Study of adsorption efficiency of different metal ions over $CaCO_3$ extracted from tap water

A thesis

Submitted in the partial fulfilment of the requirements for the award of degree of

MASTER OF SCIENCE

In

CHEMISTRY

Submitted by

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Certificate

I hereby certify that the work presented in this thesis entitled **"Study of adsorption efficiency of different metal ions over $CaCO_3$ extracted from tap water"** submitted in partial fulfilment of the requirements for the award of degree of Master of Science in Chemistry and being submitted to School of Chemistry and Biochemistry, Thapar Institute of Engineering and Technology, Patiala is an authentic record of my own work carried out under the supervision of Dr.Bonamali Pal and Dr.Satnam Singh during Jan-June 2019. The matter of my thesis has not been submitted to any other University for the award of any other degree or diploma.

Date: 8-July-2019

Mehak.

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This is to certify that the above statement made by the candidate is correct and true to be the best of our knowledge.

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Date: 8 July 2019

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Abstract

This present work describes the extraction and characterization of $CaCO_3$ extracted from boiling tap water and examines its adsorption efficiency for the removal of different metal ions(Mn^{+7}, Cr^{+6}, Cu^{+2}, Ni^{+2}). The extracted $CaCO_3$ was calcined at 400˚C and 900˚C. The $CaCO_3$ is characterized by using DLS, ZETA, SEM, TGA and UV-Visible spectroscopy techniques. The $CaCO_3$ was also used to investigate its adsorption property for the removal of different metal ions. DLS measurements showed that the particle size distribution of $CaCO_3$ lies in the range from 0.63 µm to 1.27µm. The surface morphology shows the chips, flakes, rods, sphere- like shapes and the particle size lies in between 1µm to 2µm. Zeta potential and surface charge of $CaCO_3$ -900˚C is negative in nature because the $CaCO_3$ decomposed into CaO and form $Ca(OH_2)$. The impact of adsorption of different metal ions (Mn^{+7}, Cr^{+6}, Cu^{+2}, Ni^{+2}) over $CaCO_3$ with different time intervals was also studied. The Langmuir adsorption isotherm is the best fit adsorption isotherm for this work. The kinetics studies follow the first order reaction. Mn^{+7} adsorb at higher efficiency among all the metal ions. It was concluded $CaCO_3$material will be very effective for adsorption and removal of different metal ions.

S.NO	Section	Content	Page No.
		List of abbreviation	
		List of symbol	
		Abstract	
1.		Introduction & Literature Review	1-3
2.		Objectives	3
3.		Material and Methods	
	3.1	Apparatus	4
	3.2	Reagent used	4
	3.3	Method of extraction of $CaCO_3$ from tap water	4-5
4.		Characterization	5-13
5.		Adsorption studies	
	5.1	Mn^{+7}	14-17
	5.2	Cr^{+6}	18-20
	5.3	Cu^{+2}	21-24
	5.4	Ni^{+2}	25-28
6.		Comparative Studies	
	6.1	Adsorption isotherm and Kinetic Studies	29-31
	6.2	Amount of different metal ion adsorbed	32
7.		Conclusion	33
8.		References	33-34

List of Abbreviations

RT: Room Temperature

$KMnO_4$: Potassium permanganate

$NiCl_2$: Nickel Chloride

$CuSO_4$: Copper sulphate

$K_2Cr_2O_7$: Potassium dichromate

$CaCO_3$: Calcium Carbonate

$CaCO_3$ RT: Calcium Carbonate at room temperature

$CaCO_3$ -400˚C: Calcium Carbonate calcined at 400˚C

$CaCO_3$ -900˚C: Calcium Carbonate calcined at 900˚C

mM: Milli molar

min: Minute

Calcinated at 400˚C and 900˚C: at 400˚C and 900˚C

DLS: Diffuse light scattering

SEM: Scanning electron microscopy

EDS: Energy-dispersive X-ray spectroscopy

TGA: Thermo gravimetric analysis

List of symbol

˚**C**: Degree Celsius

%: Percentage

µ: Micro

η: eta (% adsorption)

k: Rate constant

mg: mili gram

rpm: revolution per minute

a.u: arbitrary units

1. Introduction& Literature review

Calcium carbonate is originated from mineral as well as natural resources.It is present as mineral calcite and aragonite (as limestone), pearls, shells of marine organism and eggs. These are treated under high temperature to produce calcium carbonate ($CaCO_3$) and calcium oxide (CaO). $CaCO_3$ is extracted from tap water that contains a lot of hardness in the form of bicarbonates of calcium and magnesium. The tap water analysis shows that the water mostly used in house hold activities is hard water and contain $CaCO_3$ above 200 mg/l.[1] The bicarbonate of $CaCO_3$ on heating gives us the carbon dioxide and carbonate salts of calcium and can be extracted from the tap water by the mean of double distillation.

$$\mathbf{Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2}$$

Being most abundant mineral in the earth's crust and extracted from natural resources, calcium carbonate is used in many industries. [2] Such as in paper industries, in chalk industries, in making of paste, cements, toothpaste, in pharmaceutical industries as it acts as an antacid to relieve the symptoms of indigestion and heart burn. Due to industrialization and urbanisation, worldwide great problem is caused by the excessive release of different metals and they are degraded into harmless end products and released into the environment. These metal ions are discarded as waste in water that lead to the toxicity for the many life forms[3].Such as metal ion copper is discarded as waste from utensils industries, copper wires industries, nickel is used as stainless steel in many alloy industries and also incoatings, batteries, kitchen wares, medical equipment, buildings, power generation, by jewelers. Potassium permanganate is used as disinfectant. Being disinfectant, it is used for washing utensils, removing hardness. Due to excessive release of these metal ions, environment gets affected. Excess of Copper leads to metal poising in a body. It may lead to heart, kidney, and liver failure. Nickel toxicity leads to the chronic bronchitis, reduces lungs functioning and lungs cancer. Today's main topic of concern is to the removal of different metal ion from the environment. Handling for the removal of metal ions from waste water includes precipitation, membrane filtration, adsorption and ion exchange [4]. Efforts have been done for removal of these metal ions from the environment. A.Hala *et.al*[5] *(2013)* reported that the low cost adsorbents such as agricultural waste (rice hulks, fly ash) gave the better adsorption for the removal of heavy metals from the waste water. The concentration ranges of 20-60 mg/l. Results shows that Removal of Fe using rice husk increased

from 68.59% to 99.25% which shows that with the increase in amount of adsorbent, removal efficiency increases, same in the case of Pb removal. It shows the increase from from 22.22% to 87.17% with rice, while the by using fly Ash, Cd removal varied from 25.21% to 73.54%. G.Blanchard *et.al* [6] (1984) used the natural zeolites clinoptilolite as an ion exchange for the exclusion of aluminum metal from the waste water. By plotting the exchange isotherms relative to the various cations the study of Na-exchanged clinoptilolite in presence of ammonium ions has been achieved. The efficiency of the zeolite was decreased with the increasing order of heavy metals. K.Anoop *et.al*[7] (1999) used the microorganism for the removal of toxic heavy metals from the waste water. For the removal of heavy metals like lead, cadmium, nickel ions they studied the potential of fungus *Aspergillus niger*. It was found that the live fungus biomass is more effective in the removal of heavy metals than dead biomass which had been boiled in 0.1N NaOH solution for 15 min.The degree of biosorption of heavy metal ions are strongly affected by the pH of solution pre treated by boiling in 0.1 N NaOH solutions.

Nowadays $CaCO_3$ is widely used as an adsorbent material for the elimination of metal ions because of the surrounding interfacial layers over it. Due to these interfacial layers $CaCO_3$ adopt the properties like adsorption, precipitation; photo catalytic degradation, metal loading and removal of metal ions. Efforts have been done to use $CaCO_3$ due to large surface area and microporous structure as a new type of material in adsorption properties as conventional adsorbents. Nowadays, $CaCO_3$ have a lot of interest in the area of catalysis because micropores are uniformly distributed on its surface. Moreover, their efficiency to adsorb molecule/ionic species and their thermal stability lead to a great variety of applications as in materialistic industries as well as in chemical laboratory.[8]Work done on the $CaCO_3$was reported.Han-bing Zhang *et.al*[9] (2017) showed the monolayer process of absorption for removal of dyes such as methylene blue and congored dye with $CaCO_3$ modified with bentonite. A.Bathla *et.al* [10] *(2019)* examined various parameters like pH, time variation for the removal of Methylene blue and Congo red dye by the batch adsorption method.The maximum absorption capacity was shown in the pH range of 2-10. Pseudo first order kinetics of the activated charcoal prepared from coconut hulk with H_2SO_4 and its ability to remove textile dyes by the batch adsorption is reported by A.Aseel *et.al*[11]*(2017).*A mixture of physiochemical parameters like time interval, concentration of dye, dosage of adsorbent, particle size, pH of dye solution were investigated. Maximum absorption is shown at pH 3, with large particle size and more active sites.

W.Suphitcha *et.al* [12] (2013) reported that the waste water containing reactive dye was ozonated in the batch reactor and samples were collected at different time intervals. Results of decolorization proved that the color of waste water was reduced with the reaction rate. Hence the reactive dyes were removed from the textile dyes by ozonation process. The decolorization efficiency was increased to 78.29 % and 92.20 % at reaction times 4 and 6 hours respectively. N.K.Omme *et.*al[13] *(2019)*examine the photo catalytic degradation i.e., advance oxidation process (AOP) for the removal of organic pollutant or dye. The degradation mechanisms of complex organic matter in water body is accelerated by semiconductor nanoparticles (Fe_2O_3) by generating electrical energy by absorbing UV-visible portion of light energy.

Various reports are available for the work done on the adsorption of $CaCO_3$. Removal of different metal ions from the Waste water by the means of dark adsorption with catalyst $CaCO_3$ of different temperature(room temperature, 400˚Cand 900˚C) is not reported yet. So, our aim is to extract $CaCO_3$ from the tap water and the removal of different metal ions from the waste water. The main objectives are as follows:

- Extraction and characterization of $CaCO_3$extracted from boiling tap water.
- To study the effect of adsorption of different metal ions (Cu^{+2}, Ni^{+2}, Mn^{+7} and Cr^{+6}) over $CaCO_3$ calcined at different temperatures.

3. Materials and methods:

3.1 Apparatus:

Measuring Cylinder, Glass Rod, Magnetic Beads, Weighing Balance, UV Visible Photo reactor, Beakers, Petri Plates, Spatula, Centrifuge Machine, pH meter, UV Visible Spectrophotometer, Falcon Tubes, Crucible and the Hot air oven was used for the formation of desired product.

3.2 Reagents and chemicals used:

Potassium permanganate ($KMnO_4$), Potassium dichromate ($K_2Cr_2O_7$), Copper Sulphate ($CuSO_4.5H_2O$) and Nickel Chloride ($NiCl_2.3H_2O$) purchased from Loba Chemie, India.$CaCO_3$as an adsorbent, extracted from the tap water with double distillation.

3.3 Method of Extraction of Calcium Carbonate ($CaCO_3$) from tap water:

The hardness causing carbonates were collected from the boiled tap water. They were collected in the liquid form and centrifuged at 8000 rpm for 5 min at RT and washing were done thrice with ethanol and water. Later, it was dried up at 25˚C. Then the powder form obtained is further calcined at 400˚C &900˚C for 4 hours in muffle furnace as shown in fig 1.

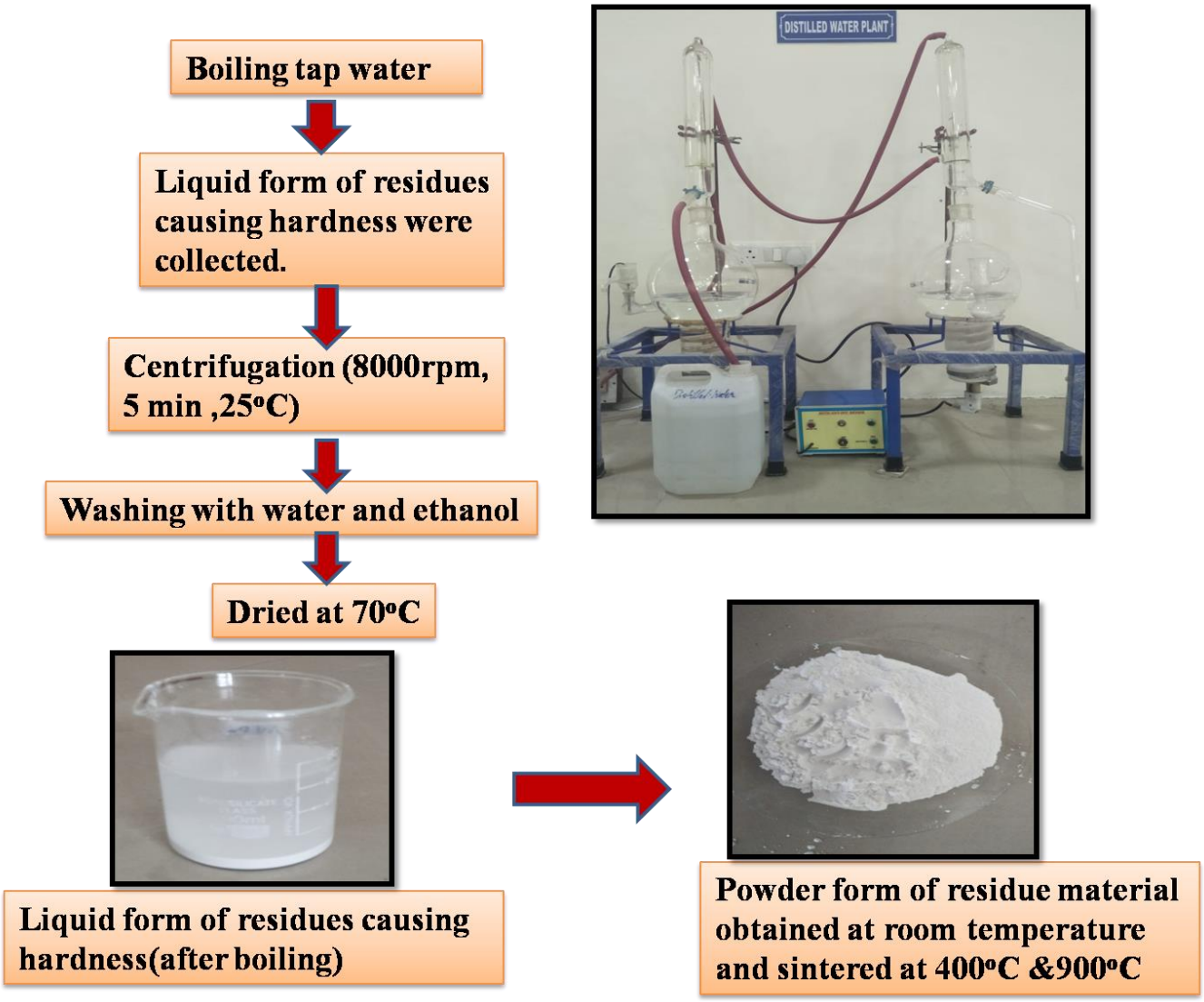


Fig 1: Process of obtaining $CaCO_3$ from boiling tap water.

4. Characterization:

To study the surface morphology, composition and surface area of the $CaCO_3$ extracted from boiled water; we have used a variety of characterization methods in this work. The following techniques are used in the experiment.

Dynamic light scattering technique (DLS): The hydrodynamic size Of $CaCO_3$ at RT and calcined at 400°C, 900°C was determined by dynamic light scattering technique (DLS). A solution was prepared by dispersing 2 mg $CaCO_3$ in 10 ml ethanol. Later ultrasonic treatment was done for 30 min so the $CaCO_3$ gets completely dispersed in the ethanol. The hydrodynamic size of $CaCO_3$ at RT, 400˚C and 900˚C was found to be 1.27µm, 1.56µm and 0.63µm respectively as shown in Fig 2

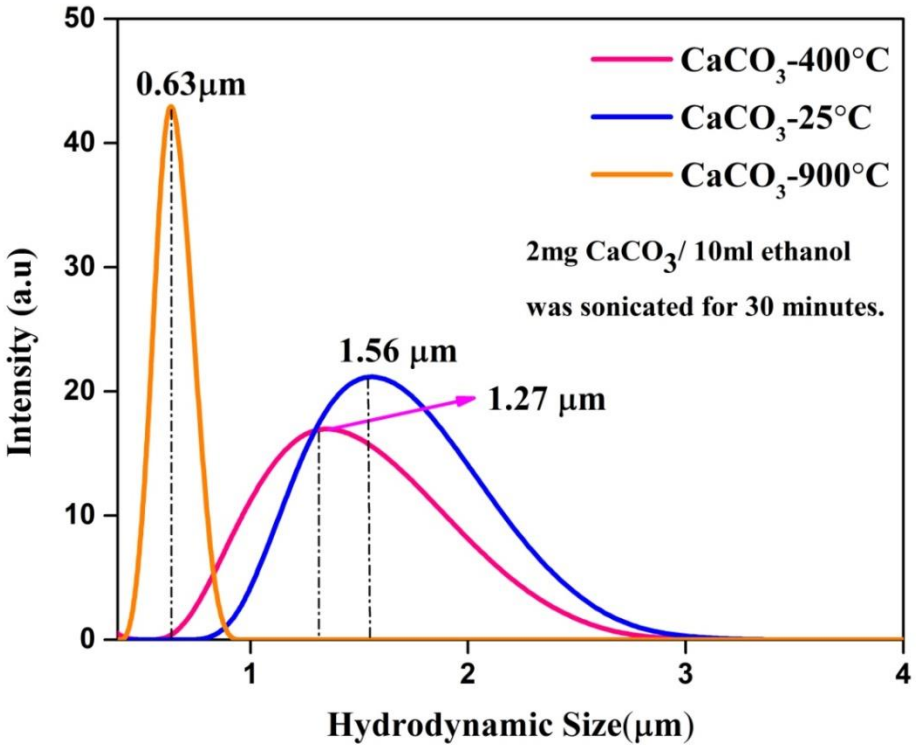


Fig 2: The average hydrodynamic size of $CaCO_3$ –RT obtained from boiling room temperature (25˚C) and calcined at 400˚C and 900˚C.

Thermo gravimetric analysis (TGA): To measures the thermal stability of $CaCO_3$ obtained from boiling tap water as a function of increasing temperature we use TGA.It was found that the thermal decomposition of $CaCO_3$ - RT and $CaCO_3$ -400˚C occurs at 655˚C and it shows two step decomposition which may be due to the release of CO_2at initial temperature and then CaO decomposes. The thermal decomposition of CaO-900˚C was observed at 645˚C and it is single step decomposition as shown in fig 3

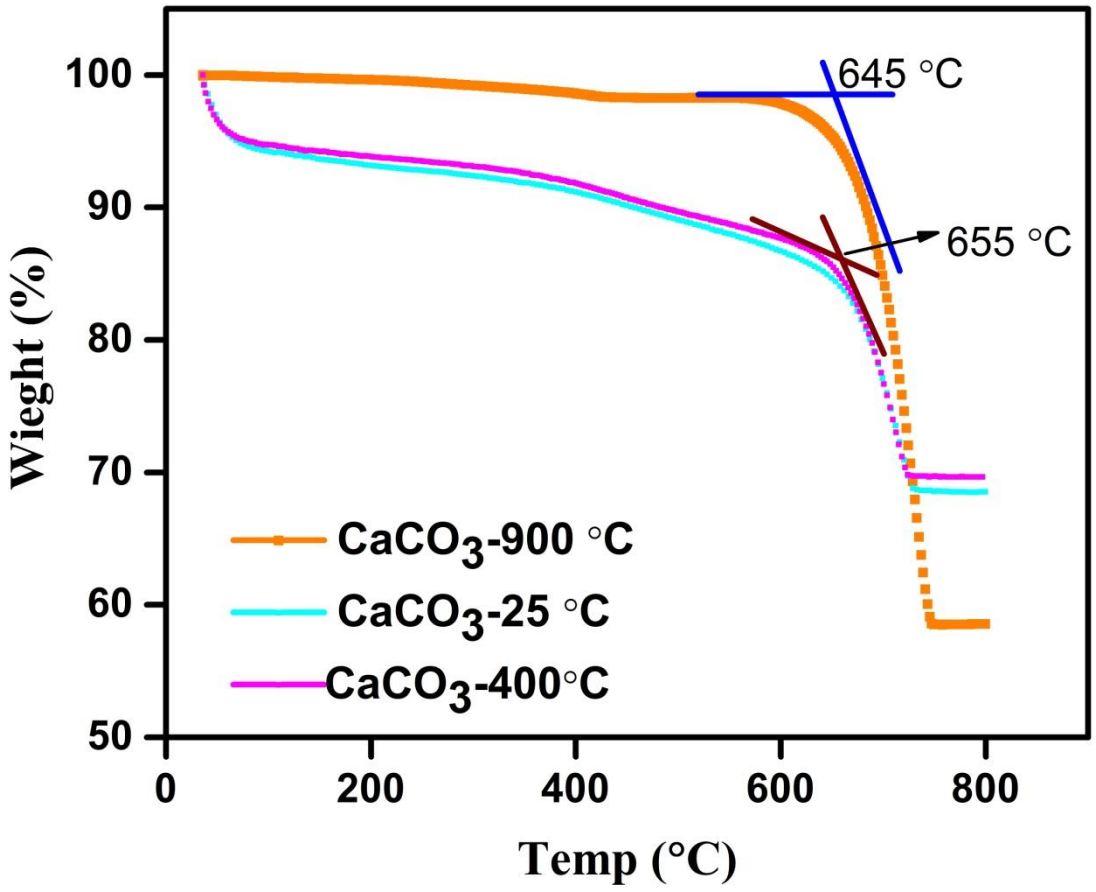
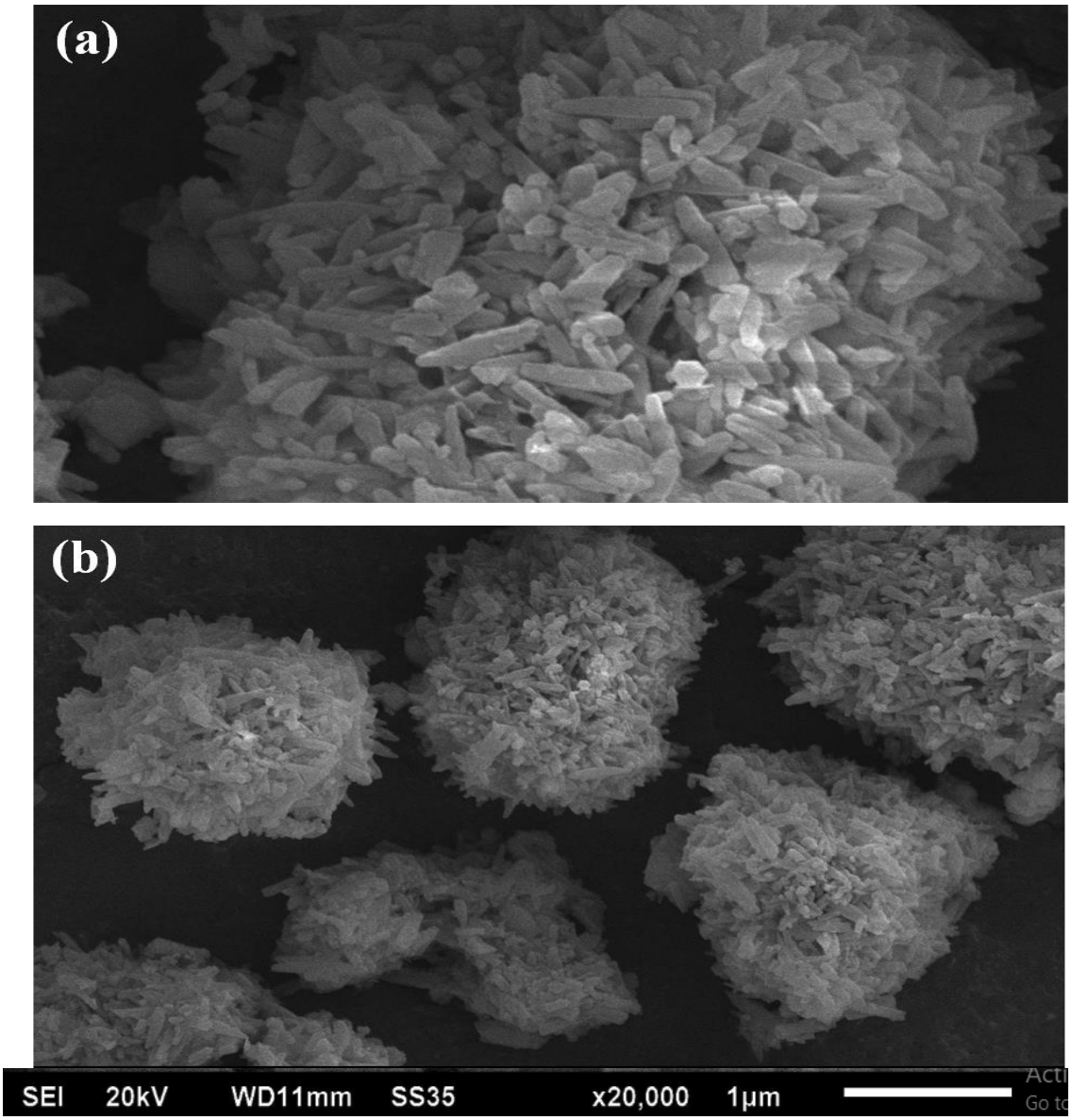
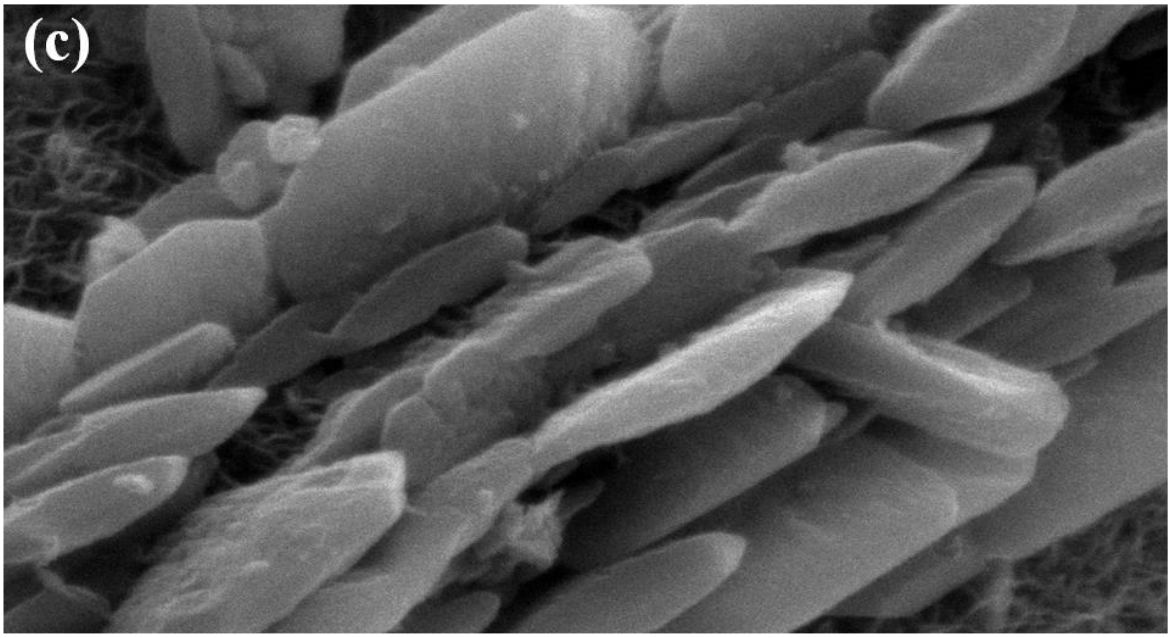
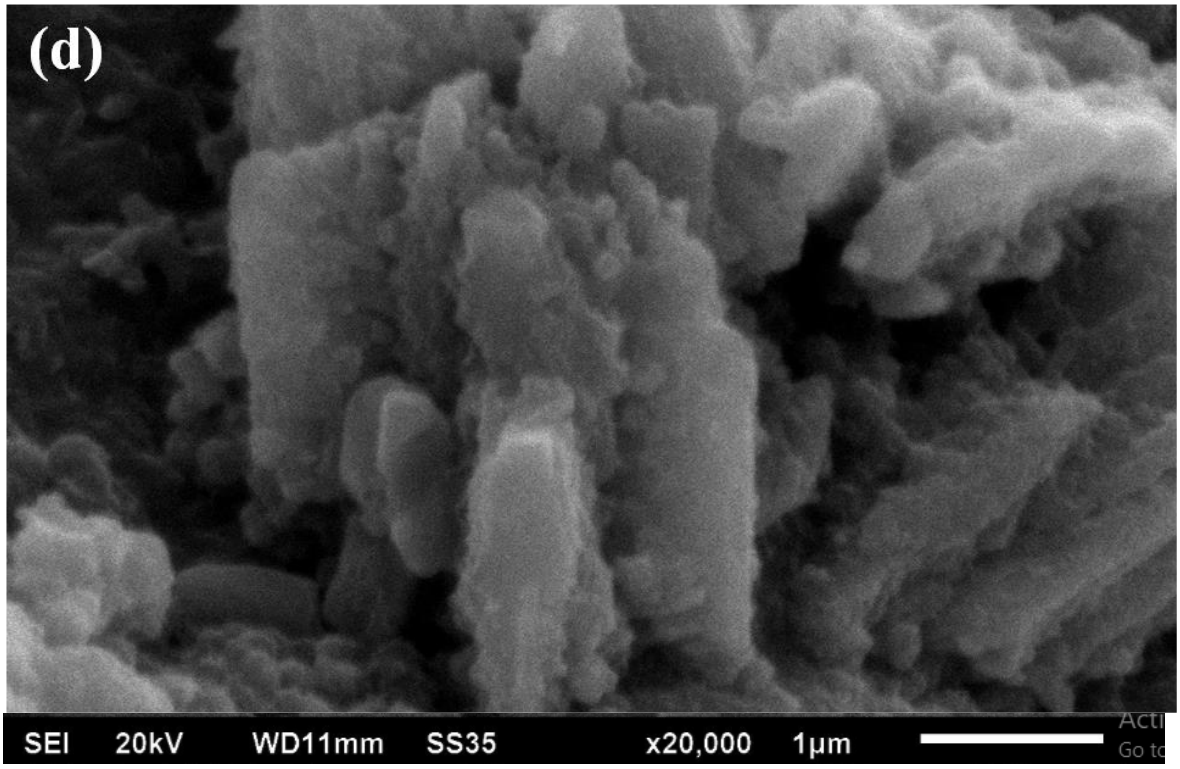


Fig 3: Thermogravimetric analaysis (TGA) of $CaCO_3$ extracted from boiling tap water at RT (25˚C), and calcined at 400˚C and 900˚C.

Scanning electron microscope (SEM): The surface morphology of $CaCO_3$ at different tmperatures was definite by scanning electron microscopy.The surface morphology of $CaCO_3$ at RT, 400˚C and 900˚C was obtained by dispersing 2 mg $CaCO_3$ in 10 ml ethanol. Later ultrasonic treatment was done for 30 min so the $CaCO_3$ gets completely dispersed in the ethanol Fig 4 (a,b) show the SEM images of $CaCO_3$ - RT the chip and flakes like structure were observed. Fig 4 (c,d) show the SEM images of $CaCO_3$ -900˚C which shows the hierarchical like structure. Fig 4 (e,f) represents the SEM images of $CaCO_3$ -400˚C which represents the rod like morphology and the particle dimension ranges from 1 to 2µm.




(c)


(d)
SEI 20kV WD11mm SS35 x20,000 1μm

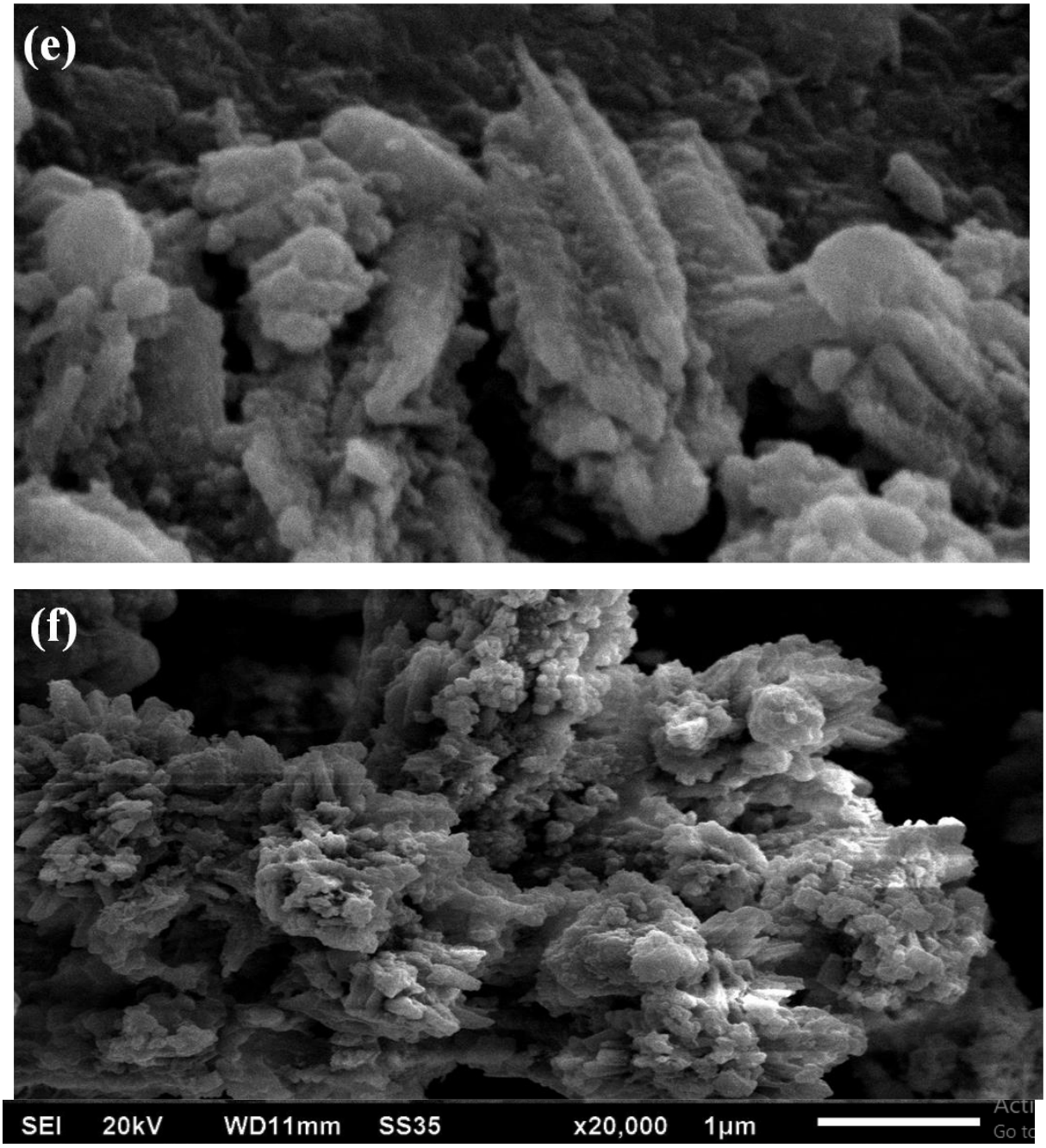


Fig 4: Scanning electron microscopy (SEM) of $CaCO_3$ extracted from boiling tap water at (a,b) RT, (c,d) 900˚C and (e,f) 400˚C

Energy-dispersive X-ray spectroscopy (EDS): The EDX analysis tells about the element present in $CaCO_3$. The figure 5 shows that the elements like C, O, and Caare present in$CaCO_3$

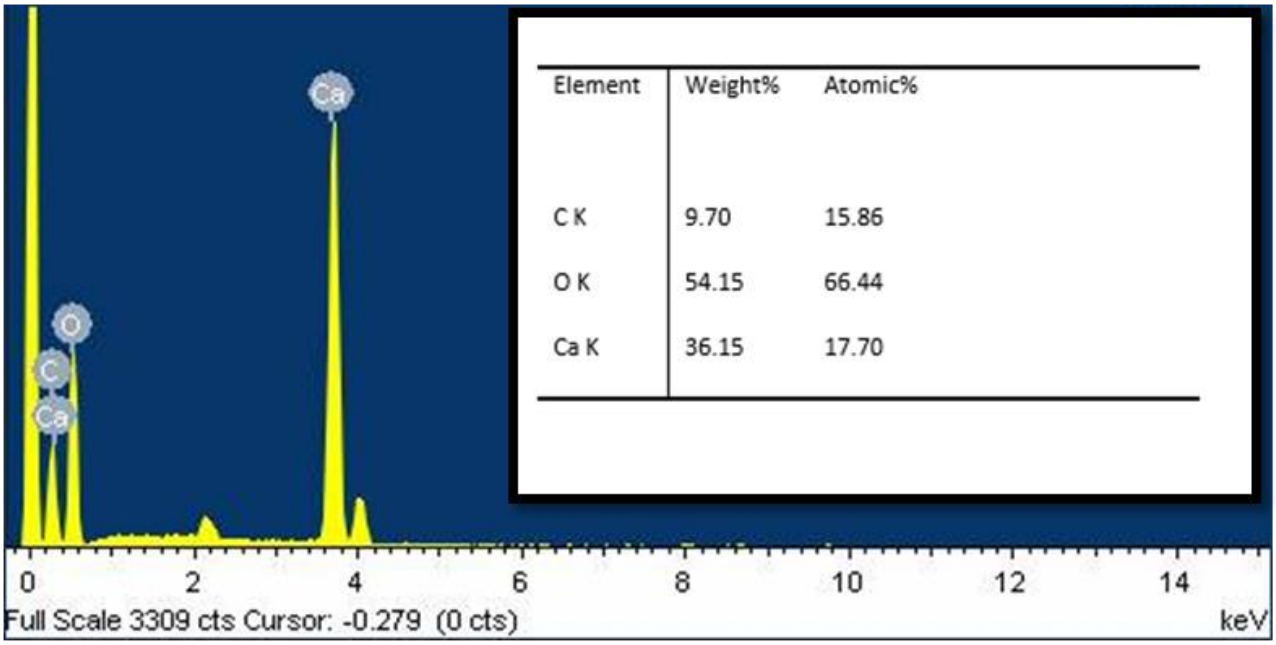


Fig 5: Energy-dispersive X-ray spectroscopy (EDX) analysis of $CaCO_3$-900˚C.

Zeta Potential: Zeta potential measures the surface charge of the catalyst.The surface charge of $CaCO_3$ at RT, 400˚C and 900˚C was obtained by dispersing 2 mg $CaCO_3$ in 10 ml ethanol. Later ultrasonic treatment was done for 30 min so the $CaCO_3$ gets completely dispersed in the ethanolIt was found that the surface charge of $CaCO_3$- RT, $CaCO_3$-400˚C and CaO-900˚C is 0.877 mV, 1.34 mV and -7.06 mV respectively. The highly negative surface charge ofCaO-900˚C is due to the formation of Ca $(OH)_2$ in water, which is negatively in charge.

$CaO + H_2O \longrightarrow Ca(OH)_2$ + undecomposed $CaCO_3$

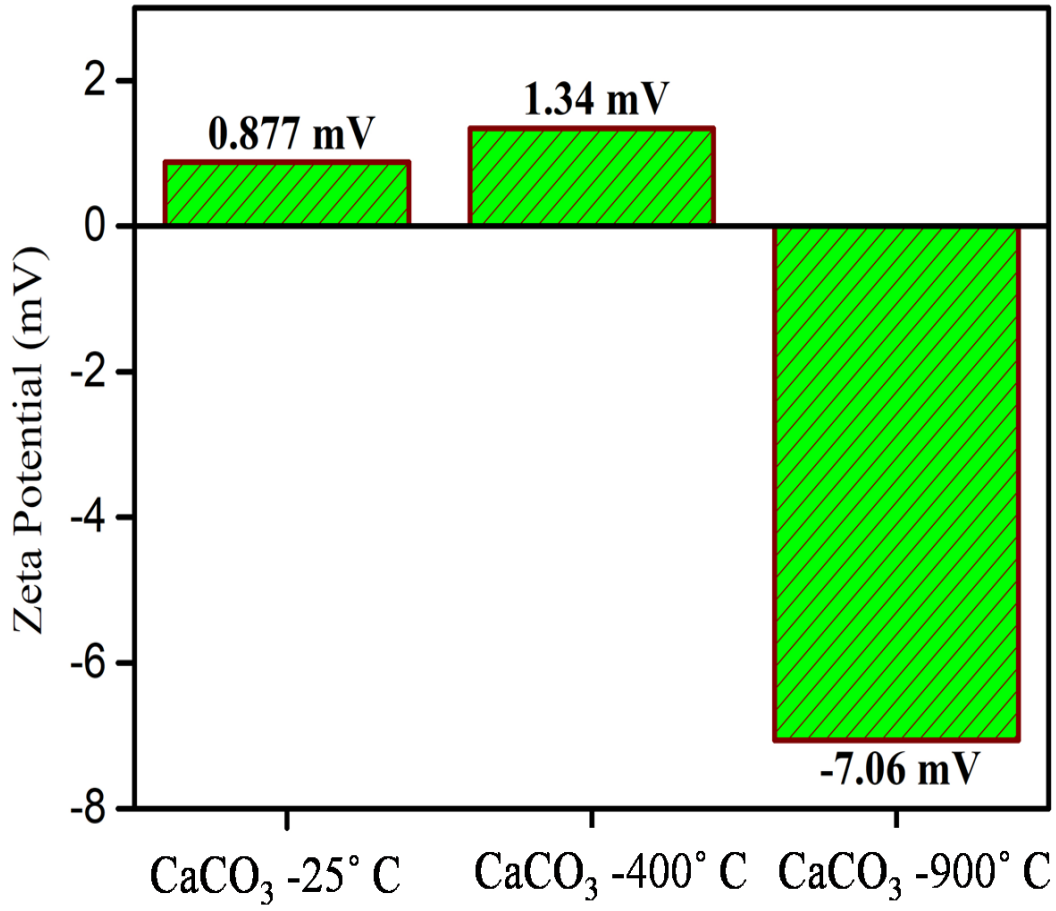


Fig 6: Zeta potential of aqueous dispersion (2 mg in 10 ml of ethanol) of $CaCO_3$ extracted from boiling tap water.

5. Adsorption studies:

5.1 $Mn^{+7}(KMnO_4)$

5.1.1 Calibration graph:

To study the dark adsorption of Mn^{+7}ions, first we make calibration graph at different concentration of $Mn^{+7}(KMnO_4)$ such as 0.75, 0.60, 0.45, 0.30, 0.15 mM. These solution prepared by taking 11mg in 250 ml of water in 250 ml beaker and further dilution was done. The absorbance of each solution was deliberate with double beam UV visible spectrometer at 525 nm and calibration graph between absorbance vs. concentration was plotted obeying Beer-Lambert law.

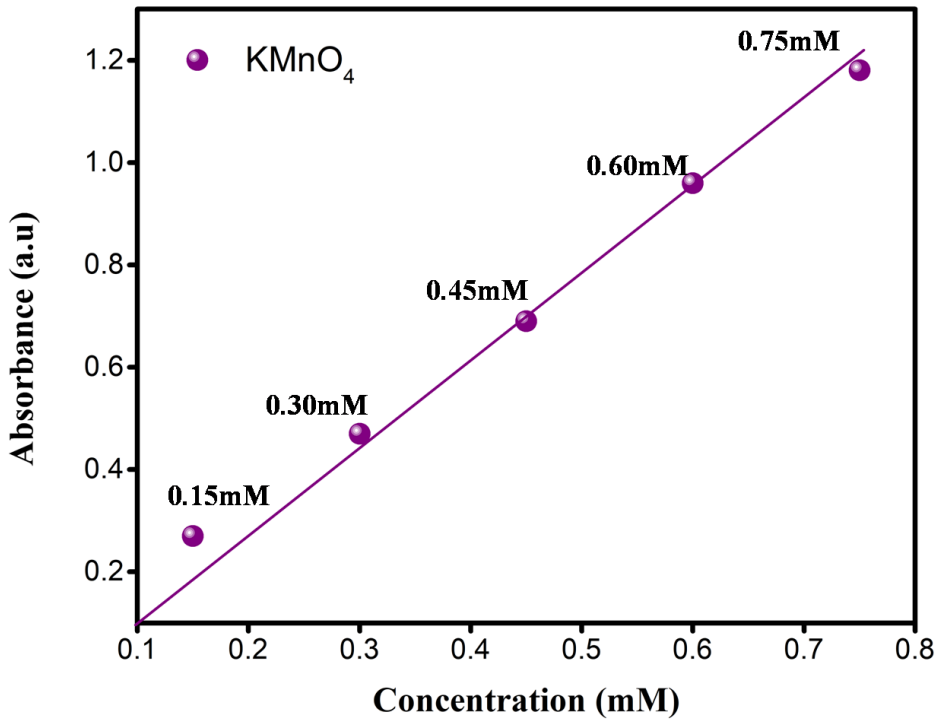


Fig 7: Concentration vs. absorbance graph of Mn^{+7} metal ion at different concentration (0.75, 0.60, 0.45, 0.30, 0.15mM) of $KMnO_4$ at 525nm.

5.1.2: Dark adsorption

Dark adsorption of Mn^{+7} ions was done by dissolving 5mg of $CaCO_3$ in 5ml of $KMnO_4$ (0.75mM). The solution was stirred for 40 min in the dark followed by centrifugation (8000 rpm, 10 min, and 25˚C). Later on, UV-Visible analysis of filtrate was done after every 10 minute at 525nm. Activities of $CaCO_3$ at different temperature (RT, 400˚C, 900˚C) were compared and adsorption spectra are shown in the fig 8

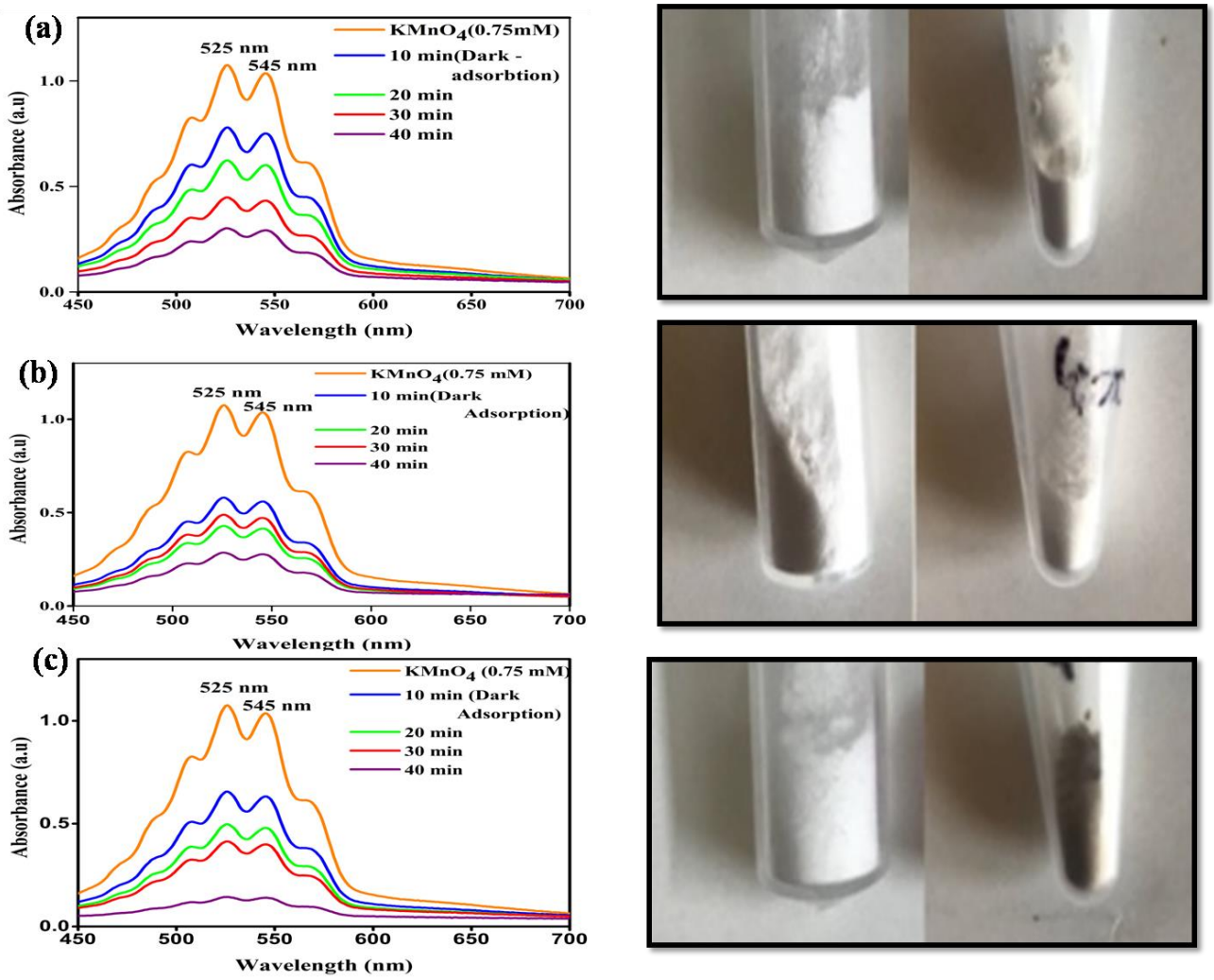


Fig 8: Adsorption spectra of Mn^{+7} (0.75mM) at 525nm over (a) $CaCO_3$-RT (b) $CaCO_3$-400˚C (c) CaO-900˚C and the change in the color of $CaCO_3$ powder at RT, 400˚C and 900˚C after adsorption of Mn^{+7} metal ions.

The % adsorption (eta) is given by **$(C_0-C_t/C_0)*100$** where C_0 is initial concentration of adsorbate and C_t is the equilibrium concentration of adsorbate at time t. It is observed that the %age adsorption of $CaCO_3$-900˚C is more because of its negative charge and positively charged metal ions adsorbed more prominently on $CaCO_3$-900˚C.

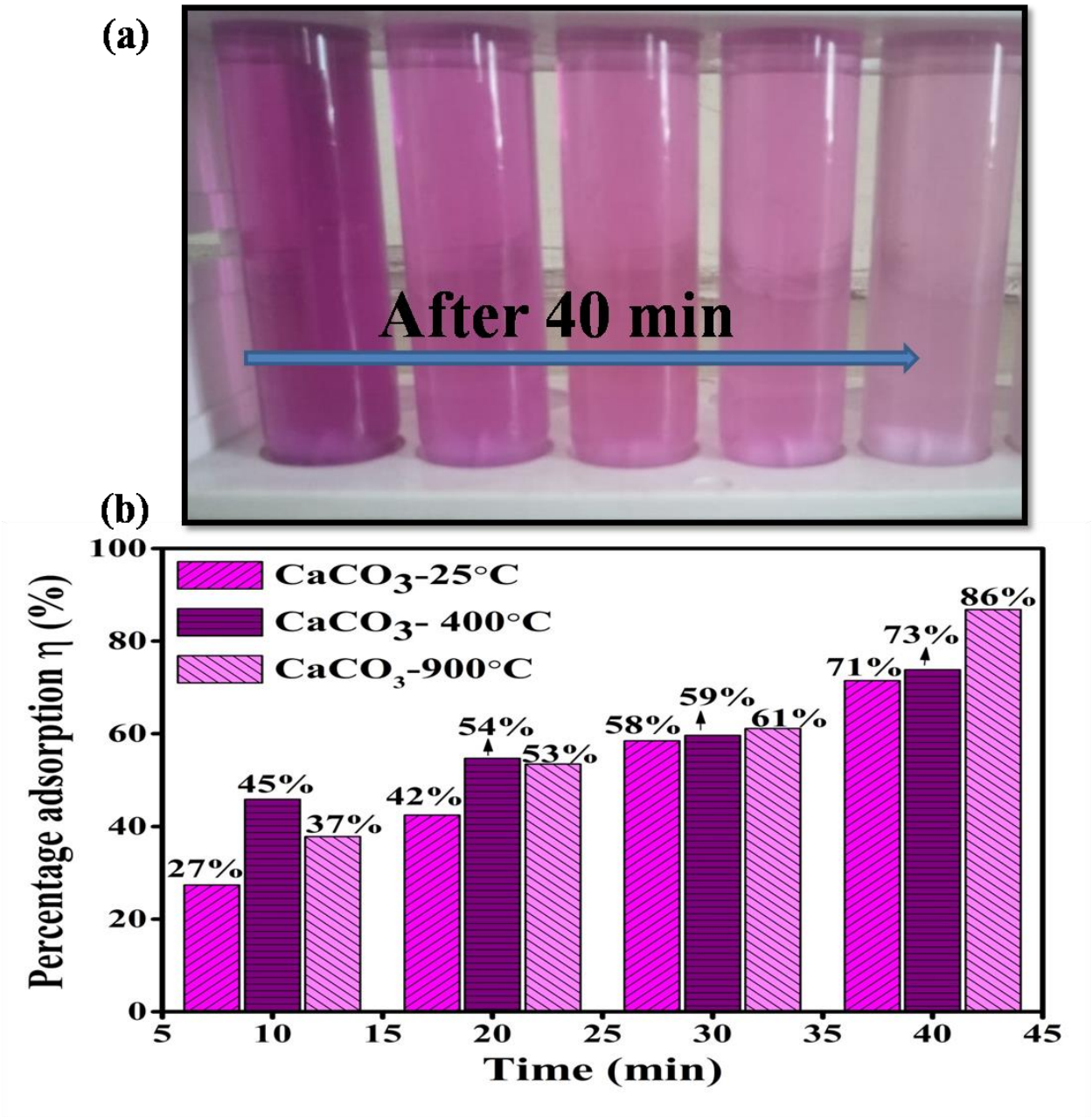


Fig 9: (a) Change in the color intensity with time during dark adsorption of Mn^{+7} ions over $CaCO_3$-RT. (b) Percentage adsorption of Mn^{+7} (0.75mM) over $CaCO_3$ at RT, 400˚C and 900˚C.

5.2: $Cr^{+6}(K_2Cr_2O_7)$

5.2.1 Calibration graph:

To study the dark adsorption of Cr^{+6} ions, first we make calibration graph of different concentration of $Cr^{+6}(K_2Cr_2O_7)$ like 0.3, 0.15, 0.075, 0.025 molar. These solution prepared by taking 29.4 mg in 50 ml of water in 100 ml beaker and further dilution was done. The absorbance of each solution was deliberate with double beam UV visible spectrometer at 352 nm and calibration graph between absorbance vs. concentration was plotted obeying Beer-Lambert law

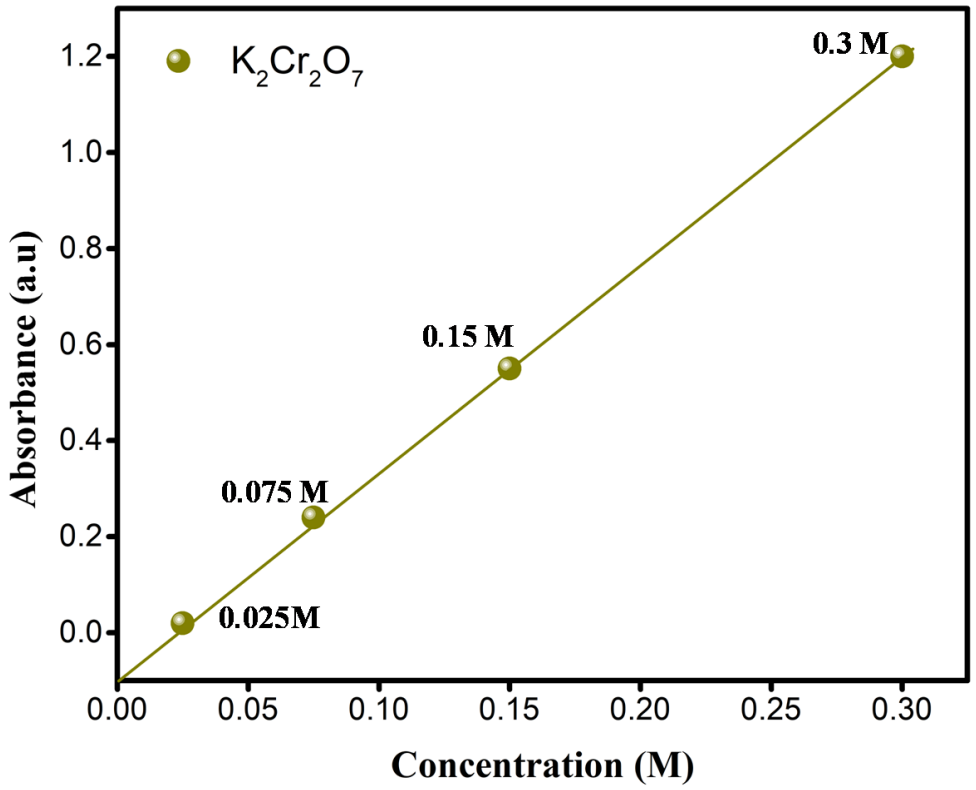


Fig 10: Concentration vs. absorbance graph of Cr^{+6} metal ion at different concentration (0.3, 0.15, 0.075, 0.015M) of $K_2Cr_2O_7$ at 325nm.

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5.2.2: Dark adsorption:

Dark adsorption of Cr^{+6} ions was done by dissolving 5mg of $CaCO_3$ in 5ml of $K_2Cr_2O_7$ (0.3M). The solution was stirred for 40 min in the dark followed by centrifugation (8000 rpm, 10 min, and RT). Later on, the UV-Visible analysis of the filtrate was done after every 10 minutes at 352nm. Activities of $CaCO_3$ at different temperature (RT, 400˚C, 900˚C) were compared and adsorption spectra are shown in the fig 11.

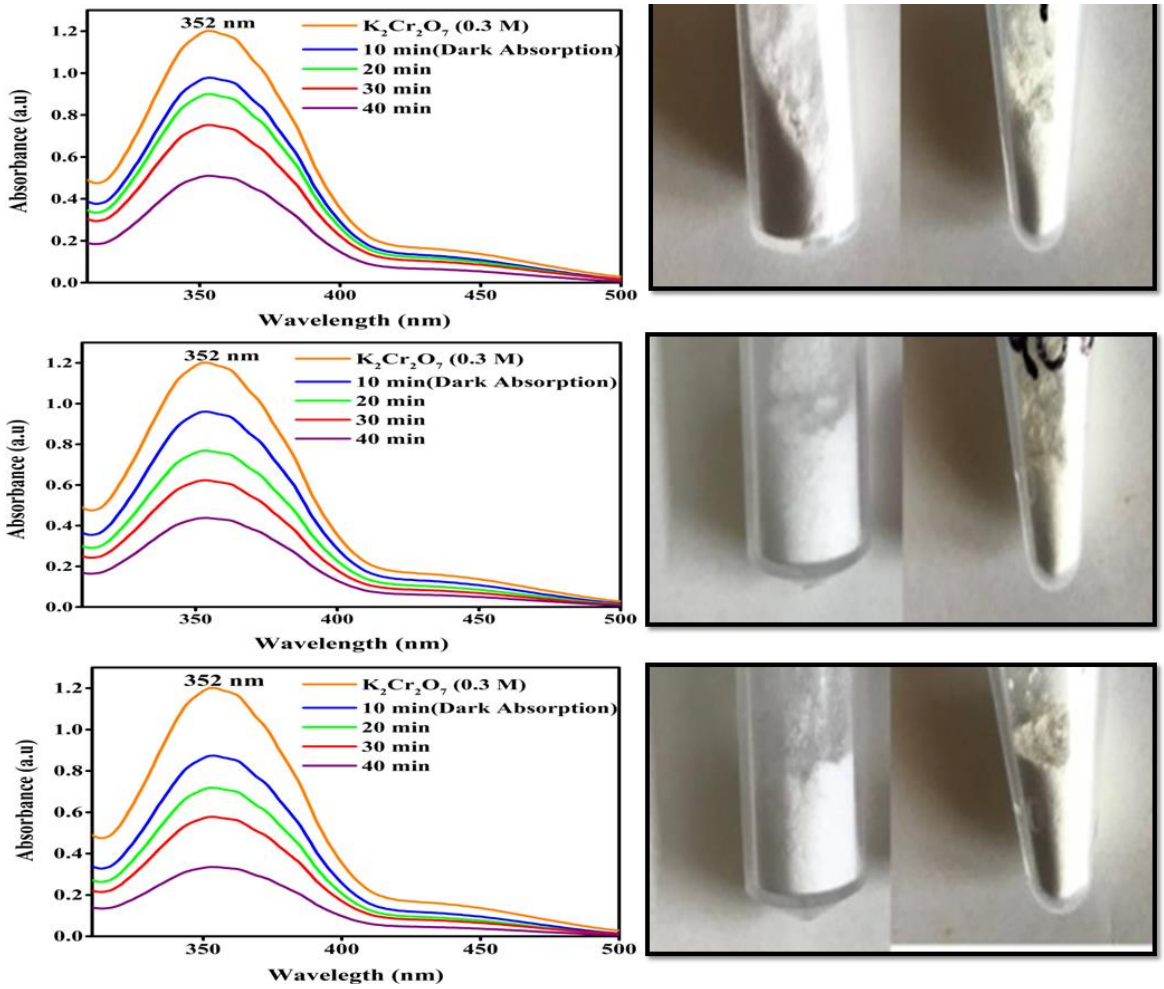

Fig 11: Adsorption spectra of Cr^{+6} (0.3M) at 325nm over (a) $CaCO_3$-RT (b) $CaCO_3$-400˚C (c) CaO-900˚C and the change in the color of $CaCO_3$ powder at RT, 400˚C and 900˚C after adsorption of Cr^{+6} metal ions.

The %age adsorption (eta) is given by **$(C_0-C_t/C_0)*100$** where C_0 is initial concentration of adsorbate and C_t is the equilibrium concentration of adsorbate at time t. It is observed that the %age adsorption of $CaCO_3$-900˚C is more because of its negative charge and positively charged metal ions adsorbed more prominently on $CaCO_3$-900˚C.

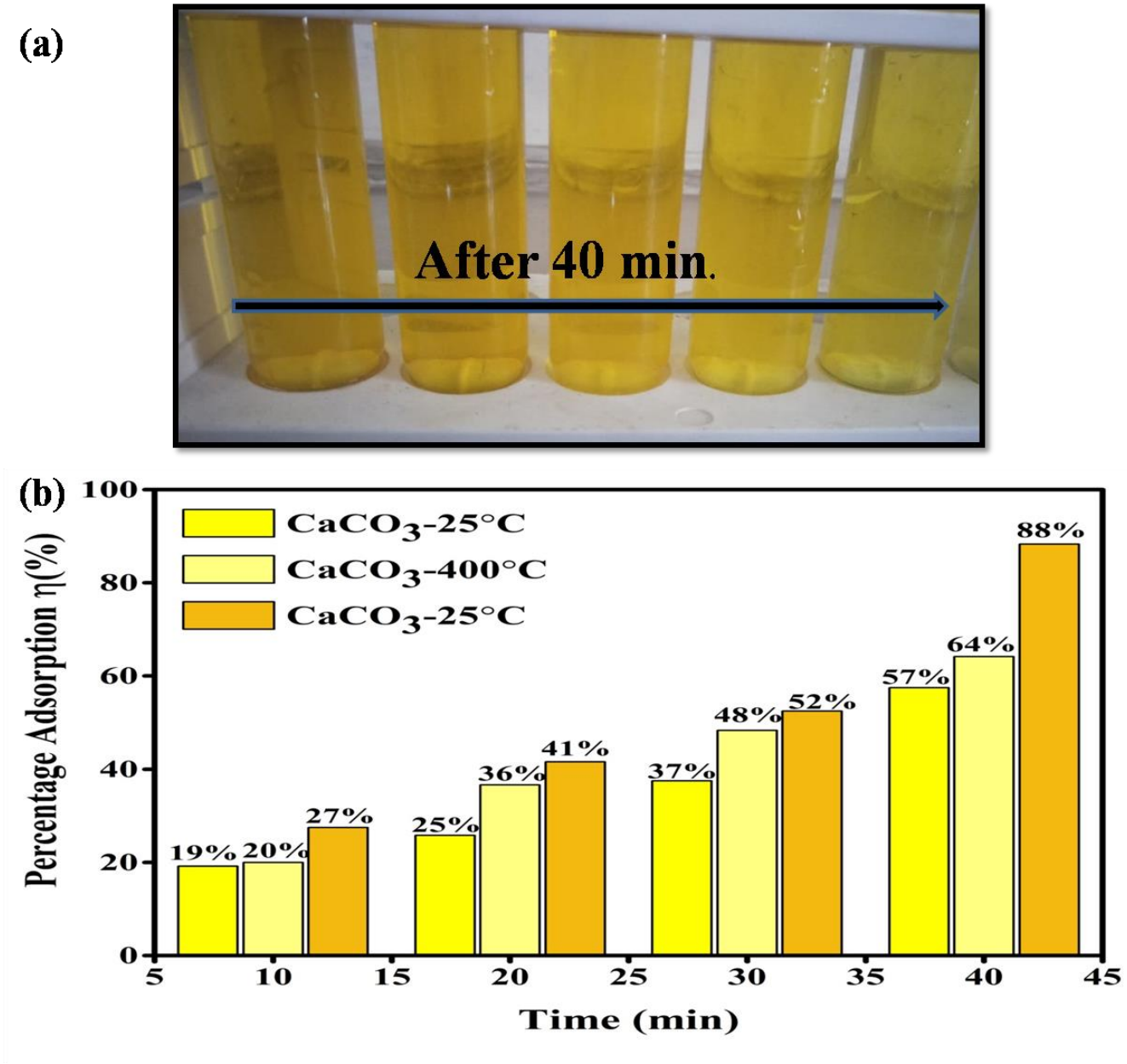

Fig 12: (a) Change in the color intensity with time during dark adsorption of Cr^{+6} ions over $CaCO_3$-RT. (b) Percentage adsorption of Cr^{+6} (0.3M) over $CaCO_3$ at RT, 400˚C and 900˚C.

5.3: $Cu^{+2}(CuSO_4.5H_2O)$

5.3.1 Calibration graph

To study the dark adsorption of Cu^{+2} ion, first we make calibration graph of different concentration of $Cu^{+2}(CuSO_4.5H_2O)$ like 0.5, 0.3, 0.15 molar. These solutions are prepared by taking 6.23 g in 50 ml of water in 100 ml beaker and further dilution was done. The absorbance of each solution was measured with double beam UV visible spectrophotometer at 785 nm and calibration graph between absorbance vs. concentration was plotted obeying beer-Lambert law.

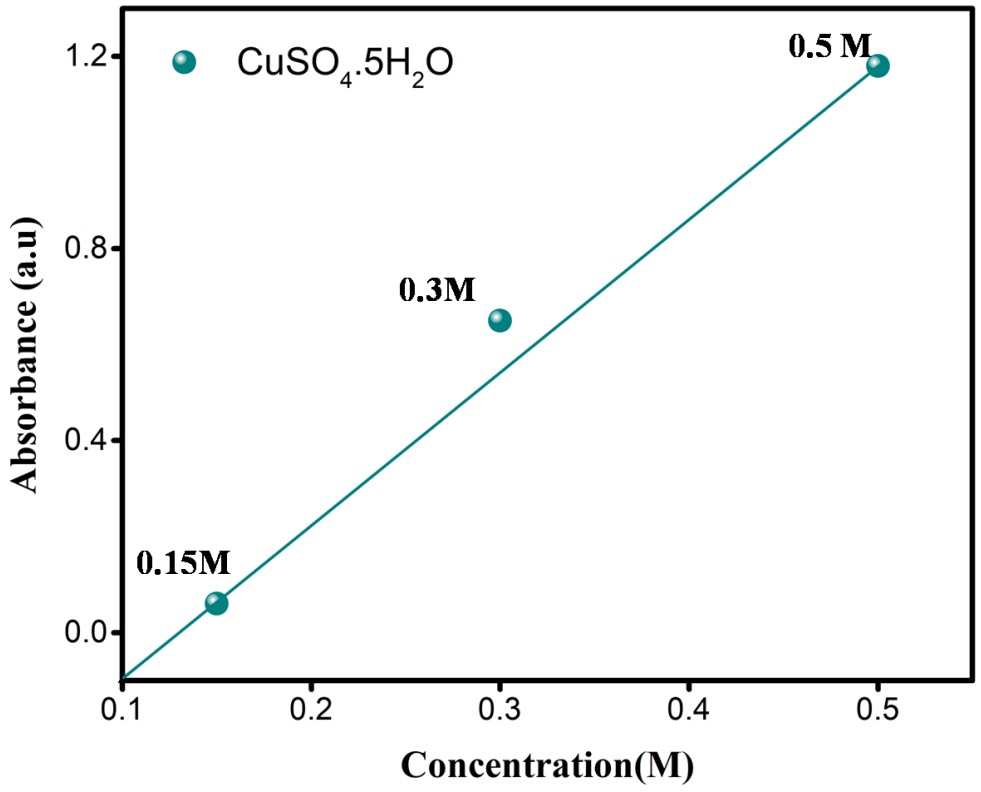

Fig 13: Concentration vs. absorbance graph of Cu^{+2} metal ion at different concentration (0.5, 0.3, 0.15 molar) of $CuSO_4$ at 785nm.

5.3.2: Dark Adsorption:

Dark adsorption of Cu^{+2} ions was done by dissolving 5mg of $CaCO_3$ in 5ml of $CuSO_4.5H_2O$ (0.5M). The solution was stirred for 40 min in the dark followed by centrifugation (8000 rpm, 10 min, and RT). Later on, the UV-Visible analysis of the filtrate was done after every 10 minutes at 785nm .Activities of $CaCO_3$ at different temperature (RT, 400˚C, 900˚C) were compared and adsorption spectra are shown in the fig 14

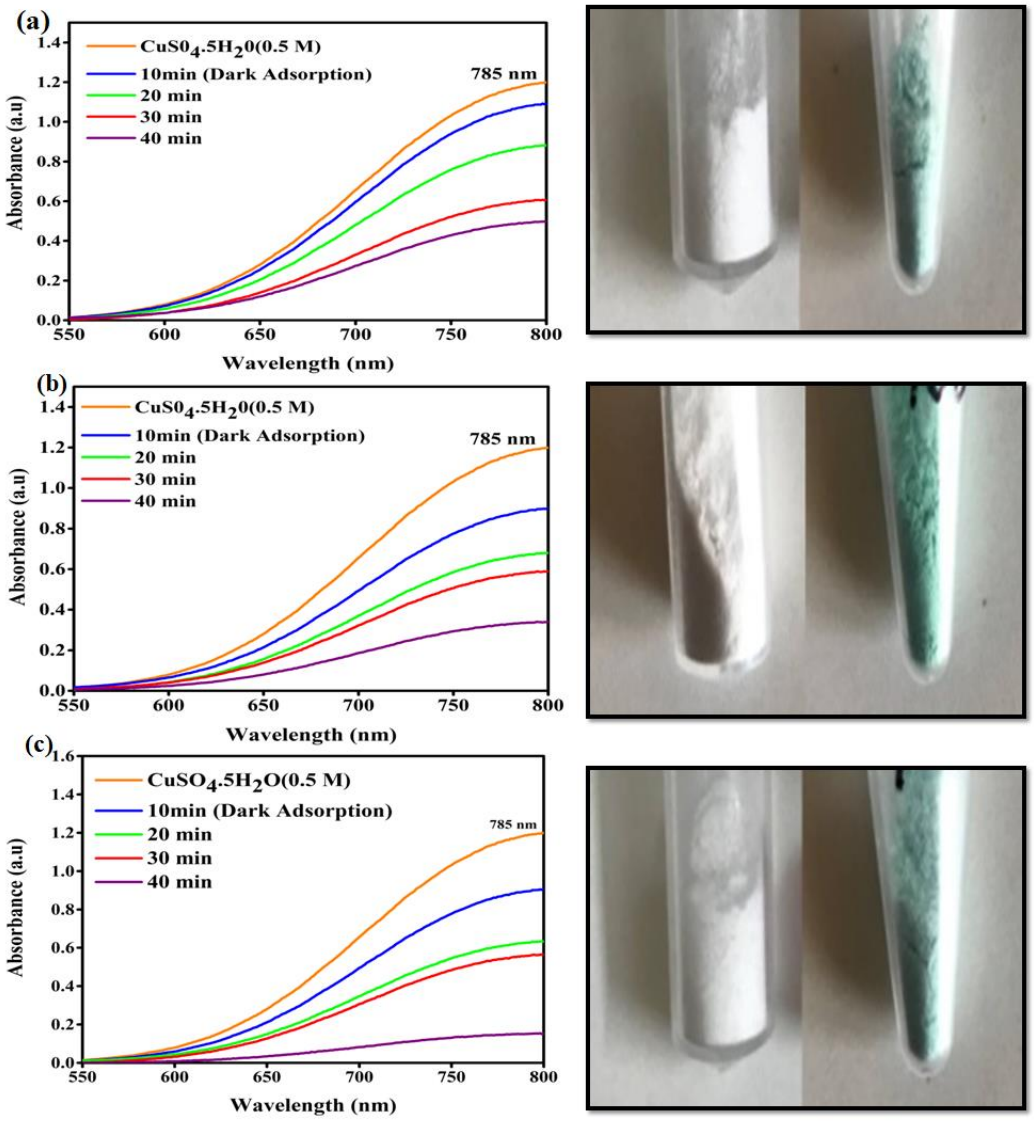

Fig 14: Adsorption spectra of Cu^{+2} (0.5M) at 785nm over (a) $CaCO_3$-RT (b) $CaCO_3$-400˚C (c) CaO-900˚C and the change in the color of $CaCO_3$ powder at RT, 400˚C and 900˚C after adsorption of Cu^{+2} metal ions.

The %age adsorption (eta) is given by **$(C_0-C_t/C_0)*100$** where C_0 is initial concentration of adsorbate and C_t is the equilibrium concentration of adsorbate at time t. It is observed that the %age adsorption of $CaCO_3$-900˚C is more because of its negative charge and positively charged metal ions adsorbed more prominently on $CaCO_3$-900˚C.

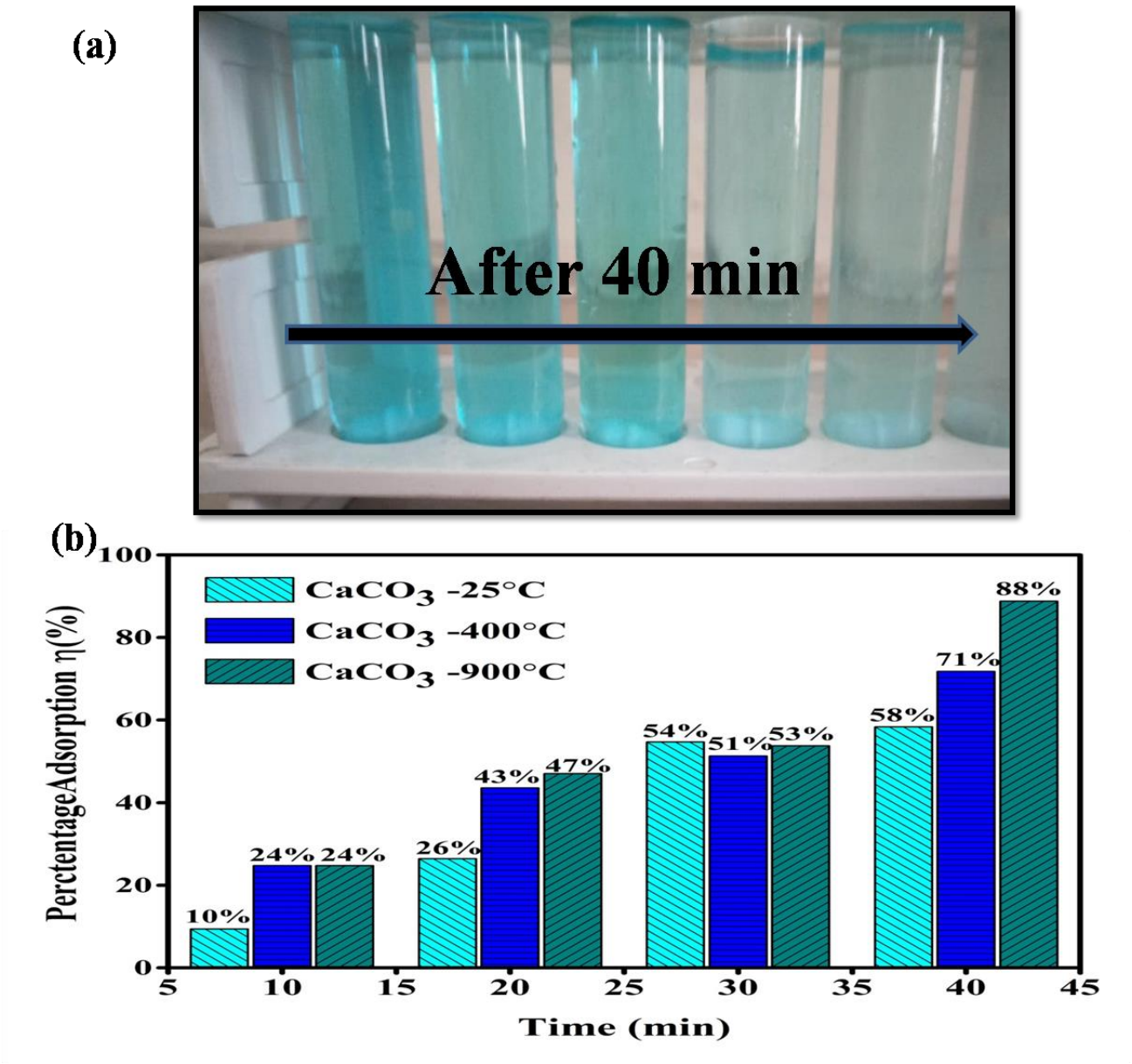

Fig 15: (a) Change in the color intensity with time during dark adsorption of Cu^{+2} ions over $CaCO_3$-RT. (b) Percentage adsorption of Cu^{+2} (0.5M) over $CaCO_3$ at RT, 400˚C and 900˚C.

5.4 Ni^{+2} ($NiCl_2.3H_2O$)

5.4.1 Calibration graph

To study the dark adsorption of Ni^{+2} ions, first we make calibration graphof different concentration of Ni^{+2}($NiCl_2.3H_2O$) like 0.5, 0.3, 0.15 molar.metal ion Ni^{+2}. These solution prepared by taking 5.34 g in 50 ml of water in 100 ml beaker and further dilutions was done. The absorbance of each solution was measured with double beam UV visible spectrophotometer at 720 nm and calibration graph between absorbance vs. concentration was plotted obeying beer-Lambert law.

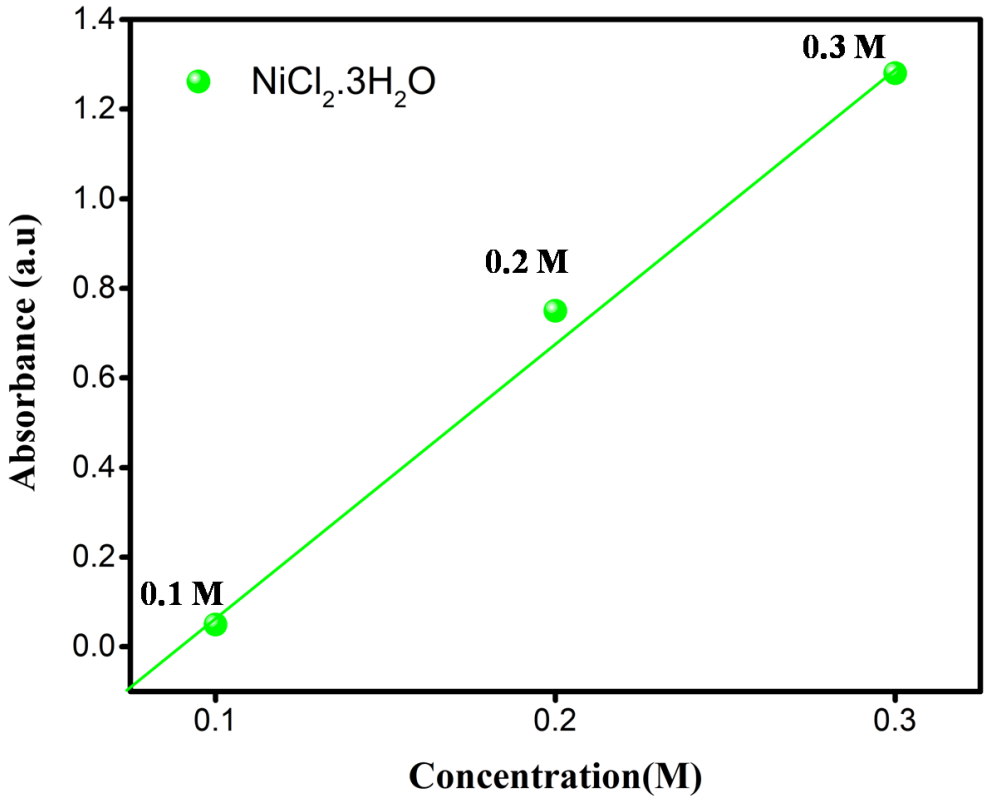

Fig 16: Concentration vs. absorbance graph of Ni^{+2} metal ion at different concentration (0.1, 0.2, 0.3 molar) of $NiCl_2$ at 720nm .

5.4.2 Dark adsorption

Dark adsorption of Ni^{+2} ions was done by dissolving 5mg of $CaCO_3$ in 5ml of $NiCl_2.3H_2O$ (0.3M). The solution was stirred for 40 min in the dark followed by centrifugation (8000 rpm, 10 min, and RT). Later on, the UV-Visible analysis of the filtrate was done after every 10 minutes at 720nm. Activities of $CaCO_3$ at different temperature (RT, 400˚C, 900˚C) were compared and adsorption spectra are shown in the fig 17

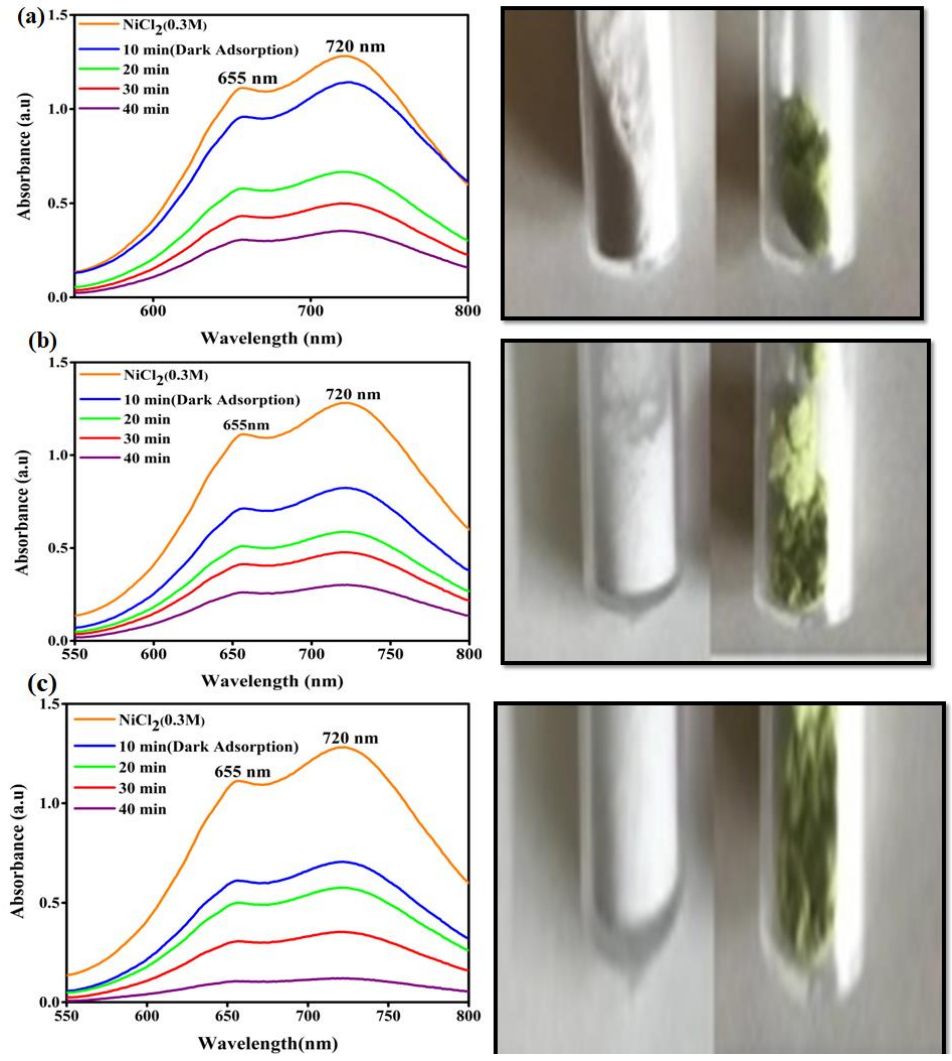

Fig 17: Adsorption spectra of Ni^{+2} (0.5M) at 720nm over (a) $CaCO_3$-RT (b) $CaCO_3$-400˚C (c) CaO-900˚C and the change in the color of $CaCO_3$ powder at RT, 400˚C and 900˚C after adsorption of Ni^{+2} metal ions

The %age adsorption (eta) is given by $\mathbf{(C_0-C_t/C_0)*100}$ where C_0 is initial concentration of adsorbate and C_t is the equilibrium concentration of adsorbate at time t. It is observed that the %age adsorption of $CaCO_3$-900˚C is more because of its negative charge and positively charged metal ions adsorbed more prominently on $CaCO_3$-900˚C.

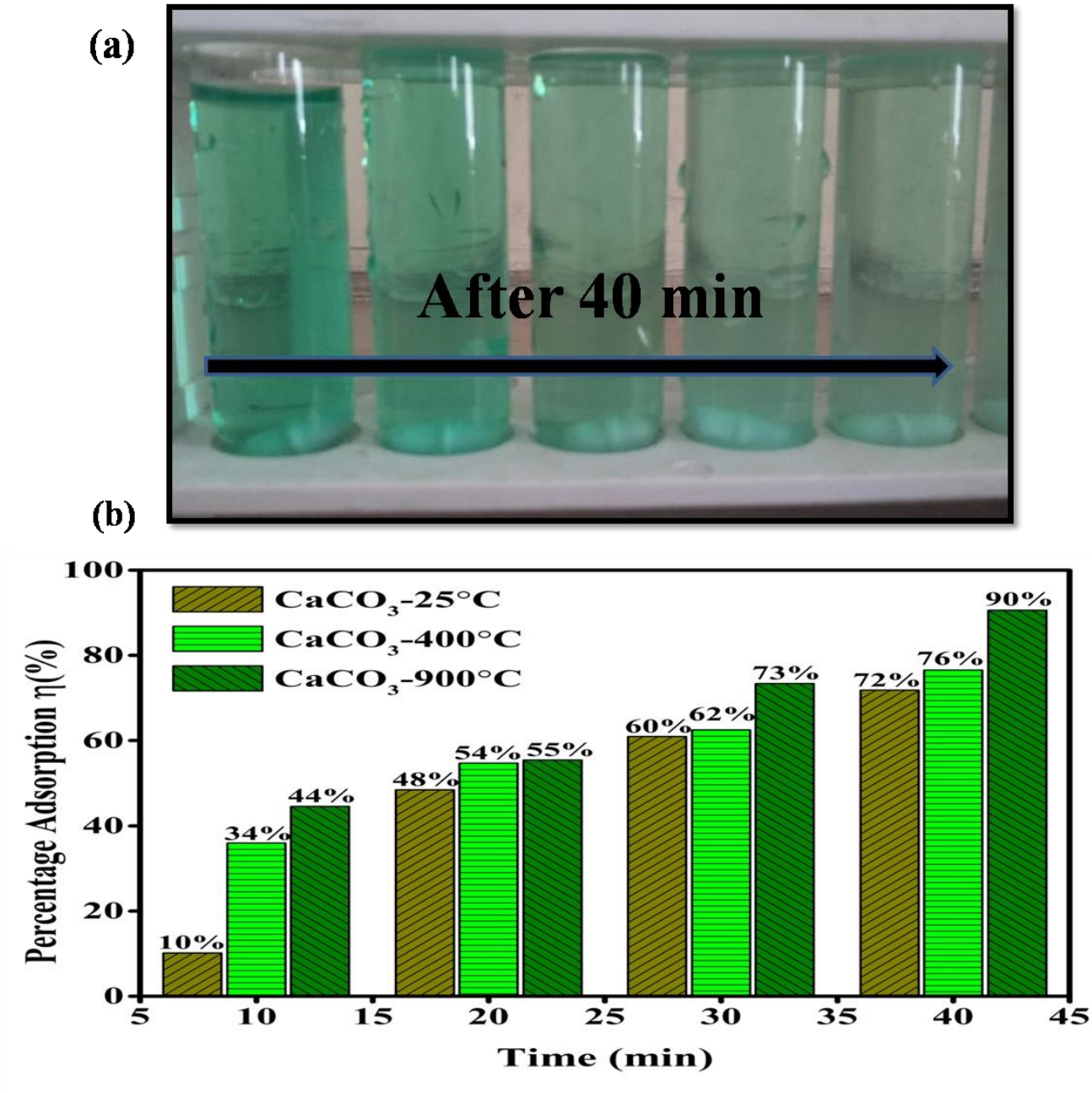

Fig 18: (a) Change in the color intensity with time during dark adsorption of Ni^{+2} ions over $CaCO_3$-RT. (b) Percentage adsorption of Ni^{+2} (0.3M) over $CaCO_3$ at RT, 400˚C and 900˚C.

6. Comparative studies

6.1 Adsorption isotherm and kinetics order:

From the data it was observed that Langmuir adsorption isotherm $\mathbf{Q_e = (C_O - C_e)\ V/m}$ is the best fit adsorption isotherm for this work. Where C_e is the equilibrium concentration of the adsorbate, C_0 is the initial concentration of the adsorbate, V is the volume used and m is the mass of the catalyst. The kinetics studies followed the first order kinetics $\mathbf{\ln C_t / C_0 = k_t}$, where C_t is the concentration of the reactant after the adsorption (mol/l), C_0 is the concentration of reactant before adsorption; t the irradiation time (min).k is rate constant of the first-order (min^{-1}) reaction. It was concluded that fitting of first-order reaction.

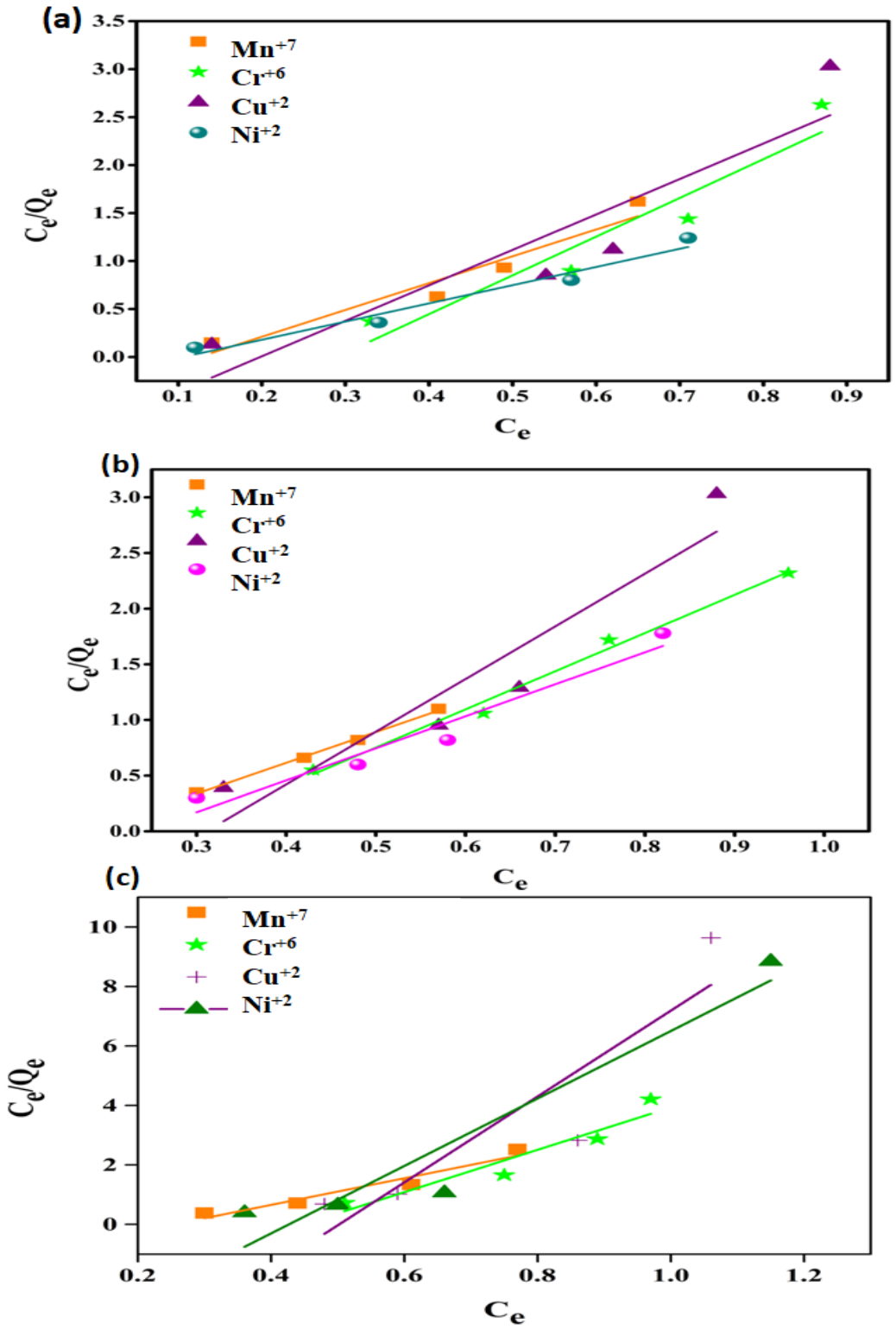

Fig 19: Langmuir adsorption isotherm of different metal ions over (a) $CaCO_3$ –RT (b) $CaCO_3$-400˚C and (c) $CaCO_3$-900˚C.

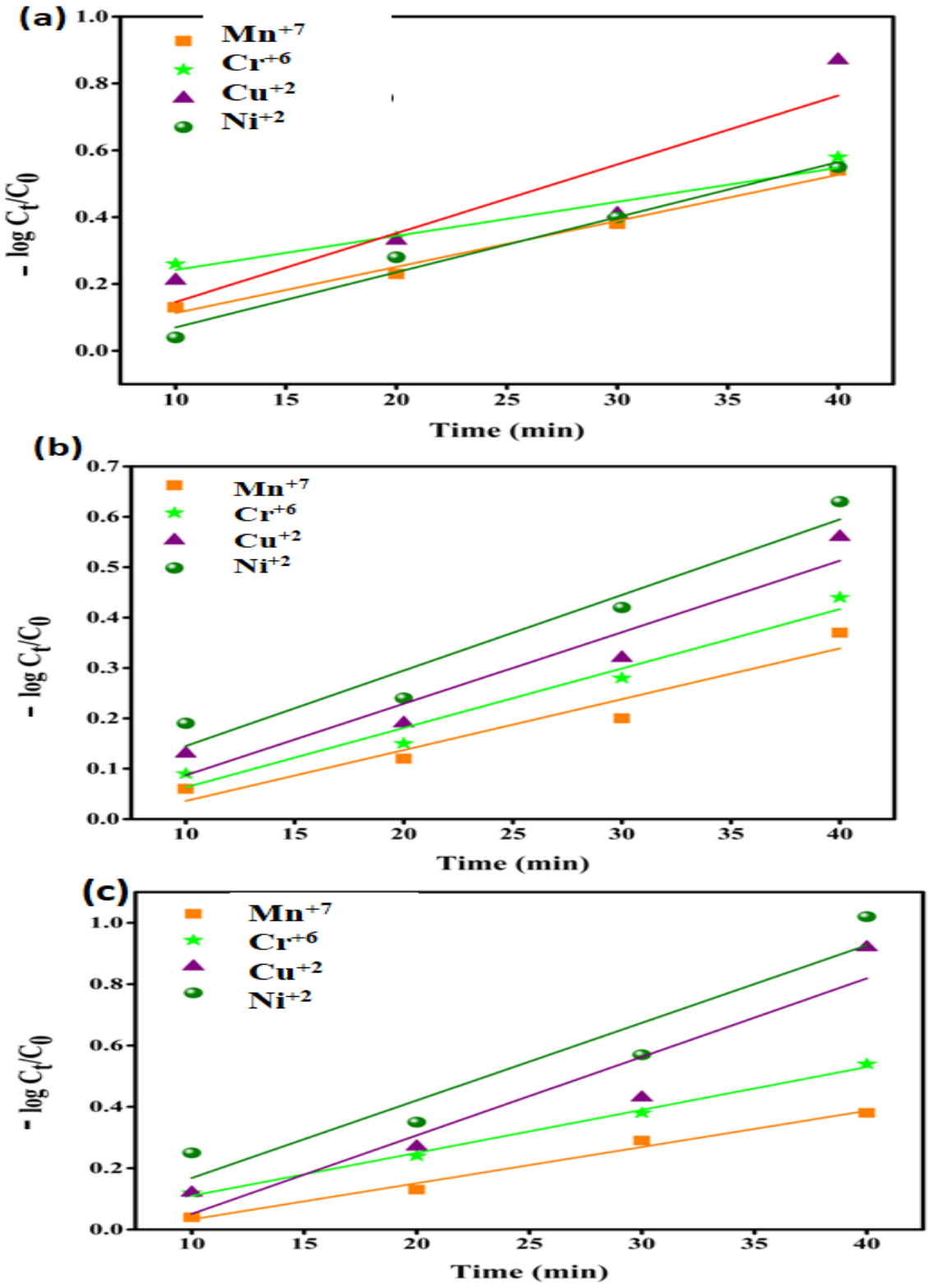

Fig 20: Adsorption constant (rate constant) of different metal ions over (a) $CaCO_3$ –RT (b) $CaCO_3$-400˚C and (c) $CaCO_3$-900˚C.

6.2: Amount of different metal ions adsorbed:

Being a physiorption process, i.e. an adsorbate is adsorbed on the surface of adsorbent by the weak vander wall forces of attraction. Metal ions having +ve charge with different oxidation states are studied. Zeta results showed that the $CaCO_3$ at 900˚C have negative charge on its surface due to the formation of $Ca(OH)_2$ which is negative in nature

$CaCO_3$-900˚C + $H_2O \longrightarrow Ca(OH)_2$

Because of higher oxidation of Mn^{+7} i.e. higher positive charge on Mn^{+7} will adsorbed on the surface of $CaCO_3$-900˚C with higher efficiency as shown on fig 20.

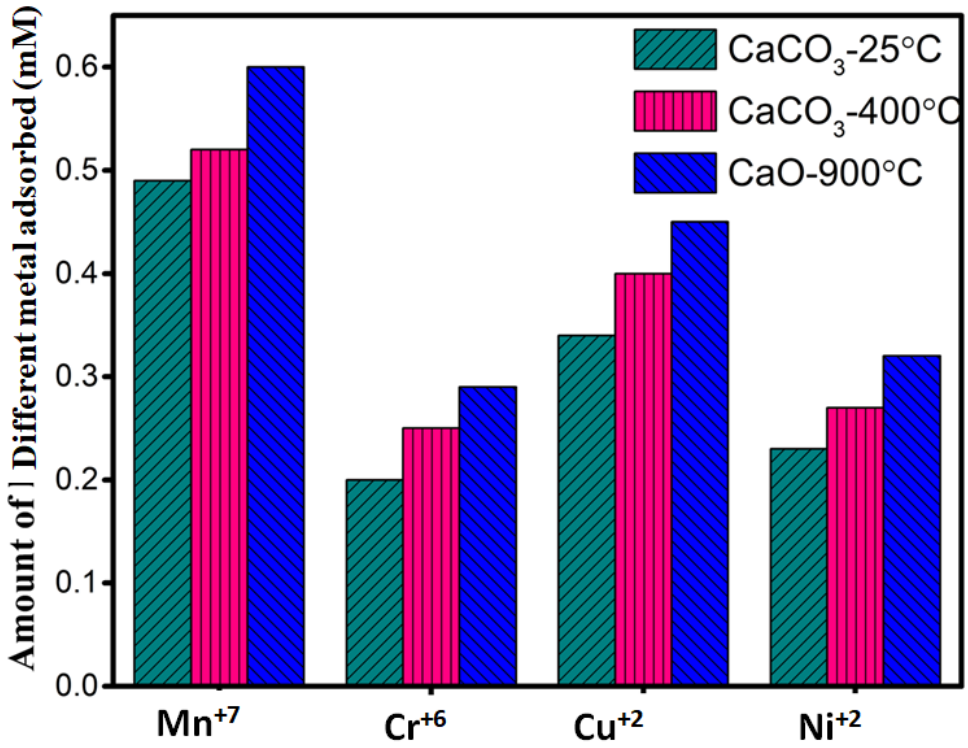

Fig 21: Amount of different metal ions adsorbed over $CaCO_3$ RT, 400˚C and 900˚ C.

7. Conclusion:

The method of extraction of $CaCO_3$ was cost-effective, nontoxic and eco-friendly. The obtained $CaCO_3$ was used for the adsorption and for removal of different metal ions. It was characterized by using DLS, SEM, TGA and UV- Visible spectroscopy with various techniques.TGA analysis shows that $CaCO_3$- RT, 400˚C is a two step thermal decomposition. Metal ions with positive oxidation state are adsorbed. Metals with higher oxidation state are adsorbed with higher efficiency.$CaCO_3$-900˚C has negative charge on its surface.

In future, the $CaCO_3$ obtained from tap water further used in the formation of chalk, in paints, and $CaCO_3$ -900˚C can be decomposed completely into CaO and its adsorption efficiency for the removal of metal ions can be studied.

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