Analysis of Topaz Gem by Using XRD, SEM and FTIR methods

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Abstract

Topaz was a very rare type of aluminium fluorosilicate mineral gemstone. Chemical formula of topaz was Al_2 (SiO_4) (F,OH).Topaz sample was colourless. Sample of topaz gem was analyzed by using X-ray powder diffraction analysis (XRD) method, scanning electron microscopy (SEM) method and fourier transform infrared (FTIR) Spectroscopy method. Results of XRD method were identified for macrocrystallographic nature such as peak location and lattice contents of sample. According to the SEM result, the morphology of the Fluo-silicate of Aluminium structure (topaz) was found. Surface morphologies of the polished samples and microstructures of the grains were observed. The FTIR result can be found hydrogen bonding in topaz-OH, Al_2 (SiO_4) (F,OH).

Keywords: Topaz gem, XRD analysis, SEM method, FTIR Spectroscopy method

Introduction

Topaz was discovered over 2000 years ago, and the most common colour of the gem. Topaz was found in many locations worldwide where rocks like pegmatite and rhyolite were formed. Topaz was amethods of colour enhancement are widely used for colouring this mineral. Today, blue colour was obtained by cobalt diffusion due to drawbacks in existing colouration methods. Brownish topazes are the most popular varieties in the jewellery trade. Blue topaz are often the result of irradiation on some colourless or pale blue topaz. The colours of irradiated blue topaz were permanent. X-ray Diffraction (XRD) observed one to reach the science at atomic scale in the analysis of crystal structure, chemical composition and physical properties of bulk and thin film crystalline or polycrystalline materials. Semiconductor industries use XRD to know crystallite size, lattice strain, chemical composition, and crystal orientation. FTIR analysis was an analytical technique used to identify organic, polymeric, inorganic materials and uses infrared light to scan test samples and observe chemical properties. Chemical analysis, infrared absorption spectra, and Raman peaks of diffused and non-diffused topaz were tested. It was useful in helping to separate a number of natural gemstones from their treated counterparts, including various sapphires, emerald and jadeite. Scanning Electron Microscopy (SEM) is a test process that scans a sample with an electron beam to produce a magnified image for analysis. SEM is preferred for particle size analysis is due to its resolution of 10nm, that is, 100Å. The SEM micrographs can give a direct view on densification, which is a very informative feature of the technology used for the fabrication of pottery.

Characteristics of Topaz

One of the test-known physical properties of topaz is its hardness. It has a hardness of 8 on the Mohs hardness scale. Diamond, corundum, and chrysoberyl are the only commonly-known minerals that are harder. Topaz forms orthorhombic crystals, often with striations that parallel the long axis of the crystal. It also has a distinct basal cleavage that breaks perpendicular to the long axis of the crystal. Chemistry compound is fluo-silicate of aluminium

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(Al_2 (SiO_4) (F,OH)).Crystal system is orthorhombic system. Refractive Index is between 1.61 and 1.623. Specific gravity is between 3.53 and 3.56. Lustre is vitreous. Most topaz is colorless or milky. Natural pink, orange, red, purple, and blue topaz are rare and valuable if they are of gem quality. It is enhancement by irradiation, surface coating, surface modification, dying, and heat treatment for coloured varieties only. Among them, irradiation is the most common method used to obtain blue topaz where colour centers were produced by exposing topaz either to gamma rays or neutrons or electrons, followed by low temperature heating. Barzil was the leading sources of gem-quality topaz today. Sri Lanka was another important producer .Topaz was also produced in Nigeria, Australia, Pakistan, Russia, India, Zimbabwe, Madagascar and Namibia.

Sample Collection and Experimental Process

The topaz sample was collected from local market. The sample is colourless and brilliant full cut form. To obtain powder about one gram was manually crushed at Universities Research Center (URC). Topaz sample was measured by using X-ray powder diffraction analysis (XRD) method, scanning electron microscopy (SEM) method and fourier transform infrared (FTIR) Spectroscopy method.

Figure 1. Colourless Topaz sample

Results and Discussion

XRD result

The results of sample obtained from the XRD analysis data was expressed the following figure(2). The phase of macrocrystaline sample was investigated by powder XRD analysis. The obtained peaks of the sample was well matched of the standard library file aluminium fluorosilicate (Al_2 (SiO_4) (F,OH)) and Fluorite(CaF_2). It was found that, the Al_2 (SiO_4) peaks were main phases and (CaF_2) peaks were secondary phases. Fluorite compound was included (Ca F_2). Some of the background patterns were also observed. The crystal structure was orthorhombic through the new lattice calculation from peak locations and Miller Indices. The XRD pattern was found that the most intense peaks were (112) at 30.564 of Two-Theta value and (250) plane at 66.7134 of Two-Theta value. Main phase of plane,(120) and secondary phase of plan,(111)were found that the conside phase at 28.0556 of Two-Theta values at XRD pattern. And other main phases planes (232),(062) and secondary phases planes (311),(400) were also conside at 55.0253 and67.7640. of Two-Theta value.

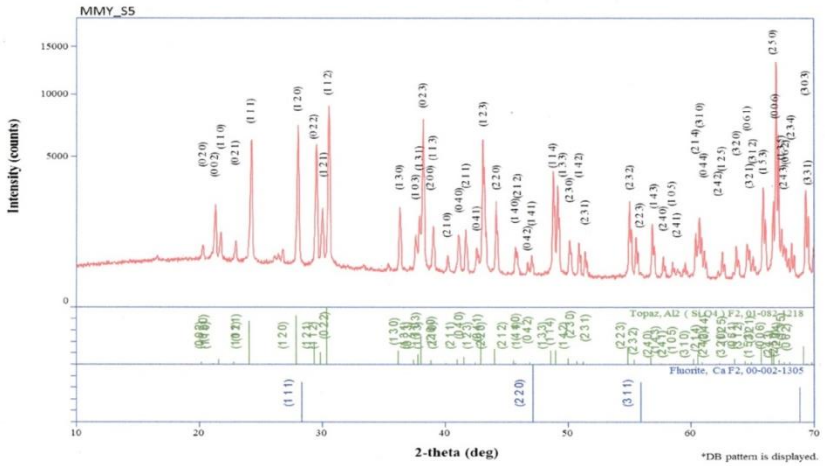

Figure 2. XRD pattern of the showing presence of various phases.

SEM result

The SEM result was shown in following figure(3). Scanning electron microscopy (SEM) was employed for the investigation of surface morphological features and grain size of the sample. SEM patterns were formed a compact interlocking rock structure of surface of sample. Grain size of figure was between 5 and 1.0 μm. Microstructure of sample was homogeneously mixed with clay.

FTIR result

The infrared absorption spectrum of topaz was an analytical method to find out the occurrence of hydroxyl groups. In the spectrums, several Raman shifts were clearly visible. Hydrogen bonding in topaz-OH, Al_2 (SiO_4) (F,OH), was investigated by IR spectroscopic analysis of the temperature dependence of the OH-stretching frequencies. In colourless topaz, the shifts were appeared at 3713.09, 2989.76, 1813.15, 1728.28, 1435.09, 1381.08, 1168.90, 1084.03, 875.71, 619.17 and 451.36cm^{-1}levels. The IR spectrum of F-topaz a strong peak was found at 3450 cm^{-1}level and a weak shoulder was found at 451.36 peak. The IR spectrum of topaz-OH can be found between 3600-3400cm^{-1}region. Figure 4 shows FTIR spectra recorded.

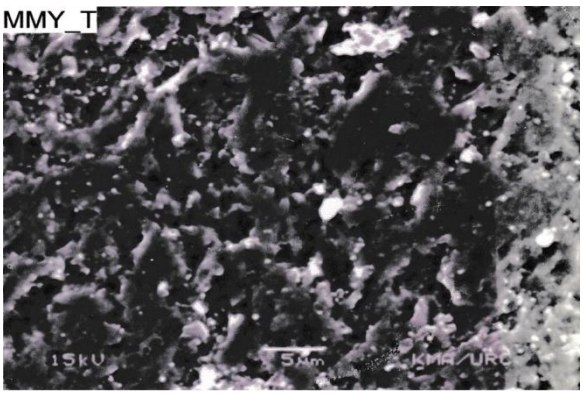

Figure 3. SEM result

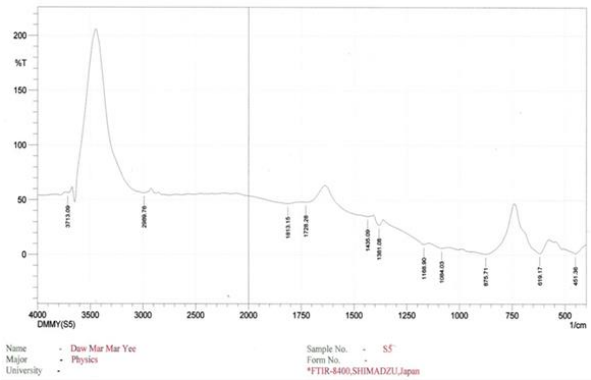

Figure 4. The FTIR spectrum of Al_2 (SiO_4)(F,OH)

Conclusion

Topaz sample analyzed by XRD, SEM and FTIR methods. The XRD analysis clearly showed that the investigated topaz sample was aluminium fluorosilicate and orthorhombic system. Chemical composition was Al_2 (SiO_4) (F,OH) and Fluorite(CaF_2) were composed of

different phases. The XRD result was found that there were the differences of peak locations and miller indies for the sample. The SEM result was shown in interlocking rock structure and grain size. The FTIR result can be found hydrogen bonding in topaz-OH, Al_2 (SiO_4) (F,OH). It was useful to enhanced for gems. Topaz is a well-known gemstone sold in a wide variety of attractive colours. Some of these colours were natural, while others were produced by treating pale or colourless topaz with heat, radiation, or metallic coating. However, compared to a similar natural stone in colour and clarity, the enhanced stone will typically have a higher value.

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