RED GOLD ANALYSIS BY USING GAMMA ABSORPTION TECHNIQUE*

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ABSTRACT

Gold is a valuable metal and also preferable materials for antique artefacts and some advanced technology products. It can be offered for the analysis of the gold as namely; neutron activation analysis, X-ray florescence technique, Auger spectroscopy, atomic absorption and wet chemistry. Some limitations exist in practice for these techniques, especially in the points of financial and applicability concepts. An advanced a practical technique is "gamma absorption technique" for the gold alloys. This technique is based on discontinuities in the absorption coefficient for gamma rays at corresponding to the electronic binding energies of the absorber. If irradiation is occurred at gamma absorption energy for gold, absorption rates of the red gold changes via the gold amounts in the alloy. Red gold is a basic and generally preferable alloy that has copper and silver additional of the gold in it. The gold amount defines as carat of the gold. Experimental studies were observed for four different carats of red gold; these are 8, 14, 18 and 22 carats. K-edge energy level of the gold is on 80 keV energy. So, Ba-133 radioisotope is preferred as the gamma source because of it has gamma energy peak in that energy. Experiments observed in the same geometry for all samples. NaI(Tl) detector and multichannel analyser were used for measurements. As a result of the experiments, the calibration curves could be drawn for red gold. For examine this curve, unknown samples are measured in experimental set and it can be determined the carat of it with the acceptability. So the red gold analysis can be observed non-destructively, easily and quickly by using the gamma absorption technique.

INTRODUCTION

Gold is one of the precious metals and it has priceless value to modern civilization. Because of its aesthetic beauty and enduring physical properties, gold is important not only to industry and the arts, but also as a commodity having long-term value. Gold, the first jewelry metal, still is the most popular.

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The popularity of gold is maintained by tradition, its distinctive color, and the carat mark. Color and carat are the primary factors to be considered in the selection of a particular gold. The carat which is a unit of fineness equal to the $^{1}/_{24}$th part of pure gold is the one way of indicating gold purity. In this system, 24 carat (24 k) gold is 1000 fine or pure gold. There are also 8, 14, 18 and 22 carat available. Color of gold depends on the additional material in gold alloys. Most of the commercially important colored alloys for jewelry and dental application are based on the gold-silver-copper system. Main gold colors are red, green, yellow and white.

Red gold is a preferable gold type that is investigated in this study. Red gold is defined in the ternary phase diagram. Copper is a main alloy element nearby the gold element in the red gold. Fig. 1 shows red gold region on the ternary phase diagram for gold alloys [1,2].

Gold analysis is important for the evaluation of the gold alloys, and their carats. There are many different methods available for the determination of gold: Wet chemistry techniques (classical fire assay fusion, alkaline cyanidation,, aqua regia acid digestion), neutron activation analysis, X-ray florescence technique, Auger spectroscopy and atomic absorption. These methods can be used for the gold analysis but it couldn't be possible to apply in practice because of some limited fact are available.

METHOD

An advanced nuclear technique as namely "Gamma Absorption Technique" is preferred for gold analysis. This method can be generally useful for the analysis of many elements and also can be called as a differential gamma ray absorption method [3].

Gamma absorption techniques is based on discontinuities in the absorption coefficient for gamma rays at energies corresponding to the electronic binding energies of the absorber [4]. The binding energies vary from element to element, are greater for inner-shell than outer-shell electrons, and increase with atomic number for a given electronic shell. The component of the gamma ray beam with an energy above the X-ray edge of the heavy element will, if the elements is present, be absorbed much more strongly that the practical application of this analytical methods depends on the availability of a gamma ray source with gamma transitions which bracket the K-absorption edge of the element of interest.

The energy of gamma radioisotope source must be appropriate to the K-absorption energy of the analyzing material so the selection of the gamma source for gamma absorption analysis is an important stage.

The sharp decrease in the half-thickness for gold that discontinuous increase in the gamma ray absorption is at 80 keV [5]. Convenient radioisotope for red gold analysis by gamma absorption technique is Ba-133 that has 80 keV characteristic radiation.

EXPERIMENTAL PROCEDURE

Samples have been supplied red gold in four carats with the different thicknesses between 0.150 mm and 1.2 mm [6]. The carat ratios of them are 8, 14, 18 and 22 and their weight ratios of the gold are %33.3, % 58.3, %75 and %91.6 respectively. Additional of the gold, copper and silver are used for the red alloy.

Experiments observed by using a 0.46 μCi ^{133}Ba point source that was selected because it emitted photons in the range of 80 keV, which is the same energy for K-edge absorption energy of gold. The source was housed under a cylindrical lead collimator with a 0.8 cm inner diameter hole for elimination of the surrounding scattering. The gold samples are placed against the gamma source on the special lead collimator.

Gamma rays were measured using NaI(Tl) scintillation detector which has high detection efficiency. The electronics consisted of a high voltage supply and multi-channel analyzer system. Count rates are taken in the same geometry for all samples [7]. Experiments repeated at least three times and average net counting rate is calculated. Block diagram of the experimental set-up can be seen in Fig. 2.

RESULTS AND DISCUSSION

As a result of the experiments could be drawn the graphs [8] in Fig.3. Furthermore graphs could also be drawn as logarithmic scale in Fig. 4 that can be call as calibration curve for the red gold.

According to our results, which are obtained from the experiments, are perfectly in correlation with each other. As from the Fig.3 and Fig. 4, the curves in both figures which belong to the low carat gold are at the upper side and as a result the high carat gold are at the bottom side. In addition, the curves within themselves are lined up from low carat gold down to high carat gold.

These results safety our expectations. Like, in low carat gold alloy the amount of gold is less, its gamma discontinuities energy which is 80 keV, is measured high values. In measures of low carat samples and as a result of this relative intensity values are high therefore the curves of those samples are in upper positions in the graphics.

In the gold alloy, other elements other than gold are also important. In the alloy, those elements can also be effective. The results of our experiments seem to be satisfying and correct despite that they are all tested with these methods.

For the control of the study, the unknown sample is welding gold which is used as jewelry connection material that is produce as 14-carat red gold is used and tested. It can be decided the type and carats of the gold thoroughly that is appointed in Fig3 and Fig 4 as a point. The results are appropriate just of the reality.

CONCLUSION

The result of the study concludes in below.

- Red gold analysis can be observed easily and quickly with using the gamma absorption technique.
- During the application of technique in nondestructively and no loose of the sample material.
- Results of the study can be arranged as the calibration curves.
- Arranging results are tested and showed that reliable.
- If the type of the gold alloy is known, then Fig. 3 or preferably Fig 4 can be used as calibration curves for the carat determination.

After this study, it can be summarized that the gold analyze by the gamma absorption technique is easy, quick, reliable, nondestructive and inexpensive.

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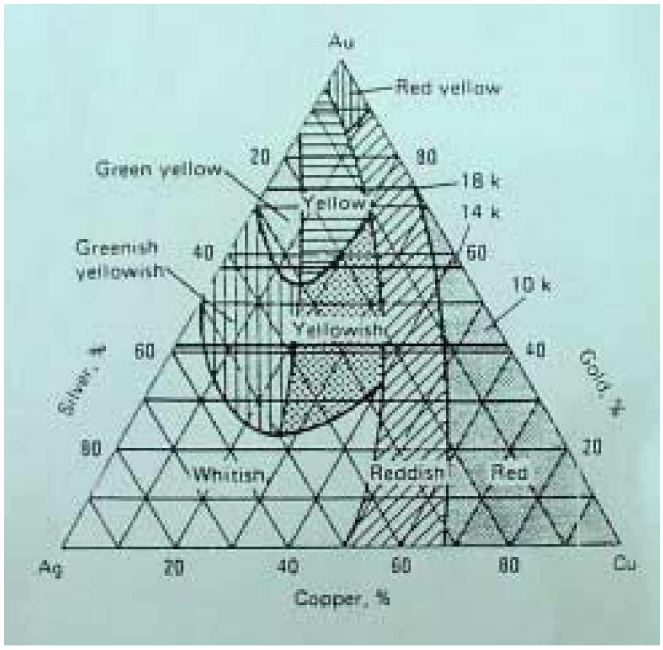

Fig. 1 Au-Ag-Cu Ternary Phase Diagram [1,2]

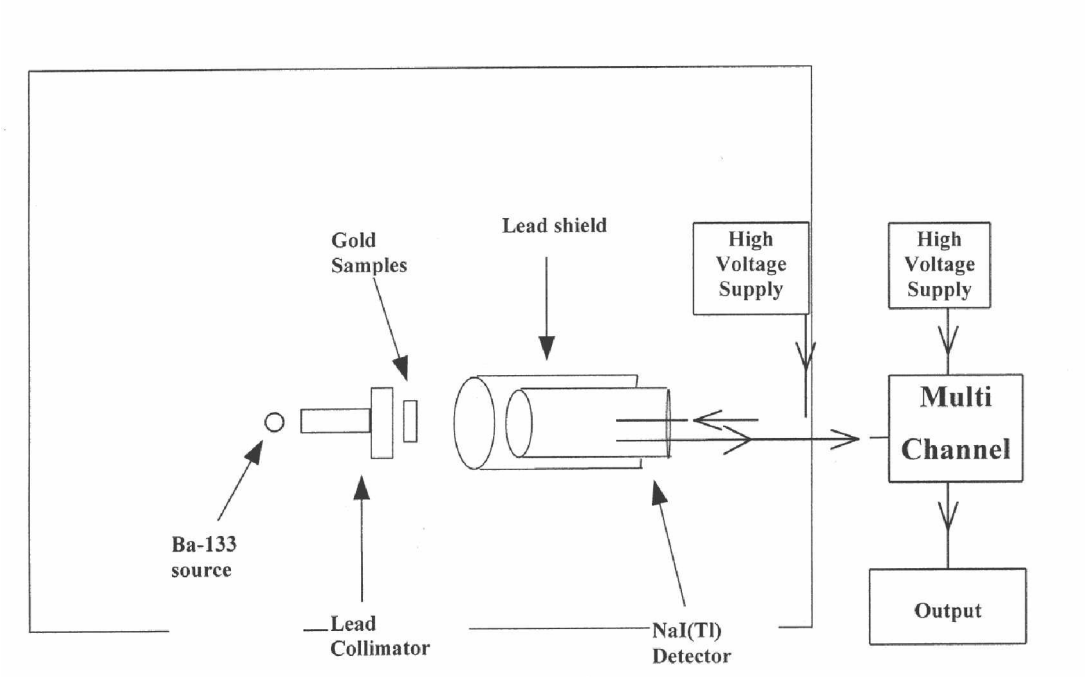

Fig. 2 Block Diagram of The Experimental Set-up

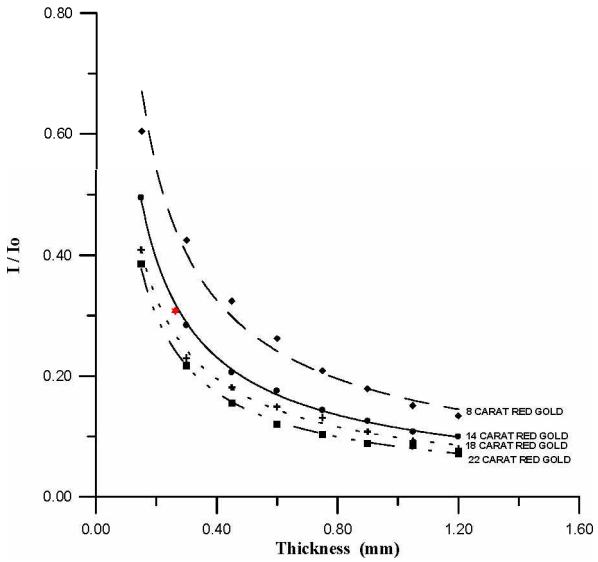

Fig. 3 Results Graphs For The Red Gold Alloys By Using Gamma Absorption Technique

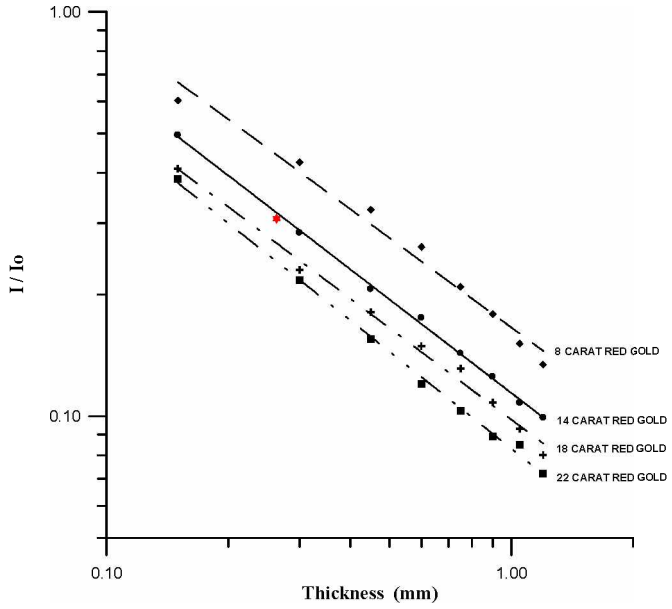

Fig. 4 Calibration Curve For Red Gold