# Improving the Value of Quartz Gemstones through Gamma Irradiation

**U.C. Jha**

**Department of Mechanical Engineering, Lovely professional university, Phagwara, Punjab (India)-144411.**

ABSTRACT

Color enhancement of gemstones through gamma irradiation is an established technology throughout the world. By value addition, the traders earned manifold prices to these colorless stones as compared to the fresh ones. For the color enhancement of these semi-precious stones, optimized doses of irradiations are required. To get the optical properties of the stones and to investigate the crystal lattice and chemical composition, X-Ray diffraction (XRD) and energy dispersive X-ray (EDX) techniques were applied in this study. The colorless pure samples of quartzes were collected and subjected to gamma irradiation doses up to 1.5 M rad or 15mGy for valuable colors of the samples. In XRD analysis of the samples, small peaks were observed in the pattern after irradiation indicating change in the phase of $SiO_2$. Stability of the colored quartz samples was determined up to 200 $^0$C by thermal treatment. After irradiation the induction of radioactivity was checked with the help of radiation detector. It was observed that no radioactivity had been found in the irradiated samples of quartz.

***Keywords: Quartz; irradiation; coloration. value addition, XRD.***

## 1. INTRODUCTION

Quartz is the second most abundant element in earth's crust. The quartz chemical formula is (SiO2), which naturally occurs in soil, sediments, moon rocks and mars. The ionizing radiation plays an important role in color enhancement of gemstones. Due to irradiation color centers in the crystals are produced which changes the absorption pattern and as a result coloring in gemstones take place [1]. Recently, artificial coloration has gained great importance because of the artificial coloration by which tons of colorless quartz can be turned into gemstones[1, 2]. Quartz minerals are of great value as they are used in various jewellery and cosmetics. The quartz value depends on different factors, such as quality, scale, purity, form, cut and colour. Colored quartz is precious rather than colourless[3]. Figure 1 shows a comparison of the smoky colored quartz.

Figure 1. Smoky, colored quartz type after gamma irradiation.

Keeping in view the socio-economic value, quartz holds a key role in the trade and business industry. Color plays an integral role in the importance of quartz as the value of the quartz depends solely on their attractive and bright colors. Keeping this end in view, various techniques like dyeing, heating and

irradiation are used to change the color of gemstones and making them precious and exotic [4, 5]. By different high energy ionizing radiations many minerals can change their colors.

Gemstones are frequently practiced with gamma irradiation for color enhancement and value addition. Topaz is one of the best examples of most irradiated gemstone for color enhancement and sky blue is the desirable color for the gemstone traders [12]. Electron spin resonance (ESR) spectrometer technique helps us to determine the ages of volcanic material, such as the development of faults and possibly sedimentation, based on various mechanisms[13].

After gamma irradiation, no radioactive elements are produced, but when the intensity of gamma rays is less, then more time is needed to produce similar effects. The use of quite strong Co-60 radiation has shown very good results of color modification for quartz during the last decades. Quartz in its stable form of silica has mainly two gem varieties, Amethyst with its violet and Citrine with its yellowish-brown shades of color. But since a few years, other varieties appeared in the market like “Greengold” or Lima quartz, the “Champagne” or “Beer” colored, and these new colors have increased the use of quartz for jewelry purposes and aroused new interest in the properties of this mineral [13].

In luminescence studies, quartz is used as natural dosimeter has much of applications such as verification of authenticity of works of art, dosimetry of nuclear accidents, monitoring of food irradiation and dating of archeological materials and sediments. For characterization of quartz, quartz is characterized on the basis of dose response and preheat related to the structure of its mineral [14,15].

## 2 Results and discussion

### 2.1 XRD Analysis of Quartz

The Quartz crystal structure lattice was investigated using XRD technique. The major peak was identified using JCPDS-ICDD (2001) PDF#8169 software data. The background and alpha-2 radiation present in the XRD pattern was earlier reported by Joseph R. Smyth. We then studied both the new and irradiated quartz with XRD which is given in Figures 3a and 3b. Although the literature study suggests that no structural changes occur when they were irradiated by high gamma-doses [16]. All diffraction peaks identified in this study (Figures 3a and 3b) are well matched with its signature SiO2 peaks. Measurements for X-ray diffraction display that $SiO_2$ has hexagonal crystal structure. Different impurities were also reported with the help of XRF technique [11]. The following Figures 3(a) and 4(a) show the XRD pattern of quartz before and after irradiation.

The XRD spectra of quartz display prominent peaks of $21^0$ to $53^0$ of the 2θ (degree) angle and indicates structure of $SiO_2$ which matched PDF# 8169. The comparative analysis of XRD pattern of fresh and irradiated quartz samples show small changes in characteristics peaks and intensities. These changes may consider as transition change in the phase of silica.

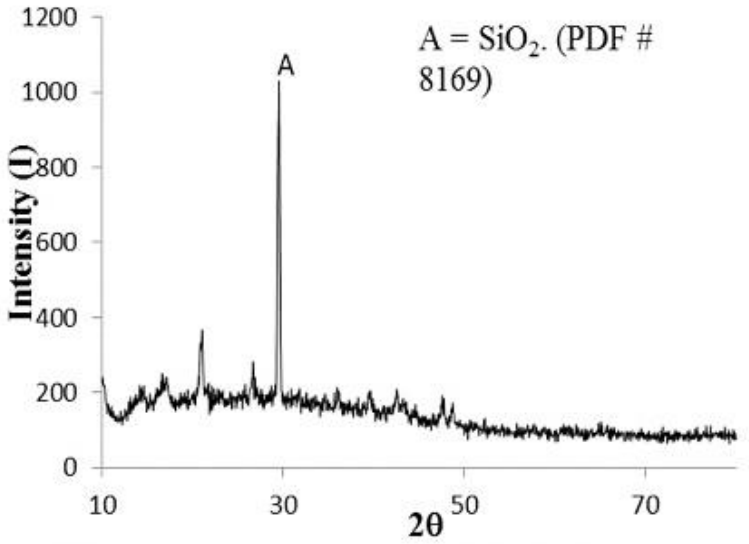


Figure 2 (a). Powder XRD pattern of quartz before irradiation.

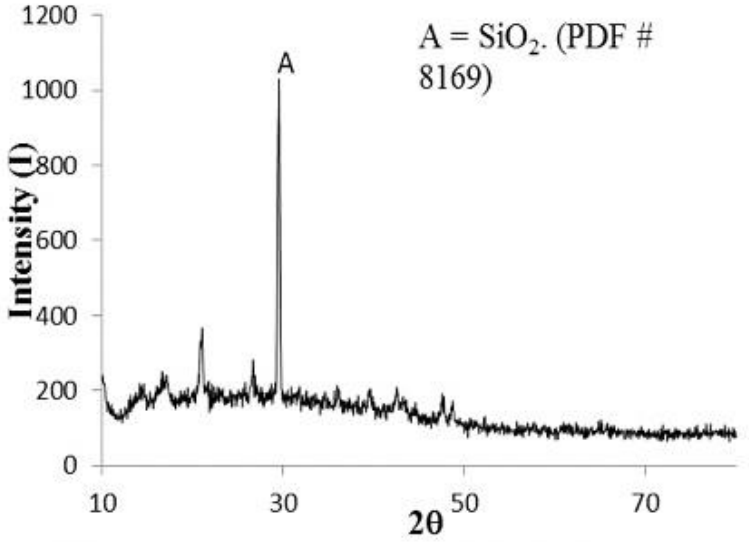


Figure 2 (b). Calculated power XRD pattern of quartz after irradiation.

### 2.2 EDX Analysis of Quartz

For weight proportion and atomic percentage of the various elements present in quartz, the EDX study of fresh and irradiated samples was performed. It is clear from Figure 4 that fresh and irradiated quartz has maximum oxygen proportion backed by silicon and total carbon quantity. Comparative analysis of samples showed that before and after treatment no improvement in the elemental composition was noted.

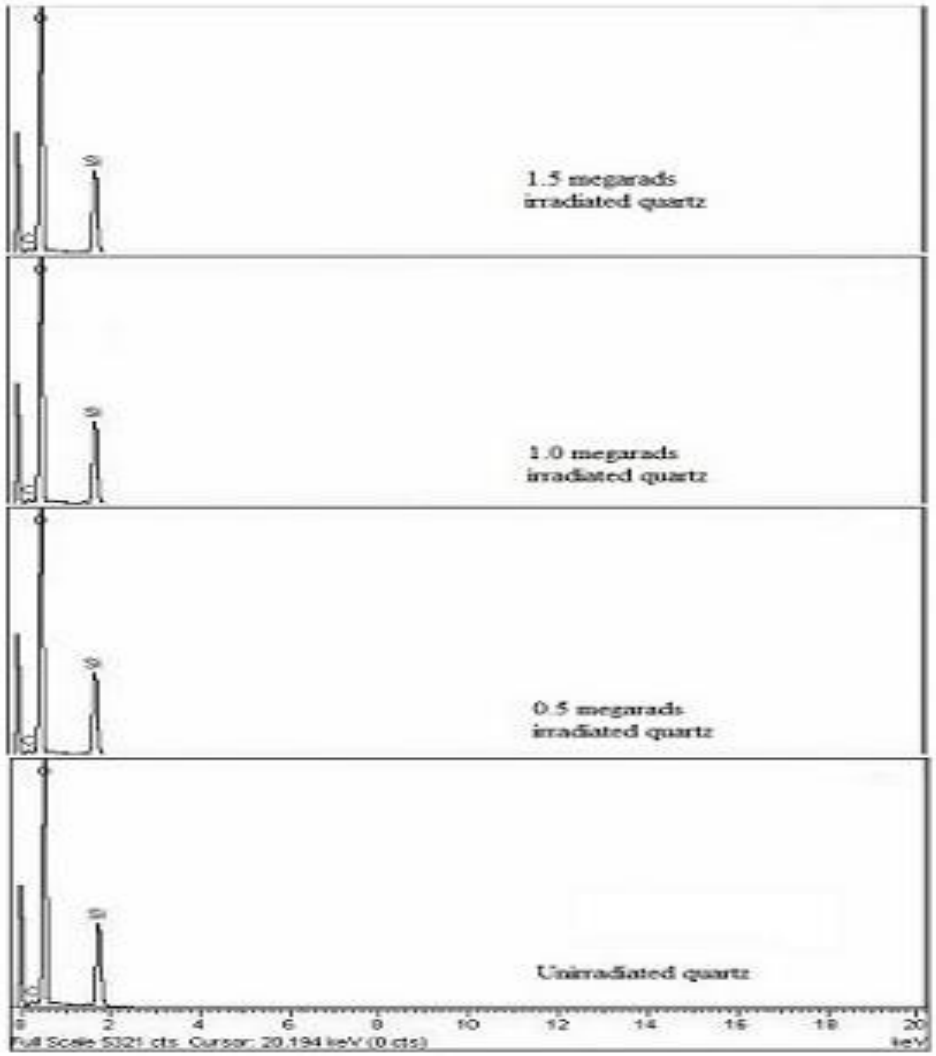


Figure 3. Smoky colored from of Quartz after gamma irradiation.

## 3.Conclusions

Optimize dose for the color enhancement of quartz is 1.5M Rad. XRD data successfully identify the quartz and a secondary phase is observed after gamma irradiation. EDX data shows that nochange has been occurred in the composition (Wt. %) of the quartz sample. Heat treatment changes the color from Smokey to garnish quartz up to 200 $^0$C while quartz become colorless between 200 $^0$C to 220 $^0$C. No radioactivity has been found in the quartz sample after gamma irradiation.

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