From Ancient Practices to Modern Science: A Review on the Synthesis and Characterization of Ayurvedic Bhasmas

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Abstract
Ayurvedic Bhasma, an ancient form of Indian traditional medicine, represents a unique class of herbo-mineral formulations prepared through a meticulous process involving calcination. This review provides a comprehensive synthesis and characterization of Ayurvedic Bhasmas, focusing on its preparation methods, physicochemical properties, and characterization. The synthesis of Bhasma involves a series of Shodhana (purification), Marana (incineration), and Bhavana (soaking and drying) processes, each contributing to the transformation of raw minerals and herbs into bioavailable nanoparticles with enhanced efficacy and reduced toxicity. The review delves into the intricate processes involved in the production of various bhasmas, prepared in our laboratory as well as reports by other researchers. It also highlights modern scientific techniques used to characterize these formulations, including XRD, SEM, TEM, FTIR, AAS, NAA, DLS etc. These techniques reveal the nanoscale size, crystalline structure, and elemental composition of bhasmas, providing insights into their therapeutic potential and safety profiles.

Key words: Ayurvedic bhasma, synthesis, characterization, modern analytical techniques

1. Ayurveda and Ayurvedic Bhasma

Ayurveda, one of the oldest systems of medicine, encompasses a rich repository of traditional knowledge. Regarded as the "science of life," it has been dedicated to the healthcare of living beings since ancient times. Ayurvedic remedies, typically derived from natural sources, are employed to treat a wide array of ailments[1,2]. Defined as a medical science focused on maintaining human health, Ayurveda offers cures and preventive measures for numerous health

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conditions. Ayurvedic formulations are composed of herbal, mineral/metal, and animal substances, which are meticulously processed to achieve therapeutic efficacy[3].

Ayurvedic Bhasmas stand as a cornerstone of Ayurvedic therapy, integral to the holistic healing tradition. Revered for their therapeutic properties, these finely powdered minerals and metals are employed extensively to address a myriad of ailments. Their efficacy and versatility ensure that Bhasmas remain a 'mainstay' in the realm of Ayurvedic medicine, continuously contributing to its enduring legacy.

The historical roots of bhasmas can be traced back to ancient Ayurvedic texts such as the *Charaka Samhita* and *Sushruta Samhita*, which detail the preparation methods and therapeutic applications of these substances. These texts highlight the extensive use of Bhasmas in treating a myriad of ailments ranging from digestive disorders to chronic diseases and mental health issues [4,5].

Modern scientific research has started to validate many of the traditional claims associated with bhasmas Studies indicate that these preparations undergo complex chemical transformations during the incineration process, resulting in nanoparticles that possess enhanced bioavailability and therapeutic properties. For instance, swarna bhasma (gold ash) has shown promise in boosting immunity and improving cognitive functions[6].

The preparation of bhasma is a meticulous and multi-step process, ensuring the removal of toxic elements and enhancing the medicinal attributes of the materials used. This involves repeated calcination and treatment with herbal juices, which not only detoxifies but also imbues the final product with beneficial organic compounds. The resultant ash is believed to balance the tridoshas (Vata, Pitta, and Kapha) and align the body’s energies, thereby promoting overall health and well-being. These bhasmas are prepared from inorganic compounds or elements, which undergo several treatments to convert them into bio-compatible forms. During synthesis, various toxic materials are removed to minimize or eliminate any adverse effects on the body. The main advantages of bhasmas are: They are easily acceptable, palatable, fast-acting and effective in smaller dosages. They have longer shelf life without losing potency and no side effects

Improperly prepared bhasmas can produce severe adverse effects, including heavy metal poisoning, hepatotoxicity, renal toxicity, and neurotoxicity, which can sometimes be fatal. Some commercially available bhasmas have been found to contain mercury and arsenic, leading to their ban in foreign countries. Therefore, quality control, safety evaluation, and standardization of bhasmas are of utmost importance. This can be achieved by characterizing bhasmas at various stages of preparation.

Historically, Ayurvedic physicians prepared bhasmas according to their needs. However, with the growing popularity of Ayurvedic medicines, the number of Ayurvedic pharmacies is rapidly increasing, leading to large-scale production of bhasmas in pharmaceutical houses. This commercialization has introduced several challenges, as new manufacturing appliances have not been standardized for quality. Consequently, the diverse synthetic procedures have made it difficult to determine whether bhasmas produced by different methods are identical in structure and properties, due to the lack of systematic studies from this perspective.

This review provides a comprehensive overview of research conducted on Ayurvedic Bhasmas over an extended period.

2. Synthesis of ayurvedic bhasma

Synthesis of bhasma involves number of steps. These are described below

2.1 Bhasmavidhi (The Process of Preparing Bhasma) [7]

Shodhana (Purification): There are two types: samanya shodhana(common purification) and Vishesh Shodhana (special purification) In this process different materials used are: Sesame oil, buttermilk, cow urine, kanji, horse gram decoction, lemon juice. This treatment leads to removal of physical and chemical impurities, increased bioavailability, reduced hardness, increased brittleness and makes the material suitable for marana process

Marana (Incineration): Mercury, arsenic, sulfur and herbal products are used during marana process. It leads to alteration in structure, composition, and color, Transformation from original inorganic form to an organic, bio-acceptable form.

Chalan (Stirring): Stirring is done using an iron rod or the stem/bark of dried plants

Dhavan (Washing): In order to remove remnants of herbal products washing is done with water

Galan (Filtration): Soluble impurities are removed by filtration.

Niruthana :(absence of alloy) It is incineration of the prepared Bhasma to confirm completion of Marana.

Putana process (Heating): : The Puta is the ancient unit of heat. The obtained product is heated in fire leading to formation of bhasma.

Mardana (Trituration): Triturating the product with other substances converts it into micro-nano particles.

Bhavana (Soaking and Drying): The product is soaked in different juices and dried in a shaded place.

Amrutikaran (Detoxification): For this purpose, cow ghee and aloe vera juice are used. This will lead to removal of toxic impurities and enhancement in Bhasma purity

Sandharan (Storage): Its purpose is to maintain good quality and preserve the properties of Bhasma

Four important steps in synthesis of Bhasmas are depicted in Fig.1

2.1.1 Traditional Heating Method

Puta System: Puta is a specialized heating system used for the incineration of metals and minerals. The choice of puta depends on the type of material being processed. Different putas are used based on the quantity of fuel required. Examples mentioned in the literature include Mahaputa, Gajaputa, Kukkutputa, Varahputa, and Kapotputa. Each type of puta has a different diameter, tailored to its specific use. The intensity of heat, mode of temperature, and duration of heating vary depending on the type of puta. Putas are selected and applied for the Maran process based on the heat resistance of the material.

In the present days instead of putas electric muffle furnace is used for heating.

2.2Ancient Ayurvedic Methods of Analysis

Classical texts have established the following parameters to ensure the proper processing of bhasma.

2.2.1 Physical Characterization:

a. **Varna (Color):** Each bhasma has a specific color, typically white, pale, or red, depending on the initial material used. Any alteration in color indicates improper preparation.
b. **Nisvadutam (Tasteless):** A properly prepared bhasma is tasteless when a small amount is placed on the tongue.
c. **Nishchandratvam (Lusterless):** Bhasma must be lusterless before therapeutic use. If observed in bright sunlight, the presence of luster indicates the need for further incineration.
d. **Varitara (ability to float):** Bhasma should be light enough to float on the surface of stagnant water. Properly incinerated bhasma will float.

e. **Unnam Test (Floating Test with Rice Grain):** This test further assesses the varitara property. A grain of rice is placed on the floating layer of bhasma. If the grain remains afloat, the bhasma is properly prepared.

f. **Rekhapurnatvam (Fineness):** Bhasma should be finely powdered for easy absorption and assimilation. When rubbed between the thumb and index finger, it should fill the lines and crevices of the skin.

g. **Slakshnatvam (non-rough/smooth nature):** The tactile sensation of bhasma, when touched with fingertips, should not cause irritation, ensuring it is safe for the gastrointestinal tract's mucous membrane.

h. **Sukshmatva (Fineness):** This characteristic, indicated by the varitara and rekhapurnatvam tests, ensures that bhasma is fine enough for proper body absorption.

i. **Anjan Sannibha (like kajal):** Properly prepared bhasma should be smooth and non-irritating to the mucous membrane.

j. **Avami:** Bhasma should not induce nausea upon administration.

2.2.2 Chemical Characterization

a. Apurnabhavta

Apurnabhavta refers to the incapability of bhasma to retain its original metallic form. In this test, bhasma is mixed with an equal quantity of mitrapanchaka (seeds of Abrus precatorius, ghee, jaggery, borax, and honey). This mixture is sealed in a sharav samputa (earthen pot) and heated. The presence of lustrous particles indicates free metal, which becomes inactive after incineration.

b. Niruttha

Niruttha tests the inability of bhasma to regain its metallic form. Bhasma is mixed with a fixed weight of a silver leaf, placed in an earthen pot (sharav samputa), and heated. After cooling, the silver is weighed. An increase in the weight of the silver indicates improperly prepared Bhasma. These tests are specific to particular bhasmas. The process is not considered complete until these standards are met.

2.2.3 Methods of Physicochemical Analysis:

Delving into the essence of natural substances and their inherent properties requires precision and diligence. In this domain, the Ash Value serves as a critical measure, assessing the quality and purity of raw drugs while revealing their unique identities. Composed of inorganic elements such as phosphates, carbonates, and silicates of sodium, potassium, magnesium, and calcium, ash represents a distinctive quantitative profile for each botanical sample, facilitating precise standardization protocols.

The total ash content reflects the transformation process, where carbon and organic matter convert into ash at temperatures above 450°C. This ash contains minerals like carbonates, phosphates, silicates, and silica, providing insights into acid insolubility and water solubility—important aspects of botanical composition.

Examining further, Acid Insoluble Ash Content refines the total ash through interaction with dilute hydrochloric acid to separate water-soluble ash. This purification process not only enhances botanical analysis but also sheds light on the complex relationship between soluble salts and aqueous environments.

The Namburi Phase Spot Test (NPST)[8], developed by Dr. Namburi Hanumantha Rao in 1970 and recognized by CCRAS, New Delhi, is an innovative method for assessing Bhasma quality. NPST utilizes chemical reactions on specialized papers to create a vivid display of color changes, capturing the dynamic nature of chemical interactions over time. Its precise measurement of sensitivity across different time intervals makes it a valuable tool for ensuring the quality of Bhasmas.

Bio-accessibility, a key factor in nutritional effectiveness, explores how nutrients are utilized within a sample, influenced by the complexities of the gastrointestinal system. Both external factors, such as the food matrix, and internal factors, like metabolic pathways, shape bio-accessibility, intertwining dietary details with physiological responses.

When it comes to estimation methods, In-vivo techniques, though time-consuming and expensive, reveal elemental bioavailability through detailed radiotracer studies, with the downside of exposure to ionizing radiation. In contrast, In-vitro techniques provide speed and cost-efficiency by mimicking digestive conditions to identify soluble and dialyzable products, offering a practical, albeit less precise, alternative to live studies. These in-vitro methods are crucial for unlocking dietary potential and pinpointing nutrient-rich supplements, demonstrating an effectiveness comparable to human and animal studies.

2.3 Modern Analytical Techniques for Characterization of Bhasma

The characterization of bhasmas involves a multidisciplinary approach, encompassing physical, chemical, and biological evaluations. This comprehensive characterization is essential for ensuring the quality, efficacy, and safety of bhasmas, thereby upholding the therapeutic principles of Ayurveda. Advances in analytical techniques continue to enhance our understanding of bhasmas, bridging traditional knowledge with modern scientific insights.

In order to characterize the bhasmas number of modern analytical techniques are available which helps to understand nature, structure, particle size, elemental content of bhasma as well as uniformity and distribution of particles in bhasmas. These are recorded in Table 2 [9-12].

2.4 Synthesis/Analysis/ Characterization of Bhasmas:

A literature review reveals extensive research on commercially available bhasmas, though fewer studies focus on their synthesis and characterization. In the early 1930s, Chopra and colleagues[13-17] analyzed the main constituents of bhasmas such as iron, tin, calcium, gold, and silver using classical chemical methods. Kumar et al.[18,19] conducted elemental analysis of bhasmas using instrumental neutron activation, identifying eighteen elements. Garg et al.[20] employed PIXE for trace element analysis to evaluate biocompatibility in various bhasmas. Sondhi et al.[21,22] utilized flame photometry, AAS, and ICPAES techniques to analyze bhasmas and their pharmacological effects. Krishnamurthy et al.[23] examined Lauha bhasmas from different manufacturers to understand their composition and structural characteristics. Krishnamachary et al.[24] studied commercially available Lauha bhasma, analyzing its morphology, structure, and chemical properties using modern techniques.

Recent advancements in analytical methods, such as spectrophotometry, flame photometry, AAS, ICP-AES, PIXE, and X-ray diffraction, have facilitated the trace elemental analysis of bhasmas. Lalla et al.[25] prepared, characterized, and analyzed Shankh bhasma, investigating its antacid activity. Mitra et al.[26] used AAS to identify twelve elements in Swarna bhasma. Prajapati et al. [27] assessed the safety and toxicity of tamra bhasma, lauha bhasma, and yashada bhasma, confirming no serious adverse effects. Such studies provide valuable scientific evidence to Ayurvedic practitioners and pharmaceutical R&D for better standardization of these traditional medicines.

Several researchers have synthesized bhasmas and analyzed them with modern techniques. Kumari etal.[28] discussed the use of modern analytical techniques such as XRD,XRF,SEM,TEM,FTIR in characterization of bhasmas along with principles of these techniques. Wijenayake et al.[29] explored the chemical and pharmacological properties of mica ash (Abhrak bhasma), noting structural changes during preparation. Wadekar et al.[30] synthesized and characterized tamra bhasma, confirming its composition matched with standard copper oxide. Gawate et al.[31] reported physicochemical characteristics of three different brands of mandur bhasma and studied hepatoprotective activity of these. Nagarajan et al.[32] characterized lead-based Naga bhasma. Pattanaik et al.[33] studied the toxicology and antioxidant properties of tamra bhasma, showing its efficacy and safety. Jagtap et al.[34] evaluated tamra bhasma's quality control parameters, finding significant copper content. Gupta et al.[35] analyzed Yashad bhasma, revealing 98.20% zinc content. Sonkar et al.[36] used NPST to analyze Mandur bhasma. Pyrgiotakis et al.[37] compared bhasma-treated and untreated cells using Raman Spectroscopy, observing significant changes in DNA/RNA and protein molecules in treated cells.

Vasant et al.[38] analyzed Talaka and Naga bhasmas, identifying As_2S_3 and PbS as major constituents. They also detected minor elements like Ca, Mg, As, Sb, Al, and Fe. Dixit and Shivhare[39] employed modern instrumental techniques to analyze pearl and Cowrie bhasmas for minor constituents such as Mg, Ca, Fe, and Zn.

In the modern era, numerous studies have utilized advanced techniques like XRD, FTIR, AAS, ICPOES, SEM, TEM, DLS, and BET to analyze various bhasmas, including gold, silver, iron, copper, and mica. Kar et.al.[40] reported synthesis and biological activity of Rajat bhasma. Formation of nanoparticles in this bhasma caused an increase in antioxidant and antimicrobial activity. Patil and Wele[41] reviewed the therapeutic potential of Swarna bhasma. Recently Garg and Kumar[42] reviewed analysis of 17 Bhasmas for their elemental content, particle distribution and toxicity. Ashvini and Kerur[43] analysed abhraka, mandur and godanti bhasmas of four different brands for more than 10 elements by AAS. Pandit et al.[44] evaluated the chemical and pharmacological properties of iron bhasmas, using AAS to determine 12 elements in addition to the main constituent, Fe. Buwa etal.[45] studied hepatoprotective action of abhrak bhasma in albino rats against hepatitis induced by CCl_4 while Pandit etal[46] demonstrated shankha bhasma’s anti-ulcer effects in rats.

Kantak et al.[47] analyzed copper bhasma during each stage of preparation using instrumental neutron activation analysis, finding copper concentrations of 92.89% and 59.79% after vishesh shodhana and marana, respectively. Bhowmick et al. [48] conducted physicochemical characterization of Jasada bhasma, identifying zinc as a major element next to oxygen and demonstrating the presence of nanoparticles. Singh[49] reported formation of nanoparticles of gold (size 45 nm) in the synthesized swarna bhasma.

Research has demonstrated that metals and minerals used in Ayurveda, once properly incinerated as bhasmas, can have therapeutic benefits without significant toxicity. Singh et al.[50] conducted histopathological studies on Naga bhasma, confirming its safety in rats. Wadekar et al.[30] studied therapeutic properties of synthesized Tamra bhasma. Brown et al.[51] characterized swarna bhasma, showing it as globular gold particles averaging 56-57 nm. These nanoparticles were found to be more effective in treating arthritis in rat models than sodium aurothiomalate.

In exploring the healthcare applications of nanomaterials, it becomes apparent that the therapeutic properties of metal-based Ayurvedic compositions may be inherently tied to their nanoscale characteristics. To harmonize the wisdom of Vedic science with contemporary scientific understanding, comprehensive physico-chemical investigations were undertaken on swarna bhasma, roupya bhasma and jasad bhasma by Amalnerkar[52]. His investigations adhered rigorously to traditional Ayurvedic preparation methods and he employed advanced analytical tools to unravel their complexities. State-of-the-art techniques such as XRD, FESEM, X-ray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), and Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were utilized. These methodologies allowed for a detailed examination of the structure, texture, morphology, and elemental/chemical composition and distribution within these metal-based formulations, thereby bridging the gap between ancient Ayurvedic knowledge and modern scientific inquiry.

Crafted from metallic raw materials, bhasmas may face challenges in complete absorption for circulation within the body. Thus, a thorough pharmacokinetic study of these bhasmas becomes crucial to accurately prescribe the appropriate dosage. Among these investigations, determining bio-accessibility stands out as a key parameter. In-vivo determination of bio-accessibility is expensive and laborious while in-vitro ones are rapid and relatively inexpensive Kantak and Rajurkar[53] reported bio-accessibility of abhrak naga and tamra bhasma. Tamra bhasma mixed with different anupana [material (honey and piper longum mixture, ghee and fermented juice of Aloe-vera) which increases palatibility and improves absorption] showed more bio-accessibility as compared with tamra bhasma without anupana.

In our laboratory, extensive studies have been carried out on bhasmas which comprises of synthesis and analysis of different bhasmas using traditional and modern analytical techniques. All the bhasmas were tested by traditional methos which indicated proper formation of bhasmas. Then these bhasmas were characterized by modern analytical techniques. Characterization of these bhasmas by FTIR revealed organometallic nature of the bhasmas showing several functional groups. Other important findings are listed in Table 2 along with method of preparation and techniques applied. Some representative characterized bhasmas are shown in Figs. 2 and 3[54].Fig. 2 presents XRD of Pittal Bhasma which clearly indicated the presence of CuO with granular appearance and polycrystalline nature. SEM of Pittal bhasma is shown in Fig. 3 Examination of this figure Shows particles with change in morphology. The Bhasma prepared by Traditional Method of heating are bigger in size than that prepared by EMF heating. During synthesis of rajat bhasma, hartal and gandhaka were used in marana process. The obtained product after this process, showed presence of As. However, after Amrutikaran with lime extract this was totally removed as evidenced by EDX spectrum[59]. Similarly in case of lauha bhasma synthesis, presence of Hg after marana process, done with cinnabar, was removed by amrutikaran with aloe vera extract[58].

3. Conclusion:

In summary, the synthesis and analysis of bhasma, a cornerstone of Ayurvedic medicine, bridges the rich heritage of traditional practices with the precision of modern scientific techniques. The synthesis of various bhasmas follows meticulously crafted traditional protocols, ensuring the transformation of raw materials into bioactive compounds through processes such as shodhana, marana, and amritikarana. These time-honored methods, passed down through generations, are crucial for maintaining the therapeutic efficacy and safety of bhasmas.

Characterization of bhasmas using traditional methods, including organoleptic properties, classical tests, and Ayurvedic parameters, provides an initial assessment of their quality and potency. However, integrating modern analytical techniques such as FTIR, XRD, SEM, AAS, ICP-MS enhances the understanding of their physicochemical properties and elemental composition. The amalgamation of traditional knowledge with modern analytical methodologies not only validates the ancient practices but also opens new avenues for standardization, quality control, and scientific validation of bhasmas. This comprehensive approach ensures that bhasmas can be safely and effectively integrated into contemporary therapeutic regimes, fostering global acceptance and utilization. Continued research and development in this field will further elucidate the mechanisms of action of bhasmas, optimizing their therapeutic potential and reinforcing their status as invaluable components of Ayurvedic medicine.

This review underscores the significance of integrating traditional knowledge with modern scientific validation to fully harness the therapeutic potential of Ayurvedic Bhasma. By bridging the gap between ancient practices and contemporary science, we can pave the way for the development of novel, effective, and safe therapeutic agents derived from traditional medicines.

Figures:

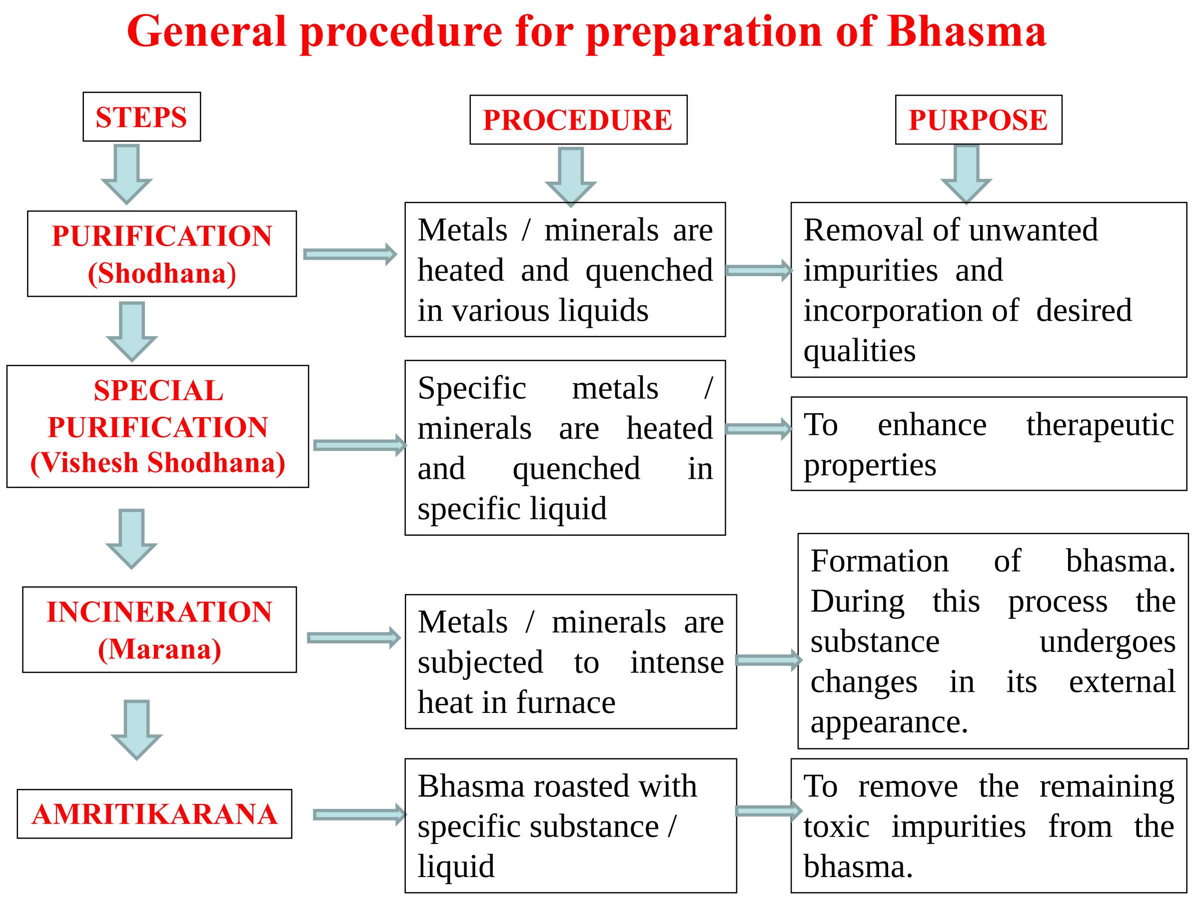

Fig. 1 General procedure for synthesis of Bhasma

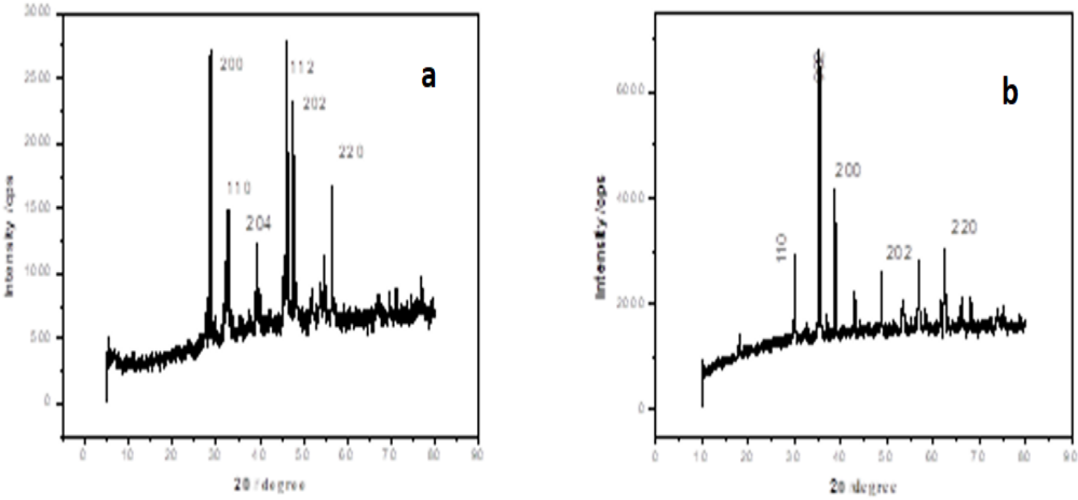

Fig.2 XRD spectra of Pittal Bhasma prepared by a) Traditional method of heating b) EMF heating

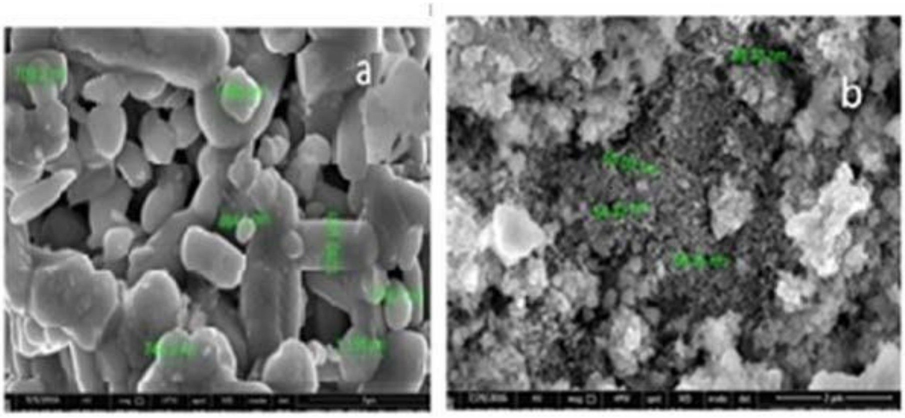

Fig.3 SEM Micrograph of Pittal Bhasma a) prepared by traditional method of heating b) prepared by EMF heating

Tables:

Table1 : Modern analytical techniques for analysis of bhasmas

Technique	**Use**
Fourier Transform Infrared Spectroscopy (FTIR)	Identifies characteristic functional groups and bonds present in the sample
Scanning Electron Microscopy (SEM)	Gives information about sample's surface topography and composition
Energy Dispersive X-ray Analysis (EDX)	It provides elemental analysis of areas as small as nanometers in diameter. EDX can determine elemental composition or map the lateral distribution of elements.
Transmission Electron Microscopy (TEM)	It directly measures nanoparticle size, grain size, size distribution and morphology
X-ray Diffractometry (XRD)	It identifies and characterizes unknown crystalline materials and crystallographic structure
Dynamic Light Scattering (DLS)	It measures particle size in the submicron region
Thermogravimetric Analysis (TGA)	It measures changes in physical and chemical properties as a function of temperature
Differential Thermal Analysis (DTA)	It provides data on physical and chemical changes
Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES)	It is used for determining metal and non-metal elements in the sample
Atomic Absorption Spectroscopy (AAS)	It determines elemental concentration in the sample
Neutron Activation Analysis (NAA)	Useful in elemental analysis of the sample
Particle Size Distribution (PSD)	It measures particle size
Brunauer Emmett Teller (BET) analysis	It helps to determine surface area of the sample

Table 2 Synthesis and analysis of different bhasmas

Bhasma and base material used	**Use**	**Synthesis method**	**Analytical methods**	**Important findings**
Mandur[55] It is iron based bhasma.	Generally used in the treatment of anemia, skin diseases and in poor digestion treatment.	Shodhana with Butter milk, Cow urine, Kanji, Horse gram decoction, Triphala decoction Bhavana with Triphala decoction Marana with Ardhgaja puta as well as Electric Muffle Furnace (EMF)	FTIR, SEM - EDAX, XRD	The Bhasma contains iron oxide in the form of Fe_2O_3 and Fe_3O_4 EDAX and SEM image clearly shows the change in morphology and decrease in particle size of the final product
Pittal[54] It is Copper and Zinc based bhasma.	Generally used in the treatment of Liver disease, anemia, Skin diseases.	Shodhana with Butter milk, Cow urine, Kanji, Horse gram decoction, Vitex nigundo and Curcuma longa linn Bhavana with *Calotropis gigantean* Marana with Ardhagaja puta as well as EMF	XRD, FTIR, SEM, EDAX, TEM and DLS.	XRD shows the presence of CuO and granular appearance and polycrystalline nature. Particle size of Bhasma prepared by traditional method 300-750 nm while that prepared by using electric muffle furnace has 250-750 nm
Yashad[56]	Preferably used in	Shodhana with Cow milk	XRD, FTIR,	XRD shows the presence of ZnO and Zn.

It is Zinc based bhasma.	Diabetes related diseases	Jarana with *Azardica indica* *Bhavana with* Orpiment purified with lime water Marana with Kukkut Puta as well as EMF	SEM, EDAX, TEM and DLS.	TEM shows the polycrystalline nature. DLS studies reveal that Bhasma prepared by EMF heating has 70 % nanoparticles in the range of 250-750nm While Traditional Method of Heating shows 200-700nm range.
Vanga [57] It is Tin based bhasma	Widely used with herbomineral formulation in Ayurveda especially for the disease related to gastrointestinal tract and genitor urinary system.	Shodhana with Sesame oil, Butter milk,Cow urine, Kanji, Horse gram decoction Bhavana with *Tamerandus indica lin* *Jarana with Aole veraTourn lin* Marana with Kukkuta puta as well as EMF	XRD, FTIR, SEM, EDAX, TEM and DLS.	The study confirmed the formation of organometallic compound SnO_2 The Particle size of Bhasma Prepared by traditional method of heating is 150-300 nm range and of that prepared by using electric muffle furnace has 50-100 nm range.

Lauha[58] It is an iron based herbo-metallic preparation and is the main constituents of iron containing formulations.	It is used in all chronic diseases and iron deficiency anemia.	Shodhana with sesame oil, butter milk, cow urine, kanji, decoction of horse gram Vishesh shodhana with Decoction of Triphala Kwatha Marana with Extract of Aloe- Vera, Cow's Urine, Decoction of Triphala Kwatha, Amritikaran with aloe vera extract	FTIR, XRD, TGA/ DTA, SEM, PSD, EDX, BET	Formation of rhombohedral α-Fe_2O_3 (hematite). amount of free iron is insignificant in the bhasma. The Particle size of the bhasma ranged between 50-200nm Amrutikarna process removed Hg from the bhsama. The specific surface area of the synthesized bhasma was found to be $12.55m^2/g$.
Rajat[59] It is silver based bhasma	Used in eye disorders, cough, jaundice, anaemia and liver disorder	Shodhana with Sesame Oil, Butter Milk ,Cow's urine, Kanji, Decoction of Horse Gram, (Kulatha kwatha) Vishesh Shodhana with Jyotishmati oil Marana with Mixture of Hartal, Gandhaka and lime juice Amritikaran with lime extract	FTIR, XRD, TGA/ DTA, SEM, PSD, EDX, BET	XRD analysis revealed α-Ag_2S (monoclinic) phase structure of bhasma. SEM and PSD indicated formation of nanoparticles in synthesized bhasma. Amrutikaran process was found to be effective in removal of arsenic in purified silver bhasma
Abhraka[60] It is prepared from abhrak or mica	Mainly used in the treatment of anemia and	Method 1 Shodhana with Cow milk	XRD, FTIR, SEM, EDAX, TEM and	XRD revealed Monoclinic $KMg_3(Si_3Al)O_{10}(OH)_2$ After amritikaran crystallite size increases SEM/TEM revealed:

	skin diseases	Marana with Jaggery + juice of Ricinis communis Amritikaran with cow ghee Method 2 Shodhana with Cow urine Marana with Cyprus rotundus+ calatropis procera Amritikaran with cow ghee Method 3 Shodhana with Triphala decoction Marana with Turmeric powder decoction + Borax Amritikaran with cow ghee	DLS, TGA/DTA, BET	Particle range 50 nm to 1 µm. Few micron size (1 to 2 micron) particles seen. Nano size particles clustered on bigger size particles. Method-1 - square type particles. Method-2 and 3 : spherical and rod-like particles . DLS revealed Method-1 - bimodal distribution of particles with ~ 50% of particles in nanorange (50-500 nm) and remaining in micron range. micron size nature attributed to agglomeration of fused structure 2. Method-2 and 3 show homogeneous distribution of particles with nearly 90% of particles falling in the region of 50-500 nm Effective diameter of bhasmas by method-1 and method-2 ranges between 500-1000 nm while that by method-3 is ~3000 nm

Naga[61] It is lead based bhasma	Used in the treatment odiabetes and skin diseases	Jarana Method: Vishesh Shodhana with lime water Jarana with Ash of Tamarindus indica and ash of Ficus religosa Marana with Realgar and juice of Citrus acida Pisti Method Vishesh Shodhana with Triphala decoction Jarana amalgam of mercury Marana with Purified sulfur and juice of Citrus acida Putapaka method Vishesh Shodhana with Juice of Vitex nigundo Jarana stem of Adhatoda vesica Marana with Decoction of Adhatoda vesica	XRD, FTIR, SEM, EDAX, TEM and DLS, TGA/DTA, BET	The specific surface area of nano sized bhasmas ranges from 5 to 16 m^2g^{-1} Bhasma prepared from jarana method shows less specific surface area (~5 m^2g^{-1}) than other two methods (pisti and putapaka method). The putapaka method shows maximum surface area ~16.53 m^2g^{-1}. The surface area is more in bhasmas prepared by samanya shodhana process than bhasma prepared without samanya shodhana process Jarana method without samanya shodhana process ~50% particles are falling in the range of 750- 1250 nm showing homogeneous distribution of particle. Pisti method with samanya shodhana process ~ 50% of particle are in the range of 350-500 nm and that without samanya shodhana process ~ 70 % of particles are in the range of 1250-1500 nm.

				Putapaka method with samanya shodhana process ~75% of particles are in the range of 50- 750 nm while in putapaka method without samanya shodhana process ~ 60% of particles in the range 50-750 nm. High diameter of particles is due to agglomeration of nano particles. More diameter observed in bhasmas prepared without samanya shodhana process.
Tamra[47] It is copper based bhasma	Ued in tumor, gland and stomach related diseases	Samanya Shodhana with Sesamum oil, Buttermilk, Cow urine, Kanji, Horsegram decoction Vishesh Shodhana with Cow urine Marana with Kajjali and juice of citrusacida	NAA	Copper concentration was found to vary after each stage of preparation and final concentration was found to be 59.79%

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