Azadi ka Amrit Mahotsav ISAS Webinar Series: A few Excerpts

Bridging the Gap between Vedic and Modern Sciences: Nano-centric Characterization of Typical Ayurvedic Bhasmas by using Ultramodern Analytical Techniques

Dr. Dinesh Amalnerkar

Professor Emeritus, Department of Technology, SPPU, Pune-411007

&

Nanoparticles Technology Laboratory, School of Mechanical Engineering
Sungkyunkwan University (SKKU)
Suwon, Gyeonggi- 440-746, South Korea
(Brain-Pool Invited Scientist)

&

Institute of Nano Science and Technology
Hanyang University, Seoul- 04763, South Korea
(Brain-Pool Invited Scientist &Visiting Professor)

** E-mail: dpa54@yahoo.co.in*

Abstract

While exploring healthcare applications of nanomaterials, it is intuitively sensed that therapeutic properties of metal based ayurvedic compositions might be associated with the nano-scale features. To bridge the gap between vedic and modern sciences, extensive physico-chemical investigations were performed on Swarnabhasma, Roupyabhasma and Jasadbhasma (prepared in accordance with traditional ayurvedic protocol in toto) using ultramodern analytical tools. X-ray Diffractometry (XRD), Field-Emission Scanning Electron Microscopy (FESEM), Xray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were predominantly employed to judge structure, texture, morphology and elemental/chemical composition & distribution in such metal based formulations

Introduction

While exploring healthcare applications of nanomaterials, it is intuitively sensed that therapeutic properties of metal based ayurvedic compositions might be associated with the nano-scale features. To get head start towards this quest, we primarily focused on Au (Swarnabhasma), Ag (Roupyabhasma) and Zn (Jasadbhasma) based herbo-metallic compositions which were prepared and successfully used in the treatment of assorted cancers and other diseases by Pune-based Ayurvedic Physician Dr. Bendale. We have conducted extensive physico-chemical investigations

on such bhasmas. Typical test samples were prepared by strictly following traditional ayurvedic protocol *in toto* under the supervision of Dr. Bendale. Ultramodern analytical tools such as X-ray Diffractometry (XRD), Field-Emission Scanning Electron Microscopy (FESEM), X-ray Photoelectron Spectroscopy (XPS), Field-Emission Transmission Electron Microscopy (FETEM), High-Resolution TEM (HRTEM), Scanning Transmission Electron Microscopy (STEM) with High Angle Annular Dark-Field (HAADF) and Elemental Mapping were employed to judge the relevant aspects of structure, texture, morphology and elemental/chemical composition & distribution.

Results and Discussion

Structurally, XRD patterns confirm the presence of (i) phase-pure face-centered cubic structure of Au in Swarnabhasma and Ag in Roupyabhasma and (ii) ZnO with hexagonal structure in Jasadbhasma (Fig.1). FETEM images disclose presence of poly-dispersed irregular shaped nanoscale morphological features (along with occasional spherical nanoparticles) in case of Swarnabhasma (Fig.2) and Roupyabhasma (Fig.3) while that of poly-dispersed faceted nanoscale morphological features in case of Jasadbhasma (Fig.4). Quite interestingly, spatial resolution for atom to atom chemical mapping by STEM-HAADF-EDS technique revealed notable presence of oxygen in case of Swarnabhasma (Fig.5) and Roupyabhasma (Fig.6) which did not specify presence of the respective metallic oxides by XRD. To ascertain the precise nature (ambient, trapped or chemically incorporated) of oxygen present in these 2 bhasmas, we have carefully examined XPS data. Survey and High Resolution Scans of Swarnabhasma (Fig.7) and Roupyabhasma (Fig.8) revealed prominent presence of chemically incorporated atomic oxygen in such bhasmas probably leading to formation of the surface/sub-surface oxides of the respective metals in such bhasma samples which cannot be ordinarily detected by bulk-technique like XRD. Since Jasadbhasma is predominantly ZnO, the pertinent XRD, STEM-HAADF-EDS (Fig.9) and XPS (Fig.10) data go hand in hand.

Such perplexing findings presented in this talk can surely play an illustrative role in bridging the gap between Vedic science and modern science.

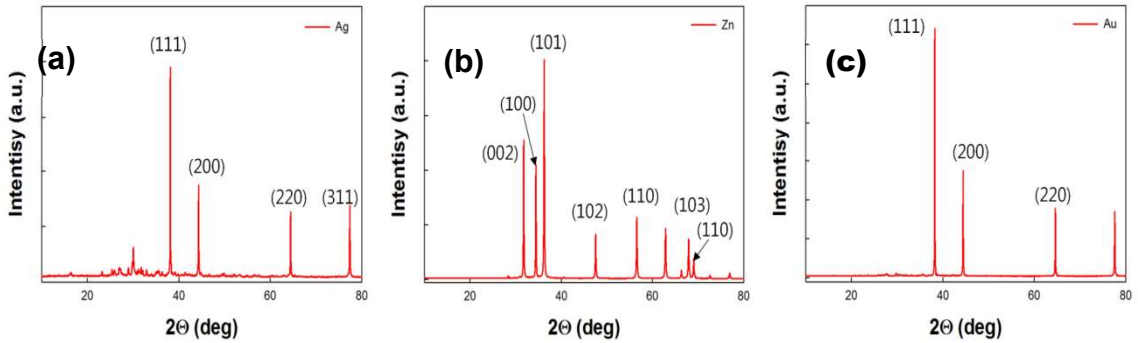

Figure 1: X-ray diffractograms of (a) Swarnabhasma, (b) Roupyabhasma and (c) Jasadbhasma samples

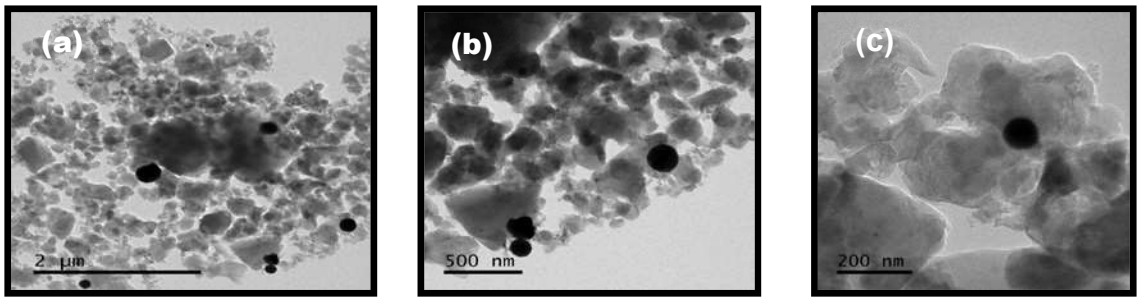

Figure 2: FETEM images of Swarnabhasma sample at (a) low, (b) intermediate and (c) high magnification

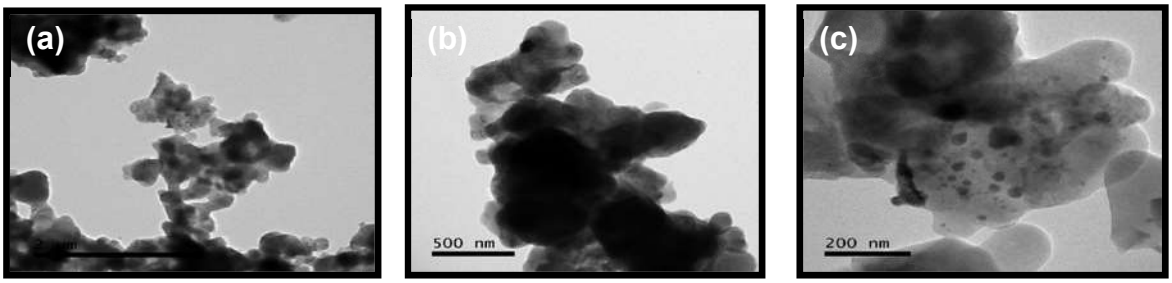

Figure 3: FETEM images of Roupyabhasma sample at (a) low, (b) intermediate and (c) high

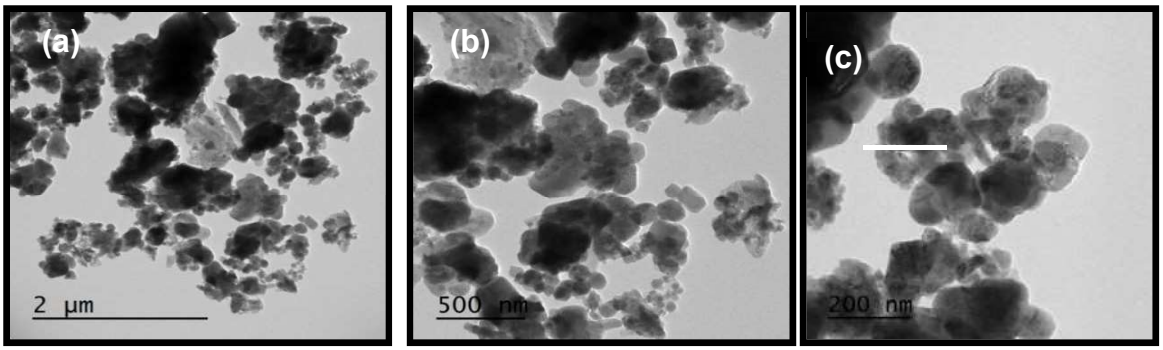

Figure 4: FETEM images of Jasadbhasma sample at (a) low, (b) intermediate and (c) high magnification

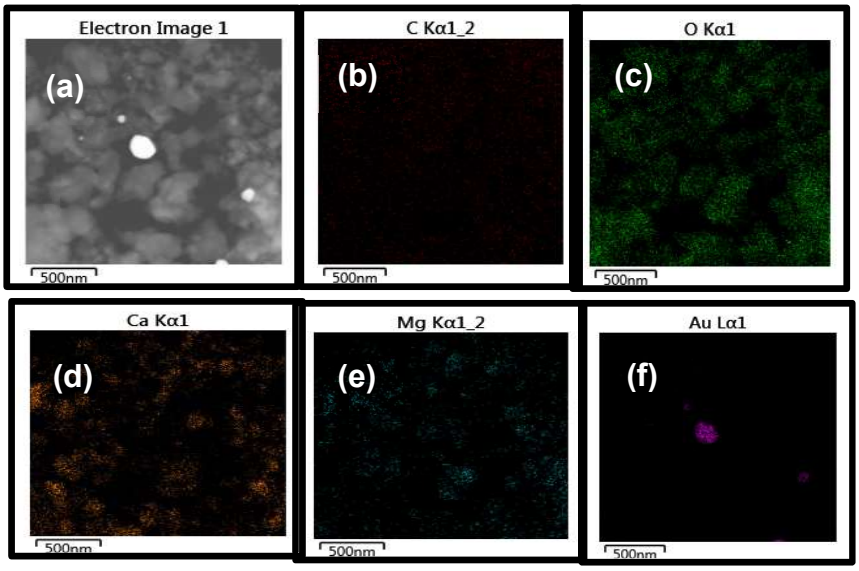

Figure 5: FETEM-STEM-HAADF elemental mapping images of Swarnabhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) C, (c) O, (d) Ca, (e) Mg and (f) Au

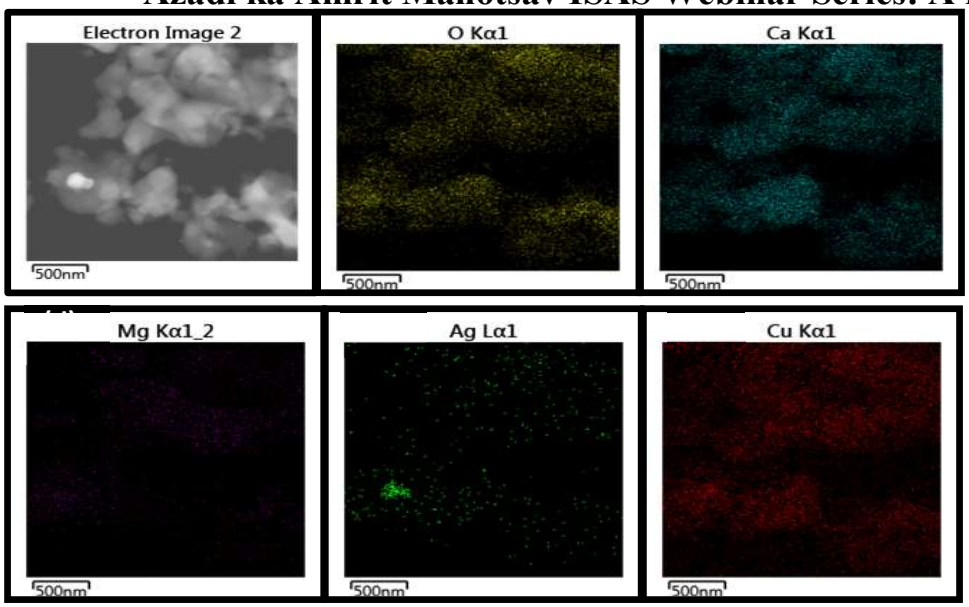

Figure 6: FETEM-STEM-HAADF elemental mapping images of Roupyabhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) O, (c) Ca, (d) Mg, (e) Ag and (f) Cu

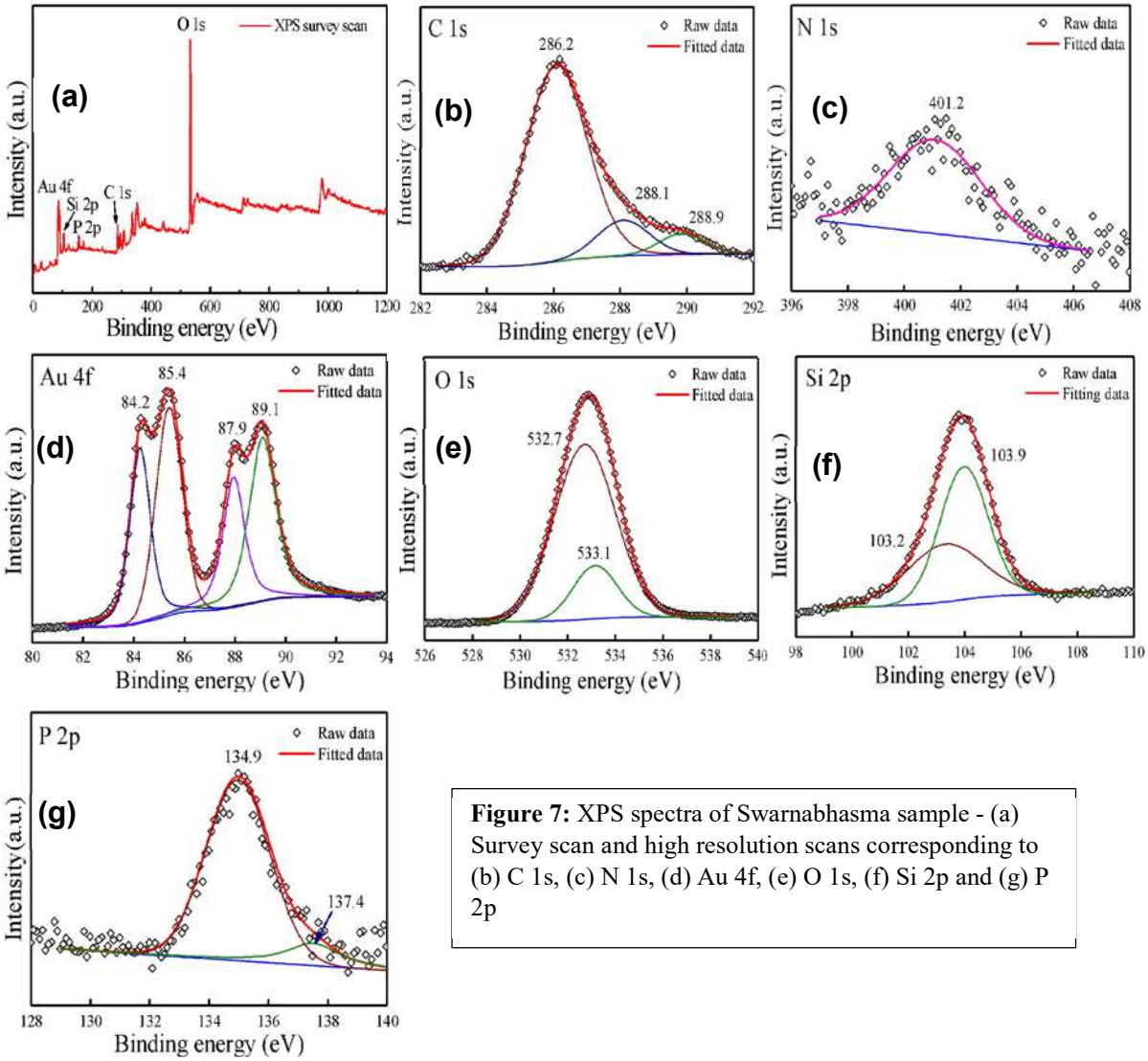

Figure 7: XPS spectra of Swarnabhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) N 1s, (d) Au 4f, (e) O 1s, (f) Si 2p and (g) P 2p

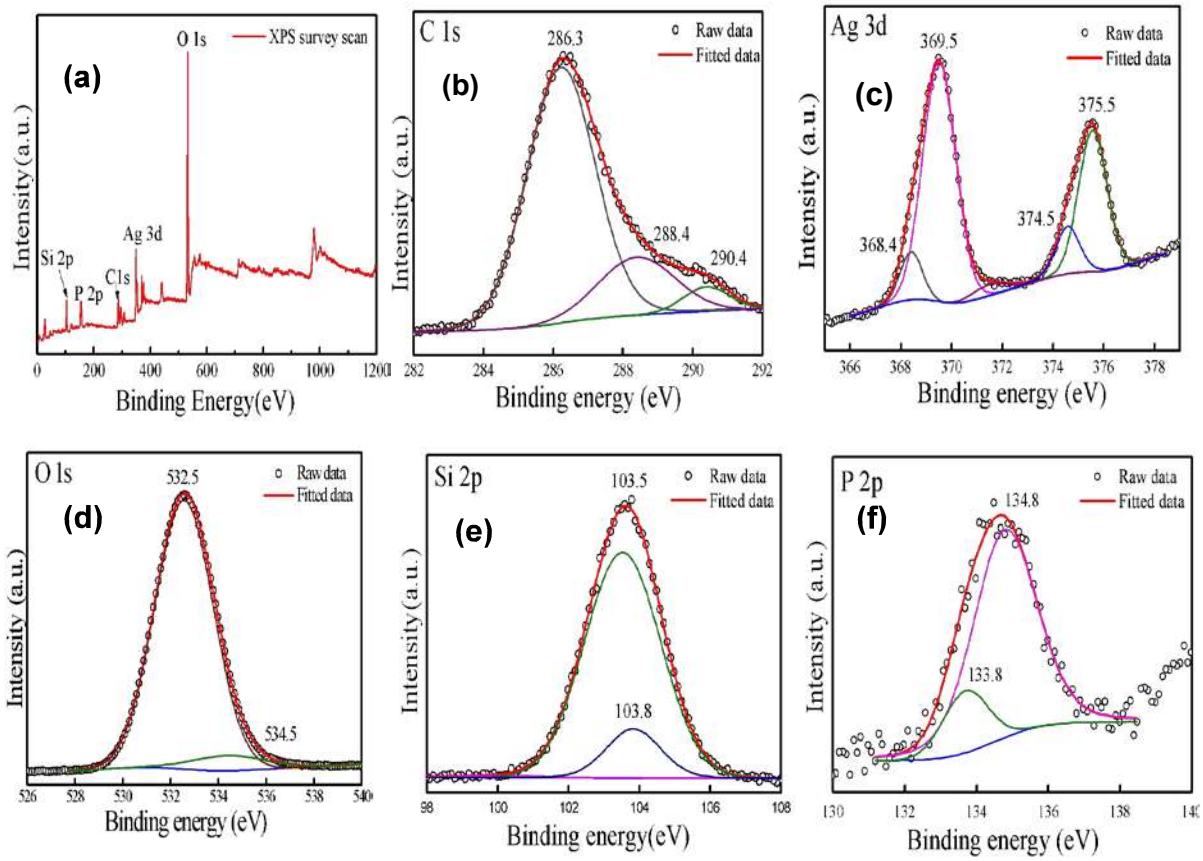

Figure 8: XPS spectra of Roupyabhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) Ag 3d, (d) O 1s, (e) Si 2p and (f) P 2p

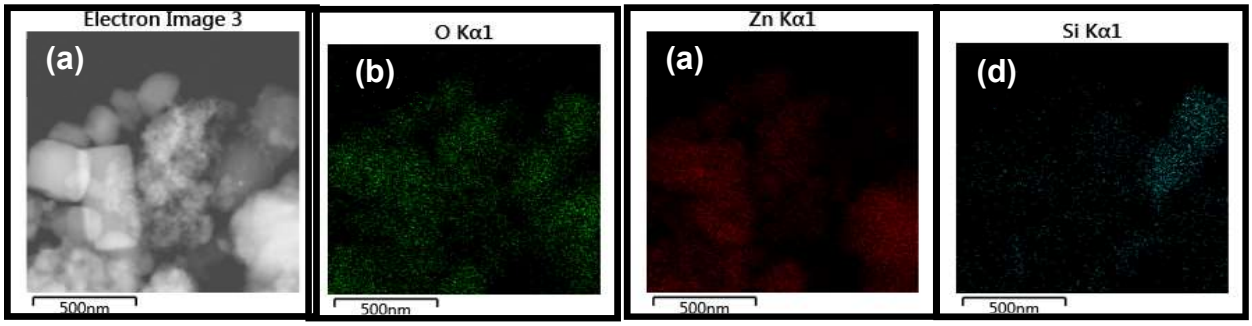

Figure 9: FETEM-STEM-HAADF elemental mapping images of Jasadbhasma sample corresponding to (a) electron image and elemental mapping images corresponding to (b) O, (c) Zn and (d) Si

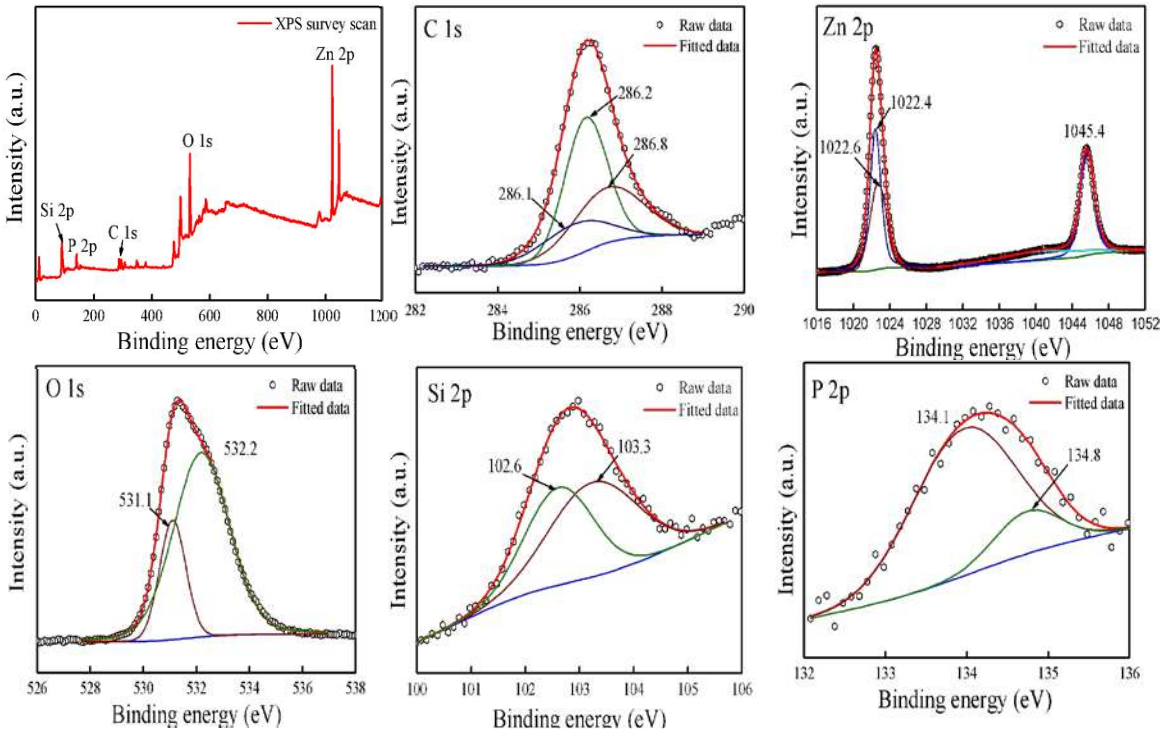

Figure 10: XPS spectra of Jasadbhasma sample - (a) Survey scan and high resolution scans corresponding to (b) C 1s, (c) Zn 2p, (d) O 1s, (e) Si 2p and (f) P 2p

Conclusions

Advanced Non-destructive Materials Characterization performed on Traditional Au,Ag and Zn based Bhasmas reveal presence of Nanoscale features along with mysterious bonding between atomic oxygen and the respective metal especially in Swarnabhasma and Roupyabhasma. This exploration can open up new vistas for structure-(medicinal) property relationship in herbo-metallic ayurvedic compositions.

References

1. Khedekar, S., Anupriya, G. R., Patgiri, B., & Prajapati, P. K. (2015). Chemical characterization of incinerated gold (Swarna Bhasma). *Advances in Applied Science Research*, *6*(12), 89-95.
2. Meghna, V., & Abhishek, U. (2016). CHARACTERIZATION OF SWARNMAKSHIKA BHASMA USING STATE OF THE ART TECHNIQUES.
3. Baker, T. A., Liu, X., & Friend, C. M. (2011). The mystery of gold's chemical activity: local bonding, morphology and reactivity of atomic oxygen. *Physical Chemistry Chemical Physics*, *13*(1), 34-46.

4. Shi, H., Asahi, R., & Stampfl, C. (2007). Properties of the gold oxides Au 2 O 3 and Au 2 O: First-principles investigation. *Physical Review B*, *75*(20), 205125.

Bio-sketch of Dr. Dinesh Amalnerkar

Dr. Dinesh Amalnerkar is currently Professor Emeritus at Department of Technology, SP Pune University. Previously, he served as the Director General of Centre for Materials for Electronics Technology (CMET, Government of India) since February, 2009 till his superannuation in November, 2014. While placed at CMET from January 1991-November 2014, he had taken up long-term visiting assignments in Gifu University, Japan &Korea Research Institute of Chemical Technology, Daejon and short-term assignments at various universities/institutes in Singapore, Switzerland, Slovenia, Bulgaria, Japan and Saudi Arabia. More recently, during 2015-17, he worked as Brain-Pool Invited Scientist and Visiting Professor at Nanoparticles Technology Laboratory (NPTL), Sungkyunkwan University and also at Institute of Nanoscience and Technology, Hanyang University, Seoul, South Korea. Dr.Dinesh Amalnerkar has long-standing research experience in multi- institutional and multi-country settings. His versatile research contributions in Functional Electronic & Nanostructured Materials and recently in Nano-bioscience include 230 research papers in International Journals, 24 Indian Patents, 3 US Patents, 1 Book Chapter and 3 Technology Transfers. He is recipient of the Materials Research Society of India's prestigious Medal Award for the year 2008 for significant contributions in Materials Science.