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Characterization properties and application of moroccan smectite in biomaterials nanotechnology

Abstract

The objective of this work was initially, it was to a new area of research that deals with the materials used in Biomaterials and Nanotechnology ceramic, the second objective was to develop oxide gels high purity from the smectites. We can consider that this dual objective is being achieved since on the one hand we have characterized these smectite; on the other hand we synthesize oxide gels from the same materials. Several techniques were used; in particular X-ray diffraction (XRD), scanning electron microscopy coupled with EDX microanalysis (SEM-EDX), differential thermal and gravimetric analyses (DTA-TGA) and finally infrared Fourier transform (FTIR) and X-ray fluorescence (XRF). The smectite fine fraction (<2µm in size), was characterized by a cation-exchange capacity (CEC) of 73.3 meq/100g.

Keywords: Biomaterials, XRD, (DTA-TGA), (SEM-EDX), FTIR, METHR, smectites, morocco

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A Er-Ramly,[1] A Moustaghfir,[1] W. Reghaghay,[1] S El Hajjaji[2]

[1]Laboratory of Research of Odontological Biomaterials and Nanotechnology, Faculty of Dental Medicne, Mohammed V University, Morocco

[2]Department of Chemistry, Mohammed V University, Morocco

Correspondence: A Er-Ramly, Laboratory of Research of Odontological Biomaterials and Nanotechnology, Faculty of Dental Medicne, Mohammed V University, Morocco, Email a.erranly@gmail.com

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Abbreviations: FTIR, fourier transform infrared spectroscopy; XRD, x-ray diffraction; DTA-TGA, differential thermal and gravimetric analyses; EDX, energy-dispersive x-ray spectroscopy; SEM-EDX, scanning electron microscopy coupled with energy-dispersive x-ray spectroscopy; CEC, cation- exchange capacity; RT, room temperature.

Experimental procedures

The crude clay as well its fine fraction (less than 2µm in size), which is isolated by sedimentation following the experimental procedure have been investigated by means of X-ray diffraction (XRD), thermal analysis (DTA and TGA), Infrared spectroscopy (IR), Fluorescence X (FX), Scanning electronic microscopy (SEM-EDX).

Results and discussion

Analysis XRD X-RAY

Associated Minerals

In some favorable cases, the associated minerals in the smectite can be identified by their main peaks. Thus, as shown in the diffractogram presented in Figure 1 on the raw smectite of Nador can easily identify: the montmorillonite (smectite) Symbolized by Mt, Feldspar symbolized by F whose main peak is located around 27.7°, magnetite symbolized by M, whose main peak is located at 35.5° and an amorphous iron oxide in the form of scales (Figure 1).

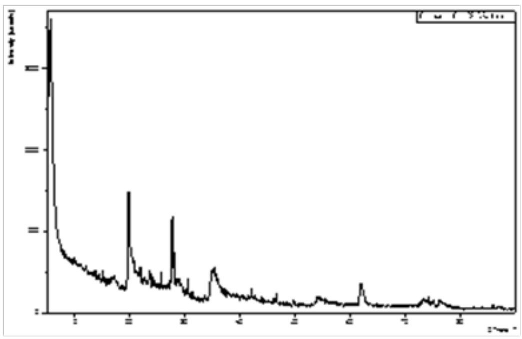

Figure 1 X-ray diffraction of powder smectite.

Analysis by SEM-EDX and XRF

EDX microanalysis shows at a first look qualitatively the structural elements of clay, namely silicon, aluminium, elements of substitution of aluminium (Mg^{2+}, Fe^{3+}) and oxygen, and the interlayer cation. Once these elements are characterized, it is important to measure them quantitatively and qualitatively. X-ray fluorescence (XRF) of sediment fine (0-2µm) smectite shows a significant percentage of silicon oxide (SiO_2) and aluminum oxide (Al_2O_3), and a low percentage K_2O and CaO which approves that it is a smectite which belongs to the families of montmorillonite (Figure 2).

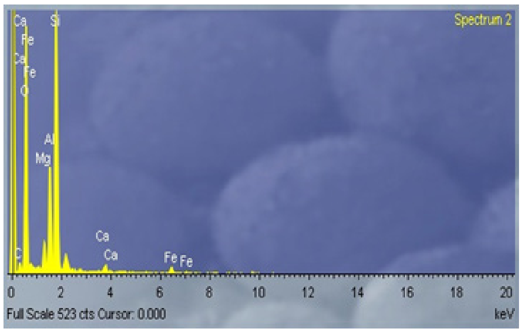

Figure 2 Energy spectrum of the particle analysed.

Thermal analysis

This is primarily a complementary method to X-ray diffraction. TGA-DTA is very useful, especially in the case of clay group characterization. Firstly the weight loss recorded in the thermo-gravimetric analysis weight of gross smectite involves four steps as shown in Figure 3, a first loss between 25°C and 110°C, a second between 110°C and 630°C, the third between 630 °C and 830 ° C and the fourth between 830°C and 1000°C (Figure 3).

Infrared analysis

The infrared absorption spectrum of smectite sedimented and degassed at different temperatures (in air, room temperature (RT) and 250°C, 400°C for 2h and 615°C for 1 h (Fig. 4) shows: Two absorption bands in the region 3421-1636 cm^{-1} due to water molecules, bands occurring at 3646 cm^{-1} correspond to Al_2OH stretching vibrations of smectites , Absorption bands in the region 1200-1000 cm^{-1} due to SiO group corresponding to the tetrahedral environment of the inner layer TOT, Three absorption bands in the region 1000 - 800 cm^{-1} due to isomorphic substitutions of Al-MOH type corresponding to the internal environment of the octahedral layer TOT where M can be Al, Fe and Mg. Two absorption bands in the region 600-400 cm^{-1} due to isomorphic substitutions TOT type corresponding to the tetrahedral environment of the inner layer TOT where T can be Al, Si (Figure 4).[1-10]

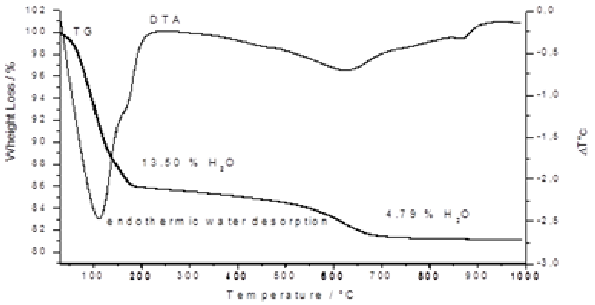

Figure 3 Curves of differential and gravimetric thermal analyses of raw smectite.

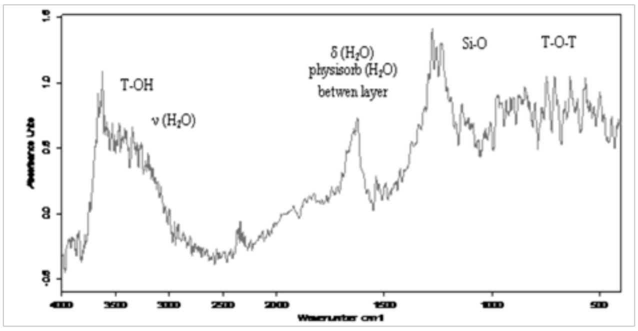

Figure 4 Infrared spectra of raw smectite.

Conclusion and perspective

It is in this kind of study that thermal analysis provides invaluable assistance to the X-ray diffraction. Indeed, the thermal study of smectite of northern Morocco allowed us to have cristobalite to 950°C, This led us firstly to classify the smectite in Wyoming domain,[3] on the other hand, other authors showed that the exothermic reaction located around 830°C is a good criterion to distinguish in the field of montmorillonite.[4] As for the peak located around 790°C, we can attribute it to the amount of iron in the octahedral sites.[5] We recommend this material for use in ceramic biomaterials, since we have characterized it and it has no toxicity with good biocompatibility.

Acknowledgements

None.

Conflict of interest

Authors declare that there is no conflict of interest.

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