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Chemical Synthesis of High-Purity Silica from Algerian Diatomite for Photovoltaic Applications

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INTRODUCTION & AIM

High-purity silica is essential for advanced technologies, especially for producing solar-grade silicon used in the photovoltaic industry. Algerian diatomite is a promising natural source of SiO_2 due to its abundance and porous structure, but it contains metallic, carbon-based, and amorphous impurities that limit its direct use. Effective purification is therefore required to meet the high purity standards needed for solar applications. This study aims to develop a simple and cost-effective alkaline treatment using 4 mol/L NaOH to remove impurities and improve the crystallinity of the material. The purification efficiency is assessed using XRD and XPS analyses to monitor structural and chemical changes. The overall goal is to produce high-purity silica from a local natural resource, supporting the development of materials suitable for the photovoltaic industry.

METHOD

In this work, we analyzed the elemental composition of diatoms using both untreated and chemically treated diatomaceous earth samples. Two types of samples were prepared: raw diatomite and diatomite purified using a sodium hydroxide (NaOH) solution.

- **Chemical Treatment**

A suspension was prepared by mixing diatomaceous earth powder with a 4 mol/L NaOH solution. The mixture was heated at 100 °C for 1 to 2 hours to allow the alkaline attack to dissolve impurities.

- **Washing Step**

After the treatment, both raw and treated samples were thoroughly rinsed several times with distilled water until a neutral pH was reached, ensuring the removal of residual NaOH.

X-ray diffraction measurements were performed using a Shimadzu LabX XRD-6000 diffractometer equipped with CuKα radiation (λ = 1.54059 Å). Diffractograms were recorded in the 2θ range of 20°–80°, with a step size of 0.02° and a scan speed of 2°/min, allowing the identification of crystalline phases.

X-ray photoelectron spectroscopy (XPS) was carried out using a system equipped with a monochromatic Al Kα source (1486.6 eV) and variable spot sizes from 30 to 400 µm. A hemispherical analyzer combined with multi-channel detectors was used to investigate the surface chemical composition and impurity levels

RESULTS & DISCUSSION

XRD Analysis

Figure 1 shows several characteristic diffraction peaks indexed as (011), (110), (111) and (012), corresponding to different crystal orientations. In the treated sample, the most intense peaks appear around 9°, 21°, and 26°, while additional peaks near 28°, 47°, and 56° indicate the presence of iron-, silicon-, and aluminum–silicon–related phases.
In contrast, the raw diatomite shows much weaker peaks, with the main quartz peak (011) reaching only about 1000 units at 2θ = 26.6°, confirming quartz in both samples. After NaOH treatment, the peaks at 9°, 21°, 26°, and 28° become more pronounced, and a new peak at 2θ = 47° appears, attributed to a silicate phase formed during the alkaline treatment.

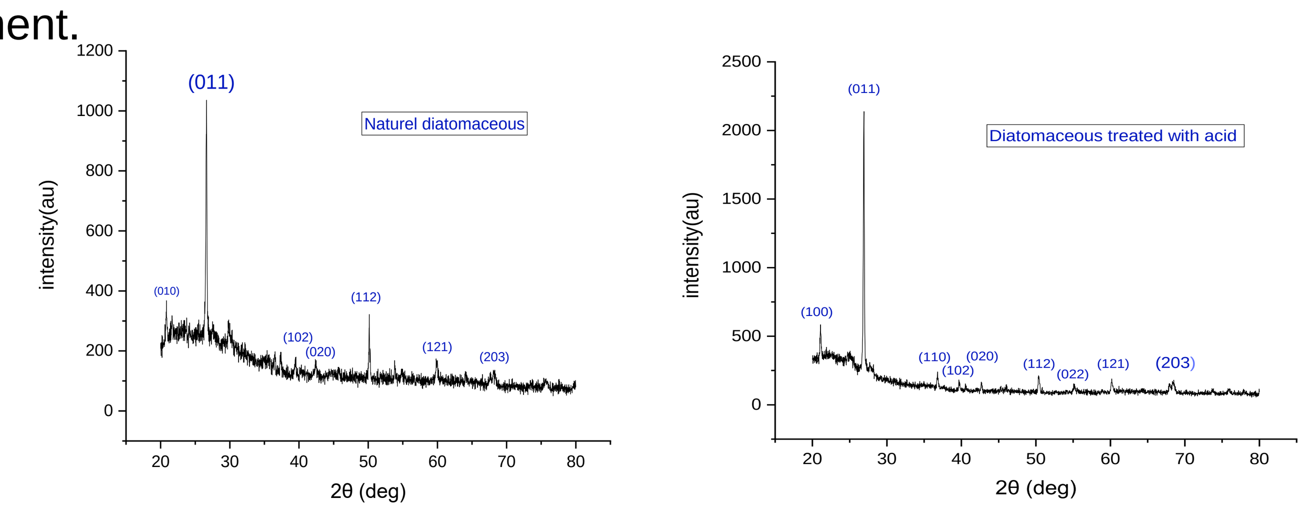

Figure.1 XRD pattern of natural diatomite and diatomite treated with NaOH

XPS Analysis

Wide-scan XPS spectra of raw and treated diatomite (Fig. 2)show the surface elements and their chemical states. Four main peaks are observed: Si 2p, O 1s, C 1s, and N 1s. After treatment, the C 1s peak decreases significantly, indicating removal of surface organic impurities, while the Si 2p peak remains unchanged, showing that NaOH treatment does not affect the silica structure.

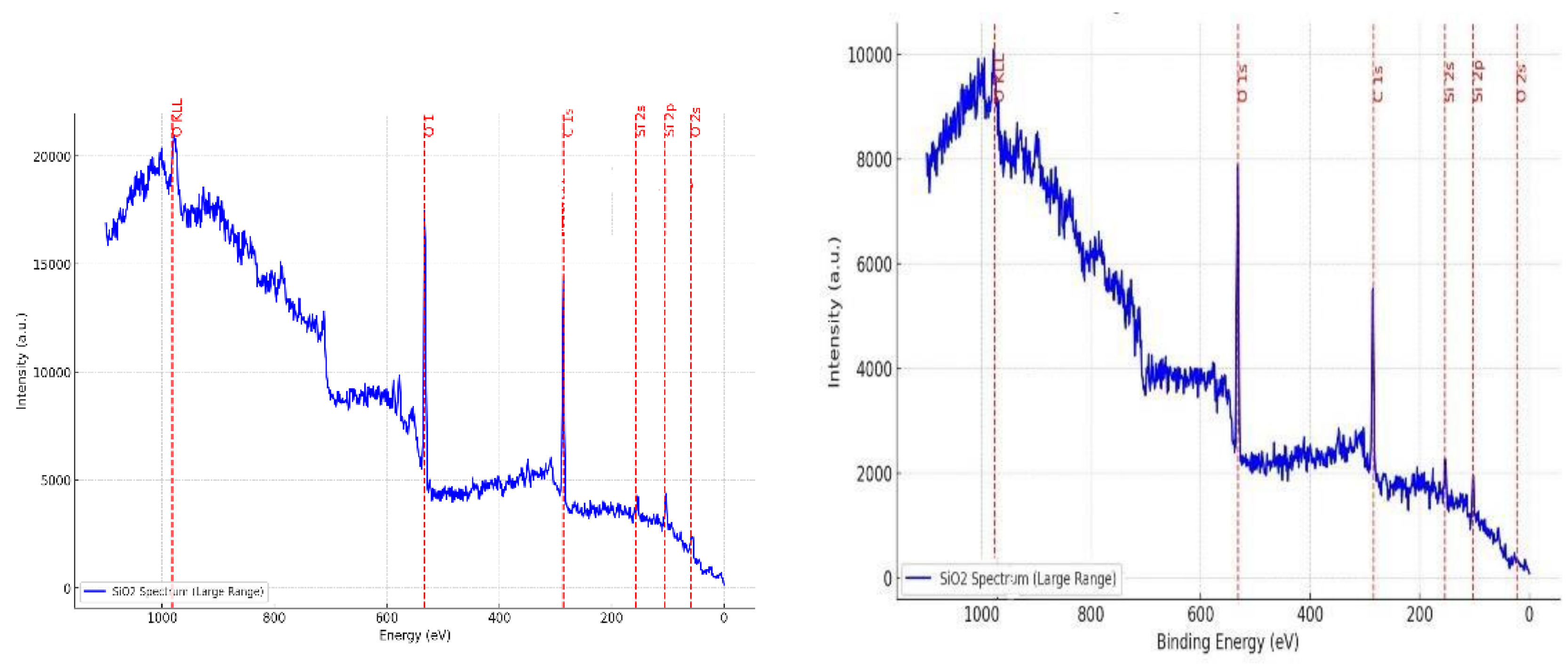

Fig. 2 Spectrum of diatoms natural and chemically treated with NaOH

CONCLUSION

NaOH treatment of Algerian diatomite efficiently produces high-purity silica with improved crystallinity and reduced surface impurities. The SiO_2 structure remains intact, making the material suitable for solar-grade silicon and other advanced applications requiring ultra-clean silica.

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