing change. Nanomaterials are distinct because of their small size and can have different mechanical, electrical, and optical properties [Hussain,C.M. *et al.*, 2019 ]. Nanomaterials has recently shown considerable potentials in the production of nano fingerprints i.e the next generation of fingerprint development procedures. Dactylography, the study of fingerprints as a technique of identification, is one of the essential sciences in criminal investigations. Dermatoglyphics, on the other hand, is the scientific study of frictional ridge patterns seen on fingers, palms of hands, toes, and soles of feet [Sodhi GS *et al.*, (2019)]. Nanotechnology is involved with the study of nanoscale materials, it is having a substantial impact in every industry. It is a widely used technique because of its ability to change and characterize matter down to individual and tiny atoms. The word "nano" is derived from the ancient Greek "Nanos," which meaning "dwarf," and describes a billionth ( $10^{-9}$ ) of a mean approximately a nanometer (nm)[Shukla RK *et al.*, (2016)]. Typically, 1nm is 40,000 times smaller than the width of a human hair, or 3–10 atoms. It focuses on novel materials or apparatus at a scale between 1 and 100 nanometers.

Silica nanomaterials were produced to detect invisible finger impression on non-absorbent surfaces. Nanomaterials provides better fingerprint images, clearer ridge patterns, and less

background. Silica nanomaterials are easily coated with dyes to facilitate latent fingerprint detection.

### **1.1.2 STATEMENT OF PROBLEM**

There are so many challenges when enhancing latent fingerprint development through the production of silica nanoparticles. This involves investigating the synthesis methods, characterizing the properties and evaluating the effectiveness of these nanoparticles in improving the visualization of these fingerprints on various surfaces. The various surfaces also poses a challenge such as surface type, humidity, and substrate interference. All these challenges makes it difficult for criminals to be held accountable for the crimes they commit.

### **1.1.3 AIM OF STUDY**

The aim of a study on the creation of silica nanoparticles for the development of latent fingerprints is probably to investigate and perfect a technique for creating silica nanoparticles that may be utilized to enhance latent fingerprints on various surfaces. Also, to provide a comprehensive overview of latent fingerprints, their importance in forensic investigations, and the existing techniques for their development.

### **1.1.4 SCOPE OF STUDY**

The goal of the project is to produce silica nanoparticles for the enhancement of latent fingerprints by investigating various facets of nanoparticle synthesis, characterization, and application. This study focuses on;

1. Synthesis and Characterization of Nanoparticles which could include techniques like scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and dynamic light scattering (DLS) to analyze size distribution, morphology, crystallinity, and stability.
2. Evaluate the efficacy of synthesized silica nanoparticles in enhancing latent fingerprints on various surfaces (porous, non-porous, and semi-porous) using established fingerprint development techniques (powders, cyanoacrylate fuming, etc.).
3. Compare the performance of silica nanoparticles with traditional fingerprint enhancement methods in terms of sensitivity, selectivity, and clarity of developed prints.
4. Explore different application methods, such as direct brushing, spraying, or immersion, to determine the most effective way to apply silica nanoparticles for latent fingerprint development.
5. Investigate the influence of application parameters (e.g., concentration of nanoparticles, application time, drying conditions) on fingerprint enhancement results.
6. Discuss the potential broader applications of silica nanoparticles beyond fingerprint enhancement, such as in forensic evidence collection and analysis.
7. Identify potential areas for further research and development to improve the effectiveness and versatility of silica nanoparticles in forensic science.

## **1.2 LITERATURE REVIEW**

The word “nano” is derived from the ancient Greek “Nanos,” which means “dwarf,” and refers to one billionth ( $10^{-9}$ ) meter or nanometer (nm). Generally, 1nm is about 3-10 atoms wide or 40,000 times smaller than the width of human hair. It is concerned with new materials or devices

at a scale that ranges between 1 to 100 nanometers. Nanotechnology is one of the advanced branches of science that is focused on nuclear, sub-atomic, and supramolecular particles planning to make nanostructures with improve functionalities. As a result, there are several forensic science uses for this universal technology. A brand-new field of forensic science called nano forensics blends forensic science and nanotechnology. It facilitates the detection and analysis of evidence at the nanoscale level, where up until now, analysis of crucial evidence was challenging due to the instrument's detection limit. Nanoparticles improve both the general and specific characteristics of fingerprints, such as the arrangement of pores and the minute details contained within them. Nanomaterials were used to create latent fingerprints because they enhance latent prints more effectively. By increasing the surface interaction with the endogenic material present on the elevations of fingerprints, it enhances disparity and finger impressions [Shukla RK, *et al.*, 2016]. In the last two decades, different types of nanoparticles were produced in various morphologies and used in forensic applications. In particular nanoparticles of silver and gold as metal nanoparticles, titanium dioxide, zinc oxide, iron oxide, europium oxide and silica nanoparticles as metal oxides nanoparticles, cadmium sulfide quantum dots (CdSQDs), cadmium selenide quantum dots (CdSeQDs), cadmium telluride quantum dots (CdTeQDs), carbon dots (CDs), polymers dots, fluorescent silica nanoparticles, fluorescent mesoporous silica nanoparticles, conjugated-polyelectrolyte dots (CPEDs), aggregation-induced emission luminogens molecules incorporated nanomaterials and rare earth metals fluorescent nanomaterials have been used for fingerprint detection method in forensic applications[H. Chen, K. Chang, X. Men, K. Sun, X. Fang, C. Ma, *et al.*, 2015].The reasons for use of these nanoparticles in fingerprint detection are described as follows: The nanoparticles of silver and gold are mostly concerned with target molecules of metabolites and explosives with

corresponded to antibodies and aptamers, respectively. Additionally they have shown various properties like large surface area, small size, thermal conductivity and electrical conductivity[X.F. Zhang, *et al.*, 2016]. The powders of metal oxides nanoparticles which include titanium dioxide, zinc oxide nanoparticles, iron oxide nanoparticles, europium oxide nanoparticles, silica nanoparticles have been used for latent fingerprint detection[Y.F. *et al.*, 2011]. These different metal oxide powders are used on fingerprint residue surfaces due to good contrast between them, better coating on the surfaces and better resolution of fingerprint images as well as ridge characteristics under day light conditions. These properties help to validate latent fingerprint identification crime scenes[Z.L. Wang 2004]. These types of materials have been used in fingerprint detection and they are used for positive identification of criminals at crime scenes [V. Prasad *et al.*, 2020]. Generally, the quantum dots (QDs) displayed high fluorescent characteristics and they are used in various applications such as optical devices, bioimaging, liquid crystal display (LCD) screen and biomarkers [M.X. Zhao, E.Z. Zeng *et al.*, 2015]. They have induced better emission properties, better quantum yields, large surface area, low size and good photo-stability [T.J. Bukowski, J.H. Simmons 2002]. The QDs have shown greater fluorescent properties to investigate fingerprint detection at different substrates of non-porous and porous substrates due to the small size of the nanoparticles which strongly interacted with the fingerprint residue and it also act as efficient nanoparticles for fingerprint development in forensic applications[C. Xu, R. Zhou, *et al.*, 2014]. Hence, these kinds of nanoparticles were significantly used for fingerprint detection due to high quality images, better visibility, good ridge characteristics, increased background contrast, higher selectivity and sensitivity [F.K. Kanodarwala *et al.*, 2019].

### 1.2.1 FORENSIC TECHNOLOGY

Forensic technology is defined as the research, assessment and identification of evidence at crime scenes which provide direct links to criminals and easy apprehension. Forensic evidence is a crucial tool for identifying criminals by investigations conducted at crime scenes prior to judgment in court. It is also an effective device to provide good records of evidence against the accused[K.S. Peng, *et al.*, 2015]. Forensic technologies are likewise implemented in fingerprint, sound profiles, ear-prints and handwriting analysis. Forensic technology is another field of science, which has been extensively applied to positively identify criminals and assist law enforcement officials in solving crimes. Forensic technology is therefore one of the key sciences used to imprison criminals and ensure that justice is attained without difficulty. Forensic technology plays a key role in crime scene research and crime scene sample analysis which assists a panel of judges and lawyers in providing evidence against criminals in a court of law. Forensic technology studies have been largely applied in the area of analytical forensic chemistry, which includes a broad range of analytical tools for conducting fundamental research. Among them, fundamental research requires forensic technological expertise and medical consistency. A need for new developments in forensic analysis has arisen because existing techniques are losing their effectiveness and reliability. This is in spite of the fact that the forensic analytical approach has stabilized in forensic technological skills research[F. Johnson, *et al.*, 2015]. Most forensic technological skills aim at gathering biological evidence for criminal identification. The various fields of science which have been applied for crime investigations include psychiatry, pathology, toxicology, entomology, anthropology and odontology[C.A. Andrade, *et al.*, 2016]. The common kinds of evidence substrates which are frequently encountered in forensic analysis include bloodstains, fabrics, fiber, glass, hair, gunshot residues

and paint [J. Bueno *et al.*, 2016]. However, forensic evidence in solving crimes is mostly gathered as fingerprints and blood stains using spectroscopic techniques. Forensic proof in identifying criminals is mostly in the form of fingerprints and bloodstains utilizing spectroscopic methods. The techniques utilized include dynamic light scattering (DLS), Raman microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM)[ R.K. Bibbs *et al.*, 2015].

### **1.2.2 FINGERPRINTS**

A vital key to solving many crimes is the identification of latent friction skin from evidence collected at the scene. Unique to every individual in the world, as well as permanence in the arrangement, this friction skin is located on the fingertips, fingers, palms as well as the feet of humans. Offering unique characteristics which can be left behind at a crime scene, this ridge detail consists of a multitude of different chemicals that come from natural excretions as well as other toxins which an individual can pick up as they touch random surfaces.

Forensic investigations mostly involve fingerprint detection. Fingerprint analysis demonstrates numerous basic principles. Latent fingerprint identification has established as the major method for personal identification in forensic science[J.J. Nordby *et al.*, 2002]. The identification process involves the matching of ridge pattern details and comparison between found the fingerprint from crime scene and control fingerprint stored on record to determine the identification. The ridge patterns demonstrated different categories of level-1 (loop, whorl, arch) and level-2 (minutiae) and level-3 (sweat pores)[ A. Jackson, *et al.*, 2017]. It is not possible for different people to have the same fingerprints as each person's fingerprints are unique. However, according to Galton evaluation most human fingerprints have the same fingerprint pattern. Human fingerprints are distinguished by a pattern of ridges and furrows on the hands, feet, and

toes that persists until death. It is possible for two persons to have the same fingerprint ridge pattern. The standard method for collecting fingerprints involves dotting the left-hand finger with ink and placing the plate(s) on paper, plastic, or aluminum. The fingerprint ridge, which includes loops, whorls, and arches, is formed when friction is produced between the finger and the surface to which it has been applied. The form and kind of coating have a significant impact on the finger's ridges. While whorls and arches are a few other fingerprint ridge forms, most human fingerprint ridges have the loops pattern. On the finger's fingerprint ridges, the arches are typically crowded. However, there are four categories of fingerprint whorls: major, lateral, twin, and accidental. The fingerprint ridge patterns rationalize the need for the fingerprint detection. Ridges are not spread over the whole finger. The ridges suddenly appear at the end and are referred to as quit ridges. Some other ridges are known as dividing ridges. Ridges can also be classified as remote ridges, diverse ridges and discrete ridges. Ridges are shown as large dots [S.B. Nikam,*et al.*, 2009]. There is a correlation between the fingerprint thumb impression assessment and the identity of the person, and fingerprint arch ridges are formed at the middle of the finger and may be branched from opposite facets of the entry. Circular and spiral ridges are known as whorl fingerprint ridges and these are very useful in assisting forensic scientists with an identity assessment. Three types of fingerprint detection have been studied in forensic science: latent, regarded, and plastic. Of these, latent fingerprint detection provides two-dimensional images of finger ridges on the substrate with sweat, oil, and other contaminants. The finger ridges are not used for identifying the person, but they are helpful in guiding the forensic scientist in choosing among the key suspects. The fingerprint images can be produced by using popular techniques which include black printer ink, chemical methods with inkless and digital fingerprint detections with pc systems to scan the finger [F. Alaca, P.C. Van Oorschot 2016].

### 1.2.3 NANOPARTICLES FOR FINGERPRINT DEVELOPMENT

Nanoparticles have recently showed considerable potential in the production of nano-fingerprints i.e. the next generation of fingerprint development procedures. Nanomaterials have a large surface area, small size, optical properties, and can easily modify the surface using various capping agents. These qualities interact well with diverse non-porous and porous substrates on fingerprint residues. Due to hydrophilic attractions on fingerprint components of substrates, nanomaterials provide better fingerprint images, clearer ridge patterns, and less background interference. Nanomaterials have the advantage of being able to detect both fresh and old fingerprints on a variety of substrates [C.A. Andrade, *et al.*, 2015]. Studies on fingerprint detection are also important in identifying criminals and providing evidence against such criminals in a court of law. Typically, in fingerprint detection the criminals are identified by their fingerprint ridges and furrows of their fingers. The invisible nature of the fingerprint is known as the latent fingerprint [C. Champod, *et al.*, 2017]. Latent fingerprint detection is the primary method of detection which has been employed to identify the fingerprints of criminals due to the easy visibility of fingerprint ridges. The most common technique for latent fingerprint detection is the powder method [B. Zein *et al.*, 2013]. Regular forensic powders are associated with polymer and dye compounds. Metallic powders are formed from metal nanoparticles like gold and silver nanoparticles. Therefore, regular and metallic forensic powders were prepared for easy use in latent fingerprint detection. They have shown less contrast, low sensitivity, high toxicity and high background interference [A.A. Prabhune *et al.*, 2017]. Apocrine, sebaceous, and developing eccrine glands in the palm, head, and nose produce various types of perspiration that can be used to discover latent fingerprints. When minerals and organic substances are present, sweat leaves the most residue on the finger pores. Choline, urea, creatinine, lactic acid,

carbohydrates, amino acids, and uric acids are all linked to eccrine sweat. Sebaceous sweat contains fatty acids, wax esters, squalene, sterol ester, and glycerides. Sebaceous sweat depends on intercourse, age, food plan, diseases and medicinal drug food plan factor which impact on the fingerprint detection. Latent fingerprint images are not very visible when the surface of the finger is contaminated. Latent fingerprint detection is also affected by the passage of time, which in turn depends on the risks imposed by substances applied, warmth, moisture, light and air [P.J. Saukko *et al.*, 2012].

Fingerprints can be easily viewed under UV irradiation due the emission properties of the powdered materials to easily identify the criminal. Aluminum foil and carbon based materials are substances which are commonly used to enhance latent fingerprint detection and to help to identify the criminal[F. Iemma, *et al.*, 2013]. The surface of latent fingerprint ridges and valleys are determined with the aid of the use of Surface Assisted Laser Desorption/Ionisation Time-Of-Flight Mass Spectrometry (SALDI-TOF-MS) with nanopowdered substances [S.Y. Chang *et al.*, 2007]. As an example, nanomaterials have been utilized for latent fingerprint detection of ridges and valley of the finger at crime scenes with nonporous surface materials [S.M. Jickells *et al.*, 2009]. Forensic technologies also help the government for the investigation of terrorist usage of materials, which include suicide bombing, secret explosive gasoline, biological samples and residues. The forensic approach has effortlessly identified terrorist usage of explosives as organic residues in motors and baggage [R.J. Colton *et al.*, 2003]. However recently, explosive identification has presently decreased due to unsuitable detection because of sensitivity, selectivity, price impact and length. These problems have been addressed by using nanosensors for the determination of terrorist materials which includes explosive gasoline and organic reagents and residues. Nanomaterials are desirable because of their high surface area, small size,

optical characteristics, and ease of surface modification using different capping agents. Different non-porous and porous substrates are easily able to interact with these types of features on fingerprint residues. The advantage of using nanoparticles is their capacity to recognize both recent and old fingerprints on a variety of substrates [ A. Lesniewski *et al.*, 2012].

#### **1.2.4 SILICA NANOPARTICLES**

Silica nanoparticles are tiny particles of silica, a compound made up of silicon and oxygen. They have a wide range of applications, including medicine, electronics and material science due to their unique properties such as high surface area and tunable surface chemistry. [Zhao, Y., & Jiang, T. 2017]. They typically have diameters ranging from a few nanometers to several hundred nanometers. They can be synthesized with various shapes such as spherical, rod-like, or even more complex geometries. Silica nanoparticles can have either porous or non-porous structures, depending on the synthesis methods used.

Silica nanoparticles can be synthesized using various methods including sol-gel synthesis, microemulsion, and Stöber process. They exhibit excellent chemical stability, high surface area, and tunable surface properties [Scherer, G. W. *et al.*, (1990)]. Silica nanoparticles are of interest in drug delivery, imaging, and theragnostic due to their biocompatibility and ability to carry payloads [Gambhir, S. S.*et al.*, (2012)].

#### **1.2.5 APPLICATIONS OF SILICA NANOPARTICLES**

**Drug Delivery:** Silica nanoparticles can be loaded with drugs and used as carriers for targeted drug delivery to specific cells or tissues. They can be designed to deliver therapeutic agents, including drugs, genes, and proteins, to specific cells or tissues. Their controlled release properties can improve drug efficacy and minimize side effects.

**Catalysis:** The high surface area of silica nanoparticles makes them suitable as catalyst supports, enhancing various chemical reactions.

**Optical Applications:** Silica nanoparticles can be engineered to exhibit unique optical properties, such as fluorescence or light scattering, making them useful in imaging and sensing applications. They can be functionalized with imaging agents, such as fluorescent dyes or contrast agents, for use in medical imaging techniques like fluorescence imaging, magnetic resonance imaging (MRI), and computed tomography (CT) scans.

**Coatings and Films:** Silica nanoparticles can be incorporated into coatings and films to improve scratch resistance, mechanical strength, and barrier properties. They have antimicrobial properties and can be incorporated into coatings, textiles, and materials used in healthcare settings to prevent microbial growth and infections.

**Electronics:** Silica nanoparticles can be used in electronics for applications such as enhancing the properties of polymers, improving thermal conductivity, and as fillers in composites. They can be utilized in energy storage devices like batteries and supercapacitors to enhance their performance and stability.

They can also be used in solar cells to improve light absorption and electron transport.

**Environmental Remediation:** Silica nanoparticles can be employed for environmental remediation, such as removing pollutants from water and soil. They can be modified to be sensitive to specific environmental pollutants or changes in conditions, making them useful in environmental monitoring and sensing applications.

**Cosmetics:** Silica nanoparticles are used in cosmetics for their ability to improve the texture, feel, and visual appearance of products. They are used in personal care products like sunscreens and cosmetics to provide a smooth texture, absorb excess oil, and provide UV protection.

**Safety Considerations:** Like all nanoparticles, the safety of silica nanoparticles is an important consideration. Studies have been conducted to assess their potential toxicological effects on human health and the environment. It's important to ensure proper handling and disposal to minimize any potential risks associated with their use.

**Ongoing Research:** Research in the field of silica nanoparticles is ongoing, focusing on improving synthesis methods, understanding their properties, and exploring new applications. While silica nanoparticles have a wide range of applications, challenges exist in terms of scalability, reproducibility, and potential agglomeration or instability of nanoparticles in certain environments. Ensuring the safe disposal of nanoparticles and understanding their long-term environmental impact is an ongoing concern.

## **1.2.6 SILICA NANOPARTICLE FOR LATENT FINGERPRINT**

Silica nanoparticles were produced to detect invisible finger impressions on non-absorbent surfaces. The average diameter of SiO<sub>2</sub> nanoparticles is 70 nm[Bhati K, Tripathy DB (2020)]. Varied mass ratios of silica and 4-(chloromethyl) phenyl trichlorosilane with 700 nm of silicon dioxide nanoparticles were used to make silica nanoparticles. Due to the creation of hydrogen bonds and electrostatic attractions with amino acids, proteins, and lipids on fingerprint residues applied to diverse substrates, silica nanoparticles are easily coated with dyes to facilitate latent fingerprint detection. Because of an amide bond formed between the negative charge of the silica

nanoparticles and the positive charge of the amine functional group on the fingerprint residue, fingerprints were formed by a new interaction between the fingerprint substrate and amine groups functionalized on silica nanoparticles. The best latent fingerprint detection was achieved with a ratio of (50:1) SiO<sub>2</sub>: 4-(chloromethyl) phenyl trichlorosilane as well as on non-porous substrates, these nanoparticles showed the best result.[Pillay K *et al.*, 2021]. The detections of Latent fingerprints on the various substrates was also conducted by using silica nanoparticles with high visibility images and better ridge patterns due to good binding with dyes and reduced photo-leaching were observed. Silica nanoparticles are easily coated with dyes to enhance latent fingerprint detection due to the formation of hydrogen bonds and electrostatic attractions with amino acids, proteins and lipids on fingerprint residues applied on the various substrates [M.A. Wood 2014]. The formation of fingerprints was due to a new interaction between the fingerprint substrate and amine groups functionalized on silica nanoparticles because of an amide bond formed between the negative charge of the silica nanoparticles and positive charge of the amine functional group on the fingerprint residue. Further, the carbodiimide (N-ethyl-N0-(3 dimethylaminopropyl) carbodiimide (EDC) hydrochloride) combined with N-hydroxysuccinimide (NHS) groups are used to create the amide bond with the fingerprint residue.[ S. Moret, A. Bécue, C. Champod 2014].

### **1.2.7 BAMBOO LEAVES SILICA**

Silicon usually has been obtained from mineral in rock and sand, however, silicon also can be obtained in organic material such as risk husk, bamboo leaf, wheat husk and another agricultural

waste. Bamboo is a source of organic silica (bio-silica). The bamboo absorbs silicic acid from the water and then convert it into SiO<sub>2</sub> hydrate in the root branches and leaves [Currie, H *et al.*,2007] Bamboo leaves have a silica content of 17 -23% by weight, higher than the silica content in rice husk (9.3-13.5% by weight) [ Abdullah, E. C *et al.*,2014]. . Bamboo leaf ash has a large SiO<sub>2</sub> content of 75.90-82.86 wt% [ Sakhivel, R., *et al.*, 2011]. The sol-gel process is widely used to produce pure silica particles due to its ability to control the particle size, size distribution and morphology through systematic monitoring of reaction parameters [ Rahman, I. A. *et al.*, 2012].

## CHAPTER TWO

### 2.0 MATERIALS AND METHODS

#### 2.1.1 Materials and Reagents

All chemicals used for this study was of analytical grade and was purchased and used without further purification. They include;

- Hydrochloric acid
- Sodium hydroxide
- Sulphuric acid
- Deionized water

#### 2.1.2 Equipment /apparatus

- Oven
- Muffle furnace
- Magnetic stirrer
- Bursner funnel and flask
- pH meter

#### 2.2.1 PREPARATION OF BAMBOO LEAVES CHARCOAL

Freshly cut bamboo leaves were obtained from university of Benin beside Yomart restaurant. The freshly obtained bamboo leaves was washed thoroughly under running twice to remove impurities from the leaves. The leaves were air-dried to drain the water in the leaves and air-dried for three days. The leaves were then dried in an oven for six minutes at a temperature of 105<sup>0</sup>C. The oven dried leaves were then weighed and crushed with a mortar and pestle. The

crushed leaves was burnt in a muffle furnace at 673k for three(3) hours under inert atmospheric condition to produce the bamboo leaves charcoal.

### **2.2.2 PROCEDURE FOR BAMBOO LEAVES ASH**

The bamboo leaves charcoal was then burnt in a muffle furnace at 700<sup>0</sup>C for three hours to produce bamboo ash. The bamboo leaves ash was then homogenized in a mortar and pestle. It was then sieved using a 525mm sieve. The sieved bamboo leave ash was then poured into an airtight container to preserve it.

### **2.2.3 PREPARATION OF BAMBOO LEAVES ASH USING OPEN AIR METHOD**

The bamboo leaves were burnt to produce bamboo ash. It was then placed in a muffled furnace to further ash at a temperature of 800<sup>0</sup>C for three hour(3). The bamboo leaves ash was then homogenized in a mortar and pestle. It was then sieved using a 525mm sieve. The sieved bamboo leave ash was then poured into an airtight container to preserve it.

### **2.2.4 SYNTHESIS OF NANOSILICA**

10g of the bamboo leaves ash was washed thoroughly with deionized water to remove the sand, dust and fine dust and to also neutralize the pH on the surface of the silica. 6N of HCL was used to reflux the neutralized bamboo leaves ash for one and a half hours with continuous and constant stirring using a magnetic stirrer. It was then filtered in order to remove the metallic impurities to extract the pure nanosilica. The bamboo leaves ash which had been filtered was then rinsed with hot deionized water repeatedly. The acid refluxed bamboo leaves ash was then boiled with 2.5N of NaOH solution at a temperature of 353k for one and a half hour. It was stirred magnetically and constant and then filtered to obtain sodium silicate. The residue was then thoroughly washed with the hot deionized water to extract sodium silicate completely. The

pH of sodium silicate that had been filtered was then reduced to two by the addition of concentrated H<sub>2</sub>SO<sub>4</sub>. It was then stirred magnetically to precipitate nano silica. The precipitate gotten was then washed three times in warm deionized water and afterwards filtered. The residues obtained was calcined that is heating at a very high temperature at 873k for three hours in a muffle furnace to obtain silica. The silica obtained was then pulverized that is reduced to fine particles to nano silica powder using mortar and pestle.

### **2.2.5 PREPARATION OF FINGERPRINT POWDER**

The fingerprint powder was formulated with 40% silica, 30% starch and 30% dye that is, a ratio of 4:3:3 respectively. 20ml Of ethanol was added to ensure homogeneity.

The silica powder, starch and dye are stirred consistently on a magnetic stirrer at a temperature of 100<sup>0</sup>c until it forms a dried paste. It was then transferred to a crucible and placed in an oven until it reaches a dry solid mass. The dried mass is then crushed to produce fine and smooth powder and sieved to obtain finer particles. The powder is then stored in an air tight container.

## CHAPTER THREE

### 3.0 RESULTS AND DISCUSSION

The table below shows the weight of the sample after the experiment was carried.

#### 3.1.1 BAMBOO LEAVES ASH USING MUFFLE FURNACE

SAMPLE	WEIGHT IN GRAMS
BLC	114.89
BLA	50.00
BLA+ HCL	57.67
BLA+NAOH	56.20
SILICA	40.15
SILICA POWDER	18.00

BLC- BAMBOO LEAVES CHARCOAL

BLA-BAMBOO LEAVES ASH

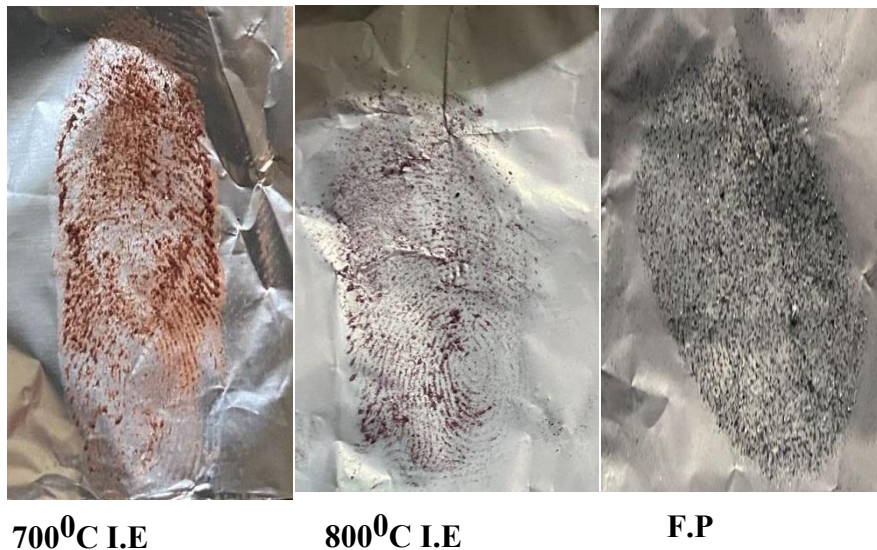
### 3.1.2 BAMBOO LEAVES CHARCOAL USING OPEN AIR METHOD

SAMPLE	WEIGHT IN GRAMS
BLC	97.65
BLA	53.67
BLA+HCL	45.36
BLA+NAOH	41.74
SILICA	20.15
SILICA POWDER	11.56

**BLC-BAMBOO LEAVES CHARCOAL**

**BLA-BAMBOO LEAVES ASH**

**COMPARISON OF FINGERPRINT IMPRESSION ON A FOIL SURFACE BETWEEN  
700<sup>0</sup>C, 800<sup>0</sup>C AND A FOREIGN POWDER(FP)**



**Fig 1:Showing the different prints using methyl orange at different temperatures and comparing to a foreign powder**

The fingerprint impression showed that the prints adhere more with the silica surface of lower temperature than that of the 800<sup>0</sup>c. this is because the silica is likely to absorb oil from the skin making it difficult to capture distinct prints. The prints from the 800<sup>0</sup>c showed more ridges than that of the 700<sup>0</sup>c which is because of the particles size of the silica. That of the 800<sup>0</sup>c had smaller particle sizes while that of the 700<sup>0</sup>c had larger particles sizes.

Comparing to that of the foreign powder, the prints made by the powder showed less ridges, it showed more adherence to the surface and had more retention time making the prints have similar characteristics as that of the 700<sup>0</sup>c.

**Fig 2: Showing different prints using methyl blue at different temperatures and comparing with a foreign powder(FP)**



**700<sup>0</sup>C I.E**

**800<sup>0</sup>C I.E**

**F.P**

The prints showed more ridges on that of the 800<sup>0</sup>c than that of the 700<sup>0</sup>c. The prints are also seen have more clarity while the other showed no clarity. The dye also contributed to how clear the prints were. Because of the blue color which is a dull color, the prints on the foil surface had less visibility.

The powder showed less retention time than that of the methyl orange and it has less adherence.

In comparison to the foreign powder, the print impression made was similar to that of the 700<sup>0</sup>c.



700<sup>0</sup>C I.E

800<sup>0</sup>C I.E

F.P

**Fig 3: showing fingerprint impression using methyl-red and comparing with a foreign fingerprint powder**

The prints showed no clarity, it adhered more to that of the 700<sup>0</sup>c but there was no ridges seen.

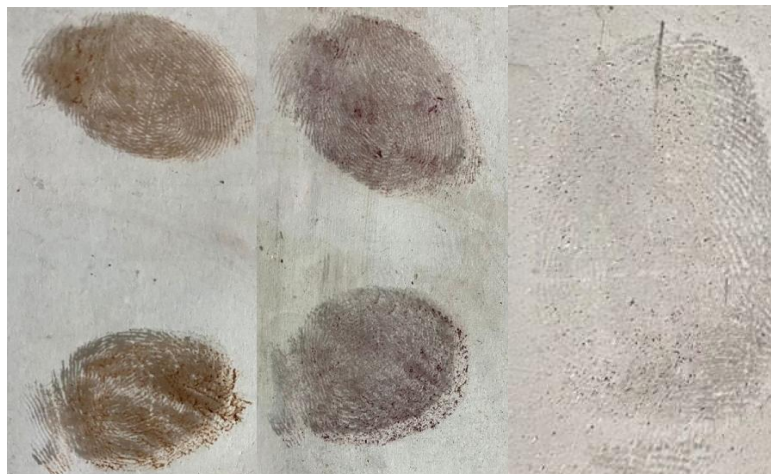
The print made by using the foreign powder showed more ridges. The particle size was a great factor for the silica powder made.

From the above experiment, it can be seen that the fingerprints on a foil surface appears more visible at a temperature of 800<sup>0</sup>c compared to that of 700<sup>0</sup>c. the foreign powder was more pronounced than that of the silica powder produced.

The foil paper having a smooth and non porous surface leads to a clear and distinct fingerprint impression as it minimizes smudging and distortion. The prints are also well preserved due to minimal interaction with oils and moisture.

The fingerprints impressions are also durable and they retain more for an extended period of time which makes it suitable for long term analysis.

## COMPARISON OF FINGERPRINT IMPRESSION ON A GLASS SURFACE BETWEEN 700<sup>0</sup>C ,800<sup>0</sup>C AND FOREIGN POWDER(FP)



700<sup>0</sup>C A.E(M.O) 800<sup>0</sup>C A.E (M.O) F.P

**Fig 4: showing the fingerprint impression using methyl orange at different temperature in and comparing with a foreign fingerprint powder**

The prints impression made showed more ridges on that of the lower temperature than that of the higher temperature. It showed more clarity than that of the 800<sup>0</sup>c. This is also due to the color of the dye, the brown color for the 700<sup>0</sup>c showed more visibility on the glass than the wine color of the 800<sup>0</sup>c.

Comparing it to the foreign fingerprint impression, the nature of the powder made the prints less visible than that made with the silica powder. It showed ridges on the print as that of the 700<sup>0</sup>c. it had more adherence to the surface and longer retention time as that of the 700<sup>0</sup>c.

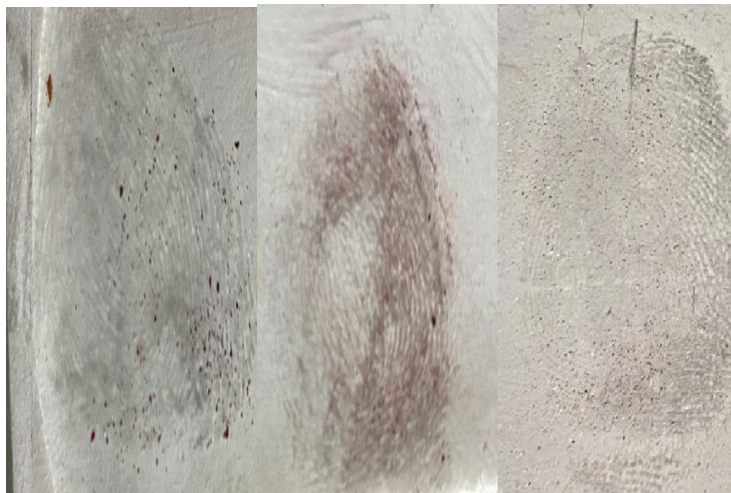


**700<sup>0</sup>C A.E(M.B)    800<sup>0</sup>C A.E(M.B)    F.P**

**Fig 5: Showing fingerprints impression using methyl blue with different temperature and comparing with a foreign powder**

The dye color had a great influence on the prints impressions made by the silica powders. The blue color on the surface gave a ashy like color which made the prints less visible and had little to no clarity. The prints made by the higher temperature showed more ridged than that of the lower temperature. It also had lesser retention time and low visibility.

In comparison to that of the foreign powder, the powder showed similar characteristics with that of the 800<sup>0</sup>c.



**700<sup>0</sup>C A.E(M.R) 800<sup>0</sup>C A.E(M.R) F.P**

**Fig 6:showing fingerprint impressions using methyl red with different temperature and comparing with a foreign powder**

The prints showed less clarity for both temperatures and less visibility. The prints on the higher temperature showed more ridges and had similar characteristics as that of the foreign powder.

This was due to the color of the dye used and the change in color when it was mixed with silica powder.

From the above results, it was observed that the silica powder produced at a temperature of 800<sup>0</sup>c showed greater efficiency than that of 700<sup>0</sup>c temperature. The fingerprint impression showed that the prints adhere more with the silica surface of lower temperature than that of the 7000c. this is because the silica is likely to absorb oil from the skin making it difficult to capture distinct prints.

It can also be observed that the color of the dye had great influence on the impressions made. Light colors had lesser visibility than that of the darker color.

## CONCLUSION

In conclusion, the production of silica nanoparticles for the latent fingerprint development represents a crucial advancement in forensic science and law enforcement. The synthesis of these nanoparticles, often through sol-gel processes or other innovative techniques, has enabled investigators to enhance their ability to visualize and lift latent fingerprints from various surfaces. Since silica is one of the most important nanomaterial, this low cost process is a great method for producing fingerprints powder. With several useful applications in forensic science, the synthesis of silica nanoparticles for latent fingerprint formation utilizing bamboo leaves is a challenging but very promising project. From this study, it is clear there are a number of benefits for latent fingerprint development associated with the extraction and use of bamboo leaves as an environmentally responsible and sustainable source of silica nanoparticles. Firstly since bamboo is a quickly renewing resource that doesn't require substantial chemical treatments, the process of obtaining silica nanoparticles from bamboo leaves is both economical and environmentally benign. This lessens the environmental impact of using conventional fingerprints creation methods and offers a practical substitute for the sometimes expensive and less sustainable commercial silica nanoparticles. The created silica nanoparticles additionally showed a high level of consistency and cleanliness, which made them perfect for improving the visibility of latent fingerprints. These nanoparticles can be customized to meet specific requirements for fingerprint enhancement by changing their size and morphology using different synthesis conditions. These nanoparticles can further enhance their adhesion to latent fingerprints by having functional groups added to their surfaces, resulting in effective development and visualization. Additionally, the use of these silica nanoparticles made from bamboo leaves in the

formation of latent fingerprints showed good outcomes. They have proven to be quite successful

at detecting latent fingerprints on both porous and non porous substrates. The produced prints contrast and clarity were enhanced by the nanoparticle exceptional adherence to the residues left behind in latent fingerprint. As a result forensic researchers and law enforcement organisations can benefit greatly from using them. This study concludes that silica gel powder can be used to form fingerprints on surfaces and produce outcomes with many colours that are comparable to those of the traditional powder. In situations where fingerprints visualization is scarce, it can serve as a suitable replacement. This is especially true when compared to other powders.

The use of silica nanoparticles made from bamboo leaves contributes a significant development in the creation of latent fingerprints. This co-friendly, economical and sustainable strategy is not only in line with international initiatives to lessen the environmental impact of scientific operations, but also has significant potential for improving the effectiveness and quality of forensic investigations. To fully realise the potential of this cutting-edge technology, continuing study and collaboration between the scientific and forensic communities will be essential as this sector develops.

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