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PURIFICATION OF TABUK SILICA USING CHEMICAL ATTACK AND THERMAL TREATMENT

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We investigate a purifying process of silica which plays a critical role as a starting material in the industry of glass and high-grade silicon. This method is a subsequent combination ofthermal treatment and acid leaching. First, Tabuk natural sand samples were submitted to rapid thermal annealing in an infra-red furnace under O_2atmosphere at fixed temperature900 °C during 1 h (to weaken impurity –Si bands). Subsequently, the samples were soaked in an aqueous acid solutioncomposedof hydrofluoric acid and nitric acidconcentration. This last acid leaching step was intended to remove the gettered impurities during the annealing step.Chemical compositions of the treated samples were analyzed by energy-dispersive X-ray diffraction (XRD) and energy dispersive X-ray(EDX) spectroscopy. Surface morphology was determinedby scanning electronic microscopy (SEM). The result indicates that all undesirable impurities in silica were successfully removed.

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1. Introduction

Silica is the natural form of silicon dioxide (SiO_2), which is a white or colorless crystalline compound foundmainly as quartz, sand, flint, and many other minerals.Silicon is the second most abundant element in the Earth’s crust.It’sextracted from the quartz which is a crystalline form of silica [1]. The production of silicon by the thermal reduction of silica with carbon is an industrial process used since the beginning of the 20 century [2,3].Unluckily, the silicon produced using this method contains many undesirable impurities that limit its use in a photovoltaic application which remains a key issue for industrial production[4,5]. Many work try to purifying the Silica to produce high purity silicon with different techniques such as Acid leaching technique [6], ultrasound process with surface cleaning, reserve flotation technique, and carbothermic reduction[7]. Khalifa and al proposed an innovative technology using thermal treatment and acid leaching process that leads to a reduction in all metallic impurities improving the purity in silica from 99.7% to 99.9%[8, 9].

In this study, we used a combined treatment based on a chemical attack by HF and HNO_3 followed by thermal heating to improve the quality of purified silicon.

The structural property of the sample wasexamined using energy dispersive X-ray diffraction (XRD), energy dispersive X-ray(EDX) spectroscopy,and surface morphology by scanning electronic microscopy (SEM).

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2. Experimental

In this work, we report on a process of silica purification intended to be used in photovoltaic applications. Silica powders used in this study as the starting material are natural sand from the region of Tabuk in Saudi Arabia. Before purification process samples were ultrasonically cleaned for 10 min in deionized water, alcohol, successively, and then dried in air at room temperature. Therefore,after the cleaning process, samples were purified with chemical treatment HF and HNO_3 to remove metallic impurities located at the surface of silica grainsfollowed by thermal heating at in infrared furnace at a temperature of 900 ◦C.

Chemical composition of the treated samples was analyzed by energy-dispersive X-ray (EDX) spectroscopy and dispersive X-ray diffraction (XRD),and the surface morphology by scanning electronic microscopy (SEM).

3. Results and discussion

3.1. Energy dispersive X-ray (EDX)

The energy dispersive X-raytechnique was used to identify the elemental composition of silica. Fig.1 (a) and (b)shows EDX spectra for untreated Silicaand purified Silica, respectively. The chemical composition of the silica before purification (red sand) Fig. (1.a) shown that many undesirable impurities were present with different concentrations likeMagnesium (Mg), aluminum (Al), Irons (Fe), and Calcium (Ca) [10,11].Whereas it can be seen fromFig. (1.b) (white sand) that these undesirableimpurities are successfully eliminated after purificationprocesses. These metal impurities introduce deep levels in silicon, recombining the minatory carriers, making their diffusion length decrease, and impacting the solar cell efficiency.

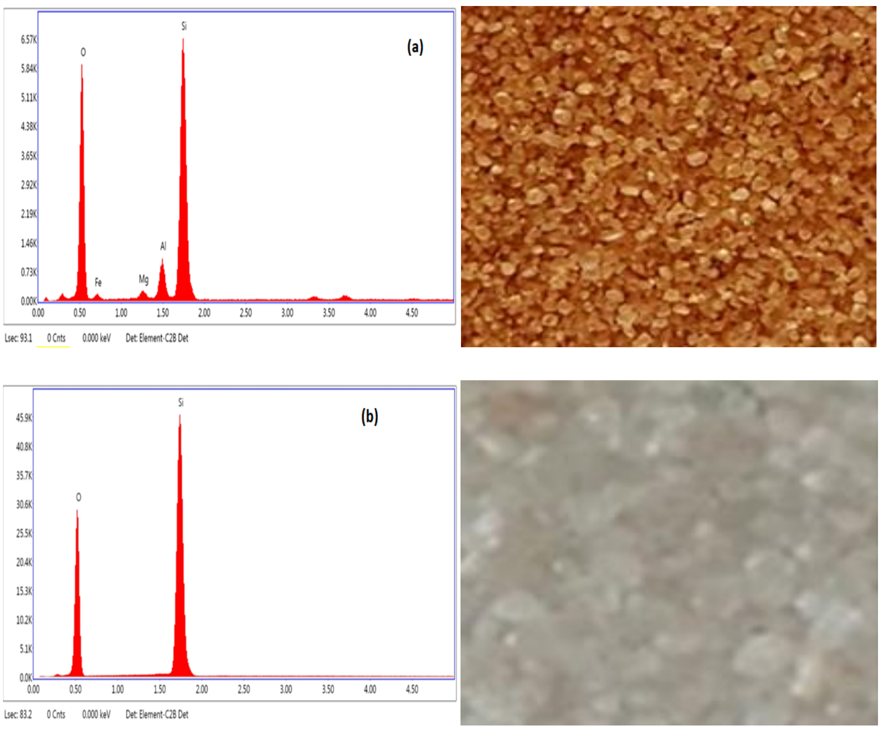

Fig.1.EDX spectra and photograph (a) untreated sand and (b) purified sand.

3.2.X-Ray diffraction

The structural property ofthesample was examined byX-Ray diffraction XRD technique using a Bruker D8 advance X ray diffractometer with Cukα radiation ($\lambda_{Cuk\alpha}$ = 0.15406 nm) operating at current and tension of 40mA and 40kV, respectively. The pattern before purification shows the presence of two phases rhombohedra (Card no. 00-024-0072) [12] and hexagonal (Card no. l00-046-1045) which are specified for hematite and quartz with a lattice parameter of an axis about 5 (Å),b axis 5 (Å), c axis 13,7 (Å) respectively. The alpha-beta and gamma were 90 degrees and 120 degrees (Fig 2.a) calculated fromas well as, the pattern visualizes the appearance of the most common peaks related to SiO_2 at2θ = 20.52º and 26.86º, besides the peaks related to other impurities like Fe_2O_3 and Al_2O_3. However, after purification,the pattern (Fig. 2, b) shows the existence of the SiO_2 peaks only which means the excellent purification of the sand. The crystal phase of this type of silica hexagonal with a lattice parameter of a-axis about 4.9 Å, b-axis- 4.9 Å, and c-axis 5.4 Å respectively[13]. The alpha, beta, and gamma were 90, 90 and, 120 degrees, respectively. As well as the calculated density 2,65 g/cm^{3}and the volume of cell 113,01*10^6 pm^3.

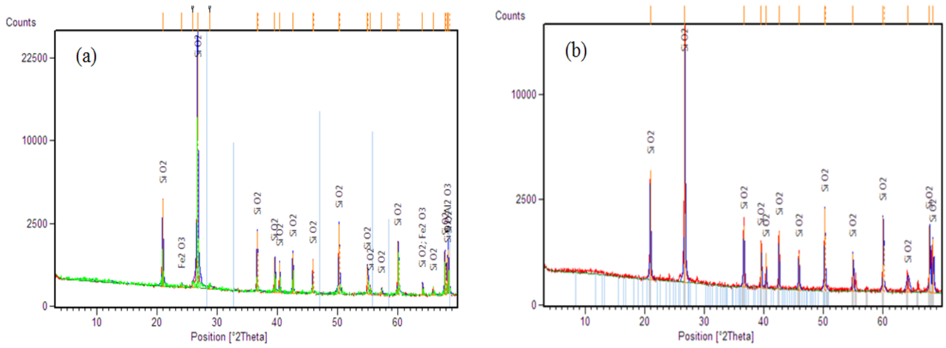

Fig.2. (a) XRD spectra untreated sand and (b) XRD spectra purified silica sand.

3.3.Scanning electronic microscopy:

Fig (3.a) shows scanning electronic microscopy images forsilica surfacemorphology extracted before the purification process. The micrograph is observed to show the agglomeration of silica with irregular particle shapes, which varies in sizes and forms. We can notice from Fig (3.b) for thepurified silica,that the size of the silica particle decrease and the form of particle changes after purification process which can be explainedby step1:the thermal annealing and step 2: acid leaching effect.The first purification step leads to agettering of impurities from the volume to the surface by rapid thermal annealing and the second one (the chemical step)aims to remove metallic impurities located at the surface of silica micro-grains [8]

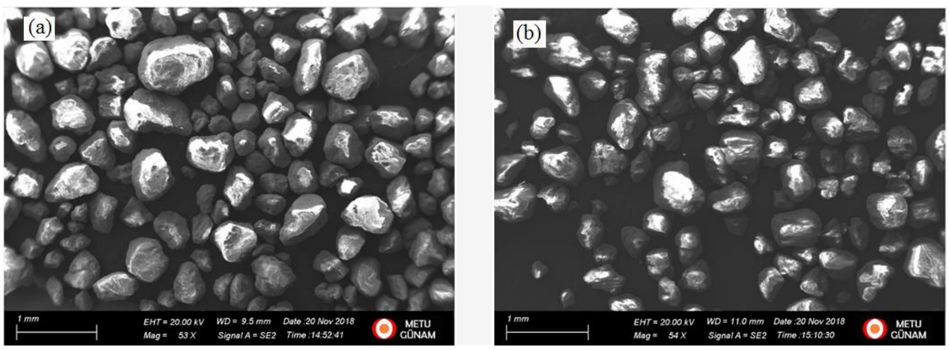

Fig.3.SEM images (a) untreated silica and (b) purified silica.

4. Conclusions

We have studied a purifying process which is a combination of thermal treatment and acid leaching. First, samples of Tabuk natural sand were submitted to rapid thermal annealing. Subsequently, the samples were soaked in an aqueous acid solution.The structural property of simple was examined by X-Ray diffraction.The patternvisualizes the appearance of the most common peaks related to SiO_2 at$2\theta = 20.52^o$ and 26.86^o, besides the peaks related to other impurities like Fe_2O_3 and Al_2O_3.However, after purification, the pattern shows the existence of the SiO_2 peaks only which means the excellent purification of the sand.EDX characterizations show that the purification process removedalmost major impurities(Fe, Ca,AL, and Mg).We conclude that this purification's method is very interestingto produce high purity silicon.

Acknowledgments

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