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Review Article

BHASMA PARIKSHA: INTEGRATING CLASSICAL EVALUATION WITH MODERN ANALYTICAL METHODS

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ABSTRACT

Bhasmas are specialized Ayurvedic metallo-mineral preparations produced through pharmaceutical procedures that may include *Shodhana* (processing and purification), *Bhavana* (wet trituration with prescribed media), and *Marana* (incineration or calcination). Classical *Bhasma Pariksha*, including *Rekhapurnata*, *Varitaratva*, *Nishcandratva*, *Niruttha*, and *Apunarbhava*, provides traditional indicators of physical characteristics and processing endpoints. However, these observations do not independently establish chemical identity, elemental purity, or biological safety. This narrative review synthesises classical *Rasashastra* texts, pharmacopoeial monographs, and published analytical studies of *Bhasma* to examine how traditional assessments can be complemented by modern analytical methods. Particle-size analysis and microscopy characterise size distributions and morphology; X-ray diffraction (XRD) identifies crystalline phases; X-ray fluorescence (XRF) and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS) support elemental characterisation; atomic absorption spectroscopy (AAS) and inductively coupled plasma techniques quantify elements; Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS) examine bonding and chemical states; and thermal, surface, pharmaceutical, and biological methods address additional quality attributes. Particular attention is given to distinguishing *Apunarbhava* from *Niruttha* and to the formulation-specific interpretation of classical tests. The review also considers mercury and arsenic speciation, pharmacopoeial standards, and the relevance of Indian regulatory requirements. An integrated, risk-based approach combining classical observations with validated instrumental methods may support more reproducible characterisation and transparent standardisation of *Bhasma*.

INTRODUCTION

Rasashastra is the branch of Ayurveda concerned with the pharmaceutical processing and therapeutic application of metals, minerals, and related substances. *Bhasma* preparation may involve *Shodhana*, *Bhavana*, *Marana*, and other substance-specific procedures intended to transform the starting material into the prescribed preparation. The resulting products are traditionally evaluated through *Bhasma Pariksha*, which includes physical, sensory, and chemical tests described in classical *Rasashastra* literature, including *Rasaratna Samuccaya* and *Rasa Taraṅgini*.[6,7].

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Important classical assessments include *Rekhapurnata* (entry of powder into the furrows of the fingers), *Varitaratva* (floating behaviour on water), *Varna* (characteristic colour), *Nishcandratva* (absence of perceptible luster), *Niswadu* (absence of the characteristic taste), and *Dantagre kacakacabhava* (absence of grittiness between the teeth). *Apunarbhava* and *Niruttha* are distinct tests concerned with the inability of a processed preparation to revert to its original metallic form or regain its alloy-forming behaviour, respectively [6,7,10].

In *Apunarbhava*, the *Bhasma* is subjected to the prescribed heating procedure with *Mitra Pañcaka*, conventionally comprising *Guḍa* (jaggery), *Guñja*, *Madhu* (honey), *Ghṛta* (ghee), and *Ṭaṅkana* (borax). The absence of metallic reversion supports the traditional endpoint. In *Niruttha*, the *Bhasma* is heated with a measured silver leaf or silver foil, and the silver's weight should not increase. An increase may

indicate uptake of metallic material by the silver under the test conditions [6,7,10].

Although classical tests remain important to pharmaceutical evaluation, their results can be influenced by sample handling, test conditions, and observer interpretation. A powder that appears fine may contain aggregates; absence of visible luster does not establish chemical phase identity; and sensory observations cannot quantify trace contaminants. Modern analytical methods can therefore contribute complementary evidence concerning particle-size distribution, morphology, crystal structure, elemental composition, chemical state, surface properties, and thermal behaviour.

Published investigations have characterised preparations such as *Svarna Bhasma* and *Abhraka Bhasma* using combinations of XRD, electron microscopy, elemental analysis, spectroscopy, and thermal techniques[8–10]. These studies illustrate the value of combining traditional observations with instrumental characterisation, while also demonstrating that results depend on the particular preparation and analytical procedure.

This review examines the relationship between classical *Bhasma Pariksha* and modern analytical methods, with the objective of developing a conceptually integrated framework for quality characterisation and standardisation.

METHODOLOGY

Review Approach

This article is a narrative review rather than a systematic review or an experimental investigation. Its scope is to organise classical *Bhasma* assessments according to their intended interpretive significance and relate them to suitable modern analytical methods.

Classical test definitions were considered alongside published studies of *Bhasma* characterisation, general analytical chemistry references, and official Indian pharmacopoeial and formulary resources. The review emphasises the distinction between traditional test endpoints and instrumental measurements.

Search strategy

A reproducible literature search should cover PubMed, Scopus, Google Scholar, and the AYUSH Research Portal, supplemented by the official portal of the Pharmacopoeia Commission for Indian Medicine and Homoeopathy (PCIM&H).

Classical *Bhasma Pariksha* and its Interpretive Scope

Classical tests provide observations of the prepared material and its behaviour under specified conditions.

Physical and sensory assessments

- *Rekhapurnata*: The powder enters the furrows of the fingers. This is traditionally associated with fineness.
- *Varitaratva*: The powder floats on water under the prescribed test conditions.
- *Unama*: A grain of rice placed on the floating *Bhasma* remains supported on the water surface, representing an extension of *Varitaratva*.
- *Varna*: The preparation exhibits the characteristic colour described for the particular *Bhasma*.
- *Nishcandratva*: Perceptible metallic luster or shining flakes are absent. This assessment is particularly relevant to *Abhraka* (mica) *Bhasma*, in which *Candrika* refers to shining flakes.
- *Nisvad*: The characteristic taste associated with the starting metal or mineral is absent according to the classical description.
- *Dantagre kacakacabhava*: Grittiness between the teeth is absent in the traditional description. This historical test should not be recommended as a modern quality-control procedure because oral examination of potentially toxic metallo-mineral powders presents avoidable exposure risks.
- *Shlakshnatva* and *Añjana-sannibha*: Smoothness and a collyrium-like appearance are described as sensory or visual attributes.
- *Nirdhuma*: Smoke is absent during the prescribed heating-related assessment.
- *Amla pariksha*: The acidic nature is assessed.
- *Avamitva*: The preparation is described as not producing nausea or vomiting in the traditional account. This is not a substitute for toxicological evaluation.

These tests do not all apply identically to every *Bhasma*. Their relevance should be determined from the substance-specific classical reference and formulation.

Chemical and processing-related assessments

Apunarbhava assesses resistance to reversion to the original metallic form after heating with *Mitra Pañcaka*. A satisfactory result is indicated by the absence of metallic reversion under the prescribed conditions.

Niruttha assesses whether the *Bhasma* exhibits metallic or alloy-forming behaviour during heating with a measured quantity of silver. The silver leaf or foil is weighed before and after the procedure. No increase in its weight is the traditional endpoint.

These tests must not be treated as synonyms. *Apunarbhava* examines non-reversion using *Mitra Pañcaka*, whereas *Niruttha* examines the absence of measurable metal uptake by silver under the prescribed conditions.

Table 1: Classical *Bhasma* tests and potential modern correlates

Classical test	Traditional interpretation	Potential complementary method	Important limitation
Rekhapurnata	Powder enters finger furrows	Particle-size distribution; microscopy	Instrumental size measurements do not reproduce the classical test.
Varitaratva	Floating behaviour on water	Particle size, density, wetting and surface-property measurements	Floating behaviour depends on the material and test conditions.
Unama	Rice grain remains supported on floating *Bhasma*	Surface and wetting studies; controlled buoyancy observations	No single instrumental parameter reproduces the test.
Varna	Characteristic colour	Standardised imaging; reflectance spectroscopy	Colour alone cannot establish phase identity.
Nishcandratva	Absence of perceptible metallic lustre	SEM and XRD; reflectance methods	Particularly relevant to shining flakes in *Abhraka Bhasma*.
Shlakshnatva / Añjana-sannibha	Smoothness or collyrium-like appearance	Microscopy and particle-size analysis	Representative sampling is essential.
Nirdhuma	Absence of smoke under prescribed conditions	Thermal analysis with controlled observations	Modern thermal methods are not direct replacements.
Amla pariksha	Response to prescribed acidic medium	Validated chemical analysis of the relevant reaction	Interpretation depends on substance and procedure.
Apunarbhava	No reversion to original metal after heating with *Mitra Pañcaka*	XRD and complementary elemental or phase analysis	Instrumental phase analysis does not itself establish the traditional endpoint.
Niruttha	No increase in silver-leaf weight after heating with *Bhasma*	Gravimetry; elemental analysis of silver before and after testing	Analytical sensitivity, contamination and sample handling must be controlled.
Nirasvada	Absence of characteristic taste	Chemical characterization of relevant constituents	Sensory assessment cannot be replaced by one universal instrumental test.
Dantagre kacakacabhava	Absence of perceived grittiness	Microscopy and particle-size analysis	Oral testing should not be used as a contemporary laboratory procedure.

Abbreviations: SEM, scanning electron microscopy; XRD, X-ray diffraction.

Modern Analytical Methods

Particle Size, Dispersion, and Morphology

Dynamic light scattering (DLS) estimates hydrodynamic diameter for particles dispersed in a liquid and commonly reports a Z-average and polydispersity index (PDI). Results depend on dispersion conditions, agglomeration, and the assumptions of the analysis. DLS cannot be interpreted as a direct measurement of dry primary-particle size.

Laser diffraction can provide a particle-size distribution, commonly expressed as D10, D50, and D90. The dispersion medium, sample preparation, and measurement settings should be reported.

Scanning electron microscopy (SEM) visualises surface morphology and aggregation, whereas transmission electron microscopy (TEM) can resolve smaller primary particles and selected internal structural features. Atomic force microscopy (AFM) provides nanoscale surface topography. A *Bhasma* that is nanosized may be supported by representative images and suitable quantitative measurements .[4,8,9].

Crystal Structure and Phase Identification

X-ray diffraction (XRD) identifies crystalline phases and helps compare raw materials, intermediates, and finished *Bhasma*. It can indicate structural changes and may support crystallite-size

estimation when the selected model's assumptions are satisfied.

Selected-area electron diffraction (SAED), generally performed alongside TEM, provides local diffraction information that may complement bulk XRD. Interpretations account for mixed phases, amorphous material, detection limits, and the quality of reference patterns.

Studies of *Svarna Bhasma* and *Abhraka Bhasma* demonstrate the use of XRD to investigate crystalline phases and processing-related structural changes [8,9]. Findings from one preparation cannot automatically be generalised to other formulations or manufacturing methods.

Elemental Composition and Quantitative Analysis

X-ray fluorescence (XRF) supports elemental screening and comparative elemental profiling. SEM coupled with energy-dispersive X-ray spectroscopy (SEM-EDS, also termed SEM-EDX) provides local elemental signals associated with observed morphology and can generate elemental maps [4].

Atomic absorption spectroscopy (AAS) quantifies selected elements. Inductively coupled plasma optical emission spectroscopy (ICP-OES, also termed ICP-AES) supports multi-element quantification, while inductively coupled plasma mass spectrometry (ICP-MS) can determine many elements at low concentrations when validated sample preparation and analytical procedures are used.

These methods differ in sensitivity, selectivity, spatial resolution, and suitability for particular matrices. Elemental detection alone does not establish the molecular species, oxidation state, or bioavailability of an element. Analytical plans may define the target analytes, detection limits, recovery, matrix effects, and applicable specifications [1,2,5].

Mercury and Arsenic Speciation

For preparations containing mercury-bearing ingredients, total mercury may be measured using validated cold-vapour AAS or a suitable direct mercury analyser. Total mercury concentration does not establish the chemical species present. Where warranted by the formulation and risk assessment, validated speciation methods should be used to distinguish relevant mercury species.

Arsenic speciation is also important for preparations made from arsenic-containing ingredients such as *Gouripashana*, *Haratala* and *Manaḥshila*. Total arsenic analysis alone cannot distinguish arsenic oxidation states or individual arsenic compounds. Depending on the matrix and research question, chromatographic separation coupled with ICP-MS, or other validated species-specific analytical methods, may provide additional evidence.

The choice of method may consider extraction recovery, preservation of the original species, matrix effects, detection limits, and the possibility of species transformation during sample preparation. Neither total-element concentration nor identification of a particular species independently establishes clinical safety.

Chemical Bonding, Oxidation State, and Surface Properties

Fourier-transform infrared spectroscopy (FTIR) identifies infrared-active vibrations and can support evaluation of functional groups or organic–inorganic interactions. Raman spectroscopy provides complementary vibrational information and may help identify selected mineral phases.

X-ray photoelectron spectroscopy (XPS) examines surface elemental composition and chemical states, including oxidation-state information where the spectra and reference data support such interpretation. XRF is primarily an elemental technique, whereas XPS is surface-sensitive; they should not be treated as interchangeable.

The Brunauer–Emmett–Teller (BET) method estimates specific surface area using gas adsorption under defined conditions. Surface area may influence adsorption, dissolution, and reactivity but does not independently predict clinical efficacy. Zeta potential characterises electrokinetic behaviour in a specified dispersion medium and may contribute to the evaluation of dispersion stability. Results depend on pH, ionic strength, medium composition, and measurement conditions.

Thermal and Supplementary Methods

Thermogravimetric analysis (TGA) records mass changes with temperature and can help assess moisture, volatile components, and thermal decomposition. Differential scanning calorimetry (DSC) measures heat-flow events, while differential thermal analysis (DTA) records temperature differences associated with thermal events.

CHNS/O analysis measures selected elemental constituents, where relevant. Gas chromatography–mass spectrometry (GC-MS) and liquid chromatography–mass spectrometry (LC-MS) can characterize suitable volatile and non-volatile organic constituents, including compounds associated with processing media, when justified by the analytical question.

X-ray absorption near-edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) can provide information about oxidation state and local atomic coordination in specialised investigations. These methods are useful for selected research questions rather than routine testing of every *Bhasma*.

Pharmaceutical Quality Control and Safety Assessment

Supporting pharmaceutical tests may include loss on drying or moisture content, pH of a defined dispersion, bulk and tapped density, and powder-flow indices such as angle of repose, Carr's index, and Hausner ratio. Procedures, sample preparation, replicates, and acceptance criteria may be specified.

Microbiological testing may be appropriate depending on the product and manufacturing context. Elemental impurities, including lead, cadmium, arsenic, and mercury, require risk-based evaluation using suitable validated methods.

For Ayurvedic products in India, applicable requirements should be determined from the relevant provisions of the Drugs and Cosmetics Act and Rules, the applicable Ayurvedic Pharmacopoeia of India (API) monograph, and other relevant official specifications. Rule 161 of the Drugs and Cosmetics Rules, 1945, addresses labelling requirements for Ayurvedic, Siddha, and Unani medicines, including prescribed limits for certain contaminants. The exact applicable limits and methods should be verified against the current regulatory text and product category.

ICH Q3D(R2) provides a framework for assessing elemental impurities in conventional pharmaceutical products. It may be used as a supplementary scientific reference where appropriate, which not be presented as the sole or automatically binding standard for Ayurvedic *Bhasma*. Indian regulatory and pharmacopoeial requirements are applicable to the particular product take precedence [3,5].

Biological investigations may include *in vitro* cytotoxicity, cellular uptake, and appropriately designed *in vivo* toxicology studies. The choice of model, exposure conditions, dose, and route should be justified by the intended research question.

Table 2: Modern analytical methods: measurement and relevance

Method	Primary information	Main application	Key caution
DLS	Hydrodynamic diameter and PDI in dispersion	Dispersion behaviour and aggregation	Not equivalent to dry primary-particle size.
Laser diffraction	Particle-size distribution, including D10, D50, and D90	Size distribution and proportion of fine particles	Report dispersion and analysis conditions.
SEM / TEM / AFM	Morphology, primary particles, or surface topography	Particle form and nanoscale features	Avoid generalizing from selected images.
XRD / SAED	Bulk or local crystalline-phase information	Phase identification and structural change	Mixed or amorphous phases and detection limits matter.
XRF / SEM-EDS	Elemental screening and spatial distribution	Elemental profiling and mapping	Does not alone establish species or oxidation state.
AAS / ICP-OES / ICP-MS	Quantitative elemental concentrations	Elemental profile and impurity assessment	Validate digestion, recovery, detection limits, and matrix effects.
CV-AAS/direct Hg analysis/ speciation	Total mercury or selected mercury species	Mercury-related quality and risk assessment	Total concentration and speciation are different endpoints.
FTIR / Raman / XPS	Vibrational information or surface chemical states	Chemical and surface characterisation	Requires appropriate controls and reference data.
BET / zeta potential	Surface area or electrokinetic potential	Surface and dispersion characterisation	Neither alone predicts clinical efficacy.
TGA / DSC / DTA	Mass changes or thermal events	Thermal behaviour and compositional clues	Report conditions for comparison.
GC-MS / LC-MS	Selected organic constituents	Characterisation of organic compounds	Suitability depends on analyte and matrix.
XANES / EXAFS	Oxidation state and local atomic coordination	Specialised chemical-state characterisation	Requires appropriate standards and interpretation.
Microbiology/ toxicology	Microbial quality or biological responses	Additional quality and safety evidence	Does not replace identity or composition testing.

Abbreviations: AAS, atomic absorption spectroscopy; AFM, atomic force microscopy; BET, Brunauer–Emmett–Teller; CV-AAS, cold-vapour atomic absorption spectroscopy; DLS, dynamic light

scattering; DSC, differential scanning calorimetry; DTA, differential thermal analysis; EDS, energy-dispersive X-ray spectroscopy; EXAFS, extended X-ray absorption fine structure; FTIR, Fourier-transform infrared spectroscopy; GC-MS, gas chromatography–mass spectrometry; ICP-MS, inductively coupled plasma mass spectrometry; ICP-OES, inductively coupled plasma optical emission spectroscopy; LC-MS, liquid chromatography–mass spectrometry; PDI, polydispersity index; SAED, selected-area electron diffraction; SEM, scanning electron microscopy; TGA, thermogravimetric analysis; TEM, transmission electron microscopy; XANES, X-ray absorption near-edge structure; XPS, X-ray photoelectron spectroscopy; XRD, X-ray diffraction; XRF, X-ray fluorescence.

DISCUSSION

Classical *Bhasma Pariksha* and modern analytical techniques provide complementary rather than interchangeable evidence. Particle-size analysis describes size distributions, microscopy reveals morphology, XRD identifies crystalline phases, and elemental methods quantify or map elements. Spectroscopic and surface-sensitive techniques investigate chemical bonding, oxidation states, and interfacial properties, while thermal and biological studies address different questions.

The distinction between *Apunarbhava* and *Niruttha* is important when establishing a reproducible assessment framework. *Apunarbhava* evaluates resistance to metallic reversion after treatment with *Mitra Pañcaka*. *Niruttha* evaluates the absence of an increase in silver weight after heating with *Bhasma*. Elemental analysis of the silver before and after *Niruttha* testing may provide additional evidence concerning possible metal uptake, provided the method is validated and analytical uncertainty is considered. [6,7,10].

The relationship between classical observations and instrumental parameters should be established through formulation-specific studies. For example, a low D90 may be consistent with a fine powder, but no universal instrumental threshold can be assigned to *Rekhapurnata* without a validated correlation study. Similarly, identifying a particular oxide or sulphide phase by XRD does not independently establish *Apunarbhava*, clinical effectiveness, or absence of toxicity.

Published studies of *Abhraka Bhasma* have used combinations of traditional tests, XRD, electron microscopy, elemental analysis, and spectroscopy [8,10]. Research on *Abhraka Bhasma* has applied complementary techniques, including XRD, SEM, TEM, FTIR, Raman spectroscopy, and thermal analysis [8,9]. Such studies demonstrate the value of multi-method characterisation but also indicate why findings must be interpreted in relation to the preparation method, sample provenance, and analytical conditions.

A practical quality-characterisation plan can begin with authenticated raw-material documentation, manufacturing records, and the relevant classical *Pariksha*. It can then incorporate basic physicochemical tests, phase identification, and elemental profiling. Select more specialised techniques, such as TEM, XPS, mercury or arsenic speciation, and X-ray absorption spectroscopy, based on the formulation and the specific quality or safety question.

The analytical plan should include a representative sampling strategy, replicate measurements, suitable reference materials, blanks, calibration, method validation, recovery assessment, and transparent reporting of uncertainty. Acceptance criteria should be supported by the relevant official standards or formulation-specific evidence rather than inferred from isolated research results.

The limitations of classical tests and the limitations of instrumental methods must both be recognised. Classical observations provide traditional processing-related information, whereas modern methods quantify selected material characteristics. Their combined use supports a more complete characterisation strategy, but interpretation requires the totality of relevant evidence.

Limitations

This narrative review synthesises classical descriptions, selected published *Bhasma* studies, pharmacopoeial resources, and general analytical principles. It is not a systematic review, does not report original laboratory measurements, and does not establish validated universal acceptance limits. Further formulation-specific studies are required to establish reproducible correlations between classical test outcomes and instrumental measurements.

CONCLUSION

Bhasma quality assessment is strengthened by integrating classical *Pariksha* with fit-for-purpose modern analysis. Classical tests retain their significance within the traditional pharmaceutical framework, while instrumental methods provide measurable evidence concerning particle size, morphology, phase composition, elemental content, chemical state, surface properties, and thermal behaviour.

Apunarbhava and *Niruttha* should be clearly distinguished in research and quality-control reporting. *Apunarbhava* concerns non-reversion to the original metallic form after the prescribed *Mitra Pañcaka* treatment, whereas *Niruttha* concerns the absence of an increase in silver weight following the prescribed heating test. Modern analytical methods

may complement these observations but should not be treated as automatic substitutes.

Future research should prioritise authenticated samples, validated methods, appropriate Indian pharmacopoeial and regulatory requirements, formulation-specific acceptance criteria, and direct comparison of classical and instrumental observations. This approach may improve the reproducibility, transparency, and scientific interpretability of *Bhasma* characterization.

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