NAA OF SOME ANCIENT INDIAN COINS

N.S.Rajurkar and B.D.Fulsoundar
(*Department of Chemistry, University of Poona, Pune-411 007, India*)

ABSTRACT

The radioactivity induced in the coins from Satvahanas, Ahmadshah Bahamani, Gujrat Sultan, Nizamshahi and Marathas after (n,γ) reactions for the elements of interest is measured on multichannel analyzer coupled to high purity germanium detector and percentage of these elements is determined by comparator method of NAA. All these coins are found to be copper based with the presence of As, Sb, In, Au, Sn and Mn.

Keywords Neutron activation analysis, Ancient coins, Elemental analysis, India

1 INTRODUCTION

The study of the coins can being helpful in various ways. Dated coins or those can otherwise being identified with a particular epoch help the archaeologists fix the level of the age which he belongs to and organize the chronology of rules. The designs of coins describe the religion and mythology of the society and also reflects evolution of its art. The portraits on coins reveal about prominent personalities of ancient times. These types of informations are obtained from coins by scientific techniques of description and classification. A somewhat more complex scientific procedure involves assaying the metallic content of coinage over a long period in order to obtain information about the economic history of the society as well as availability/scarcity of metals from region to region. Among the various methods for elemental analysis, XRF and NAA are particularly attractive in case of ancient coin analysis because they can be used as non-destructive methods. However, the former technique provides the surface concentration while NAA provides the data on bulk concentrations and hence is more advantageous. Though sample becomes radioactive after neutron activation, it decays completely with no residual activity after certain interval of time. The present investigation is undertaken to study the metallic contents of ancient Indian coins from the 2nd century B.C.~the 2nd century A.D. and the 14th ~18th century A.D. using a non-destructive neutron activation analysis [1] (NAA) technique. The technique was used by several workers[2~4] for analysing ancient coins from different regions and eras.

2 EXPERIMENTAL

The various ancient coins under examination were collected from the coin collector and identified with the help of numismatists. These coins were used for analysis without any pre or post irradiation treatment in order to avoid any damage to them. Californium-252 spontaneous fission neutron irradiation facility with an integrated neutron flux of $\sim 10^9$ n s^{-1} available at our university had been used for activation purpose.

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It is to be noted that arrangement of facility is such that a uniform flux is obtained at different positions in the inner and outer cores, the former being 1.6 times greater than the latter. Further, fast neutron component at the irradiation position is negligibly small and samples are exposed to thermal neutrons only. All the irradiations in the present work were done in the outer core for 12 h. The activities of the various radioisotopes formed after (n,γ) reactions were measured by a solid state detector system supplied by EG&G ORTEC. The system consisted of a high purity germanium (HPGe) detector with a resolution of 1.95 keV for the 1332 keV γ ray photopeak of ^{60}Co and a 8k multichannel analyzer interfaced with an IBM PC/XT. The analysis of each spectrum was done using MCA program provided by EG&G ORTEC. The induced activities of various radioisotopes were measured at their photopeak energies: ^{64}Cu (511 keV for 50 s), ^{76}As (559 keV for 1000 s), ^{122}Sb (564 keV for 1000 s), ^{198}Au (412 keV for 1000 s), ^{56}Mn (847 keV for 500 s), ^{125}Sn (332 keV for 500 s) and ^{116}In (1097 keV for 1000 s).

The determination of percentages of different elements is done by comparator method of NAA. For this purpose calibration curves, using standard AR grade metal foils/powders of the elements of interest, were prepared under identical conditions as those of samples; the extent of activities induced in samples and standards being of the same order. As these calibration curves showed a straight line passing through origin, it indicates that self-shielding effect is almost negligible for the elements studied. The activity at the end of irradiation in each case was calculated using half-life of concerned isotope and a cooling time for the measurement. Each measurement was done at least twice and the results presented are an average of these.

3 RESULTS AND DISCUSSION

Table 1 indicates that all the coins studied in the present work are copper based with minor/trace indium, arsenic, antimony, gold, manganese and tin; presence and extent of the associated elements being different from coin to coin. Further examination of Table 1 shows that percentage of copper is found to vary between 50% $\sim$ 74% and is in the order: the 16th century <2nd century B.C.$\sim$2nd century A.D.<17th century$\sim$early 19th century <17th century <14th century.

Thus, no any specific trend in copper content with respect to era has been observed and the variation can be accounted for availability of source of copper of that dynasty and minting technique of corresponding emperor. Further examination of Table 1 shows that arsenic is the associated impurity of all the coins except coin of Pulumair and present up to the level of 0.25% only (with exception of coin Nizamshahi 2 having 1.275%). Marshall[5] has reported that copper mines at Khetri, Alwar, Sighbhum and Afganistan contain arsenic. Hence it can be revealed that coins containing arsenic may be derived from the copper ores of either of these places. Similarly, antimony is also found to be present upto level of 0.16% which again is a common impurity of some copper ores.

Presence of manganese in few of the coins indicates its association with iron ores. While the precious metal gold is tought to be deliberately added in some of the coins to

indicate the glorious period of the particular dynasty. Another metal of interest which is found in most of the coins is indium, ranging between $0.18\times10^{-3}\% \sim 5.6\times10^{-3}\%$. This metal must be intentionally added in these coins as it is known to protect the metals against wear and corrosion. The addition of small quantities of indium in alloys has the general effect of hardening and strengthening the metal. Thus, its presence in coins shows improved fabrication technique of that period. Further, higher percentage of tin found in some coins from Satvahanas and Vishnukundin indicates that it must be used as a coinage metal of that period.

Table 1

NAA of copper, arsenic and indium in some ancient coins from India

Coin name with era	W/g	Percentage of elements						
		Cu	As/10^{-2}	In/10^{-3}	Sb	Au/10^{-3}	Mn/10^{-3}	Sn
Satvahanas (the 2nd century B.C.~2nd century A.D.)								
1.	2.577	61.4±0.8	24.5±0.5	1.14±0.02	0.0493±0.0003	5.5±0.1	37.4±0.4	–
2.	2.363	59±1	18.5±0.6	1.11±0.01	–	–	–	–
3. Satkarni	2.367	67±1	18.4±0.5	5.6±0.2	–	–	14.0±0.3	25.6±0.1
4. Pulumair	2.875	55.07±0.09	–	–	–	–	–	22.6±0.3
Vishnukundin (the 2nd century B.C.~2nd century A.D.)								
1.	6.463	55.5±0.3	1.57±0.02	3.76±0.01	–	5.7±0.2	1.17±0.03	26.93±0.01
Bahamani Ahmadshah II (the 14th century)								
1.	8.185	74.2±0.4	16.8±0.2	0.403±0.005	0.0105±0.0001	5.99±0.03	–	–
2.	8.031	73.9±0.3	19.9±0.3	0.454±0.001	0.0256±0.0007	5.7±0.1	–	–
3.	8.127	71±1	8.03±0.03	0.3591±0.0007	–	–	–	–
4.	8.183	69.08±2	13.8±0.2	0.233±0.008	0.0181±0.0007	5.2±0.2	0.63±0.03	–
Gujrat Sultan (the 16th century)								
1.	11.248	51.7±0.9	14.4±0.1	0.983±0.002	0.142±0.001	3.6±0.1	–	–
2.	10.635	55.6±0.2	1.14±0.05	–	–	–	–	–
3.	9.248	56±1	6.2±0.1	–	0.159±0.001	–	–	–
4.	11.222	50±0.3	13.6±0.2	0.49±0.01	0.060±0.002	8.41±0.05	–	–
Nizamshahi (the 17th century)								
1.	7.052	66.5±0.2	8.4±0.2	–	–	–	–	–
2.	6.500	69.49±0.03	127±2	0.77±0.02	–	–	–	–
3.	9.162	62.5±0.1	10.9±0.3	0.26±0.03	–	6.8±0.2	–	–
4.	9.527	62.1±0.4	18.6±0.3	0.172±0.005	0.144±0.002	–	–	–
Marathas (the 17th~early 19th century)								
1.	8.285	61.2±0.8	17.6±0.3	–	–	–	–	–
2.	10.971	60.61±0.03	5.9±0.1	–	0.0239±0.0001	–	–	–
3.	9.368	60.7±0.8	19.92±0.08	–	0.0233±0.0003	–	–	–
4.	10.390	64.5±0.02	35±1	–	0.0238±0.0003	–	–	–

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