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PREPARATION & CHARACTERIZATION OF *VANGA BHASMA*, A TIN-BASED HERBO-METALLIC PREPARATION

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ABSTRACT

Vanga bhasma is a tin-based herbo-metallic preparation, prescribed for urinary disorders and general debility. The practitioners of *Ayurveda* had devised a series of steps to convert bio-incompatible metallic raw material (tin) to a bio-compatible form (*Vanga bhasma*). These include (i) Purification of metallic ingredients by normal purification using five different treating liquids in series (ii) Special purification by trituration of purified metal with herbal extracts (iii) Calcination to prepare fine powders. Characterization of intermediates obtained at different stages highlight the gradual reduction in mass percentage of tin during *puta*, which is attributed to the formation of complexes with the organic moieties present in the treating agents. Also, with successive *puta* steps, decrease in particle size and the increase in BET surface area were observed. Lower particle size and increased surface area are expected to improve bioavailability of *Vanga bhasma*.

Keywords: *Vanga bhasma*, *Puta*, Purification, X-ray diffraction, Surface area, Elemental analysis

INTRODUCTION

Ayurveda is an ancient, time-tested indigenous system of medicine. The difference between *Ayurveda* and the other systems of medicine stems from the availability of several therapeutic approaches [1]. It is believed that *Ayurveda* had its origin in *Atharvaveda* which consists of many hymns, narrating information on various subjects including human health, engineering and astrology [2]. Despite its long existence and practice, *Ayurvedic* system is less popular compared to other traditional systems of medicine. The higher popularity and acceptance of Chinese system of medicine could be attributed to China's success in promoting its therapies through research and evidence-based approaches [3]. This aspect which has remained missing in *Ayurvedic* system has forced researchers to work towards establishing the scientific basis in the practices of *Ayurveda*. Hence, it is imperative to study the stage-wise transformations that take place during the preparation of *Ayurvedic* medicines along with the characterization of final product. This will serve to elucidate the chemical nature of *Ayurvedic* medicines apart from understanding the role of various constituents added during various preparation steps [4, 5].

Bhasmas are herbo-metallic preparations, prescribed by the Ayurvedic practitioners for treatment of various ailments. These are prepared from metallic raw materials and herbal ingredients, by processing them through a series of purification and calcination steps. *Vanga bhasma* is a tin-based herbo-metallic preparation prescribed for treatment of urinary diseases, loss of appetite, inflammatory disorders among others [6].

The present work focuses on the changes in morphology, elemental composition, surface area and crystalline nature during '*puta*' (calcination) in the preparation of *Vanga bhasma*.

MATERIALS & METHODS

Materials

The raw material, tin was procured from the market in Trichy, India. Aloe vera was taken from the herbal garden at SASTRA University, whose authenticity was confirmed through organo-leptic, macroscopic and microscopic analyses. Cow's urine was obtained from Shanmugha Farms, SASTRA University.

Methods

Preparation of *Vanga bhasma*

The preparation of *Vanga bhasma* involves three stages: (i) A normal purification step (ii) Special purification step (iii) *puta* (calcination) step [7]. In normal purification step, the raw material is subjected to heat treatment in different treating liquids. In a typical procedure, the raw material is heated to its melting point and poured in sufficient quantity of treating liquid. The solid particles formed are recovered by filtration while the spent liquid is rejected. This procedure was repeated thrice by using fresh treating liquids each time. The treating liquids used were sesame oil, butter milk, rice gruel, cow urine and horse gram decoction [7]. The solid material obtained after normal purification was subjected to similar heat treatment in lime water for seven times. The solid material obtained after treatment with lime water was heated during in an iron pan along with the addition of *Achyranthes aspera* Linn., followed by mixing with lime using iron spatula for about two hours. This was heated to 360 C in about 4-6 hours followed by cooling which facilitates solidification. The material at this stage is expected to be soft enabling mixing by trituration with aloe vera juice. A paste was obtained after trituration with aloe vera, which was then made into thin flat discs called *cakrikas*. These were dried under sunlight and taken in an earthen bowl, covered with another earthen bowl with interface between them sealed with a clay-smeared cloth. This arrangement is referred to as *sarava samputa* (inset of Fig. 2) in Ayurveda [7]. *Puta* (calcination) was carried out in a pit measuring 90 cm in all three directions, lined with bricks. Approximately 150 cow dung cakes were stacked in the pit, above which s*arava samputa* was placed, followed by stacking of another 150 cow dung cakes, representing a heap (Fig. 2). The cow dung cakes were ignited that provided the heat required for calcination process. After all the cow dung cakes were burnt, the arrangement was left undisturbed to allow cooling of *sarava samputa*. The material was recovered by breaking sarava samputa. This process was repeated seven times with the preparation of *cakrikas* using fresh aloe vera juice every time. The temperature profile during *puta* was monitored using a K-type thermocouple connected to a digital temperature indicator.

Characterization of *Vanga Bhasma*

The morphology of *vanga bhasma* was studied using a Field Emission Scanning Electron Microscope (JSM 5701F, JEOL, Japan). The crystalline phases present in the sample were identified using a powder X-ray diffractometer (D8 Focus, Bruker AXS, Germany). The elemental composition of *vanga bhasma* was determined using an X-ray fluorescence spectrometer (S8 Tiger, Bruker, Germany). The surface area of the samples was determined using a BET surface area analyzer (ASAP 2020, Micromeritics, USA) by studying the adsorption and desorption isotherms of Nitrogen in the sample.

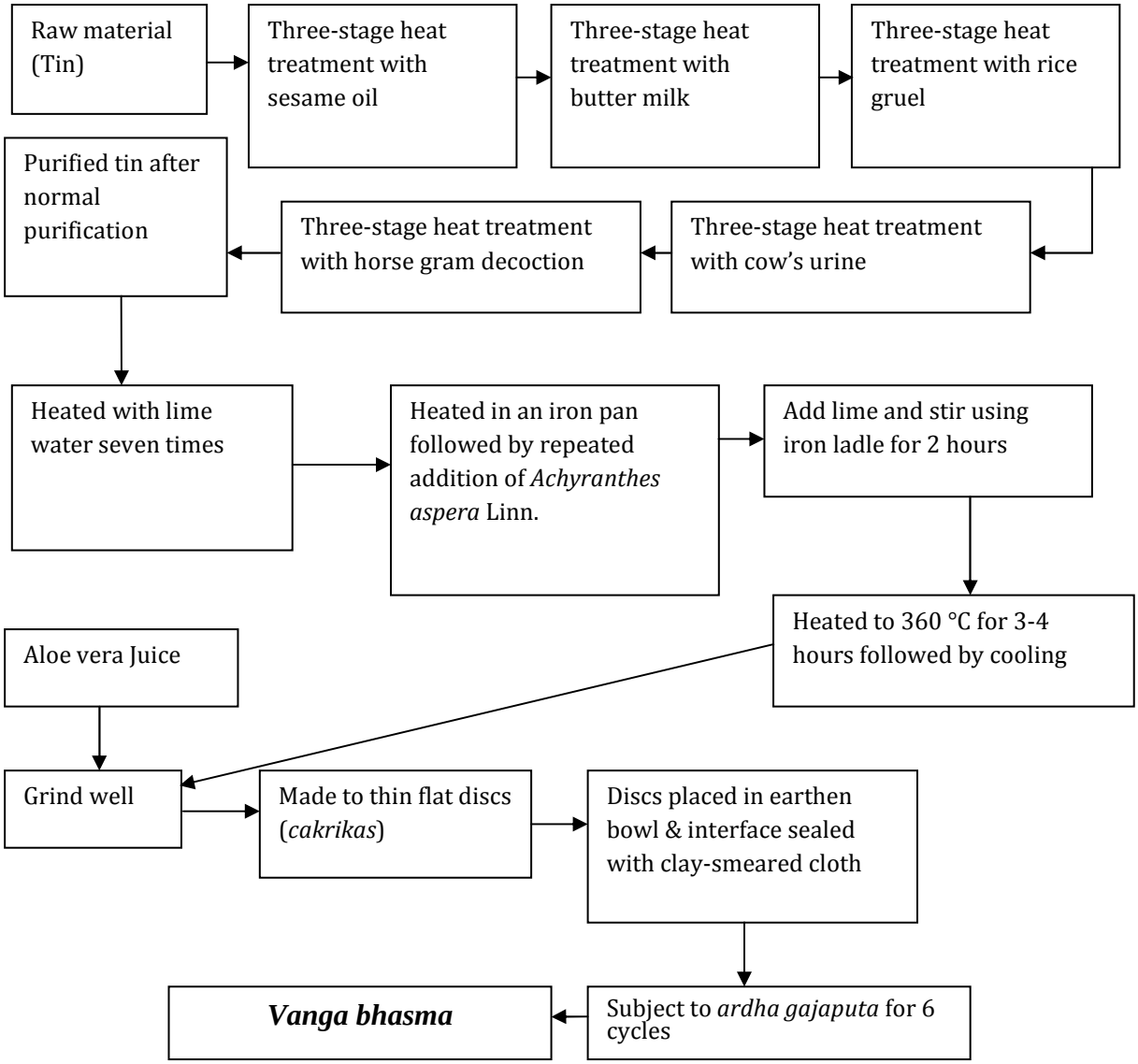


Fig. 1: Process flow diagram for the preparation of *Vanga bhasma*

Fig. 2: Photograph of 'puta' in progress. The inset shows the arrangement for puta with cakrikas placed inside earthen bowls with interface sealed by clay-smeared cloth

RESULTS AND DISCUSSION

The purified vanga (tin) obtained after normal and special purification steps, is subjected to trituration with the juice of Aloe vera for about 6 hours. Aloe vera contains useful compounds like polymannans, anthraquinones and lectins [8,9,10]. Anthraquinones are well-known metal-chelators capable of coordinating with nickel, cobalt, tin etc. [11, 12]. The tirturation of purified tin in Aloe vera juice results in the reduction in particle size of tin, accompanied by an increase in surface area. Since most of the solid-fluid interactions take place at the external surface of the solid, these interactions are promoted through increase in surface area by the presence of particles of smaller sizes [13,14,15,16,17]. Tirturation of metallic particles in Aloe vera juice is analogous to wet grinding by which finer particles can be obtained. During the six hours of tirturation, coordination compounds are expected to be formed with the organic constituents present in Aloe vera. The metal-juice paste obtained after trituration, supposedly containing metal complexes, were subjected to '*puta*' for further physico-chemical transformation.

The process of calcination in the herbo-metallic preparation is carried out in a unique way. The dimensions of the pit used for the calcination, along with the specifications on the number of cow dung cakes used for heating, impose a specific temperature profile on the material being calcined. Figure 3 shows the variation of temperature with time during a specific *puta* step. It may be observed from Figure 3 that the temperature increases with time and reaches a peak value of around 850-1000 C in about 2 hours. During this period, the increase in temperature could result in increased surface energy for the particles leading to their coalescence. The temperature profile during the cooling phase indicates controlled cooling which would result in formation of particles of well defined morphology and crystallinity.

Figure 4 shows the electron micrographs of intermediate obtained after each *puta*. Appreciable changes in morphology accompanied with appearance of sub-200 nm particles are evident with increasing *puta* cycle. The polygonal nature of the particles is due to the attritional mechanism of size reduction employed.

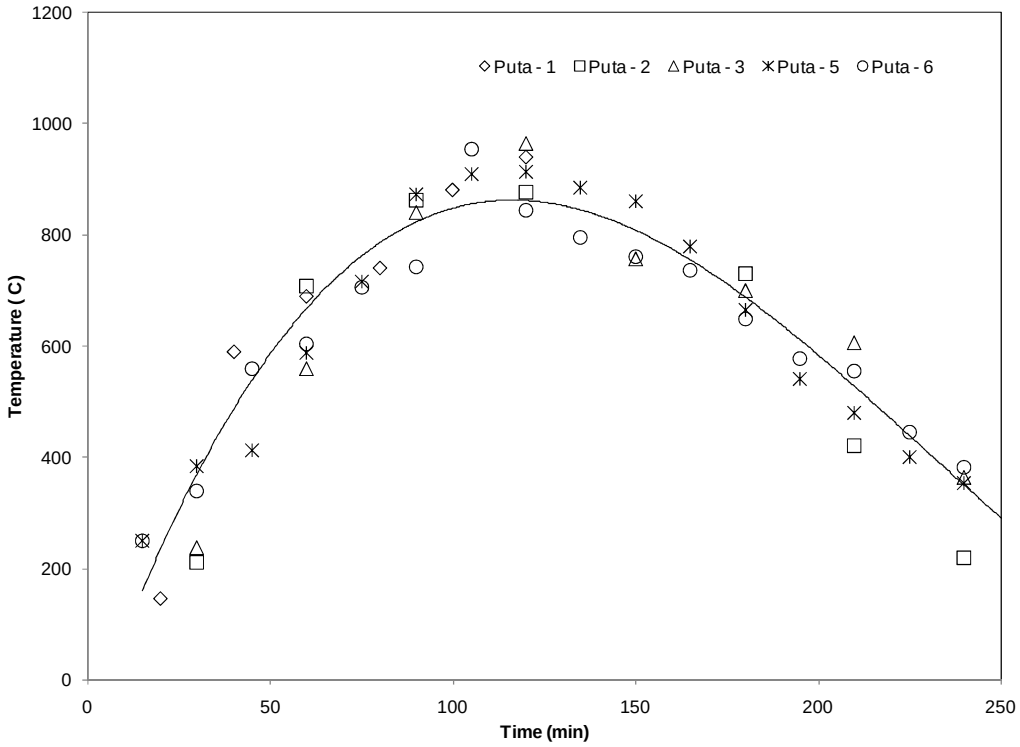
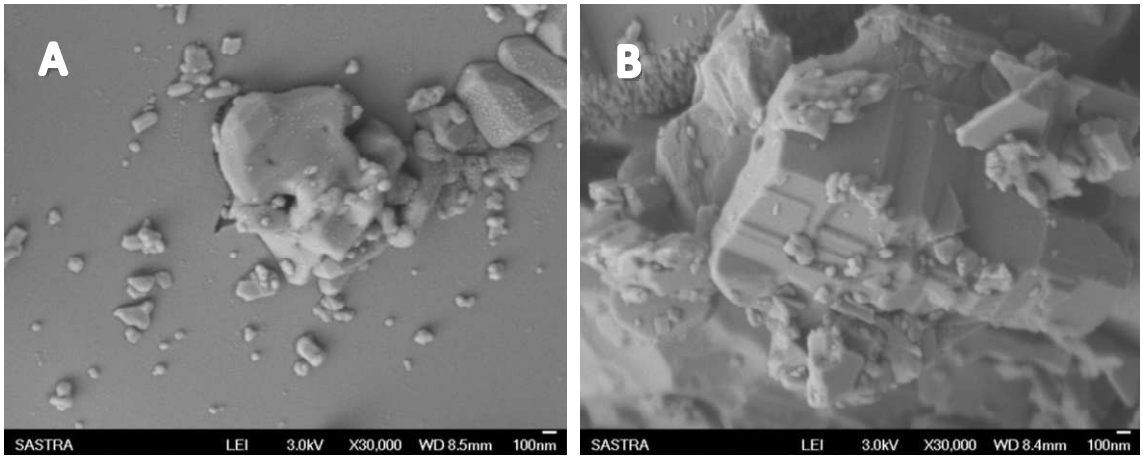


Fig. 3: Temperature profile during *puta.*



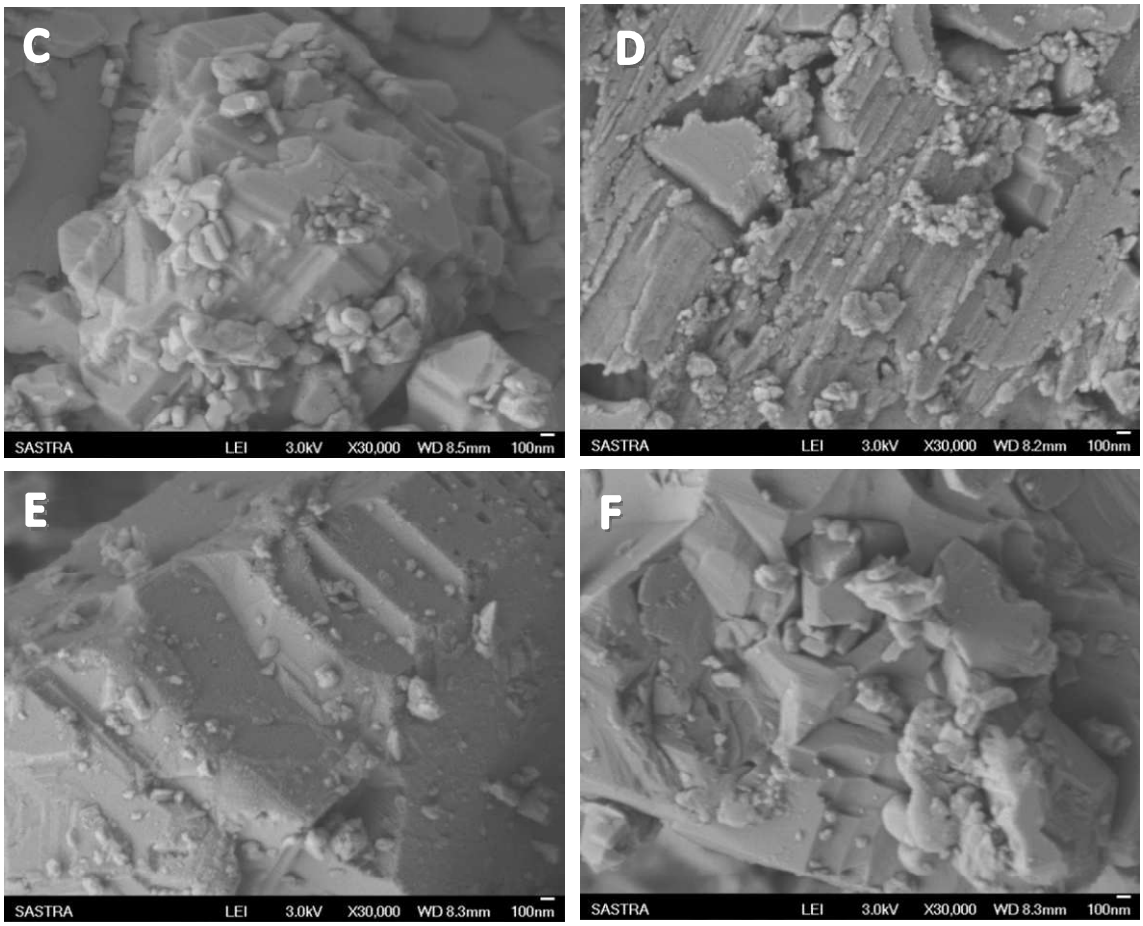


Fig. 4: Scanning electron micrographs of [A-E] intermediates obtained after each *puta*; [F] the final product.

The presence of several nanoparticles, along with the non-spherical shape of the particles result in increased surface area, as evident from the Nitrogen adsorption isotherms for the intermediate obtained after 1st *puta* and that for the final product (Figure 5). This is an important feature, as the importance of nanoparticles in facilitating therapy is fairly established[18, 19]. It is evident from Figure 5 that the intermediate from 1st *puta* showed very poor adsorption characteristics owing to low surface area (23.8 m^2/kg) while the final product showed excellent adsorption characteristics with minimal hysteresis. This could be attributed to the higher surface area (3744 m^2/kg) of the final product.

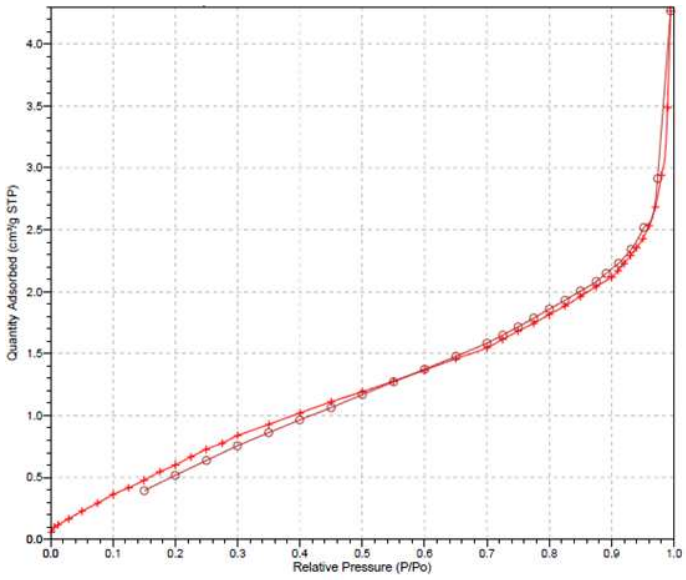


Fig. 5: BET isotherms of [A] intermediate after 1st *puta*; [B] final product.

The X-ray diffractogram of intermediates obtained after each *puta* and that of the final product are shown in Figure 6. It is evident that all the intermediates and the final product are crystalline, with predominant peaks at '2θ' of 26.9, 34.2, 38.3 and 52.08 representing SnO_2. The intensity corresponding to other peaks (2θ of 31, 32.3 and 50.4 corresponding to SnO) relative to the above major peaks decrease with increase in *puta* cycle (Figure 6), with their disappearance in the final product. The crystallinity of the product could be attributed to the temperature profile sustained during '*puta*'. During the synthesis of nanomaterials, amorphous materials are subjected to calcination to transform the same to crystalline materials, with degree of crystallinity increasing with increasing calcination temperature. Since the maximum temperature attained during *puta* is high (800-1000 °C), the crystallinity of the final product is very high. The elemental composition of *vanga bhasma* is shown in table 1. The presence of tin in the form of oxide is evident from the percentage of oxygen and tin in the *vanga bhasma*. This was also confirmed by the X-ray diffraction analysis as discussed earlier.

Table 1: Elemental composition of *vanga bhasma*

Element	Sn	O	Si	Al	Ca	K
Composition (%)	59.80	26.38	5.58	1.70	1.59	0.72

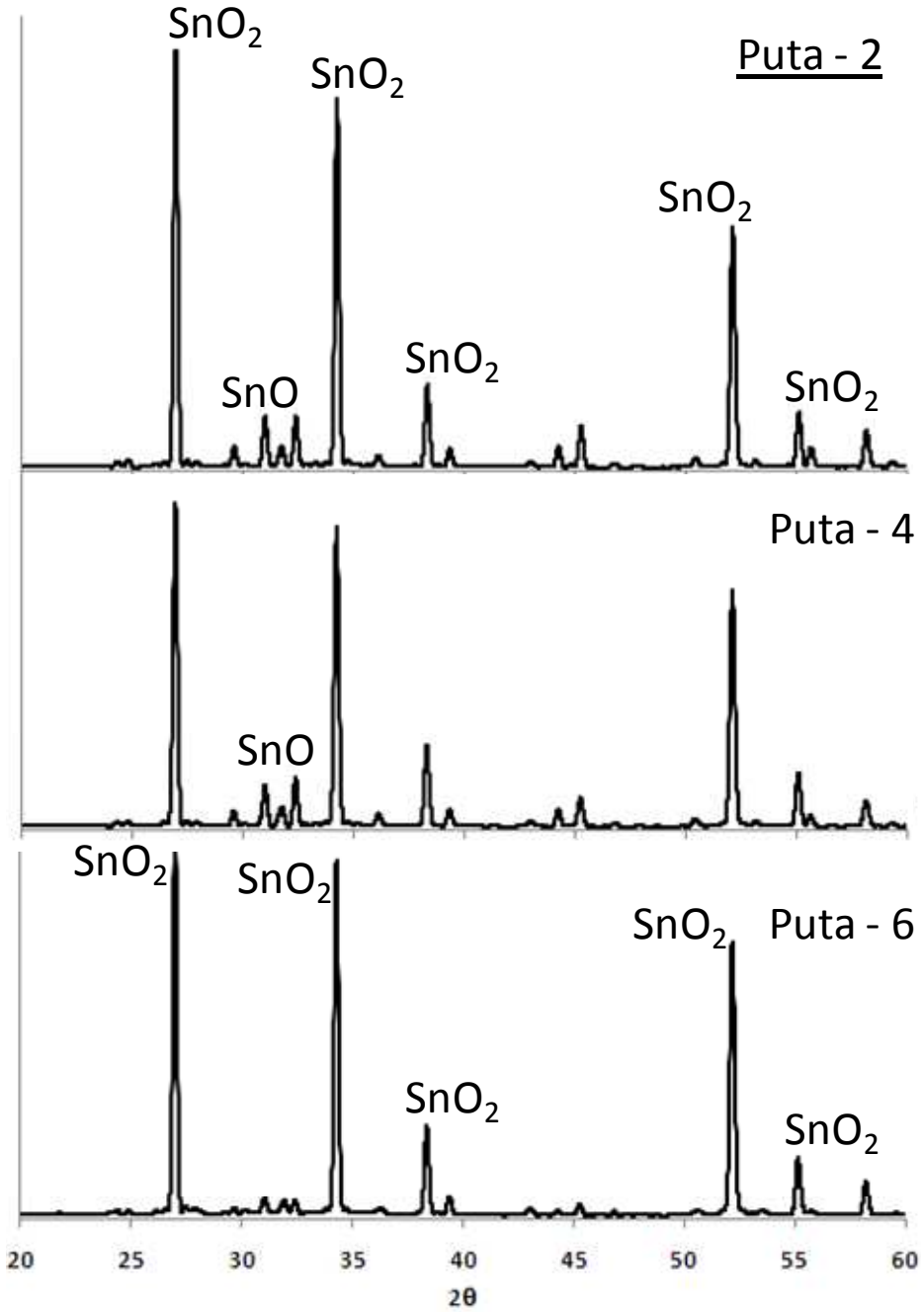


Fig. 6: X-ray diffractogram of intermediates after each puta showing the presence of SnO_2 and SnO phases. Note that SnO is absent in the final product

CONCLUSIONS

The temperature pattern observed over different '*puta*' cycles indicate a consistent pattern, of certain degree of heating and cooling, essential for the formation of particles of well-defined morphology and crystallinity, which were confirmed through scanning electron microscopy and X-ray diffractometry. Significant increase in surface area as a result of six cycles of *puta* confirmed the essentiality of *puta* step for administering metallic supplements in bio-compatible form. *Vanga bhasma* was found to contain essential elements like sodium and calcium, apart from tin as the major constituent.

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