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Chemical and Optical Characterization of Sri Lankan Dolomite for Advanced Waste Water Treatment Uses

Suresh Aluvihara[1*], C.S. Kalpage[1], P.W.S.K. Bandaranayke[2], W.M.A.T. Bandara[3]

[1]Department of Chemical and Processing Engineering, Faculty of Engineering, University of Peradeniya, 20400, Central Province, Sri Lanka
[2]Department of Physics, Faculty of Science, University of Peradeniya, 20400, Central Province, Sri Lanka
[3]Department of Chemistry, Faculty of Science, University of Peradeniya, 20400, Central Province, Sri Lanka ladesh

Abstract: Dolomite is a mineral which is having an industrial demand because of the distinct properties of such dolomite including refractory applications and lime products. The chemical characterization of Sri Lankan dolomites based on advanced industrial applications was the major objective of the existing research. The selected dolomite samples were analyzed using X-ray fluorescence (XRF) spectrometer; Fourier transforms infrared (FT-IR) spectrometer and optical microscope. The major outcomes of the investigation showed 99% of Ca with trace amount (<1%) of potassium according to the X-ray fluorescence (XRF) results, higher calcite content with lower dolomite content according to the Fourier transform infrared spectroscopic (FT-IR) results, massive and tabular crystals including colorless crystals, white crystals and reddish crystals according to the microscopic analysis. Therefore, it is possible to recommend these dolomites for some more advanced industrial applications such as an adsorber for dissolved metals in waste water, softening material for water and recovering material for some organic and inorganic compounds because of the adsorption capacities of both calcite and dolomites for some metals and some other compounds such as the salts.

Keywords: *Dolomite; FT-IR characterization; XRF characterization Microscopic analysis; Water treatment uses.*

Introduction: Dolomite is a mineral which is belonged to the mineral group of carbonates. This mineral is usually found as a part of dolomite rocks or dolomitic marbles in hydrothermal veins also associated with magnesite, calcite and some other minerals at some specific locations around the world. Among the identified deposits of dolomitic rocks, the Matale area in Sri Lanka is well known region for dolomitic rocks. The characterization and confirmation of the quality of dolomite mineral are the important role in technological aspects. Some of common industrial uses of dolomites are as follows [1-6].

- Refractory materials
- Products of lime

Some typical characteristics of dolomites are given in the Table 1 [5-12].

Table 1. Characteristics of dolomite.

Characteristic	Description
Chemical formula	$CaMg(CO_3)_2$
Color	Colorless, white, pale brown, grayish white, reddish white, pink, greenish white, pale black
Streak	White
Luster	Vitreous, pearly
Hardness	3.5
Magnetism	None
Density (gcm-3)	2.9
Diaphaneity	Transparent, translucent
Tenacity	Brittle
Cleavage	Non-evident
Crystal system	Trigonal
Reaction with diluted hydrochloric acid	Fizzes

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Corresponding author details:
E-mail address: sureshaluvihare@gmail.com
Tel: +94758578194

According to outcomes of the past researches, there were realized the advanced industrial uses such as the water treatment applications and recovering material for some specific components [1-6].

In the most of researches, it was highlighted the advanced chemical characteristic namely as adsorption which is useful in the most of water treatment applications of dolomites and some of other solid materials such as clays, activated carbons [1-8].

Adsorption is a chemical process which is occurred on the surface of some solid material that attaching of some foreign component of a liquid or gas on the solid surface due to the electrostatic forces between such solid material and some specific components in the relevant gas phase of liquid phase. Usually the process of adsorption is defined with their components as given in the below [1- 9].

- Adsorbate – The detaching compound from the gas phase or liquid phase.
- Adsorber - Solid material that provides the surface for the attaching of foreign components.

Since the process of adsorption is a surface based phenomenon, the surface area of the adsorber plays a huge role in the progress of the adsorption activity. However, the adsorption capacities of solid materials (adsorbers) are varied with the chemical composition of both adsorber and adsorbates. The most of research results showed that the higher adsorption capacity of carbonate minerals in the removal of heavy metals from waste water and recovering of metals from some liquids [1-11]. Sri Lanka is a country that rich in most of well known industrial minerals including dolomite, calcite, graphite and a series of gem minerals. Also according to the availability and distribution of the resources in Sri Lanka, it is possible to observe some different characteristics from such mineral resources. Matale region is a famous location for the dolomite rocks and those dolomite rocks are currently using in following industrial purposes.

- Ceramic industry
- Terrazzo industry

The development of such dolomite rocks for some advanced industrial applications is an essential factor for the modern world because it is possible to find some specific characteristics from such dolomite rocks under the advanced analysis.

In the existing research, it was expected to chemical characterization of the dolomites that available in Matale region, Sri Lanka for most of advanced industrial uses such as the more water treatment uses, recovery material and air purification material apart from their current applications.

Materials and Methodology: The dolomite samples were collected from a dolomite crushing plant near by the Matale city in Sri Lanka. It was confirmed that the dolomite samples had not been contaminated with some chemical or some other solutions. One of the collected dolomite sample is shown in the Fig. 1.

Fig. 1: Crushed dolomite sample.

The selected portion from the collected dolomite samples was oven-dried at for 24 hours while maintaining the temperature 105^0C-110^0C [1, 2, 7, 8, 9].

The dried dolomite chips were crushed using a ceramic crucible and the finer portion (<0.075) was selected using a sieve of 0.075mm. One of the powdered dolomite samples is shown in the Fig. 2.

Fig. 2: Powdered dolomite.

Three of powdered samples were prepared from the dolomite chips following above methodology.

The final representative dolomite sample was selected from each powdered dolomite portions using coning and quartering method for each of analysis as shown in the Fig. 3.

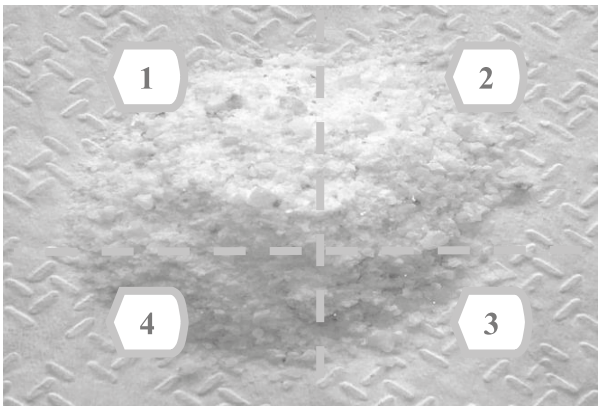

Fig. 3: Coning and quartering method.

Coning and quartering is typically applicable in the selection of a representative portion from a bulk of solid materials such as clays and sands. According to the limitations of definitions of the coning and quartering method, the final representative sample should be the integration of any two quarters which are exiting along a same diagonal.

Three selected dolomite samples were allocated for in order of the analysis of X-ray fluorescence (XRF) spectrometer, Fourier transforms infrared (FT-IR) spectrometer and Optical microscope based on the analysis of following characteristics.

- X-ray fluorescence (XRF) spectrometer- Analysis of the elemental composition of dolomite (metallic elements)
- Fourier transforms infrared (FT-IR) spectrometer- Analysis of the functional groups and types of bonds
- Optical microscope- Analysis of the colors and crystal shapes
- The photographs of the used analytical instruments are shown in Fig.4, Fig. 5 and Fig. 6.

Fig. 4: X-ray fluorescence (XRF) spectrometer.

Fig. 5: Fourier transforms infrared (FT-IR) spectrometer.

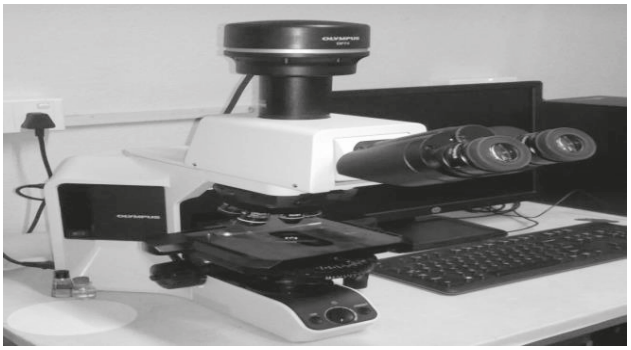

Fig. 6: Optical microscope.

Results and Discussion: According to the obtained results, the elemental compositions of dolomites are interpreted in the below.

The X-ray fluorescence (XRF) spectroscopy of dolomite is shown in the Fig. 7 and the elemental chemical composition of dolomite is shown in the Table 2.

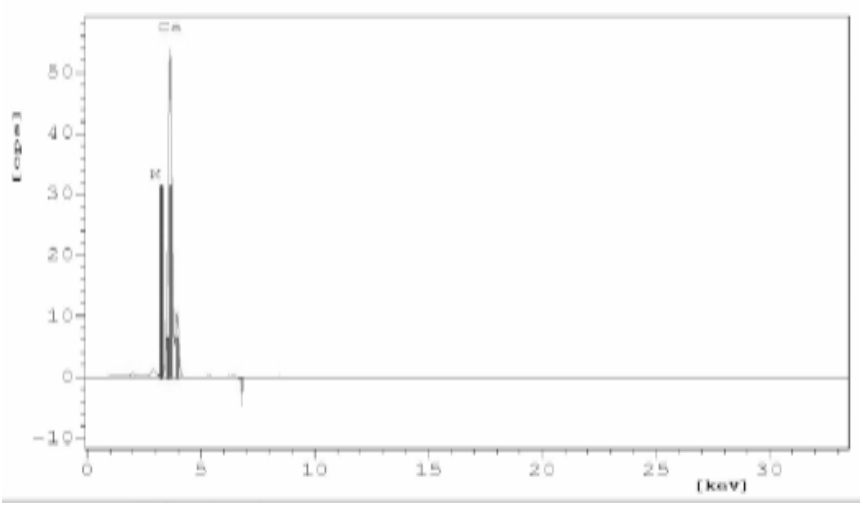

Fig. 7: X-ray fluorescence (XRF) spectroscopy of dolomite.

Table 2. Elemental composition of dolomite.

Color	Atomic Number	Element	Content (%)
	20	Calcium	99.46
	19	Potassium	0.54

According to the observed results for the analysis of dolomite using X-ray fluorescence (XRF) spectrometer, the majority of Ca was obtained in such dolomite as >99% of Ca with trace amount of K in such dolomite samples. Usually the Ca is presented in dolomite or calcite samples in the forms of CaO and $CaCO_3$. Therefore these dolomite rocks may have the following advanced characteristics [1, 3, 4-11].

- Ion exchanging capacity – Ca^{2+} is a good exchangeable ion for some other undesirable ions such as the toxic ions.
- Heat resistant capacity – CaO is a strong material against some of huge heat transferring environments.
- Adsorbent – $CaCO_3$ is a good adsorber for some of heavy metals.

In the further describing of the elemental composition of this dolomite rocks, it was not detected the most important element Mg which is a major element that found in dolomite.

However the content of Mg in the existing dolomite samples would be ultra trace amount when comparing with other elements because it was not detected as an element in the existing experiment [1, 3,4].

The Fourier transform infrared (FT-IR) spectroscopy of dolomite is shown in the Fig. 8 and the assignment of such graph is given in the Table 3.

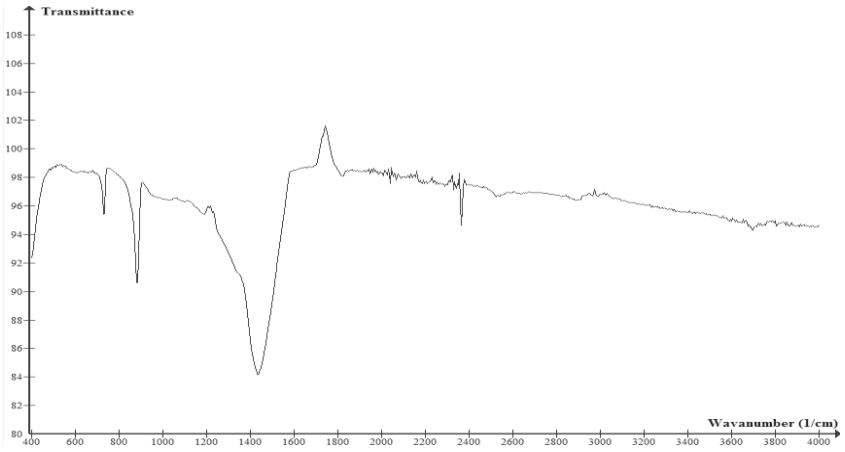

Fig.8: Fourier transforms infrared (FT-IR) spectroscopy (transmittance) of dolomite.

Table 3. Assignments of FT-IR spectroscopy of dolomite.

Wave Number (Cm^{-1})	Assignment
729	Si-O stretching of feldspar
881	Out plane bending of calcite
1433	CO_3 stretching
2365	-
3699	OH stretching

The FT-IR spectrums of dolomite rocks and their basic assignments showed the major peaks of wave numbers at 729cm^{-1}, 881cm^{-1}, 1433 cm^{-1}, 2365 cm^{-1} and 3699 cm^{-1} which denote the presence of outer plain bending of calcite and CO_3 stretching. However the spectrums of calcite and dolomite are much similar and the elemental analysis results helped in the detection of exact chemical composition of such dolomite rocks. According to the existing results of the current research that it is possible to conclude the presence of large amount of calcite in this rocks while having some trace amount of dolomites.

When comparing of this chemical and mineralogical composition of dolomite rocks, it is possible make some forecasts of their applicability in advanced industrial uses such as the adsorbate for the dissolved metals in waste water such as Cd, Pd, Ni and Hg because the carbonate minerals were identified as strong adsorbing agents and demobilizing agent in most of past researches [1, 3, 4, 8, 12].

The important microscopic views of dolomites are shown in the Fig. 9, Fig. 10 and Fig. 11.

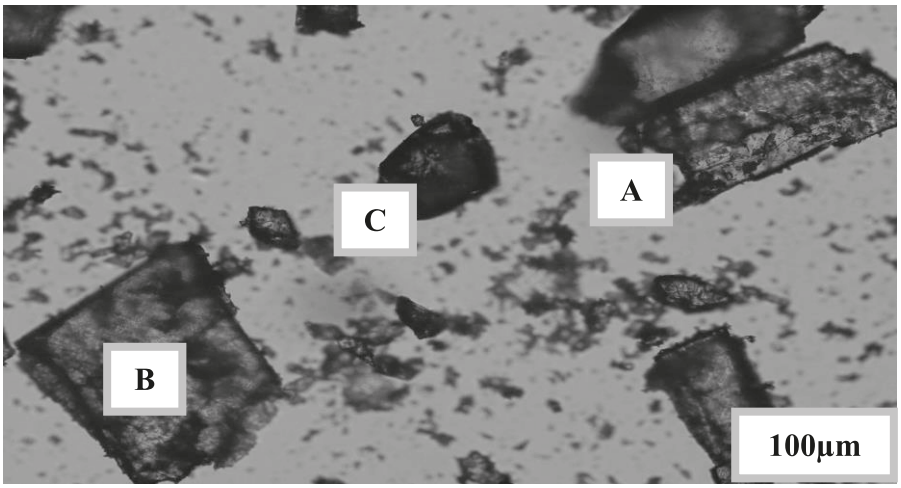

Fig. 9: Microscopic views of the structure of dolomite.

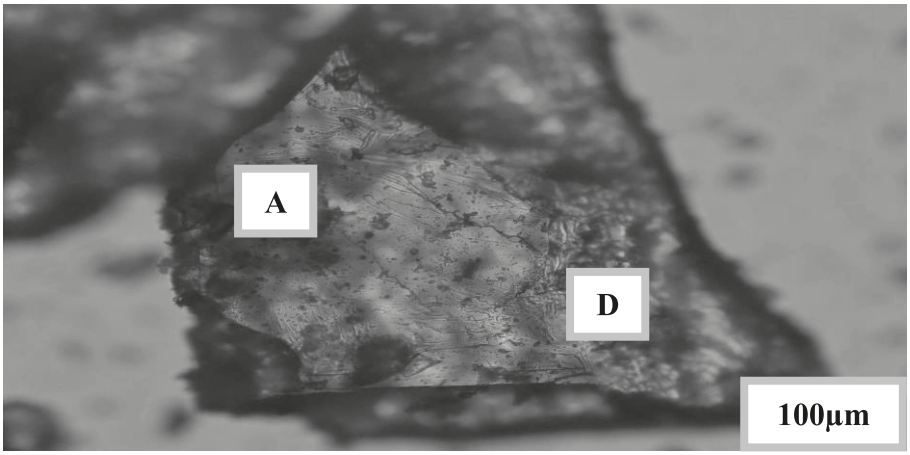

Fig. 10: Microscopic views of the structure of dolomite.

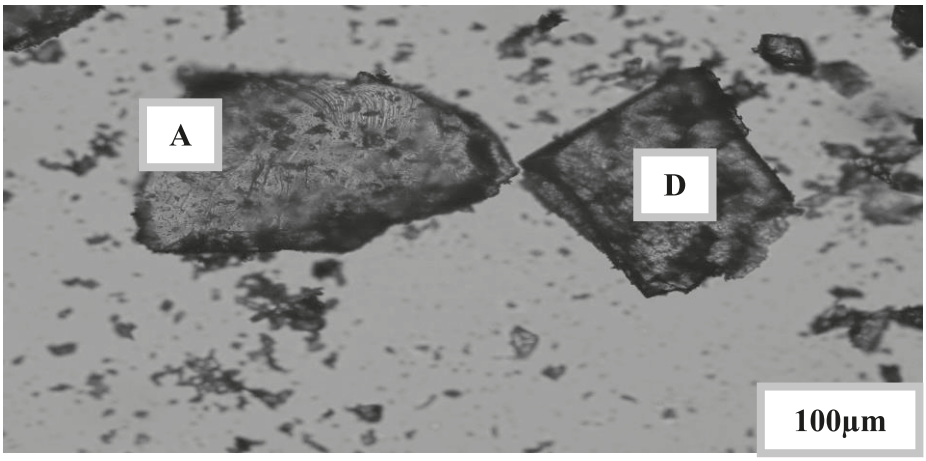

Fig. 11. Microscopic views of the structure of dolomite.

The microstructures of dolomites interpreted some important characteristics of both dolomites and calcites which are invisible with naked eyes. The dominant observations are discussed and analyzed in the below [1, 3, 10, 11, 12].

- A- Tabular and massive crystals with some flat surfaces, curvatures, cavities and ripple marks on the crystal surfaces.
- B- Colorless crystals and white crystals either transparent or translucent.
- C- Reddish color crystals in trace percent
- D- Cleavage planes

Beside of the descriptive characteristics, there were not observed the impurities or some other hazardous elements in dolomites with respect to any of experiment.

As the overall discussion regarding the characteristics of dolomites, this dolomite rocks can be further developed for some advanced applications such as the water treatment applications and more chemical uses including as following tasks [1-12].

- Removal of heavy metals
- Removal or reduction of harness
- Adjust the PH value (acidity) of water
- Recovering of metals form both water and air
- Ion exchanging materials

In the applications of such dolomite rocks for industrial works, it is possible to expect some different progresses and different capacities based on the forms such as the powder form, bed form, massive form and heat treated forms as follows.

- Fly ash and bottom ash

Conclusions and Remarks for Future Works: The analyzed dolomite rocks were composed with huge amount (>99%) of Ca with trace amount of K (<1%) as the elements, majority of calcite with the ultra minority of dolomite in white color, colorless and reddish color crystals in both calcite and dolomite with an exiguous amount of impurities in the mass. Based on the analysis, these dolomitic rocks can be further recommended for the advanced water treatment applications, refractory material and composite materials. The following suggestions should be further used in research works that related with the dolomite rocks.

- Advanced microscopic analysis such as Scanning electron microscope (SEM) or Transmittance electron microscope (TEM) analysis.
- Advanced compositions analysis such as Neutron activation analysis (NAA).
- Advanced mineralogical analysis such as X-ray diffraction (XRD) analysis.

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