



CHARACTERIZATION OF ZINC OXIDE BASED NANO SIDDHA MEDICINE NAGA PARPAM – POTENTIAL NUTRITIVE SUPPLEMENT IN CANCER

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ABSTRACT

Naga Parpam is a Zinc Oxide based nano medicine, used in Siddha system. Physicochemical analysis is done for standardization of this medicine and to have knowledge of the working principle of this medicine. It has anticancer activity and it is seen in autoimmune diseases, there is a definite imbalance in the metals and in cancer, Zinc is depleted in cell level whereas it is accumulated in the blood plasma. Hence, for substitution of Zinc, it has to penetrate the cells and also it should be non-toxic, for which, Naga Parpam is considered. FTIR, SEM, EDAX, XRD and PL studies were done. The morphology shows that in Naga Parpam there are different sized particles, which falls in the nano size. This shows that this drug can penetrate at different penetration depths. Presence of Zinc, Oxygen, Silicon, Magnesium and Potassium has been established by EDAX studies. FTIR confirms the presence of ZnO, SiO₂ and Mg. XRD confirms the presence of ZnO in hexagonal wurtzite structure. Secondary phase is seen, which is mainly due to Mg present in the sample. The broad peak at 525 nm, which is the characteristic peak for ZnO, from the PL studies also shows the disruption of structure due to the presence of Mg, which is also confirmed by the secondary phase in XRD. It is concluded that Naga Parpam is a potential candidate for substitution of Zn, in Zn depleted auto immune diseases and also in cancer.

KEY WORDS: Zinc Oxide, Nano Particles, Siddha, Naga Parpam, Auto immune diseases, Cancer.

INTRODUCTION

Naga Parpam is a Zinc Oxide based Siddha medicine, which has Zinc Oxide as the main ingredient and traces of other minerals are also reported by many researchers. It should not be confused with Naga Bhasma, which is an Ayurvedic medicine, with Lead as its basic ingredient. Yashad Bhasma is an Ayurvedic medicine which has Zinc Oxide as the main ingredient. Though there are several works on the physio-chemical analysis of Yashad Bhasma is available, very few works are done for the physio-chemical analysis of Naga Parpam. Balakrishnan et.al.¹, has stated that this medicine has Zinc, Oxygen and Iron in the sample. Hence, the physio-chemical analysis of Naga Parpam is investigated in this paper.

The size of bhasmas fall in the range of nano meters and so bhasmas can be called as nano medicines². Typically, in nanotechnology the size of nano particles should be less than or equal to 100 nanometers³. However, this definition of size does not impair the functionality of medicinal substances in nano scale, because it has a large surface area which is the functional part of a nano medicine. The large surface area is able to bind, adsorb and carry other compounds such as drugs, probes and proteins which explain the effectiveness of nano medicines in small quantities. The size of nano particles in the context of nano medicine is considered to be 10 nm to 1000 nm^{4,5}.

Naga Parpam is Zinc Oxide nano medicine, with some minerals, which vary due to the ingredients used and also due to the process involved in the synthesis of this Parpam.

Biodegradable nano particles have been extensively investigated for sustained and targeted/localized delivery of different agents including plasmid DNA, proteins and peptides and low molecular weight compounds⁶. DNA interaction studies were carried out and it was found that at maximum transfection efficiency, the zeta potential of nanoparticles was positive after forming a complex with DNA. The maximum level of reporter gene expression was mediated by nano particles⁷. Gold nano particle-oligonucleotide complexes are studied as intracellular gene regulation agents for the control of protein expression in cells. By chemically tailoring the density of DNA bound to the surface of gold nano particles, tunable gene knockdown has been demonstrated⁸. Hence, it is established that the nano particles acts in the gene level.

Nano particles can act favourably or unfavourably on living systems at nano level. When nano particles are administered as medicine, its toxicological effects are to be evaluated. Hence, for the administration of nano particles as medicine, its benefits and side effects of the use of nano particles in medicine⁹. Chemically stable metallic nano particles have no significant cellular toxicity, whereas nano particles able to be oxidized, reduced or dissolved are cytotoxic and even genotoxic for cellular organisms¹⁰. A large number of nano particles that can pass even through relatively impermeable membranes such as blood brain barrier. Numerous studies have discussed the toxicity of various nano particles, and the recent advancements done in the field of nanotechnology is to make it less toxic. "Green synthesis" of nano particles is one such approach¹¹. Bhasmas are nano medicines used for thousands of years and they are green synthesized nano materials, which is biocompatible and nontoxic. Bhasmas are generally safe drugs for human beings in spite of the presence of seemingly toxic elements

and compounds as indicated by recent studies using modern analytical techniques¹².

Metals such as Cu, Fe, Zn, Mn, Mo, Co, Mg, Ca, K, and Na have biologically significant functions in living system. Some metals such as Al, Cr, Cd, Ni, and Pb are always toxic, when introduced into a living system and also its functions have not been determined fully. But there are some shifts in metal metabolism which are specific, are tabulated in Table 1. If the depleted metals are administered, therapeutic effects are seen¹³. The complex compounds of bio metals with different types of drugs are the considered most promising tool for introducing the required metal into the body.

It is seen from Table 1 that Zn plays an important role in the biological process and also it is either accumulated or depleted in some auto immune disease as listed.

Further, Zn is an important trace mineral that people need to stay healthy. This element is second only to iron in its concentration in the body. Zn is found in cells throughout the body. Zn is involved in numerous aspects of cellular metabolism¹⁴. Zn is required for the catalytic activity of more than 200 enzymes^{15,16}. Further, Zn is essential for genetic stability and function^{17,18}. Zn is found to be deficient in cancer patients when compared with healthy controls^{19,20}. There is accumulation of Zn, in the blood plasma but, there is deficiency in cell level. This indicates that if Zn is substituted by normal means, which is not in the nano scale, there will be further accumulation in the blood plasma, and it cannot penetrate the cell. If Zn has to be supplied to the cells, which are deficient in Zn, Zn has to be given in a form, which is non-toxic and also it has to penetrate the cells. Hence, Zn should be substituted as nano particle, so that it penetrates the cell. Hence, Naga Parpam is considered for our study.

ZnO is considered non-toxic, bio-safe and biocompatible²¹. It is well established that ZnO has antioxidant properties²². ZnO has antibacterial property; hence, they are used in a variety of antimicrobial applications^{23,24}. Due to the high stability, ZnO nano particles (NP) are used in many biomedical applications. One of the primary advantages for considering ZnO nano particles for use in cancer is the inherent preferential cytotoxicity against cancer cells in vitro. ZnO nano particles exhibit high degree of cancer cell selectivity with the ability surpass the therapeutic indices of some commonly used chemotherapeutic agents in similar ex vivo studies^{25,26}. From the above table it is seen that there is depletion of Zn in carcinogenesis.

Toxicity studies are to be carried out, if chemically synthesized materials are to be used as drugs. But there is no need for toxicity tests if Ayurvedic and Siddha drugs are used. Further, if there is a disease, which is caused by deficiency of a metal, and if the disease is auto immune disease, then the root cause lies in the genes and only a nano medicine can handle such situation. If there is a safe nano medicine available, it is the Bhasma, in Ayurveda and Parpam in Siddha.

The importance of this work lies in the fact that these Ayurvedic and Siddha drugs, which contains metals, are age old and readily available if properly standardized, they can be used as substitutes for metal deficiencies and they can be effectively used in the above-mentioned diseased conditions. Hence, Naga Parpam which is ZnO is considered and its physio-chemical and morphological studies are carried out.

MATERIALS AND METHODS

Synthesis of Naga Parpam

Naga parpam which is a Siddha medicine, prepared from zinc. Pure Zn sheets are heated red hot, kept in a vessel and the juice of *Eclipta prostrata*, is added to it, just as the process of quenching. This is done again and again till Zn becomes a powder. Now this powder is grinded with *Aloe vera* juice and small flakes are covered in clay which is calcinated at low temperature. The temperature is not mentioned. Again, these flakes are taken and grinded with *Aloe vera* juice and flakes are made and again heated as above. This process is done three to four times till the parpam is formed²⁷. In the present work, Naga Parpam was procured from a reputed Siddha manufacturer, Indian Medical Practitioner's Co-Operative Society (IMPCOPS) for characterization.

Instruments Used For Analysis

Both morphological analysis and elemental analysis were performed using WEGA3 TESCAN, which is an integrated tool for Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDAX) analysis. X-Ray Diffraction (XRD) of the sample was performed using Rigaku Ultima III XRD. The Fourier Transform Infra-Red (FTIR) Spectra were recorded using FTIR spectrometer Perkin Elmer make for vibrational analysis of the samples and to confirm the compounds present in the sample. The range of scanning was from 400 cm⁻¹ to 4500 cm⁻¹. Photoluminescence (PL) studies were done using spectrofluorimeter JASCO FP - 8000 Series model.

Table 1. Depletion and accumulation of metals in diseases

Disease	Depletion	Accumulation
Rheumatoid arthritis	Fe, Zn	Cu, Al, Mn, Mo, Cr
Atherosclerosis	Cr, Mn, Zn	
Cancer genesis	Cu, Fe, Mg	Zn, Mn
Diabetes	Cu, Mn, Cr	Zn

Table 2. Presence of elements in Naga parpam

Elements	Naga Parpam	
	Weight %	Atomic %
Zn	67.4	34.74
O	28.86	60.78
Si	2.65	3.18
Mg	0.67	0.93
K	0.42	0.36
TOTAL	100	99.99

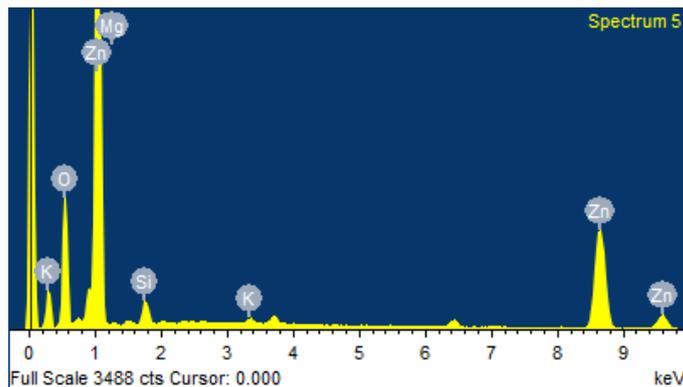


Figure 1 EDAX of Naga Parpam

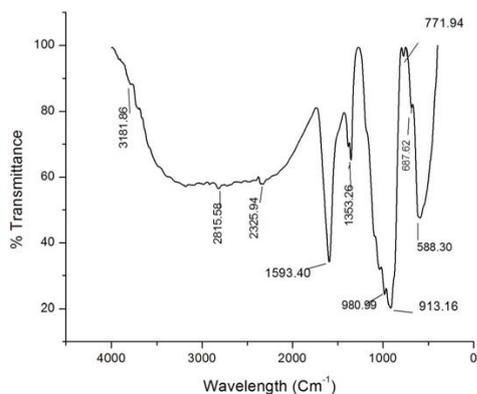


Figure 2 FTIR of Naga Parpam

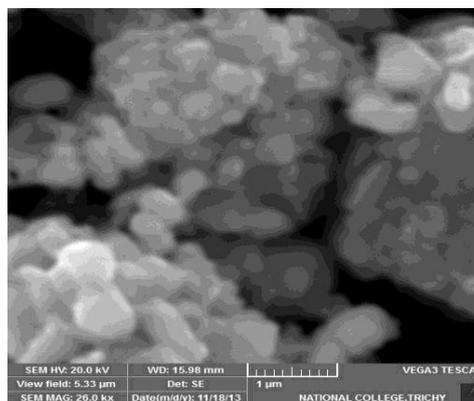


Figure 3 SEM Image of Naga Parpam

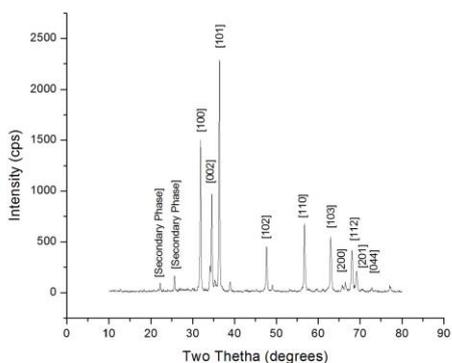


Figure 4 XRD of Naga Parpam

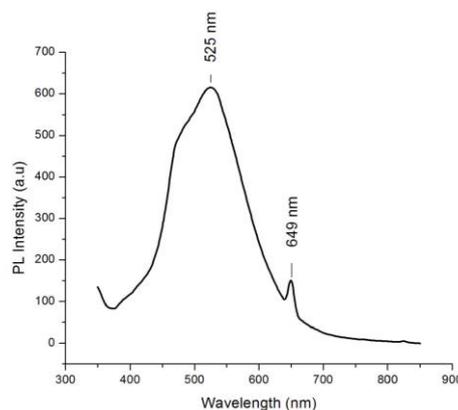


Figure 5 PL spectra of Naga Parpam

RESULTS AND DISCUSSION

Elemental Analysis with Energy Dispersive X-Ray Analysis (EDAX) of Naga Parpam

This analysis of the sample gives the percentage of elements present in the sample.

EDAX spectrum shown in Figure 1, reveal that the sample contains Zn 67.4%, O 28.86%, Mg 0.67%, Si 2.65% and K 0.42% by weight. By atomic percent Zn 34.74%, O 60.78%, Mg 0.93%, Si 3.18% and K 0.36%. The values are tabulated in Table 2.

The process of preparation of Naga Parpam, involves juices from natural origin like *Eclipta prostrata* and *Aloe vera*. The EDAX analysis of Naga parpam shows the presence of Mg and K, other than Zn, O and Si, which is attributed to the preparation method, which involves *Eclipta prostrata*, which has high levels of Mg

and K²⁸. But, other trace metals such as Cu, Fe, Al, Co, Ni, Pb and Cr which are reported²⁸, in *Eclipta prostrata*, are not present in the final product. This may be due to purification methods involved in the process. The parpam is prepared by heating the flakes prepared using clay. This is the main reason for higher percentage of Si in the sample.

FTIR of Naga Parpam

The FTIR of Naga parpam is shown in the Figure 2. The peaks observed at 1353.26 cm⁻¹ and 1383.08 cm⁻¹ are attributed to O-H in plane bending. The peaks at 1593.40 cm⁻¹ and 913.16 cm⁻¹ are attributed to H-O-H bending. The broad peaks at 3181.86 cm⁻¹, 2325.94 cm⁻¹ and 2815.58 cm⁻¹ are attributed to O-H stretching, which could also include Si-OH stretching mode²⁹. The characteristic peak of ZnO is at 771.94 cm⁻¹³⁰. The peak at 588.30

is attributed to ZnO stretching. 980.99 cm^{-1} is contributed to the Si - O stretching vibration³¹. The peak at 687.62 cm^{-1} is due to Mg - O stretching vibration³². Further, EDAX study show the presence of K, which cannot be detected by FTIR as Infra-red rays are transparent to K.

SEM analysis of Naga Parpam

SEM image of Naga parpam is shown in Figure 3. The morphology shows that the particles are slightly agglomerated, and its size is less than 100 nm which is the minimum size in the scale.

Further, there are different sized particles seen in the image. SEM image of Naga parpam shows that there are different sized particles found in the sample. This gives us the clue for the action of this medicine. For the same chemical composition, with different sizes of the same drug, the drug has different penetration levels in the tissues. Due to difference in the size of the drug, size dependent biological functions also differ. Hence, the same drug is given for different ailments and the drug has different degrees of action³³. This proves the size dependence of this medicine.

XRD analysis of Naga Parpam

The XRD spectra is shown in Figure 4. The peaks at $2\theta = 31.67^\circ$, 34.31° , 36.14° , 47.40° , 56.52° , 62.73° , 66.28° , 67.91° , 69.03° and 72.48° are assigned to (100), (002), (101), (102), (110), (103), (200), (112), (201) and (004) of ZnO NPs. All the characteristic peaks of synthesized ZnO nano particles could be observed and were very consistent with the standard values as in JCPDS card 36-1451, indicating that the ZnO nano particles are of the hexagonal wurtzite structure. The peaks at 21 and 26 are attributed to the secondary phase, which is mainly due to Mg present in the sample³⁴, though the percentage of Mg is only 0.67% by weight as established by EDAX studies. Doping of Mg causes disruption of the hexagonal structure, forming secondary phase. Though the weight percentage of Si is 2.65%, Si goes into the hexagonal wurtzite structure and no secondary phase is formed due to the doping of Si, which has been established in our previous study³⁵. The average crystallite size of the nano particles is calculated to be 37.15 nm.

PL spectra of Naga Parpam

PL studies were also conducted on the sample, which is Naga Parpam shown in Figure 5. There is a broad peak at 525 nm, this is due to deep level emission (DLE). This strong green emission in the spectra is attributed to oxygen vacancy (V_o). This phenomenon is due to band transition from zinc interstitial (Zn_i) to oxygen vacancy (V_o) defect levels in ZnO³⁶. The broad peak at 525 nm is one of the characteristic peaks of ZnO. Usually, for ZnO samples, broad and strong green emission is observed if the synthesis involves high temperatures. Further, from XRD studies, it is seen that there is secondary phase, which is due to Mg doping, which disrupts the structure of ZnO. The presence of Mg is established by both EDAX and FTIR studies. The broad peak is also attributed to the filling of oxygen in the vacancies. The strong DLE peak at 649 nm (1.92 eV) observed is attributed to the doping of SiO₂.

CONCLUSION

EDAX of Naga Parpam reveals that the sample contains Zn, O, Mg, Si and K. XRD analysis shows all the characteristic peaks of ZnO nano particles, the secondary phase shows the presence of other elements. The average crystallite size of the nano particles was calculated to be 37.15 nm. FTIR analysis also confirms the presence of ZnO, Si and Mg. SEM analysis shows the surface morphology and confirms the particle size to be less than 100 nm.

The PL study shows a broad peak at 525 nm, which is due to deep level emission, which is attributed both to oxygen vacancy and to disruption of structure due to the presence of Mg. The peak at 649 nm observed is attributed to the doping of SiO₂. Hence, from these analyses, it is concluded that Naga Parpam, which is a nano medicine, may be considered as an active drug for depleted Zn, at cell level, which is seen in auto immune diseases and also in cancer.

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